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LNAPL Transmissivity, Bioventing Respirometry, and NSZD Testing Work Plan

BNSF Wishram Railyard, Wishram, Washington

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Prepared for

BNSF Railway Company
605 Puyallup Avenue
Tacoma, Washington 98421

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LNAPL Transmissivity, Bioventing Respirometry, and NSZD Testing Work Plan

BNSF Wishram Railyard,
(Ecology Site Name BNSF Track Switching Facility)
Wishram, Washington

Prepared by:

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The findings, recommendations, specifications, or professional opinions presented in this report were prepared in accordance with the generally accepted professional engineering practice and within the scope of the project. No other warranty, either expressed or implied, is provided.

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Section 1: Introduction

Kennedy/Jenks Consultants, Inc. (KJ) has prepared this Work Plan to conduct field activities to aid in feasibility evaluation of remediation alternatives at the BNSF Railway Company (BNSF) Railyard in Wishram, Washington (site). The objectives of the field activities described in this Work Plan are to 1) evaluate transmissivity of light non-aqueous phase liquid (LNAPL) on the site, 2) assess the performance of the existing bioventing system operating in the vicinity of the Maintenance Shop, 3) assess potential for bioventing in the vicinity of the submerged LNAPL south of the mainline, and 4) evaluate occurrence of natural source zone depletion (NSZD) at the site. The site layout map, including the locations of the bioventing system and the wells to be included in testing, is provided on Figure 1.

This Work Plan includes: 1) site background information and 2) a description of field activities and objectives. Example field forms for use during field activities are included in Appendix A and standard operating guidelines (SOGs) in Appendix B. Responses to the Washington State Department of Ecology's (Ecology's) comments to the Draft Work Plan (KJ July 2019) are included in Appendix C.

1.1 Site Background

The Wishram Railyard was originally developed by the Spokane, Portland, and Seattle (SP&S) Railway between 1910 and 1912. Fueling of steam locomotives with oil was conducted at the site from approximately 1912 through 1956 and fueling of diesel locomotives was conducted from the early 1950s to the 1970s (NWOR 2014, Grande 1992). Figure 2 shows historical site features. Historical locomotive fueling-related activities and fuel handling and storage are the likely source of petroleum hydrocarbon impacts in site soil and groundwater. Further site history is provided in the *Draft Remedial Investigation Report* (Draft RI Report) (KJ 2019).

Environmental investigations and interim remedial actions conducted at the site since 2002 have identified petroleum hydrocarbons at concentrations exceeding the Model Toxics Control Act (MTCA) Method A cleanup levels (CULs) for soil and groundwater. In October 2015, BNSF entered into an Agreed Order (AO) with Ecology to perform a remedial investigation (RI). Upland RI field activities were substantially conducted between March 2016 and December 2018 in accordance with the *Remedial Investigation Work Plan* (RIWP) (KJ 2017) and *Remedial Investigation Work Plan Addendum* (RIWP Addendum) (KJ 2018). The Draft RI Report, summarizing RI activities was submitted by KJ and BNSF to Ecology for review on 31 May 2019.

Section 2: Scope of Work

2.1 LNAPL Transmissivity Testing

Apparent LNAPL thickness monitoring has been performed in the oil head monitoring (OHM) wells (OHM-1, OHM-2, OHM-3, and OHM-4; see Figure 1) since December 2016 on a monthly (2017) to quarterly (2018 and 2019) basis. LNAPL typical of heavy-end residual hydrocarbons has been observed in wells OHM-1, OHM-2, and OHM-3. A measurable LNAPL thickness greater than 0.01 foot has not been observed in OHM-4.

The RI included initial assessment of the potential mobility and recoverability of LNAPL on the site based on the results of laboratory testing of LNAPL physical properties and simulations of *in situ* LNAPL behavior. Field LNAPL transmissivity testing is intended to provide additional information to quantify potential NAPL mobility and provide information for evaluation of remediation alternatives.

Depths to air/LNAPL and LNAPL/groundwater interfaces will be measured using an oil/water interface probe prior to LNAPL removal. LNAPL baildown testing will be performed at OHM wells containing apparent LNAPL thicknesses greater than 0.5 foot (expected to include OHM-1, OHM-2, and OHM-3). The field protocol for measuring the depths to air/LNAPL and LNAPL/water interfaces involves freezing the oil/water interface probe in distilled water using dry ice, lowering the probe through LNAPL, allowing ice to melt, and then slowly retrieving the probe until encountering the LNAPL/water interface. Due to the time involved in these manual measurements (up to 1 hour), fluid and LNAPL recharge into the well will also be monitored using a level logging pressure transducer to record the potentiometric surface and an oil/water interface probe to gauge the depth to the top of the fluid column (e.g. air/water or air/LNAPL interface). The pressure transducer will be suspended in the well below the initial LNAPL/groundwater interface.

Prior to LNAPL transmissivity testing, samples of LNAPL and groundwater will be collected from OHM wells OHM-1, OHM-2, and OHM-3. LNAPL samples will be collected from near the LNAPL-air interface using a single-use cup attached to a rod. Groundwater samples will be collected using a peristaltic pump with the tubing inlet positioned below the LNAPL-groundwater interface. Samples will be collected in laboratory-provided containers and labeled with the sample name, date, and time. LNAPL samples from each OHM well will be transported, under chain-of-custody protocol, to Analytical Resources Inc. (ARI) of Tukwila, Washington, for analysis of extractable petroleum hydrocarbons (EPH) using Ecology methods. A set of LNAPL and groundwater samples from wells OHM-1 and OHM-3 will also be transported, under chain-of-custody protocol, to PTS Laboratories (PTS) of Houston, Texas for analysis of fluid properties that may affect potential mobility and treatability including surface tension and interfacial tensions [three phase pairs; oil/water, oil/air, and water/air (at ambient temperature)] by the DuNuoy Method ASTM D971.

Following sample collection, LNAPL will be removed from each test well using high vacuum extraction techniques: a stinger tube, connected via flexible hose to a mobile vacuum truck at the surface, will be lowered into the well and submerged below the LNAPL surface. LNAPL will initially be removed from the top of the column and the stinger tube will be lowered down the well to continue removing LNAPL. To the extent possible, removal of groundwater will be minimized. Transparent vacuum hose will be used to observe recovered fluids; however, the viscosity of the LNAPL may prevent visual observation of the composition of recovered fluids (e.g. if LNAPL, water, or a mixture). The volume of total fluids recovered from each well will be recorded based on fluid levels in the vacuum truck.

Following LNAPL removal, the depth to air/LNAPL interface will be measured at intervals of approximately 1 to 2 minutes for the first 30 minutes, 5 minutes for the next 30 minutes, 1 to 3 hours for the remainder of the first day, and approximately 2 to 4 times per day for 3 to 4 days. It is anticipated that manual measurement of the depths to air/LNAPL and LNAPL/groundwater interfaces will be performed at increasing time intervals following LNAPL removal and will be continued intermittently (weekly to monthly depending on field results), for four consecutive intervals after initiating the test.

An estimation of LNAPL transmissivity will be performed in accordance with ASTM guide E2856-13 for *Estimation of LNAPL Transmissivity* (ASTM 2013). Measurements will be recorded on a field form similar to that provided in ASTM guide E2856-13 (see Appendix A).

LNAPL and water recovered from the wells during high vacuum extraction activities will be collected in the vacuum truck and disposed offsite at an appropriate disposal facility.

2.2 Respirometry Testing – Existing Bioventing System

A bioventing system has been in operation at the site since June 2012 to address residual petroleum hydrocarbon impacts in soil north of the mainline tracks. The bioventing system operates by injecting ambient air into the unsaturated zone through four wells (SVE-12-1 through SVE-12-4) (Figure 1). The bioventing system operated in continuous mode (24 hours a day, 7 days a week) between June 2012 and April 2017, when the system blower failed. The blower was replaced on 28 November 2017, and the bioventing system was restarted in continuous mode.

Periodic monitoring of injection flow rates and induced pressures at the four injection wells and four monitoring wells in its vicinity (WMW-3, WMW-7, WMW-8, and WMW-12) has been performed since restarting the system in November 2017. Well construction information is provided in Table 1. System operational data collected between November 2017 and May 2019 is provided in Table 2. Soil gas measurements collected on 28 and 29 November 2017, before and after replacement of the system blower, are provided in Table 3. The average induced pressures at the monitoring wells between November 2017 and May 2019 have been approximately 0 (WMW-3), 0.04 (WMW-12), 0.2 (WMW-8), and 1.9 (WMW-7) inches of water. Using a criterion of 0.1 inches of water, the estimated radius of influence (ROI) of the system is approximately 90 feet, based on wellhead pressure measurements at or above 0.1 inches of water at well WMW-8, located approximately 90 feet from injection well SVE-12-1. Monitoring well WMW-7 is also located within this ROI while wells WMW-3 and WMW-12 are outside.

The evaluation of LNAPL remediation at many sites has demonstrated the importance of NSZD and enhanced biological degradation by introducing atmospheric air into the subsurface to increase subsurface oxygen concentrations (i.e., bioventing). Respirometry testing will provide information to assess the biodegradation rate of the adsorbed petroleum hydrocarbons and LNAPL in the smear zone.

2.2.1 Baseline Soil Gas Measurements

A component of the bioventing and NSZD evaluations is collection of soil gas (oxygen, carbon dioxide, hydrogen sulfide, and methane) and volatile organic compounds (VOCs) measurements from test and monitoring wells. At least 1 day prior to soil gas measurements, either vapor monitoring well plugs or modified well caps with barbed fittings will be installed at the wells selected for monitoring to allow collection of soil gas measurements. An RKI Eagle 2 multi-gas meter, or similar, will be used for soil gas measurements. Soil gas VOC concentrations will be measured using a photoionization detector (PID). The operating manual for the RKI Eagle 2, including documentation regarding instrument calibration, and KJ's SOG for PID measurements are provided in Appendix B. Measurements will be collected using the low purge volume well head method (Sweeney and Ririe 2017). The depths to LNAPL (if present) and groundwater will also be measured.

Monitoring wells for which soil gas measurements will be collected are identified on Figure 1.

2.2.2 Respirometry Test

Respirometry testing will include collecting soil gas (oxygen, carbon dioxide, hydrogen sulfide, and methane) and VOCs measurements as described in Section 2.2.1 from seven wells once during system operation (immediately before shutdown) and at increasing time intervals, for a period up to approximately 4 days (96 hours) following system shutdown to assess oxygen consumption. Proposed wells for respirometry testing include injection wells SVE-12-1 through SVE-12-4, monitoring wells WMW-7 and WMW-8, which are located within the system's ROI, and monitoring well WMW-12, which is not located within the ROI, but will be included to provide background data for comparison.

Respirometry test results will be analyzed to estimate biodegradation rates based on oxygen utilization rates as described in Leeson and Hinchee (1996).

Upon the conclusion of the field activities identified in Section 2.3 and 2.4 of this Work Plan, the bioventing system will be returned to continuous operation. Templates of the field forms to be used for respirometry data collection are provided in Appendix A.

2.3 Bioventing Test

A bioventing test will be performed south of the mainline tracks, in the vicinity of submerged LNAPL areas (Figure 1). The proposed bioventing test activities include: 1) an initial soil gas survey of select monitoring wells, 2) an air injection test to approximate system radius of influence (ROI), and 3) a respirometry test (following the injection test).

An existing monitoring well, either WMW-1 or WMW-3, will be used as the bioventing injection test well. Criteria for well selection include approximately 1 foot or more of open well screen above the groundwater table (Table 1), proximity to inferred LNAPL or residual total petroleum hydrocarbon (TPH) impacts (Figure 1), dissolved phase TPH concentrations above MTCA

Method A CULs, proximity to other monitoring wells, and areas with limited traffic and easy access.

For both wells, the open well screen above groundwater table may be a limiting factor. Groundwater levels will be measured during baseline soil gas gauging (see Section 2.2.1). Well WMW-1 meets the other criteria and is the preferred location if the open well screen criterion is met during testing. Well WMW-3 meets the LNAPL and dissolved phase impacts criteria; however, this well is approximately 95 feet from the nearest monitoring well and is located adjacent to a gravel roadway through the railyard.

If neither well WMW-1 nor WMW-3 have approximately 1 foot open well screen, well WMW-11 will be used as the test well. Templates of the field forms to be used for the bioventing pilot study are provided in Appendix A.

2.3.1 Air Injection Test

A soil gas survey (see Section 2.2.1) will be conducted to measure baseline concentrations of soil gas (oxygen, carbon dioxide, hydrogen sulfide, and methane) and VOCs in the two potential test wells (WMW-1 and WMW-3) and four other wells (WMW-11, WMW-15, WMW-16, and WMW-17) located within approximately 100 feet of the well WMW-1.

Following the soil gas survey, an air injection test will be performed at the test well to assess air injection into the formation and the optimum injection flow rate for the multi-day injection test. A regenerative blower will be used to apply three different injection flow rates for approximately 1 hour each. Injection flow rate steps will be applied at approximately 10 standard cubic feet per minute (scfm), 15 scfm, and 20 scfm. Actual flow rates may vary based on site conditions. Pressure response will be measured in the wells identified above at approximately 30-minute intervals during the step tests with a differential pressure gage.

After the completion of step testing, a 48-hour continuous injection test will commence at the test well. The injection rate will be determined based on results of the step test. A portable generator will be used to supply power to the injection blower during the test.

Prior to the end of the test, a soil gas survey and a round of wellhead pressure measurements will be collected from adjacent wells to evaluate the oxygen/carbon dioxide (O_2/CO_2) concentrations and pressure ROIs relative to the injection location. These measurements will also be used as baseline operational data for a respirometry test, which will be performed after shutdown of the injection blower and following similar procedures to those described in Section 2.2.2.

The pressure ROI will be estimated based on plotting the logarithm of the wellhead pressure measurements versus distance from the test well. A value of 0.1 inches of water will indicate adequate pressure distribution. Respirometry test results will be analyzed to estimate biodegradation rates based on oxygen utilization rates as described in Leeson and Hinchee (1996).

2.4 Natural Source Zone Depletion Assessment

Two approaches will be employed to assess the potential for NSZD at the site: 1) measurement of soil gases from monitoring wells and 2) carbon traps.

2.4.1 Soil Gas Measurements

In addition to respirometry testing at the seven wells listed in Section 2.2, soil gas (oxygen, carbon dioxide, hydrogen sulfide, and methane) and VOC measurements data will also be collected from 14 monitoring wells located south of the mainline. The selected wells are located approximately 150 feet or more from the existing bioventing system. Soil gas measurements will be performed approximately 3 to 4 days after the existing system has been shut down for respirometry testing as described in Section 2.2.2.

Monitoring wells were selected for NSZD soil gas data collection based on groundwater sampling results for total petroleum hydrocarbons (TPH) as diesel-range organics (DRO) and/or oil-range organics (ORO) compared to MTCA Method A CULs. Wells were also selected based on their proximity to inferred shallow and/or submerged petroleum hydrocarbons impacts. Selected wells include:

- Nine wells which frequently contain DRO/ORO at concentrations above MTCA Method A CULs: WMW-1, WMW-3, WMW-9, WMW-11, WMW-15, WMW-16, WMW-17, WMW-26, and WMW-29.

- Three wells which intermittently contain DRO/ORO above MTCA Method A CULs: WMW-10, WMW-14, and WMW-28.

- Two wells in which neither DRO nor ORO have been detected above MTCA Method A CULs: WMW-27, and WMW-13.

A multi-gas meter will be used for soil gas measurements and soil gas VOC concentrations will be measured using a PID. Measurements will be collected using the low purge volume well head method (Sweeney and Ririe 2017). Soil gas data will be collected from these 10 wells towards the end of respirometry/bioventing testing to reduce possible influence due to the operation of the bioventing system or bioventing test.

NSZD data will be analyzed in accordance with the Interstate Technology & Regulatory Council (ITRC) document *Evaluating Natural Zone Depletion at Sites with LNAPL* (ITRC 2009).

2.4.2 Carbon Traps

At sites contaminated with petroleum hydrocarbons, LNAPL losses can occur through natural biodegradation processes such as methanogenesis (Amos et al. 2005), in which CO_2 and methane (CH_4) are generated by an anaerobic process during natural degradation of organic materials such as petroleum hydrocarbons. As both of these gases are transported from the LNAPL source toward the atmosphere, CH_4 encounters atmospheric O_2 and, through aerobic processes, generates CO_2 in the shallow surface soil layer and the vadose zone. Field screening tools have been developed to quantify biodegradation rates and estimate NSZD over time.

At the site, CO_2 flux will be measured by trapping CO_2 and storing it for laboratory analysis, using a technology developed at Colorado State University Center for Contaminant Hydrology (CCH), and now commercialized by E-Flux, LLC (E-Flux). The E-Flux method measures carbon (to estimate total CO_2 flux) and carbon isotopes (i.e., ^{14}C) to determine the contribution of petroleum hydrocarbon degradation to the total carbon flux from the soil to the ground surface (Zimbron et al. 2011). This process will help assess and estimate natural LNAPL losses from biodegradation (i.e., NSZD). Research performed by CCH shows LNAPL losses on the order of thousands of gallons per acre per year at petroleum-impacted sites can be determined by measuring CO_2 flux. See the attached Standard Operating Procedure (SOP) for additional information about the CO_2 trap technology (Appendix B).

Criteria for locating traps are as follows:

- Areas that provide a range of known and documented site conditions (LNAPL thickness, depth to water, water level fluctuations, etc.), ideally adjacent to existing groundwater monitoring wells with LNAPL or known dissolved phase petroleum hydrocarbon impacts (using information from boring logs, historical water level and LNAPL measurements).

- Areas where existing monitoring wells exhibit CH_4 and CO_2 concentrations, indicating biodegradation and/or methanogenesis. (As part of this field effort, qualitative measurements of CH_4 will be measured at the head space of applicable monitoring wells, and the results will be used to help in the determination of CO_2 trap locations.)

- Areas largely free of surface layers that would limit attenuation of gases from the subsurface to the atmosphere (e.g., asphalt, concrete, track structures, or heavily compacted areas).

- Areas free from known surface flooding.

- Areas with limited traffic and easy access (i.e., traps will require protection as they will be located above the ground surface and could provide a tripping hazard).

Figure 1 shows the 11 proposed carbon trap locations at the site (locations numbered 1 to 11). Actual trap locations will be selected in the field based on results of the measured soil gas parameters (as discussed in Sections 2.2 and 2.3.1), proximity to railroad track structures, presence of surface layers, and information about railyard activities from BNSF personnel at the site. The 11 locations are summarized below:

- Background Locations: 1 and 3 (near WMW-12 and WMW-13). Areas not known to be influenced by petroleum impacts (i.e., non-impacted vadose zone, not overlying dissolved phase impacts or LNAPL).

- Maintenance Shop (current bioventing system): 2 (near WMW-7). Historical apparent LNAPL thicknesses measured in well; sheen observed in groundwater purge water.

- Above Smear Zone and/or Submerged LNAPL Areas: 4, 5, 6, 7, and 10. Groundwater samples from nearby wells have contained DRO and/or ORO above MTCA CULs. Areas within inferred extent of smear zone impacts and submerged LNAPL based on laser induced fluorescence (LIF) logs.

- Near Shallow Impacts: 6 (WMW-1 location). Groundwater samples from this well have contained DRO and ORO above MTCA CULs and methane.

- Dissolved Phase Impacts: 8 and 9 (south of former Power House, Figure 1) and 11 (WMW-26 location, former Engine House footprint). Groundwater samples from nearby wells have contained DRO and/or ORO above MTCA CULs and methane.

2.4.2.1 Trap Deployment and Retrieval

CO_2 samples will be collected in accordance with the SOP for field deployment and retrieval of CO_2 traps (see Attachment A).

E-Flux will provide custom-made canisters filled with the CO_2 sorbent material, as well as additional field components for trap deployment: receivers for ground installation and covers to protect the traps from rainfall. The traps will be loaded, sealed, and shipped by E-Flux to KJ. One blank will be included (trip blank will not be opened in the field) to be analyzed and used for correction of field sample results. KJ will record trap deployment and recovery times on chain-of-custody (COC) forms provided with the traps. During trap deployment, meteorological data will be recorded from weather tracking sources in the area and groundwater temperatures will be recorded by data logging pressure transducers installed in nearby monitoring wells.

Field activities including water level and temperature measurements, an initial round of soil gas sampling, and one round of trap deployment for approximately 2 weeks are proposed for August 2019. While trap deployment is expected to last for 2 weeks, the deployment duration will be determined by KJ and E-Flux, based primarily on weather conditions (whether or not surface soil becomes saturated during a rain event, causing limited attenuation of gases from the subsurface to the atmosphere). E-Flux will provide laboratory analytical results and interpretation within 4 weeks after receiving traps from the field.

2.4.2.2 Laboratory Analysis

Upon trap retrieval, the sorbent material will be vacuum-dried at the laboratory, and homogenized. The total carbonate will be quantified using method ASTM D4373–02 (Standard Test Method for Rapid Determination of Carbonate Content of Soil). The laboratory at E-Flux uses the following quality control and quality assurance protocols during CO_2 analysis: triplicate analysis, trip blank analysis, and visual confirmation that the top CO_2 traps are not saturated. Carbon isotopic (^{14}C) analysis on the trap bottoms is used to determine the modern and fossil fuel (i.e., petroleum hydrocarbon) fractions of the CO_2 sorbed. Modern CO_2 is naturally produced by soils that have not been impacted by hydrocarbons, due to processes caused by plants (roots) and microbes. This carbon dating analysis is based on Accelerator Mass Spectroscopy (AMS), following ASTM Method D6866–12 (Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis).

2.4.2.3 Data Evaluation

CO_2 traps located at the ground surface will be used to generate time-weighted measurements of CO_2 flux. Each trap consists of two sorbent elements: the bottom captures CO_2 from surface soil and the top intercepts atmospheric CO_2. CO_2 passing through the trap reacts to form carbonates. The sorbent elements are analyzed by the laboratory for total carbonate mass, and CO_2 flux is estimated by dividing the carbonate mass by the cross-sectional area on the trap, taking into account the time the trap was deployed in the field. The estimated CO_2 flux is then converted to an estimated LNAPL biodegradation rate by selecting an appropriate (stoichiometric) ratio between CO_2 and LNAPL. (Note: LNAPL biodegradation rates are corrected to subtract out background rates of CO_2 quantified by background sampling and/or ^{14}C analysis).

Analytical results reported by E-Flux will include CO_2 fluxes as well as estimates of natural LNAPL biodegradation rates. Carbon dating results will be reported as the petroleum hydrocarbon fraction of the total fluxes.

2.5 Health and Safety

The site-specific Health and Safety Plan (HASP) will be updated, as needed, in accordance with the Federal Occupational Safety and Health Act (OSHA). The HASP will be in compliance with OSHA standards for potentially hazardous field investigations (29 CFR 1910.120). The HASP will establish general health and safety protocols to be used by personnel during field activities to reduce the possibility of injury and exposure to potentially hazardous materials.

2.6 Schedule

Field activities for this scope of work will be conducted in July or August 2019, during the seasonal low groundwater period, with a currently scheduled start date of 22 July 2019 for the LNAPL transmissivity tests (Section 2.1), respirometry test of the existing bioventing system (Section 2.2), and NSZD testing based on soil gas measurements (Section 2.4.1). Other field activities included in this work plan will be performed in August 2019.

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Tables

MONITORING WELL CONSTRUCTION SUMMARY
BNSF Wishram Rail Yard, Wishram, Washington

Well ID	Installation Date	Ecology Well Tag ID No.	Northing (feet)	Easting (feet)	Top of Casing Elevation[a] (feet amsl)	Flushmount Lid Elevation (feet amsl)	Well Depth (feet bgs)	Well Screen Diameter and Material[b]	Screen Interval (feet bgs)	Screen Interval (feet amsl)	Screen Length (feet)	Average Open Screen June-Sept (feet)	North Area Bioventing Respirometry	South Area Bioventing Respirometry	NSZD - Soil Gas Monitoring	LNAPL Baildown Transmissivity	LNAPL Sample Collection
Shallow Monitoring Wells[c]																	
WMW-1	09/12/2003	AHQ578	118101.05	1520597.16	172.42	172.98	20	2-inch PVC	10 - 20	162.98 - 152.98	10	0.8		X	X		
WMW-3	09/12/2003	AHQ580	118194.16	1520598.29	172.97	173.44	20	2-inch PVC	10 - 20	163.44 - 153.44	10	1.2		X	X		
WMW-5	04/05/2004	AKS192	118234.80	1520759.98	172.61	172.99	25	2-inch PVC	15 - 25	157.99 - 147.99	10	-4.3					
WMW-7	04/05/2004	AKS194	118349.93	1520548.97	174.12	174.71	20	2-inch PVC	10 - 20	164.71 - 154.71	10	2.5	X				
WMW-8 [d]	02/03/2012	RE06703	118297.12	1520437.09	173.65	174.18	22	2-inch PVC	7 - 22	167.18 - 152.18	15	4.9	X				
WMW-9 [d]	02/02/2012	RE06703	118150.38	1520456.83	173.12	173.80	23.5	2-inch PVC	8.5 - 23.5	165.30 - 150.30	15	3.1			X		
WMW-10 [d]	02/02/2012	RE06703	118082.76	1520444.31	172.96	173.53	22.5	2-inch PVC	7.5 - 22.5	166.03 - 151.03	15	3.7			X		
WMW-11 [d]	02/03/2012	RE06703	118082.47	1520522.35	172.89	173.35	22	2-inch PVC	7 - 22	166.35 - 151.35	15	4.2		X	X		
WMW-12	10/11/2016	BJX218	118232.55	1520334.13	173.25	173.58	25	2-inch PVC	6 - 21	167.58 - 152.58	15	5.5	X				
WMW-13	10/11/2016	BJX219	118115.77	1520385.06	173.58	173.84	25	2-inch PVC	6 - 21	167.84 - 152.84	15	5.7			X		
WMW-14	10/18/2016	BJX228	118058.74	1520450.04	177.15	177.58	30	2-inch PVC	12 - 27	165.58 - 150.58	15	3.5			X		
WMW-15	10/18/2016	BJX227	118060.70	1520514.17	176.99	177.35	30	2-inch PVC	12 - 27	165.35 - 150.35	15	3.3		X	X		
WMW-16	10/17/2016	BJX222	118055.77	1520597.43	176.74	176.94	30	2-inch PVC	11.33 - 26.33	165.61 - 150.61	15	3.5		X	X		
WMW-17	10/13/2016	BJX224	118048.42	1520674.59	176.54	177.01	30	2-inch PVC	12 - 27	165.01 - 150.01	15	3.1		X	X		
WMW-18	10/12/2016	BJX220	118060.67	1520761.30	176.72	177.05	30	2-inch PVC	12 - 27	165.05 - 150.05	15	3.0					
WMW-19	07/31/2018	BKL001	118053.08	1520376.20	176.99	177.27	21.5	2-inch PVC	11.5 - 21.5	165.77 - 155.77	10	3.7					
WMW-20	08/02/2018	BKL002	118072.91	1520868.44	176.92	177.18	21.5	2-inch PVC	11.5 - 21.5	165.68 - 155.68	10	3.6					
WMW-21	08/07/2018	BKL009	118086.23	1520957.27	176.06	176.36	21.5	2-inch PVC	11.5 - 21.5	164.86 - 154.86	10	2.8					
WMW-22	08/07/2018	BKL010	118153.92	1521131.00	176.37	176.68	21.5	2-inch PVC	11.5 - 21.5	165.18 - 155.18	10	3.2					
WMW-23	08/06/2018	BKL011	118198.10	1521229.78	176.15	176.43	21.5	2-inch PVC	11.5 - 21.5	164.93 - 154.93	10	3.0					
WMW-24	08/02/2018	BKL003	118278.95	1520806.69	173.20	173.51	17	2-inch PVC	7 - 17	166.51 - 156.51	10	4.2					
WMW-26	08/03/2018	BKL006	118354.84	1521006.08	173.48	173.79	17	2-inch PVC	7 - 17	166.79 - 156.79	10	4.4			X		
WMW-27	08/03/2018	BKL005	118255.49	1521044.81	172.14	172.40	17	2-inch PVC	7 - 17	165.40 - 155.40	10	3.1			X		
WMW-28	08/02/2018	BKL004	118227.24	1520890.14	172.22	172.55	17	2-inch PVC	7 - 17	165.55 - 155.55	10	3.3			X		
WMW-29	08/03/2018	BKL007	118380.39	1521178.63	173.49	173.74	17	2-inch PVC	7 - 17	166.74 - 156.74	10	4.3			X		
WMW-30	08/06/2018	BKL008	118449.49	1521397.13	172.94	173.21	17	2-inch PVC	7 - 17	166.21 - 156.21	10	3.7					
WMW-31	08/08/2018	BKL012	118721.84	1521266.72	173.24	173.47	17	2-inch PVC	7 - 17	166.47 - 156.47	10	3.7					
WMW-32	08/08/2018	BKL013	118953.33	1521922.05	173.78	174.03	17	2-inch PVC	7 - 17	167.03 - 157.03	10	4.4					

TABLE 1

MONITORING WELL CONSTRUCTION SUMMARY
BNSF Wishram Rail Yard, Wishram, Washington

Well ID	Installation Date	Ecology Well Tag ID No.	Northing (feet)	Easting (feet)	Top of Casing Elevation[a] (feet amsl)	Flushmount Lid Elevation (feet amsl)	Well Depth (feet bgs)	Well Screen Diameter and Material[b]	Screen Interval (feet bgs)	Screen Interval (feet amsl)	Screen Length (feet)	Average Open Screen June-Sept (feet)	North Area Bioventing Respirometry	South Area Bioventing Respirometry	NSZD - Soil Gas Monitoring	LNAPL Baildown Transmissivity	LNAPL Sample Collection
Deep Monitoring Wells[b]																	
RMD-1	10/12/2016	BJX223	118060.34	1520519.17	176.89	177.30	44.6	2-inch PVC	29.6 - 44.6	147.70 - 132.70	15	-14.4					
RMD-2	10/14/2016	BJX226	118055.39	1520602.01	176.59	176.82	50	2-inch PVC	30 - 50	146.82 - 126.82	20	-15.2					
RMD-3	10/14/2016	BJX225	118048.23	1520679.29	176.90	177.18	60	2-inch PVC	40 - 60	137.18 - 117.18	20	-24.9					
RMD-4	10/12/2016	BJX221	118060.86	1520765.80	176.79	177.11	65	2-inch PVC	45 - 65	132.11 - 112.11	20	-30.0					
RMD-5	08/20/2018	BLK014	118058.78	1520457.20	176.65	177.41	45	2-inch PVC	30 - 45	147.41 - 132.41	15	-14.7					
RMD-6	08/21/2018	BLK015	118073.77	1520875.03	176.55	177.20	65	2-inch PVC	45 - 65	132.20 - 112.20	20	-29.9					
Oil Head Monitoring Wells																	
OHM-1	11/02/2016	BJX232	118166.15	1520658.80	172.68	173.05	80.5	4-inch PVC	15 - 80	158.05 - 93.05	65	-4.3				X	X
OHM-2	10/27/2016	BJX230	118183.98	1520688.80	172.73	173.04	51.5	4-inch PVC	16 - 51	157.04 - 122.04	35	-5.2				X	X
OHM-3	10/28/2016	BJX229	118245.91	1520690.92	172.82	173.12	42.2	4-inch PVC	16.8 - 41.8	156.32 - 131.32	25	-6.1				X	X
OHM-4 [e]	10/20/2016	BJX231	118158.29	1520505.62	173.51	173.80	25.8	4-inch Steel	20.4 - 25.4	153.40 - 148.40	5	-8.8					
AS/SVE Wells																	
AS-12-1	01/12/2012	--	118333.77	1520534.96	174.54	--	19.3	2-inch PVC	16.75 - 19.3	157.78-155.23	2.55	-162.2					
AS-12-2	01/13/2012	--	118318.59	1520508.90	174.61	--	19.3	2-inch PVC	16.75 - 19.25	157.85-155.35	2.5	-162.2					
AS-12-3	01/16/2012	--	118330.87	1520494.59	174.46	--	19.5	2-inch PVC	17 - 19.5	157.45-154.95	2.5	-162.2					
SVE-12-1	01/16/2012	--	118341.05	1520516.79	174.44	--	8.5	4-inch PVC	5.5 - 8.5	168.93-165.93	3	3	X				
SVE-12-2	01/15/2012	--	118408.33	1520576.96	175.32	--	9.0	4-inch PVC	6.0 - 9.0	169.32-166.32	3	3	X				
SVE-12-3	01/15/2012	--	118433.88	1520619.32	176.71	--	10.4	4-inch PVC	6.4 - 10.4	170.71-167.71	3	3	X				
SVE-12-4	01/13/2012	--	118451.64	1520661.89	176.68	--	10.1	4-inch PVC	6.1 - 10.1	170.58-166.58	4	4	X				

Notes:

(a) Deep monitoring well screens constructed with 2-inch diameter Schedule 40 polyvinyl chloride (PVC) screen with 0.020-inch slot size.
(b) Oil head monitoring well screens constructed with 4-inch diameter Schedule 40 PVC pre-packed screen with 0.040-inch slot size.
(c) Shallow monitoring well screens constructed with 2-inch diameter Schedule 40 PVC screen with 0.010-inch slot size.
(d) Well identification (ID) tag numbers unknown / not assigned for wells WMW-8 through WMW-11. Notice of intent numbers shown.
(e) OHM-4 well screen constructed with 4-inch diameter type 304 stainless steel screen with 0.040-inch slot size.

Ecology Well Tag ID No. = Unique well tag ID assigned by State of Washington Department of Ecology (Ecology).
amsl = above mean sea level
bgs = below ground surface
LNAPL = light non-aqueous phase liquid
AS/SVE = air sparge/soil vapor extraction
WMW-7 Well included in existing bioventing system monitoring.
WMW-16 Well included in natural source zone depletion (NSZD) evaluations and/or bioventing injection test.
X = well included in the indicated field testing activity.
LNAPL sample collection = collection of LNAPL and/or groundwater from indicated well for analysis of Extractable Petroleum Hydrocarbons (EPH) by the Ecology method and/or LNAPL physical properties.

Average open screen between June and September calculated for 2016, 2017, and 2018 as difference between top of well screen elevation and average groundwater elevation. Positive value indicates the length of screen above water table. Negative values indicate well screen is submerged.

BIOVENTING SYSTEM OPERATIONAL DATA - NOVEMBER 2017 TO MAY 2019
BNSF Wishram Rail Yard, Wishram, Washington

Well ID	Well Screen Depth (ft bgs)	Well Diameter (inch)	Date_Time	Injection Temp (deg F)	Injection Flow Rate (cfm)	Injection Pressure (inches H2O)	Wellhead Vacuum/ Pressure (inches H2O)
SVE-12-1	5.5 - 8.5	4	11/28/17 16:05	--	83	110.8	--
SVE-12-2	6.0 - 9.0	4	11/28/17 16:00	--	36.2	83.1	--
SVE-12-3	6.4 - 10.4	4	11/28/17 15:55	--	36.7	110.8	--
SVE-12-4	6.1 - 10.1	4	11/28/17 16:10	--	48.4	83.1	--
SVE-12-1	5.5 - 8.5	4	11/29/17 09:45	--	--	--	58
SVE-12-2	6.0 - 9.0	4	11/29/17 10:50	--	--	--	66
SVE-12-3	6.4 - 10.4	4	11/29/17 10:58	--	--	--	66
SVE-12-4	6.1 - 10.1	4	11/29/17 11:05	--	--	--	64
WMW-7	10 - 20	2	11/29/17 09:20	--	--	--	4.0
WMW-8	7 - 22	2	11/29/17 10:08	--	--	--	0.5
WMW-12	6 - 21	2	11/29/17 10:30	--	--	--	0.12
SVE-12-1	5.5 - 8.5	4	02/28/18 16:05	--	25.22	53.5	53.5
SVE-12-2	6.0 - 9.0	4	02/28/18 16:00	--	19.82	53.5	53.5
SVE-12-3	6.4 - 10.4	4	02/28/18 15:55	--	16.54	54	53.5
SVE-12-4	6.1 - 10.1	4	02/28/18 16:10	--	103.6 [a]	52	37.5
WMW-7	10 - 20	2	02/28/18 16:15	--	--	--	5
WMW-8	7 - 22	2	02/28/18 16:20	--	--	--	0.6
WMW-12	6 - 21	2	02/28/18 16:26	--	--	--	0.11
SVE-12-1	5.5 - 8.5	4	06/22/18 15:45	--	--	38.3	39
SVE-12-2	6.0 - 9.0	4	06/22/18 15:46	--	--	38.9	36.5
SVE-12-3	6.4 - 10.4	4	06/22/18 15:45	--	--	39.7	39.7
SVE-12-4	6.1 - 10.1	4	06/22/18 15:47	--	--	39.7	28.8
WMW-7	10 - 20	2	06/22/18 16:20	--	--	--	3.0
WMW-8	7 - 22	2	06/22/18 16:25	--	--	--	0.2
WMW-12	6 - 21	2	06/22/18 16:30	--	--	--	0.02
SVE-12-1	5.5 - 8.5	4	08/08/18 07:25	--	36	13.7	11.3
SVE-12-2	6.0 - 9.0	4	08/08/18 07:27	--	8	13.8	13.9
SVE-12-3	6.4 - 10.4	4	08/08/18 07:28	--	25	13.7	13.0
SVE-12-4	6.1 - 10.1	4	08/08/18 07:30	--	13	13.8	13.7
WMW-7	10 - 20	2	08/08/18 08:40	--	--	--	1.2
WMW-8	7 - 22	2	08/08/18 08:50	--	--	--	0.09
WMW-12	6 - 21	2	--	--	--	--	--
SVE-12-1	5.5 - 8.5	4	08/08/18 12:40	--	40	17.5	14.4
SVE-12-2	6.0 - 9.0	4	08/08/18 12:42	--	12.2	17.9	--
SVE-12-3	6.4 - 10.4	4	08/08/18 12:45	--	28	17.7	--
SVE-12-4	6.1 - 10.1	4	08/08/18 12:47	--	14.1	18	--
WMW-7	10 - 20	2	08/08/18 12:30	--	--	--	1.6
WMW-8	7 - 22	2	08/08/18 12:25	--	--	--	0.16
WMW-12	6 - 21	2	--	--	--	--	--
SVE-12-1	5.5 - 8.5	4	08/09/18 12:30	--	43	17.3	--
SVE-12-2	6.0 - 9.0	4	08/09/18 12:32	--	4.8	17.5	--
SVE-12-3	6.4 - 10.4	4	08/09/18 12:34	--	30	17.5	--
SVE-12-4	6.1 - 10.1	4	08/09/18 12:38	--	11	17.7	--
SVE-12-1	5.5 - 8.5	4	08/10/18 08:30	137	51	18.1	--
SVE-12-2	6.0 - 9.0	4	08/10/18 08:29	135	6.18	30.1	--
SVE-12-3	6.4 - 10.4	4	08/10/18 08:28	131.2	31.5	14.6	--
SVE-12-4	6.1 - 10.1	4	08/10/18 07:40	130	18.4	30.1	--
WMW-7	10 - 20	2	08/10/18 07:35	--	--	--	1.1
WMW-8	7 - 22	2	08/10/18 08:10	--	--	--	0.12
WMW-12	6 - 21	2	08/10/18 08:15	--	--	--	0.005
SVE-12-1	5.5 - 8.5	4	08/10/18 10:05	109.5	40	11.4	9.6
SVE-12-2	6.0 - 9.0	4	08/10/18 10:10	--	12	9.1	14.6
SVE-12-3	6.4 - 10.4	4	08/10/18 10:15	--	35	20.4	20.1
SVE-12-4	6.1 - 10.1	4	08/10/18 10:20	--	15	25.7	25.3
WMW-7	10 - 20	2	08/10/18 10:00	--	--	--	1.0

BIOVENTING SYSTEM OPERATIONAL DATA - NOVEMBER 2017 TO MAY 2019
BNSF Wishram Rail Yard, Wishram, Washington

Well ID	Well Screen Depth (ft bgs)	Well Diameter (inch)	Date_Time	Injection Temp (deg F)	Injection Flow Rate (cfm)	Injection Pressure (inches H2O)	Wellhead Vacuum/ Pressure (inches H2O)
SVE-12-1	5.5 - 8.5	4	03/14/19 12:53	107.2	14.54	7.4	--
SVE-12-2	6.0 - 9.0	4	03/14/19 12:52	87.2	4.69	8	--
SVE-12-3	6.4 - 10.4	4	03/14/19 12:51	114.6	20.19	11.6	--
SVE-12-4	6.1 - 10.1	4	03/14/19 12:50	110.5	8.87	13.2	--
WMW-7	10 - 20	2	03/14/19 13:02	--	--	--	1.0
WMW-8	7 - 22	2	03/14/19 13:06	--	--	--	0.1
WMW-12	6 - 21	2	03/14/19 13:11	--	--	--	0.02
WMW-3	10 - 20	2	03/14/19 13:28	--	--	--	0
SVE-12-1	5.5 - 8.5	4	05/07/19 07:29	122	28.7	6.9	--
SVE-12-2	6.0 - 9.0	4	05/07/19 07:25	106	6.06	4.7	9.0
SVE-12-3	6.4 - 10.4	4	05/07/19 07:27	125.9	23.71	12.3	12.1
SVE-12-4	6.1 - 10.1	4	05/07/19 07:28	123.4	10.22	14.3	14.6
WMW-7	10 - 20	2	05/07/19 08:00	--	--	--	0.7
WMW-8	7 - 22	2	05/07/19 08:13	--	--	--	0.05
WMW-12	6 - 21	2	05/07/19 08:15	--	--	--	0.01
SVE-12-1	5.5 - 8.5	4	05/09/19 07:23	109.8	26.5	7.3	--
SVE-12-2	6.0 - 9.0	4	05/09/19 07:18	96.4	10.01	8.5	8.5
SVE-12-3	6.4 - 10.4	4	05/09/19 07:20	117.6	29.73	12.8	12
SVE-12-4	6.1 - 10.1	4	05/09/19 07:21	109.6	24.28	14.7	14.4
WMW-7	10 - 20	2	05/09/19 07:32	--	--	--	0.7
WMW-8	7 - 22	2	05/09/19 07:36	--	--	--	0.01
WMW-12	6 - 21	2	05/09/19 07:40	--	--	--	0.015
WMW-3	10 - 20	2	05/09/19 07:45	--	--	--	0

Notes:
Injection flow rate in cubic feet per minute (cfm) and temperature in degrees Fahrenheit (deg F) measured using a Velocicalc 9565 meter.
Injection / induced wellhead vacuum (-) or pressure (+) (in inches of H_2O) measured with Dwyer magnehelic pressure gauges or Dwyer digital manometer.
ft bgs = feet below ground surface
(a) injection flow rate recorded 2/28/2018 for well SVE-12-4 is anomalous.
-- = not measured

TABLE 3

SOIL GAS MONITORING DATA - NOVEMBER 2017
BNSF Wishram Rail Yard, Wishram, Washington

Injection Well — Screen Interval: 5.5 - 8.8 feet bgs

Well ID	Fluid Depth/Probe Depth (ft)	Well Diameter (inch)	Date/Time	Purge Time Before Reading (minutes)	System Status (On / Off)	O_2 (%) [(a)]	CO_2 (%)	CH_4 (%) (LEL) [(a)]	H_2S (%)	Inches of H_2O
SVE-12-1	Dry	4	11/28/17 13:05	2	Off	20.9	0.5	1.0	0.0	--
			11/28/17 13:07	2	Off	20.9	0.7	1.0	0.0	--
			11/28/17 13:09	2	Off	20.9	0.8	1.0	0.0	--
			11/28/17 13:11	2	Off	20.9	0.8	1.0	0.0	--
			11/29/17 10:50	--	On	21.8	0.0	1.0	0.0	58

Injection Well — Screen Interval: 6.0 - 9.0 feet bgs

Well ID	Fluid Depth/Probe Depth (ft)	Well Diameter (inch)	Date/Time	Purge Time Before Reading (minutes)	System Status (On / Off)	O_2 (%) [(a)]	CO_2 (%)	CH_4 (%) (LEL) [(a)]	H_2S (%)	Inches of H_2O
SVE-12-2	Dry	4	11/28/17 13:38	2	Off	20.9	0.6	1.0	0.0	--
			11/28/17 13:40	2	Off	20.9	0.6	1.0	0.0	--
			11/28/17 13:42	2	Off	20.8	0.7	1.0	0.0	--
			11/28/17 13:44	2	Off	20.8	0.7	1.0	0.0	--
			11/29/17 10:58	--	On	21.6	0.0	1.0	0.0	66

Injection Well — Screen Interval: 6.4 - 10.4 feet bgs

Well ID	Fluid Depth/Probe Depth (ft)	Well Diameter (inch)	Date/Time	Purge Time Before Reading (minutes)	System Status (On / Off)	O_2 (%) [(a)]	CO_2 (%)	CH_4 (%) (LEL) [(a)]	H_2S (%)	Inches of H_2O
SVE-12-3	<0.01 LNAPL, Trace Water	4	11/28/17 12:23	2	Off	20.9	0.6	1.0	0.0	--
			11/28/17 12:25	2	Off	20.8	0.8	1.0	0.0	--
			11/28/17 12:27	2	Off	20.6	0.9	1.0	0.0	--
			11/28/17 12:29	2	Off	20.6	0.9	1.0	0.0	--
			11/29/17 11:05	--	On	22.1	0.0	1.0	0.0	66

Injection Well — Screen Interval: 6.1 - 10.1 feet bgs

Well ID	Fluid Depth/Probe Depth (ft)	Well Diameter (inch)	Date/Time	Purge Time Before Reading (minutes)	System Status (On / Off)	O_2 (%) [(a)]	CO_2 (%)	CH_4 (%) (LEL) [(a)]	H_2S (%)	Inches of H_2O
SVE-12-4	Dry	4	11/28/17 13:50	2	Off	20.3	1.1	1.0	0.0	--
			11/28/17 13:52	2	Off	20.1	1.2	1.0	0.0	--
			11/28/17 13:54	2	Off	20.0	1.2	1.0	0.0	--
			11/28/17 13:56	2	Off	20.0	1.2	1.0	0.0	--
			11/29/17 9:45	--	On	22.4	0.0	1.0	0.0	64.00

SOIL GAS MONITORING DATA - NOVEMBER 2017
BNSF Wishram Rail Yard, Wishram, Washington

WMW-7: 33 feet from injection well SVE-12-1. Inside Pressure ROI. Screen Interval: 10 - 20 feet bgs

Well ID	Fluid Depth/Probe Depth (ft)	Well Diameter (inch)	Date/Time	Purge Time Before Reading (minutes)	System Status (On / Off)	O_2 (%) [a]	CO_2 (%)	CH_4 (%) (LEL) [a]	H_2S (%)	Inches of H_2O
MW-7	11.76	2	11/28/17 14:45	2	Off	19.5	1.5	1.0	0.0	--
			11/28/17 14:47	2	Off	19.6	1.7	1.0	0.0	--
			11/28/17 14:49	2	Off	18.6	1.7	1.0	0.0	--
			11/28/17 14:51	2	Off	18.2	1.7	1.0	0.0	--
			11/29/17 9:20	1	On	19.9	2.5	1.0	0.0	4.00
			11/29/17 9:34	1	On	20.9	1.5	1.0	0.0	--
			11/29/17 9:35	1	On	20.9	1.6	1.0	0.0	--
			11/29/17 9:36	1	On	20.9	1.7	1.0	0.0	--
			11/29/17 9:37	1	On	20.9	1.7	1.0	0.0	--

WMW-8: 91 feet from injection well SVE-12-1. Inside Pressure ROI. Screen Interval: 7 - 22 feet bgs

Well ID	Fluid Depth/Probe Depth (ft)	Well Diameter (inch)	Date/Time	Purge Time Before Reading (minutes)	System Status (On / Off)	O_2 (%) [a]	CO_2 (%)	CH_4 (%) (LEL) [a]	H_2S (%)	Inches of H_2O
MW-8	11.32	2	11/28/17 15:13	2	Off	21.3	0.0	1.0	0.0	--
			11/28/17 15:15	2	Off	21.0	0.2	1.0	0.0	--
			11/28/17 15:17	2	Off	20.9	0.4	1.0	0.0	--
			11/29/17 10:08	1	On	17.9	1.3	1.0	0.0	0.50
			11/29/17 10:15	1	On	19.6	0.8	1.0	0.0	--
			11/29/17 10:16	1	On	19.4	0.9	1.0	0.0	--
			11/29/17 10:17	1	On	19.3	0.9	1.0	0.0	--
			11/29/17 10:19	1	On	19.3	0.9	1.0	0.0	--

WMW-12: 212 feet from injection well SVE-12-1. Outside of Pressure ROI. Screen Interval: 6 - 21 feet bgs

Well ID	Fluid Depth/Probe Depth (ft)	Well Diameter (inch)	Date/Time	Purge Time Before Reading (minutes)	System Status (On / Off)	O_2 (%) [a]	CO_2 (%)	CH_4 (%) (LEL) [a]	H_2S (%)	Inches of H_2O
MW-12	10.89	2	11/28/17 15:24	2	Off	21.6	0.0	1.0	0.0	--
			11/28/17 15:26	2	Off	21.4	0.1	1.0	0.0	--
			11/28/17 15:28	2	Off	21.4	0.1	1.0	0.0	--
			11/29/17 10:30	1	On	20.9	0.3	1.0	0.0	0.12
			11/29/17 10:32	1	On	21.1	0.2	1.0	0.0	--
			11/29/17 10:33	1	On	21.1	0.1	1.0	0.0	--
			11/29/17 10:34	1	On	21.1	0.1	1.0	0.0	--

Notes:
Bioventing system blower was replaced on November 28, 2017. Green shading indicates background data collected on November 28, 2017 while the system was off.
Blue shading indicates data collected on November 29, 2017 while the bioventing system was running.
Soil gas [oxygen (O_2), carbon dioxide (CO_2), methane (CH_4), and hydrogen sulfide (H_2S)] measurements recorded with a RKI Eagle 2 Meter.
Wells were purged with a Cole Parmer Air Admiral vacuum pump at an extraction flow rate of approximately 26 to 29 cubic feet per second (cfs).
(a) Ambient air readings on November 29, 2017 were 21.3% O_2, 0.0% CO_2, 1% CH_4 (20% LEL), and 0% H_2S. Field measurements for O_2 and CH_4 may be biased high.

H_2O = water
-- = not measured
ft = feet
btoc = below top of casing

Figures

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

- Deep Monitoring Well
- Shallow Monitoring Well
- Abandoned Monitoring Well
- Inferred Lateral Extent of Smear Zone Diesel and/or Oil Impacts
- Inferred Lateral Extent of Submerged Diesel and/or Oil Impacts
- Approximate Lateral Extent of Dissolved Phase Diesel and/or Oil
- Oil-Head Monitoring Well
- Bioventing Injection Well
- Air Sparge (AS) Well
- Proposed Carbon Trap Location
- WMW-16 Well included in bioventing/NSZD testing
- WMW-7 Well included in respirometry study

Note:
1. Locations are approximate.

N

0 50 100
Scale: Feet

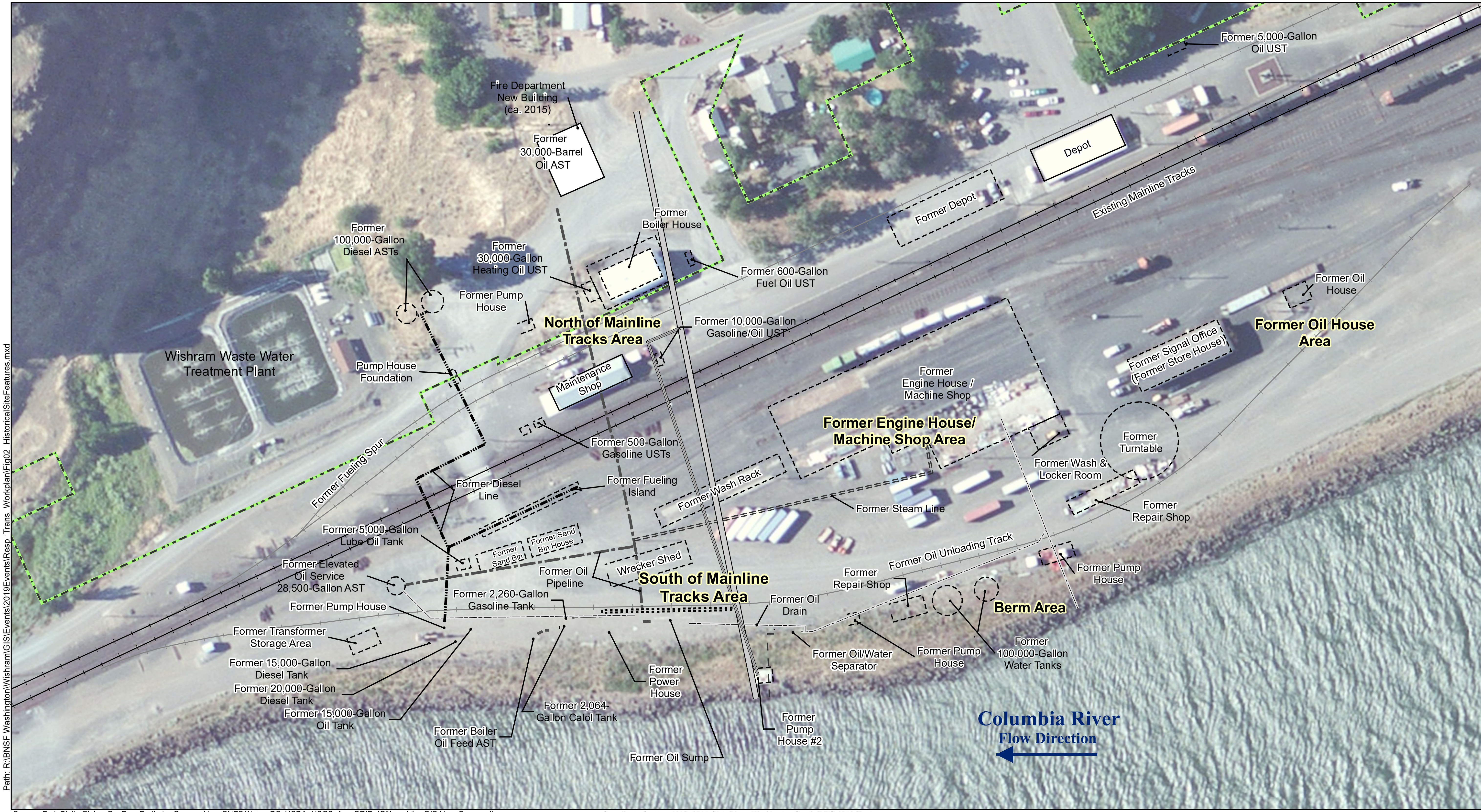
Kennedy/Jenks Consultants

BNSF Wishram Railyard
Wishram, Washington

Site Features

1996120*07
July 2019

Figure 1



Path: R:\BNSF Washington\Wishram\GIS\Events\2019Events\Resp_Trans_Workplan\Fig02_HistoricalSiteFeatures.mxd

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

- Approximate BNSF Property Line
- Existing Site Feature
- Former Site Feature
- Former Bunker Fuel / Oil Pipeline
- Former Oil Drain
- Former Oil Trough
- Former Sewer Line (Potential)
- Stormwater Underdrain (A portion removed from service circa 1960)
- Stormwater Underdrain (Rerouted portion circa 1960)
- Former Diesel Line
- Former Steam Line

Note:
1. Locations are approximate.

N

0 50 100
Scale: Feet

Kennedy/Jenks Consultants

BNSF Wishram Railyard
Wishram, Washington

Current and Historical Site Features

1896120.07
June 2019

Figure 2

Appendix A

Field Forms

Well____________________ Site____________________

Baildown/Slug Test Field Form

Project #:		Site Name:	
Well:		Samplers:	
Evacuation Method:		Weather:	

Well Information		LNAPL Information	
Casing Diameter (INCHES):		Fluid Type:	
Total Depth (FT):		Volume Removed:	
Depth to Top of Screen (FT):		Evacuation Method:	
Screen Length (FT):		LNAPL Well Volume:	

Length and volumetric units need to be specified

Length Units: **Volume Units:**

Borehole Diameter (INCHES):
Filter Pack Specific Yield (LNAPL)
0.175

Effective Well Radius (FT)

	LNAPL Well Volume
ft^3	
gal	
ml	

Period	Date	Time HH:MM	Elapsed Time (min)	DTP (feet)	DTW (feet)	Comments
Initial						
Removal Start						Test Start
Removal Stop						LNAPL/Slug Volume Removed (gal): Water Volume Removed (gal):

Well______________________ Site______________________

Period	Date	Time HH:MM	Elapsed Time (min)	DTP (feet)	DTW (feet)	Comments

FIELD FORM

WATER TABLE/LNAPL THICKNESS MEASUREMENTS
BNSF WISHRAM

Monitoring Personnel:

Well	Date / Time	Depth to LNAPL (ft btoc)	Depth to Water (ft btoc)	LNAPL Thickness (ft)	Well Status
OHM-1					
OHM-2					
OHM-3					
OHM-4					
OHM-1					
OHM-2					
OHM-3					
OHM-4					

Additional Notes:

CALIBRATION FIELD FORM
BNSF WISHRAM

Calibration Field Form

Project: ________________________

Date: ___________________________

PID CALIBRATION					
Date	**Time**	**Calibration Gas Type**	**Calibration Value**	**Meter Response**	**Notes**

MULTI GAS METER CALIBRATION										
		Calibration Values				**Meter Response**				
Date	**Time**	**O_2 (%)**	**CO_2 (%)**	**CH_4 (%)**	**H_2S (%)**	**O_2 (%)**	**CO_2 (%)**	**CH_4 (%)**	**H_2S (%)**	**Notes**

System Parameter Field Form

Project: BNSF Wishram

System: Bioventing

Date: ___________________________

Screening Equipment: ____________________________

Well ID	Well Screen Depth (ft)	Well Diameter (inch)	Date/Time	Injection Flow Rate (cfm)	Injection Pressure (inches H_2O)	Wellhead Vacuum/ Pressure (inches H_2O)
SVE-12-1	5.5 - 8.5					
SVE-12-2	6 - 9					
SVE-12-3	6.4 - 10.4					
SVE-12-4	6.1 - 10.1					
WMW-7	10 - 20					
WMW-8	7 - 22					
WMW-12	6 - 21					
SVE-12-1	5.5 - 8.5					
SVE-12-2	6 - 9					
SVE-12-3	6.4 - 10.4					
SVE-12-4	6.1 - 10.1					
WMW-7	10 - 20					
WMW-8	7 - 22					
WMW-12	6 - 21					

System Parameter Field Form

Project: BNSF Wishram

System: Bioventing

Date: ___________________________

Screening Equipment: ____________________________

Well ID	Well Screen Depth (ft)	Well Diameter (inch)	Date/Time	Injection Flow Rate (cfm)	Injection Pressure (inches H_2O)	Wellhead Vacuum/ Pressure (inches H_2O)

BIOVENTING WELLHEAD MEASUREMENTS
BNSF WISHRAM

System Parameter Field Form

Project: ________________________

System: ________________________

Date: ___________________________

Meter: ____

Screening Equipment: ____________________________

Purging Equipment: ______________________________

Purging Flowrate: ________________________________

Well ID/Depth	Date/Time	Depth to Water (feet btoc)	Purge Time (minutes)	Vacuum/ Pressure (inches H_2O)	O_2 (%)	CO_2 (%)	CH_4 (%)	H_2S (%)	VOCs (ppm)	Notes
SVE-12-1										
SVE-12-1										
SVE-12-1										
SVE-12-1										
SVE-12-1										
SVE-12-2										
SVE-12-2										
SVE-12-2										
SVE-12-2										
SVE-12-2										
SVE-12-3										
SVE-12-3										
SVE-12-3										
SVE-12-3										
SVE-12-3										
SVE-12-4										
SVE-12-4										
SVE-12-4										
SVE-12-4										
SVE-12-4										

BIOVENTING WELLHEAD MEASUREMENTS
BNSF WISHRAM

System Parameter Field Form

Project: ________________________

System: ________________________

Date: ________________________

Meter: ________________________

Screening Equipment: ________________________

Purging Equipment: ________________________

Purging Flowrate: ________________________

Well ID/Depth	Date/Time	Depth to Water (feet btoc)	Purge Time (minutes)	Vacuum/ Pressure (inches H_2O)	O_2 (%)	CO_2 (%)	CH_4 (%)	H_2S (%)	VOCs (ppm)	Notes
WMW-7										
WMW-7										
WMW-7										
WMW-7										
WMW-7										
WMW-8										
WMW-8										
WMW-8										
WMW-8										
WMW-8										
WMW-12										
WMW-12										
WMW-12										
WMW-12										
WMW-12										

BIOVENTING WELLHEAD MEASUREMENTS
BNSF WISHRAM

System Parameter Field Form

Project: ________________________

System: ________________________

Date: ___________________________

Meter: ____

Screening Equipment: ____________________________

Purging Equipment: ______________________________

Purging Flowrate: ________________________________

Well ID/Depth	Date/Time	Depth to Water (feet btoc)	Purge Time (minutes)	Vacuum/ Pressure (inches H_2O)	O_2 (%)	CO_2 (%)	CH_4 (%)	H_2S (%)	VOCs (ppm)	Notes

SOIL GAS WELLHEAD MEASUREMENTS
BNSF WISHRAM

System Parameter Field Form

Project: ______________________

System: ______________________

Date: ______________________

Meter: ______________________

Screening Equipment: ______________________

Purging Equipment: ______________________

Purging Flowrate: ______________________

Well ID/Depth	Date/Time	Depth to Water (feet btoc)	Purge Time (minutes)	Vacuum/ Pressure (inches H_2O)	O_2 (%)	CO_2 (%)	CH_4 (%)	H_2S (%)	VOCs (ppm)	Notes
WMW-1										
WMW-1										
WMW-1										
WMW-1										
WMW-3										
WMW-3										
WMW-3										
WMW-3										
WMW-9										
WMW-9										
WMW-9										
WMW-9										
WMW-10										
WMW-10										
WMW-10										
WMW-10										
WMW-11										
WMW-11										
WMW-11										
WMW-11										
WMW-13										
WMW-13										
WMW-13										
WMW-13										

SOIL GAS WELLHEAD MEASUREMENTS
BNSF WISHRAM

System Parameter Field Form

Project: _______________________

System: _______________________

Date: __________________________

Meter: ____

Screening Equipment: ___________________________

Purging Equipment: _____________________________

Purging Flowrate: _______________________________

Well ID/Depth	Date/Time	Depth to Water (feet btoc)	Purge Time (minutes)	Vacuum/ Pressure (inches H_2O)	O_2 (%)	CO_2 (%)	CH_4 (%)	H_2S (%)	VOCs (ppm)	Notes
WMW-14										
WMW-14										
WMW-14										
WMW-14										
WMW-15										
WMW-15										
WMW-15										
WMW-15										
WMW-16										
WMW-16										
WMW-16										
WMW-16										
WMW-17										
WMW-17										
WMW-17										
WMW-17										
WMW-26										
WMW-26										
WMW-26										
WMW-26										
WMW-27										
WMW-27										
WMW-27										
WMW-27										

SOIL GAS WELLHEAD MEASUREMENTS
BNSF WISHRAM

System Parameter Field Form

Project: ________________________

System: _________________________

Date: ___________________________

Meter: ____

Screening Equipment: ____________________________

Purging Equipment: ______________________________

Purging Flowrate: ________________________________

Well ID/Depth	Date/Time	Depth to Water (feet btoc)	Purge Time (minutes)	Vacuum/ Pressure (inches H_2O)	O_2 (%)	CO_2 (%)	CH_4 (%)	H_2S (%)	VOCs (ppm)	Notes
WMW-28										
WMW-28										
WMW-28										
WMW-28										
WMW-29										
WMW-29										
WMW-29										
WMW-29										

Appendix B

Standard Operating Guidelines

Standard Operating Guideline
SOG-3 Measuring Groundwater Levels

Introduction

This guideline describes the field procedure typically followed by Kennedy Jenks when measuring groundwater levels. Groundwater levels in wells will be measured prior to commencing developing, purging, sampling, and pumping tests.

Equipment

- Electronic water level monitoring probe or other measuring device
- Decontamination supplies (e.g., buckets, Alconox, distilled water, squirt bottle)
- Field notebook
- Groundwater purge-and-sample form(s) if in conjunction with groundwater sampling
- Keys for locks (if necessary)
- Tools to open well covers (e.g., socket wrench, spanner wrench)
- Disposable gloves (as a minimum), and other protective clothing (as necessary).

Typical Procedure

1. If more than one well will be measured, begin depth measurement in the order in terms of lowest to highest chemical concentrations in the monitoring wells.
2. Remove well caps from all wells prior to initiation of water level measurement activities. This will allow wells to equilibrate, if necessary.
3. If the potential exists for floating product (LNAPL) to be present, use an electric oil-water interface probe or oil-sensitive paper to measure depth of the floating product (also known as air/LNAPL interface) and the electronic depth probe to measure the depth-to-water (also known as the LNAPL/water interface). Record both depths in field notebook or applicable field form and note the water depth as the "depth with oil layer present." Unless otherwise instructed, always measure depths to floating product layer and groundwater from the top of the north side of the well casing.
4. If the potential exists for high viscosity LNAPL, an alternate procedure may be required to measure the LNAPL/water interface. This procedure includes freezing the oil/water interface probe in distilled water using dry ice, lowering the probe through LNAPL, allowing ice to melt (approximately 20 to 30 minutes), and then slowly retrieving the probe until encountering the LNAPL/water interface. As above, record both depths in field notebook or field form, measuring depths from the top of the north side of the well casing.
5. When floating product is not present, measure depth-to-water using a pre-cleaned water level probe from the top of the north side of the well casing, unless otherwise instructed.
6. Repeat measurements a minimum of three times or have field partner confirm measurement.
7. Record time of day the measurement was taken using military time (e.g., 16:00).
8. Decontaminate water level and/or oil-water interface probe and line prior to reuse (refer to SOG for Equipment Decontamination).

Standard Operating Guideline
SOG-4: Procedures for using a Photoionization Detector (PID)

INTRODUCTION

This guideline describes the procedures typically followed by Kennedy Jenks personnel during operation of a photoionization detector (PID).

EQUIPMENT

- RAE Systems model Plus Classic or equivalent
- Calibration gas with regulator, tubing, and Tedlar® bag
- Locking storage bags or pint plastic jars with aluminum foil covering
- Toolkit
- Operations manual
- Spare batteries
- Pens, field logbook, and/or appropriate field forms
- Personal protective equipment as specified in the health and safety plan.

PROCEDURES

Calibrate PID at the office prior to commencement of field activities to check instrument is in proper working order. At a minimum, calibrate before use each day (or more frequently as necessary) as indicated below. The initial daily calibration may be performed at the office (if located in proximity to the site), motel, or in the field.

1. Check the battery charge level. If in doubt, charge the battery as described in the manual. The battery should typically be recharged daily after use.
2. Turn unit on. Do not look into the sensor (ultraviolet radiation hazard). The probe or pump should make an audible sound (whine or solid tone) confirming operation.
3. Perform zero and calibration procedures as described in the operating manual. Calibration can be performed for specific compounds so that the instrument response is proportional to the calibration gas concentration. Isobutylene calibrant is available; the instrument manual provides response factors for other compounds. Note: Verify that the ionizing lamp in the PID is suitable for the compounds being evaluated. Consult the operation manual or other guidance for ionization potentials and response factors for common compounds. A PID is not suitable for detecting methane. The instrument should be calibrated under ambient conditions to account for temperature and humidity. Use instrument manufacturer-designed moisture trap on probe when testing saturated soil or water samples.

4. Once calibrated, the unit is ready for use. Position the intake assembly close to the area in question because the sampling rate allows only for localized readings.
5. A slow, sweeping motion of the intake assembly helps to prevent the bypassing of problem areas.
6. For ambient air monitoring, set the alarm at the desired level. Be prepared to evacuate the work area if the preset alarm sounds.
7. For soil monitoring, use the headspace method below:
   a. Place a consistent amount of soil into a sealable plastic bag (i.e., approximately 100 grams of soil).
   b. Seal the plastic bag.
   c. Wait a consistent amount to time (typically several minutes).
   d. Open the bag slightly, insert the intake assembly into bag, and observe the peak reading.

   Static voltage sources, such as power lines, radio transmissions, or transformers, may interfere with measurements. Consult the operating manual for a discussion of necessary considerations.
8. Record the measurements on the field logbook or other appropriate field form.

SPECIAL NOTES

Read the operator's manual thoroughly. As with any field instrument, accurate results depend on the operator being completely familiar with the unit. Be aware that moisture may affect readings. Clean and maintain the instrument and accessories to obtain representative readings.

In the event the instrument has to be shipped via a courier service (i.e., UPS, FedEx, etc.) from the office to a field location, ship the instrument (including calibration gas) via ground in accordance with Department of Transportation regulations and courier service requirements.

Standard Operating Guideline
SOG-10 Handling and Disposal of Investigation-Derived Waste

Introduction

Environmental site investigations usually result in generation of some regulated waste, particularly if the project involves drilling and construction of monitoring wells. Any potentially hazardous or dangerous material that is generated during a site investigation must be handled and disposed of in accordance with applicable regulations (22 CCR, Chapter 30). This guideline provides a procedure to be used for dealing with investigation-derived wastes that have the potential of being classified as hazardous or dangerous, including soil cuttings, well development water, and decontamination water.

Equipment

- DOT-approved packaging (typically DOT 17E or 17H drums)
- Funnel
- Bushing wrench
- 15/16-inch socket wrench
- Shovel
- Appropriate markers (spray paint, paint pen)
- Plastic sheeting
- Drip pans
- Pallets

Typical Procedures

Preparing Containers

1. Place each container on a pallet if it is to be moved with a fork lift after it is full.
2. Place plastic sheeting under containers for soil and drip pans under containers used to hold water.
3. Ensure that packaging materials are compatible with the wastes to be stored in them. Bung-type drums should be used to contain liquids. If a liquid is corrosive, a plastic or polymer drum should be used.
4. Solids should be placed in open-top drums. Liners are placed in the drums if the solid material is corrosive or contains free liquids. Gaskets are also used on open-top drums.

Storing Wastes

1. As waste materials are generated, place them directly into storage containers.
2. Do not fill storage drums completely. Provide sufficient outage so that the containers will not be overfull if their contents expand.
3. After filling a storage drum, seal it securely, using a bung wrench or socket wrench, for a bung-type or open-top drum, respectively.

4. Label drums or other packages containing hazardous or dangerous materials and mark them for storage or shipment. To comply with marking and labeling requirements, affix a properly filled out yellow hazardous waste marker and a DOT hazard class label to each waste container. Do not mark drums with Kennedy Jenks' name. All waste belongs to the client. Mark accumulation start date.
5. During an ongoing investigation, use a paint marker to mark the contents, station number, date, and quantity of material on each drum or other container. Do not mix investigation-derived wastes with one another or with other materials. Do not place items such as Tyvek, gloves, equipment, or trash into drums containing soils or liquids, and do not mix water and soil. Disposable protective clothing, trash, soil, and water materials should be disposed of in separate containers.
6. Upon completion of field work, or the portion of the project that generates wastes, notify the client as to the location, number, contents, and waste type of waste containers. Remind the client of the obligation to dispose of wastes in a timely manner and in accordance with applicable regulations.

Regulations

22 CCR, Chapter 30 *California Hazardous Waste Regulations*.

49 CFR 100-177, *Federal Transportation of Hazardous Materials Regulations*.

EPA Region X, Technical Assistance Team. 1984. *Manual for Sampling, Packaging, and Shipping Hazardous Materials*. Seattle, WA: EPA.

RKI INSTRUMENTS

EAGLE 2

Operator's Manual

geotech

1-800-833-7958

Part Number: 71-0154RK

Revision: CC

Released: 3/12/19

Full EAGLE 2 Operator's Manual available here:
http://www.geotechenv.com/Manuals/RKI_Manuals/Eagle_2_Operators_Manual.pdf

WARNING

Read and understand this instruction manual before operating instrument. Improper use of the gas monitor could result in bodily harm or death.

Periodic calibration and maintenance of the gas monitor is essential for proper operation and correct readings. Please calibrate and maintain this instrument regularly! Frequency of calibration depends upon the type of use you have and the sensor types. Typical calibration frequencies for most applications are between 1 and 3 months, but can be required more often or less often based on your usage.

Table of Contents

WARNING: ***Understand manual before operating. Substitution of components may impair intrinsic safety. To prevent ignition of a hazardous atmosphere, batteries must only be changed or charged in an area known to be nonhazardous. Not tested in oxygen enriched atmospheres (above 21%).***

NOTE: RKI Instruments, Inc. recommends that you refer to ISA-RP12.13, Part II-1987 or an equivalent international recommended practice for guidance in the use of combustible gas detection instruments.

Chapter 1: Introduction

Overview

This chapter briefly describes the EAGLE 2 gas monitor. This chapter also describes the *EAGLE 2 Operator's Manual* (this document). Table 1 at the end of this chapter lists the specifications for the EAGLE 2.

About the EAGLE 2

Using an advanced detection system consisting of up to six gas sensors, the EAGLE 2 sample draw gas monitor is capable of detecting the presence of combustible gas, oxygen (O_2), carbon monoxide (CO), hydrogen sulfide (H_2S), and various other toxic gases simultaneously. The EAGLE 2's rugged, reliable, and easy-to-use design makes it ideally suited for a wide range of applications, including sewage treatment plants, utility manholes, tunnels, hazardous waste sites, power stations, petrochemical refineries, mines, paper mills, drilling rigs, and fire fighting stations. The EAGLE 2 offers a full range of features including:

- Simultaneous monitoring of one to six gases. The standard configuration includes four sensors for combustible gas (%LEL, ppm, and %volume), oxygen, carbon monoxide (CO), and hydrogen sulfide (H_2S).
- Choice of three operating modes:
  - Normal Mode for typical confined space or area monitoring. Normal Mode is the standard factory setting.
  - Bar Hole Mode for checking of bar holes when searching for underground gas leaks
  - Leak Check Mode for locating leaks in valves and piping
- Sample-drawing pump with up to 125 foot range
- Liquid crystal display (LCD) for complete and understandable information at a glance
- Ultrabright alarm LEDs
- Distinctive audible alarm for dangerous gas conditions or unit malfunction
- Microprocessor control for reliability, ease of use, and advanced capabilities
- Data logging functions (when used in Normal Mode)
- Alarm trend data (when used in Normal Mode)
- STEL and TWA (when used in Normal Mode) and over range alarms
- Peak readings (when used in Normal Mode)
- Built-in time function
- Lunch break feature
- RF shielded high impact plastic case
- CSA classified for Class I, Division I, Groups A, B, C, and D hazardous atmospheres

WARNING: ***The Model EAGLE 2 detects oxygen deficiency, elevated levels of oxygen, combustible gases, carbon monoxide, and hydrogen sulfide, all of which can be dangerous or life threatening. When using the EAGLE 2, you must follow the instructions and warnings in this manual to assure proper and safe operation of the unit and to minimize the risk of personal injury. Be sure to maintain and periodically calibrate the EAGLE 2 as described in this manual.***

NOTE: ONLY THE COMBUSTIBLE GAS DETECTION PORTION OF THIS INSTRUMENT HAS BEEN ASSESSED FOR PERFORMANCE.

Specifications

Table 1: Standard Sensor Specifications

	Combustible Gas, Methane (CH_4) Calibration Standard	Oxygen (O_2)	Hydrogen Sulfide (H_2S)	Carbon Monoxide (CO)
Detection Range	0 - 100 %LEL	0 - 40 volume%	0 - 100.0 ppm	0 - 500 ppm
Reading Increment	1 %LEL	0.1 volume %	0.5 ppm	1 ppm
Alarm 1 Factory Setting	10 %LEL*	19.5 volume %*	5.0 ppm*	25 ppm*
Alarm 2 Factory Setting	50 %LEL	23.5 volume %	30.0 ppm	50 ppm
STEL Alarm	n/a	n/a	5.0 ppm	200 ppm
TWA Alarm	n/a	n/a	1.0 ppm	25 ppm

* *When calibrating the EAGLE 2 with the Auto Calibration or the Single Calibration method, the calibration gas value must be equal to or higher than the alarm 1 setting. See "Updating the Alarm Point Settings" on page 106 for instructions to change the alarm points if necessary for the desired calibration gas value.*

Table 2: EAGLE 2 Specifications

Sampling Method	Sample Draw
Response Time	T90 Within 30 Seconds
Display	Graphics LCD Display
Operating Temperature & Humidity	-20°C to 50˚C/Below 85% RH (Without Condensation)
Indication Accuracy	**Combustible Gas (LEL), Catalytic Type Sensor** • -10°C to 40˚C: 5% of full scale • -20°C to 50˚C: 6% of full scale **Combustible Gas (ppm), Catalytic Type Sensor** • ± 25 ppm or ± 5% of reading (whichever is greater) **Oxygen** • ± 0.5% O_2 **Hydrogen Sulfide** • ± 5% of reading or ± 2 ppm H_2S (whichever is greater) **Carbon Monoxide** • ± 5% of reading or ± 5 ppm CO (whichever is greater)

Safety/ Regulatory	186718 CSA classified as Intrinsically Safe. Exia. Class I, Groups A, B, C, & D. Temperature Code T3C.
Power Supply	• Four C size alkaline batteries, standard • Four C size Ni-MH batteries, optional
Continuous Operating Hours @ 25 °C	• Alkaline Batteries: 16 Hours (Non Alarm Operation, Fully Charged) • Ni-MH Batteries: 18 Hours (Non Alarm Operation, Fully Charged)
Case	High-impact Plastic, RF Shielded, Dust and Weather Proof
Standard Accessories	• 5 foot hose • Hydrophobic probe • Shoulder Strap
Optional Accessories	• Rechargeable NiMH Batteries • 115 VAC Charger • 12 VDC Charger • Hoses of Various Lengths, See “General Parts List” on page 79. • Dilution Fitting (1:1 and 3:1) • Various Probes, See “General Parts List” on page 79 • Product CD, includes Data Logger Management Program and Maintenance Data Loader Program • IrDA/USB Cable for connecting to a computer when using the Data Logger Management Program and Maintenance Data Loader Program (not needed if computer has an infrared port)
Dimensions and Weight	Approximately 171(H) x 65(W) x 39(D) mm (5.6”H x 2.5”W x 1.5”D) Approximately 310 g (11 oz.)

About this Manual

The *EAGLE 2 Operator’s Manual* uses the following conventions for notes, cautions, and warnings.

NOTE: Describes additional or critical information.

CAUTION: *Describes potential damage to equipment.*

WARNING: ***Describes potential danger that can result in injury or death.***

Chapter 2: Description

Overview

This chapter describes the EAGLE 2 instrument and accessories.

Instrument Description

The EAGLE 2 includes the case, sensors, LCD, control buttons, printed circuit boards, alarm LEDs, infrared communication port, buzzer, battery case and batteries, and flow system.

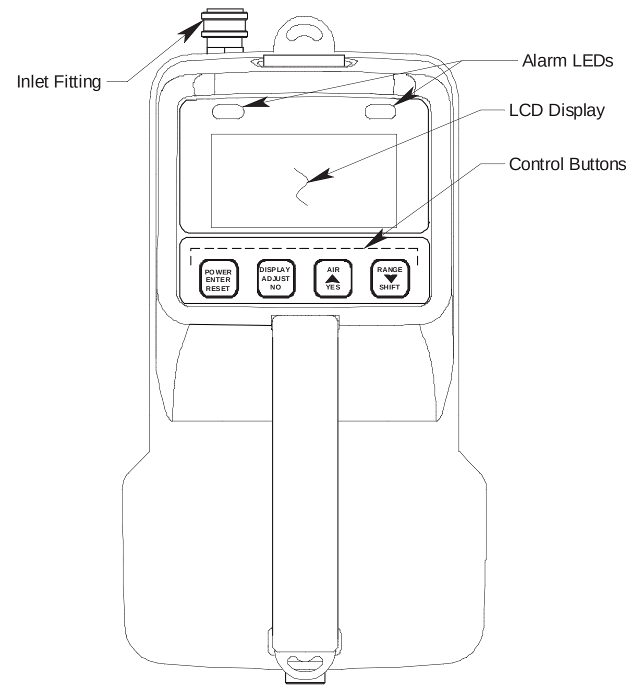


Figure 1: Component Location, Top View

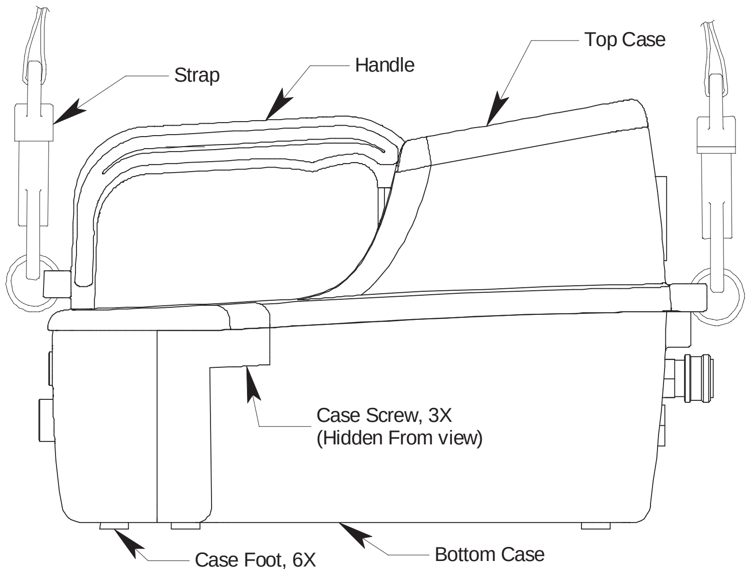


Figure 2: Component Location, Side View

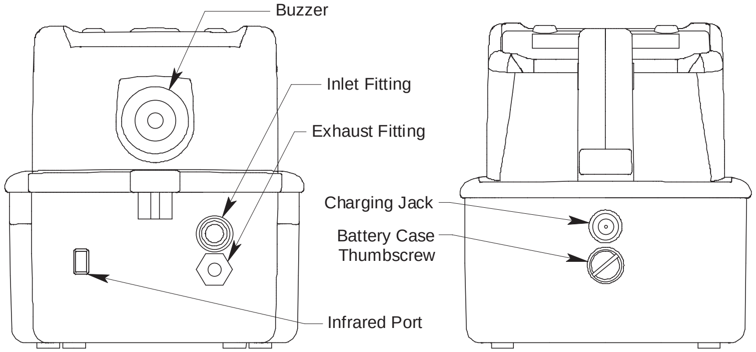


Figure 3: Component Location, Front & Back

Case

The EAGLE 2's sturdy, high-impact plastic case is radio frequency (RF) resistant and is suitable for use in many environmental conditions, indoors and out. The case is dust proof and water resistant. It's two main components, the top case and bottom case, are held together with three screws located on the bottom case. The interface between the top case and bottom case is gasketed. A sturdy, well balanced handle on the top case allows you to hold the instrument comfortably. A clear plastic window is located on the top case to the front of the handle for viewing the LCD.

A removable battery case is located at the rear of the bottom case. A thumbscrew secures the battery case to the bottom case. The interface between the battery case and the bottom case is gasketed. Six raised feet on the bottom of the case, four on the bottom case and two on the battery compartment, raise the EAGLE 2 slightly from the surface on which it rests.

Sensors

The EAGLE 2 uses up to six sensors to monitor combustible gas, oxygen (O_2), carbon monoxide (CO), hydrogen sulfide (H_2S), and various other toxic gases simultaneously. The sensors are located inside the EAGLE 2 bottom case and are installed in the flow chamber. The sensors described below are the four standard sensors. See "Appendix D: PID Sensors" for a description of the PID sensors, "Appendix E: ESM-01 Toxic Sensors" for a description of the ESM-01 toxic sensors, "Appendix F: TC Sensors" for a description of the TC sensors, "Appendix G: Infrared Carbon Dioxide Sensors" for a description of the IR CO_2 sensors, "Appendix H: Infrared Methane Sensor" for a description of the IR methane sensors, and "Appendix I: Infrared Hydrocarbon Sensor" for a description of the IR hydrocarbon sensor. The standard sensors use different detection principles as described below.

Catalytic Combustible Gas Sensor (LEL Sensor)

The catalytic combustible gas (LEL) sensor detects combustible gas in the %LEL range. It uses a catalytic element for detection. The reaction of gas with oxygen on the catalyst causes a change in the resistance of the element which changes the current flowing through it. The current is amplified by the EAGLE 2's circuitry, converted to a measurement of combustible gas concentration, and displayed on the LCD.

The LEL sensor housing includes a sintered metal flame arrestor on one end that allows gas to diffuse into the sensor. On the other end, five pins extend from the sensor. The sensor cable connects to these pins on one end and terminates in a four-position connector on the other end which plugs into the **HC** socket on the main PCB (see "Main PCB" on page 19).

Oxygen Sensor

The O_2 sensor is a galvanic type of sensor. A membrane behind the openings on the sensor face allows gas to diffuse into the sensor at a rate proportional to the partial pressure of oxygen. The oxygen reacts in the sensor and produces a voltage proportional to the concentration of oxygen. The voltage is measured by the EAGLE 2's circuitry, converted to a measurement of gas concentration, and displayed on the LCD.

The sensor includes a short cable that terminates in a round 7-position connector. It mates with the **OXY** pins on the main PCB (see "Main PCB" on page 19).

CO and H_2S Sensors

The CO and H_2S sensors are electrochemical sensors that consist of three precious metal electrodes in a dilute acid electrolyte. A gas permeable membrane covers the sensor face and allows gas to diffuse into the electrolyte. The gas reacts in the sensor and produces a current proportional to the concentration of the target gas. The current is amplified by the EAGLE 2's circuitry, converted to a measurement of gas concentration, and displayed on the LCD.

The CO and H_2S sensors are physically very similar. Except for their markings and wire colors, they look almost identical. A three-position connector at the end of a 2-wire cable from each sensor plugs into a socket on the main PCB. The sockets on the main PCB for the CO and H_2S sensors are labeled **CO** and **H2S.** Normally, the CO connector plugs into the **CO** socket and the H2S plugs into the **H2S** socket. However, because of the way that the main PCB circuitry is arranged, if the CO sensor is plugged into the H2S socket and the H2S sensor is plugged into the CO socket, the sensors will still operate properly and the CO and H2S readings will still appear on the channels that are programmed for those gases.

LCD

A digital LCD (liquid crystal display) is visible through a clear plastic window in the top case. The LCD simultaneously shows the gas reading for all installed sensors. The LCD also shows information for each of the EAGLE 2's operating modes.

Control Buttons

Four control buttons are located below the LCD. They are, from left to right, POWER ENTER RESET, DISPLAY ADJUST NO, AIR ▲ YES, and RANGE ▼ SHIFT.

Table 3: EAGLE 2 Control Button Functions

Button	Function(s)
POWER ENTER RESET	• turns the EAGLE 2 on and off • silences and resets audible alarm if Alarm Latching is set to **Latching** and Alarm Silence is set to **ON** • enters instructions, values, and settings into the EAGLE 2's microprocessor
DISPLAY ADJUST NO	• activates Display Mode • silences and resets audible alarm if Alarm Latching is set to **Latching** and Alarm Silence is set to **ON** • enters instructions into the EAGLE 2's microprocessor
AIR ▲ YES	• activates the demand zero function (adjusts the EAGLE 2's fresh air reading) • silences and resets audible alarm if Alarm Latching is set to **Latching** and Alarm Silence is set to **ON** • enters instructions into the EAGLE 2's microprocessor • moves the cursor on the LCD up the screen • increases the value of a parameter available for adjustment • scrolls through parameter options

Table 3: EAGLE 2 Control Button Functions

Button	Function(s)
RANGE ▼ SHIFT	• changes the detection units of the combustible gas channel (when Catalytic Units is set to **CHANGE OK** in Setup Mode) • silences and resets audible alarm if Alarm Latching is set to **Latching** and Alarm Silence is set to **ON** • enters instructions into the EAGLE 2's microprocessor • moves the cursor on the LCD down the screen • decreases the value of a parameter available for adjustment • scrolls through parameter options

Printed Circuit Boards (PCBs)

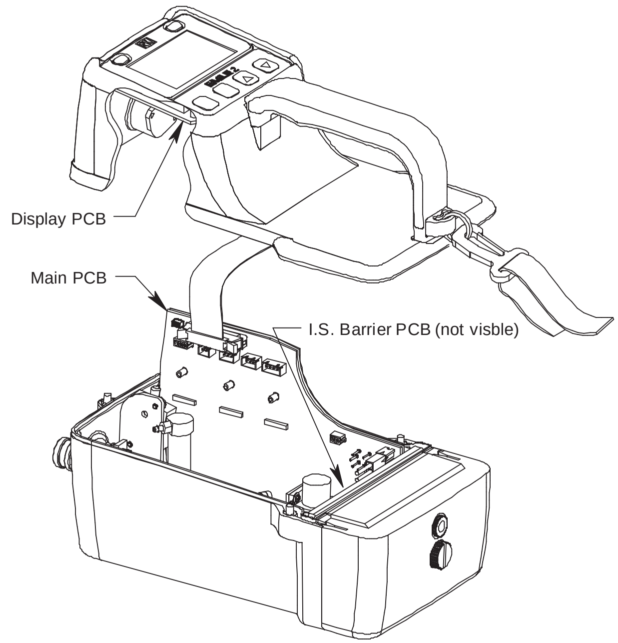


Figure 4: EAGLE 2 PCBs

The EAGLE 2's PCBs analyze, record, control, store, and display the information collected. The main PCB and I.S. barrier PCB are located in the bottom case. The display PCB is located in the top case. The display PCB and I.S. barrier PCB are not user serviceable and are not involved in any user performed maintenance. The main PCB is not user serviceable, but it is involved in the replacement of sensors, so it is described below.

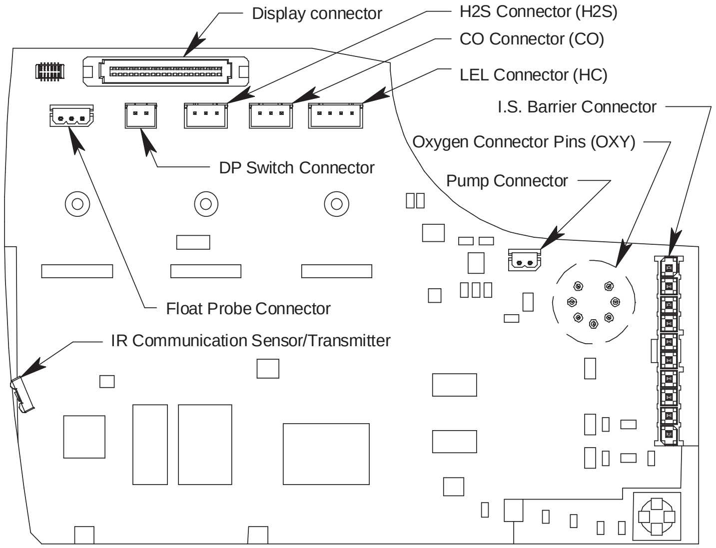


Figure 5: Main PCB

The main PCB is located on the right side of the bottom case. It slides into guiding grooves at the bottom, front, and rear of the bottom case. It is held in place by the top case. Connectors for the sensors, differential pressure switch, pump, display PCB, optional float probe, and I.S. barrier PCB are located on the main PCB. In addition, an IR transmitter/receiver is located at the front of the PCB behind the IR port on the front of the bottom case.

Alarm LEDs

Two sets of red alarm LEDs (light emitting diodes) are visible through two raised, frosted plastic lenses in the top case. Each set has two LEDs. They are above the LCD, one above the left corner and one above the right corner. The alarm LEDs alert you to gas, low battery, and failure alarms.

Infrared Communications Port

An infrared (IR) communications port is located on the left front of the bottom case when the instrument is viewed from the front. The data transmitted through the port is in standard IrDA protocol. A computer's infrared port or an IrDA/USB cable connected to a USB port can be used to download data saved by the EAGLE 2 to a computer using the Eagle 2 Data Logger Management Program. See the Data Logger Management Program operator's manual for data logging and downloading instructions.

Buzzer

A solid-state electronic buzzer is located on the front of the top case. It is a panel mounting type of buzzer and is water resistant and sealed to the inside of the top case with an O-ring. The buzzer sounds for gas alarms, malfunctions, low battery voltage, and as an indicator during use of the EAGLE 2's many display and adjustment options.

Battery Case & Batteries

Four C-size alkaline batteries (standard) or optional rechargeable C-size Ni-MH batteries power the EAGLE 2. They are installed in the battery case which is located at the rear of the bottom case. The battery case is secured to the bottom case with a thumbscrew.

Instrument run time is dependent upon battery type. At 25°C, alkaline batteries power the EAGLE 2 for 16 hours of non-alarm operation. Ni-MH batteries will power the EAGLE 2 for 18 hours of non-alarm operation. The current battery voltage is viewable in Display Mode (see "Display Mode" on page 41).

When the EAGLE 2 detects low battery voltage, a low battery warning is activated. When battery voltage is too low for operation, the EAGLE 2 sounds a dead battery alarm.

The alkaline or Ni-MH batteries can be accessed for replacement by unscrewing the thumbscrew that secures the battery case to the bottom case and pulling the battery case away from the bottom case. The Ni-MH batteries can be recharged by using the EAGLE 2 charger (see "Replacing or Recharging the Batteries" on page 69).

NOTE: Use of batteries or battery chargers not specified by RKI Instruments, Inc. will void the CSA classification and may void the warranty.

WARNING: ***To prevent ignition of a hazardous atmosphere, batteries must only be changed or charged in an area known to be nonhazardous.***

Flow System

The EAGLE 2 flow system consists of the inlet fitting, hydrophobic filter, pump, internal tubing, differential pressure (DP) switch, sensor chamber, charcoal filter, and exhaust fitting.

Inlet Fitting

The inlet fitting is on the right front (when viewed from the front) of the bottom case. It is a nickel plated brass quick connect fitting. It mates with either the sample hose or with the hydrophobic probe.

Hydrophobic Filter

The hydrophobic filter is located in the bottom case above the sensors. Normally the hydrophobic probe accessory (see "Hose and Probe" on page 21) will prevent water and particulate contamination from entering the flow system, but if the probe is not used, the hydrophobic filter will stop water and particulates from penetrating further into the flow system. If it becomes dirty or water logged, replace it (see "Replacing the Hydrophobic Filter" on page 73).

Pump

A diaphragm pump inside the rear of the bottom case draws the sample to the sensors. It can draw sample from as far as 125 feet from the EAGLE 2.

CAUTION: *Sample hose lengths of more than 125 feet are not recommended for the*

EAGLE 2 because of flow rate reduction and increased response time. Consult RKI Instruments, Inc. for sample hose lengths longer than 125 feet.

Internal Tubing

The flow system includes polyurethane tubing to route the sample between the various components of the flow system. The internal sample tubing is not user serviceable.

Differential Pressure (DP) Switch

The DP switch is inside the front of the bottom case. It senses the EAGLE 2's flowrate by monitoring the pressure drop between points in the flow system. When the flowrate becomes too low for safe operation of the EAGLE 2, a set of contacts inside it open and the EAGLE 2 indicates a low flow alarm.

Sensor Chamber

A PVC block in the bottom case is configured to accept the four gas sensors. It routes the sample to each sensor. The LEL sensor and the oxygen sensor are retained in the sensor chamber by brackets. The CO and H_2S sensors are each pushed past two sealing O-rings into the chamber and are retained by the O-ring compression force.

Charcoal Filter

The charcoal filter is located in the front of the flow chamber next to the CO sensor. It contains activated charcoal. The CO sensor will respond if exposed to H_2S and certain hydrocarbon gases. The charcoal filter scrubs these gases out of the sample to avoid false CO readings. If false or elevated CO readings are noticed, especially in the presence of H_2S, change the charcoal filter. The charcoal inside the filter cannot be replaced; the entire filter must be replaced.

Exhaust Fitting

The exhaust fitting is located below the inlet fitting. It routes the gas sample out of the EAGLE 2. It includes a female 10-32 thread that can be used for the installation of a hose barb or other type of fitting that has a male 10-32 thread so that the exhaust can be routed to a particular location with flexible tubing if desired.

Standard Accessories

Standard accessories include the shoulder strap, the sample hose, and the hydrophobic probe.

Shoulder Strap

A comfortable elastic shoulder strap clips to the EAGLE 2 at the front and rear of the top case. It clips to stainless steel rings that are installed in features on the top case. It can be removed from the EAGLE 2 by opening the clip at each end of the strap and removing it from the strap ring at the front and rear of the top case.

Hose and Probe

A 5 foot polyurethane sample hose and a 10 inch hydrophobic probe are included as standard. The hose has a male quick connect fitting on one end and a female quick connect fitting on the other end. The probe has a male quick connect fitting. Normally, the male end of sample hose is installed in the EAGLE 2 inlet fitting and the probe is installed in the female end of the hose. However, if the sample hose is not needed for monitoring a particular area, the probe may be installed directly to the inlet fitting. Sample hose lengths

are available from 5 feet (standard length) to 125 feet (see "General Parts List" on page 79). A Teflon lined hose is provided with all units that contain a PID sensor. This hose must be used when operating a PID EAGLE 2 (see "Appendix D: PID Sensors" on page 125).

CAUTION: *Sample hose lengths of more than 125 feet are not recommended for the EAGLE 2 because of flow rate reduction and increased response time. Consult RKI Instruments, Inc. for hose lengths longer than 125 feet.*

The probe includes a replaceable particle filter and hydrophobic filter disk that prevent particulates and water from entering the EAGLE 2's flow system. See "Replacing the Hydrophobic Probe's Particle Filter and Hydrophobic Filter Disk" on page 72 for instructions to replace the particle filter and hydrophobic filter disk.

NOTE: When using the probe with a PID EAGLE 2, be sure that the particle filter is not installed.

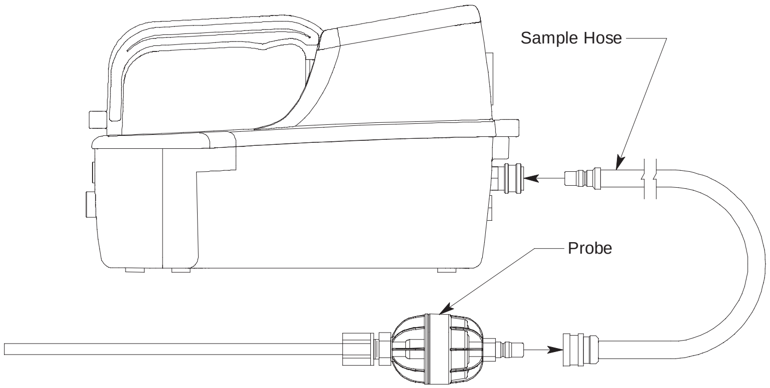


Figure 6: Sample Hose and Hydrophobic Probe

Optional Accessories

Several optional accessories are available for the EAGLE 2. They include rechargeable Ni-MH batteries, battery chargers, various special probes, and dilution fittings. The most commonly used optional accessories are described below. Detailed instructions regarding the use of these and other available accessories are included in other parts of this manual. Data logging accessories are briefly described in “Data Logging” on page 52.

Rechargeable Ni-MH Batteries

Rechargeable Ni-MH batteries are available for the EAGLE 2. A fully charged set of Ni-MH batteries will power the EAGLE 2 for 18 hours. The batteries will last for a minimum of 500 charge cycles. See “General Parts List” on page 79 for ordering information.

Battery Chargers

Three battery chargers are available for the EAGLE 2 to charge the optional Ni-MH batteries, the standard AC charger, a DC charger with a vehicle plug adapter, and an AC/DC charger with a vehicle plug adapter.

AC Charger

The standard AC charger consists of the charging module, which includes all of the charging circuitry, and an AC adapter. The charging module includes a five foot cable with a connector on the end that mates with the EAGLE 2 charging socket. The AC adapter plugs into a 115 VAC wall outlet and connects to the charging module with a jack on the end of a five foot DC output cable. The AC adapter will also work for 100 VAC or 220 VAC if an appropriate plug adapter is provided. The AC charging station is shown below in Figure 7.

Figure 7: EAGLE 2 AC Charger

DC Charger

An optional DC powered charger is available with a vehicle plug 12 VDC adapter. It uses the same charging module as the standard AC charger.

Figure 8: EAGLE 2 DC Charger

AC/DC Charger

A charger is also available that includes both the AC adapter and the 12 VDC vehicle plug adapter. The charging module is the same as the one used for the AC charger and the DC charger.

Optional Probes

Various optional probes designed for specific applications are available for the EAGLE 2. They include the following:

- 30 inch aluminum probe

Figure 9: 30 Inch Aluminum Probe

This probe is designed for applications where it is necessary to put the probe tip in areas that are out of reach with the standard probe. A small breather hole near the end of the probe tube prevents interruption of sampling and a low flow alarm if the probe tip is blocked.

- 30 inch stainless steel probe

Figure 10: 30 Inch Stainless Steel Probe

This probe is physically the same as the 30 inch aluminum probe and is intended for applications where a high level of corrosion resistance is required in the long probe tube.

- 4 foot stainless steel probe

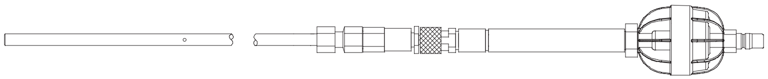


Figure 11: 4 Foot Stainless Steel Probe

This probe is designed for areas where it is necessary to put the probe tip in areas that are out of reach for even the 30 inch probes. A stainless steel probe tube is used because the length of the probe tube requires a high degree of rigidity. Stainless steel is more rigid than other normally used materials. A small breather hole near the end of the probe tube prevents interruption of sampling and a low flow alarm if the probe tip is blocked.

- Barhole probe

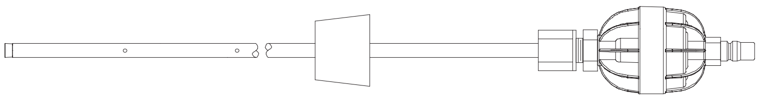


Figure 12: Barhole Probe

This probe is designed specifically for barhole testing. See “Appendix K: Using the EAGLE 2 in Bar Hole Mode” for an in-depth discussion of using the EAGLE 2 in Bar Hole Mode.

- 10 inch probe with dust filter

Figure 13: 10 Inch Probe With Dust Filter

This probe is designed for use where drawing water or moisture into the EAGLE 2 is not a concern. Instead of a hydrophobic filter, a cotton dust filter is used.

- 32 inch telescoping probe with dust filter

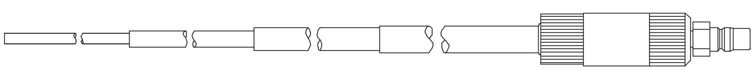


Figure 14: 32 Inch Telescoping Probe with Dust Filter

This probe is designed for use where it is necessary to put the probe tip in areas not accessible with the 10 inch probe with dust filter and applications where the probe tube must be collapsible for storage.

- 7 foot telescoping probe with dust filter

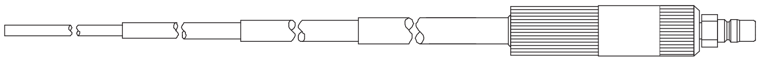


Figure 15: 7 Foot Telescoping Probe with Dust Filter

This probe is designed for use where it is necessary to put the probe tip in areas not accessible with the 32 inch telescoping probe with dust filter and applications where the probe tube must be collapsible for storage.

See “General Parts List” on page 79 for probe ordering information.

External Dilution Fittings

Two external dilution fittings are available for the EAGLE 2, a 1:1 dilution fitting and a 3:1 dilution fitting. They are designed to mate with the inlet fitting and accept a sample hose or probe. The fittings are made with brass and nickel plated brass and are appropriate for use with the four standard gases. The 1:1 fitting is normally used when it is necessary to introduce air into a sample that has no oxygen or a very low level of oxygen, such as a nitrogen purged sample. Both the 1:1 and 3:1 fittings can also be used when one of the target gas levels in the sample area will likely be present in a concentration above the detection range for that gas. Since the fittings partially consist of unplated brass, they are not appropriate for detection of elevated levels of H_2S or of gases that are easily absorbed such as Cl_2 or SO_2.

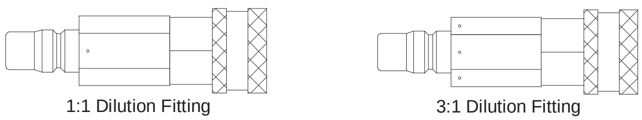


Figure 16: 1:1 and 3:1 Dilution Fittings

Chapter 3: Operation

Overview

This chapter explains how to use the EAGLE 2 to perform confined space entry monitoring or general area monitoring in Normal Mode. There are three operational modes in Normal Mode: Measuring Mode, Display Mode, and Calibration Mode. While in Normal Mode, the unit is normally operating in Measuring Mode. Display Mode and Calibration Mode are accessible from Measuring Mode. Display Mode is described in this chapter. Calibration Mode is described in “Chapter 4: Calibration Mode” on page 54.

Special versions of the EAGLE 2 can also operate in Leak Check Mode and Bar Hole Mode. See “Appendix K: Using the EAGLE 2 in Bar Hole Mode” and “Appendix L: Using the EAGLE 2 in Leak Check Mode” for operating instructions for Bar Hole and Leak Check Mode, respectively.

Start Up

This section explains how to start up the EAGLE 2, get it ready for operation, and turn it off.

NOTE: The screens illustrated in this section are for a standard 4-gas unit. The screens displayed by your EAGLE 2 may be slightly different.

Turning On the EAGLE 2

To illustrate certain functions, the following description of the EAGLE 2 start up sequence assumes that the following menu items in Setup Mode are turned on: LUNCH BREAK, CAL REMINDER, and USER/STATION ID. If any of these items are turned off, then the corresponding screens will not appear.

The EAGLE 2 may be used with a sample hose or with the probe installed directly to the inlet fitting. Determine which configuration works best for your application.

1. Connect the sample hose or probe to the EAGLE 2’s quick connect inlet fitting.
2. If using a sample hose, connect the probe to the sample hose’s quick connect fitting.
3. Press and briefly hold down the POWER ENTER RESET button. Release the button when you hear a beep.
4. The LCD will show the following screen for about ten seconds.

```
GAS MONITOR
RKI
INSTRUMENTS
EAGLE 2
```


5. The Battery Voltage Screen appears for a few seconds.

```
BATTERY MIN:
  4.3 VOLTS

BATTERY NOW:
  5.2 VOLTS
```

6. The Active Gases Screen appears for a few seconds indicating which channels are active and their target gas.

```
ACTIVE GASES

CH4    OXY
H2S    CO
```

7. If LUNCH BREAK is turned on (see “Updating the Lunch Break Setting” on page 118), the Resume Measurement Screen appears. The unit counts down from 5 seconds in the lower right corner of the LCD to the right of “MEASUREMENTS”.

```
LUNCH BREAK MODE ON

      RESUME
   PEAK AND TWA
 MEASUREMENTS?  2
```

- To continue accumulating peak and time-weighted average (TWA) readings from the last time the EAGLE 2 was used, press and release the AIR ▲ YES button before the countdown reaches 0 or allow the countdown to reach 0. If you do not press the AIR ▲ YES button within the 5 second countdown, the EAGLE 2 automatically resumes accumulating the peak and TWA readings.The EAGLE 2 will also continue to keep track of operating time including the operating time from the last time the EAGLE 2 was used. See “Time in Operation Screen” on page 50 for more information about how the EAGLE 2 tracks the operating time. The short-term exposure limit (STEL) reading is reset each time the EAGLE 2 is turned on.
- To reset the accumulation of these measurements, press and release the DISPLAY ADJUST NO button before the countdown reaches 0.

8. The gas alarm setpoints are displayed by three screens in sequence: the Low Alarm Screen, High Alarm Screen, and STEL/TWA Alarm Screen. Each screen remains on the LCD for three seconds.

```
  A  CH4     10 %LEL
 L L  OXY 19.5 vol%
O A  H2S  10.0 ppm
WR   CO      25 ppm
   M  CH4    10 vol%
   S
```

```
  A  CH4     50 %LEL
HL  OXY 23.5 vol%
I A  H2S  30.0 ppm
GR  CO       50 ppm
HM CH4     50 vol%
  S
```

```
ALARMS  STEL & TWA
  H2S(ppm)  15.0  10.0
   CO (ppm)   200    25
```

9. After the alarm screens, if CAL REMINDER is turned on, the screen that appears next depends on how CAL PAST DUE ACT is set in the Setup Mode Menu (see “Updating the Calibration Past Due Action Setting” on page 113).

- If the unit is due for calibration and CAL PAST DUE ACT is set to CONFIRM TO CAL, then the following screen displays and the buzzer sounds in a double pulsing pattern.

```
CALIBRATION DATE
    IS PAST DUE

      PERFORM
  CALIBRATION?
```

To perform a calibration, press and release the AIR ▲ YES button. The EAGLE 2 will enter Calibration Mode and the LCD will show the Calibration Mode main menu. See “Chapter 4: Calibration Mode” on page 54 for instructions to calibrate the EAGLE 2. When you are done with the calibration and exit Calibration Mode, the unit will begin the startup sequence. If the calibration was successful, the screen above will not appear again until the unit is due for calibration. If the calibration was not successful, the screen above will again appear in the startup sequence.

To continue without performing a calibration, press and release the DISPLAY ADJUST NO button.

- If the unit is due for calibration and CAL PAST DUE ACT is set to MUST CALIBRATE, then the following screen displays and the buzzer sounds in a double pulsing pattern.

```
CALIBRATION DATE
    IS PAST DUE

ENTER TO PERFORM
    CALIBRATION
```

The EAGLE 2 cannot be used until a successful calibration has been performed. Press and release the ENTER button to enter Calibration Mode. See “Chapter 4: Calibration Mode” on page 54 for instructions to calibrate the EAGLE 2.

NOTE: In this situation, even if the password function has been turned on, no password is required to perform a calibration.

When you are done with the calibration and exit Calibration Mode, the unit will begin the startup sequence. If the calibration was successful, the screen above will not appear again until the unit is due for calibration. If the calibration was not successful, the screen above will again appear in the startup sequence.

- If the unit is due for calibration and CAL PAST DUE ACT is set to NOTIFICATION ONLY, then the following alert screen displays and the buzzer sounds in a double pulsing pattern.

```
CALIBRATION DATE

    IS PAST DUE
```

Press and release the POWER ENTER RESET button to acknowledge the alert and continue with the startup sequence.

10. The Date/Time Screen appears for a few seconds.

```
9/12/2008

15:00:00
```

11. If USER/STATION ID is turned on (see “Turning the User/Station ID Function On or Off” on page 109), the ID Screen appears for a few seconds.

```
USER ID
MIKE
STATION ID
PUMP 1
SERIAL NUMBER
E2A515
```

If USER/STATION ID is turned off, only the serial number is shown.

12. If the EAGLE 2 experiences a sensor failure during start up, a screen indicating which sensor failed appears and the buzzer sounds a pulsing tone twice per second. In the example below, the H_2S sensor has failed.

```
FAILED SENSOR(S)

<  >   <  >
<H2S>  <  >

ENTER TO CONTINUE
```

If you wish to continue, press and release the POWER ENTER RESET button to acknowledge the failure. The gas reading for the failed sensor will be replaced by “XXX”. Replace the failed sensor as soon as possible.

13. The EAGLE 2 is now monitoring for gas in Measuring Mode. The Normal Operation Screen appears displaying the current gas reading for each target gas.

```
CH4      0%LEL
OXY  20.9vol%
H2S    0.0ppm
CO       0ppm
```

Performing a Demand Zero

Before using the EAGLE 2, it is recommended to set the fresh air readings for the target gases by performing a demand zero. This will set the CH_4, H_2S, and CO channels to zero and the OXY channel to 20.9%.

1. Find a fresh-air environment. This is an environment free of toxic or combustible gases and of normal oxygen content (20.9%).
2. Turn on the unit as described above in “Turning On the EAGLE 2”.
3. Press and hold the AIR ▲ YES button. The LCD prompts you to continue holding the AIR ▲ YES button and the buzzer will pulse while you hold the button.
4. Continue to hold the AIR ▲ YES button until the LCD prompts you to release it. The EAGLE 2 will set the fresh air reading for all channels. Start up is complete and the unit is now ready for monitoring.

Turning Off the EAGLE 2

1. Press and hold the POWER ENTER RESET button.
2. The buzzer will pulse for about five seconds.
3. Release the button when GOODBYE and the RKI logo appear on the display. When GOODBYE and the RKI logo disappear and the backlight turns off, the unit is off.

Using the Battery Charger for Continuous Operation

The battery charger can be used with an AC adapter or a vehicle plug DC adapter to run the EAGLE 2 in continuous operation instead of charging the batteries. Batteries do not need to be installed in the EAGLE 2 but if there are batteries installed, they must be NiMH batteries and they must have a charge.

WARNING: ***Use the EAGLE 2 charger’s continuous operation mode to power the EAGLE 2 only if NiMH batteries are installed in the EAGLE 2 or if no batteries are installed in the EAGLE 2. Do not use the charger for continuous operation if alkaline batteries are installed.***

1. Place the EAGLE 2 in the area to be monitored.
2. Plug the power adapter into either an AC outlet or into a vehicle outlet depending on which charger is being used.
3. Set the switch on the module to “CONT. OPERAT.”.
4. Make sure the EAGLE 2 is off.
5. Make sure the adapter and module are connected.
6. Make sure that the NiMH batteries are either charged or removed.

NOTE: If the batteries are not charged, the EAGLE 2 will not turn on and will instead give a “Charge Batteries” indication when it is powered up after Step 7 below.

7. Insert the module’s round plug into the EAGLE 2’s charging jack as shown in Figure 17 below.

Figure 17: Connecting the EAGLE 2 to the Charger

8. See “Chapter 3: Operation” on page 27 for instructions for start-up and operation of the EAGLE 2.
9. While the charging module is powering the EAGLE 2, its amber LED will be off and its green LED will be on.

Measuring Mode, Normal Operation

When the EAGLE 2 completes its startup sequence, it is in Measuring Mode. In Measuring Mode the EAGLE 2 continuously monitors the sampled atmosphere and displays the gas concentrations present for its target gases. In a low-light environment, press and release any button to turn on the display backlight. See “Updating the Backlight Delay Setting” on page 110 to program backlight duration. If the Confirmation Alert feature is turned on in the Setup Mode menu (see “Updating the Confirmation Alert Setting” on page 115), the EAGLE 2 beeps periodically to confirm that it’s operating.

Monitoring an Area

1. Start up the EAGLE 2 as described above in “Start Up” on page 27. It is now in Measuring Mode.

```
CH4      0%LEL
OXY  20.9vol%
H2S     0.0ppm
CO        0ppm
```

2. Take the EAGLE 2 to the monitoring area.

   Put the probe tip in the area to be monitored.

NOTE: If the particle filter or hydrophobic filter become dirty or clogged, replace them. If water enters the probe, dry out or replace the particle filter (if installed) and shake any water out of the probe or off of the hydrophobic filter. If you notice that water has entered the flow system through the probe, replace the probe’s hydrophobic filter and inspect the O-ring for filter particles. See “Replacing the Hydrophobic Probe’s Particle Filter and Hydrophobic Filter Disk” on page 72 for instructions to replace the particle filter and the hydrophobic filter.

3. Wait 10 - 15 seconds and observe the display for gas readings. If a reading is observed, allow the reading to stabilize to determine the gas concentrations present.

NOTE: Response time increases with the length of the sample hose. Long sample hoses will require more time to show a response at the EAGLE 2. The maximum sample hose length recommended for the EAGLE 2 is 125 feet. Consult RKI Instruments, Inc. for longer sample hose lengths.

4. If a gas alarm occurs, take appropriate action. See “Responding to Alarms” on page 40.

Using Optional Sample Hoses

The standard sample hose for the EAGLE 2 is 5 feet long. Optional hoses are available up to 125 feet long. If you are considering using a longer hose, keep in mind that a longer hose will increase the EAGLE 2’s response time and the flowrate may decrease close to the low flow alarm point.

CAUTION: *Sample hose lengths of more than 125 feet are not recommended for the EAGLE 2 because of flow rate reduction and increased response time. Consult RKI Instruments, Inc. for hose lengths longer than 125 feet.*

The chart below illustrates how response time is affected by the sample hose length.

Table 4: EAGLE 2 Response Time vs. Sample Hose Length

Hose Used	Typical Time to 90% of Response (T90)
Probe Only	12 seconds
Probe & 5 Foot Hose	15 seconds
Probe & 25 Foot Hose	25 seconds
Probe & 50 Foot Hose	35 seconds
Probe & 75 Foot Hose	45 seconds
Probe & 100 Foot Hose	60 seconds
Probe & 125 Foot Hose	75 seconds

Using Exhaust Tubing

The EAGLE 2’s exhaust fitting has a female 10-32 thread to allow for the installation of a hose barb fitting with a 10-32 thread to which a flexible exhaust tube can be connected. If you utilize this feature, the tubing used must have a minimum internal diameter of 1/8 inch. RKI Instruments, Inc. recommends using flexible polyurethane tubing with a maximum exhaust tube length of 20 feet. Consult RKI Instruments, Inc. for exhaust tubing lengths longer than 20 feet.

Combustible Gas Detection

There are three issues to keep in mind when monitoring for combustible gas.

- The catalytic combustible sensor will respond to any combustible gas. The standard calibration gas for the EAGLE 2 catalytic combustible channel is methane (CH_4). If the instrument is calibrated to a different combustible gas, such as hexane or propane, the gas name for the catalytic combustible channel will reflect the target gas.

  The table below lists the conversion factors for several hydrocarbon gases **if the EAGLE 2 is calibrated to methane**. To use this table, multiply the display reading on the combustible gas channel by the factor in the appropriate row to obtain the actual gas concentration. For example, if you are detecting pentane and the display reads 10% LEL for the catalytic combustible channel, you actually have 10% LEL x 1.95   19.5% LEL pentane present.

Table 5: Full Response Mode Conversion Factors (Methane Calibration)

Target Gas	LEL Factor	PPM Factor	Target Gas	LEL Factor	PPM Factor
Acetone	1.40	0.70	Isobutane	1.61	0.58
Benzene	1.75	0.42	Isopropanol	2.22	0.89
Butyl Acrylate	3.95	1.34	Methane	1.00	1.00
Butyl Acetate	3.38	0.88	Methanol	1.23	1.48
2-Butyl Alcohol	1.94	0.66	Methyl Acetate	1.37	0.85
1-Butyl Alcohol	2.65	0.74	Methyl Acrylate	1.10	0.62
Cyclohexane	1.82	0.47	Methyl Ethyl Ketone	2.53	0.71
Cumene	3.90	0.70	Methyl Isobutyl Ketone	2.53	0.61
Ethylene Dichloride	2.75	3.41	Mixed Xylenes	2.36	0.52
Ethyl Alcohol	1.38	0.91	Nonane	2.87	0.46
Ethyl Chloride	1.26	0.96	Pentane	1.95	0.59
Ethyl Acrylate	2.45	0.69	Propane	1.50	0.63
Hexane	2.44	0.54	Styrene	2.94	0.53
Hydrogen	1.16	0.93	Toluene	2.16	0.48
			Vinyl Acetate Monomer	1.48	0.77

* Vapor pressure too low for significant LEL reading

- The EAGLE 2 provides the catalytic combustible sensor with some protection against exposure to high levels of combustible gas which can damage the sensor. It does this by turning off the combustible sensor power temporarily when it determines that an over scale (more than 100% LEL) concentration of combustible gas is present that may damage the sensor. Nevertheless, concentrations of combustible gas of more than 100% LEL can still affect the zero level or calibration of the combustible sensor if the concentration is high enough.

CAUTION: *Do not expose the catalytic combustible sensor to high concentrations of combustible gas such as that from a butane lighter. Exposure to high concentrations of combustible gas may adversely affect the performance of the sensor.*

CAUTION: *Any rapid increase in the combustible gas reading on the catalytic combustible channel followed by a declining or erratic reading may indicate a gas concentration above the LEL which may be hazardous.*

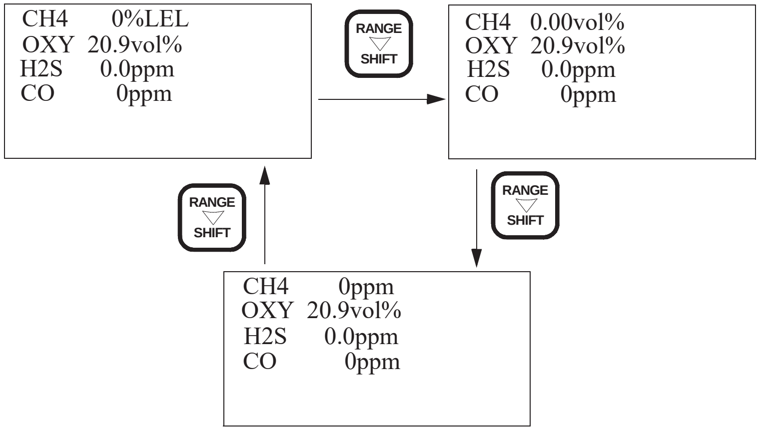
- Some gases such as silicone vapors, chlorinated hydrocarbons, and sulphur compounds can contaminate the detection elements inside the combustible sensor damaging the sensor and result in reduced response to combustible gas. Make every effort to avoid these gases. The catalytic combustible sensor has an integral H_2S scrubber for protection from H_2S exposure resulting from normal use, but you should avoid exposure to high levels of H_2S and other sulphur compounds.

Monitoring Combustible Gas in the PPM or %Volume Range

The standard factory configuration for the EAGLE 2 allows the user to use the RANGE ▼ SHIFT button to change the displayed detection units of the catalytic combustible channel between %LEL, ppm, and %volume. It is possible to disable this capability and set the EAGLE 2 to display only one of the detection units by using the Catalytic Units menu item in Setup Mode. See "Setting the Catalytic Detection Units" on page 105 for instructions to set this Setup Mode Menu item.

The detection range of the combustible catalytic channel when set for ppm or %volume will correspond to 0 - 100% LEL for the configured gas. For example, the LEL for methane (CH_4) is 5% volume, or 50,000 ppm. So if the catalytic combustible channel is displayed in terms of %volume, the full scale is 5.00% and if it is displayed in terms of ppm, the full scale is 50,000 ppm.

If the Catalytic Units menu item in Setup Mode is set to **CHANGE OK**, the standard factory setting, then you can change the catalytic combustible channel's units by pressing and releasing RANGE ▼ SHIFT.



Monitoring Combustible Gas in the PPM Range

There are special considerations that must be taken into account when monitoring combustible gas in the ppm range with the catalytic combustible channel. Because of the high sensitivity in the lower part of the ppm range, the catalytic combustible channel needs more time than the warm-up period to stabilize after the EAGLE 2 is turned on if it is going to be used for ppm level detection. The reading increments in the ppm range are smallest in the lower part of the range and increase as the reading increases as follows:

- 5 ppm increments from 0 ppm to 200 ppm
- 10 ppm increments from 200 ppm to 1,000 ppm
- 50 ppm increments from 1,000 ppm to 10,000 ppm
- 250 ppm increments from 10,000 ppm to 50,000 ppm

If the catalytic combustible channel is configured for the user defined gas in Setup Mode (see “Configuring the Combustible Gas” on page 101), the ppm ratio defined for the gas must be considered. For example, if the ppm ratio is set higher than 50,000 ppm, then when the display units are set as ppm, the reading will not go above 50,000 ppm which is equivalent to 33 % LEL and 5 %volume. So if the gas reading is higher than 50,000 ppm, the ppm unit reading will indicate 50,000 ppm and also indicate an overscale condition. The %LEL and %volume unit readings will still increase up to 100% LEL and 15 %volume respectively, which are equivalent to 150,000 ppm.

The catalytic combustible sensor is slightly affected by humidity. This is not apparent when the EAGLE 2 is used for %LEL or %volume detection, but because of the high sensitivity in the ppm range, significant humidity changes can affect the ppm reading, especially in the lower part of the range. Take care to allow the unit to acclimate to a new environment for about a minute and perform a demand zero in a fresh air location when you move between areas of different humidity.

CAUTION: *If the catalytic combustible channel is being calibrated with a gas concentration of 1000 ppm or lower, the a 24 inch humidifier must be used for accurate calibration. See “Chapter 4: Calibration Mode” on page 54 for more explanation and instructions for calibration.*

To monitor for combustible gas in the ppm range:

1. Start up the EAGLE 2 as described in “Start Up” on page 27.
2. Allow the EAGLE 2 to run for 3 - 5 minutes after the startup sequence is complete and it is in Measuring Mode. This allows the catalytic combustible sensor to stabilize sufficiently for ppm monitoring.

NOTE: This extra stabilization period is not necessary if monitoring in the %LEL or %volume range.

3. Set the catalytic combustible channel’s units to be ppm by using the RANGE ▼ SHIFT button.
4. Perform a demand zero as described in “Performing a Demand Zero” on page 31.
5. Proceed to monitor for gas as described in “Monitoring an Area” on page 33.

Measuring Mode, Alarms

This section covers alarm indications in Measuring Mode. It also describes how to reset the EAGLE 2 after an alarm has occurred and how to respond to an alarm condition.

NOTE: False alarms may be caused by radio frequency (RF) or electromagnetic (EMI) interference. Keep the EAGLE 2 away from RF and EMI sources such as radio transmitters or large motors.

Alarm Indications

The EAGLE 2 will sound an alarm and flash the LED arrays when one of the target gas concentrations rises above the Low Alarm level, or in the case of oxygen falls below the Low Alarm level, for that gas.

The EAGLE 2 also sounds an alarm and flashes the LED arrays when one of the target gas concentrations rises above the High Alarm level and when the STEL and TWA alarm levels are reached for CO and H_2S.

NOTE: If an alarm condition occurs while you are in Display Mode, the EAGLE 2 will automatically bring up the alarm screen instead.

When a failure condition occurs, such as a sensor failure, low flow, or dead battery condition, the unit will also sound an alarm and flash the LED arrays.

The table below summarizes the types of alarms produced by the EAGLE 2 and their indications.

Table 6: Alarm Types and Indications

Alarm Type	Visual Indications	Audible Indication
Low Alarm Concentration of gas rises above the Low Alarm setting or falls below the Low Alarm setting for O_2.	• **ALRM1** appears next to gas reading • Alarm LED arrays flash once per second • Backlight turns on	Pulsing tone once per second
High Alarm Concentration of gas rises above the High Alarm setting.	• **ALRM2** appears next to gas reading • Alarm LED arrays flash twice per second • Backlight turns on	Pulsing tone twice per second
TWA or STEL Concentration of CO or H_2S rises above the TWA or STEL alarm setting.	• Alarm LED arrays flash once per second • Backlight turns on • **TWA** or **STEL** appears next to gas reading	Pulsing tone once per second

Table 6: Alarm Types and Indications

Alarm Type	Visual Indications	Audible Indication
Over Range	• **OVER** appears next to gas reading • Gas reading indicates full scale • Alarm LED arrays flash twice per second • Backlight turns on	Pulsing tone twice per second
Low Flow	• The display indicates **FAIL LOW FLOW LEVEL** • Alarm LED arrays flash in a double pulsing pattern once per second • Backlight turns on	Double pulsing tone once per second
Low Battery Warning	• **BATT** appears vertically along the left side of LCD	None
Dead Battery Alarm	• Gas readings replaced by **RECHARGE INSTRUMENT BATTERIES** • Alarm LED arrays flash in a double pulsing pattern once per second	Double pulsing tone once per second
Sensor Failure	• **FAILED SENSOR(S)** appears at the top of the display and the failed sensor(s) are indicated • Alarm LED arrays flash in a double pulsing pattern once per second	Double pulsing tone once per second

Resetting and Silencing Alarms

You can set the EAGLE 2's gas alarms as latching or self-resetting alarms (see "Updating the Alarm Latching Setting" on page 108).

- Self-resetting alarms (ALARM LATCHING set to SELF RESET)

  Self-resetting alarms automatically shut off and reset when the gas reading falls below (or rises above for an oxygen low alarm) the alarm setting. You cannot reset self-resetting alarms with the POWER ENTER RESET button. You can set self-resetting alarms with or without the alarm silence feature (see "Updating the Alarm Silence Setting" on page 108).

- Latching alarms (ALARM LATCHING set to LATCHING)

  Latching alarms will remain in effect until the gas reading falls below (or rises above for an oxygen low alarm) the alarm setting and they are reset with the POWER ENTER RESET button. You can set latching alarms with or without the alarm silence feature (see "Updating the Alarm Silence Setting" on page 108).

ALARM SILENCE On and Alarms Set to LATCHING:

ALARM SILENCE set to ON and ALARM LATCHING set to LATCHING are the factory settings. When the EAGLE 2 goes into gas alarm, press and release any button to silence the buzzer. If the gas concentration was still above the alarm level when the button was pressed, the LED arrays continue to flash, and the EAGLE 2 continues to display the current alarm level.

The gas reading must fall below (or rise above for an oxygen low alarm) an alarm setting before you can reset the alarm. When the alarm condition passes, press and release the POWER ENTER RESET button to reset the alarm. The LED arrays turn off and the EAGLE 2 alarm indications on the display turn off.

ALARM SILENCE Off and Alarms Set to LATCHING:

The gas reading must fall below (or rise above for an oxygen low alarm) an alarm setting before you can reset the alarm. When the alarm condition passes, press and release the POWER ENTER RESET button to reset the alarm. The LED arrays and buzzer turn off and the EAGLE 2 alarm indications on the display turn off.

ALARM SILENCE On and Alarms Set to SELF RESETTING:

When the EAGLE 2 goes into gas alarm, press and release any button to silence the buzzer. The POWER ENTER RESET button will not reset the alarm. When the gas reading falls below (or rises above for an oxygen low alarm) an alarm setpoint, the alarm will automatically reset. The LED arrays turn off and the EAGLE 2 alarm indications on the display turn off.

With ALARM SILENCE Off and Alarms Set to SELF RESETTING:

When the EAGLE 2 goes into gas alarm, the POWER ENTER RESET button will not silence or reset the alarm. When the gas reading falls below (or rises above for an oxygen low alarm) an alarm setpoint, the alarm will automatically reset. The LED arrays and buzzer turn off and the EAGLE 2 alarm indications on the display turn off.

Responding to Alarms

This section describes response to gas, over range, battery, and sensor failure alarms.

Responding to Gas Alarms

1. Determine which gas alarm has been activated.
2. Follow your established procedure for an increasing gas condition or a decreasing oxygen condition.
3. If necessary, reset the alarm using the POWER ENTER RESET button once the alarm condition has passed.

Responding to Over Range Alarms

WARNING: ***An over range condition may indicate an extreme combustible gas, toxic gas, or oxygen concentration. Confirm a normal condition with a different EAGLE 2 or with another gas detecting device.***

1. Determine which channel is in alarm.
2. Follow your established procedure for an extreme gas condition.
3. Reset the alarm using the POWER ENTER RESET button once the alarm condition has cleared.
4. Calibrate the EAGLE 2 as described in "Chapter 4: Calibration Mode" on page 54.

5. If the over range condition continues or if you are not able to successfully calibrate the unit, you may need to replace the sensor that has triggered the over range alarm.
6. If the over range condition continues after you have replaced the sensor, contact RKI Instruments, Inc. for further instructions.

Responding to Battery Alarms

WARNING: ***The EAGLE 2 is not operational as a gas monitoring device during a dead battery alarm. Take the Model EAGLE 2 to a non-hazardous area and replace or recharge the batteries as described in "Replacing or Recharging the Batteries" on page 69.***

The EAGLE 2 is fully functional during a low battery warning. However, only a limited amount of operating time remains, approximately 1 - 2 hours. The amount of time depends on how often the LCD backlight is used and how often the unit is responding to alarm conditions. Recharge the Ni-MH batteries or replace the alkaline batteries as soon as possible as described in "Replacing or Recharging the Batteries" on page 69.

NOTE: Alarms and the LCD back light consume battery power and reduce the amount of operating time remaining.

Responding to Sensor Failure Alarms

1. Determine which sensor has triggered the sensor failure alarm.
2. Try calibrating the sensor first, as described in "Chapter 4: Calibration Mode" on page 54 before replacing it.
3. If the sensor failure continues, replace the sensor as described in "Replacing a Sensor" on page 76.
4. If the sensor failure condition continues after you have replaced the sensor, contact RKI Instruments, Inc. for further instructions.

Display Mode

Two other operating modes are accessible when the EAGLE 2 is in Measuring Mode. They are Display Mode and Calibration Mode. This section describes using the EAGLE 2 in Display Mode. In Display Mode you can:

- display peak readings
- display the minimum operating and current battery voltage
- select how the active channels are displayed on the LCD
- turn the catalytic LEL sensor on or off (if there is a TC or infrared combustible channel along with a catalytic combustible channel)
- enable or disable methane elimination mode (if the catalytic combustible gas channel is configured appropriately in the **CONFIGURE GASES** item in Setup Mode)
- temporarily configure the catalytic combustible channel for a target gas other than the one used for calibration (if the **RELATIVE RESPONSE** item in Setup Mode is set to **ON**)
- display STEL readings *(H_2S and CO only)*
- display TWA readings *(H_2S and CO only)*

- display alarm settings
- select the user ID (if the **USER/STATION ID** item in Setup Mode is set to **ON**)
- select the station ID (if the **USER/STATION ID** item in Setup Mode is set to **ON**)
- display time in operation
- display date and time
- display remaining data logging time and clear data logger memory (if the **DATA LOG MEMORY** item in Setup Mode is set to **ON**)

Tips for Using Display Mode

- To enter Display Mode and scroll from one screen to the next or skip an item when a question is asked, press and release the DISPLAY ADJUST NO button.
- To enter an item when a question is asked, press and release the AIR ▲ YES button.
- To change a flashing parameter, use either the AIR ▲ YES button or RANGE ▼ SHIFT button.

NOTE: Each screen displays for 20 seconds. If you do not press a button within 20 seconds, the EAGLE 2 automatically returns to Measuring Mode.

Peak Screen

The peak screen displays the highest (lowest for oxygen) concentrations detected since the EAGLE 2 was turned on. Peak readings are stored in the EAGLE 2's memory until a higher level is detected (lower for oxygen), the peak reading is cleared, or the EAGLE 2 is turned off.

The lunch break feature enables the EAGLE 2 to save peak readings when it is turned off so it can continue them when it is turned on again. See "Turning On the EAGLE 2" on page 27

```
  CH4    0%LEL
P OXY  20.9vol%
E H2S   0.0ppm
A CO      0ppm
K
```

To clear the peak readings, do the following:

1. With the Peak Screen displayed, press and release the POWER ENTER RESET button. The following screen will appear.

```
      CLEAR

  PEAK READINGS?
```

2. Press and release the AIR ▲ YES button. The peak readings will be reset and the unit will return to the Peak Screen.

If you do not want to clear the peak readings, press and release the DISPLAY ADJUST NO button and the unit will return to the Peak Screen without clearing the peak readings.

Battery Voltage Screen

The Battery Voltage Screen displays the minimum operating voltage and the current battery voltage. Fully charged alkaline batteries typically indicate 6.0 volts; fully charged Ni-MH batteries typically indicate 5.2 volts. This screen also displays during the startup sequence.

```
BATTERY MIN:
  4.3 VOLTS

BATTERY NOW:
  5.2 VOLTS
```

Gas Display Screen

The Gas Display Screen gives you the option to select how the active channels are displayed.

```
 SELECT

GASES  DISPLAYED
```

You can display all of them on the screen at the same time, one at a time with automatic scrolling, or one at time with manual scrolling. The factory setting displays all of the active channels at the same time. To select how to display the active channels, do the following:

1. With the Gas Display Screen displayed, press and release the AIR ▲ YES button. The following screen will appear with the cursor blinking.

```
  SELECT
> DISPLAY ALL
  SCROLL AUTO
  SCROLL MANUAL
```

2. Use the AIR ▲ YES and RANGE ▼ SHIFT buttons to place the cursor next to the desired choice.
3. Press and release the POWER ENTER RESET button. The unit continues to the STEL Screen and the display configuration will reflect your choice when you return to Measuring Mode.

   If you do not want to change the setting, press and release the DISPLAY ADJUST NO button and the unit will return to the Gas Display Screen.

Catalytic (LEL) Sensor Screen

This screen appears only when either a TC sensor or an infrared combustible sensor is installed in an EAGLE 2 along with a catalytic combustible LEL sensor. See "Appendix F: TC Sensors", "Appendix H: Infrared Methane Sensor", or "Appendix I: Infrared Hydrocarbon Sensor" for a description of this screen and instructions to use it.

Methane Elimination Mode Screen

This screen displays only if the EAGLE 2 catalytic combustible channel is setup for one of the gases in the CONFIGURE GASES menu item in Setup Mode that supports methane elimination (See "Configuring the Combustible Gas" on page 101).

```
METHANE ELIMINATION
       MODE


     DISABLED
```

The standard setup for methane (CH_4) does not support methane elimination. When applicable, use this screen to enable and disable the methane elimination feature. See "Appendix J: Methane Elimination Mode" for more discussion of the methane elimination feature.

1. With the Methane Elimination Mode Screen displayed, press and release the AIR ▲ YES or RANGE ▼ SHIFT button to toggle to the desired setting, ENABLED or DISABLED.
2. Press and release the POWER ENTER RESET button. The unit will save the setting and proceed to the next menu item.

   If you changed the setting and do not want to save the change, press and release the DISPLAY ADJUST NO button to continue to the next menu item without saving the change.

Catalytic Sensor Relative Response Screen

This screen displays only if **RELATIVE RESPONSE** in Setup Mode is set to ON (see "Updating the Catalytic Sensor Relative Response Setting" on page 106). Use this screen to temporarily change the gas configuration of the catalytic combustible channel.

```
       SELECT
 RELATIVE RESPONSE
 TO CALIBRATED GAS
FOR CATALYTIC SENSOR
```

You can select from a list of gases whose response relative to the configured gas, normally methane, is programmed into the EAGLE 2's memory. This includes several pre-defined gases and 5 gases that can be entered into the EAGLE 2 in the field using the Eagle 2 Maintenance Data Loader Program. In order to program a field defined gas into the

EAGLE 2, gas testing must be performed to determine the gas' response factor relative to methane. See the Eagle 2 Maintenance Data Loader Program Operator's manual for details regarding the gas testing and programming user defined gases into the EAGLE 2's relative response list. The last five items in the gas list are reserved for field defined gases.

The relative response feature enables you to temporarily monitor for the selected gas without having to recalibrate the EAGLE 2. The EAGLE 2 will clear the gas configuration change when it is turned off and will return to the programmed configuration when it is turned on again.

Because of normal variation between sensors, these relative response factors are typical factors. If you use this feature, the response to the selected gas will not be as accurate as it would be if you configured and calibrated the catalytic combustible channel to the target gas.

NOTE: For maximum accuracy, configure and calibrate the EAGLE 2's catalytic combustible channel to the desired target gas.

1. With the Relative Response Screen displayed, press and release AIR ▲ YES. A list of gases will appear on the screen with **EXIT** at the top of the list. There are multiple screens of gases.

```
>EXIT
  ACETONE
  BENZENE
  BUTYL ACRYLATE
  BUTYL ACETATE
  2-BUTYL ALCOHOL
```

The following is the complete list of factory defined gases.

Table 7: Relative Response Gas List

Acetone	Cumene	Isobutane	Methyl Ibutyl Ketone	Mixed Xylenes
Benzene	Ethylene Dichloride	Isopropanol	Nonane	Field Defined Gas
Butyl Acrylate	Ethyl Alcohol	Methane	Pentane	Field Defined Gas
Butyl Acetate	Ethyl Chloride	Methanol	Propane	Field Defined Gas
2-Butyl Alcohol	Ethyl Acrylate	Methyl Acetate	Styrene	Field Defined Gas
1-Butyl Alcohol	Hexane	Methyl Acrylate	Toluene	Field Defined Gas
Cyclohexane	Hydrogen	Methyl Ketone	Vinyl Acetate	

2. Use the AIR ▲ YES or RANGE ▼ SHIFT buttons to move the cursor next to the desired gas.
3. Press and release POWER ENTER RESET. The catalytic combustible channel will be configured to the selected gas and the EAGLE 2 will proceed to the STEL Screen. This configuration will be in force until either a different gas is selected in Display Mode or the unit is turned off.

NOTE: If a PID sensor is installed in the EAGLE 2 and **CATALYTIC SENSOR RELATIVE RESPONSE** is set to ON in Setup Mode, a PID Sensor Relative Response Screen appears after the Catalytic Sensor Relative Response Screen. If **CATALYTIC SENSOR RELATIVE RESPONSE** is set to OFF, the PID Sensor Relative Response Screen will still appear after the Methane Elimination Mode Screen. See "PID Relative Response Feature" on page 128 for a description of the relative response feature for the PID sensor.

NOTE: If Methane Elimination Mode is enabled, the Catalytic Sensor Relative Response screen does not appear.

STEL Screen

The STEL Screen displays the short term exposure limit (STEL) readings *for H_2S and CO only*. The STEL reading is the average reading *over the last 15 minutes*.

```
S H2S   0.0ppm
T CO      0ppm
E
L
```

TWA Screen

The TWA Screen displays the time weighted average (TWA) readings *for H_2S and CO only*.

```
T H2S   0.0ppm
W CO      0ppm
A
```

The TWA reading is the average reading *over the last 8 hours*. If 8 hours have not elapsed since the last time the TWA reading was cleared, the average is still calculated over 8 hours. The missing time is assigned a 0 value for readings. If the lunch break feature is turned off, the TWA is cleared when the EAGLE 2 is turned off.

The lunch break feature enables the EAGLE 2 to remember TWA readings when it is turned off so it can continue them when it is turned on again. See "Turning On the EAGLE 2" on page 27

View Alarm Settings Screen

The View Alarm Settings Screen gives you the option to view the gas alarm settings for all active channels.

```
VIEW ALARM

SETTINGS?
```

To view the gas alarm settings, do the following:

1. With the View Alarm Settings Screen displayed, press and release the AIR ▲ YES button. The following screen appears showing Channel 1 alarm points.

```
CHANNEL  1
CH4 0-   100 %LEL
LO ALRM:    10 %LEL
HI ALRM:    10 %LEL
LO ALRM: 5000 ppm
HI ALRM:25000 ppm
```

2. If the channel description is too long to fit across the screen, press and release the POWER ENTER RESET button to view the remainder of the displayed channel's description. Press and release the POWER ENTER RESET button again to return to the previous screen.

```
CHANNEL  1
CH4 0-    100 %LEL
LO ALRM:    10 %LEL
HI ALRM:    10 %LEL
LO ALRM: 5000 ppm
HI ALRM:25000 ppm      ▼
```


```
CHANNEL  1
METHANE
LO ALRM:    10 %LEL
HI ALRM:    10 %LE L
LO ALRM: 5000 ppm
HI ALRM:25000 ppm      ▼
```

3. If the number of alarm settings is too many to display on one screen, a down arrow will appear in the lower right corner of the display indicating that there are additional alarm points. Press and release the RANGE ▼ SHIFT button to scroll down and display the remainder of the gas alarm settings for the displayed channel and again to return to the previous screen.

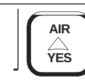
```
CHANNEL  1
CH4 0-  100 %LEL
LO ALRM:    10 %LEL
HI ALRM:    10 %LEL
LO ALRM: 5000 ppm
HI ALRM:25000 ppm      ▼
```


```
CHANNEL  1
CH4 0-  100 %LEL
LO ALRM:  OFF vol%
HI ALRM:   OFF vol%
                       ▲
```


4. Press and release the AIR ▲ YES button to scroll through screens that display the rest of the active channels' alarm settings.

```
CHANNEL  1
CH4 0-  100 %LEL
LO ALRM:     10 %LEL
HI ALRM:     50 %LEL
LO ALRM: 5000 ppm
HI ALRM:25000 ppm      ▼
```


```
CHANNEL  2
OXY 0- 40.0 vol%
LO ALRM: 19.5 vol%
HI ALRM:   23.5 vol%
```




```
CHANNEL  3
H2S 0-100.0 ppm
LO ALRM:        5.0 ppm
HI ALRM:       30.0 ppm
STEL ALRM:    5.0 ppm
TWA ALRM:     1.0 ppm
```


```
CHANNEL  4
CO  0-  500 ppm
LO ALRM:        25 ppm
HI ALRM:        50 ppm
STEL ALRM: 200 ppm
TWA ALRM:    25 ppm
```

Select User ID Screen

This screen displays only if USER/STATION ID in the Setup Mode menu is set to ON (see "Turning the User/Station ID Function On or Off" on page 109). Use this screen to select a user ID from the user ID list in the EAGLE 2's memory. The current user ID is displayed. A user ID can be up to 16 characters long. The EAGLE 2 can store up to 32 user IDs.

```
SELECT
USER ID?

CURRENT USER ID
JOHN
```

The user ID provides a way to identify the EAGLE 2 user during a data logging session. If the user ID is changed during an operating session, a new data session is initiated with the new user ID attached to it. This allows you to change the user ID during operation and have each user ID that was used during an operating session saved for the corresponding data. See the Eagle 2 Data Logger Management Program Operator's Manual for a detailed description of data logging and the user ID.

The user ID list cannot be edited using the EAGLE 2 user interface. The Eagle 2 Maintenance Data Loader Program is required to define or change user IDs in the user ID list. For a detailed description of editing the list of user IDs stored in the EAGLE 2, see the Eagle 2 Maintenance Data Loader Program Operator's Manual.

To select a different user ID:

1. With the Select User ID Screen displayed, press and release the AIR ▲ YES button. A screen appears that includes the current user ID which is indicated by the cursor next to it.

```
  Bruce
> John
  Mike
  ----------------
  ----------------
  ----------------
```

   The user IDs are displayed in groups of six. The previous group of six is displayed when the cursor is moved up past the top of the LCD. The next group of six is displayed when the cursor is moved down past the bottom of the LCD. The list will not "wrap around" to the previous screen if the cursor is moved up from the first user ID or to the next screen if the cursor is moved down from the last user ID. Any of the user IDs in the list that have not been changed from the factory setting will be shown as dashes (-).

2. Use the AIR ▲ YES and RANGE ▼ SHIFT buttons to move the cursor up and down the screen and scroll through the available user IDs to find the desired user ID.
3. When the desired user ID is displayed, place the cursor next to it, press and release the POWER ENTER RESET button.

NOTE: To exit the selection screen without saving a change, press and release the DISPLAY ADJUST NO button. You will return to the Select User ID screen without saving the user ID change.

4. The unit will save the selected user ID as the current one and proceed to the Select Station ID Screen.

Select Station ID Screen

This screen displays only if USER/STATION ID in the Setup Mode menu is set to ON (see "Turning the User/Station ID Function On or Off" on page 109). Use this screen to select a station ID from the station ID list in the EAGLE 2's memory. The current station ID is displayed. A station ID can be up to 16 characters long. The EAGLE 2 can store up to 128 station IDs.

```
    SELECT
  STATION ID?

CURRENT STATION
Pump 2
```

The station ID provides a way to identify a location where monitoring was done during a data logging session. If the station ID is changed during an operating session, a new data session is initiated with the new station ID attached to it. This allows you to change the station ID during operation and have each station ID that was used during an operating session saved for the corresponding data. See the Eagle 2 Data Logger Management Program Operator's Manual for a detailed description of data logging and the station ID.

The station ID list cannot be edited using the EAGLE 2 user interface. The Eagle 2 Maintenance Data Loader Program is required to define or change station IDs in the station ID list. For a detailed description of editing the list of station IDs stored in the EAGLE 2, see the Eagle 2 Maintenance Data Loader Program Operator's Manual.

To select a different station ID:

1. With the Select Station ID Screen displayed, press and release the AIR ▲ YES button. A screen appears that includes the current station ID which is indicated by the cursor next to it.

```
  Pump 2
> Pump 3
  Valve 5
  ----------------
  ----------------
  ----------------
```

   The station IDs are displayed in groups of six. The previous group of six is displayed when the cursor is moved up past the top of the LCD. The next group of six is displayed when the cursor is moved down past the bottom of the LCD. The list will not "wrap around" to the previous screen if the cursor is moved up from the first station ID or to the next screen if the cursor is moved down from the last station ID. Any of the station IDs in the list that have not been changed from the factory setting will be shown as dashes (-).

2. Use the AIR ▲ YES and RANGE ▼ SHIFT buttons to move the cursor up and down the screen and scroll through the available station IDs to find the desired station ID.
3. When the desired station ID is displayed, place the cursor next to it, press and release the POWER ENTER button.

NOTE: To exit the selection screen without saving a change, press and release the DISPLAY ADJUST NO button. You will return to the Select Station ID screen without saving the station ID change.

4. The unit will save the selected station ID as the current one and proceed to the Time in Operation Screen.

Time in Operation Screen

The Time In Operation Screen displays the length of time since the EAGLE 2 was turned on if the lunch break feature is turned off. With the lunch break feature turned off, the time in operation is reset when the EAGLE 2 is turned off. See "Updating the Lunch Break Setting" on page 118 for a description of the lunch break feature.

```
  TIME IN
 OPERATION
    45
  MINUTES
```

If the lunch break feature is turned on, the time in operation will only be reset if you do not choose to resume the peak and TWA measurements when the EAGLE 2 is turned on in the Resume Measurement Screen described in Step 7 on page 28 in "Turning On the EAGLE

2”. If you choose to resume the peak and TWA measurements during startup, the EAGLE 2 will include the time in operation when the unit was last turned off in the current time in operation.

Date/Time Screen

The Date/Time Screen displays the current date and time.

9/26/2009
09:08:35

Data Logging Screen

CAUTION: *Once you clear the data logger, you cannot retrieve any data previously stored in the data logger.*

The Data Logging screen displays the time remaining until the data logger memory is full and asks if you want to clear the data logger memory.

DATA LOGGING
200 HRS
REMAINING
ERASE LOG MEMORY?

To return to Measuring Mode while at the Data Logging Screen, press and release the DISPLAY ADJUST NO button.

To clear the data logger memory, do the following:

1. With the Data Logging Screen displayed, press and release the AIR ▲ YES button. The following screen appears asking you to confirm that you want to clear the data logger memory.

LOG MEMORY
CLEAR DATA LOG?

2. If you do not want to clear the data logger memory at this point or at Step 3 below, press and release the DISPLAY ADJUST NO button. The unit will return to Measuring Mode.

3. If you want to clear the data logger memory, press and release the AIR ▲ YES button. The following screen appears asking you to reconfirm that you want to clear the data logger memory.

LOG MEMORY
ARE YOU SURE YOU
WANT TO PERMANENTLY
ERASE DATA FROM
MEMORY?

4. If you want to clear the data logger memory, press and release the AIR ▲ YES button. The unit will display the following screen as it clears the data.

PLEASE WAIT
....

5. The periods below “PLEASE WAIT” will disappear one at a time from right to left as the data is cleared. When the last period disappears, the unit is finished clearing the data and will display the following screen for a few seconds, then return to Measuring Mode.

CLEARED

Data Logging

NOTE: The EAGLE 2 only logs data while in Normal Mode. If the EAGLE 2 is used in Leak Check Mode or Bar Hole Mode, no downloadable data will be logged while it is in either of these two modes.

The EAGLE 2 features the ability to log data to its internal memory and download it to a computer via the infrared communications port on the front of the unit. It logs gas readings during normal operation, alarm data, and calibration data.

To utilize the EAGLE 2’s downloading capability, you will need the Eagle 2 Data Logger Management Program and a computer with an infrared port or a USB port that runs one of the following operating systems: Windows 7, Windows 8, or Windows 10. If your computer has an infrared port, then no additional accessories are needed to download data from the EAGLE 2. If your computer does not have an infrared port but does have a USB port, a USB/IrDA adapter cable can be used to download data from the EAGLE 2 using the USB port. The Eagle 2 Data Logger Management Program is available at www.rkiinstruments.com/eagle2. The USB/IrDA adapter cable is also available from RKI

Instruments, Inc.

The data logging capacity depends on how often the EAGLE 2 stores data, how many channels are active, and how often the EAGLE 2 is turned on and off. The table below illustrates how much data logging time is available for the various interval times. It assumes that the unit is setup with four sensors, is only turned on once, and there are no alarm occurrences. See “Updating the Data Log Interval Setting” on page 111 for instructions on setting the data logging interval time.

Table 8: Data Logging Capacity, 4-gas EAGLE 2

Interval Time	Data Logging Time
5 seconds	239 hours (10 days)
10 seconds	479 hours (20 days)
20 seconds	959 hours (40 days)
30 seconds	1439 hours (60 days)
1 minute	2879 hours (120 days)
3 minutes	8639 hours (360 days)
5 minutes	14,399 hours (600 days)
10 minutes	28,798 hours (2,000 days)

For a complete description of the Data Logger Management Program and procedures for downloading data to a computer, see the Eagle 2 Data Logger Management Program Operator’s Manual.

Chapter 4: Calibration Mode

Overview

This section describes the EAGLE 2 in Calibration Mode. In Calibration Mode, you can move through a menu of screens to do the following:

- Perform a span adjustment on all channels simultaneously using auto calibration
- Perform a span adjustment on one channel at a time using single calibration
- Perform a fresh air (zero) adjustment

NOTE: You can set up the EAGLE 2 to alert you during the startup sequence when calibration is due. See “Updating the Calibration Reminder Setting” on page 113

CAUTION: *BEFORE EACH DAY’S USAGE, SENSITIVITY IN THE %LEL RANGE MUST BE TESTED ON A KNOWN CONCENTRATION OF THE COMBUSTIBLE TARGET GAS, METHANE, EQUIVALENT TO 25 - 50% OF FULL SCALE CONCENTRATION (the %LEL full scale is 100 %LEL). ACCURACY MUST BE WITHIN -0 to + 20% OF ACTUAL. ACCURACY MAY BE CORRECTED BY FOLLOWING THE CALIBRATION INSTRUCTIONS FOR THE COMBUSTIBLE CHANNEL BELOW.*

If the combustible channel passes the above response test and does not require calibration, the unit should still be calibrated periodically. The optimum frequency of calibration depends heavily on how the EAGLE 2 is used. For example, instruments used daily may need to be calibrated weekly or monthly, while instruments that are used only a few times a year may need to be calibrated before each use. Typical calibration frequencies range from monthly to quarterly. Make sure to perform the combustible channel response test as described above and make sure to develop a calibration schedule tailored to your application that takes this test and required calibration resulting from this test into account.

Calibration Supplies and Equipment

To calibrate the EAGLE 2, you will need:

- Known calibrating samples of the gases being detected. The combustible and toxic gas samples should have concentrations between 10 and 50% of the full scale value. For example, if you are calibrating the catalytic combustible gas channel, your calibration cylinder should have a combustible gas concentration between 10% LEL and 50% LEL. An oxygen-free source, such as 100% nitrogen is recommended for setting the oxygen zero.

NOTE: The catalytic combustible channel can be set up for and calibrated to a number of different combustible gases. See "Configuring the Combustible Gas" on page 101 for instructions. Be sure that you are using an appropriate calibration cylinder for the target gas of the catalytic combustible channel.

CAUTION: *When using auto calibration with the standard 4-gas EAGLE 2, although the EAGLE 2 can be calibrated with an oxygen concentration of up to 19.5%, RKI Instruments, Inc. recommends that the multi-gas cylinder have an oxygen concentration in the range of 10% - 16% oxygen.*

- A demand-flow regulator to provide adequate sample gas flow

WARNING: ***RKI Instruments, Inc. recommends that you dedicate a regulator for use with chlorine (Cl_2) gas and that you do not use that dedicated regulator for any other gases, particularly hydrogen sulfide (H_2S).***

- Non-absorbent tubing
- A 24 inch humidifier tube if you are calibrating the catalytic combustible channel with a gas concentration of 1000 ppm or lower

WARNING: ***If you are using a calibration kit that includes a gas bag and a fixed flow regulator or dispensing valve, do not apply gas directly to the EAGLE 2 with the regulator or dispensing valve or damage to the pump will result. See "Appendix A: Calibrating with a Sample Bag" on page 82 for instructions to properly use a gas bag kit.***

To calibrate the %LEL, oxygen, CO, and H_2S sensors at the same time, automatically, with no need for a zero-oxygen source, you can use the auto calibration feature with a 4-gas cylinder. If the H_2S channel is not active, then a 3-gas cylinder may be used for auto calibration. This chapter includes instructions for auto calibration with a demand-flow regulator and a 4-gas cylinder. This chapter also includes instructions for calibrating one channel at a time using single calibration.

Entering Calibration Mode

To enter Calibration Mode, do the following:

1. Find a fresh-air environment. This is an environment free of toxic or combustible gases and of normal oxygen content (20.9%).
2. While in Measuring Mode, press and hold the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both buttons.
3. If the unit prompts you for the password, enter it by using the AIR ▲ YES and RANGE ▼ SHIFT buttons to select each password number and then pressing and releasing POWER ENTER RESET to enter the number and move on to the next one.
4. The Calibration Mode Screen displays with the cursor next to **AUTO CALIBRATION**.

```
  CALIBRATION MODE

> AUTO CALIBRATION
  SINGLE CALIBRATION
  PERFORM AIR ADJUST
  NORMAL OPERATION
```

NOTE: The following screens illustrate a four-gas EAGLE 2 for detection of CH_4 (%LEL using catalytic sensor), oxygen, H_2S, and CO. Your EAGLE 2 may display slightly different screens.

Calibrating Using the Auto Calibration Method

This method allows you to calibrate the CH_4 (%LEL sensor), oxygen, H_2S, and CO sensors simultaneously. It is designed for use with the RKI 4-gas calibration cylinder and is the quickest and easiest method to calibrate the EAGLE 2.

Setting the Fresh Air Reading

1. While in the Calibration Mode Screen, move the cursor to the **PERFORM AIR ADJUST** menu item by using the RANGE ▼ SHIFT button.

```
  CALIBRATION MODE

  AUTO CALIBRATION
  SINGLE CALIBRATION
> PERFORM AIR ADJUST
  NORMAL OPERATION
```

2. Press and release the POWER ENTER RESET button. The following screen appears.

```
PERFORM

AIR ADJUST?
```

3. Press and release the AIR ▲ YES button to continue.
   If you do not want to continue, press the DISPLAY ADJUST NO button and the unit will return to the Calibration Mode Screen.
4. The EAGLE 2 will indicate that it is adjusting the zero reading for a few seconds, then indicate that the operation is complete before returning to the Calibration Mode Screen.

```
ADJUSTING ZERO

RELEASE AIR BUTTON
```

↓

```
ADJUSTING ZERO

COMPLETE
```

↓

```
CALIBRATION MODE

  AUTO CALIBRATION
  SINGLE CALIBRATION
> PERFORM AIR ADJUST
  NORMAL OPERATION
```


Performing a Span Adjustment in Auto Calibration

1. Install the demand flow regulator onto the calibration cylinder.
2. Connect the sample tubing to the demand flow regulator.
3. Install the probe on the EAGLE 2 inlet fitting. Make sure the probe is complete with internal O-ring and membrane and that the two halves of the probe are tightened firmly together to avoid leaks that can affect the calibration. See Figure 21, "Replacing the Particle Filter and Hydrophobic Filter Disk" on page 72 for an illustration of the internal parts of the probe.
4. Move the cursor next to the **AUTO CALIBRATION** menu item by using the AIR ▲ YES button.

```
CALIBRATION MODE

> AUTO CALIBRATION
  SINGLE CALIBRATION
  PERFORM AIR ADJUST
  NORMAL OPERATION
```

5. Press and release the POWER ENTER RESET button to display the Calibration Gas Values Screen.

```
CAL GAS VALUES
CH4     50  %LEL
OXY   12.0  vol%
H2S   25.0  ppm
CO      50  ppm
ENTER TO BEGIN CAL
```

   The gas concentrations displayed in the Calibration Gas Values Screen must match the gas concentrations listed on the 4-gas calibration cylinder.
   If *all* concentrations match, go to Step 16.
   If *one or more* concentrations *do not* match, continue with Step 6.
   If you do not want to continue with the calibration, press and release the DISPLAY ADJUST NO button to return to the Calibration Mode Screen.

NOTE: The RKI 4-gas cylinder typically contains 12% O_2 by volume. When using the auto calibration method, be sure to set the "OXY" auto calibration value to agree with the concentration listed on the cylinder's label, not zero.

6. To adjust the values on the screen, press and hold the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both. The following screen appears with the cursor next to **CH4**.

```
ADJUST AUTO
CALIBRATION VALUES
> CH4     50  %LEL
  OXY   12.0  vol%
  H2S   25.0  ppm
  CO      50  ppm      ▼
```

7. Place the cursor next to the channel whose gas value you want to change using the AIR ▲ YES and RANGE ▼ SHIFT buttons.
8. Press and release the POWER ENTER RESET button to select the channel. The calibration gas value begins to flash.
9. Use the AIR ▲ YES and RANGE ▼ SHIFT buttons to adjust the calibration gas setting to the desired value.

NOTE: The calibration gas value cannot be set lower than the low alarm setting. If the calibration gas value listed on the calibration cylinder is lower than the current low alarm setting, enter Setup Mode and change the low alarm setting. See "Updating the Alarm Point Settings" on page 106 for instructions. If you need to change the alarm point setting only to perform a calibration, make sure that you change the alarm point setting back to its original value once the calibration has been performed.

10. Press and release the POWER ENTER RESET button to save the change. The calibration gas value stops flashing.
11. Repeat Step 7 through Step 10 for any other channels that need to be changed.
12. When you are done adjusting the calibration gas values, move the cursor down past the bottom of the screen next to **END**.

```
   ADJUST AUTO
CALIBRATION VALUES
> END              ▲
```

13. Press and release the POWER ENTER RESET button. The following screen appears.

```
  DO YOU WANT TO
STORE NEW VALUE(S)
  IN MEMORY FOR
FUTURE CALIBRATIONS?

 PRESS YES OR NO
```

14. If you select YES by pressing and releasing the AIR ▲ YES button, the changes that you made will be saved in the EAGLE 2's memory as the new auto calibration gas values.

    If you select NO by pressing and releasing the DISPLAY ADJUST NO button, the changes you made will be used for any calibrations performed during the current operating session only. The EAGLE 2 will delete the changes when the unit is turned off and will load the previous set of auto calibration values when it is turned on again.

15. When you make your selection and press the desired button, the unit returns to the Calibration Gas Values Screen.

```
  CAL GAS VALUES
  CH4     50  %LEL
  OXY   12.0  vol%
  H2S   25.0  ppm
  CO      50  ppm
ENTER TO BEGIN CAL
```

16. Press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen with **CAL IN PROCESS** flashing.

```
  CAL IN PROCESS
  CH4      0   %LEL
  OXY   20.9   vol%
  H2S    0.0   ppm
  CO       0   ppm
 ENTER WHEN DONE
```

    If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the Cal Gas Values Screen.

    If you do want to continue with the calibration, proceed to the next step.

17. Connect the tubing from the demand flow regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for one minute.

NOTE: If you are calibrating the catalytic combustible channel with a gas concentration of 1000 ppm or lower, you must use a 24 inch humidifier tube to connect the demand flow regulator to the rigid tube on the probe.

18. Press and release the POWER ENTER RESET button to set the span adjustment for each channel to the programmed values.

19. If all channels passed calibration, the following screen sequence occurs.

```
AUTO CALIBRATION
      DONE
   REMOVE GAS
```

```
AUTO CALIBRATION

       END
```

```
 CALIBRATION MODE

> AUTO CALIBRATION
  SINGLE CALIBRATION
  PERFORM AIR ADJUST
  NORMAL OPERATION
```

If any of the sensors cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and lists the sensor(s) that failed to calibrate. In the example below, the oxygen and H_2S channels failed calibration. The other sensors calibrated normally.

```
    FAIL SENSOR

  <  >  <OXY>
  <H2S>  <  >

 ENTER TO CONTINUE
```

The buzzer and alarm LED arrays activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and return to the Calibration Mode Screen. Attempt to calibrate again. If the failure continues, investigate the cause. See "Troubleshooting" on page 67.

20. Disconnect the tubing from the probe.
21. Unscrew the demand flow regulator from the calibration cylinder.
22. Use the RANGE ▼ SHIFT button to place the cursor next to the **NORMAL OPERATION** menu option, then press and release the POWER ENTER RESET button to return to Measuring Mode.

Calibrating Using the Single Calibration Method

Single Calibration allows you to calibrate one channel at a time. This is useful if you only want to calibrate one or two channels.

Setting the Fresh Air Reading

1. While in the Calibration Mode Screen, move the cursor to the **PERFORM AIR ADJUST** menu item by using the RANGE ▼ SHIFT button.

```
 CALIBRATION MODE

  AUTO CALIBRATION
  SINGLE CALIBRATION
> PERFORM AIR ADJUST
  NORMAL OPERATION
```

2. Press and release the POWER ENTER RESET button. The following screen appears.

```
     PERFORM

   AIR ADJUST?
```

3. Press and release the AIR ▲ YES button to continue.

   If you do not want to continue, press the DISPLAY ADJUST NO button and the unit will return to the Calibration Mode Screen.

4. The EAGLE 2 will indicate that it is adjusting the zero reading for a few seconds, then indicate that the operation is complete before returning to the Calibration Mode Screen.

```
ADJUSTING ZERO

RELEASE AIR BUTTON
```

```
ADJUSTING ZERO

COMPLETE
```

```
CALIBRATION MODE

AUTO CALIBRATION
  SINGLE CALIBRATION
> PERFORM AIR ADJUST
NORMAL OPERATION
```

Performing a Span Adjustment in Single Calibration

1. Install the demand flow regulator onto the calibration cylinder.
2. Connect the sample tubing to the demand flow regulator.
3. Install the probe on the EAGLE 2 inlet fitting. Make sure the probe is complete with internal O-ring and membrane and that the two halves of the probe are tightened firmly together to avoid leaks that can affect the calibration. See Figure 21, “Replacing the Particle Filter and Hydrophobic Filter Disk” on page 72 for an illustration of the internal parts of the probe.
4. Move the cursor next to the **SINGLE CALIBRATION** menu item by using the AIR ▲ YES button.

```
CALIBRATION MODE

AUTO CALIBRATION
> SINGLE CALIBRATION
PERFORM AIR ADJUST
NORMAL OPERATION
```


5. Press and release the POWER ENTER RESET button. The Select Sensor Screen appears with the cursor flashing.

```
SELECT SENSOR
TO CALIBRATE
    >ESCAPE
CH4    OXY
H2S    CO
```

6. Move the cursor next to the sensor you want to calibrate with the AIR ▲ YES and RANGE ▼ SHIFT buttons. In the example below, the CH_4 sensor is selected for span adjustment.

```
SELECT SENSOR
TO CALIBRATE
     ESCAPE
>CH4    OXY
 H2S    CO
```

If you do not want to proceed with the span adjustment, press and release the DISPLAY ADJUST NO button or place the cursor next to **ESCAPE** and press and release POWER ENTER RESET to return to the Calibration Mode Screen.

To proceed with the calibration, continue with the next step.

7. Press and release the POWER ENTER RESET button to proceed to the Single Calibration Gas Value Screen for the selected channel. The calibration gas value is flashing.

```
SINGLE CALIBRATION

  CH4    50 %LEL
UP/DOWN TO ADJUST
CALIBRATION VALUE
 ENTER WHEN DONE
```

8. If necessary, adjust the calibration gas value to match the cylinder concentration with the AIR ▲ YES and RANGE ▼ SHIFT buttons.

NOTE: The calibration gas value cannot be set lower than the low alarm setting. If the calibration gas value listed on the calibration cylinder is lower than the current low alarm setting, enter Setup Mode and change the low alarm setting. See “Updating the Alarm Point Settings” on page 106 for instructions. If you need to change the alarm point setting only to perform a calibration, make sure that you change the alarm point setting back to its original value once the calibration has been performed.

9. Press and release the POWER ENTER RESET button to proceed to the Single Calibration Apply Gas Screen. **CAL IN PROCESS** is flashing.

```
SINGLE CALIBRATION
     APPLY GAS
  CH4    0 %LEL

  CAL IN PROCESS
 ENTER WHEN DONE
```

10. Connect the tubing from the demand flow regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for one minute.

NOTE: If you are calibrating the catalytic combustible channel with a gas concentration of 1000 ppm or lower, you must use a 24 inch humidifier tube to connect the demand flow regulator to the rigid tube on the probe.

11. Press and release the POWER ENTER RESET button to perform the calibration.
12. When the span adjustment is made, the EAGLE 2 calculates the range of adjustment, minimum and maximum, it could have made based on its response level to the applied gas. This calculated range is independent of the calibration gas value that was entered in Step 8 and Step 9 above. The adjustment range is included on the result screen to indicate the condition of the sensor. If the calibration gas value is in the adjustment range, the span adjustment will pass. If the calibration gas value is out of the adjustment range, the span adjustment will fail.

    If the span adjustment is successful, the following screens display.

```
CH4 CALIBRATION
     DONE
(  35  -  98%LEL)
  REMOVE GAS
```

```
SELECT SENSOR
 TO CALIBRATE
    ESCAPE
> CH4    OXY
  H2S    CO
```

In the example above, the EAGLE 2 could have adjusted the reading as low as 35 %LEL and as high as 98 %LEL.

If the span adjustment is not successful, a screen displays that indicates a calibration failure.

```
    FAILED SENSOR
(  11  -  43%LEL)
     <CH4>


  ENTER TO CONTINUE
```

In the example above, the EAGLE 2 could have adjusted the reading as low as 11 %LEL and as high as 43 %LEL. Since the calibration gas value entered was 50 %LEL, the unit failed the span adjustment. The buzzer and alarm LED arrays activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and return to the Select Sensor Screen. Attempt to calibrate again. If the failure continues, investigate the cause. See "Troubleshooting" on page 67.

NOTE: The adjustment range will only appear in the calibration results screen if the Span Factor item in Setup Mode is set to ON. If the Span Factor is set to OFF, the adjustment range will not appear.

13. Disconnect the tubing from the EAGLE 2's probe.
14. Repeat Step 6 through Step 13 for any other channels you want to calibrate. Make sure you use an appropriate calibration cylinder for each sensor.

CAUTION: *When calibrating the oxygen sensor, verify the concentration of oxygen listed on the cylinder's label. For oxygen-free samples (100% nitrogen for example), set the oxygen calibration value to 0.0%.*

15. After the last channel is calibrated, disconnect the calibration tubing from the probe, then unscrew the demand flow regulator from the calibration cylinder.
16. With the Select Sensor Screen displayed, place the cursor next to **ESCAPE** using the AIR ▲ YES button.

```
SELECT SENSOR
TO CALIBRATE
   >ESCAPE
CH4    OXY
H2S    CO
```

17. Press and release the POWER ENTER RESET button to return to the Calibration Mode Screen.
18. Use the RANGE ▼ SHIFT button to place the cursor next to the **NORMAL OPERATION** menu item, then press and release the POWER ENTER RESET button to return to Measuring Mode.

Chapter 5: Maintenance

Overview

This chapter describes troubleshooting procedures for the EAGLE 2. It also includes procedures for replacing and recharging the batteries and replacing various consumable parts.

WARNING: ***RKI Instruments, Inc. recommends that service, calibration, and repair of RKI instruments be performed by personnel properly trained for this work. Replacing sensors and other parts with original equipment does not affect the intrinsic safety of the instrument.***

Troubleshooting

The troubleshooting table describes error messages, symptoms, probable causes, and recommended action for problems you may encounter with the EAGLE 2.

Table 9: Troubleshooting the EAGLE 2

Symptoms	Probable Causes	Recommended Action
• The LCD is blank.	• The unit may have been turned off. • The alkaline batteries may need to be replaced or the Ni-MH batteries recharged.	1. To turn on the unit, press and briefly hold the POWER ENTER RESET button. 2. If the unit does not turn on, replace the alkaline batteries or recharge the Ni-MH batteries. 3. If the difficulties continue, contact RKI Instruments, Inc. for further instruction.
• The LCD shows abnormally high or low readings but other gas detection instruments do not.	• The EAGLE 2 may need to be recalibrated. • The sensor for the affected channel(s) may need replacement.	1. Recalibrate the unit. 2. If the difficulties continue, replace the sensor for the affected channel(s) and calibrate the affected channel(s). 3. If the difficulties continue, contact RKI Instruments, Inc. for further instruction.
• The unit indicates flow failure and does not recover when POWER ENTER RESET is pressed and released.	• The probe tube is clogged. • The hydrophobic filter disk in the probe is dirty. • The sample hose has a kink or obstruction. • The internal hydrophobic filter is dirty. • The pump is malfunctioning.	1. Inspect the probe tube for any obstructions. 2. Inspect the hydrophobic filter disk in the probe and replace if necessary. 3. Inspect the sample hose for kinks or obstructions and replace if necessary. 4. Inspect the internal hydrophobic filter and replace if necessary. 5. If difficulties continue, contact RKI Instruments, Inc. for further instruction.

Table 9: Troubleshooting the EAGLE 2

Symptoms	Probable Causes	Recommended Action
• Auto calibration or single calibration fails.	• The auto calibration values may not match the cylinder gas concentrations (auto calibration only). • The charcoal filter is saturated causing an elevated CO reading. • The sample gas is not reaching the sensors because of a bad connection. • The calibration cylinder may be out of gas or is outdated. • The sensor for the affected channel(s) may need replacement.	1. Check all calibration tubing for leaks or for any bad connections. 2. Make sure the EAGLE 2 has been properly set up for calibration. 3. Change the charcoal filter. 4. Verify that the calibration cylinder contains an adequate supply of fresh test sample. 5. If the fail condition continues, replace the sensor(s). 6. If the difficulties continue, contact RKI Instruments, Inc. for further instruction.
• Display indicates "SYSTEM FAIL 12" during startup.	• A memory error has occurred.	1. Press and hold the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both. The Enter Password Screen will appear. 2. Enter the password, "1994", to proceed to the Set Default Screen. 3. Press and release the AIR ▲ YES button twice to restore the defaults. See "Restoring the Default Settings" on page 117 for a description of issues to consider when restoring the defaults. 4. If difficulties continue, contact RKI Instruments, Inc. for further instruction.

Replacing or Recharging the Batteries

WARNING: ***To prevent ignition of a hazardous atmosphere, batteries must only be changed or charged in an area known to be nonhazardous.***

Replace or charge the batteries when the EAGLE 2 indicates that it is in low battery warning. When in low battery warning, BATT appears vertically along the left side the LCD.

```
  CH4      0%LEL
B OXY  20.9vol%
A H2S     0.0ppm
T CO        0ppm
T
```

Replacing the Batteries

NOTE: Use Duracell Procell PC 1400 alkaline batteries, Duracell MN 1400 alkaline batteries, Energizer E93 or Energizer EN93, or RKI Instruments, Inc. 4 9-1330RK Ni-MH batteries to maintain the CSA classification of the EAGLE 2. Use of other batteries or mixing alkaline and rechargeable batteries will void the CSA classification and may void the warranty.

1. Turn off the EAGLE 2.

WARNING: ***Do not remove the batteries while the EAGLE 2 is on.***

2. Loosen the battery case thumbscrew by turning it counterclockwise until it disengages from the bottom case. If necessary, use a coin or large flat blade screwdriver to loosen it.

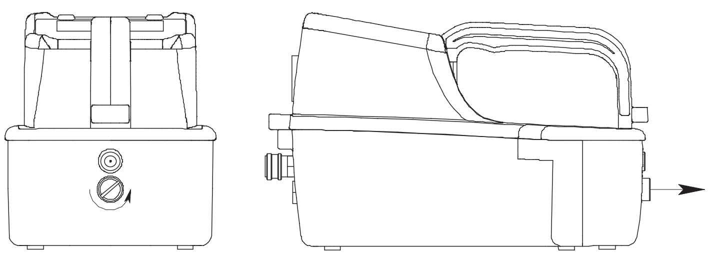


Figure 18: Removing the Battery Case

3. Pull the battery case away from the bottom case. The thumbscrew is captive and will not fall out.
4. Carefully remove the old batteries. Verify that the battery compartment and electrical contacts are clean.

5. Carefully install the new C-size batteries. Follow the battery diagram inside the battery case. Make sure the batteries are pushed in all the way.

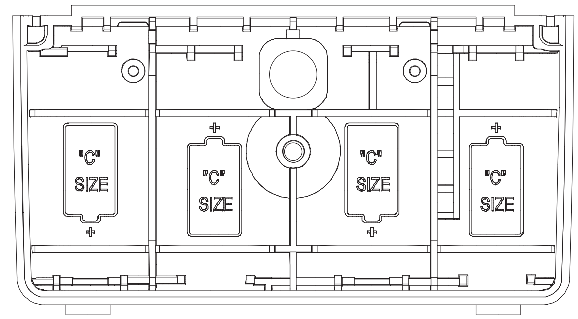


Figure 19: Installing the Batteries

6. Reinstall the battery case onto the bottom case tightening the thumbscrew firmly by hand so that there is no visible gap between the battery case and the bottom case.

Recharging the Ni-MH Batteries

CAUTION: *Use with Ni-MH battery p/n 49-1330RK. Charge only with RKI charger model 49-2175RK, 49-2176RK, or 49-2177RK. Use of other rechargeable batteries or chargers or charging of other rechargeable batteries in the EAGLE 2 will void the warranty.*

WARNING: ***Do not plug the charger cable into a battery pack that contains alkaline batteries. Do not attempt to charge alkaline batteries.***

The charging module can either be used with an AC adapter or a vehicle plug DC adapter. Both adapters plug into the module which then plugs into the EAGLE 2.

1. Plug the power adapter into either an AC outlet or into a vehicle outlet depending on which charger is being used.
2. Make sure the switch on the module is set to "BATT. CHARGER".
3. Make sure the EAGLE 2 is off.
4. Make sure the adapter and module are connected.

5. Insert the module's round plug into the EAGLE 2's charging jack as shown in Figure 20 below.

NOTE: The battery pack does not need to be attached to the EAGLE 2 case in order to charge. It may be charged separately. This allows a spare battery pack to be charged while the EAGLE 2 is in use.

Figure 20: Connecting the EAGLE 2 to the Charger

6. While the batteries are charging, the green indicator LED will be off and the amber one will be on.
7. The charging module has an internal timeout feature set at 9.5 hours. A full charge should be reached in less than 9.5 hours. When a full charge has been reached, both the green and yellow LEDs will be on.
8. If charging should fail, the green indicator LED will be off and the amber one will be blinking.

Table 10 summarizes the battery charger conditions.

Table 10: Battery Charger Conditions

Amber LED	Green LED	Status
ON	OFF	CHARGING
ON	ON	READY/FULL
BLINKING	OFF	FAIL
OFF	ON	CONTINUOUS OPERATION

Replacing the Hydrophobic Probe's Particle Filter and Hydrophobic Filter Disk

Inspect the probe's internal components if you notice that the EAGLE 2's pump sounds bogged down or if an unexplained low flow alarm occurs. Replace the particle filter if it appears to be dirty. Replace the hydrophobic filter disk if it appears dirty or saturated with liquid. Replace the O-rings in the probe if either of them appears damaged.

1. Grasp each end of the clear probe body firmly and unscrew the two halves from each other. One half includes a plastic tube fitting and the probe tube. The other half includes a metal fitting that mates with the EAGLE 2 inlet fitting.

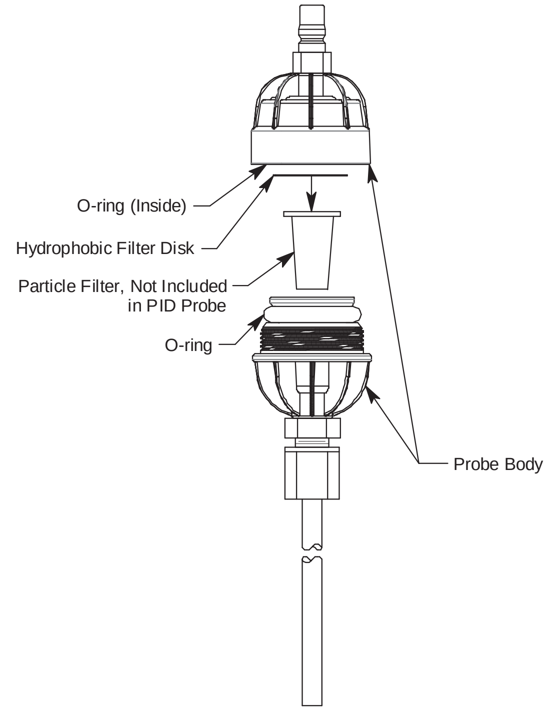


Figure 21: Replacing the Particle Filter and Hydrophobic Filter Disk

2. Remove the white hydrophobic filter disk from the top of the particle filter or from the probe body.
3. Remove the particle filter from the probe body.

4. Clean the inside of the probe body if necessary.
5. Hold the probe half that has the plastic tube fitting and the probe tube with the fitting and tube facing down.
6. Place the new cone-shaped particle filter into the probe body so that the wide part of the filter is facing up.

NOTE: Do not install the particle filter into a probe intended to be used with a PID EAGLE 2.

7. Place the new filter disk flat on top of the particle filter. Make sure it is centered over the particle filter.
8. Carefully screw the other half of the probe body onto the half with the particle filter and filter disk while keeping the probe oriented vertically to keep the disk centered.
9. When you feel the O-ring being compressed, grasp both ends of the probe and tighten them together very firmly to ensure a seal.
10. To test the seal, do the following.
    - install the probe on the EAGLE 2
    - startup the EAGLE 2
    - confirm that a low flow alarm occurs when you cover the end of the probe tube with your finger
    - if a low flow alarm does not occur, hand tighten the probe further
    - if a low flow alarm still does not occur when you cover the probe tube with your finger, disassemble the probe, inspect the placement of the O-rings and filter disk, reassemble the probe, and re-test it.

Replacing the Hydrophobic Filter

Replace the hydrophobic filter inside the bottom case when it becomes dirty or clogged. An unexplained low flow alarm may indicate that the hydrophobic filter is dirty and needs to be replaced.

1. Verify that the EAGLE 2 is off.
2. Place the EAGLE 2 upside down on a flat surface or hold it upside down.
3. Unscrew the three case screws until they disengage from the top case. They are captive screws so they will not fall off of the bottom case.
4. Turn the EAGLE 2 right side up and carefully lift the top case away from the bottom case. Be careful not to lift it so far that it pulls on the main PCB with the cable that connects the top case to the main PCB.
5. Lay the top case down next to the bottom case to allow access to the flow system.

6. Locate the hydrophobic filter. It is over the oxygen sensor. Note which side of the hydrophobic filter has the RKI logo and part number. This is the inlet side and should be facing toward the front of the EAGLE 2.

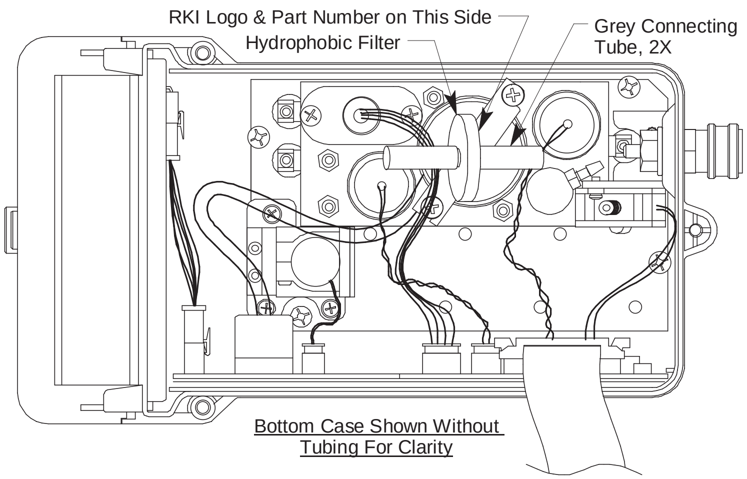


Figure 22: Replacing the Hydrophobic Filter

7. Pull the grey connecting tubes off of each end of the filter and remove it.
8. Install the new filter with the red RKI logo and part number on the inlet side of the flow chamber, facing the front of the EAGLE 2. Make sure to push the grey connection tubes all the way onto the filter's hose barbs.
9. Confirm that the main PCB is seated in its slots and that its bottom edge is resting on the bottom of the bottom case. If the main PCB is not seated properly, then it may be damaged when the top case is re-installed.
10. Make sure that the top case gasket is fully seated in its groove and carefully put the top case back on the bottom case. If you have any difficulty mating the top and bottom cases, inspect the placement of the main PCB and the placement of the top case gasket.
11. Turn the EAGLE 2 upside down and tighten the three case screws to secure the top case to the bottom case.

Replacing the Charcoal Filter

1. Verify that the EAGLE 2 is off.
2. Place the EAGLE 2 upside down on a flat surface or hold it upside down.
3. Unscrew the three case screws until they disengage from the top case. They are captive screws so they will not fall off of the bottom case.
4. Turn the EAGLE 2 right side up and carefully lift the top case away from the bottom case. Be careful not to lift it so far that it pulls on the main PCB with the cable that connects the top case to the main PCB.
5. Lay the top case down next to the bottom case to allow access to the flow system.
6. Locate the charcoal filter. It is next to the CO sensor at the front of the flow chamber.

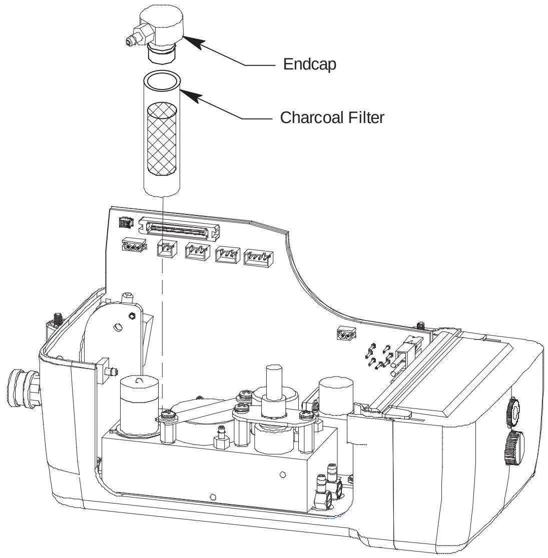


Figure 23: Replacing the Charcoal Filter

7. Grasp the black charcoal filter endcap and pull it off of the charcoal filter.
8. Grasp the top of the charcoal filter firmly and pull it out of the flow chamber. Insert the replacement charcoal filter into the filter position in the flow chamber and push it in until it bottoms out.
9. Insert the charcoal filter endcap into the end of the charcoal filter and push it in until it bottoms out.
10. Confirm that the main PCB is seated in its slots and that its bottom edge is resting on the bottom of the bottom case. If the main PCB is not seated properly, then it may be damaged when the top case is re-installed.

11. Make sure that the top case gasket is fully seated in its groove and carefully put the top case back on the bottom case. If you have any difficulty mating the top and bottom cases, inspect the placement of the main PCB and the placement of the top case gasket.
12. Turn the EAGLE 2 upside down and tighten the three case screws to secure the top case to the bottom case.

Checking the Combustible Gas Sensor's Condition

If you suspect that the combustible sensor has been contaminated or may be reaching the end of its operational life, do the following to confirm it is still operating properly:

1. Perform a calibration using single calibration as described in "Calibrating Using the Single Calibration Method" on page 62.
2. When you perform the span adjustment, note the adjustment range on the result screen as described in Step 12 and Step on page 65.
3. A new sensor can typically be adjusted to more than twice the calibration gas concentration. If the result screen indicates that the EAGLE 2 could not adjust the combustible gas reading to be at least 10% higher than the calibration gas concentration, then the sensor should be replaced as soon as possible.

Replacing a Sensor

1. Verify that the EAGLE 2 is off.
2. Place the EAGLE 2 upside down on a flat surface or hold it upside down.
3. Unscrew the three case screws until they disengage from the top case. They are captive screws so they will not fall off of the bottom case.
4. Turn the EAGLE 2 right side up and carefully lift the top case away from the bottom case. Be careful not to lift it so far that it pulls on the main PCB with the cable that connects the top case to the main PCB.
5. Lay the top case down next to the bottom case to allow access to the flow system.

6. Locate the sensor you want to replace and remove it from the flow chamber.

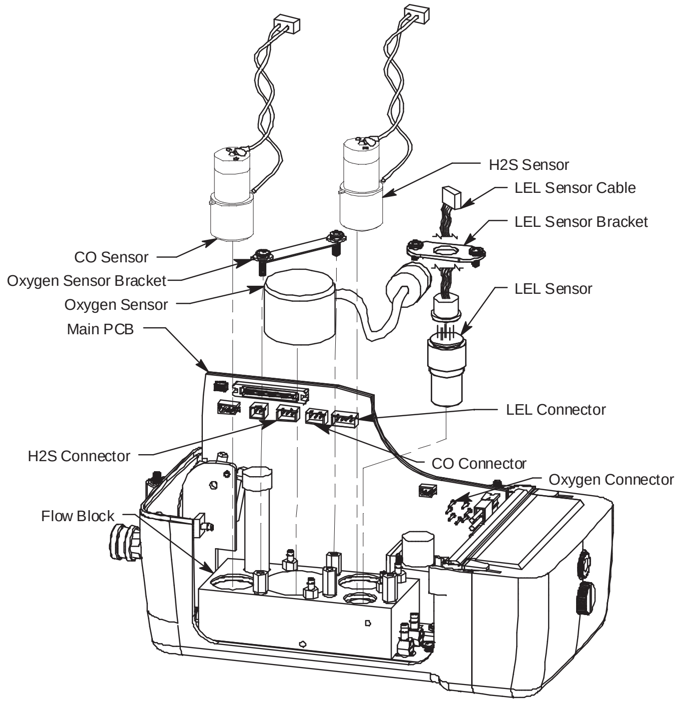


Figure 24: Replacing a Sensor

7. To remove the LEL sensor, do the following:
   - Unscrew and remove the two screws that hold down the LEL sensor bracket.
   - Grasp the LEL sensor connector and gently pull it up until it either disengages from the LEL sensor or the LEL sensor comes out of the flow chamber with the connector.
   - If the sensor came out with the connector, remove the sensor from the connector.
   - If the sensor stayed in the flow chamber, grasp the sensor and pull it out of the flow chamber.
8. To remove the oxygen sensor, do the following:
   - Unscrew the two screws that hold the oxygen sensor bracket a few turns so that you can rotate and remove the oxygen sensor bracket. Make sure to note the routing of the oxygen sensor cable to the main PCB so that you can route the replacement sensor cable the same way. Also make sure that the O-ring in the bottom of the flow chamber does not come out with the sensor.

   - Move the hydrophobic filter towards the bottom case side wall and pull the oxygen sensor out of the flow chamber.
   - Hold the main PCB to support it where the oxygen sensor cable connects to it.
   - Grasp the connector on the end of the sensor cable and pull the connector away from the main PCB to disconnect it from the main PCB.
9. To remove the H_2S and CO sensors, do the following:
   - Grasp the sensor firmly and rock it back and forth slightly while pulling on it. Make sure to note the routing of the sensor cable to the main PCB so that you can route the replacement sensor cable the same way.
   - If the sensor does not come out of the flow chamber easily enough using this method, grasp it with a pair of pliers and rock it back and forth slightly while pulling on it.

CAUTION: *If using pliers to remove a sensor, be careful not to damage the sensor in case you find that the sensor is still functional and does not need to be replaced.*

   - Hold the main PCB to support it where the sensor cable connects to it.
   - Grasp the connector on the end of the sensor cable and pull the connector away from the main PCB to disconnect it from the main PCB.
10. Install the new sensor.
11. To install the LEL sensor, do the following:
   - Plug the replacement sensor into the sensor connector on the LEL sensor cable.
   - Insert the LEL sensor into the LEL sensor chamber in the flow chamber.
   - Line up the holes in the LEL sensor bracket with the two standoffs on either side of the LEL sensor chamber.
   - Install the two sensor bracket screws tightening them a little at a time alternately to push the sensor into its chamber evenly.
12. To install the oxygen sensor, do the following:
   - Confirm that the sealing O-ring is still in the bottom of the oxygen sensor chamber in the flow chamber and insert the oxygen sensor face down into the chamber.
   - Route the sensor cable the same way the old sensor cable was routed and connect it to the main PCB. Make sure to support the main PCB when making the connection.
   - Reinstall the oxygen sensor bracket and tighten both bracket screws firmly.
13. To install the H_2S and CO sensors, do the following:
   - Insert the sensor face down into the sensor chamber in the flow chamber.
   - Push the sensor in until it bottoms out.
   - Route the sensor cable the same way the old sensor cable was routed and connect it to the main PCB. Make sure to support the main PCB when making the connection.

14. Confirm that the main PCB is seated in its slots and that its bottom edge is resting on the bottom of the bottom case. If the main PCB is not seated properly, then it may be damaged when the top case is re-installed.
15. Make sure that the top case gasket is fully seated in its groove and carefully put the top case back on the bottom case. If you have any difficulty mating the top and bottom cases, inspect the placement of the main PCB and the placement of the top case gasket.
16. Turn the EAGLE 2 upside down and tighten the three case screws to secure the top case to the bottom case.
17. Calibrate the new sensors as described in "Chapter 4: Calibration Mode" on page 54.

General Parts List

Table 11 lists part numbers for the EAGLE 2's replacement parts and accessories.

Table 11: General Parts List

Part Number	Description
06-1248RK-03	Calibration kit tubing,3 foot length
07-7210RK	O-ring for inlet fitting half of probe
07-7304RK	O-ring for tube half of probe
13-1061RK	Panel screw, captive, 6-32 x 1/2 inch, for bottom case
13-1081RK	Thumbscrew, captive, 10-32 x 2 inches, for battery case
30-0600RK-01	Pump
33-0156RK-01	Filter element, hydrophobic disk, for standard 80-0131RK-10 probe, pack of 5
33-0173RK	Internal hydrophobic filter
33-1200RK	Particle filter for standard 80-0131RK-10 probe
33-2002RK-01	Humidifier, 24 inch, for calibration of catalytic combustible channel with gas concentrations of 1000 ppm or lower
33-6090RK	Charcoal filter
35-0110RK	Dummy sensor, CO or H_2S sensor position
35-0111RK	Dummy sensor, oxygen sensor position
35-0112RK	Dummy sensor, LEL sensor position
47-1016RK	Vehicle plug 12 VDC adapter cable for charger
47-5010RK	TC/LEL sensor cable
47-5084RK	USB/IrDA adapter module, Legasic, for use with all premier portables (without USB cable)

Table 11: General Parts List (cont.)

Part Number	Description
47-5084RK-01	USB/IrDA adapter assembly, Legasic, for use with all premier portables (with module and USB cable)
47-5085RK	Cable, USB A to USB mini, 6 feet, for USB/IrDA adapter module
49-0115RK	AC adapter
49-1130RK	C size alkaline battery
49-1330RK	C size Ni-MH battery
49-2174RK	Charging module
49-2175RK	115/220 VAC charger
49-2176RK	12 VDC charger
49-2177RK	115/220 VAC and 12 VDC charger
61-0155RK	LEL combustible sensor, catalytic, hydrogen specific, no shrink tubing (for H_2 specific units sold before 3/6/2019)
61-0155-01	LEL combustible sensor, catalytic, hydrogen specific, with shrink tubing (for H_2 specific units sold after 3/6/2019)
65-0601RK	Oxygen sensor
65-2005RK	Carbon monoxide (CO) sensor
71-0154RK	Operator's Manual, EAGLE 2 (this document)
71-0170RK	Operator's Manual, Eagle 2 Data Logger Management Program
71-8003RK	EAGLE 2 Product CD, includes Data Management Program, User Setup Program, and all operator's manuals
80-0131RK-10	10 inch hydrophobic probe (standard probe)
80-0133RK-10	30 inch aluminum probe
80-0134RK-10	4 foot stainless steel hydrophobic probe
80-0135RK-10	30 inch stainless steel hydrophobic probe
80-0136RK	32 inch telescoping fiberglass probe w/dust filter
80-0137RK	10 inch probe w/dust filter
80-0143RK	7 foot telescoping fiberglass probe w/dust filter
80-0156RK-10	30 inch fiberglass hydrophobic probe
80-0160RK-12	12 foot extendable probe
80-0160RK-18	18 foot extendable probe
80-0405RK	Dilution fitting, 1:1

Table 11: General Parts List (cont.)

Part Number	Description
80-0406RK	Dilution fitting, 3:1
80-05XXRK	Sample hose. Replace “XX” with length in feet. 5 foot hose is standard. Available lengths for the EAGLE 2 are 3, 4, 5, 6, 10, 15, 20, 25, 30, 35, 40, 50, 75, 100, and 125 feet.
81-0090RK-01	Calibration cylinder, 34 liter steel, three-gas (CH_4/O_2/CO)
81-0090RK-03	Calibration cylinder, 103 liter, three-gas (CH_4/O_2/CO)
81-0154RK-02	Calibration cylinder, 58 liter; four-gas (CH_4/O_2/ H_2S/CO)
81-0154RK-04	Calibration cylinder, 34 liter aluminum; four-gas (CH_4/O_2/ H_2S/CO)
81-1054RK	Regulator, demand-flow type, for 34 liter aluminum/58 liter/103 liter calibration cylinders (cylinders with internal threads)
81-1055RK	Regulator, demand-flow type, for 17 liter and 34 liter steel calibration cylinders (cylinders with external threads)
81-5302RK	Calibration kit, for LEL/Oxy/CO unit, w/demand flow regulator, 103 liter cylinder
81-5401RK	Calibration kit, for LEL/Oxy/H_2S/CO unit, w/demand flow regulator, 58 liter cylinder
ES-87RW-H2S	Hydrogen Sulfide (H_2S) sensor
NC-6260B	LEL combustible sensor, catalytic

Appendix A: Calibrating with a Sample Bag

Overview

The EAGLE 2 can be calibrated with a gas bag calibration kit instead of a demand flow regulator kit. This appendix describes how to use a sample bag calibration kit to calibrate the EAGLE 2. A parts list at the end of this appendix lists spare parts for the calibration kit.

Calibration Supplies and Equipment

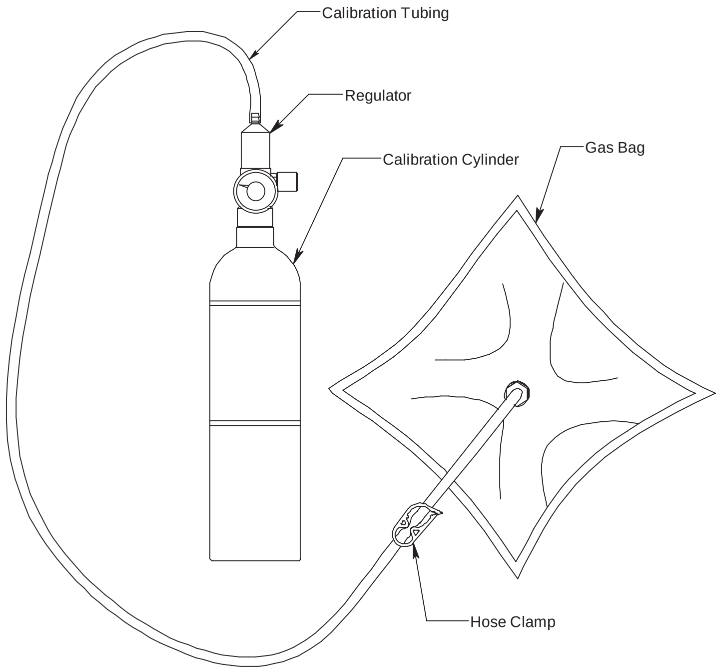


Figure 25: Gas Bag Calibration Kit

To calibrate the EAGLE 2, you will need:

- Known calibrating samples of the gases being detected. The combustible and toxic gas samples should have concentrations between 10 and 50% of the full scale value. For example, if you are calibrating the catalytic combustible gas channel, your calibration cylinder should have a combustible gas concentration between 10% LEL and 50% LEL. An oxygen-free source, such as 100% nitrogen is recommended for setting the oxygen zero.

NOTE: The catalytic combustible channel can be set up for and calibrated to a number of different combustible gases. See “Configuring the Combustible Gas” on page 101 for instructions. Be sure that you are using an appropriate calibration cylinder for the target gas of the catalytic combustible channel.

CAUTION: *When using auto calibration with the standard 4-gas EAGLE 2, although the EAGLE 2 can be calibrated with an oxygen concentration of up to 19.5%, RKI Instruments, Inc. recommends that the multi-gas cylinder have an oxygen concentration in the range of 10% - 16% oxygen.*

- A gas collection bag with hose clamp
- A 6 LPM fixed-flow regulator or a dispensing valve

WARNING: RKI Instruments, Inc. recommends that you dedicate a regulator for use with chlorine (Cl_2) gas and that you do not use that dedicated regulator for any other gases, particularly hydrogen sulfide (H_2S).

- Calibration tubing

To calibrate the combustible gas, oxygen, CO, and H_2S sensors at the same time, automatically, with no need for a zero-oxygen source, you can use the auto calibration feature with a 4-gas cylinder. If the H_2S channel is not active, then a 3-gas cylinder may be used for auto calibration. This document includes instructions for auto calibration with a fixed flow regulator or dispensing valve, a sample bag, and a 4-gas cylinder. This document also includes instructions for calibrating one channel at a time using single calibration.

Entering Calibration Mode

To enter Calibration Mode, do the following:

1. Find a fresh-air environment. This is an environment free of toxic or combustible gases and of normal oxygen content (20.9%).
2. While in Measuring Mode, press and hold the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both buttons.
3. If the unit prompts you for the password, enter it by using the AIR ▲ YES and RANGE ▼ SHIFT buttons to select each password number and then pressing and releasing POWER ENTER RESET to enter the number and move on to the next one.

4. The Calibration Mode Screen displays with the cursor next to **AUTO CALIBRATION**.

```
 CALIBRATION MODE

> AUTO CALIBRATION
  SINGLE CALIBRATION
  PERFORM AIR ADJUST
  NORMAL OPERATION
```

NOTE: The following screens illustrate a 4-gas EAGLE 2 for detection of CH_4 (%LEL using catalytic sensor), oxygen, H_2S, and CO. Your EAGLE 2 may display slightly different screens.

Calibrating Using the Auto Calibration Method

This method allows you to calibrate the CH_4 (%LEL catalytic combustible sensor), oxygen, H_2S, and CO sensors simultaneously. It is designed for use with the RKI 4-gas calibration cylinder and is the quickest and most convenient method to calibrate the EAGLE 2.

Setting the Fresh Air Reading

1. While in the Calibration Mode Screen, move the cursor to the **PERFORM AIR ADJUST** menu item by using the RANGE ▼ SHIFT button.

```
 CALIBRATION MODE

  AUTO CALIBRATION
  SINGLE CALIBRATION
> PERFORM AIR ADJUST
  NORMAL OPERATION
```

2. Press and release the POWER ENTER RESET button. The following screen appears.

```
     PERFORM

   AIR ADJUST?
```

3. Press and release the AIR ▲ YES button to continue.
   If you do not want to continue, press the DISPLAY ADJUST NO button and the unit will return to the Calibration Mode Screen.

4. The EAGLE 2 will indicate that it is adjusting the zero reading for a few seconds, then indicate that the operation is complete before returning to the Calibration Mode Screen.

```
ADJUSTING ZERO

RELEASE AIR BUTTON
```

↓

```
ADJUSTING ZERO

COMPLETE
```

↓

```
CALIBRATION MODE

AUTO CALIBRATION
SINGLE CALIBRATION
> PERFORM AIR ADJUST
NORMAL OPERATION
```

Performing a Span Adjustment in Auto Calibration

1. Slide the tubing clamp onto the tubing and connect the tubing to the sample bag's inlet fitting. Leave the clamp unclamped for now.
2. Install the probe on the EAGLE 2 inlet fitting. Make sure the probe is complete with internal O-ring and membrane and that the two halves of the probe are tightened firmly together to avoid leaks that can affect the calibration. See Figure 21, "Replacing the Particle Filter and Hydrophobic Filter Disk" on page 72 for an illustration of the internal parts of the probe.
3. Move the cursor next to the **AUTO CALIBRATION** menu item by using the AIR ▲ YES button.

```
CALIBRATION MODE

> AUTO CALIBRATION
SINGLE CALIBRATION
PERFORM AIR ADJUST
NORMAL OPERATION
```


4. Press and release the POWER ENTER RESET button to display the Calibration Gas Values Screen.

```
CAL GAS VALUES
CH4      50  %LEL
OXY   12.0  vol%
H2S   25.0  ppm
CO       50  ppm
ENTER TO BEGIN CAL
```

The gas concentrations displayed in the Calibration Gas Values Screen must match the gas concentrations listed on the 4-gas calibration cylinder.
If *all* concentrations match, go to Step 15.
If *one or more* concentrations *do not* match, continue with Step 5.
If you do not want to continue with the calibration, press and release the DISPLAY ADJUST NO button to return to the Calibration Mode Screen.

NOTE: The RKI 4-gas cylinder typically contains 12% O_2 by volume. When using the auto calibration method, be sure to set the "OXY" auto calibration gas value to agree with the concentration listed on the cylinder's label, not zero.

5. To adjust the values on the screen, hold down the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both. The following screen appears with the cursor next to **CH4**.

```
ADJUST AUTO
CALIBRATION VALUES
> CH4      50  %LEL
  OXY   12.0  vol%
  H2S   25.0  ppm
  CO       50  ppm    ▼
```

6. Place the cursor next to the channel whose gas value you want to change using the AIR ▲ YES and RANGE ▼ SHIFT buttons.
7. Press and release the POWER ENTER RESET button to select the channel. The calibration gas value begins to flash.
8. Use the AIR ▲ YES and RANGE ▼ SHIFT buttons to adjust the calibration gas setting to the desired value.

NOTE: The calibration gas value cannot be set lower than the low alarm setting. If the calibration gas value listed on the calibration cylinder is lower than the current low alarm setting, enter Setup Mode and change the low alarm setting. See "Updating the Alarm Point Settings" on page 106 for instructions. If you need to change the alarm point setting only to perform a calibration, make sure that you change the alarm point setting back to its original value once the calibration has been performed.

9. Press and release the POWER ENTER RESET button to save the change. The calibration gas value stops flashing.
10. Repeat Step 6 through Step 9 for any other channels that need to be changed.

11. When you are done adjusting the calibration gas values, move the cursor down past the bottom of the screen next to **END**.

```
     ADJUST AUTO
  CALIBRATION VALUES
  > END              ▲
```

12. Press and release the POWER ENTER RESET button. The following screen appears.

```
    DO YOU WANT TO
  STORE NEW VALUE(S)
    IN MEMORY FOR
 FUTURE CALIBRATIONS?

   PRESS YES OR NO
```

13. If you select YES by pressing and releasing the AIR ▲ YES button, the changes that you made will be saved in the EAGLE 2's memory as the new auto calibration gas values.

    If you select NO by pressing and releasing the DISPLAY ADJUST NO button, the changes you made will be used for any calibrations performed during the current operating session only. The EAGLE 2 will delete the changes when the unit is turned off and will load the previous set of auto calibration values when it is turned on again.

14. When you make your selection and press the desired button, the unit returns to the Calibration Gas Values Screen.

```
    CAL GAS VALUES
    CH4      50  %LEL
    OXY    12.0  vol%
    H2S    25.0  ppm
    CO       50  ppm
  ENTER TO BEGIN CAL
```

15. Press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen. **CAL IN PROCESS** is flashing.

```
    CAL IN PROCESS
    CH4       0   %LEL
    OXY    20.9   vol%
    H2S     0.0   ppm
    CO        0   ppm
   ENTER WHEN DONE
```

    If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the Calibration Gas Values Screen.

    If you do want to continue with the calibration, proceed to the next step.

16. Connect the gas bag tubing to the regulator's or dispensing valve's hose barb fitting.
17. Fill the gas collection bag by screwing the fixed flow regulator or dispensing valve onto the calibration cylinder and turning the knob counterclockwise.
18. Allow the gas to dispense until the gas collection bag is a little over half full.
19. Turn the knob clockwise to stop the gas flow, clamp down the hose clamp and remove the regulator or dispensing valve from the cylinder.
20. Disconnect the tubing from the regulator or dispensing valve.
21. Open the hose clamp on the gas bag tubing.
22. Connect the tubing from the gas bag to the rigid tube on the probe. Allow the gas to flow for one minute.

NOTE: If you are calibrating the catalytic combustible channel with a gas concentration of 1000 ppm or lower, you must use a 24 inch humidifier tube to connect the gas bag to the rigid tube on the probe.

23. Press and release the POWER ENTER RESET button to set the span adjustment to the programmed values.
24. If all channels passed calibration the following screen sequence occurs.

```
 AUTO CALIBRATION            AUTO CALIBRATION
       DONE         ---->
   REMOVE GAS                      END
                                    |
                    +---------------+
                    v
       CALIBRATION MODE

   > AUTO CALIBRATION
     SINGLE CALIBRATION
     PERFORM AIR ADJUST
     NORMAL OPERATION
```

If any of the sensors cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and lists the sensor(s) that failed to calibrate. In the example below, the oxygen and H_2S channels failed calibration. The other sensors calibrated normally.

```
FAIL SENSOR

< >  <OXY>
<H2S>  < >

ENTER TO CONTINUE
```

The buzzer and LED arrays activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and return to the Calibration Mode Screen. Attempt to calibrate again. If the failure continues, investigate the cause. See “Troubleshooting” on page 67.

25. Disconnect the tubing from the probe.
26. Use the RANGE ▼ SHIFT button to place the cursor next to the **NORMAL OPERATION** menu option, then press and release the POWER ENTER RESET button to return to Measuring Mode.

Calibrating Using the Single Calibration Method

Single Calibration allows you to calibrate one channel at a time. This is useful if you only want to calibrate one or two channels.

Setting the Fresh Air Reading

1. While in the Calibration Mode Screen, move the cursor to the **PERFORM AIR ADJUST** menu item by using the RANGE ▼ SHIFT button.

```
CALIBRATION MODE

AUTO CALIBRATION
SINGLE CALIBRATION
> PERFORM AIR ADJUST
NORMAL OPERATION
```

2. Press and release the POWER ENTER RESET button. The following screen appears.

```
PERFORM

AIR ADJUST?
```

3. Press and release the AIR ▲ YES button to continue.
   If you do not want to continue, press the DISPLAY ADJUST NO button and the unit will return to the Calibration Mode Screen.

4. The EAGLE 2 will indicate that it is adjusting the zero reading for a few seconds, then indicate that the operation is complete before returning to the Calibration Mode Screen.

```
ADJUSTING ZERO

RELEASE AIR BUTTON
```

↓

```
ADJUSTING ZERO

COMPLETE
```

↓

```
CALIBRATION MODE

AUTO CALIBRATION
SINGLE CALIBRATION
> PERFORM AIR ADJUST
NORMAL OPERATION
```

Performing a Span Adjustment in Single Calibration

1. Slide the tubing clamp onto the tubing and connect the tubing to the sample bag’s inlet. Leave the clamp unclamped for now.
2. Connect the other end of the tubing to the regulator’s or dispensing valve’s hose barb fitting.
3. Install the probe on the EAGLE 2 inlet fitting. Make sure the probe is complete with internal O-ring and membrane and that the two halves of the probe are tightened firmly together to avoid leaks that can affect the calibration. See Figure 21, “Replacing the Particle Filter and Hydrophobic Filter Disk” on page 72 for an illustration of the internal parts of the probe.

4. Move the cursor next to the **SINGLE CALIBRATION** menu item by using the AIR ▲ YES button.

```
 CALIBRATION MODE

 AUTO CALIBRATION
> SINGLE CALIBRATION
 PERFORM AIR ADJUST
 NORMAL OPERATION
```

5. Press and release the POWER ENTER RESET button. The Select Sensor Screen appears with the cursor flashing.

```
SELECT SENSOR
TO CALIBRATE
   >ESCAPE
CH4    OXY
H2S    CO
```

6. Move the cursor next to the sensor you want to calibrate with the AIR ▲ YES and RANGE ▼ SHIFT buttons. In the example below, the CH_4 sensor is selected for span adjustment.

```
 SELECT SENSOR
 TO CALIBRATE
    ESCAPE
>CH4    OXY
 H2S    CO
```

If you do not want to proceed with the span adjustment, press and release the DISPLAY ADJUST NO button or place the cursor next to **ESCAPE** and press and release POWER ENTER RESET to return to the Calibration Mode Screen.

If you do want to continue with the calibration, proceed with the next step.

7. Press and release the POWER ENTER RESET button to proceed to the Single Calibration Gas Value Screen for the selected channel. The calibration gas value is flashing.

```
SINGLE CALIBRATION

  CH4    50 %LEL
UP/DOWN TO ADJUST
CALIBRATION VALUE
 ENTER WHEN DONE
```


8. If necessary, adjust the calibration gas value to match the cylinder concentration using the AIR ▲ YES and RANGE ▼ SHIFT buttons. For this example, the calibration gas value is entered as 50 %LEL.

NOTE: The calibration gas value cannot be set lower than the low alarm setting. If the calibration gas value listed on the calibration cylinder is lower than the current low alarm setting, enter Setup Mode and change the low alarm setting. See "Updating the Alarm Point Settings" on page 106 for instructions. If you need to change the alarm point setting only to perform a calibration, make sure that you change the alarm point setting back to its original value once the calibration has been performed.

9. Press and release the POWER ENTER RESET button to proceed to the Single Calibration Apply Gas Screen. **CAL IN PROCESS** is flashing.

```
SINGLE CALIBRATION
     APPLY GAS
  CH4    0 %LEL

  CAL IN PROCESS
 ENTER WHEN DONE
```

10. Fill the gas collection bag by screwing the fixed flow regulator or dispensing valve onto the calibration cylinder and turning the knob counterclockwise.
11. Allow the gas to dispense until the gas collection bag is a little over half full.
12. Turn the knob clockwise to stop the gas flow, clamp down the hose clamp and remove the regulator or dispensing valve from the cylinder.
13. Disconnect the tubing from the regulator or dispensing valve.
14. Open the hose clamp on the gas bag tubing.
15. Connect the tubing from the gas bag to the rigid tube on the probe. Allow the gas to flow for one minute.

NOTE: If you are calibrating the catalytic combustible channel with a gas concentration of 1000 ppm or lower, you must use a 24 inch humidifier tube to connect the gas bag to the rigid tube on the probe.

16. Press and release the POWER ENTER RESET button to make the span adjustment.
17. When the span adjustment is made, the EAGLE 2 calculates the range of adjustment, minimum and maximum, it could have made based on its response level to the applied gas. This calculated range is independent of the calibration gas value that was entered in Step 8 and Step 9 above. The adjustment range is included on the result screen to indicate the condition of the sensor. If the calibration gas value is in the adjustment range, the span adjustment will pass. If the calibration gas value is out of the adjustment range, the span adjustment will fail.

18. If the span adjustment is successful, the following screens display.

```
   CH4 CALIBRATION
        DONE
( 35  -  98%LEL)
     REMOVE GAS
```

→

```
 SELECT SENSOR
 TO CALIBRATE
     ESCAPE
> CH4    OXY
  H2S    CO
```

In the example above, the EAGLE 2 could have adjusted the reading as low as 35 %LEL and as high as 98 %LEL.

If the span adjustment is not successful, a screen displays that indicates a calibration failure.

```
   FAILED SENSOR
( 11  -  43%LEL)
   <CH4>


ENTER TO CONTINUE
```

In the example above, the EAGLE 2 could have adjusted the reading as low as 11 %LEL and as high as 43 %LEL. Since the calibration gas value entered was 50 %LEL, the unit failed the span adjustment. The buzzer and alarm LED arrays activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and return to the Select Sensor Screen. Attempt to calibrate again. If the failure continues, investigate the cause. See “Troubleshooting” on page 67.

NOTE: The adjustment range will only appear in the calibration results screen if the Span Factor item in Setup Mode is set to ON. If the Span Factor is set to OFF, the adjustment range will not appear.

19. Disconnect the tubing from the EAGLE 2’s probe.
20. Repeat Step 6 through Step 19 for any other channels you want to calibrate. Make sure you use an appropriate calibration cylinder for each channel.

CAUTION: *When calibrating the oxygen channel, verify the concentration of oxygen listed on the cylinder’s label. For oxygen-free samples (100% nitrogen for example), set the oxygen zero setting to 0.0%.*

21. After the last channel is calibrated, disconnect the calibration tubing from the probe.

22. With the Select Sensor Screen displayed, place the cursor next to **ESCAPE** using the AIR ▲ YES button.

```
SELECT SENSOR
TO CALIBRATE
   >ESCAPE
CH4    OXY
H2S    CO
```

23. Press and release the POWER ENTER RESET button to return to the Calibration Mode Screen.
24. Use the RANGE ▼ SHIFT button to place the cursor next to the **NORMAL OPERATION** menu item, then press and release the POWER ENTER RESET button to return to Measuring Mode.

Parts List

Table 12: Sample Bag Calibration Kit Spare Parts

Part Number	Description
06-1248RK-03	Calibration kit tubing, 3 foot length
81-0090RK-01	Calibration cylinder, 3-gas mix, LEL/Oxygen/CO, 34 liter steel
81-0154RK-04	Calibration cylinder, 4-gas mix, LEL/Oxygen/CO/H_2S, 34 liter aluminum
81-1001RK	Dispensing valve, for 17/34 liter steel cylinders (cylinders with external threads)
81-1051RK-60	Regulator with gauge and knob, 6 LPM, for 34 liter aluminum/58 liter/103 liter cylinders (cylinders with internal threads)
81-1126RK	Gas bag with clamp and hose barb, 9” x 9”, 2 liter
81-5302RK-LV	Calibration kit, for LEL/Oxy/CO unit, w/gas bag, 34 Liter
81-5401RK-LV	Calibration kit, for LEL/Oxy/H_2S/CO unit, w/gas bag, 34 Liter

Appendix B: Setup Mode

Overview

This appendix describes the EAGLE 2 in Setup Mode. In Setup Mode, you can:

- set the date and time
- set the date format
- set the battery type
- configure the channels
- configure the gas for a catalytic or PID channel
- set the detection units for the catalytic channel
- turn the catalytic sensor relative response feature on or off
- set the alarm points
- change the alarm latching setting
- turn the alarm silence feature on or off
- turn the user/station ID function on or off
- set the auto calibration values
- set the backlight delay time
- turn the automatic fresh air adjust feature on or off
- set the data logging interval time
- turn the data logger overwrite feature on or off
- turn the data log memory clear feature on or off
- adjust the display contrast
- turn the calibration reminder feature on or off
- set the calibration past due action
- set the calibration interval
- select the leak check/bar hole mode operation setting
- set the bar hole measurement time
- turn the zero follower on or off for each channel
- set the zero suppression level for each channel (except oxygen)
- turn the confirmation alert feature on or off
- turn the password feature on or off and set the password
- reset the instrument parameters to their default settings
- turn the lunch break function on or off
- turn the span factor on or off
- select the language
- return to normal operation

The EAGLE 2 is factory-set to suit most applications. Update settings in Setup Mode only if required for your specific application. The description of each item below indicates the factory setting for each item.

Tips for Using Setup Mode

- When in the main menu, the cursor (>) flashes in front of a menu item indicating that the item is selected.
- Use the RANGE ▼ SHIFT button to move the cursor down through the main menu and submenu items, and to lower values or change the setting in a specific option.
- Use the AIR ▲ YES button to move the cursor up through the main menu and submenu items, and to raise values or change the setting in a specific option.
- A down arrow in the lower right corner or an up arrow in the upper right corner of the LCD indicates that additional menu items can be viewed by pressing and releasing the RANGE ▼ SHIFT button in the case of the down arrow or the AIR ▲ YES button in the case of the up arrow. The example below illustrates a down arrow in the lower right corner.

```
>SET DATE & TIME
 SET DATE FORMAT
 SET BATTERY TYPE
 CONFIGURE CHANNELS
 CONFIGURE GASES
 CATALYTIC UNITS      ▼
```

- Use the POWER ENTER RESET button to enter a selected menu item with the cursor next to it and to enter and save settings during programming.
- An adjustable parameter that is flashing can be adjusted with the AIR ▲ YES and RANGE ▼ SHIFT buttons.
- Press the DISPLAY ADJUST NO button while in a screen where you are entering or updating parameters to exit the screen without saving any changes.

Using Setup Mode

WARNING: The EAGLE 2 is not in operation as a gas detector while in Setup Mode.

1. Take the EAGLE 2 to a non-hazardous location and turn it off if it is on.
2. Press and hold the AIR ▲ YES and RANGE ▼ SHIFT buttons, then press and hold the POWER ENTER RESET button. When you hear a beep, release the buttons.

3. The LCD will show the following screen for a few seconds with the “S” in the lower right corner indicating the unit is entering Setup Mode.

```
GAS MONITOR
INSTRUMENTS
EAGLE 2     S
```

4. The “S” will then disappear and the following screen will appear for a few seconds.

```
GAS MONITOR
INSTRUMENTS
EAGLE 2
```

5. If the unit prompts you for the password, enter it by using the AIR ▲ YES and RANGE ▼ SHIFT buttons to select each password number and then pressing and releasing the POWER ENTER RESET button to enter it and move on to the next number until all of the numbers are entered. The main menu displays. It displays six menu items at a time.

```
>SET DATE     TIME
 SET DATE FORMAT
 SET BATTERY TYPE
 CONFIGURE CHANNELS
 CONFIGURE GASES
 CATALYTIC UNITS     ▼
```

6. Use the AIR ▲ YES or RANGE ▼ SHIFT button to move the cursor up and down the menu items and to view additional menu items. A down arrow in the lower right corner of the LCD or an up arrow in the upper right corner of the LCD indicates that there are additional menu items accessible by moving the cursor down past the last menu item on the LCD or up past the first menu item on the LCD.

Setting the Date and Time

1. From the main menu, place the cursor next to **SET DATE & TIME**.
2. Press and release POWER ENTER RESET. The date and time will be displayed with the last two digits of the year flashing.

```
SET DATE     TIME

    12/21/2009
    MM/DD/YYYY
     11:02:12
```


3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired year.
4. Press and release POWER ENTER RESET to save the setting. The month setting flashes.
5. Repeat Step 3 and Step 4 to enter the month, day, hours, minutes, and seconds settings. The main menu displays after you enter the seconds setting.

Setting the Date Format

The date can be displayed in two ways, month/day/year (factory setting) or day/month/year.

1. From the main menu, place the cursor next to **SET DATE FORMAT**.
2. Press and release POWER ENTER RESET. The Set Date Format screen appears with the current setting flashing.

```
SET DATE FORMAT

UP/DOWN THEN ENTER

MM/DD/YYYY
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Setting the Battery Type

This menu item allows you to select between alkaline and Ni-MH batteries. Since the discharge characteristics of alkaline and Ni-MH batteries are different, the EAGLE 2 uses this setting to ensure that the low battery *warning* is in effect long enough before a dead battery *alarm* to allow the user to change the batteries without a dead battery alarm occurring. This setting has no effect on battery charging.

1. From the main menu, place the cursor next to **SET BATTERY TYPE**.
2. Press and release POWER ENTER RESET. The Battery Type screen appears with the current setting flashing.

```
BATTERY TYPE

UP/DOWN THEN ENTER

ALKALINE
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Configuring the Channels

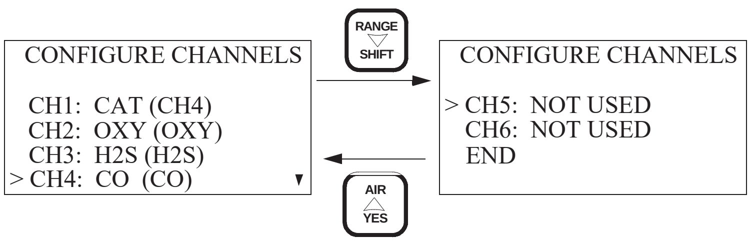
This menu item allows you to set the channel type for each of the six channels or to turn one or more channels off. Although the standard EAGLE 2 is factory configured for four channels, combustible gas (catalytic sensor), oxygen, H_2S, and CO, with channels 5 and 6 turned off, the EAGLE 2 can be factory and field configured for a variety of active channels and detector types. It is not normally necessary to change the factory channel configuration.

CAUTION: *Before changing the channel configuration, confirm that the correct sensors and electronic hardware are installed in the EAGLE 2 and that its construction and flow system are appropriate for the installed sensors. Operation of the EAGLE 2 with a flow system or construction not compatible with the installed sensors will result in inaccurate readings. Consult RKI Instruments, Inc. if you cannot confirm either of these items.*

1. From the main menu, place the cursor next to **CONFIGURE CHANNELS**.
2. Press and release POWER ENTER RESET. The Configure Channels screen appears with the cursor flashing next to **CH1**.

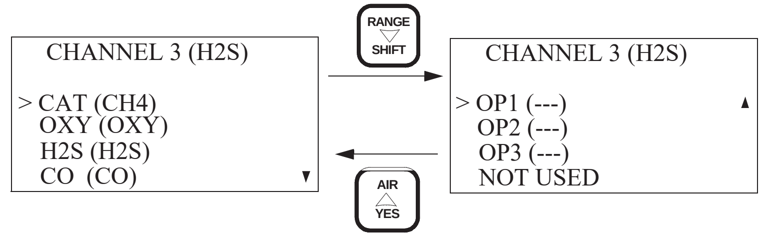
```
 CONFIGURE CHANNELS

> CH1:  CAT (CH4)
  CH2:  OXY (OXY)
  CH3: H2S (H2S)
  CH4:  CO  (CO)        ▼
```

The standard 4-gas configuration is shown below.



3. Use AIR ▲ YES or RANGE ▼ SHIFT to move the cursor next to the channel you want to configure.

4. Press and release POWER ENTER RESET. The available configuration options are shown. In the example below, channel 3 has been selected for configuration.



5. Use AIR ▲ YES and RANGE ▼ SHIFT to move the cursor next to the desired configuration for the selected channel. In the example below, the cursor has been moved next to the **NOT USED** selection.

```
 CHANNEL 3 (H2S)

  OP1 (---)         ▲
  OP2 (---)
  OP3 (---)
> NOT USED
```

The OP1, OP2, and OP3 options are not defined for a standard 4-gas EAGLE 2. These options are only defined when hardware specific to optional sensors is factory installed in the EAGLE 2. The "---" in the gas name field indicates that hardware necessary to support an optional sensor is not installed. If your EAGLE 2 supports one or more of these optional sensors, the target gas will appear instead of "---". See "Appendix C: Sub PCBs" on page 121 for a description of this optional hardware and how it affects CHANNEL CONFIGURATION.

6. Press and release POWER ENTER RESET to select the channel configuration. In the example below, channel 3 has been turned off by selecting **NOT USED**.

```
 CONFIGURE CHANNELS

  CH1:  CAT (CH4)
  CH2:  OXY (OXY)
> CH3:  NOT USED
  CH4:  CO  (CO)        ▼
```

7. Repeat Step 5 and Step 6 for any other channels you want to configure.
8. Use RANGE ▼ SHIFT to move the cursor next to the **END** menu item.

NOTE: If you want to exit to the main menu without saving any channel configuration changes, press and release DISPLAY ADJUST NO.

9. Press and release POWER ENTER RESET to save the changes and return to the main menu.

Configuring the Combustible Gas

This menu item allows you to configure the gas for a catalytic, TC (thermal conductivity), or PID (photo ionization detector) sensor. Only a catalytic sensor is used in a standard EAGLE 2, so only a catalytic sensor can be configured in a standard EAGLE 2. PID or TC sensors can only be configured if additional hardware not in a standard EAGLE 2 is factory installed.

1. From the main menu, place the cursor next to **CONFIGURE GASES**.
2. Press and release POWER ENTER RESET. The Configure Gases Screen appears with the cursor flashing next to CAT.

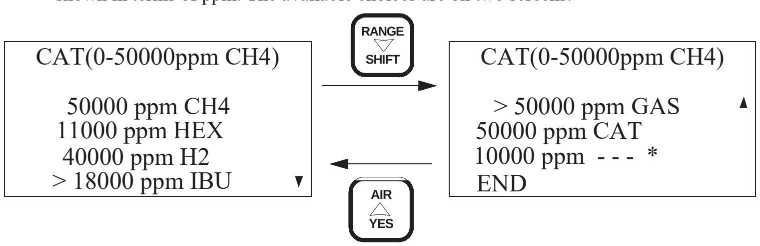
```
   CONFIGURE GASES

> CAT :  CH4 (CAT)
  OP1 :  --- (---)
  OP2 :  --- (---)
  OP3 :  --- (---)      ▼
```

   The OP1, OP2, and OP3 options are not defined in a standard 4-gas EAGLE 2. These options are only defined when hardware specific to optional sensors is factory installed in the EAGLE 2. See “Appendix C: Sub PCBs” on page 121 for a description of this optional hardware and how it affects CONFIGURE GASES.

3. To change the catalytic sensor gas configuration, press and release POWER ENTER RESET.
4. A screen appears with gas configuration choices for the catalytic channel.

```
 CAT(0-50000ppm CH4)

> 50000 ppm CH4
  11000 ppm HEX
  40000 ppm H2
  18000 ppm IBU         ▼
```

For each gas, the LEL (lower explosive limit) and gas name is displayed. The LEL is shown in terms of ppm. The available choices are on two screens.



All of the gases except for the one with the asterisk (*) next to it are pre-defined. The gas with the asterisk next to it is user defined. The user defined gas can be used if the desired gas is not one of the pre-defined gases. Below is a brief description of each choice.

- 50000 ppm CH4
  This selection is for methane (CH_4) and is the standard factory setting. The LEL for methane is 5 %volume, or 50,000 ppm. If the gas is configured for this choice, the methane elimination feature is inactive and the Methane Elimination Mode Screen will not appear in Display Mode. See “Methane Elimination Mode Screen” on page 44 for a description of the Methane Elimination Mode Screen. See “Appendix J: Methane Elimination Mode” for a description of Methane Elimination Mode.
- 11000 ppm HEX
  This selection is for hexane. The LEL for hexane is 1.1%, or 11,000 ppm. If the gas is configured for this choice, the methane elimination feature is active and the Methane Elimination Mode Screen is accessible in Display Mode. See “Methane Elimination Mode Screen” on page 44 for a description of the Methane Elimination Mode Screen. See “Appendix J: Methane Elimination Mode” for a description of Methane Elimination Mode.
- 40000 ppm H2
  This selection is for hydrogen (H_2). The LEL for hydrogen is 4%, or 40,000 ppm. If the gas is configured for this choice, the methane elimination feature is inactive, the Methane Elimination Mode Screen will not appear in Display Mode, and the catalytic sensor voltage is set to 1.1 volts. The standard catalytic sensor voltage is 2.4 volts. Because the detector voltage is set to 1.1 volts, the catalytic sensor will not respond significantly to methane and many other combustible gases, but will respond to hydrogen.

WARNING: ***Do not configure the catalytic sensor gas to hydrogen if you are monitoring for general hydrocarbons. Only use this selection if you are monitoring exclusively for hydrogen or if you do not want to see a significant response to other combustible gases.***

- 18000 ppm IBU
  This selection is for isobutane. The LEL for isobutane is 1.8%, or 18,000 ppm. If the gas is configured for this choice, the methane elimination feature is inactive and the Methane Elimination Mode Screen will not appear in Display Mode. See “Methane Elimination Mode Screen” on page 44 for a description of the Methane Elimination Mode Screen. See “Appendix J: Methane Elimination Mode” for a description of Methane Elimination Mode.
- 50000 ppm GAS
  This selection is for a generic combustible gas with the LEL set to 50000 ppm. If the gas is configured for this choice, the methane elimination feature will be active, but the Methane Elimination Mode Screen will not appear in Display Mode, so methane elimination cannot be turned off. In addition, the relative response feature is inactive even if it is set to ON in the Setup Mode Relative Responses menu item.

CAUTION: *The* **50000 ppm GAS** *gas configuration is normally set at the factory for very specific applications. Consult RKI Instruments, Inc. before configuring the gas for* **50000 ppm GAS**.

- 50000 ppm CAT

  This selection is for users who want their catalytic channel to be configured with the standard factory settings but would like the gas name to be displayed as something other than CH_4 so that it doesn't get confused with other combustible sensors that might be installed (IR, TC). The LEL is set to 50,000 ppm. If the gas is configured for this choice, the methane elimination feature is inactive and the Methane Elimination Mode Screen will not appear in Display Mode. See "Methane Elimination Mode Screen" on page 44 for a description of the Methane Elimination Mode Screen. See "Appendix J: Methane Elimination Mode" for a description of Methane Elimination Mode.

- 10000 ppm - - - *
  This selection is a user defined selection. The factory setting is 10000 ppm - - - *, with the asterisk (*) indicating that it is user defined. If this selection has been updated in the field, it will appear differently, but the asterisk will always remain next to the menu item to indicate it is user defined. If you choose the user defined selection, the unit will prompt you to enter four parameters: a three character gas name, the LEL value in terms of ppm, the response factor relative to methane, and the detector voltage. When you configure the gas as the user defined choice, the methane elimination feature is active and the Methane Elimination Mode Screen is accessible in Display Mode. See "Methane Elimination Mode Screen" on page 44 for a description of the Methane Elimination Mode Screen. See "Appendix J: Methane Elimination Mode" for a description of Methane Elimination Mode.

5. Use AIR ▲ YES and RANGE ▼ SHIFT to move the cursor next to the desired gas for the catalytic channel.
6. If you placed the cursor next to one of the pre-defined gases, press and release POWER ENTER RESET to select the gas and proceed to Step 15.

   If you placed the cursor next to the user defined gas with the asterisk (*), press POWER ENTER RESET and proceed with Step 7.
7. The user defined gas setup screen appears with the first character of the gas name flashing. The current gas name and range are shown on the top line of the screen.

   ```
   CAT(0-50000ppm CH4)
     CHANGE TO NAME
          - - -
    10000 - 150000
    10000 ppm RATIO
      1.00 FACTOR
   ```
8. Enter the gas name. Use AIR ▲ YES and RANGE ▼ SHIFT to display the desired character, then press POWER ENTER RESET to enter the displayed character and move to the next character. Repeat until all three characters are entered. When the last character is entered, the ppm ratio value will be flashing.
9. Use AIR ▲ YES and RANGE ▼ SHIFT to display the desired ppm value. This value is called the ppm ratio and must be the ppm equivalent of the LEL for the gas being defined. For example, if you are defining propane, the LEL for propane is 21,000 ppm, so you must enter 21000 ppm (2.1% volume).

NOTE: If you define a gas whose LEL is above 50,000 ppm, the %LEL reading in Measuring Mode will reflect the defined ppm ratio, but the ppm reading in Measuring Mode will not indicate above 50,000 ppm. For example, if you set the ratio to be 150,000 ppm and set the catalytic combustible channel to display the reading in ppm, the gas reading will not indicate higher than 50,000 ppm, the equivalent of 33 %LEL and 5% volume for this ratio, but will continue to indicate %LEL readings up to 100 %LEL and %volume readings up to 15 %volume, the equivalent of 150,000 ppm, if the display units are changed to %LEL or %volume. In addition, all adjustable ppm parameters cannot be set higher than 50,000 ppm.

10. Press and release POWER ENTER RESET to enter the ppm ratio. The FACTOR for the gas begins to flash. The FACTOR for the gas is the response factor for the user defined gas relative to methane. The response factor must be obtained by testing the user defined gas and comparing its response to methane. This parameter is used by the relative response feature. See "Catalytic Sensor Relative Response Screen" on page 44 for a description of the relative response feature and how to use it. See "Combustible Gas Detection" on page 34 for a list of response factors for several common hydrocarbon gases that have already been tested.
11. Use AIR ▲ YES and RANGE ▼ SHIFT to increase or decrease the response factor to the desired number.
12. Press and release POWER ENTER RESET to enter the response factor. The sensor voltage setting screen appears with the sensor voltage flashing. The current gas and range is shown at the top of the screen and the current sensor voltage is shown at the bottom of the screen.

    ```
     CAT(0-50000ppm CH4)

         SETTING EV
     UP/DOWN THEN ENTER

            2.40
    ```

    The sensor voltage setting defines whether the catalytic sensor voltage is set for full response, 2.40 volts, or methane elimination, 1.30 volts. If the sensor voltage is set to 2.40 volts, the unit will default to Full Response Mode when turned on, but the methane elimination feature can be turned on in the Methane Elimination Mode Screen in Display Mode. If the sensor voltage is set to 1.3 volts, the unit will default to Methane Elimination Mode when turned on, but the methane elimination feature can be turned off in the Methane Elimination Mode Screen in Display Mode.
13. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired catalytic sensor voltage, 1.30 volts or 2.40 volts.

14. Press and release POWER ENTER RESET. The confirmation screen appears. In the example below, the user defined gas has been selected and defined as propane with the gas name set to PRO.

```
CHANGE TO PRO ?

PRESS YES OR NO
```

15. If you want to accept the gas configuration change, press and release AIR ▲ YES. The unit will return to the Configure Gases screen.

```
CONFIGURE GASES

> CAT :  PRO (CAT)
    OP1 :  --- (---)
    OP2 :  --- (---)
  OP3 :  --- (---)        ▼
```

If you do not want to accept the gas configuration change, press and release DISPLAY ADJUST NO to return to the screen with the gas choices shown in Step 4 on page 101. You can either scroll down to **END** and press POWER ENTER RESET to return to the Configure Gases screen or continue from Step 4 on page 101 to select a new gas.

16. Use RANGE ▼ SHIFT to place the cursor next to **END** and press POWER ENTER RESET to return to the main menu.
17. Be sure to perform a calibration on the catalytic combustible channel using an appropriate calibration cylinder for the target gas.

Setting the Catalytic Detection Units

This menu item allows you to display the combustible gas units on the catalytic sensor channel as ppm, %LEL, %vol, or selectable between the three units (the **CHANGE OK** option). The factory setting is **CHANGE OK**.

1. From the main menu, place the cursor next to **CATALYTIC UNITS**.
2. Press and release POWER ENTER RESET. The Catalytic Units screen appears with the current setting flashing at the bottom of the screen.

```
CATALYTIC UNITS

UP/DOWN THEN ENTER

CHANGE OK
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to scroll through the choices, **CHANGE OK**, **vol% ONLY**, **%LEL ONLY**, and **ppm ONLY**.
4. When the desired setting is on the screen, press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Catalytic Sensor Relative Response Setting

This menu item allows you to turn the catalytic sensor relative response feature on and off. The catalytic sensor relative response feature enables you to change the catalytic sensor's response to gas on the fly so that the catalytic channel is roughly calibrated to an alternate gas. For example, if the catalytic channel is setup for and calibrated to methane, you can select hexane from a gas list accessible from the Catalytic Sensor Relative Response Screen in Display Mode so that the catalytic channel responds to gas as if it were calibrated to hexane. See "Catalytic Sensor Relative Response Screen" on page 44 for instructions to use the relative response feature.

The factory setting for **CATALYTIC SENSOR RELATIVE RESPONSE** is **OFF**.

1. From the main menu, place the cursor next to **RELATIVE RESPONSE**. Press and release POWER ENTER RESET. The Catalytic Sensor Relative Response screen appears with the current setting flashing.

```
CATALYTIC SENSOR
RELATIVE RESPONSE

UP/DOWN THEN ENTER

OFF
```

2. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting, **ON** or **OFF**.
3. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Alarm Point Settings

This menu item allows you to update one or more alarm points (the reading at which the EAGLE 2 recognizes the alarm condition).

1. From the main menu, place the cursor next to **ALARM POINTS**.
2. Press and release POWER ENTER RESET. The Change Alarm Point Settings Screen appears and all detection channels are displayed.

```
CHANGE ALARM
POINT SETTINGS
> 1: CH4   2: OXY
  3: H2S   4: CO

END
```

3. Move the cursor next to the channel of the alarm point you want to update. Press and release POWER ENTER RESET. The channel's alarm points are displayed (in this example for the catalytic combustible sensor channel).

```
CH4 0-  100 %LEL

>LO ALRM :       10 %LEL
 HI ALRM :       50 %LEL
 LO ALRM:     5000 ppm
 HI ALRM :   25000 ppm ▼
```

4. Move the cursor next to the alarm point or alarm operation (oxygen only) that you want to update.

   If you selected the oxygen channel, you can set the alarm rising/falling operation in addition to the alarm points.

NOTE: If Inert Mode is active, you can change the oxygen alarm points for both Normal Mode and Inert Mode. For more information about changing Inert Mode alarm settings, see “Appendix N: Using the EAGLE 2 in Inert Mode” on page 261.

```
  OXY 0- 40.0 vol%

>FALLING AND RISING
 LO ALRM :   19.5 vol%
 HI ALRM :   23.5 vol%
 END
```

5. Press and release POWER ENTER RESET. The alarm point or alarm operation (oxygen only) will begin to flash.
6. Use AIR ▲ YES and RANGE ▼ SHIFT to adjust the alarm point or alarm operation (oxygen only) to the desired setting. Keep the following in mind:
   - The low alarm cannot be set higher than the high alarm and the high alarm cannot be set lower than the low alarm.
   - Any alarm setting can be turned off by adjusting it to its lowest setting. The setting will be displayed as **OFF.**
   - In addition to setting the oxygen alarm points, you can also select one of the following operation modes: low alarm decreasing and high alarm increasing (**FALLING AND RISING**); low and high alarm decreasing (**BOTH FALLING**); low and high alarm increasing (**BOTH RISING**). The factory setting is **FALLING AND RISING**.
   - In order to appropriately set the calibration gas value during a calibration, the low alarm setting must be lower than the desired calibration value.
7. If you want to continue with the change, press and release POWER ENTER RESET to accept the setting.

   If you want to exit this screen without saving any change to the alarms, press and release DISPLAY ADJUST NO until you return to the Change Alarm Point Settings Screen.
8. Repeat Step 4- Step 7 for any additional changes you want to make.
9. When you are done making changes, use RANGE ▼ SHIFT to move the cursor next to **END**.
10. Press and release POWER ENTER RESET to save the new settings and return to the Change Alarm Point Settings Screen.
11. Use RANGE ▼ SHIFT to move the cursor next to **END.**
12. Press and release POWER ENTER RESET to return to the main menu.

Updating the Alarm Latching Setting

With **ALARM LATCHING** set to **LATCHING** (factory setting), the EAGLE 2 remains in alarm condition until the alarm condition passes *and* the POWER ENTER RESET button is pressed.

With **ALARM LATCHING** set to **SELF RESET**, the EAGLE 2 automatically resets an alarm when the alarm condition passes.

1. From the main menu, place the cursor next to **ALARM LATCHING**.
2. Press and release POWER ENTER RESET. The Alarm Latching Screen appears.

```
   ALARM LATCHING


UP/DOWN THEN ENTER

      LATCHING
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Alarm Silence Setting

With **ALARM SILENCE** set to **ON** (factory setting), pressing and releasing any button silences the buzzer when the EAGLE 2 is in alarm. The LEDs continue to flash and the display continues to show the alarm. When the gas concentration falls below the alarm level, pressing and releasing POWER ENTER RESET clears all alarm indications for that alarm. If an alarm condition occurs, you may still enter Display Mode by pressing the DISPLAY button. The buzzer will be silenced but the LEDs will continue to flash. If you return to Measuring Mode and there is still an alarm condition, the LEDs will continue to flash and the buzzer will remain off. Once the condition clears, press POWER ENTER RESET to clear the alarm indications.

With **ALARM SILENCE** set to **OFF**, you cannot silence the buzzer. If an alarm condition occurs, and you enter Display Mode, the buzzer will not be silenced and the LEDs will continue to flash. Upon return to Measuring Mode, if there is still an alarm condition, you must wait until it clears before you can press POWER ENTER RESET to clear the alarm indications.

1. From the main menu, place the cursor next to **ALARM SILENCE**.
2. Press and release POWER ENTER RESET. The Alarm Silence Option Screen appears.

```
       ALARM
  SILENCE OPTION

UP/DOWN THEN ENTER

        ON
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Turning the User/Station ID Function On or Off

With **USER/STATION ID** set to **ON**, the ID Screen displays during start up and the Select User ID Screen and Select Station ID Screen appear in Display Mode. The ID's can be selected in Display Mode.

With **USER/STATION ID** set to OFF (factory setting), the ID Screen does not display during start up and the Select User ID Screen and Select Station ID Screen do not appear in Display Mode.

1. From the main menu, place the cursor next to **USER/STATION ID**.
2. Press and release POWER ENTER RESET. The User and Station ID's Screen appears.

```
     USER AND
   STATION ID'S

UP/DOWN THEN ENTER

        OFF
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Autocal Values

The EAGLE 2 stores calibration gas value settings. This allows you to calibrate all EAGLE 2 channels simultaneously with a calibration cylinder that contains all required target gases (for example the RKI 4-gas calibration cylinder).

The EAGLE 2 includes default auto calibration settings for most target gases. For gases without a default auto calibration value, the setting is 0.

NOTE: You can also update auto calibration settings in Calibration Mode. Updating the auto calibration gas values in Calibration Mode is normally done when performing a calibration. Updating these settings in Setup Mode allows you to update the settings without performing a calibration.

1. From the main menu, place the cursor next to **ADJ AUTOCAL VALUES**.
2. Press and release POWER ENTER RESET. The Adjust Auto Calibration Values Screen appears. The auto calibration value for each channel is shown.

```
    ADJUST AUTO
CALIBRATION VALUES
> CH4     50   %LEL
  OXY   12.0   vol%
  H2S   25.0   ppm
  CO      50   ppm      ▼
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to place the cursor next to the auto calibration value you want to change.
4. Press and release POWER ENTER RESET. The auto calibration value begins to flash indicating it can be adjusted.

5. Use AIR ▲ YES and RANGE ▼ SHIFT to adjust the auto calibration value to the desired value.
6. Press and release the POWER ENTER RESET button to accept the value.
7. Repeat Step 3 - Step 6 for each auto calibration value you want to change. If you want to return to the main menu at any time without saving any changes, press and release the DISPLAY ADJUST NO button until you return to the main menu.
8. Use RANGE ▼ SHIFT to move the cursor next to the **END** menu item. Press and release the POWER ENTER RESET button to save the changes and return to the main menu.

Updating the Backlight Delay Setting

This setting indicates the length of time the LCD illuminates when you press any button. The minimum setting is 0 seconds; the maximum setting is 255 seconds. The factory setting is 30 seconds.

1. From the main menu, place the cursor next to **BACKLIGHT DELAY**.
2. Press and release POWER ENTER RESET. The Backlight Delay Screen appears.

```
  BACKLIGHT DELAY


UP/DOWN THEN ENTER

    30 SECONDS
```

3. Use AIR ▲ YES and RANGE ▼ SHIFT to adjust the time to the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Auto Fresh Air Setting

This setting allows you to configure the EAGLE 2 so that a fresh air adjustment takes place automatically as part of the instrument startup sequence. If **AUTO FRESH AIR ADJ** is set to **ON**, the EAGLE 2 performs a fresh air adjustment at the end of the startup sequence before entering Normal Operation. The factory setting is **OFF**.

WARNING: ***If the automatic fresh air feature is turned on, you must startup the EAGLE 2 in a known fresh air environment, an environment free of toxic or combustible gases and of normal oxygen content (20.9%). If this feature is on and the EAGLE 2 is started up in the presence of a target gas, the readings and alarms will not be accurate or reliable.***

1. From the main menu, place the cursor next to **AUTO FRESH AIR ADJ**.
2. Press and release POWER ENTER RESET. The Fresh Air Adjust Screen appears.

```
 FRESH AIR ADJUST
    ON POWERUP

UP/DOWN THEN ENTER

        OFF
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Data Log Interval Setting

This setting indicates how often the EAGLE 2 saves readings to the data logger. The following interval times can be selected: 10 minutes, 5 minutes, 3 minutes, 1 minute, 30 seconds, 20 seconds, 10 seconds, or 5 seconds. The factory setting is 30 seconds.

1. From the main menu, place the cursor next to **DATA LOG INTERVAL**.
2. Press and release POWER ENTER RESET. The Data Log Interval Screen appears.

```
DATA LOG INTERVAL

UP/DOWN THEN ENTER

30 SECONDS
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Data Log Overwrite Setting

With **DATA LOG OVERWRITE** set to **ON** (factory setting), the EAGLE 2 writes over the oldest data with new data when the data logger memory is full.

With **DATA LOG OVERWRITE** set to **OFF**, the EAGLE 2 stops saving data to the data logger when the data logger memory is full.

1. From the main menu, place the cursor next to **DATA LOG OVERWRITE**.
2. Press and release POWER ENTER RESET. The Overwrite Log Data Screen appears.

```
OVERWRITE LOG DATA
WHEN MEMORY IS FULL?

UP/DOWN THEN ENTER

ON
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Data Log Memory Setting

With **DATA LOG MEMORY** set to **ON** (factory setting), the Data Logging Screen in Display Mode asks whether you want to clear the logged data in addition to showing the log time remaining (see "Data Logging Screen" on page 51).

With **DATA LOG MEMORY** set to **OFF**, the Data Logging Screen only shows the remaining log time and does not give you the opportunity to clear the logged data.

1. From the main menu, place the cursor next to **DATA LOG MEMORY**.
2. Press and release POWER ENTER RESET. The Prompt to Clear Data Log Memory? Screen appears.

```
PROMPT TO CLEAR
DATA LOG MEMORY?

UP/DOWN THEN ENTER

ON
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the LCD Contrast Setting

The contrast setting controls the LCD contrast. Select the setting so the characters on the display are easy to see. It can be set from 1 to 15. The factory setting is 8. The higher the setting, the darker the characters and LCD background.

1. From the main menu, place the cursor next to **ADJUST CONTRAST**.
2. Press and release POWER ENTER RESET. The Adjust Contrast Screen appears.

```
ADJUST CONTRAST

UP/DOWN THEN ENTER

8
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to adjust the setting so that the characters on the LCD are easy to see.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Calibration Reminder Setting

With **CAL REMINDER** set to **ON** (factory setting), the EAGLE 2 will give an indication at start up if it is due for calibration. The type of indication will depend on the **CAL PAST DUE ACT** setting (see the next menu item below).

1. From the main menu, place the cursor next to **CAL REMINDER**.
2. Press and release POWER ENTER RESET. The Calibration Reminder Screen appears.

```
CALIBRATION
REMINDER

UP/DOWN THEN ENTER

ON
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Calibration Past Due Action Setting

This item defines what indication is given during start up when calibration is due and **CAL REMINDER** is set to **ON**.

With **CAL PAST DUE ACT** set to **CONFIRM TO CAL** (factory setting), the EAGLE 2 will give an indication at start up if calibration is past due and require the user to decide whether to perform a calibration or continue and use the EAGLE 2 without calibrating. Press and release DISPLAY ADJUST NO to continue without calibrating or AIR ▲ YES to perform a calibration.

With **CAL PAST DUE ACT** set to **MUST CALIBRATE**, if the unit is due for calibration, the EAGLE 2 will give an indication at start up that calibration is past due and prompt you to press and release POWER ENTER RESET to enter Calibration Mode and perform a calibration. Using any other button will have no effect. A successful calibration must be performed in order to use the instrument.

NOTE: Even if the password function is turned on in **CHANGE PASSWORD**, no password will be required to perform a calibration during startup.

With **CAL PAST DUE ACT** set to **NOTIFICATION ONLY,** the EAGLE 2 will give an indication at startup that calibration is past due. You must press and release POWER ENTER RESET to acknowledge the indication and proceed with the startup sequence.

1. From the main menu, place the cursor next to **CAL PAST DUE ACT**.
2. Press and release POWER ENTER RESET. The Calibration Past Due Action Screen appears.

```
CALIBRATION PAST
DUE ACTION

UP/DOWN THEN ENTER

CONFIRM TO CAL
```


3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Calibration Interval

This setting defines the amount of time between calibrations. The time can be set in 1 day increments. The minimum setting is 1 day and the maximum setting is 365 days. The factory setting is 90 days.

1. From the main menu, place the cursor next to **CAL INTERVAL**.
2. Press and release POWER ENTER RESET. The Set Calibration Interval Screen appears.

```
SET CALIBRATION
INTERVAL

UP/DOWN THEN ENTER

90 DAYS
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.

Tip: Press and hold AIR ▲ YES or RANGE ▼ SHIFT to rapidly scroll through the settings.

4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating LC/BH Mode Setting

With **LC/BH MODE SELECT** set to **LC & BH**, the Mode Select Screen appears when the unit is turned on. You are able to select from Normal Mode, Leak Check Mode, and Bar Hole Mode.

With **LC/BH MODE SELECT** set to **BAR HOLE ONLY**, the Mode Select Screen appears when the unit is turned on. You are able to select from Normal Mode and Bar Hole Mode.

With **LC/BH MODE SELECT** set to **LEAK CHECK ONLY**, the Mode Select Screen appears when the unit is turned on. You are able to select from Normal Mode and Leak Check Mode.

With **LC/BH MODE SELECT** set to **OFF**, the Mode Select Screen does not appear when the unit is turned on and the unit goes into Normal Mode after the start up sequence.

This setting is factory set to **OFF** when a unit is shipped unless the instrument is ordered for bar hole measurement or leak checking use. See "Appendix K: Using the EAGLE 2 in Bar Hole Mode" and "Appendix L: Using the EAGLE 2 in Leak Check Mode" for discussions of Bar Hole Mode and Leak Check Mode, respectively.

1. From the main menu, place the cursor next to **LC/BH MODE SELECT.**

2. Press and release POWER ENTER RESET. The Leak Check/Bar Hole Mode Screen appears.

```
LEAK CHECK /
BAR HOLE MODE

UP/DOWN THEN ENTER

OFF
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Setting the Bar Hole Measurement Time

This setting indicates the length of time the unit will sample when a bar hole measurement is initiated in Bar Hole Mode. It can be set to 30 (factory setting), 45, or 60 seconds.

1. From the main menu, place the cursor next to **BH MEASURING TIME.**
2. Press and release POWER ENTER RESET. The Bar Hole Measuring Time Screen appears.

```
BAR HOLE
MEASURING TIME

UP/DOWN THEN ENTER

30 SECONDS
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Zero Follower Settings

The **ZERO FOLLOWER** setting is not intended for field adjustment. The default setting for most target gases is **ON**. The default setting for carbon dioxide channels and some configurations of non-standard toxic gas channels is **OFF**. The oxygen channel does not support this feature.

Zero Suppression Settings

The **ZERO SUPRESSION** setting is not intended for field adjustment. The typical setting is 2% of full scale. The oxygen channel does not support this feature.

Updating the Confirmation Alert Setting

With **CONFIRMATION ALERT** set to **BEEP AND LIGHT**, the EAGLE 2 beeps and flashes the LED arrays once every 15 minutes to verify that it is operating.

With **CONFIRMATION ALERT** set to **LIGHT ONLY**, the EAGLE 2 flashes the LED arrays once every 15 minutes to verify that it is operating.

With **CONFIRMATION ALERT** set to **BEEP ONLY**, the EAGLE 2 beeps once every 15 minutes to verify that it is operating.

With **CONFIRMATION ALERT** set to **OFF** (factory setting), the EAGLE 2 does not sound a confirmation alert.

1. From the main menu, place the cursor next to **CONFIRMATION ALERT.**
2. Press and release POWER ENTER RESET. The Confirmation Alert Screen appears.

```
CONFIRMATION ALERT

UP/DOWN THEN ENTER

OFF
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Turning the Password Function On or Off

With **CHANGE PASSWORD** set to **ON**, the EAGLE 2 prompts you for a password when you enter Calibration Mode or Setup Mode.

NOTE: If a calibration is due and **CAL REMINDER** is set to **ON** and **CAL PAST DUE ACT** is set to **MUST CALIBRATE**, no password will be required to perform a calibration during startup.

With **CHANGE PASSWORD** set to **OFF** (factory setting), no password is required to enter Calibration Mode or Setup Mode.

1. From the main menu, place the cursor in front of **CHANGE PASSWORD**.
2. Press and release POWER ENTER RESET. The Password Protection Screen appears.

```
PASSWORD
PROTECTION

UP/DOWN THEN ENTER

OFF
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. If you selected **OFF,** press and release POWER ENTER RESET to save the setting and return to the main menu.

   If you selected **ON**, continue with Step 5.

5. Press and release POWER ENTER RESET. The Set Password Screen appears. The factory set pass password of 0000 is at the bottom of the screen with the first 0 flashing.

SET PASSWORD
0000

6. Use AIR ▲ YES or RANGE ▼ SHIFT to display a number from 0 to 9.
7. Press and release POWER ENTER RESET to enter the selection and advance to the next number.
8. Repeat Step 6 and Step 7 to select the remaining numbers. When you press and release POWER ENTER RESET to enter the last number, the password is saved and you return to the main menu.

Restoring the Default Settings

Each of the EAGLE 2 setup parameters, such as the auto calibration values, zero and span settings, or parameters in Setup Mode, has a default setting. For the items in Setup Mode, the default settings are the same as the standard factory settings. If you want to return the EAGLE 2 to its default configuration, it is possible to do so by using the Default Settings menu item in Setup Mode. Returning the EAGLE 2 to its default configuration can be useful if various setup parameters have been changed in the field and you want to return the EAGLE 2 to its original configuration as shipped from the factory.

The standard default gas configuration is LEL/oxygen/H_2S/CO. If you have turned any channels off or have added channels to your EAGLE 2, you will have to re-setup your EAGLE 2 to the desired gas combination if you restore the EAGLE 2 to its default configuration.

There are some special EAGLE 2 configurations that may have a different default configuration than the standard. Consult RKI Instruments, Inc. for information regarding non-standard default configurations.

WARNING: ***When the EAGLE 2 is restored to its default configuration, the zero and span values for each channel are reset. You must recalibrate all active channels if you restore the EAGLE 2 to its default configuration.***

1. From the main menu, place the cursor in front of **DEFAULT SETTINGS**.
2. Press and release POWER ENTER RESET. The Restore Default Configuration? Screen appears asking if you want to restore the default configuration.

RESTORE DEFAULT CONFIGURATION?

3. If you do not want to restore the default configuration, press and release DISPLAY ADJUST NO to return to the main menu.

   If you do want to restore the default configuration, continue with Step 4.
4. Press and release AIR ▲ YES. A screen appears asking you to confirm that you want to restore the default configuration.

ARE YOU SURE YOU WANT TO SET DEFAULT CONFIGURATION?

5. Press and release AIR ▲ YES. The screen will indicate that the default configuration has been restored and return to the main menu.

Updating the Lunch Break Setting

With **LUNCH BREAK** set to **OFF** (factory setting), the EAGLE 2 automatically starts new TWA and PEAK reading collection and resets the time in operation at startup.

With **LUNCH BREAK** set to **ON**, the Resume Measurements Screen displays during startup. From this screen, you can choose to continue accumulating TWA and PEAK readings and the time in operation from the last time the EAGLE 2 was used or start collecting new readings and reset the time in operation.

1. From the main menu, place the cursor next to **LUNCH BREAK.**
2. Press and release POWER ENTER RESET. The Lunch Break Screen appears.

LUNCH BREAK
UP/DOWN THEN ENTER
OFF

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Span Factor Setting

With **SPAN FACTOR** set to **ON** (factory setting), the EAGLE 2 will display the span adjustment range for a sensor in the calibration results screen while in Single Calibration. The span adjustment shows how low and how high the reading could have been adjusted.

With **SPAN FACTOR** set to **OFF**, this span adjustment does not appear in the calibration results screen.

1. From the main menu, place the cursor next to **SPAN FACTOR**.
2. Press and release POWER ENTER RESET. The Span Factor Screen appears.

```
SPAN FACTOR DISPLAY

UP/DOWN THEN ENTER

ON
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Language Setting

This setting allows you to select the language for the EAGLE 2's user interface. The available choices are English (factory setting), Spanish, French, Italian, and German.

1. From the main menu, place the cursor next to **SELECT LANGUAGE.**
2. Press and release POWER ENTER RESET. The Select Language Screen appears with the cursor in front of the current language.

```
  SELECT LANGUAGE
> ENGLISH
  ESPANOL
  FRANCAIS
  ITALIANO
  DEUTSCH           ▼
```

3. Use AIR ▲ YES or RANGE ▼ SHIFT to move the cursor in front of the desired language.

   If you do not wish to select a new language, either press and release DISPLAY ADJUST NO or move the cursor all the way to the bottom of the list in front of **END** and press and release POWER ENTER RESET. The unit will return to the main menu.
4. Press and release POWER ENTER RESET to save the new language setting and return to the main menu. The EAGLE 2's user interface will now be in the newly selected language.

NOTE: If you select a language other than English, a prompt will appear during startup that allows you to change the language back to English if desired.

Exiting Setup Mode

1. From the main menu, place the cursor in front of **NORMAL OPERATION** at the bottom of the menu.
2. Press and release POWER ENTER RESET.
3. A screen appears that asks if you want to save the changes you have made.

```
SAVE ALL CHANGES
  IN MEMORY?
```

NOTE: If you entered Setup Mode and did not make any changes, the above screen will still appear. In this case, press and release DISPLAY ADJUST NO to proceed to exit Setup Mode and begin the EAGLE 2's startup sequence.

4. If you do not want to save the changes, press and release DISPLAY ADJUST NO. The unit will begin its startup sequence without saving the changes.

   If you do want to save the changes, press and release AIR ▲ YES and continue with the next step.
5. A confirmation screen appears asking if you are sure you want to save the changes.

```
  ARE YOU SURE YOU
  WANT TO SAVE ALL
CHANGES IN MEMORY?
```

6. If you want to save the changes, press and release AIR ▲ YES to save the changes. A screen will appear for a few seconds indicating that the changes have been saved and the unit will begin its start-up sequence.

   If you do not want to save the changes, press and release DISPLAY ADJUST NO to proceed to the unit's start-up sequence without saving changes.

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RKI Eagle 2

The Eagle 2 is a next generation portable gas meter capable of measuring up to six gas combinations in real-time. The monitor includes three operating modes that include normal mode for confined space or area monitoring, borehole mode for checking underground gas leaks, and leak check mode for locating leaks in valves and pipes. Featuring an ergonomic hand-held design and glove friendly buttons, the Eagle 2 provides reliable operation in many environmental and H&S gas detection applications.

FEATURES

- **Strong internal pump – sample draw up to 125 feet**
- **Auto calibration and demand zero functions**
- **Adjustable level alarms plus TWA and STEL**
- **Methane elimination for environmental use**
- **Data logging standard**
- **Intrinsically Safe (IS) design, SCA approval**
- **EFI/EMI/Chemical/Weather resistant enclosure**
- **Multilingual – 5 languages**
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Six-Gas Portable Monitor

geotech

RKI Eagle 2

SPECIFICATIONS

Enclosure	Weatherproof, chemical resistant, RFI/EMI coated high impact polycarbonate-PBT blend. Can operate in 2.0" of water without leakage. Ergonomically balanced with rugged top mounted handle. Water & dust resistant equivalent to IP-64.
Dimensions	9.5" L x 5.25" W x 5.875" H
Weight	3.8 Lbs. (standard 4-gas with batteries).
Detection Principle	Catalytic combustion, electrochemical cell, galvanic cell, infrared, Photoionization detector, and thermal conductivity.
Sampling Method	Powerful, long-life internal pump (over 6,000 hours) can draw samples over 125 feet. Flow rate approximately 2.0 SCFH.
Display	3 display modes: display all gases, large font-autoscroll, or large font-manual scroll. Polyurethane protected overlay. Backlight, illuminates for alarms and by demand, with adjustable time.
Language	Readout can display in 5 languages (English, French, German, Italian, or Spanish).
Alarms	2 Alarms per channel plus TWA and STEL alarms for toxics. The two alarms are fully adjustable for levels, latching or self reset, and silenceable.
Alarm Method	Buzzer 95 dB at 30 cm, four high intensity LED's.
Controls	4 External glove friendly push buttons for operation, demand zero, and auto-calibration. Buttons also access LEL/ppm, alarm silence, peak hold, TWA/STEL values, battery status, conversion factors, and many other features.
Continuous Operation	At 70°F, 18 hours using alkaline batteries, or 20 hours using NiMH.
Power Source	4 alkaline or NiMH, size C batteries (Charger has alkaline recognition to prevent battery damage if charging is attempted with alkalines).
Operating Temp. & Humidity	-20°C to 50°C (-4°F to 122°F), 0 to 95% RH, non-condensing.
Environmental	IP-64
Response Time	30 Seconds to 90% (for most gases) using standard 5 ft. hose.
Safety Rating	Intrinsically Safe, Class I, Groups A, B, C, D. Approvals: CSA/CE
Standard Accessories	Shoulder strap, alkaline batteries, hydrophobic probe, and 5 foot hose, internal hydrophobic filter.
Optional Accessories	• Dilution fitting (50/50) • NiMH batteries • Battery charger, 115 VAC, 220 VAC, or 12 VDC (charge time 4 hours) • Continuous operation adapter, 115 VAC or 12 VDC • Extension hoses • IRDA cable for datalogging download
Warranty	Two year material and workmanship, one year for PID sensor.

The EAGLE 2 can be configured with up to 6 gas sensors from the list below.

Gases & Detectable Ranges

Gas	Measuring Range	Accuracy *Which ever is greater
Standard Confined Space Gases		
Hydrocarbons (CH_4, std)	0-100% LEL 0-5% Vol. (CH_4)	±5% of reading or ±2% LEL (*)
	0-50,000 ppm	±50 ppm or ±5% of reading (*)
Oxygen (O_2)	0-40% Vol.	±0.5% O_2
Carbon Monoxide (CO)	0-500 ppm	±5% of reading or ±5 ppm CO (*)
Hydrogen Sulfide (H_2S)	0-100 ppm	±5% of reading or ±2 ppm H_2S (*)
Toxics		
Ammonia (NH_3)	0-75 ppm	±10% of reading or ±5% of full scale (*)
Arsine (AsH_3)	0-1.5 ppm	
Chlorine (Cl_2)	0-3 ppm	
Hydrogen Cyanide (HCN)	0-15 ppm	
Phosphine (PH_3)	0-1 ppm	
Sulfur Dioxide (SO_2)	0-6 ppm	
IR Sensors		
Carbon Dioxide (CO_2)	0-10,000 ppm 0-5% Vol. 0-60% Vol.	±5% of reading or ±2% of full scale (*)
Methane (CH_4)	0-100% LEL/ 0-100% Vol.	
Hydrocarbons	0-100% LEL/ 0-30% Vol.	
PID Sensors		
VOC	0-2,000 ppm 0-50 ppm	—
TC Sensors		
Methane (CH_4)	0-100% Vol.	±5% of reading or ±2% of full scale (*)
Hydrogen (H_2)	0-10% Vol. 0-100% Vol.	
Hydrogen Specific		
Hydrogen (H_2)	0-100% LEL 0-40,000 ppm	±5% of reading or ±2% of full scale (*)

Specifications subject to change without notice.

CALL GEOTECH TODAY (800) 833-7958

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Deployment notes

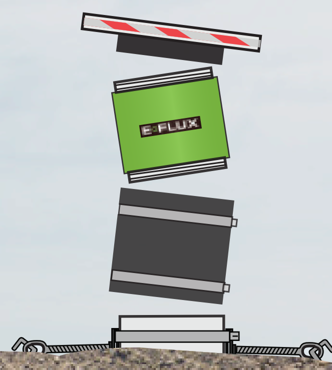
- Keep the traps upright.
- The travel blank should not be opened.
- Turn off the irrigation system a week before deployment.
- Avoid saturated soils and/or standing water.
- Traps are moisture-resistant but not waterproof. Keep dry.
- Keep the traps capped unless deployed.
- The recommended deployment period is 14 days with a deployment range of 3-28 days.

Retrieval notes

- If heavy rain is predicted, retrieve the traps before the rain event.
- Shipper is obligated to disclose if the traps have been in contact with contaminant before shipping back to E-Flux.
- Cap the traps with the originally provided solid caps.
- Before capping the traps, remove insects and organic matter.
- Keep the traps upright.
- Fill in the retrieval information on the chain-of-custody form(s).
- Remove the travel blank from the ziplock bag and place it in the cooler before shipping the cooler back to E-Flux.
- The travel blank is never opened.
- Keep the field components for future rounds of testing.
- Do not use ice to preserve the traps.
- Expedited shipping is optional.
- Ship traps to:

  E-Flux
  200 W Lake Street, RIC 0922
  Fort Collins, CO 80523-0922

  (970) 492-4360



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Fossil Fuel Trap:
4-inch receiver with stabilizing tensors

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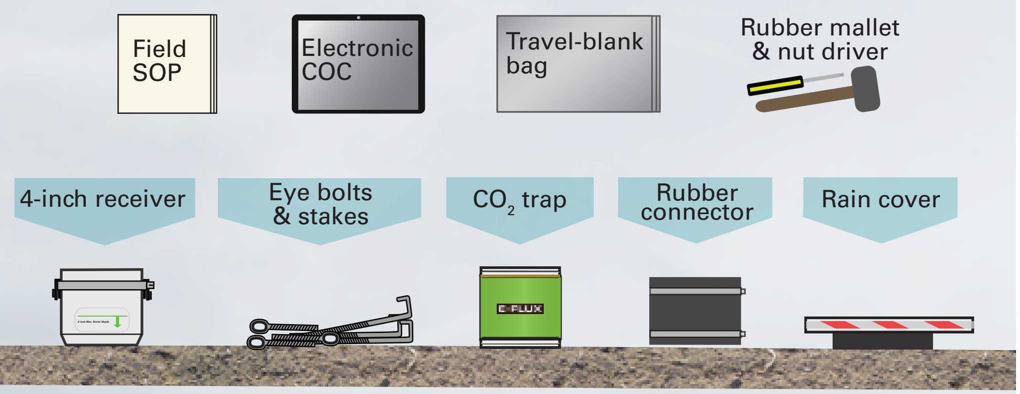
Fort Collins, CO 80523-0922

(970) 492-4360
info@soilgasflux.com

Provided equipment

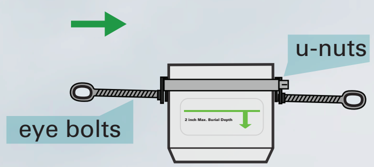


Receiver installation

1

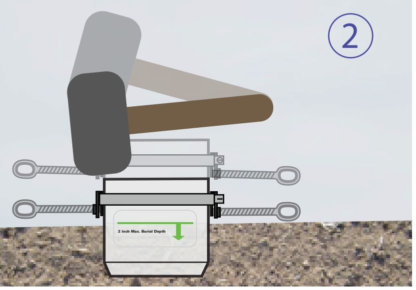
Tighten the eye bolts through the u-nuts.

Place the beveled side of the 4-inch receiver vertically on the ground.



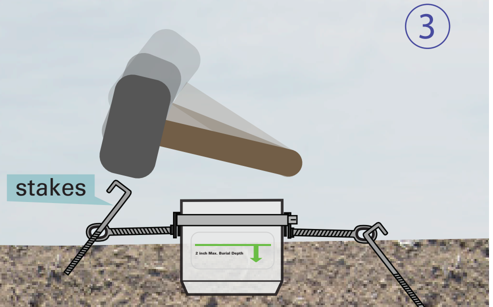
2

Using the rubber mallet, hammer the receiver two inches into the ground. Keep the receiver vertical. If the soil is too hard for the receiver to penetrate, use a knife to cut a ring in the soil.



3

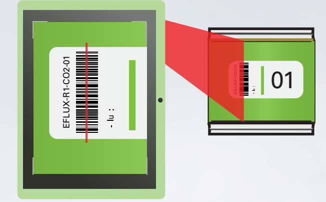
Hammer the stakes through the eye screws on a 45° angle.



Trap deployment

1

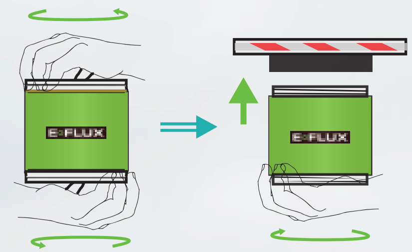
Use the electronic and paper chain-of-custody forms to record deployment information for each trap.



2

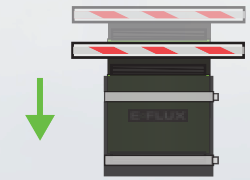
Remove the top and bottom caps from the trap.

Screw the rain cover on the top side of the trap.



3

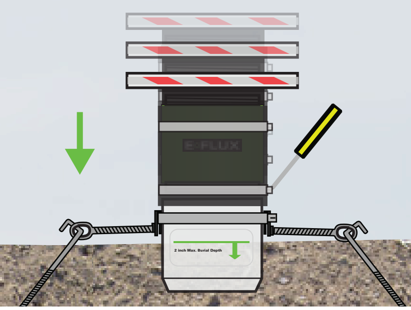
Slide the trap into the rubber connector.



4

Slide the trap and rubber connector into the installed receiver pipe.

Tighten the top and bottom clamps of the connector with the nut driver.



5

After all traps are deployed, scan the travel blank and place it in the provided ziplock bag. Then place it in the provided cooler.

Do not open the travel blank.

Keep the trap upright.

Appendix C

Responses to Ecology Comments

DRAFT RESPONSE TO COMMENTS ON
LNAPL TRANSMISSIVITY, BIOVENTING RESPIROMETRY, AND NSZD TESTING WORK PLAN

Comments from:
John Mefford, Cleanup Project Manager, CRO Toxics Cleanup Program, State of Washington Department of Ecology, 23 July 2019 and additional comments received 14 August 2019.

Comment Number	Section	Ecology Comment	BNSF Response
General Comments			
1		Ecology views the proposed tests favorably in that the results will help inform the remedial alternatives for the Feasibility Study. However, we do not view the remedial options that these tests may support as a presumptive remedy. Specifically, we consider Natural Source Zone Depletion (NSZD) in its role as a polishing component that may potentially be implemented at the end of an active remedial effort or possibly in conjunction with more active remedial components since the Columbia River/Lake Celilo is a surface water receptor.	BNSF currently does not have a presumptive remedy for the site. Comment is noted.
2		How long the source(s) will last is a key question. Ecology eventually expects the NSZD rates will be coupled with estimates of NAPL source mass so that a restoration timeframe as one of the criteria under WAC 173-340-360 (Selection of cleanup actions) can be calculated. An alternate method may be to look at average TPH concentration divided by the NSZD rate. It may also be necessary to evaluate the microbial kinetics of substrate contaminant utilization to assist in the prediction of the time required to bioremediate the site. It may be necessary to incorporate thermal or other enhancements to reduce the restoration period. Garg, et. al, 2017 (GWMR 37, No. 3, pp. 62-81) attempted to answer a number of relevant questions that may improve understanding of NSZD. The answers they obtained may assist for optimization of NSZD as a proposed remedy component.	Comment is noted.
3		The RI investigation had had a number of LIF co-located soil sample collections but core sampling for determination of TPH saturation was limited to three cores. Determination of pore fluid saturations across the smear zone and through the soil column in the groundwater zone of submerged NAPL is an important parameter to assess.	Core sampling was performed in 2013 from three (3) co-located LIF locations (TG-D6, TG-F2, and TG-F6) and in 2016 from soil borings for the four (4) OHM wells (OHM-1 through OHM-4). Please see Table 24 of the *Draft Remedial Investigation Report BNSF Wishram Railyard (Ecology Site Name BNSF Track Switching Facility) Wishram, Washington* (Draft RI Report) (KJ 2019).

DRAFT RESPONSE TO COMMENTS ON
LNAPL TRANSMISSIVITY, BIOVENTING RESPIROMETRY, AND NSZD TESTING WORK PLAN

Comments from:
John Mefford, Cleanup Project Manager, CRO Toxics Cleanup Program, State of Washington Department of Ecology, 23 July 2019 and additional comments received 14 August 2019.

Comment Number	Section	Ecology Comment	BNSF Response
Section 2: Scope of Work			
4	**Section 2.1, LNAPL Transmissivity Testing**	You mention results of laboratory testing of LNAPL physical properties and simulations of in situ LNAPL behavior. What are the simulations and are these simulations in the RI report?	Results of LNAPL fluid sampling and soil core analyses from samples collected in 2013 and 2016 are presented in Section 2.3.3.4 of the Draft RI Report. Simulations are discussed in Section 2.3.3.4.4. The American Petroleum Institute (API) LNAPL distribution and recovery model (LDRM) based on a formulation by Charbeneau (2003) was used to evaluate LNAPL transmissivity, discharge rate, and recoverability. **Ecology response (08/14/2019)**: Adamski et al., 2005 states that the significant assumptions required by the LDRM model is homogeneity of the medium, vertical equilibrium of the NAPL/groundwater system, and unconfined/water table ground water conditions. Section 2.2.7.3 (Groundwater Flow Evaluation) of the draft RI Report indicates that Figure 30B has graphs that illustrate there are consistent, short time span fluctuations. Table 15, (Vertical Hydraulic Gradient Measurements) of that same report also shows that the vertical gradient varies in time at each reported well. Per ASTM 2856, Section X3.2.2.1, equilibrium LNAPL thickness in the well allows the user to derive the capillary head between the fluid couplets of interest. Based on that statement, the opposite could be stated in that non-equilibrium conditions would not allow one to derive the capillary head between the fluids or would cast doubt on the results at the least. According to ASTM E2856, Section 4.2.1.1, tidal influences and a vertical gradient on the water table affect measurements and could distort the transmissivity results. Wouldn't the fluctuation of dam-controlled lake levels be similar to tides in that the water level is variable on the order of hours or days? Appendix X1 of this ASTM standard discusses considerations regarding the determination of transmissivity in that type of environment. Given this information, does the condition of vertical equilibrium between the in-well NAPL and formation NAPL hold such that we can say it represents quasi-equilibrium conditions such that we can have confidence in the output of the LDRM? [Adamski et al., GWM&R 25, no. 1:100-112; ASTM E2856, *Standard Guide for Development of Conceptual Site Models and Remediation Strategies for Light Nonaqueous-Phase Liquids Released to the Subsurface*} ***Response:*** Comments are noted. Evaluation of the LNAPL baildown test data will include review of water level data collected by transducers installed in monitoring wells near OHM wells and in the Columbia River (1 transducer). Per ASTM 2856 X1.3.2, due to the expected low transmissivity, Kennedy Jenks is evaluating LNAPL transmissivity over a long (multiple months) timeframe. Given that the river stage changes are random, unpredictable, and of low magnitude (+/- a few feet) compared to the LNAPL thickness (10-30 feet thick), the impacts to LNAPL transmissivity from river stage changes are expected to be negligible. Additionally, because the LNAPL body is below the potentiometric surface and not within the smear zone, the small change in hydraulic head observed in the OHM wells is expected to have negligible impact on LNAPL migration into/out of wells.

DRAFT RESPONSE TO COMMENTS ON
LNAPL TRANSMISSIVITY, BIOVENTING RESPIROMETRY, AND NSZD TESTING WORK PLAN

Comments from:
John Mefford, Cleanup Project Manager, CRO Toxics Cleanup Program, State of Washington Department of Ecology, 23 July 2019 and additional comments received 14 August 2019.

Comment Number	Section	Ecology Comment	BNSF Response
5	**Section 2.1, LNAPL Transmissivity Testing**	Provide disposal documentation in the subsequent standalone report or in the Feasibility Study.	Comment is noted. Waste manifests will be provided in a results summary.
6	**Section 2.1, LNAPL Transmissivity Testing and Associated Field Form**	Provide more detail on the frequency of measurements. Our expectation is that the measurements will be collected at sufficient intervals to plot the data in the API LNAPL Transmissivity Workbook. Section 6.2.35 of ASTM E2856-13 describes a best practice for the frequency of measurement of the interfaces. The field form provided at the end of ASTM E2856 is a more complete data collection form for each well location than the simplified field form in the draft Work Plan. Our expectation is that sufficient data will be collected to enter the data into the API LNAPL Transmissivity Workbook and that data will be presented to Ecology as part of a deliverable, either as a standalone document or as an appendix to the Feasibility Study.	LNAPL baildown testing results will be evaluated using the API LNAPL Transmissivity Workbook. Measurements will be collected on an appropriate frequency, based on the high viscosity of the LNAPL, using a field form similar to that provided in ASTM E2856-13. Text will be revised as follows: *"Depths to air/LNAPL and LNAPL/groundwater interfaces will be measured using an oil/water interface probe prior to LNAPL removal. LNAPL baildown testing will be performed at OHM wells containing apparent LNAPL thicknesses greater than 0.5-foot (expected to include OHM 1, OHM-2, and OHM-3). The field protocol for measuring the depths to air/LNAPL and LNAPL/water interfaces involves freezing the oil/water interface probe in distilled water using dry ice, lowering the probe through LNAPL, allowing ice to melt, and then slowly retrieving the probe until encountering the LNAPL/water interface. Due to the time involved in these manual measurements (up to 1 hour), fluid and LNAPL recharge into the well will also be monitored using a level logging pressure transducer to record the potentiometric surface and an oil/water interface probe to gauge the depth to the top of the fluid column (e.g. air/water or air/LNAPL interface). The pressure transducer will be suspended in the well below the initial LNAPL/groundwater interface."* And later in same section: *"Following LNAPL removal, the depth to air/LNAPL interface will be measured at intervals of approximately 1 to 2 minutes for the first 30 minutes, 5 minutes for the next 30 minutes, 1 to 3 hours for the remainder of the first day, and approximately 2 to 4 times per day for 3 to 4 days. It is anticipated that manual measurement of the depths to air/LNAPL and LNAPL/groundwater interfaces will be performed at increasing time intervals following LNAPL removal and will be continued intermittently (weekly to monthly depending on field results), for four consecutive intervals after initiating the test."*

DRAFT RESPONSE TO COMMENTS ON
LNAPL TRANSMISSIVITY, BIOVENTING RESPIROMETRY, AND NSZD TESTING WORK PLAN

Comments from:
John Mefford, Cleanup Project Manager, CRO Toxics Cleanup Program, State of Washington Department of Ecology, 23 July 2019 and additional comments received 14 August 2019.

Comment Number	Section	Ecology Comment	BNSF Response
7	**Section 2.2, Respirometry Testing - Existing Bioventing System**	a. You state that periodic monitoring of injection flow rates and induced pressures was performed at wells, WMW-3, -7, -8, and -12 in 2018 and 2019. However, I have been unable to find any reference to this remedial action in the RI Work Plan or its Addendum and to my knowledge, this data has not yet been submitted to Ecology. If not, please submit this data. b. The draft plan states that the estimated radius of influence (ROI) of the existing system is approximately 90 feet, based on wellhead pressure measurements. This distance sounds relatively high. Is this ROI determined for soil vapor extraction or for bioventing? c. Per the USACE manual, the ROI should differ depending on whether the system is SVE or BV. For bioventing, the oxygen ROI is a function of both air flowrates and oxygen utilization rates so it depends on site geology, well design, and microbial activity. d. Each well labeled as soil vapor extraction is screened entirely within the vadose zone with a screen interval between 3 to 4 feet in length. Each well labeled air sparge is screened entirely in the saturated zone and has a screen interval of about 2.5 feet. In contrast, wells, WMW-3, -7, -8, and -12 are screened into the saturated zone as shown in Table 1. These latter wells were not designed initially for respirometry testing. What is the effect of having a screened interval that extends from vadose zone into the saturated zone? What is the effect of having the majority of the screened interval extending into the saturated zone? e. In addition, according to Leeson and Hinchee (1996), Vol. 2, Section 2.6, states that proper construction is essential for monitoring localized pressure and soil gas concentrations. They state: *"To the extent possible, the monitoring points must be located in contaminated soils with greater than 1,000 mg/Kg of total petroleum hydrocarbon. If monitoring points are not located in contaminated soil, meaningful in situ respiration data cannot be collected."* Can you verify that these well placements exist in areas where TPH is present at those concentrations?	a. Data will be provided to Ecology along with results from Work Plan activities. b. The ROI is determined for air injection via the current bioventing system using the criteria specified in the Work Plan (i.e., measured minimum of 0.1 inches of water pressure response). **Ecology response (08/14/2019)**: I note that the work plan only mentions one wellhead (WMW-8) as the only location where you measured a water pressure response. That evaluates in one direction away from the SVE well, SVE-12-1, while Figure 21, for example, shows the distribution of contamination extending southwards. That line from SVE-12-1 to WMW-8 is generally transverse to the majority of the contaminant mass that resides in the smear zone. I presume that you are relying on the assumption of homogeneity as applicable in the other directions. ***Response:*** The pressure ROI has been determined based on induced pressure measurements at three wells (WMW-7, WMW-8, and WMW-12). Text will be revised as follows: *"System operational data collected between November 2017 and May 2019 is provided in Table 2. Soil gas measurements collected on 28 and 29 November 2017, before and after replacement of the system blower, are provided in Table 3. The average induced pressures at the monitoring wells between November 2017 and May 2019 have been approximately 0 (WMW-3), 0.04 (WMW-12), 0.2 (WMW-8), and 1.9 (WMW-7) inches of water. Using a criterion of 0.1 inches of water, the estimated radius of influence (ROI) of the system is approximately 90 feet, based on wellhead pressure measurements at or above 0.1 inches of water at well WMW-8, located approximately 90 feet from injection well SVE-12-1."* c. Comment is noted. Note, bioventing can be performed either by injecting or extracting air. Under extraction operations, bioventing is equivalent to SVE. d. Selection of wells for respirometry testing is based on location (wells within the pressure ROI) and having open screen above the groundwater table. Because the test measures concentration in soil gas at depth, and there is no lithologic barrier between vadose zone and shallow groundwater, there is not expected to be an impact to the measurements from the various screen interval types. e. Soil samples were not collected for laboratory analysis from the soil borings for the SVE-12-# series wells nor from WMW-7 and WMW-8. Available field and laboratory data are briefly summarized below and in the Draft RI Report: A strong petroleum odor and sheen were observed at 9 feet bgs in the WMW-7 boring and at 10 feet bgs in the WMW-8 boring, indicating concentrations were likely above 1,000 mg/kg. Apparent LNAPL thicknesses were measured in both wells, ranging 0.01 to 1.50 feet between 2004 and 2015 in well WMW-7, and 0.02 to 0.20 feet between 2012 and 2016 in well WMW-8 (Table 9). Soil samples at depths of 8, 10, and/or 12 feet bgs were collected from borings #7, #9, #10 (in 2002), and WSB-2 (in 2003), which were located in the vicinity of SVE-12-3 and SVE-12-4. Results for these samples were above 1,000 mg/kg for DRO and/or ORO (see Table 18 of Draft RI Report). Note: DRO and ORO were below reporting limits in a soil sample collected from 9.5 to 10 feet bgs in boring B-18-25 (in 2018) in a similar location to WSB-2 and apparent LNAPL thicknesses have not been measured in wells WMW-7 or WMW-8 since 2016.

DRAFT RESPONSE TO COMMENTS ON
LNAPL TRANSMISSIVITY, BIOVENTING RESPIROMETRY, AND NSZD TESTING WORK PLAN

Comments from:
John Mefford, Cleanup Project Manager, CRO Toxics Cleanup Program, State of Washington Department of Ecology, 23 July 2019 and additional comments received 14 August 2019.

Comment Number	Section	Ecology Comment	BNSF Response
8	**Section 2.2.1, Baseline Soil Gas Measurements**	a. Will this step assess the vadose zone gas composition that is necessary to determine before application of the carbon traps? b. Page 53 of Sweeney and Ririe, 2017 shows a well cap with valves. I assume you will install this type of cap with discrete sampling ports. Please confirm this detail. The USACE engineering manual, EM-1101-1-4001, shows an alternate wellhead completion design (Figure 5-19, pa 169). c. With the existing bioventing system, did you obtain baseline soil gas measurements as well as measurements collected periodically to ensure that the system is delivering enough oxygen to meet the demand produced by biodegradation? If so, provide this data. If available, have you tracked the relative volatility shift in the petroleum hydrocarbon fingerprint of the soil vapors? d. I did not see any monitoring points near the existing system that would allow periodic monitoring of the soil gas. According to the USACE Engineering Manual, Soil Vapor Extraction and Bioventing (EM-1110-1-4001, 2002), a *"sufficient number of monitoring points must be properly place to determine if vadose zone oxygen levels are being maintained*." e. With the existing system, have you assessed rebound after system shutoff and/or have you assessed whether the oxygen uptake rates have declined over time? Rebound may indicate presence of diffusion-limited soils. Have you assessed the target soil concentration by any other method?	a. Yes, this step will provide background data for carbon traps. b. A vapor monitoring well plug from www.envirodesignproducts.com or modified well cap with valves/hose barb fittings will be used for soil gas sampling. Text will be revised as follows: *"At least one day prior to soil gas measurements, either vapor monitoring well plugs or modified well caps with barbed fittings will be installed at the wells selected for monitoring to allow collection of soil gas measurements. A RKI Eagle 2 multi-gas meter, or similar, will be used for soil gas measurements. Soil gas VOC concentrations will be measured using a photoionization detector (PID). The operating manual for the RKI Eagle 2, including documentation regarding instrument calibration, and KJ's standard operating guideline (SOG) for PID measurements are provided in Appendix B."* c. Soil gas data exists from startup after replacing the blower in 2017 and from this proposed test in 2019 only. Baseline data, prior to system installation / startup in 2012 was not collected. **Ecology response (08/14/2019)**: Please provide the data that was obtained after the blower replacement in 2017 in the subsequent report. ***Response:*** Bioventing system operational data collected between 28 November 2017 and 7 May 2019 have been included in a new Table 2 and soil gas data from 28 and 29 November 2017 in a new Table 3 in the Work Plan. d. Existing wells (SVE-12-# and monitoring wells) are being used for this purpose. e. No. Respirometry tests have not been conducted on the current system so it is not possible to evaluate change in oxygen utilization over time.

DRAFT RESPONSE TO COMMENTS ON
LNAPL TRANSMISSIVITY, BIOVENTING RESPIROMETRY, AND NSZD TESTING WORK PLAN

Comments from:
John Mefford, Cleanup Project Manager, CRO Toxics Cleanup Program, State of Washington Department of Ecology, 23 July 2019 and additional comments received 14 August 2019.

Comment Number	Section	Ecology Comment	BNSF Response
9	**Section 2.2.1, Baseline Soil Gas Measurements**	a. What is the sensitivity of the RKI Eagle 2 multi-gas meter in parts per million for assessing the concentrations of oxygen, carbon dioxide, hydrogen sulfide, and methane? b. Will you follow a company standard operating procedure (SOP) for calibration of the multi-meter and the PID? Please include the SOP or equivalent documentation regarding instrument calibration.	a. Specification sheet and manual for the RKI Eagle 2 multi-gas meter will be included in Appendix B. Gas: Measuring Range, and Accuracy: Oxygen (O_2): 0-40% Volume (Vol.), +/- 0.5% O_2 Carbon Dioxide (CO_2): 0-60% Vol., +/- 5% of reading or +/- 2% full scale Hydrogen Sulfide (H_2S): 0-100 ppm, +/-5% of reading or +/- 5 ppm Methane (CH_4): 0-100% LEL, +/- 5% of reading or +/- 2% full scale b. Yes. The manufacturer's manual, including documentation regarding instrument calibration, and KJ's Standard Operating Guideline (SOG) for PID meter calibration will be provided in Appendix B.
10	**Section 2.2.2, Respirometry Test**	a. You mention the performance of an JSR test to estimate the biodegradation rate. Concerning the assimilative capacity of the substrate (Arcadis, Remediation Engineering: Design Concepts, 2017) are there other mass transfer limitations that may need to be assessed? b. Have you assessed any of the factors, e.g. moisture content, pH, alkalinity that may affect observed in situ biodegradation rates (Section 1.4.3 of Leeson and Hinchee, 1996)?	a. The substrate at the site is mostly comprised of fine to medium-grained silica sand. Its expected assimilative capacity is low. b. No. Further assessment of in situ biodegradation rates will inform BNSF if investigation of these factors is warranted.
11	**Section 2.3, Bioventing Test**	a. Comment #7 on proper well construction applies here for the proposed purpose of WMW-1. I was unable to find the soil analytical results for WMW-1, -3, or -11. Is the soil analytical data available? b. The plan refers to Figure I in lieu of the soil analytical data. This figure shows a footprint of dissolved-phase contamination generalized by exceedance of MTCA Method A groundwater cleanup concentrations but the footprint is not depicted with isoconcentration lines.	a. Please see text for criteria used for selection of wells WMW-1, -3, and/or -11 for the test (e.g. available screen, dissolved phase impacts, proximity to LNAPL extents). Available lab analytical results for groundwater samples from these wells is included in the Draft RI Report. No soil samples were collected for laboratory analyses. b. Comment is correct. Figure shows approximate extents of the inferred smear zone and submerged LNAPL along with dissolved phase extents. BNSF has not generated dissolved phase petroleum hydrocarbon contours.
12	**Section 2.4.1, Soil Gas Measurements**	a. You mention seven wells for respirometry tests. However, Section 2.2 lists eight wells. Please correct if this is a typo. b. The annulus space of SVE/Bioventing wells should be tightly sealed. How can you ensure that the groundwater monitoring wells to be used have a sufficient seal to prevent short-circuiting? c. Other requirements for soil gas monitoring points and bioventing wells are listed in the USACE Engineering Manual, EM-1110-1-4001. Does the construction of the groundwater wells meet these criteria? d. How do you know that 4 days is sufficient time for the soil gas to reach equilibrium after system shutdown? Is this an arbitrary number or is it based on empirical data?	a. Seven wells is correct. Wells WMW-3 and WMW-12 are both located outside the pressure-based ROI; well WMW-12 has been retained for background comparison. Text will be revised as follows: *"Proposed wells for respirometry testing include injection wells SVE-12-1 through SVE 12 4, monitoring wells WMW-7 and WMW-8, which are located within the system's ROI, and monitoring well WMW-12, which is not located within the ROI, but will be included to provide background data for comparison."* b. Wells were installed in accordance with Ecology guidelines and have competent seals. Additionally, the native material is fine- to medium-grained sands and is relatively permeable given the estimate ROI of the northern system. As such, short circuiting is not expected to be a concern. However, the estimated ROI based on monitoring data collected will further inform BNSF of potential test issues. c. In general, yes. Wells are constructed with PVC, the annulus is backfilled with sand and sealed with bentonite. Well diameters may be different from the USACE document as their original intent was not for a bioventing system. d. USEPA Manual, Principles and Practices of Bioventing Volume II: Bioventing Design (EPA/540/R-95/534a, Sept 1995) was reviewed for respirometry test guidance. According to this document, the in-situ respiration test should be terminated when the oxygen level is about 5 percent, or after 5 days of sampling. Monitoring frequency will be every 1 to 4 hours the first day, and every 4 to 12 hours thereafter depending on rate of oxygen use. Measurement frequency will be determined in the field based on review of data collected.

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Comment Number	Section	Ecology Comment	BNSF Response
13	**Section 2.4.2, Carbon Traps**	a. The proposed CO2 passive traps have a two-week sampling period. Will this period only provide a snapshot of the intrinsic biodegradation rate? Temperature is a significant factor in biodegradation. Therefore, the timing of this test will capture the highest biodegradation rates when the ambient temperatures are near their highest. Are there plans for more than one two-week sampling event? b. Do you intend to use other methods in lieu of having multiple two-week events to obtain a better annual representation of intrinsic biodegradation? For instance, long-term thermal monitoring using an existing well may provide information applicable throughout the year. In addition, the thermal monitoring can be coupled with source mass estimates for evaluation of the longevity of impact if NSZD is proposed as a remedy component. c. At a minimum, will groundwater temperature be measured in the nearest wells when performing the flux measurements?	a. Yes, it is a snapshot in the sense of 2 weeks out of 52 weeks. The purpose of the test is to evaluate whether significant biodegradation is occurring. Pending results, an additional test may be performed during a colder season, with consideration of other meteorological conditions (i.e., performing during a snowy / rainy season may limit the duration of the test). b. Future monitoring efforts will be evaluated once a remedy has been selected and approved by Ecology. The purpose of this test is to help inform BNSF of the potential for remediating petroleum hydrocarbons using various methods. c. Groundwater temperature is being monitored by pressure transducers installed in multiple wells in the general vicinity of the proposed carbon trap locations. Text will be revised as follows: d. *"During trap deployment, meteorological data will be recorded from weather tracking sources in the area and groundwater temperatures will be recorded by data logging pressure transducers installed in nearby monitoring wells. "*
14	**Section 2.4.2, Carbon Traps**	a. Changes in atmospheric pressure such as high winds may influence the CO2 flux. Does evaluation of NSZD require collection of any meteorological data?	a. Meteorological data will be reviewed from weather tracking data sources for the region. NSZD evaluation does not require the collection of meteorological data, however, Ecology is correct that it can impact the carbon traps. BNSF is conducting the test to inform the FS of the relative magnitude of biodegradation. Meteorological events are not expected to have a significant impact on the results, based on their intended use. As indicated in Section 2.4.2.1, if a rain event is predicted that could result in saturation of the surface soil, then the deployment duration may be less than two weeks.
15	**Section 2.4.2, Carbon Traps**	a. You did not include a duplicate sample at any of the NSZD locations. I recommend collection of a duplicate sample at one of the sample locations for assessment of variability in the data.	a. In our experience, field duplicate carbon trap samples have not been collected during carbon trap investigations at other facilities. For this initial assessment to inform the FS of the relative magnitude of biodegradation, duplicate sampling locations were not proposed. Two background trap locations are proposed for comparison to traps located in impacted areas. The laboratory will perform the following quality control and quality assurance procedures: duplicate total carbon analyses, travel blank analysis, and confirmation that the top sorbent layer has not been saturated (i.e., the bottom layer has not been contaminated with atmospheric CO_2).