FINAL
03 FEBRUARY 2017

Air Sparge and Soil Vapor Extraction System
Operations & Maintenance Manual
Joint Base Lewis-McChord Area of Concern 9-2
Lewis North Credit Union

Joint Base Lewis-McChord
Pierce County, Washington

Joint Base Lewis-McChord Public Works – Environmental Division
IMLM-PWE
MS 17 Box 339500
Joint Base Lewis-McChord, Washington 98433
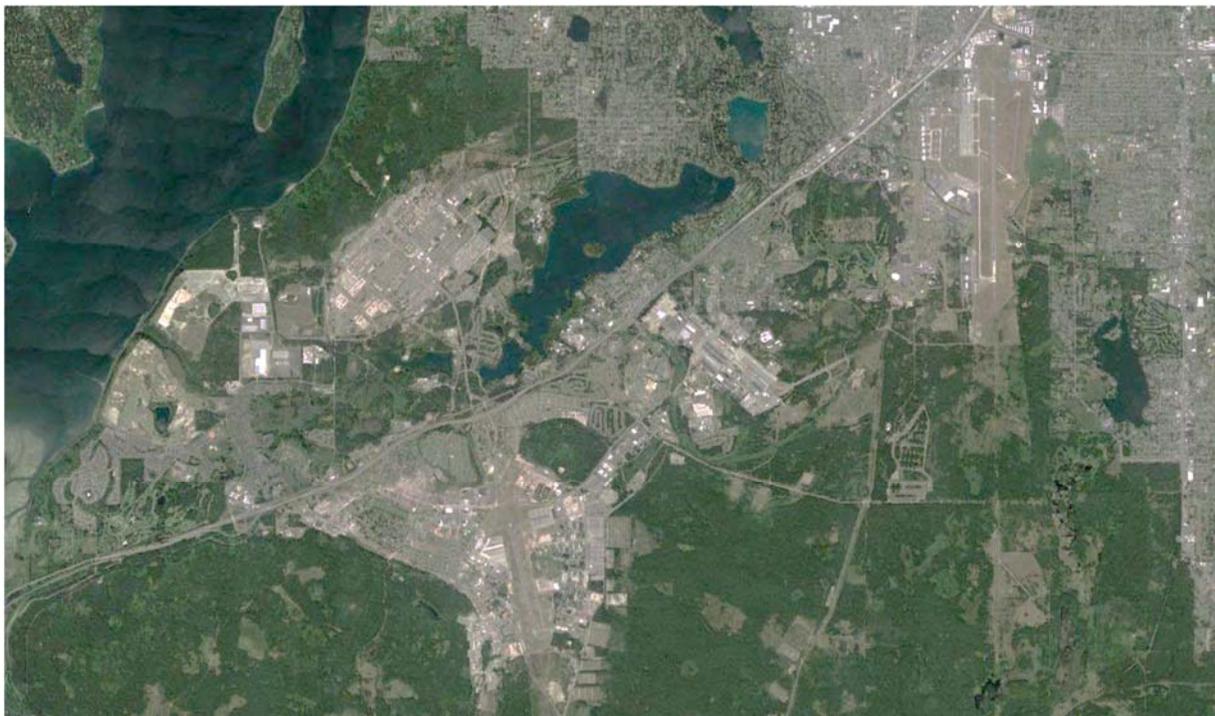
DEPARTMENT OF THE ARMY
HEADQUARTERS, JOINT BASE LEWIS-MCCHORD
1010 LIGGETT AVENUE, BOX 339500, MAIL STOP 14A
JOINT BASE LEWIS-MCCHORD, WA 98433-9500

REPLY TO
ATTENTION OF

February 3, 2017

Public Works

Mr. Charles Hoffman
Washington Department of Ecology
Attention: Hazardous Waste & Toxics Reduction
PO Box 47775
Olympia, Washington 98504-7775

Dear Mr. Hoffman:

Enclosed for your review is one paper copy of the <u>Final Air Sparge and Soil Vapor Extraction System, Operations and Maintenance Manual, Joint Base Lewis-McChord Area of Concern 9-2, Lewis North Credit Union</u>. This final version incorporates revisions per your comments received on January 12, 2017.

If you have any questions or need clarification, please contact me at (253) 477-3742.

Sincerely,

GHEBRESLLASSIE.MESERET.C.101   Digitally signed by GHEBRESLLASSIE.MESERET.C.1015675159
5675159   DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA,
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Meseret C. Ghebresllassie
Installation Restoration Program Manager
Public Works Department

FINAL

AIR SPARGE AND SOIL VAPOR EXTRACTION SYSTEM
OPERATIONS & MAINTENANCE MANUAL

JOINT BASE LEWIS-MCCHORD AREA OF CONCERN 9-2
LEWIS NORTH CREDIT UNION

CONTRACT NO. W912DW-11-D-1031, TASK ORDER 0001

FEBRUARY 3, 2017

JOINT BASE LEWIS-MCCHORD
FORT LEWIS, WASHINGTON

SEALASKA ENVIRONMENTAL SERVICES, LLC
POULSBO, WASHINGTON

Prepared by: _____
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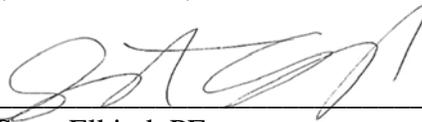
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Air Sparge and Soil Vapor Extraction System, O&M Manual   Final
Contract No. W912DW-11-D-1031   February 3, 2017
ERS Task Order 0001

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ACRONYMS AND ABBREVIATIONS

AOC	Area of Concern
AS	air sparge
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CFR	Code of Federal Regulations
DTW	depth to water
Ecology	Washington State Department of Ecology
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
FLAO	Fort Lewis Agreed Order
IA	Interim Action
IDW	Investigation-derived waste
IRP	Installation Restoration Program
JBLM	Joint Base Lewis-McChord
MTCA	Model Toxics Control Act
MW(s)	Monitoring Well(s)
PCS	petroleum contaminated soil
PID	photoionization detector
PSCAA	Puget Sound Clean Air Agency
psig	pounds per square inch gauge
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
SAP	Sampling and Analysis Plan
scfm	standard cubic feet per minute
Sealaska	Sealaska Environmental Services LLC
SSD	Sub-slab Depressurization
SSHP	Site Safety and Health Plan
SVE	Soil Vapor Extraction
SVP	soil vapor probe
TPH-G	gasoline-range total petroleum hydrocarbons

ACRONYMS AND ABBREVIATIONS (continued)

|	
µg/m^3	micrograms per cubic meter
USACE	United States Army Corps of Engineers
USAEC	US Army Environmental Command
UST	underground storage tank
VI	vapor intrusion
VOC	volatile organic compound
WAC	Washington Administrative Code
ZOI	zone of influence

1   INTRODUCTION

This document outlines a plan for operation, monitoring, and maintenance of a sub-slab depressurization (SSD), air sparge (AS), and soil vapor extraction (SVE) system installed to remediate petroleum-impacted soil and groundwater at a former fueling station (Building A1033, i.e., site Area of Concern [AOC] 9-2) on Joint Base Lewis-McChord (JBLM) [Figure 1-1]. A brief review of site history is provided, followed by an outline of the operating strategy and plan for ongoing monitoring. Conditions for varying system operating conditions and criteria for system shutdown are provided.

Figure 1-2 is the site map for the new America's Credit Union (hereafter referred to as the Credit Union). The long axis of the Credit Union building (JBLM building number 11574) is oriented southwest to northeast. For ease of discussion, the 17th Street end of the building is referred to as "north."

Conditions at AOC 9-2, the site of a former vehicle fueling station, are described in the Fort Lewis Agreed Order Draft Feasibility Study for Seven Sites (Versar 2009a) and the Remedial Investigation Report for nine Agreed Order Sites (Bussey 2008). A list of historical depth to water and field parameter measurements for eight monitoring wells (MW) at the site is provided in Appendix A, Table A-1. Historical groundwater analytical results for total petroleum hydrocarbons as gasoline (TPH-G) and benzene, toluene, ethylbenzene and xylene (BTEX) concentrations detected in six groundwater monitoring wells at AOC 9-2 is provided in Appendix A, Table A-2. Both groundwater and soils are impacted by gasoline released from the former gas station. A combined AS and SVE system was installed to promote stripping of volatile organic hydrocarbons from the groundwater and the soils in the vadose zone at the site. The SVE system is configured to also function for SSD to protect building occupants. The goal of remediation by AS-SVE is to satisfy Washington State Department of Ecology (Ecology) Model Toxics Control Act (MTCA) Method A cleanup standards for groundwater.

A pilot test, conducted in early 2012, indicated that the existing AS/SVE/SSD system is capable of effecting site remediation. Performance monitoring will continue until results indicate that MTCA cleanup levels are achieved or until volatile organic compounds (VOC) concentrations reach asymptotic conditions and no further removal is possible. Confirmation monitoring will verify that cleanup levels have been achieved. The Interim Action (IA) Work Plan (Versar 2013b) defined criteria for system shutdown, including extent of VOC removal as indicated by SVE exhaust and VOC concentrations in soil gas and groundwater.
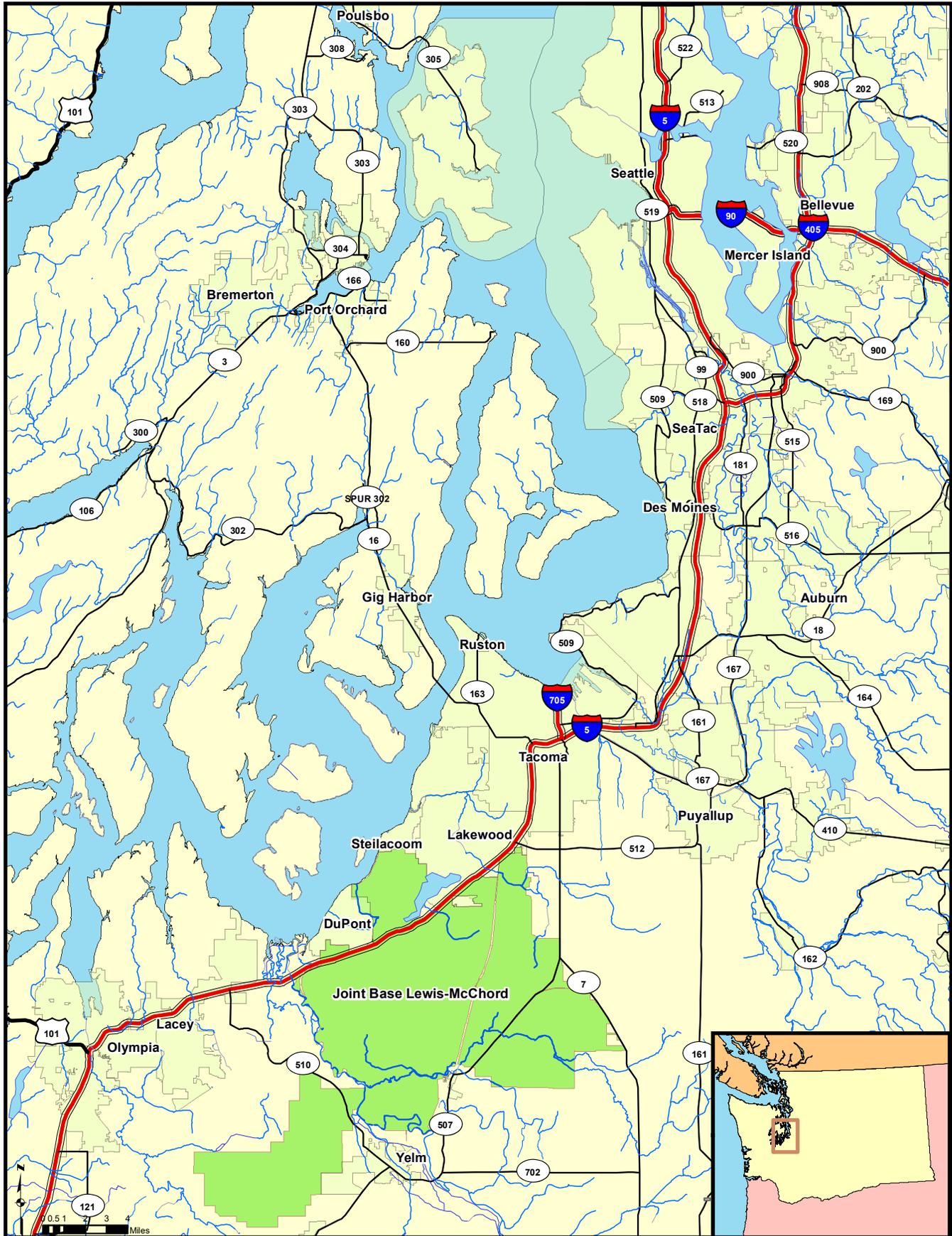
Poulsbo
308
305
303
101
303
304
166
Bremerton
Port Orchard
160
3
300
106
302
SPUR 302
16
Gig Harbor
Ruston
163
705
5
Tacoma
Steilacoom
Lakewood
DuPont
Joint Base Lewis-McChord
7
101
Lacey
Olympia
510
507
Yelm
702
121
161

522
513
5
Seattle
519
90
Bellevue
405
Mercer Island
908
202
520
900
99
900
509
518
169
SeaTac
181
515
Des Moines
516
Auburn
18
509
167
164
161
167
Puyallup
512
410
162

0.5 1   2   3   4
Miles

1-2

Figure 1-2
Location of Lewis
North Credit Union

Map Data: Coordinate System: UTM, Zone 10 Horizontal Datum: WGS 84	USACE	SEALASKA	Figure 1-2 Location of Lewis North Credit Union

Path: E:\Users\JBLM\TO 01A\Credit Union\O&M Report - 2015\Maps\SVE_Fig_1-2_LOC.mxd
Date: 5/25/2016

1.1 BACKGROUND

The former vehicle fueling station site is located on the southwest corner of the intersection of 17th Street and A Street on Lewis North (Figures 1-1 and 1-2). The station, constructed in 1967, consisted of a 10 feet x 15 feet office and a 30 feet x 60 feet metal canopy. Records indicate that two 4,000-gallon tanks were removed in 1990. Significant soil contamination was encountered during the removal of two additional 4,000-gallon gasoline underground storage tanks in 1994. As a result, 1,138 cubic yards of petroleum contaminated soil was removed at that time. Figure 1-3 illustrates the limits of the 1994 underground storage tank (UST) removal and excavation. The excavation was limited by groundwater and the foundation of the former Building A1033. A 1996 Site Assessment Report (USACE 1996) outlines events associated with the 1994 UST removal and subsequent investigations, including monitoring well installation.

In 1998 a 10,000-gallon gasoline tank, associated piping, and fuel dispenser were removed. No additional soil removal took place during the 1998 tank removal because no evidence of a release associated with this tank was discovered. The 1998 UST removal and details of associated site characterization are presented in the June 1999 Field Report for JBLM UST & Petroleum Contaminated Soil (PCS) Removal and Disposal (Garry Struthers & Associates 1999).

The building was demolished in 2002. Two additional USTs were discovered during the June 2009 excavation for construction of a Credit Union building. The USTs were located adjacent and north of the four USTs removed in 1990 and 1994. The tanks removed in 2009 were estimated to have a capacity of about 1,000 gallons each and appeared to have been closed-in-place with concrete fill. Figure 1-3 illustrates the location of the excavation limits associated with the 2009 UST removal. Six soil samples were collected from the floors and walls of the UST excavation. Laboratory results indicate that diesel is present in the soil at concentrations below MTCA Method A levels for unrestricted use.

Construction of a Credit Union building at AOC 9-2 was completed in early 2010. Because gasoline is present in groundwater underlying the site, it was elected to install a sub-slab depressurization SSD/SVE system during building construction in order to protect building occupants. Two AS wells were also installed during construction. A pilot test and vapor intrusion survey were conducted in early 2012 to evaluate the effectiveness of AS/SVE for site remediation and SSD for protection of building occupants (Versar 2012). The results of pilot testing and vapor intrusion monitoring (Versar 2013a) suggested that the existing system is sufficient to effect site remediation.

1.2   HYDROGEOLOGY

The unconfined upper Vashon Aquifer consists of glacial outwash deposits generally underlain by lower permeability Vashon Till deposits. Table 1-1 lists depth to groundwater and results of field parameter measurements. Depth to groundwater is typically 35 to 45 feet below ground surface (bgs). The regional direction of groundwater flow in the Vashon Aquifer across the JBLM Cantonment Area is generally to the west toward Puget Sound. Groundwater typically flows west to southwest toward Puget Sound at AOC 9-2. Groundwater velocity at AOC 9-2 is roughly estimated to be about 1 foot per day. There are no known potential receptors currently located downgradient of AOC 9-2.

Detailed background information is included in the Fort Lewis Agreed Order (FLAO) Remedial Investigation Report (Bussey 2008). In summary, seven monitoring wells (designated as 95-A17-1, 95-A17-2, 95-A17-3a, 95-A17-4, 96-A17-5, 96-A17-6, and 07-A17-7) were installed prior to construction of the AS-SVE system. Those wells were sampled in groundwater monitoring events conducted from 1995 to present. One additional monitoring well (10-A17-8) was completed and developed on 08 October 2010.

1.3   OPERATIONS AND MONITORING -- PURPOSE AND SCOPE

Ongoing performance monitoring will evaluate the progress of the AS/SVE system in removing VOCs from soil and groundwater, and monitor the effectiveness of the SSD system in mitigating vapor intrusion (VI).

The objective of the AS/SVE system is to remediate groundwater to MTCA guideline concentrations (Table 1-2). More important is protection of building occupants from VOC intrusion by ensuring operation of the SVE blower to maintain the SSD system.

Ongoing operation and performance monitoring performed:

- Maintain sub-slab depressurization for protection of building occupants from VOC intrusion and removal of VOCs for site remediation.

- Maximize number of daily AS cycles.

- Monitor zones of influence (ZOI) of SVE and AS systems.

- Monitor VOC concentrations in SVE exhaust.

- Monitor the effectiveness of SSD and vapor mitigation system.

- Monitor and maintain operation and performance of the SVE and AS systems.

- Observe decreases in VOC concentrations in groundwater.

Weekly operations and monitoring activities include:

- Inspection of AS and SVE blowers for pressure, flow, temperature, and any possible mechanical anomalies.

- Measurement of SVE exhaust flow and VOC concentrations by photoionization detector (PID).

- Measurement of ambient air near SVE blower for VOC concentrations by PID.

- Drain SVE knockout drum as necessary.

The primary operations and monitoring activity to be performed on a quarterly schedule:

- Download data from continuous water level monitoring probes installed in five groundwater monitoring wells at AOC 9-2. The data will be downloaded and analyzed to assess groundwater mounding effect induced by regular operation of the AS blower.

The primary operation and monitoring activities to be performed on a semi-annual schedule:

- Measure soil vapor probe pressures.

- Sample groundwater monitoring wells at AOC 9-2. Groundwater samples will be submitted to the laboratory for analysis for TPH-G and BTEX.

The primary operation and monitoring activity to be performed on an annual schedule:

- Collect indoor and ambient background air samples to assess the possibility of soil vapor intrusion into the Credit Union.

Confirmation sampling will be conducted once the results of performance monitoring indicates that MTCA groundwater cleanup standards have been met. Contingency technologies for expanding the existing system and/or stimulating in situ bioremediation may be recommended if monitoring indicates that AS/SVE operation has not removed VOCs to satisfy MTCA cleanup standards.

17th St

N

0 6 12   24
SCALE IN FEET

SVP-3a

SVP-2a

SVP-1a/b

Vacuum Port
SSD-N2

Former Bldg A1033

Well 95-A17-4

SVP-7a/b

Vacuum Port
SSD-N1

former 1000 gal
fuel oil tanks

Well 95-A17-7

Soil Vapor
Extraction Blower

Well 95-A17-3a

Vacuum Port
SSD-3

Approximate extent
of 2009 excavation

former 10,000 gal
gasoline tank

SVE-BS2

SVE-BS1

Air Sparge
Well ASW2

SVP-4a

Air Sparge
Well ASW1

SVP-5a/b

North Base
Credit Union
Bldg 11574

Rotary Vane
Blower

SVP-6a

Vacuum Port
SSD-S2

New Monitoring Well
10-A17-8

former 4000 gal
gasoline tanks

Approximate extent
of 1994 excavation

Well 95-A17-2

SVP-8a

Vacuum Port
SSD-S1

St

Figure 1-3
Limits of Tank Excavations
and Locations of Vapor
Probes and AS/SVE Systems

Figure 6 - Pilot workplan.dwg/11x17

1-7

2   SYSTEM DESCRIPTION

The remedial system consists of an SVE system supplemented by an AS system. In addition, a vapor barrier underlies the building slab. The SVE blower maintains a negative pressure under the vapor barrier and beyond the building into the parking lot. The combination vapor barrier and SVE comprise the SSD system. The AS system consists of a blower supplying two AS wells installed to strip VOCs from groundwater for extraction by the SVE blower. Figure 2-1 shows the layout of the SVE system.

2.1   VAPOR BARRIER

A polyolefin vapor barrier was installed under the entire slab during building construction. Figure 2-1, Detail 3 illustrates the building footing, vapor barrier (membrane), and underlying fill layer. Two layers of 15 mil (15/1000 of an inch) Stego Wrap, polyolefin vapor barrier were installed under the concrete floor of the building. All vapor barrier penetrations were sealed with tape. A concrete slab was poured over the vapor barrier. All slab penetrations and seams were sealed with self-leveling caulk. A series of smoke tests were performed before and after slab installation to ensure the integrity of the vapor barrier. The contractor sealed any leaks in seams and floor penetrations detected during each smoke testing event. Smoke testing and repair were repeated until no smoke leaks were observed. The combination of the sub-slab vapor barrier and sealed slab penetrations provides passive protection against fuel vapors entering the building. Vapor sampling ports penetrate the building footings at five points to allow for measurement of vacuum pressure and sub-slab air quality. Figure 2-1, Detail 3, illustrates the building footing, slab and sub-slab monitoring port.

2.2   SOIL VAPOR EXTRACTION/ SUB-SLAB DEPRESSURIZATION SYSTEM

The SVE/SSD system is designed with a three-tiered system for protection of occupants of the Credit Union building:

- A vapor barrier under the building slab.

- A positive pressure maintained inside by the building HVAC system.

- A negative sub-slab pressure maintained by the SVE blower.

Gasoline vapors are drawn into 4-inch schedule 40, perforated PVC pipe installed in two sets of lateral trenches under the slab of the new building. Trenches are installed to a depth

of about 7 feet below the concrete floor slab (Figure 2-1, Detail 2). The laterals are installed about 10 feet inside the edges of the building.

A manifold on the SVE blower suction line divides the vapor extraction laterals into north and south zones as shown in Figure 2-1. Extraction lines are equipped with pressure gauges and control valves at the suction side of the blower to allow for control of the vacuum pressure in each zone (Figure 2-2). Taps for flow elements are installed at each AS well head to measure flow (Figure 2-1, Detail 1).

The north zone is located nearest the source area and is expected to extract more VOCs. Although the lithology appears to be fairly uniform across the site, some variation in air extraction is expected between zones. Air flow and vacuum pressure can be measured for each SVE zone. Bulk soil gas VOC concentrations are measured at the SVE blower exhaust port.

The SVE system consists of a GAST R6P-350A blower housed in a small shack on a concrete pad located near the southwest corner of the site adjacent to the stormwater pond. The blower is equipped with a knock-out drum to collect condensed water vapors.

The SVE system maintains a negative pressure under the slab and vapor barrier. In addition, the building HVAC system is designed to maintain a positive pressure in the building interior. By maintaining this pressure differential over the slab and sub-slab system, soil vapors will be drawn into the underlying extraction laterals, and away from the membrane.

Approximately 95% of the building site is covered with either asphalt or concrete. The capped site minimizes infiltration of surface air, maximizing the effectiveness of the SVE system. In addition, planting areas along the building foundation are planted with grass rather than less dense shrubbery. These barriers provide an upper boundary for the SVE operation. Because most of the site is covered with asphalt or concrete, the ZOI is expected to extend under and beyond the footprint of the Credit Union and well beyond the area of contamination. This large ZOI is important, because soil vapor data indicate that VOCs are present west of the building.

2.3   AIR SPARGE SYSTEM

Figure 2-1 shows the site plan including the AS system layout. Figure 2-3 shows details of the AS blower arrangement. The AS system consists of a rotary vane blower, piping, and two vertical AS wells.

Typical Vertical Air Sparging Well Construction
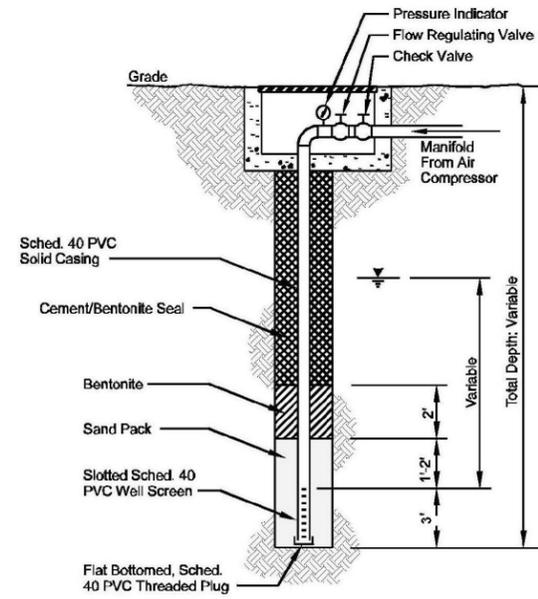
1 Air Sparge Well Construction
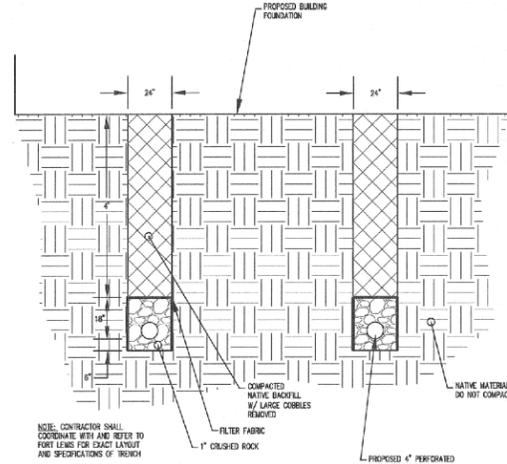
2 Vapor Extraction System Trench

3 Typical Footing

Figure 2-1
AOC 9-2
Air Sparge and Soil
Vapor Extraction Layout

USACE   SEALASKA

Map Data:
Coordinate System: UTM, Zone 10
Horizontal Datum: WGS 84

Legend

△ Soil Vapor Probe
◼ Vacuum Port
◇ Air Sparge Well
◯ Monitoring Well
◯ Monitoring Well w/Transducer

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Date: 6/6/2016

Elevation View
Scale 3/4" = 1 ft

4 in Sch 40 PVC

4 in PVC Ball Valve

Flow Meter

Vacuum Gauge

From South Lateral

GAST Model FM200 Liquid Separator 19 Gal capacity

Vacuum relief valve

2 in Sch 40 PVC

GAST Model R6P Regenerative Blower

5 ft x 4 ft shed 2x4 Construction Metal siding & roof, vented. To confrom to Fort Lewis building requirements One end/wall removable for equipment access

2 in Sch 40 PVC

6"

6'

6 in monolithic slab w/6 in woven wire

SOIL VAPOR EXTRACTION BLOWER DETAILS
Scale 3/4 "= 1 ft

19 gal GAST Model RMS 200 Liquid Separator

GAST Model R6P Blower or equivalent

4 in Sch 40 PVC

Relief valve

2 in Sch 40 PVC

4 in PVC ball valve

3/4 in drain valve

2 in rubber clamped fitting

Vent exhaust to atmosphere

208v 3 phase panel w/disconnect & w/ 5 hp starter

3'

5'

Figure 2-2
Soil Vapor Extraction Details

to Well #1

Utility Vault
Model 575-LA
by others

6"

2 in Sch 40 Steel
(steel to extend to Well #1)

Air Filter

2 inch saddle w/
access port for
vane anemometer

2 in Brass
Ball Valve

20 in min

10 in min

4'-8"

3'

Cover

P   T

0 - 40 psi
Pressure
Gauge

100-300 Deg
Temp Gauge

208v 3ph panel
w/disconnect
by others

GAST
Model 6066
7.5 hp Blower
or equivalent

3'

Note: Total vault depth w/ cover is 5 ft
Vault cover to extend min 2 inches
above final grade.

7'

2-6

AIR SPARGE BLOWER DETAILS
Scale 1 "= 1 ft

Figure 2-3
Air Sparge System
Details

Figure 10b AS&SVE Detail.dwg

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ERS Task Order 0001

The AS blower is a GAST Model 6066 compressor installed in a concrete vault located in the planting strip at the east edge of the property. The blower supplies air to the two AS wells. As discussed in the Draft Design Report (Versar 2009b), the AS compressor is sized to account for the piping and fitting head loss from the injection wells. The AS compressor discharges at over 15 pounds per square inch gauge (psig) at a minimum of 20 standard cubic feet per minute (scfm) per well.

A manifold connects the AS blower to two AS wells (Figure 1-3, ASW-1 and ASW-2). Flow control valves, flow measuring ports, and pressure gauges are installed at the head of each sparge well. Valves at the AS wells can be adjusted to balance flow and pressure to each well.

A manifold connects the air supply line to the tops of well AS-1 and well AS-2. Valves at the tops of the wells are used to control air flow. From well AS-2, the manifold extends to a stub-out at the east side of the building footings for connection to a potential third AS well. Pressure indicators, flow regulating valves, and check valves are installed on the air supply manifold in the vaults at the top of the AS wells. Taps for flow elements are installed at each well head to measure air flow rate.

2.4 SOIL VAPOR PROBES

Eleven soil vapor probes (SVP) were installed in March 2010. SVPs were placed at 20-foot intervals extending perpendicular to the midpoint of the north lateral as shown in Figure 1-3. Two sets of two probes were installed at a distance of 20 feet from the northeast side of the building, near the source and plume area. One probe was installed at the approximate bottom depth of the extraction laterals (i.e., 7 feet). The other probe was installed at the calculated depth of influence of the extraction laterals (Versar 2009b). For example, 20 feet from the building, the upper probe was set at 7 feet. The lower probe was set at about 15 feet, the estimated maximum depth of influence at that point.

The probes were installed to depths within the calculated ZOI. The pairs of probes closest to the building were driven to 7 and 15 feet. The more distant probes were installed to 10 feet. The soil vapor probes were designated SVP-1a/b through SVP-8a. Table 2-1 identifies the probes, distances from the building, and depth. Figure 1-3 shows locations of permanent vapor monitoring and sub-slab pressure monitoring points, including:

- Three vapor monitoring locations at two depths (SVP-1a/b, SVP-5a/b, and SVP-7a/b);
- Five vapor monitoring locations at one depth (SVP-2a, SVP-3a, SVP-4a, SVP-6a, and SVP-8a);

- One mid-building, sub-slab monitoring point (SSD-3);

- Four corner, sub-slab monitoring points (SSD-S1, SSD-S2, SSD-N1, and SSD-N2);

- SVE blower suction lines from north and south zones (SVE-BS1 and SVE-BS2); and

- SVE blower exhaust (11574-SVE-BE-1).

As illustrated in Figure 2-4, the ZOI slopes up and away from the extraction laterals.

Soil vapor samples may be collected from the SVPs and analyzed for TPH-G and BTEX to evaluate the effect of the AS/SVE system. Soil gas pressures may also be measured at the SVPs to assess the extent of influence of the AS and SVE blowers.

Table 2-1.　Soil Vapor Probe Locations and Depths

Probe Number	Affected by SVE Zone	Perpendicular to Building Wall	Approximate Distance from Wall (feet)	Vapor Probe Depth (feet)
SVP-1a	North	West	20	7
SVP-1b	North	West	20	15
SVP-2a	North	West	40	10
SVP-3a	North	West	60	7
SVP-4a	South	West	40	10
SVP-5a	North	East	20	7
SVP-5b	North	East	20	15
SVP-6a	North	East	40	10
SVP-7a	North	North	20	7
SVP-7b	North	North	20	15
SVP-8a	South	East	40	10

2.5　GROUNDWATER MONITORING WELLS

Eight groundwater monitoring wells are installed at AOC 9-2 (see Figure 1-3). Monitoring well construction details are provided in Table 2-2. A monitoring well (MW 10-A17-8) was installed within the excavation limits of the former USTs within the calculated ZOI of the eastern sparge well (AS-1).

Table 2-2.   Monitoring Well Construction Details, Fort Lewis Agreed Order Site AOC 9-2

Location ID	Northing NAD 27	Easting NAD 27	TOC Elevation (ft AMSL)	Well Depth (ft bgs)	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Completion Date
AOC 9-2 (Formerly Building A1033, Now Building 11574)							
95-A17-1	660636.2	1477935.7	236.9	42.5	27.1	42.1	18-Aug-95
95-A17-2	660603.4	1477725.7	235.9	42.2	27.0	42.0	17-Aug-95
95-A17-3a	660699.7	1477730.7	235.9	44.5	29.3	44.3	17-Aug-95
95-A17-4	660734.1	1477793.9	236.8	42.5	26.6	42.0	18-Aug-95
96-A17-5	660832.5	1477581.5	233.9	45.0	44.8	29.8	22-Jan-96
96-A17-6	660896.0	1477694.5	235.1	45.0	44.8	29.8	22-Jan-96
07-A17-7	660693	1477589	233.2	37	22	37	21-Jun-07
10-A17-8	660665	1477794	235.8	39	29	39	8-Oct-10

Notes:
AOC 9-2 monitoring wells were re-surveyed in December 2011.
TOC – Top of casing
ft AMSL – Feet above mean sea level
ft bgs – Feet below ground surface
- – Not applicable, no data

Recent groundwater contour maps (Figures 2-5 and 2-6) indicate the highest concentrations of VOCs in the area of the suspected UST leakage, near the north end of the Credit Union building. The maps indicate a relatively flat groundwater gradient. Seasonal variations in the direction of groundwater were observed, with flow generally toward the south and southwest. Future groundwater monitoring events should consider the automatic timer settings for air sparging. Monitoring wells near the AS wells will experience a rise to mounded level and return to static level within about 90 minutes of a sparge event. Mounding effects are observed almost immediately at monitoring wells 95-A17-2, 95-A17-3a, and 95-A17-4. The mounding effect at monitoring wells may not be observed at monitoring wells at or beyond the site perimeter. When operating at a 30 minute AS cycle, mounding effects are negligible at perimeter wells MW 96-A17-5 and 07-A17-7. Results of groundwater monitoring should be correlated with data downloaded from the Leveloggers. Increases in VOC concentrations at groundwater monitoring wells, particularly those not near the AS wells, may suggest plume mobilization. In that case, changes in AS operation should be considered, as discussed in Section 4.1.2.

North View of Proposed Credit Union

Estimated Eastern Extent of SVE Influence

Estimated Western Extent of SVE Influence

Approx 20 ft

Approx 20 ft

Approx 20 ft

Approx 20 ft

25 ft

30 ft

Estimated Lower Extent of SVE System Influence

Approx Wet Season Water Table

Approx Dry Season Water Table

Estimated Extent of Air Sparge Influence

Air Sparge Wells

0 10 20 30
SCALE IN FEET

Figure 2-4
Cross Section Showing Vapor Probes and Estimated Vertical and Horizontal ZOI for Air Sparge and SVE Systems
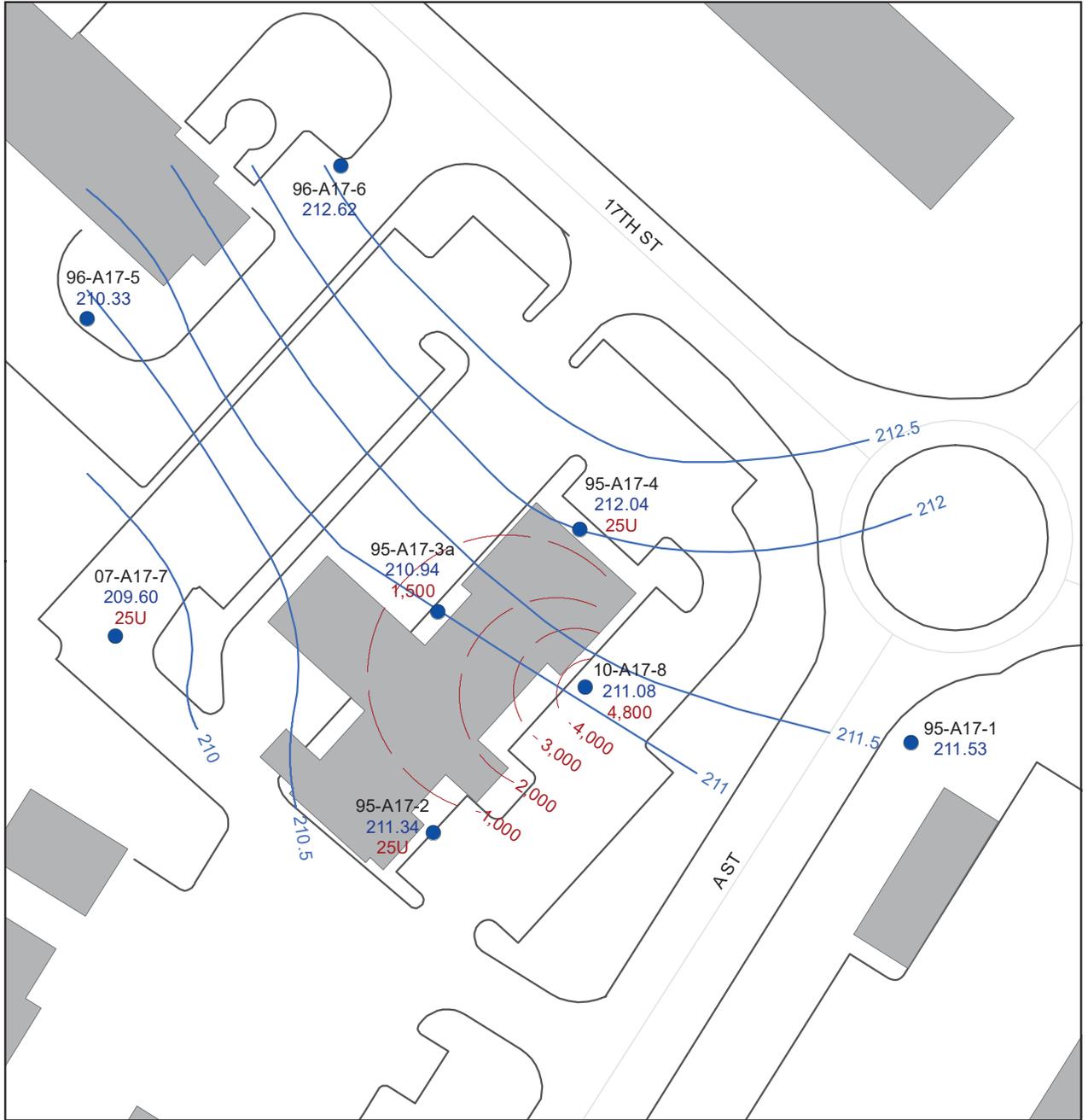
Notes:

Depth to water measurements
collected April 21, 2015.

Groundwater samples collected
April 22-23, 2015.

Legend

● Monitoring Well

—— Groundwater Elevation (famsl)

—— TPH-G Concentration (µg/L)

96-A17-6
212.62

96-A17-5
210.33

95-A17-4
212.04
25U

95-A17-3a
210.94
1,500

07-A17-7
209.60
25U

10-A17-8
211.08
4,800

95-A17-1
211.53

95-A17-2
211.34
25U

212.5

212

211.5

211

210

210.5

4,000

3,000

2,000

1,000

17TH ST

A ST

N

0 15 30   60
Feet

USACE | **SEALASKA** | **Figure 2-5**
Groundwater Elevation and
TPH-G Concentration Contours April 2015
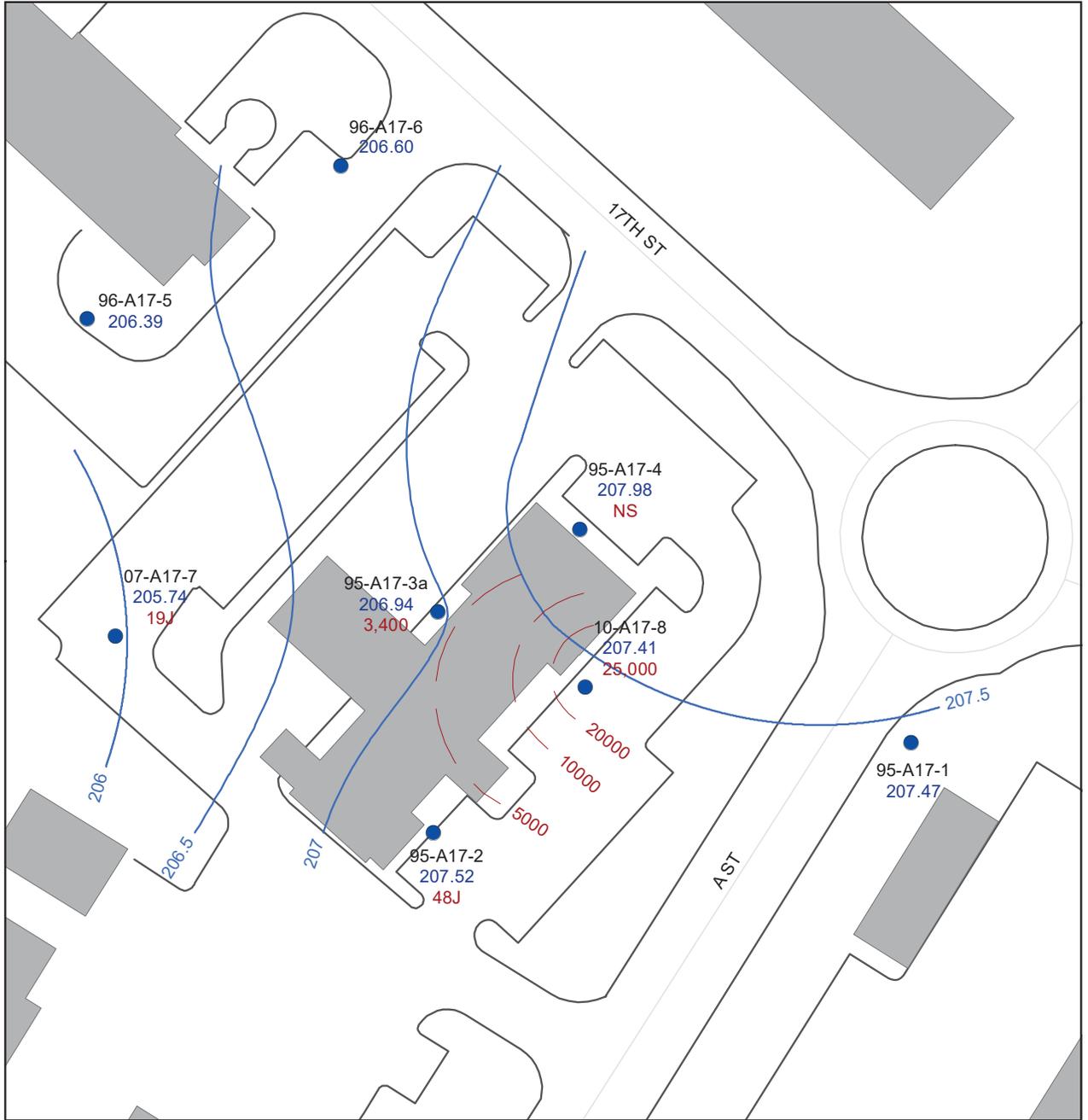
Notes:

Depth to water measurements
collected September 1, 2015.

Groundwater samples collected
September 1-2, 2015.

NS - Not planned for sampling.

Legend

● Monitoring Well

⌣ Groundwater Elevation (famsl)

⌣ TPH-G Concentration (µg/L)

96-A17-6
206.60

96-A17-5
206.39

95-A17-4
207.98
NS

07-A17-7
205.74
19J

95-A17-3a
206.94
3,400

10-A17-8
207.41
25,000

20000
10000
5000

95-A17-2
207.52
48J

207.5

95-A17-1
207.47

206
206.5
207

17TH ST
A ST

N

0 15 30 60
Feet

USACE | **SEALASKA**

Figure 2-6
Groundwater Elevation and
TPH-G Concentration Contours September 2015

3   PROJECT ORGANIZATION AND RESPONSIBILITIES

The project team consists of an Operation, Maintenance, and Reporting Team; project and program managers from the US Army Corps of Engineers (USACE) and US Army Environmental Command (USAEC); the JBLM Installation Restoration Program (IRP) Program Manager; and personnel from Sealaska Environmental Services LLC (Sealaska), Ecology, Credit Union, and the contracted laboratories. Table 3-1 shows anticipated roles and responsibilities for this project.

3.1   PLANNING AND COORDINATION

Before conducting each AS/SVE system vapor sampling event, the Sealaska will ensure that applicable delivery orders with the contracted laboratory (currently ARS in Kelso, Washington) are established, and will notify the Credit Union point-of-contact of upcoming monitoring events.

Table 3-1.   Project Team Roles and Responsibilities for Ongoing Performance Monitoring for AS/SVE and SSD Systems

Project Role	Name, Company Phone Number, Email	Responsibilities
USACE Project Manager	Ember Korver 206-764-3479 ember.e.korver@usace.army.mil	Project management
USACE Technical Lead	Jayson Osbourne 206-369-2615 jayson.b.osborne@usace.army.mil	Technical support, document review
JBLM IRP Program Manager	Meseret Ghebresllassie 253-477-3742 meseret.c.ghebresllassie.civ@mail.mil	Program management, Document review
Project Manager	Scott Elkind Sealaska 360-626-3991 scott.elkind@sealaska.com	Communication and coordination with project team, JBLM and USACE managers, and Ecology
System Operation & Maintenance Manager	Bob Thomas Sealaska 253-930-2768 bob.thomas@sealaska.com	Communication and coordination with project team. Preparation of planning documentation and reports
Field Professional	Tom Malamakal Sealaska 425-623-2951 tom.malamakal@sealaska.com	Coordination and completion of fieldwork. Preparation of planning documentation and reports.
Analytical Laboratory – air and soil vapor samples	Kelly Buettner Eurofins-Air Toxics, Ltd. 916-985-1000 kbuettner@airtoxics.com	Analysis of air samples
Regulatory Review	Charles Hoffman Ecology 360-407-6344 chof461@ecy.wa.gov	Review planning and reporting documents
Credit Union Branch Manager	Claire Mancilla 253-912-3228; cmancilla@youracu.org	Current Branch Manager
Credit Union Facilities Engineer	Paul Winchell 253-912-3223 pwinchell@youracu.org	Facilities Engineer

4   OPERATION, MAINTENANCE AND MONITORING

4.1   SYSTEM OPERATION

The IA Work Plan (Versar 2013b) specifies the following operations based on the results of pilot testing:

- Adjust and balance pressure and flows to SVE zones and AS wells at settings defined in Pilot Test and Startup Report (Versar 2013a).

- Maintain continuous operation of the SVE blower until the site is remediated.

- Operate the AS blower in pulsed mode with an inter-sparge period of at least one hour.

   o   Monitor wells downgradient of AS wells for mounding effect.

   o   Increase AS frequency if no indication that selected AS cycle is increasing groundwater gradient or mobilizing gasoline plume.

Maintenance will focus on the following system elements:

- Maintain integrity of SVE suction lines and blower.

- Empty SVE knockout drum of water (check at least once weekly).

- Maintain integrity of AS blower lines and AS well heads and blower.

- Empty AS blower knockout bottle of water.

The SVE blower knockout drum collects about one-half to a full drum of water per week during the rainy season. The water is collected by the extraction laterals under the building. The extraction laterals are greater than 15 feet above groundwater. The water in the knockout drum is presumed to be rain water that is drawn from the planting beds and under the building slab by the low suction from the SVE blower. Sampling and analysis of the water indicated non-detect for TPH-G and BTEX. However, the knockout water will be transported for treatment at one of the JBLM air stripper systems.

4.1.1   System Startup and Shutdown

The AS and SVE blowers operate independently. In addition to removal of VOCs, the SVE blower is critical to maintenance of the SSD system for protection of building occupants. The SVE blower should only be turned-off for brief maintenance or after confirmation

sampling demonstrates that remedial action objectives have been met. Procedures for startup and shutdown of the AS and SVE blowers are outlined in the following sections.

4.1.1.1   AS Blower Startup

The AS blower is located in a subsurface concrete vault on the east side of the Credit Union building (see Figure 1-3). The AS blower should only be operated when the SVE blower is operating. The AS blower may be operated in automatic or manual modes. Below is the sequence for AS blower startup:

1. Perform safety checks before entering the blower vault:

    a. Complete Confined Space Entry Checklist (Appendix C: Field Forms). The AS vault is a non-permit confined space provided that air monitoring is performed prior to entry and results indicate safe conditions.

    b. Inspect AS blower vault. Survey air in vault with PID and 4-gas meter. Enter the vault only if VOCs are not present and oxygen, lower explosive limit and other gases are at safe conditions as defined in the Site Safety and Health Plan (SSHP) included in the Project Management Plan (Sealaska 2016b).

    c. Confirm if the AS blower is operating. Hearing protection is required in the vault and within 10 feet in area around vault lid when the AS blower is operating.

2. Verify that valve at blower discharge is 100% open. Check pressure gauge downstream of the blower discharge valve. The AS blower typically discharges at 14 to 16 psig. If the blower discharge pressure is higher than 18 psig, check positions of downstream AS valves. Discharge pressures over 20 psig probably indicate a downstream obstruction and need for investigation and repair.

3. Verify that valves at AS well heads are open to the desired position. AS well head valves have remained in full open position since system construction. However, changes in valve position may be performed to direct more sparged air to a particular well.

4. The motor starter panel powers the blower through a timer panel. Select "Auto" or "Hand" mode on the blower timer. The blower will operate with the motor starter panel "On" and the timer in "Hand" mode. Verify blower operation in "Hand" mode before relying on the timer. If necessary, reset blower timer to correct day and time. Program the blower timer for desired time, frequency and duration of air sparging. The existing blower timer allows for four on-off cycles per 24-hour period. After programming AS cycle time, enter "Run" or "Hand" for the desired operation.

5. Return during a scheduled sparge event to verify timer operation.

6. Check blower discharge line and AS well head pressures during operation.

7. During weekly inspections, check AS line and sparge well heads for signs of corrosion or air leaks.

4.1.1.2 AS Blower Shutdown

Follow safety procedures outlined in Section 4.1.1.1. The AS blower may be turned off at the timer by switching from "Run" to "Off." The timer and blower may be completely disabled by switching off the motor starter panel in the AS blower vault.

In the event of an emergency the AS compressor may be turned off at the motor starter panel. Complete power to the AS compressor can be disabled at the breaker in the electrical panel in the Credit Union Mechanical room.

4.1.1.3 SVE Blower Startup

The SVE blower is located in the shed at the northwest corner of the Credit Union parking lot (see Figure 1-3). The SVE blower is not equipped with a timer because it must remain in continuous operation to removed subsurface VOCs and protect building occupants from possible intrusion of petroleum hydrocarbons.

Hearing protection is required in the SVE blower shed. Low concentration VOCs (generally less than 30 parts per billion-volume) are discharged from the SVE exhaust line. Operators should minimize exposure to VOC exhaust, for instance only the few seconds required for flow and PID readings.

The SVE blower is started with the motor starter panel switch in the "On" position.

- SVE Suction Line Valves: Verify that the SVE suction line valves are sufficiently open to allow air flow. During blower operation, the SVE suction line valves are typically in the 75% open (south SVE zone) and 100% open (north SVE zone). With these valve settings, suction pressures typically range from about 3.0 in H_2O vacuum to 10 in H_2O vacuum.

4.1.1.4 Ongoing Inspection

Inspect SVE suction lines for air leaks (hissing), cracks or other damage. If gauges on suction lines indicate vacuum pressures significantly different than historical values (normally between 3 and 9 psig), investigate the following possible causes:

- Positions of SVE valves may have been changed;

- Gauge may have failed; or

- SVE line is damaged by possible blockage or leak.

4.1.2   SVE Blower Shutdown

The SVE blower should only be turned-off for brief maintenance or in the event that confirmation sampling indicates that remedial action objectives are satisfied. Turn off the SVE blower by lowering the motor starter panel switch to "Off." If the SVE blower will be off for an extended period, verify that the knockout drum is emptied of water.

In the event of an emergency the SVE Blower may be turned off at the motor starter panel. Complete power to the SVE blower shed can be disabled at the breaker in the electrical panel in the Credit Union Mechanical room.

4.1.3   Coordination of Air Sparge and Soil Vapor Extraction Systems

The SVE blower will be operated at settings defined in the system pilot test (valve SVE-BS-1 at 75% open, and valve SVE-BS-2 at 100% open). Valves on the AS blower lines have been set to 100% open but may be adjusted to balance pressures at the heads of each AS well. The SVE blower will be operated continuously in order to extract VOCs and minimize the risk of vapor intrusion to the Credit Union building.

4.1.4   Pulsed Operation of AS Blower

Pulsing of the AS blower results in a rise and fall of groundwater levels within the treatment zone. Constant operation of the AS blower will mound groundwater, creating a steeper gradient with the possibility of further mobilizing the affected groundwater. Pulsed operation of the AS blower with a cycle time that ends shortly after reaching the peak mounded groundwater level will minimize the effect on local groundwater gradient. The pilot test determined that groundwater was lifted to maximum height within 60 minutes of startup of the AS blower. Groundwater returned to the pre-sparge depth within 35 minutes after the blower was turned off. The SVE system collects VOCs during operation of the AS blower and continues removal for several hours after start of the AS blower.

The optimum number of AS pulses was defined based on changes in water levels at the site. Groundwater level fluctuations are monitored to determine the mounding effect of air sparging. The earliest effects of mounding with air sparging is observed at wells MW 95-A17-3a and MW 10-A17-8, nearest the AS wells. Changes in depth to water (DTW) are continuously measured

at monitoring wells: 95-A17-2, 95-A17-3a, 95-A17-4, 96-A17-5, and 07-A17-7. Those five monitoring wells are configured with Solinst Levelogger DTW probes (Appendix B) equipped with data loggers for continuous monitoring. Groundwater levels are also monitored by manual DTW probes during semi-annual monitoring events. A sparge duration and frequency of one hour per day, initiated in July 2014, resulted in a slight mounding effect at the most distant monitoring wells, 96-A17-5 and 07-A17-7. In October 2014, the sparge duration was decreased 30 minutes and the pulse frequency increased to four cycles per day. Negligible mounding effects at the distant monitoring wells were observed during four, 30 minute AS pulses per day. The existing timer on the AS blower allows for only four on-off cycles per day. The AS pulse regimen of four, 30 minute cycles remains in effect as of the date of this document.

The following actions will be implemented for operation and monitoring of the AS/SVE system:

- Operate the SVE blower continuously to maintain constant negative sub-slab pressure and extract VOCs removed by air sparging.

- Ensure that when the AS blower is operating, MW 10-A17-8 is capped to prevent vapors from venting directly to the atmosphere.

- Maintain the existing AS pulse regimen. Allow an inter-sparge period of at least 1 hour to allow groundwater levels to stabilize (i.e., a 2-hour sparge--inter-sparge cycle). Increase AS pulse frequency to as many cycles per day as possible, if system remains effective as described below.

The following procedure is recommended if changes in AS pulse duration and frequency are desired:

- Use Levelogger data loggers to continuously monitor groundwater levels at monitoring wells: 95-A17-2, 95-A17-3a, 95-A17-4, 96-A17-5, and 07-A17-7 to assess the effect of AS pulsing. Allow at least 14 days of operation after each change in AS duration, frequency of operation, and/or AS well valve positions in order to observe possible cycles in AS mounding.

- Begin with valves at AS well heads open 100%. If no changes in groundwater levels are observed at MWs near the site perimeter (MW 96-A17-5 or MW 07-A17-7), then increase pulse frequency. Increase pulse frequencies if no effect on perimeter monitoring wells is observed in Levelogger data. Maintain an inter-sparge period of at least two hours.

- If a rise in downgradient DTW is observed, reduce the duration of the sparge cycle. Allow operation at the reduced duration for at least 14 days. Retrieve Leveloggers and download water level data. Reduce the duration of the AS cycle. Again, retrieve

water level data and determine if there is a downgradient mounding effect.

- If increases in DTW at site perimeter wells continue to be correlated to AS operation even with reduced sparge cycles, then close AS well head valves to 75% open. With each adjustment in sparge duration, valve position or sparge frequency, retrieve and analyze Levelogger data to assess the extent of downgradient groundwater mounding.

- If a rise in downgradient DTW is observed, reduce the duration of the AS cycle. Continue to reduce the duration of the AS cycle until no rise in groundwater at perimeter wells is observed. If a downgradient mounding effect cannot be eliminated with reduction in sparge duration, reduce the AS valve positions to 50%. (Consult blower curve. Do not exceed maximum blower pressure)

4.2 SYSTEM INSPECTION AND MAINTENANCE

Routine maintenance will be conducted on the AS/SVE system during weekly and monthly inspections. Table 4-1 outlines weekly, monthly, quarterly, semi-annual, and annual system inspection activities.

Blank log sheets for the AS/SVE system are included in Appendix C. Field personnel will begin each site visit by recording the date, time, and purpose of visit in the Daily Site Log stored in the SVE building. All observations, sampling, and maintenance will be recorded in inspection log sheets and stored in the project trailer. Log sheets and field notes will be scanned, uploaded, and stored in a project-specific folder on the Sealaska network.

System inspection and maintenance are performed to ensure integrity of the vapor mitigation system, pressurized AS system, and vacuum SVE system. Two blowers and associated equipment require routine inspection for mechanical integrity. The system has pressurized pipe and components on the AS side and components under low vacuum on the SVE side. Basic maintenance includes checking and sealing air leaks, and removing water from monitoring ports and knockout containers. Monitoring is performed to ensure that negative pressure is maintained under the building to remove VOCs and protect building occupants. VOC concentrations are measured at the SVE blower exhaust and in ambient air in and around the building. Condition of SVE suction lines and AS pressure lines are routinely monitored. SVPs in the parking lot surrounding the Credit Union building allow for assessment of extent of influence of the AS/SVE system.

Table 4-1.   Inspection, Monitoring, Maintenance Activities, and Frequencies for the
AS/SVE/SSD System

Weekly Monitoring, Inspection, and Maintenance Activities

Weekly monitoring, maintenance, and inspection tasks include:

SVE System:

- Note any unusual noises in blowers.
- Note any possible leakages from SVE vacuum pipe and fittings.
- Note any visual oil leaks around the blower.
- Check temperature of SVE blower suction and SVE exhaust lines.
- Measure pressure, vacuum, and air flow velocity on the SVE suction lines.
- Record SVE exhaust temperature for each blower.
- Compare SVE flow, vacuum, and temperature to historical readings. Note any significant differences and troubleshoot possible problem.
- Note any possible air leaks from AS blower pipe and fittings.
- Measure AS blower discharge temperature with infrared thermometer. Compare with temperature gauge.
- Compare AS pressures and temperatures to historical readings. Note any significant differences and troubleshoot possible problem.
- Check water level in knock out drum, record water level and drain if necessary.
- Record pressure readings at AS well heads. Remove standing water around each well head.
- Check temperature of AS blower discharge line.
- Check temperatures of AS well heads.
- Use PID to monitor SVE blower exhaust.
- Check condition of various safety signs and reattach or replace if necessary.

Monthly Monitoring, Inspection, and Maintenance Activities

Monthly monitoring, maintenance, and inspection includes all weekly tasks listed and:

- Sub-slab depressurization (SSD) Ports:
- Clear water from SSD ports as necessary.
- Measure vacuum pressures at five building foundation monitoring points (SSD) ports.
- Measure suction pressures for each SSD extraction zone.
- Compare SSD differential pressure to historical readings. Note any significant differences and troubleshoot possible problem.
- Tighten fittings at AS well heads and AS injection lines if necessary.
- Check blower shafts for alignment. Repair if necessary.
- Check operating temperatures and pressures and compare to blower specifications.
- Check condensate bottle and air filter on intake to AS compressor. Empty bottle and clean filter if necessary.

Quarterly Monitoring, Inspection, and Maintenance Activities

Quarterly monitoring, maintenance, and inspection includes all tasks listed above and:

- SVE exhaust – four Tedlar bag samples collected at equally-spaced intervals for 8 hours during maximum daily AS blower cycles.

Table 4-1.   Inspection, Monitoring, Maintenance Activities, and Frequencies for the
AS/SVE/SSD System (continued)

| **Semi-Annual Monitoring, Inspection, and Maintenance Activities** |
| Semi-Annual monitoring, maintenance, and inspection includes all tasks listed above and: |
| • Vacuum pressures at parking lot soil vapor probes (with and without AS blower operating).
 • Groundwater quality monitoring.
 • Groundwater level measurements. |
| **Annual Monitoring, Inspection, and Maintenance Activities** |
| Annual monitoring, maintenance, and inspection includes all tasks listed above and: |
| • Vapor Intrusion Monitoring (interior and ambient air samples by Summa canister).
 • SVP screening by PID or Flame Ionization Detector (FID) and samples by Tedlar bag. |

4.3   PERFORMANCE MONITORING

Performance monitoring will involve sampling to observe trends in groundwater and soil vapor conditions, SVE and SSD performance, measurement of blower ZOIs, and abilities of the blowers to strip and remove VOCs. Performance monitoring will focus on verification of:

- Negative sub-slab pressure maintained by the SVE system;

- Removal of VOCs to improve soil vapor quality;

- Balance of air flow between SVE zones; and

- Air flow to AS wells.

In addition, annual vapor intrusion monitoring will assess the effectiveness of the SVE and SSD systems in mitigating VI from the underlying gasoline plume (see Section 4.4).

Table 4-2 outlines the various media, monitoring parameters, and equipment to be employed in monitoring. Table 4-3 outlines parameters and frequency of ongoing performance monitoring for the AS/SVE/SSD systems.

Other documents related to performing sampling and monitoring at the North Fort Credit Union AS/SVE system include the project SSHP, Sampling and Analysis Plan (SAP) for VI Monitoring (Versar 2013b), and the SAP for groundwater monitoring (Versar 2014).

4.3.1   AS/SVE/SSD System

Monitoring of the AS/SVE/SSD system performance will focus on the mechanical systems, parking lot soil vapor probes and sub-slab soil gas pressures. The effectiveness of the SSD system in mitigating VI will be assessed by measuring the pressure differentials across the

building floor slab. Negative pressure differentials are expected during SVE operation.
Vacuum pressure will be measured at the five sub-slab monitoring ports to determine
differential pressure between the sub-slab and building interior and sub-slab and ambient
outside air. Sub-slab pressure differentials will be monitored weekly throughout the
performance monitoring phase.

Table 4-2. Media, Monitoring Parameters, and Equipment

Medium	Monitoring Parameters	Equipment and/or Method	Monitoring Points
Groundwater	- DTW - pH, specific conductivity, temperature, turbidity, DO - TPH-G (NWTPH-Gx) and BTEX (EPA Method 8260C)	- DTW probe - Levelogger[1] - Horiba U-22 or similar meter - Bladder or submersible pump - Disposable bailer	Monitoring wells: 95-A17-2, 95-A17-1; 95-A17-3a, 95-A17-4, 10-A17-8
Soil Vapor Pressure	Low vacuum and low positive pressure	Magnehelic differential pressure gauges (vacuum)[1]	Soil vapor probes: SVP-1a/b; SVP-2a; SVP-3a; SVP-4a; SVP-5a/b; SVP-6a; SVP-7a/b; SVP-8a
Soil Vapor Chemistry	- TPH-G, BTEX using TO-15 GC/MS Full Scan - Tedlar Bag Method	- Peristaltic pump (Preferred) - Vacuum pump (if peristaltic pump not available) - Tedlar bags - PID or FID for field screening[1]	Soil vapor probes and SVE exhaust
Vapor Intrusion and Ambient Air Monitoring	Summa Method TO-15 GC/MS Full Scan SIM for VOC and TPH-G	Summa canisters with flow regulators configured for an 8-hour sample	- Building interior (lobby, conference room, and custodian's closet) - Exterior: upwind and parking area near neighboring gas station
Sub-slab Pressure	Low vacuum and low positive pressure	Magnehelic vacuum gauges (Models: 2000-00N (0.05 to 0.2 inches water); 2000-00 (0 to 0.25 inches water); 2000-0 (0 to 0.5 inches water)[1]	Sub-slab ports: SSD-N1, SSD-N2; SSD-S1; SSD-S2; SSD-3

Table 4-2.   Media, Monitoring Parameters, and Equipment (continued)

Medium	Monitoring Parameters	Equipment and/or Method	Monitoring Points
Air Sparge Blower	• Pressure • Temperature • Flow	• Positive pressure gauges • Temperature gauges • Infrared Temperature Gun[1] • Blower curve for flow	• Pressure gauges on blower discharge and sparge lines • Temperature gauge on blower discharge line
Extracted Soil Vapor	• Flow • Pressure • TPH-G, BTEX • Laboratory analyses	• Testo Compact Mini-Vane Anemometer • Vacuum gauge (Magnehelic brand)[1] • PID (RAE Systems Portable ppb VOC monitor) or FID[1]	• All monitoring at suction risers from north and south extraction lines to blower and blower exhaust
Indoor Air	• TPH-G, BTEX • Laboratory analyses	• Summa canisters, Method TO-15 for TPH-G and BTEX • PID or FID for field screening[1]	• Interior Rooms (lobby, custodian's closet, conference room)
Ambient Air	• TPH-G, BTEX • Laboratory analyses	• Summa canisters, Method TO-15 for TPH-G and BTEX • PID or FID for field screening[1]	• HVAC intake • West Edge of Property • Property Boundary at Gas Station

Notes:
[1] See Appendix B for monitoring equipment information.

Table 4-3. Parameters and Frequency of Monitoring for AS/SVE and SSD Systems

Operating Condition	Parameter and Location	Frequency of Monitoring
Performance Monitoring	SVE blower suction pressures for each extraction zone	Weekly
	Groundwater Quality Monitoring (MW: 95-A17-2, 95-A17-1; 95-A17-3a, 95-A17-4, 10-A17-8)	Semi-annually
	Groundwater Level Measurements	Concurrent with groundwater quality monitoring and data-logging DTW measurements
	Pressure differentials at building foundation monitoring points	Monthly
	Soil vapor monitoring at soil vapor probes	Annually
	Pressure differentials at soil vapor probes	Semi-annually
	Vapor intrusion and ambient air monitoring	Annually
	SVE Exhaust • Flow • Temperature • Pressure • VOCs by PID or FID • VOCs by Tedlar bag	• Weekly: Flow, temperature, pressure and PID/FID monitoring • Quarterly: Four Tedlar bag samples collected at equally spaced intervals for 8 hours during maximum daily AS blower cycles
Safety Monitoring To Verify Vapor Extraction/ Capture System Performance	PID or FID monitoring of ambient air near SVE blower building	Quarterly: PID/FID monitoring of ambient air around SVE blower building
	Indoor air quality monitoring with PID or FID	In the event of loss of SSD vacuum pressure
	Indoor air quality sampling with Summa canisters for laboratory characterization	In the event of loss of SSD vacuum pressure, elevated PID readings for interior air or other evidence of possible vapor intrusion into building

Table 4-3. Parameters and Frequency of Monitoring for AS/SVE and SSD Systems (continued)

Operating Condition	Parameter and Location	Frequency of Monitoring
Confirmation Monitoring (performed after satisfying Criteria for System Shutdown).	SVE Exhaust • Flow • Temperature • Pressure • VOCs by PID or FID	Restart blower and monitor weekly for one month after Shutdown Criteria are satisfied
	SVE Exhaust • Soil Vapor by Tedlar bag for TPH-G, BTEX	• Fourth week of monitoring after Shutdown Criteria are satisfied • Four Tedlar bags collected at two hour intervals for 8 hours at maximum AS frequency
	Soil Vapor Probes • Soil Vapor by Tedlar bag for TPH-G, BTEX	• After monitoring by PID/FID indicates no VOCs • One Tedlar bag sample from each SVP during maximum AS blower operation (11 total Tedlar bag Samples)
	Groundwater Quality Monitoring (MWs: 95-A17-2, 95-A17-1; 95-A17-3a, 95-A17-4, and 10-A17-8)	One time after Shutdown Criteria Satisfied
	Groundwater Level Measurements	Concurrent with groundwater quality monitoring
Post-Shutdown Monitoring	• Groundwater Quality Monitoring • Groundwater Level Measurements	Quarterly for five quarters. Discontinue if water quality remains below MTCA cleanup levels for five consecutive quarters

Notes:
BTEX – Benzene, toluene, ethylbenzene and xylenes
FID – Flame Ionization Detector
PID – Photoionization Detector
SSD – Sub-slab depressurization
SVP – Soil vapor probe
TO-15 – Laboratory analysis for gasoline and BTEX in air samples
TPH-G – Gasoline-range total petroleum hydrocarbons

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4.3.2   Air Flow and Temperature at AS Wells and from SVE Zones

Flow monitoring ports are installed in the supply lines to the AS wells and in the suction lines of the SVE blower. Saddle taps are installed for flow monitoring in order to minimize the flow distortion that may result from a tee or other pipe fitting. A portable vane anemometer will be used to measure flow and temperature of air flowing through each SVE suction line. The vane anemometer probe must be inserted through the pipe tap to position the propeller in the center of the pipe and in-line with the direction of air flow. Gauges installed on each SVE zone indicate suction pressures. Valves on each SVE line allow for flow adjustment.

Because the vane anemometer is not suited for the higher pressures of the AS lines, pressure and temperatures may be measured and used to estimate air flows using the AS blower curve. Gauges installed at the blower discharge and on each AS well head indicate air pressures. A portable infrared temperature gun will be used to read line temperatures. Valves on each AS well head allow for flow adjustment.

4.3.3   Vacuum Pressure Monitoring

Magnehelic gauges, configured for differential pressure readings, will be connected to the various vacuum monitoring points. The gauges will be available to accommodate the range of vacuum pressures at the site. A pressure range from 0 to 10 inches of water may be observed in the extraction laterals. The smallest differential pressures will be observed at the outermost parking lot SVPs. A gauge with a range as low as 0.005 inches of water vacuum will be available for SVP readings. In the event that changes in operating conditions occur during SVP monitoring, the system will be allowed to reach steady state. Upon blower startup, steady state is recognized at vapor monitoring points by an immediate decrease from ambient pressure followed by stabilization at some negative pressure. Pressure readings will be monitored for each operating condition until the stable condition is achieved.

Vacuum pressures will be routinely measured at the SVE blower suction lines from north and south zones (SVE-BS1 and SVE-BS2);

Differential pressures will be routinely measured at the following monitoring points:

- One mid-slab, sub-slab monitoring point (SSD-3);
- Four corner, sub-slab monitoring points (SSD-S1, SSD-S2, SSD-N1, and SSD-N2);

- Three SVP monitoring locations at two depths (SVP-1a/b, SVP-5a/b, and SVP-7a/b); and

- Five SVP monitoring locations at one depth (SVP-2a, SVP-3a, SVP-4a, SVP-6a, and SVP-8a).

4.3.3.1   Pressure at Soil Vapor Probes

The pilot test demonstrated that the horizontal ZOI exerted by the SVE blower extends from the two extraction laterals under the building to the outermost SVPs. ZOI is defined by measurement of pressure differentials at SVPs.

Eleven soil vapor probes are installed at the site. Three locations consist of two probes, installed to different depths. The combination of radial and vertical probe placement will allow for three-dimensional assessment of SVE ZOI.

Figure 1-3 shows the locations of SVPs. Appendix B contains catalog cuts for the types of Magnehelic and digital pressure gauges that will be employed in monitoring pressures in sub-slab ports and soil vapor probes. Monitoring well MW 10-A17-8 will be plugged for the AS ZOI evaluation because that well may vent soil vapor during and shortly after operation of the AS blower.

A portable Magnehelic gauge, configured for differential pressure reading, will be connected to the SVPs to measure soil vapor pressure. Soil vapor pressures will be monitored to verify the extent of the estimated ZOI. Monuments and SVP valves will be purged of surface water as necessary. Teflon tubing will be used to connect a Magnehelic gauge to the SVP barb. The gauge will be positioned to zero inches of water and the valve reopened. Differential pressures for each SVP will be recorded in field logs. Soil vapor pressures will be plotted on a site map.

4.3.3.2   Building and Sub-Slab Pressure Gradient

Passive and active systems impede intrusion of soil vapors into the Credit Union building. The sub-slab vapor barrier is designed to prevent migration of soil gases into the building. Mechanical systems (blowers) will induce a pressure gradient to further protect against soil vapor intrusion. The HVAC system maintains a positive pressure in the Credit Union building. Suction from the SVE blower through the extraction laterals maintains a negative pressure under the building slab and parking lot. Building interior pressures will be slightly above atmospheric pressure. A differential pressure gauge will be used to measure the pressure gradient between the building interior and sub-slab. The interior to sub-slab pressure gradient will be measured at the interior monitoring point. Interior and sub-slab

pressures will be compared to atmospheric (barometric) pressure measurements. Differential pressure readings at exterior sub-slab monitoring points (SSD-3, SSD-S1, SSD-S2, SSD-N1, and SSD-N2) will measure the difference between atmospheric and sub-slab conditions. Sub-slab differential pressures on the order of 0.010 to 0.05 inch of water are expected.

4.3.4   Soil Vapor Monitoring

The effect of air sparging on soil vapor concentrations will be observed at the SVE exhaust and SVPs. Weekly monitoring of SVE exhaust will be conducted using a PID. Performance monitoring will also include semi-annual pressure monitoring of SVPs. Soil vapor samples will be collected annually from the eleven SVPs during normal operation of the AS and SVE systems.

4.3.4.1   Vapor Monitoring -- SVE Exhaust

Vapor samples will be collected to analyze long-term system performance and to verify the system is compliant with the Puget Sound Clean Air Agency's (PSCAA) total maximum allowable emission standard of 15 pounds of benzene per year and 50,000 pounds of total VOCs per year. During the pilot test, peak VOC concentrations were observed 12 to 14 hours after sparging. It is believed that peak VOC concentrations are now appearing much earlier after operation of the AS blower. Increased sparge frequency is likely to equalize SVE exhaust concentrations through the day. Bulk daily SVE exhaust concentrations will decrease with ongoing AS/SVE operation. Weekly monitoring of SVE exhaust is typically performed by PID. SVE blower exhaust will be monitored by PID. Procedures for SVE exhaust monitoring are outlined in Section 5.3.2, Sampling and Analysis Plan. Table 4-3 outlines sampling parameters and frequencies. Sample times may be adjusted based on field observations and results of earlier sampling events as performance monitoring progresses.

4.3.4.2   Vapor Monitoring – Soil Vapor Probes

SVP pressures will be measured semi-annually. Differential pressure (between subsurface and ambient) will be measured by Magnehelic gauge at each SVP location.

Soil gas samples will be collected from the eleven SVPs during Confirmation Monitoring. Procedures for sampling SVPs are outlined in Section 5.3.1, Sampling and Analysis Plan.

4.4   VAPOR INTRUSION MONITORING

VI monitoring will be performed annually per the VI SAP (KTA 2011) and under similar conditions and locations as those employed in the 2012 and 2015 VI monitoring events (Versar 2013a, Sealaska 2016a). VI monitoring consists of employing Summa canisters (spherical stainless steel vessels under vacuum), at strategic locations inside and outside the Credit Union.

The Credit Union point of contact, JBLM Fire Department, and JBLM Police will be notified prior to the VI monitoring event. All vapor intrusion monitoring will be performed with the AS blower operating at the optimum inter-sparge cycle frequency defined in an earlier phase. VI monitoring is outlined in Section 5.3.6, Sampling and Analysis Plan.

5   SAMPLING AND ANALYSIS PLAN

The SAP describes procedures for conducting AS/SVE system vapor sampling and other air sampling at the site. Groundwater monitoring is also conducted at the Credit Union. Protocols for completing groundwater monitoring are presented Fort Lewis Agreed Order Groundwater Monitoring Plan (Sealaska 2014). However, Section 5.2 includes a brief discussion of the groundwater sampling to be conducted at the site.

Vapor samples will be collected to analyze long-term system performance and to verify the system is compliant with the PSCAA total maximum allowable emission standard of 15 pounds of benzene per year.

Performance monitoring will be conducted according to the procedures outlined in Section 4.3 of this manual. Table 4-3 outlines parameters and frequency of ongoing performance monitoring for the AS/SVE/SSD systems.

5.1   PRIOR COORDINATION

Before conducting each groundwater and AS/SVE system vapor sampling event, the Sealaska will ensure that applicable delivery orders with the contracted laboratory (Eurofins-Air Toxics) are established and will notify the Credit Union point of contact (current Branch Manager) about the events. JBLM IRP will also be notified prior to the start of any sampling event.

5.2   GROUNDWATER MONITORING

Although not covered in this O&M manual, the following is a brief discussion of the groundwater sampling to be conducted at the site. Groundwater samples will be collected and analyzed to monitor the effectiveness of the AS/SVE system at mitigating volatile constituents in the saturated zone. Monitoring well locations, and 2015 water table and TPH-G concentration contours are presented in Figures 2-5 and 2-6.

During each event, an electronic water level indicator will be used to measure the static water level in all monitoring wells currently used in the groundwater monitoring program at AOC 9-2. All measurements will be recorded to the nearest 0.01-foot from the top of the PVC casing.

Five monitoring wells will be sampled (95-A17-2, 95-A17-3a, 95-A17-4, 07-A17-7, and 10-A17-8) and depth to water will be measured in three additional wells (95-A17-1, 96-A17-5, and 96-A17-6). A standard low-flow purging procedures will be to purge water prior to

sampling. The pump intakes are positioned approximately 2 to 4 feet above the bottom of the monitoring well screen. A pump controller will be used to limit the purging flow rate to less than 1 liter per minute. During purging, relative water levels will be monitored with an electronic water level indicator and water quality parameters such as pH, specific conductivity, temperature, dissolved oxygen, and turbidity are measured with a pre-calibrated Horiba or similar meter to verify stabilization.

Groundwater samples will be collected immediately after the field measurements have stabilized without turning off the pumping system. In the event that drawdown is excessive or that water quality parameters do not stabilize, then the monitoring well will be purged until three well volumes have been removed or the pump is covered by less than 2 feet of water, whichever occurs first.

5.3   PERFORMANCE MONITORING

The following sections provide the approach for completing performance monitoring of the AS/SVE system.

5.3.1   Vapor Sampling – Soil Vapor Probes

Performance monitoring will include semi-annual sampling of SVPs. One Tedlar bag sample will be collected at each SVP.

Differential pressure (between subsurface and ambient) will be measured by Magnehelic gauge at each SVP location. Soil vapor samples will be collected into 1-liter Tedlar bags by peristaltic pump or vacuum pump. A PID or FID, if available, will be used to assess real-time concentrations of VOCs in soil vapor. PID/FID readings will be collected at the SVE blower exhaust and SVPs. The instrument will be calibrated with isobutylene prior to each field mobilization and every 8 hours during ongoing field work. Each SVP will be purged of soil gas until PID readings from the pump discharge stabilize. The hose barb on the Tedlar bags are equipped with tubing barbs with in-line valves that can be open and closed. Vapor sampling points are capped with a similar valve also equipped with a tubing barb. The suction side of the soil vapor pump will be attached by Teflon tubing to the valved fitting at the sampling location. The discharge side of the pump will be attached by Teflon tubing to the hose barb on the Tedlar bags. With the Teflon tubing attached to both the hose barb and sampling port the in-line valve will be opened to allow air from the vapor sampling point to flow into the bag. The Tedlar bag will be filled, purged of one volume then refilled for the sample. After the Tedlar bag has a substantial amount of air in it the valve will be closed and the hose barb will be disconnected from the tubing. Care will be taken not to fill the Tedlar

bag too full to minimize the possibility of tearing during transport to the lab. In order to obtain more representative soil vapor samples, approximately two volumes of Tedlar bags will be purged from soil vapor probes prior to collection of the sample for laboratory analysis. New tubing will be used for each sample point. Tedlar bag samples will be submitted to Eurofins-Air Toxics laboratory in Folsom, California for analysis for TPH-G and BTEX by Method TO-15.

5.3.2   Vapor Sampling – SVE Exhaust

SVE blower exhaust will be monitored by PID after startup of the AS blower. Tedlar bag samples will also be collected from the SVE blower exhaust. The bag will be filled, purged and refilled under the pressure of the SVE exhaust. After daily operation of the AS blower is started, three SVE samples will be collected each quarter for eight quarters (2 years). Collection of SVE exhaust samples will begin at least 10 hours after operation of the AS blower. The current plan for quarterly SVE exhaust monitoring specifies collection of four Tedlar bag samples collected at equally-spaced intervals over 8 hours. Sample times may be adjusted based on field observations and results of earlier sampling events as quarterly performance monitoring progresses.

5.3.3   Horizontal Zone of Influence

The Pilot Test demonstrated that the horizontal ZOI exerted by the SVE blower extends from the two extraction laterals under the building to the outermost SVPs. ZOI is defined by measurement of pressure differentials at SVPs. A Magnehelic gauge, configured for differential pressure measurement, will be used at all SVPs. Bypassing well MW 10-A17-8 which will be plugged for the AS ZOI evaluation. Soil vapor pressures will be plotted on a site map.

5.3.4   Building and Sub-Slab Pressure Gradient

Passive and active systems impede intrusion of soil vapors into the Credit Union building. The sub-slab vapor barrier is designed to prevent migration of soil gases into the building. Mechanical systems (blowers) induce a pressure gradient to further protect against soil vapor intrusion. The HVAC system maintains a positive pressure in the Credit Union Building. Suction from the SVE blower through the extraction laterals maintains a negative pressure under the building slab and parking lot. Building interior pressures are slightly above atmospheric pressure. A differential pressure gauge is used to measure the pressure gradient between the building interior and sub-slab. The interior-to-sub-slab pressure gradient is measured at the interior monitoring point. Interior and sub-slab pressures are

compared to atmospheric (barometric) pressure measurements. Differential pressure readings at exterior sub-slab monitoring points (SSD-3, SSD-S1, SSD-S2, SSD-N1, and SSD-N2) measure the difference between atmospheric and sub-slab conditions. Sub-slab differential pressures on the order of 0.02 to 0.05 inch of water are expected.

5.3.5 Air Flow to AS Wells and from SVE Zones

Flow monitoring ports are installed in the supply lines to the air sparge wells and in the suction lines of the SVE blower. Saddle taps are installed for flow monitoring in order to minimize the flow distortion that may result from a tee or other pipe fitting. A portable vane anemometer will be used to measure flow and temperature of air flowing through each SVE suction line. The vane anemometer probe must be inserted through the pipe tap to position the propeller in the center of the pipe and in-line with the direction of air flow. Gauges installed on each SVE zone indicate suction pressures. Valves on each SVE line allow for flow adjustment.

Because the vane anemometer is not suited for the higher pressures of the AS lines, pressure and temperatures are measured and used to estimate air flows using the AS blower curve. Gauges installed at the blower discharge and on each AS well head indicate air pressures. A portable infrared temperature gun is used to read line temperatures. Valves on each AS well head allow for flow adjustment.

5.3.6 Vapor Intrusion and Ambient Air Monitoring

VI monitoring will be performed annually according to a VI SAP (KTA 2011). The VI SAP was submitted for Ecology review in August 2011 and finalized in October 2011. The Credit Union point of contact, JBLM Fire Department, and JBLM Police will be notified prior to the VI monitoring event. All vapor intrusion monitoring will be performed with the AS blower operating at the inter-sparge cycle frequency defined in an earlier phase. Indoor and outdoor (ambient) air samples will be collected concurrently using evacuated 6-liter Summa canisters.

5.3.6.1 Ambient Air Sampling

Per the VI SAP, indoor and outdoor (ambient) air samples will be collected concurrently using evacuated 6-liter Summa canisters. Canisters will be provided and certified clean by Eurofins-Air Toxics laboratory. One spare Summa canister and flow regulator will be ordered from the laboratory in the event that one canister fails. Canisters will be equipped with vacuum gauges and flow regulators set to collect 8-hour time-integrated samples. Unless otherwise noted, outdoor air samples will be collected at a minimum height of 6 feet.

Summa canisters for ambient air sampling will be located at:

- South edge of the Credit Union property, on the boundary of the parking lot at the adjacent fueling station and mini-mall. An 8-hour, time-integrated sample will be collected at this location.

- West edge of the Credit Union property, on the boundary of the parking lot at the adjacent Fire Station. This sampling location was defined as the upwind direction in the VI SAP (KTA 2011). An 8-hour time-integrated sample will be collected at this location.

- Air intake to HVAC system at the west side of the building. This canister will be placed at the elevation of the air intake on top of the cage that protects the building heat pumps. An 8-hour, time-integrated sample will be collected at this location at the height of the air intake.

5.3.6.2   Vapor Intrusion Monitoring

In accordance with the VI SAP, indoor air samples will be collected by Summa canisters equipped with vacuum gauges and calibrated flow regulators and sampling canes specified to draw air from a height of 4 feet from the floor. Time-integrated samples will be collected for 8 hours from all indoor locations. Summa canisters for indoor air sampling will be located at:

- Credit Union lobby.

- Custodian's closet, located in the north wing of the building. The custodian's closet is the area with the most floor penetrations nearest to the source area. The door to the closet will be closed to allow for the most conservative (high concentration) vapor collection.

- Conference room. The conference room is the largest room in the Credit Union building. The southeast corner of the conference room overlies the former UST area.

A kitchen, two restrooms, custodian closet and storage room share the north wing of the building with the conference room. The door between the Credit Union lobby and conference facilities will remain closed and locked throughout VI monitoring per usual Credit Union policy. Credit Union personnel will unlock the door to allow sampling personnel access to the conference facility when necessary.

All functions in the building will be allowed to proceed as normal during VI monitoring. No modifications will be made to HVAC settings, door positions, use or activities of building

personnel or customers. However, unlike the 2012 VI monitoring event, automatic metered room deodorizers will be deactivated at least 24 hours before and remain off through the duration of the sampling events.

Canister locations will be photographed, measured and identified on building floor plans. After sample collection, Summa canisters will be secured in the Sealaska JBLM job trailer and shipped under proper chain of custody by overnight carrier to Eurofins-Air Toxics Laboratory in Folsom, California for analysis by Method TO-15 for TPH-G and BTEX.

Analyses of ambient air samples will be compared to indoor air samples to assess possible effects of background air on indoor air quality.

5.3.6.3   Possible Interior Sources of Volatile Organic Compounds

Vapor intrusion monitoring (Versar 2013a) indicated that the automatic, metered room deodorizer used in the Credit Union restrooms interferes with analyses for gasoline-range VOCs. Automatic room deodorizers will be turned off at least 24 hours before any vapor intrusion monitoring events. In addition, an inventory of possible addition VOC sources will be completed. Any potential VOC sources will be stage away from the Summa canister used for sampling or removed from the site prior to initiation of vapor intrusion monitoring.

5.4   WEATHER DATA

Weather conditions will be recorded for the period around each monitoring event. Field readings will be collected for temperature, barometric pressure, and relative wind speed. Online weather data from sites such as the National Weather Service may also be consulted for real time and historical weather. A Solinst Barologger (see Appendix B) is installed at the SVE building to monitor site-specific barometric pressure. Barologger data can be uploaded to a laptop computer and correlated with Levelogger readings to follow trends in groundwater depth and correlate with pressure readings at SVE and SSD monitoring ports and SVPs. Official weather data may also be collected from the National Climatic Data Center (NCDC) for the dates and times of the special monitoring events.

5.5   FIELD RECORDKEEPING

The following forms will be utilized to document monitoring events at this site: Field Checklist, Daily Field Report, and AS/SVE System Performance Forms. The Field Checklist is designed to assist with planning and coordination prior to a field event. The Daily Field Report is used to document field activities on a daily basis. The AS/SVE System

Performance Forms are used to record AS/SVE system parameters and vapor sample data. Blank field forms are included in Appendix C.

5.6   INVESTIGATION-DERIVED WASTE

IDW will be handled and disposed of as follows:

- PPE and Teflon tubing used for vapor sampling will be disposed of in a Sealaska dumpster as part of the normal solid waste stream.

5.7   SAMPLE LABELING, HANDLING, AND SHIPMENT

Sample labels for AS/SVE system vapor samples will indicate the site location (AOC 9-2), sampler's initials, parameters to be analyzed, time, date, and sample name. For example, a Summa canister sample collected from the Credit Union lobby on 2 February 2009 was labeled "AOC92120209Lobby." A sample collected from the SVE exhaust at 13:20 hours on 2 November 2011 was labeled "AOC9-2SVE111102-1320."

Sample packaging and shipping procedures are based on Environmental Protection Agency (EPA) specifications and United States Department of Transportation regulations as specified in 49 Code of Federal Regulations (CFR) 173.6 and 49 CFR 173.24. On the day of collection, all samples will be delivered by courier to the current laboratory under contract to JBLM. Samples will be identified as "Environmental Samples" and not as hazardous material. The following are general packaging procedures for Tedlar bag samples:

- Attach sample labels securely to each sample container.
- Use plastic bubble-wrap bags, sheets, or Styrofoam packing material to protect sample containers.
- Use insulated plastic or metal-clad plastic coolers as shipping containers.
- Place the original chain of custody form in the cooler in a sealed plastic bag.
- Place two signed custody seals over the lid of the cooler and cover with clear plastic tape.
- Cover and seal the cooler drain with plastic tape.
- Use strapping tape to shut the cooler.
- Attach the completed shipping label to the top of the cooler.

For Summa canisters, after sampling the canisters will be packaged in the boxes in which they were provided and returned to the laboratory.

5.8   CHAIN OF CUSTODY DOCUMENTATION

Chain of custody procedures are employed to maintain and document sample possession. A sample is considered under a person's custody if it is in that person's physical possession, within visual sight of that person after taking physical possession, secured by that person so that the sample cannot be tampered with, or secured by that person in an area that is restricted to unauthorized personnel.

The originator (the sampler) will fill in all requested information on the custody record and will sign and date the record in the first "relinquished by" box. Original signed custody records listing the samples in the cooler will accompany all shipments of samples. (Note: it is possible that more than one custody form will be needed per cooler to list all the samples contained in the cooler.) The originator of the custody record will keep the bottom copy (usually pink).

6　QUALITY ASSURANCE PROJECT PLAN

The following Quality Assurance Project Plan (QAPP) is designed to show plans for compliance with Quality Assurance (QA)/Quality Control (QC) portions of a SAP per WAC 173-340-820. It should be noted that some elements of a typical QAPP are not repeated if included elsewhere in this Plan.

The purpose of QA/QC procedures for this site is to provide assurance that field and analytical procedures produce data of acceptable quality to evaluate long-term trends of contaminant concentrations at the site.

This section includes the QA/QC procedure for air-related sampling only. Groundwater sampling QA/QC procedures are provided in the Fort Lewis Agreed Order Groundwater Monitoring Plan (Sealaska 2014).

6.1　DATA QUALITY OBJECTIVES

DQOs define the type, quantity, and quality of data that are needed to answer specific environmental questions, and support environmental decisions. DQOs are developed using a systematic planning process described in the Guidance for the Data Quality Objectives Process (EPA 2006). The DQOs consist of the following seven iterative steps:

1. State the problem.
2. Identify the goals of the study.
3. Identify information inputs.
4. Define the boundaries of the study.
5. Develop the analytic approach.
6. Specify performance or acceptance criteria.
7. Develop the plan for obtaining data.

Step 1: State the problem.
- Monitoring of the AS/SVE system is necessary to assess performance and ensure that SVE exhaust is not exceeding PSCAA emissions limits.

- There is a potential for contaminants in groundwater to volatilize to indoor or ambient air. Contaminants of concern include TPH-G and BTEX.

Step 2: Identify the goals of the study.
- Assess the presence, concentration, and potential migration of volatile compounds into indoor or ambient air.

- To confirm whether or not contaminants in indoor or ambient air are exceeding MTCA Method B Air Cleanup Levels for carcinogens and non-carcinogen compounds. Contaminants include benzene (0.32 micrograms per cubic meter [$\mu g/m^3$]), toluene (2,300 $\mu g/m^3$), ethylbenzene (460 $\mu g/m^3$), and total xylenes (46 $\mu g/m^3$).

- To confirm SVE emissions are not exceeding PSCAA emissions limits of 15 pounds of benzene per year or 50,000 pounds of VOCs per year.

Step 3: Identify information inputs.
- Monitoring of system components will be completed as shown in Table 4-3.

- Vapor intrusion and ambient air monitoring results.

- SVE exhaust monitoring results.

Step 4: Define the boundaries of the study.
- The AOC 9-2 site, Credit Union Building, and area immediately adjacent (see Figure 1-2).

- Vapor intrusion and ambient air monitoring will be conducted annually.

- SVE exhaust monitoring will be completed quarterly.

Step 5: Develop the analytic approach.
- If petroleum hydrocarbon or BTEX concentrations are detected in indoor air, then the AS/SVE system operation will be evaluated to assess performance and adjusted as needed.

Step 6: Specify performance or acceptance criteria.
- To minimize sampling error, samples will be collected by Sealaska personnel who are trained in the collection air monitoring data and air samples.

- Air samples for laboratory testing will be analyzed by an accredited laboratory. The primary laboratory for this project is Eurofins-Air Toxics laboratory in Folsom, California.

Step 7: Develop the plan for obtaining data.
- Collection of air data and air samples will be completed as shown in Table 4-3.

6.2   FIELD QUALITY CONTROL SAMPLES

Duplicate air samples will be collected in the following frequency:

- Soil vapor duplicate samples will be collected at a frequency of one for every 10 primary samples. A second Tedlar bag (duplicate) will be filled with air from the SVE system immediately following the primary sample.

6.3   LABORATORY QUALITY CONTROL

The project laboratory will be responsible for conducting laboratory QC procedures and reporting laboratory QC results in accordance with laboratory standard operating procedures. The project laboratory will perform and report the following laboratory QC once per batch of BTEX samples for benzene and toluene: method blank, blank spike, matrix spike, and matrix spike duplicate. The laboratory will perform and report a method blank and blank spike for each batch of samples analyzed for TPH-G. The laboratory will perform and report results of surrogate recoveries for each sample analyzed for BTEX and TPH-G. The current project laboratory's control limits for acceptable surrogate recoveries are shown in Table 6-1.

Table 6-1.   Surrogate Recovery Control Limits

Analytical Method	Surrogate Analyte	Acceptable Surrogate Recovery Range (%)
	1,2-Dichloroethane-d4	71 - 122
TO-15	4-Bromofluorobenzene	75 - 119
	Toluene-d8	90 - 108

6.4   QA/QC REVIEW AND VERIFICATION

Data quality will be reviewed and verified by Sealaska personnel to determine if the data are suitable for use. Project data as well as QA/QC data (i.e., field QC results, lab QC results, PQLs, and holding times) will be evaluated in terms of precision, accuracy, representativeness, comparability, and completeness. Results of these evaluations will be summarized in the annual report. Corrective action for field or laboratory data will be evaluated on a case by case basis, and may include re-sampling. Other corrective actions for field or laboratory procedures will be taken as needed in consultation with Ecology.

7 CRITERIA FOR SYSTEM SHUTDOWN

7.1 CLEANUP CRITERIA

Table 7-1 lists criteria to be considered in evaluating shutdown of the AS/SVE system. The objective of the AS/SVE system is to remediate groundwater to MTCA guideline concentrations (Table 1-2). However, some SVE systems AS/SVE systems often reach a point of mass transfer limitation after extended operation. Depending on the soil type, the rate of VOC diffusion through soil is exceeded by the extracted air flow rate and VOCs in SVE exhaust reach asymptotic concentrations. Soil gas monitoring will be performed to verify VOC removal from the vadose zone before the AS/SVE system is shutdown. Pulsed venting, discussed in the IA Work Plan (Versar 2013b) will be performed in the event of asymptotic VOC concentrations from the SVE exhaust. Contingent technologies may be implemented if pulsed venting is not effective in achieving a rebound in VOC removal.

Table 7-1. Criteria to Be Considered in Evaluating Shutdown of AS/SVE System

Soil Vapor Extraction Blower Exhaust
Total emissions and/or gasoline constituents are not evident.
Total emissions or individual VOCs exiting blower exhaust reach asymptotic conditions for at least one month.
No rebound is observed in exhaust concentrations upon system restart, following reasonable shutdown period (one week).
Pulsed venting down time exceeds pulse venting operating time.
Soil Gas Analysis
Soil gas constituents collected from remediation area reach asymptotic conditions.
Soil gas constituents collected from remediation area indicate levels of non-detection with reasonable detection limits and concentrations.
Soil gas constituents collected from the remediation area indicate levels of residual mass that are no longer a threat to groundwater.
Soil gas concentrations do not significantly rebound following reasonable system shutdown period.
Groundwater Monitoring
Groundwater monitoring parameters (TPH-G and BTEX) are present at concentrations below MTCA cleanup levels for two consecutive sampling events.

Notes:
BTEX – Benzene, toluene, ethylbenzene and xylenes analyzed using EPA Method TO-15.
TPH-G – Gasoline-range total petroleum hydrocarbons analyzed using TO-15 for air and soil vapor samples.
MTCA – Washington Department of Ecology Model Toxics Control Act

8   CONFIRMATION SAMPLING

Confirmation Sampling will be performed to verify that sufficient remediation has occurred after performance monitoring indicates achievement of cleanup criteria. See the IA Work Plan (Versar 2013b) for details on Confirmation Sampling of soil vapor and groundwater.

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9   PROJECT REPORTING

The following section provide information on project reporting required for AOC 9-2.

9.1   ANNUAL PERFORMANCE MONITORING REPORTS

Annual Performance Monitoring Reports for AOC 9-2 will be prepared until the cleanup criteria are satisfied. Annual Performance Monitoring Reports will include the following:

- Investigation chronology;

- Discussion of AS/SVE system maintenance activities;

- A site map for each site showing relevant surface features, sampling locations, groundwater elevations obtained during the groundwater monitoring events, and VOC concentrations detected during the groundwater monitoring events;

- Discussion of sampling methodology including any deviations from this plan;

- Results of air monitoring;

- Comparison of laboratory results with cleanup standards;

- Summary of differential pressures at SSD ports and SVPs;

- Trends in VOCs at SVE exhaust;

- Trends in VOCs at groundwater monitoring wells;

- Comparisons of DTW variations at groundwater monitoring wells;

- Notes on any changes in system operation;

- Descriptions of anomalies in system performance;

- AS and SVE ZOIs and comparison to results of pilot test and other monitoring events;

- Copies of original field forms;

- Laboratory certificates of analysis with chain of custody records;

- An evaluation of the data, discussion of the influence and effectiveness of the AS/SVE components and system;

- Recommendations for modifying AS pulse frequency and duration; and

- Recommendations for modifying SVE valve settings.

A Results section will present the findings of groundwater monitoring and system-wide performance monitoring. The Results section will identify the optimum AS/SVE operating conditions as developed in the pilot test. The report will address the effectiveness of the SSD system at maintaining negative sub-slab pressures. The reports will conclude with recommendations for modification or expansion in design of the final system for remediation of the AOC 9-2 site.

A draft copy of each Performance Monitoring Report will be submitted to Ecology for review.

9.2   ANNUAL JBLM GROUNDWATER MONITORING REPORTS

Results of groundwater monitoring will be submitted in the Annual FLAO Groundwater Monitoring Report. The Annual FLAO Monitoring Report, submitted to Ecology, includes results for AOC 9-2 and three other FLAO sites.

9.3   CONFIRMATION MONITORING REPORTS

Once the site cleanup criteria and the criteria for system shutdown have been achieved, a Confirmation Monitoring Report will be submitted. This report will include a request for No Further Action at the site. A Draft version of the Confirmation Monitoring Report will be submitted to Ecology for review. Ecology comments will be addressed and a final report will be submitted.

10 REFERENCES

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APPENDIX A

HISTORICAL GROUNDWATER MONITORING DATA

Table A-1. AOC 9-2 Depth to Water and Groundwater Parameter Measurements

Well ID TOC Elevation	Date	DTW (ft btoc)	GWELEV (ft AMSL)	pH	Cond. (µS/cm)	DO (ppm)	ORP (mv)	Temp ºC
95-A17-1	1-Aug-95	30.49	204.77	-	-	-	-	-
236.9	1-Feb-96	24.21	211.05	-	-	-	-	-
	1-Sep-96	28.2	207.06	-	-	-	-	-
	1-Mar-97	22.8	212.46	-	-	-	-	-
	1-Aug-97	26.4	208.86	-	-	-	-	-
	1-Mar-98	24.06	211.2	-	-	-	-	-
	1-Sep-98	29.2	206.06	-	-	-	-	-
	1-Mar-99	21.1	214.16	-	-	-	-	-
	1-Aug-99	27.01	208.25	-	-	-	-	-
	1-Mar-00	23.93	211.33	-	-	-	-	-
	1-Sep-00	28.99	206.27	-	-	-	-	-
	1-Mar-01	29.51	205.75	-	-	-	-	-
	1-Aug-02	29.6	205.66	-	-	-	-	-
	28-Oct-03	30.11	205.15	-	-	-	-	-
	20-Oct-04	30.94	204.32	-	-	-	-	-
	9-Nov-05	30.51	204.75	-	-	-	-	-
	14-Jun-07	26.33	208.93	-	-	-	-	-
	21-Mar-08	26.33	208.93	-	-	-	-	-
	8-Aug-08	29.78	205.48	-	-	-	-	-
	9-Mar-09	27.57	207.69	-	-	-	-	-
	25-Aug-09	29.87	207.03	-	-	-	-	-
	22-Feb-10	26.1	210.8	-	-	-	-	-
	24-Aug-10	28.6	208.3	-	-	-	-	-
	24-Feb-11	25.1	211.8	-	-	-	-	-
	9-Sep-11		Could Not Locate					
	14-Mar-12	25.5	211.4	-	-	-	-	-
	16-Aug-12	27.9	209	-	-	-	-	-
	21-Feb-13	24.28	212.62	-	-	-	-	-
	13-Aug-13	28.8	208.1	-	-	-	-	-
	10-Mar-14	23.6	213.3	-	-	-	-	-
	22-Sep-14	28.67	208.23	-	-	-	-	-
	21-Apr-15	25.37	211.53	-	-	-	-	-
	1-Sep-15	29.43	207.47	-	-	-	-	-
95-A17-2	1-Aug-95	30.2	204.59	-	-	-	-	-
235.9	1-Feb-96	24.24	210.55	-	-	-	-	-
	1-Sep-96	27.71	207.08	-	-	-	-	-
	1-Mar-97	22.34	212.45	-	-	-	-	-
	1-Aug-97	26.08	208.71	-	-	-	-	-
	1-Mar-98	23.82	210.97	-	-	-	-	-
	1-Sep-98	28.7	206.09	-	-	-	-	-
	1-Mar-99	20.6	214.19	-	-	-	-	-
	1-Aug-99	26.55	208.24	-	-	-	-	-
	1-Mar-00	23.49	211.30	-	-	-	-	-
	1-Sep-00	28.51	206.28	-	-	-	-	-
	1-Mar-01	29.09	205.70	-	-	-	-	-
	1-Aug-02	28.92	205.87	-	-	-	-	-
	28-Oct-03	29.65	205.14	-	-	-	-	-
	28-Apr-04	27.97	206.82	-	-	-	-	-

Table A-1. AOC 9-2 Depth to Water and Groundwater Parameter Measurements (continued)

Well ID TOC Elevation	Date	DTW (ft btoc)	GWELEV (ft AMSL)	pH	Cond. (µS/cm)	DO (ppm)	ORP (mv)	Temp ºC
95-A17-2 Cont.	20-Oct-04	30.47	204.32	-	-	-	-	-
	9-Nov-05	30	204.79	-	-	-	-	-
	31-Oct-06	30.38	204.41	6.89	0.155	-	-	13.30
	14-Jun-07	26.03	208.76	6.90	0.153	-	-	13.30
	21-Nov-07	28.82	205.97	6.06	0.107	-	-	13.30
	21-Mar-08	26.02	208.77	7.32	0.139	-	-	12.43
	8-Aug-08	29.37	205.42	7.19	0.114	1.45	195.33	12.57
	9-Mar-09	27.21	207.58	7.24	0.124	0.62	148.75	13.33
	25-Aug-09	29.49	206.41	6.66	0.106	0.76	252.00	13.10
	22-Feb-10	25.5	210.40	-[1]	-	-	-	-
	24-Aug-10	27.82	208.08	-[1]	-	-	-	-
	24-Feb-11	24.4	211.50	5.48[1]	0.126	3.06	-	12.80
	9-Sep-11	27.25	208.65	6.27	0.111	3.60	230.00	16.00
	14-Mar-12	24.73	211.17	-	-	5.96	26.00	11.20
	16-Aug-12	27.03	208.87	-	-	-	-	-
	21-Feb-13	25.37	210.53	7.45	-	5.07	23.00	13.20
	13-Aug-13	28.4	207.50	6.60	0.176	0.47	24.00	13.60
	10-Mar-14	Low Water Level, Unable to Collect Sample						
	22-Sep-14	27.7	208.20	6.50	0.147	5.90	173.00	17.20
	23-Apr-15	24.56	211.34	6.26	0.191	8.30	206	14.71
	1-Sep-15	28.38	207.52	6.49	0.196	9.40	125	16.83
95-A17-3a 235.9	1-Aug-95	30.41	204.81	-	-	-	-	-
	1-Feb-96	24.65	210.57	-	-	-	-	-
	1-Sep-96	28.06	207.16	-	-	-	-	-
	1-Mar-97	22.31	212.91	-	-	-	-	-
	1-Aug-97	26.1	209.12	-	-	-	-	-
	1-Mar-98	23.51	211.71	-	-	-	-	-
	1-Sep-98	28.7	206.52	-	-	-	-	-
	1-Mar-99	20	215.22	-	-	-	-	-
	1-Aug-99	26.44	208.78	-	-	-	-	-
	1-Mar-00	23.16	212.06	-	-	-	-	-
	1-Sep-00	28.54	206.68	-	-	-	-	-
	1-Mar-01	29.51	205.71	-	-	-	-	-
	1-Aug-02	29.14	206.08	-	-	-	-	-
	30-Jun-03	28.94	206.28	-	-	-	-	-
	28-Oct-03	29.85	205.37	-	-	-	-	-
	28-Apr-04	28.06	207.16	-	-	-	-	-
	20-Oct-04	30.88	204.34	-	-	-	-	-
	24-May-05	28.75	206.47	-	-	-	-	-
	9-Nov-05	30.32	204.90	-	-	-	-	-
	14-Jun-06	26.99	208.23	-	-	-	-	-
	31-Oct-06	30.86	204.36	6.49	0.253	-	-	12.60
	14-Jun-07	26.09	209.13	6.51	0.252	-	-	12.60
	21-Nov-07	29.21	206.01	6.05	0.205	-	-	13.00
	21-Mar-08	26	209.22	7.35	0.237	0.70	-	12.37
	8-Aug-08	29.42	205.80	7.16	0.214	0.97	-25.75	12.28
	9-Mar-09	27.07	208.15	7.04	0.227	0.71	-177.00	12.88
	25-Aug-09	29.46	206.44	6.03	0.199	0.77	233.00	13.10

Table A-1. AOC 9-2 Depth to Water and Groundwater Parameter Measurements (continued)

Well ID TOC Elevation	Date	DTW (ft btoc)	GWELEV (ft AMSL)	pH	Cond. (µS/cm)	DO (ppm)	ORP (mv)	Temp ºC
95-A17-3a Cont.	22-Feb-10	25.6	210.30	6.52	0.205	0.47	-196.00	12.80
	23-Aug-10	29.1	206.80	4.80	0.200	1.17	-125.00	13.10
	24-Feb-11	24.55	211.35	5.86	0.191	0.73	-	13.00
	9-Sep-11	27.62	208.28	6.07	0.177	4.87	-98.00	14.40
	14-Mar-12	24.85	211.05	-	-	-	-	-
	16-Aug-12	27.47	208.43	-	-	-	-	-
	21-Feb-13	25.66	210.24	-	-	-	-	-
	13-Aug-13	27.85	208.05	-	-	-	-	-
	14-Mar-14	22.9	213.00	6.36	0.223	7.70	26.00	13.60
	23-Sep-14	28.07	207.83	6.30	0.147	2.90	42.00	14.70
	22-Apr-15	24.96	210.94	6.5	0.329	5.20	0	14.5
	2-Sep-15	28.96	206.94	6.57	0.403	0.0	-56	15.50
95-A17-4 236.8	1-Aug-95	29.91	205.24	-	-	-	-	-
	1-Feb-96	23.65	211.50	-	-	-	-	-
	1-Sep-96	27.56	207.59	-	-	-	-	-
	1-Mar-97	21.75	213.40	-	-	-	-	-
	1-Aug-97	25.85	209.30	-	-	-	-	-
	1-Mar-98	23.35	211.80	-	-	-	-	-
	1-Sep-98	28.7	206.45	-	-	-	-	-
	1-Mar-99	19.7	215.45	-	-	-	-	-
	1-Aug-99	26.33	208.82	-	-	-	-	-
	1-Mar-00	22.93	212.22	-	-	-	-	-
	1-Sep-00	28.1	207.05	-	-	-	-	-
	1-Mar-01	29.05	206.10	-	-	-	-	-
	1-Aug-02	29.04	206.11	-	-	-	-	-
	28-Oct-03	29.51	205.64	-	-	-	-	-
	20-Oct-04	30.5	204.65	-	-	-	-	-
	9-Nov-05	29.8	205.35	-	-	-	-	-
	14-Jun-07	25.72	209.43	-	-	-	-	-
	21-Mar-08	25.77	209.38	6.15	0.13	-	-	14.37
	8-Aug-08	29.31	205.84	7.15	0.14	6.81	130.00	12.00
	9-Mar-09	26.91	208.24	7.12	0.14	7.03	228.25	13.83
	25-Aug-09	29.32	207.48	-	-	-	-	-
	21-Feb-10	25.38	211.42	5.95	0.14	4.97	285.00	13.30
	24-Aug-10	27.95	208.85	-	-	-	-	-
	24-Feb-11	24.37	212.43	6.01	0.14	6.91	-	13.30
	9-Sep-11	27.45	209.35	6.09	0.13	5.90	353.00	14.30
	14-Mar-12	24.89	211.91	-	-	6.36	26.00	11.20
	16-Aug-12	27.29	209.51	-	-	-	-	-
	21-Feb-13	25.49	211.31	6.69	-	6.47	-146.00	13.50
	13-Aug-13	27.85	208.95	-	-	-	-	-
	14-Mar-14	22.5	214.30	6.26	0.18	8.55	32.00	13.50
	23-Sep-14	27.99	208.81	-	-	-	-	-
	22-Apr-15	24.76	212.04	6.31	0.18	9.4	206	14.4
	1-Sep-15	28.82	207.98	-	-	-	-	-

Table A-1. AOC 9-2 Depth to Water and Groundwater Parameter Measurements (continued)

Well ID TOC Elevation	Date	DTW (ft btoc)	GWELEV (ft AMSL)	pH	Cond. (µS/cm)	DO (ppm)	ORP (mv)	Temp ºC
96-A17-5	1-Feb-96	22.44	211.14	-	-	-	-	-
233.9	1-Sep-96	26.2	207.38	-	-	-	-	-
	1-Mar-97	20.75	212.83	-	-	-	-	-
	1-Aug-97	24.6	208.98	-	-	-	-	-
	1-Mar-98	22.25	211.33	-	-	-	-	-
	1-Sep-98	27.3	206.28	-	-	-	-	-
	1-Mar-99	18.9	214.68	-	-	-	-	-
	1-Aug-99	25.05	208.53	-	-	-	-	-
	1-Mar-00	21.92	211.66	-	-	-	-	-
	1-Sep-00	27.07	206.51	-	-	-	-	-
	1-Mar-01	27.76	205.82	-	-	-	-	-
	1-Aug-02	27.68	205.90	-	-	-	-	-
	28-Oct-03	28.3	205.28	-	-	-	-	-
	9-Nov-05	28.47	205.11	-	-	-	-	-
	14-Jun-07	24.47	209.11	-	-	-	-	-
	21-Mar-08	24.48	209.10	-	-	-	-	-
	8-Aug-08	27.93	205.65	-	-	-	-	-
	9-Mar-09	25.71	207.87	-	-	-	-	-
	25-Aug-09	28.03	205.87	-	-	-	-	-
	21-Feb-10	24.29	209.61	-	-	-	-	-
	24-Aug-10	26.66	207.24	-	-	-	-	-
	24-Feb-11	23.26	210.64	-	-	-	-	-
	9-Sep-11	26.15	207.75	-	-	-	-	-
	14-Mar-12	25.7	208.20	-	-	-	-	-
	16-Aug-12	26.01	207.89	-	-	-	-	-
	21-Feb-13	24.28	209.62	-	-	-	-	-
	13-Aug-13	26.93	206.97	-	-	-	-	-
	10-Mar-14	21.85	212.05	-	-	-	-	-
	23-Sep-14	26.66	207.24	-	-	-	-	-
	21-Apr-15	23.57	210.33	-	-	-	-	-
	1-Sep-15	27.51	206.39	-	-	-	-	-
96-A17-6	1-Feb-96	22.95	209.66	-	-	-	-	-
235.1	1-Mar-01	28.18	204.43	-	-	-	-	-
	28-Oct-03	27.25	205.36	-	-	-	-	-
	9-Nov-05	27.41	205.20	-	-	-	-	-
	14-Jun-07	23.41	209.20	-	-	-	-	-
	21-Mar-08	23.43	209.18	-	-	-	-	-
	8-Aug-08	26.91	205.70	-	-	-	-	-
	9-Mar-09	24.62	207.99	-	-	-	-	-
	25-Aug-09	26.98	208.12	-	-	-	-	-
	21-Feb-10	23.2	211.90	-	-	-	-	-
	24-Aug-10	25.5	209.60	-	-	-	-	-
	25-Feb-11	22.14	212.96	-	-	-	-	-
	9-Sep-11	25.11	209.99	-	-	-	-	-
	14-Mar-12	22.56	212.54	-	-	-	-	-
	16-Aug-12	24.93	210.17	-	-	-	-	-
	21-Feb-13	23.2	211.90	-	-	-	-	-

Table A-1. AOC 9-2 Depth to Water and Groundwater Parameter Measurements (continued)

Well ID TOC Elevation	Date	DTW (ft btoc)	GWELEV (ft AMSL)	pH	Cond. (µS/cm)	DO (ppm)	ORP (mv)	Temp ºC
96-A17-6 Cont.	13-Aug-13	25.85	209.25	-	-	-	-	-
	10-Mar-14	20.6	214.50	-	-	-	-	-
	23-Sep-14	26.59	208.51	-	-	-	-	-
	21-Apr-15	22.48	212.62	-	-	-	-	-
	1-Sep-15	28.5	206.60	-	-	-	-	-
07-A17-7 233.2	16-Nov-07	27.85	206.20	7.27	0.170	-	-	12.80
	26-Mar-08	24.88	209.17	7.18	0.138	0.79	38.33	12.67
	26-Aug-08	28.33	205.72	7.25	0.161	0.35	-158.25	12.85
	3-Mar-09	26.09	207.96	-	-	-	-	-
	25-Aug-09	28.46	204.74	6.70	0.132	0.23	172	13.20
	21-Feb-10	24.30	208.90	5.82	0.067	0.24	131	11.9
	24-Aug-10	26.71	206.49	5.64	0.132	0.37	76	14.1
	24-Feb-11	23.20	210.00	5.24	0.038	5.66	-	10.6
	9-Sep-11	26.20	207.00	6.05	0.125	1.82	243	16.5
	14-Mar-12	23.63	209.57	-	-	6.8	26	9.5
	16-Aug-12	26.02	207.18	7.34	-	1.06	28	18.6
	21-Feb-13	24.28	208.92	7.48	-	2.49	22	9.9
	13-Aug-13	27.00	206.20	5.97	0.099	0.59	57	13.3
	14-Mar-14	21.45	211.75	5.97	0.059	6.3	46	11.6
	23-Sep-14	26.74	206.46	6.2	0.101	2	2	14
	22-Apr-15	23.60	209.60	6.17	0.130	4.9	28	12.8
	2-Sep-15	27.46	205.74	6.55	0.180	0.0	49	14.85
10-A17-8 235.8	29-Nov-10	26.87	208.93	-	-	-	-	-
	25-Feb-11	24.30	211.50	-	-	-	-	-
	9-Sep-11	26.68	209.12	5.82	0.208	1.99	230	16
	18-Nov-11	29.00	206.80	-	-	-	-	-
	14-Mar-12	24.81	210.99	-	-	-	-	-
	16-Aug-12	27.18	208.62	-	-	-	-	-
	21-Feb-13	25.53	210.27	-	-	-	-	-
	13-Aug-13	28.02	207.78	6.6	0.176	0.48	24	13.6
	10-Mar-14	22.85	212.95	6.01	-	2	47	14.7
	22-Sep-14	27.13	208.67	6.4	0.159	4.4	-21	18.9
Duplicate	22-Sep-14	27.13	208.67	6.4	0.159	4.4	-21	18.9
	22-Apr-15	24.72	211.08	6.43	0.297	4.53	-11	17.3
Duplicate	22-Apr-15	24.72	211.08	6.43	0.297	4.53	-11	17.3
	1-Sep-15	28.39	207.41	6.31	0.371	3.40	-35	19.54
Duplicate	1-Sep-15	28.39	207.41	6.31	0.371	3.40	-35	19.54

Notes:

[1] Pump is broken and caught in well. Well casing is possibly bent. Sample collected using a disposable bailer.

New TOC elevations surveyed on 11 June 2010 were used beginning with August 2009 data.

TOC –	Top of casing
DTW (ft btoc) –	Depth to water (feet below top of casing). Static DTW collected prior to purging beginning in 2015
GWELEV (ft AMSL) –	Groundwater elevation (feet above mean sea level)
Cond. (µS/cm) –	Conductivity (microsiemens per centimeter)
DO (ppm) –	Dissolved oxygen (parts per million)
ORP (mv) –	Oxygen / reduction potential (millivolts)
Temp. (ºC) –	Temperature (degrees Celsius)
- –	No data, not applicable

Table A-2. Results of Groundwater Sampling for TPH-G and BTEX Concentrations

Well ID	Date	TPH-G (µg/L)	Benzene (µg/L)	Toluene (µg/L)	Ethyl benzene (µg/L)	Total Xylenes (µg/L)
95-A17-1	28-Oct-03	100U	0.5U	0.5U	0.5U	1U
	20-Oct-04	100U	1U	1U	1U	3U
	9-Nov-05	100U	1U	1U	1U	3U
95-A17-2	28-Oct-03	4,700	1.6	2.9	102	184
	28-Apr-04	200U	1	1U	1	3U
	20-Oct-04	760	1	1U	18	2
	9-Nov-05	1,900	1U	2	54	67
	31-Oct-06	100U	1U	1U	1U	3U
	14-Jun-07	500U	1U	1U	1U	3U
	7-Nov-07	3,000	1U	1	12	12
	8-Mar-08	500U	1U	1U	1U	3U
	26-Aug-08	500U	1U	1U	1U	3U
	9-Mar-09	500U	1U	1U	1U	3U
	25-Aug-09	500U	1U	1U	1U	3U
	26-Mar-10	50U	1U	1U	1U	3U
	24-Aug-10	No Sample Collected				
	24-Feb-11	50U	1U	1U	1U	3U
	9-Sep-11	50U	1U	1U	1U	3U
	14-Mar-12	50U	1U	1U	1U	2U
	16-Aug-12	50U	1U	1U	1U	2U
	21-Feb-13	250U	0.20U	0.20U	0.20U	0.40U
	13-Aug-13	No Sample Collected				
	10-Mar-14	No Sample Collected				
	22-Sep-14	250U	0.5U	0.080J	0.5U	0.5U
	23-Apr-15	25U	0.1U	0.1U	0.1U	0.2U
	1-Sep-15	48J	0.1U	0.08J	0.07J	0.37J
95-A17-3a	30-Jun-03	32,000	690	1,200	1,100	4,800
	28-Oct-03	10,400	200	270	270	1,200
	28-Apr-04	23,000	600	800	780	3,500
	20-Oct-04	8,200	160	100	310	740
	24-May-05	25,000	630	650	810	3,400
	9-Nov-05	6,000	220	170	280	940
	14-Jun-06	29,000	490	500	840	4,000
	31-Oct-06	26,000	590	380	840	3,000
	14-Jun-07	30,000	310	360	610	2,700
	7-Nov-07	30,000	360	270	730	2,700
	8-Mar-08	35,000	410	400	870	3,600
	26-Aug-08	17,700	175	162	517	1,819
	9-Mar-09	31,200	399	335	772	2,762
	25-Aug-09	27,300	209	245	629	2,370
	22-Feb-10	25,000	320	390	990	3,650
	24-Aug-10[1/]	1,300	73	12	42	24
	24-Feb-11	27,000	270	350	1,100	3,970
	9-Sep-11	13,000	140	110	480	1,620
	14-Mar-12	8,700	91	170	350	330
	16-Aug-12	16,000	110	240	610	2,440
	21-Feb-13	20,000	75	190	480	1,880

Table A-2. Results of Groundwater Sampling for TPH-G and BTEX Concentrations (continued)

Well ID	Date	TPH-G (µg/L)	Benzene (µg/L)	Toluene (µg/L)	Ethyl benzene (µg/L)	Total Xylenes (µg/L)
95-A17-3a Cont.	13-Aug-13[2/]	21,000	92	460	460	2,100
	14-Mar-14	15,000	36	100	230	1,210
	23-Sep-14	1,400	3.7	15	16	216
	22-Apr-15	1,500	21	25	33	166
	2-Sep-15	3,400	28	34	120	242
95-A17-4	28-Oct-03	100U	0.5U	0.5U	0.5U	1U
	20-Oct-04	100U	1U	1U	1U	3U
	9-Nov-05	100U	1U	1U	1U	3U
	14-Jun-07	500U	1U	1U	1U	3U
	8-Mar-08	500U	1U	1U	1U	3U
	26-Aug-08	300	1U	1U	1U	3U
	9-Mar-09	500U	1U	1U	1U	3U
	21-Feb-10	50U	1U	1U	1U	3U
	9-Sep-11	50U	1U	1U	1U	3U
	14-Mar-12	50U	1U	1U	1U	2U
	21-Feb-13	250U	0.20U	0.20U	0.20U	0.40U
	14-Mar-14	250U	0.20U	0.20U	0.20U	0.40U
	22-Apr-15	25U	0.1U	0.1U	0.1U	0.2U
96-A17-5	28-Oct-03	100U	0.5U	0.5U	0.5U	1U
	9-Nov-05	100U	1U	1U	1U	3U
07-A17-7	7-Nov-07	3,400	130	6.8	130	31
	8-Mar-08	2,100	47	3.8	120	8.3
	26-Aug-08	1,990	132	5.7	199	4.6
	25-Aug-09	2,500U	79.1	5U	94.1	15U
Duplicate	25-Aug-09	2,500U	79.5	5U	95	15U
	21-Feb-10	50U	2.5	1U	1U	3U
	24-Aug-10[1/]	18,000	210	220	690	2,500
	24-Feb-11	50U	1U	1U	1U	3U
	9-Sep-11	1,600	44	15	79	46
	14-Mar-12	50U	1U	1U	1U	2U
	16-Aug-12	150	4.7	3.9	1U	3U
	21-Feb-13	250U	0.20U	1.6	0.20U	0.40U
	13-Aug-13	250U	0.6	0.85	0.2U	0.4U
Duplicate	13-Aug-13	250U	0.57	0.63	0.25	0.4U
	14-Mar-14	250U	0.20U	0.25	0.20U	0.4U
	23-Sep-14	250U	0.5U	0.5U	0.5U	0.5U
	22-Apr-15	25U	0.1U	0.1U	0.1U	0.2U
	2-Sep-15	19J	0.1U	0.1U	0.05J	0.2U
10-A17-8	29-Nov-10	71,000	2,100	8,400	1,900	9,600
	25-Feb-11	22,000	720	1,000	490	2,220
Duplicate	25-Feb-11	21,000	730	1,100	490	2,210
	9-Sep-11	26,000	330	300	740	4,200
	18-Nov-11	74,000	900	6,200	2,200	11,500
	14-Mar-12	19,000	710	1,300	490	2,000
	22-May-12	13,000	630	830	350	2,050
	16-Aug-12	59,000	1,500	3,400	1,600	8,800

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Table A-2. Results of Groundwater Sampling for TPH-G and BTEX Concentrations (continued)

Well ID	Date	TPH-G (µg/L)	Benzene (µg/L)	Toluene (µg/L)	Ethyl benzene (µg/L)	Total Xylenes (µg/L)
10-A17-8 Cont.	21-Feb-13	34,000	1,100	2,000	640	3,700
	13-Aug-13	70,000	770	3,600	1,700	8,900
	10-Mar-14	9,500	160	330	160	1,030
	22-Sep-14	3,500	46	90	61	410
Duplicate	22-Sep-14	3,700	50	110	65	440
	22-Apr-15	4,800	470	260	100	810
Duplicate	22-Apr-15	5,000	380	210	89	670
	1-Sep-15	25,000	170	800	740	3,750
Duplicate	1-Sep-15	24,000	180	870	770	3,920
MTCA Cleanup Level		**800**	**5**	**1,000**	**700**	**1,000**

Notes:

[1] It is suspected that these samples' labels were switched.

[2] Sample was labelled as 95-A17-2 by mistake.

    TPH-G –   Gasoline Range Total Petroleum Hydrocarbons

    µg/L –   Micrograms per liter

    BOLD –   Analyte detected above practical quantification limit

    BOLD –   Analyte detected above MTCA Method A cleanup level

    U –   Analyte not detected above result reporting limit

    - –   No data, not applicable

APPENDIX B

INFORMATION FOR MONITORING EQUIPMENT

Contents:

- Solinst Levelogger

- Solinst Barologger

- RAE Systems Photoionization Detector

- Magnehelic Gauges

- Infrared Temperature Gun

- Testothermoanemometer
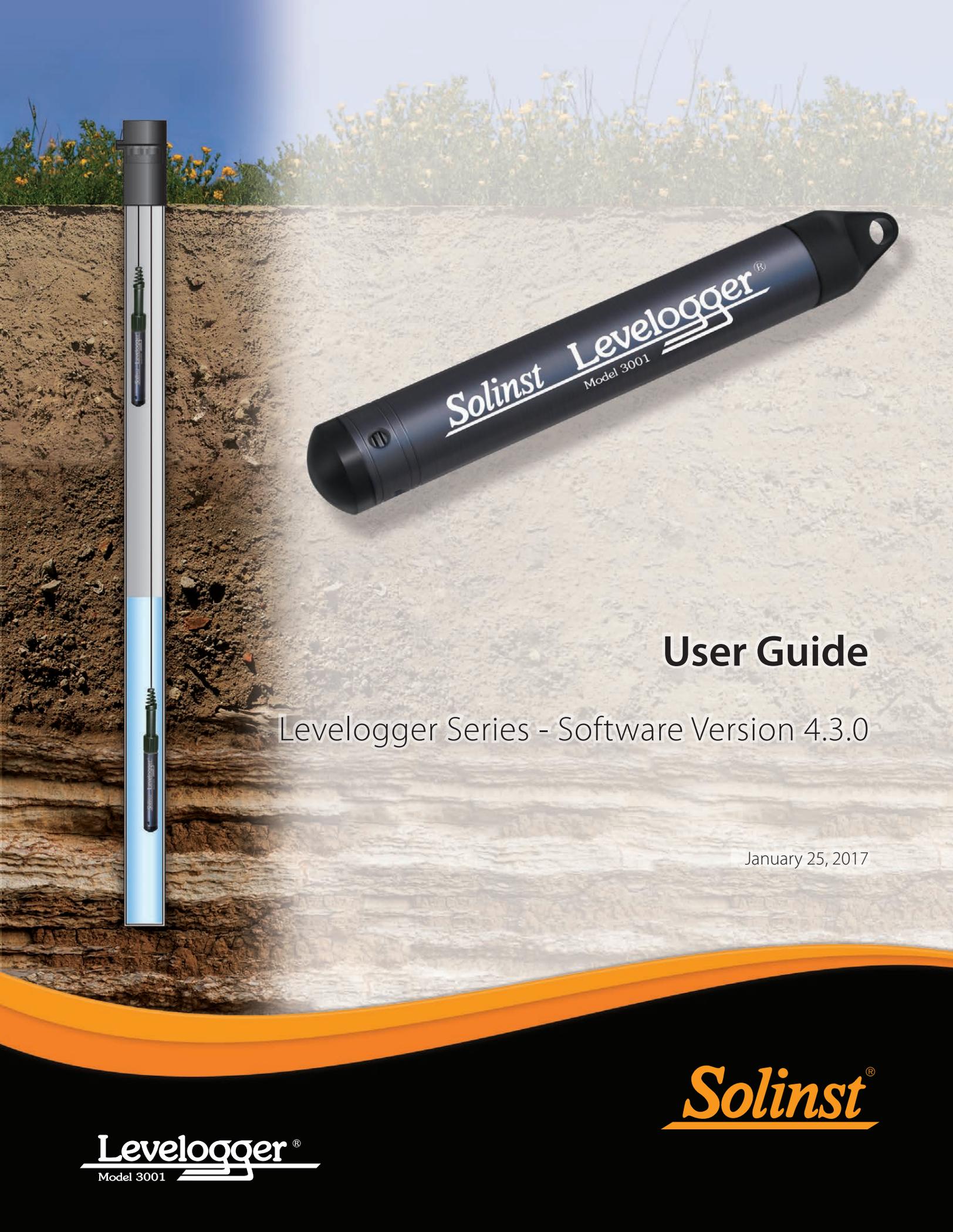
User Guide

Levelogger Series - Software Version 4.3.0

January 25, 2017

Solinst®

Levelogger®
Model 3001

1 Introduction

This User Guide focuses on the current Levelogger Series, which includes:

- Levelogger Edge
- Barologger Edge
- Levelogger Junior Edge
- LTC Levelogger Edge
- Rainlogger Edge

Software Version 4.3.0 is also compatible with Levelogger Gold, Barologger Gold, Levelogger Junior, LTC Levelogger Junior and Rainlogger dataloggers. For details on setting up Gold Series dataloggers, see Section 5.9. Software Version 4.3.0 is compatible with the AquaVent and Leveloader Gold, which have separate User Guides.

This Windows based software provides many convenient features. You can view and program datalogger settings, begin logging sessions, monitor real-time readings, download data, manage data files, perform data compensations, and save and export data files. Depending on the type of datalogger, there will be differences in programming options. See below for a summary of the differences:

Datalogger Programming Options			
Datalogger Type	**Sampling Options**	**Memory Capacity**	**Battery Life**
Levelogger Edge (Barologger Edge)	Linear (0.125 second to 99 hours), Compressed Linear, Event Based, Schedule, Repeat Schedule, Real Time View, Future Start/Stop	40,000 sets of readings or up to 120,000 Compressed. Slate or Continuous Mode (see note)	10 years based on 1 reading per minute
Levelogger Junior Edge	Linear (0.5 second to 99 hours), Real Time View, Future Start	40,000 sets of readings in Slate Mode	5 years based on 1 reading per minute
LTC Levelogger Edge	Linear (2 seconds to 99 hours), Event Based, Schedule, Repeat Schedule, Real Time View, Future Start/Stop	27,000 sets of readings in Slate Mode or Continuous Mode.	8 years based on 1 reading every 5 minute
Rainlogger Edge & Rainlogger	Event Based (records tips from tipping-bucket rain gauge), Real Time View , Future Start	Up to 60,000 tip time logs in Slate Mode	10 years based on 2 parameters logged every 10 minutes
Levelogger Gold	Linear (0.5 second to 99 hours), Event Based, Schedule, Real Time View, Future Start/Stop	40,000 sets of readings, Slate or Continuous Mode	10 years based on 1 reading per minute
Barologger Gold	Linear (0.5 second to 99 hours), Event Based, Schedule, Real Time View, Future Start/Stop	40,000 sets of readings, Slate or Continuous Mode	10 years based on 1 reading per minute
Levelogger Junior	Linear (0.5 second to 99 hours), Real Time View, Future Start	32,000 sets of readings in Slate Mode	5 years based on 1 reading per minute
LTC Levelogger Junior	Linear (5 seconds to 99 hours), Real Time View, Future Start	16,000 sets of readings in Slate Mode	5 years based on 1 reading every 5 minutes

1.1 Levelogger Series

1.1.1 Levelogger Edge

The Levelogger Edge is an absolute (non-vented) datalogger, which measures groundwater and surface water levels and temperature. Water levels are displayed as temperature compensated pressure readings, and can be barometrically compensated with the aid of a Barologger Edge.

Levelogger Edge Technical Specifications	
Level Sensor:	Piezoresistive Silicon with Hastelloy Sensor
Ranges:	15, 10, 20, 30, 100, 200 m
Accuracy	± 0.05% FS
Normalization:	Automatic Temperature Compensation
Temp. Comp. Range:	0ºC to 50ºC
Temperature Sensor:	Platinum Resistance Temperature Detector (RTD)
Temp. Sensor Accuracy:	± 0.05ºC
Temp. Sensor Resolution:	0.003ºC
Battery Life:	10 years (based on 1 reading/minute)
Clock Accuracy:	± 1 minute/year (-20ºC to 80ºC)
Operating Temperature:	-20ºC to 80ºC
Maximum # Readings:	40,000 (up to 120,000 using data compression)
Memory:	FRAM, Continuous or Slate mode
Communication Speed:	9600 bps, 38,400 bps with USB optical reader
Com Interface:	Optical Infra-red: USB, RS-232, SDI-12
Size:	7/8" x 6.25" (22 mm x 159 mm)
Weight:	129 grams (4.5 oz.)
Corrosion Resistance:	Titanium based PVD coated body and superior corrosion resistant Hastelloy sensor
Other Wetted Materials:	Delrin®, Viton®, 316L Stainless Steel
Sampling Modes:	Linear, Event & User-Selectable Schedule with Repeat Mode, Future Start, Future Stop, Real Time View
Measurement Rates:	0.125 second to 99 hours
Barometric Compensation:	High accuracy, air-only, Barologger Edge

LT Edge Models	Full Scale	Accuracy
M5	5 m (16.4 ft.)	± 0.05% FS
M10	10 m (32.8 ft.)	± 0.05% FS
M20	20 m (65.6 ft.)	± 0.05% FS
M30	30 m (98.4 ft.)	± 0.05% FS
M100	100 m (328.1 ft.)	± 0.05% FS
M200	200 m (656.2 ft.)	± 0.05% FS

⚠ NOTE

Solinst recommends using the most recent firmware, Version 3.003 and up, when using a Levelogger Edge with Software Version 4.3.0.

⚠ NOTE

The Model number refers to the depth of submergence below water level that the pressure sensor can withstand. i.e.: The Levelogger Edge, which is available in M5, M10, M20, M30, M100, and M200 ranges has actual water level ranges of 5 m (16.40 ft), 10 m (32.80 ft), 20 m (65.60 ft), 30 m (98.40 ft), 100 m (328.0 ft), and 200 m (656.2 ft), respectively.

1.1.2 Barologger Edge

The Barologger Edge uses algorithms based on air pressure only. It measures and logs changes in atmospheric pressure, which are then used to compensate water level readings recorded by a Levelogger Edge, Levelogger Junior Edge, or LTC Levelogger Edge.

Barologger Edge Technical Specifications	
Level Sensor:	Piezoresistive Silicon with Hastelloy Sensor
Accuracy	± 0.05 kPa
Normalization:	Automatic Temperature Compensation
Temp. Comp. Range:	-10ºC to 50ºC
Temperature Sensor:	Platinum Resistance Temperature Detector (RTD)
Temp. Sensor Accuracy:	± 0.05ºC
Temp. Sensor Resolution:	0.003ºC
Battery Life:	10 years (based on 1 reading/minute)
Clock Accuracy:	±1 minute/year (-20ºC to 80ºC)
Operating Temperature:	-20ºC to 80ºC
Maximum # Readings:	40,000 (120,000 using data compression)
Memory:	FRAM, Continuous or Slate mode
Communication Speed:	9600 bps, 38,400 bps with USB optical reader
Com Interface:	Optical Infra-red: USB, RS-232, SDI-12
Size:	7/8" x 6.25" (22 mm x 159 mm)
Weight:	129 grams (4.5 oz.)
Corrosion Resistance:	Titanium based PVD coated body and superior corrosion resistant Hastelloy sensor
Other Wetted Materials:	Delrin®, Viton®, 316L Stainless Steel
Sampling Modes:	Linear, Event & User-Selectable Schedule with Repeat Mode, Future Start, Future Stop, Real Time View
Measurement Rates:	0.125 second to 99 hours

LT Edge Models	Full Scale (FS)	Accuracy
Barologger	Air Only	±0.05 kPa

! NOTE

Solinst recommends using the most recent firmware, Version 3.003 and up, when using a Barologger Edge with Software Version 4.3.0.

1.1.3 Levelogger Junior Edge

The Levelogger Junior Edge provides an inexpensive alternative for measuring groundwater and surface water levels and temperature.

Levelogger Junior Edge Technical Specifications	
Level Sensor:	Piezoresistive Silicon with Hastelloy Sensor
Ranges:	5, 10 m
Accuracy	± 0.1% FS
Normalization:	Automatic Temperature Compensation
Temp Comp. Range:	0ºC to 40ºC
Temperature Sensor:	Platinum Resistance Temperature Detector (RTD)
Accuracy:	± 0.1ºC
Resolution:	0.1ºC
Battery life:	5 years (based on 1 reading/minute)
Clock Accuracy:	± 1 minute / year (-20ºC to 80ºC)
Operating Temperature:	-20ºC to 80ºC
Memory:	FRAM, Slate Mode
Maximum # Readings	40,000 (no data compression)
Com Interface:	Optical Infra-red: USB, RS-232, SDI-12
Communication Speed:	9600 bps
Size:	7/8" x 5.6" (22 mm x 142 mm)
Weight:	4.2 oz (119 grams)
Wetted Materials:	Delrin®, Viton®, 316L Stainless Steel, Hastelloy
Sampling Mode:	Linear, Future Start, Real Time View
Measurement Rates:	0.5 seconds to 99 hours
Barometric Compensation:	High accuracy, air-only, Barologger Edge

LT Models	Full Scale (FS)	Accuracy
M5	5 m (16.4 ft.)	± 0.1% FS
M10	10 m (32.8 ft.)	± 0.1% FS

! NOTE

Solinst recommends using the most recent firmware, Version 3.003 and up, when using a Levelogger Junior Edge with Software Version 4.3.0.

! NOTE

The Levelogger Junior Edge looks very similar to the previous Levelogger Junior. To determine the difference, look at the serial number on the body of the Levelogger.
If the fourth number in the serial number is 1, it is a Levelogger Junior. If the fourth number is a 2, it is a Levelogger Junior Edge.

1.1.4 LTC Levelogger Edge

The LTC Levelogger Edge provides an accurate and convenient method to measure level, temperature and conductivity all in one probe.

LTC Levelogger Edge Technical Specifications	
Level Sensor:	Piezoresistive Silicon with Hastelloy Sensor
Ranges:	15, 10, 20, 30, 100, and 200 m
Accuracy	± 0.05% FS
Normalization:	Automatic Temperature Compensation
Temp Comp. Range:	0ºC to 50ºC
Temperature Sensor:	Platinum Resistance Temperature Detector (RTD)
Accuracy:	± 0.05ºC
Resolution:	0.003ºC
Conductivity Sensor:	4-Electrode Platinum
Full Range:	0 to 100,000 µS/cm
Calibrated Range:	50 to 80,000 µS/cm
Accuracy:	±1% > 30,000 µS/cm; ±2% 500 - 30,000 µS/cm; ±30 µS < 500 µS/cm
Resolution:	± 0.1 µS/cm
Normalization:	Specific Conductance normalized to 25ºC for full range
User Calibration Points:	1413, 5000, 12,880, 80,000 µS
Battery Life:	8 years (based on 1 reading every 5 minutes)
Clock Accuracy:	± 1 minute / year
Operating Temperature:	-20ºC to 80ºC
Memory:	FRAM, Continuous or Slate Mode
Maximum Readings:	27,000
Communication Speed:	9600 bps, 38,400 bps with USB optical reader
Com Interface:	Optical Infrared: USB, RS-232, SDI-12
Size:	7/8" x 7.5" (22 mm x 190 mm)
Weight:	200 g (7.05 oz.)
Corrosion Resistance:	Titanium ceramic PVD coated body and superior corrosion resistant Hastelloy pressure sensor
Other Wetted Materials:	Hastelloy, Delrin®, Viton®, Platinum
Sampling Mode:	Linear, Event & User-Selectable Schedule with Repeat Mode, Future Start, Future Stop, Real Time View
Measurement Rates:	2 seconds to 99 hours
Barometric Compensation:	High accuracy, air-only, Barologger

LTC Edge Models	Full Scale	Accuracy
M5 C80	5 m (16.4 ft.)	± 0.05% FS
M10 C80	10 m (32.8 ft.)	± 0.05% FS
M20 C80	20 m (65.6 ft.)	± 0.05% FS
M30 C80	30 m (98.4 ft.)	± 0.05% FS
M100 C80	100 m (328.1 ft.)	± 0.05% FS
M200 C80	200 m (656.2 ft.)	± 0.05% FS

NOTE

Solinst recommends using the most recent firmware, Version 1.000, when using a LTC Levelogger Edge with Software Version 4.3.0.

1.1.5 Rainlogger Edge

The Rainlogger Edge is designed for use with most standard tipping-bucket rain gauges with a normally-open style reed switch output. It records each tip time from the tipping-bucket, and outputs the amount of rainfall per programmed time period (based on rainfall calibration constant).

Rainlogger Edge Technical Specifications	
Battery Life:	10 years (logging 2 parameters/10 minutes)
Clock Accuracy:	± 1 minute/year
Operating Temperature:	-20˚C to 80˚C
Maximum # Readings:	Up to 60,000 tip times
Memory:	FRAM, Slate mode only
Communication:	Optical infra-red: USB, RS-232, SDI-12
Measurement:	Records each tip by the tipping-bucket rain gauge and outputs the amount of rainfall
Sampling Mode:	Event Based, Future Start, Real TIme View
Size:	7/8" x 5.5" (22 mm x 140 mm)
Weight:	1.6 oz (44 grams)
Materials:	ABS, Delrin®, Viton®

> **⚠ NOTE**
>
> Solinst recommends using the most recent firmware, Version 3.001, when using a Rainlogger Edge with Software Version 4.3.0.

1.1.6 Leveloader Gold

The Leveloader Gold is a data transfer device for use with all versions of Leveloggers. It can be used to download, store, and transfer data from Levelogger to PC, as well as, save settings files for transfer to a Levelogger. Also allows real time viewing of Levelogger readings. The Leveloader is used with Levelogger Software, see separate Leveloader Gold User Guide.

> **⚠ NOTE**
>
> Solinst recommends using the most recent firmware, Version 2.002, when using a Leveloader Gold with Software Version 4.3.0.

1.1.7 Levelogger Gold

The Levelogger Gold is an absolute (non-vented) datalogger, which measures groundwater and surface water levels and temperature. Water levels are displayed as temperature compensated pressure readings, and can be barometrically compensated with the aid of a Barologger.

Levelogger Gold Technical Specifications	
Level Sensor:	Piezoresistive Silicon in 316L Stainless Steel
Ranges:	15, 30, 65, 100, 300 ft. (5, 10, 20, 30, 100 m)
Accuracy	0.05% FS
Normalization:	Automatic Temperature Compensation
Temp. Comp. Range:	10ºC to 40ºC
Temperature Sensor:	Platinum Resistance Temperature Detector (RTD)
Temp. Sensor Accuracy:	± 0.05ºC
Temp. Sensor Resolution:	0.003ºC
Battery Life:	10 Years - based on one reading/min
Clock Accuracy:	± 1 minute/year
Operating Temperature:	-20ºC to 80ºC
Maximum # Readings:	40,000 of level and temperature
Memory:	EEPROM Slate, Continuous, and redundant backup of last 1200 readings
Communication:	Optical Infra-red: USB, RS-232, SDI-12
Communication Speed:	9600 bps
Size:	7/8" x 6" (22 mm x 154 mm)
Weight:	6.3 oz (179 grams)
Corrosion Resistance:	Zirconium Nitride (ZrN) Coating
Other Wetted Materials:	316L Stainless Steel, Delrin®, Viton®
Sampling Modes:	Linear, Event & User-Selectable with 30 separate line items, Future Start, Future Stop, Real Time View
Measurement Rates:	0.5 sec to 99 hrs
Barometric Compensation:	High accuracy, air-only, Barologger Gold

LT Models	Full Scale (FS)	Accuracy
F15, M5	16.4 ft., 5 m	± 0.010 ft., 0.3 cm
F30, M10	32.8 ft., 10 m	± 0.016 ft., 0.5 cm
F65, M20	65.6 ft., 20 m	± 0.032 ft., 1 cm
F100, M30	98.4 ft., 30 m	± 0.064 ft., 1.5 cm
F300, M100	328.1 ft., 100 m	± 0.164 ft., 5 cm

⚠ NOTE

To use the Levelogger Gold with Software Version 4.3.0, ensure you are using version 2.007 firmware.

Contact Solinst if you need to upgrade your firmware from version 1.016 or lower.

1.1.8 Barologger Gold

The Barologger Gold uses algorithms based on air pressure only. It measures and logs changes in atmospheric pressure, which are then used to compensate water level readings recorded by a Levelogger.

Barologger Gold Technical Specifications	
Level Sensor:	Piezoresistive Silicon in 316L Stainless Steel
Accuracy	0.05% FS
Normalization:	Automatic Temperature Compensation
Temp. Comp. Range:	0ºC to 40ºC
Temperature Sensor:	Platinum Resistance Temperature Detector (RTD)
Temp. Sensor Accuracy:	± 0.05ºC
Temp. Sensor Resolution:	0.003ºC
Battery Life:	10 Years - based on one reading/min
Clock Accuracy:	± 1 minute/year
Operating Temperature:	-20ºC to 80ºC
Maximum # Readings:	40,000 of pressure and temperature
Memory:	EEPROM Slate, Continuous, and redundant backup of last 1200 readings
Communication:	Optical Infra-red: USB, RS-232, SDI-12
Communication Speed:	9600 bps
Size:	7/8" x 6" (22 mm x 154 mm)
Weight:	6.3 oz (179 grams)
Corrosion Resistance:	Zirconium Nitride (ZrN) Coating
Other Wetted Materials:	316L Stainless Steel, Delrin®, Viton®
Sampling Modes:	Linear, Event & User-Selectable with 30 separate line items, Future Start, Future Stop, Real Time View
Measurement Rates:	0.5 sec to 99 hrs

LT Models	Full Scale (FS)	Accuracy
Barologger	Air Only	± 0.003 ft., 0.1 cm

1.1.9 Levelogger Junior

The Levelogger Junior functions like the Levelogger Gold; provides an inexpensive alternative for measuring groundwater and surface water levels and temperature.

Levelogger Junior Technical Specifications	
Level Sensor:	Piezoresistive Silicon in 316L Stainless Steel
Ranges:	15, 30 ft. (5, 10 m)
Accuracy	± 0.1% FS
Normalization:	Automatic Temperature Compensation
Temp Comp. Range:	10ºC to 40ºC
Temperature Sensor:	Platinum Resistance Temperature Detector (RTD)
Accuracy:	± 0.1ºC
Resolution:	0.1ºC
Battery life:	5 years (based on 1 reading/minute)
Clock Accuracy:	± 1 minute / year
Operating Temperature:	-20ºC to 80ºC
Memory:	Non-volatile EEPROM, FRAM back-up, Slate mode only
Maximum # Readings	32,000 (no data compression)
Com Interface:	Optical Infra-red: USB, RS-232, SDI-12
Communication Speed:	9600 bps
Size:	7/8" x 5.5 " (22 mm x 140 mm)
Weight:	154 g (5.4 oz)
Wetted Materials:	Delrin®, Viton®, 316L Stainless Steel
Sampling Mode:	Linear, Future Start, Real Time View
Measurement Rates:	0.5 seconds to 99 hours
Altitude Input:	-980 to 16,400 ft. (-300 to 5,000 m)
Barometric Compensation:	High accuracy, air-only, Barologger Gold

LT Models	Full Scale (FS)	Accuracy
F15, M5	16.4 ft., 5 m	± 0.020 ft., 0.6 cm
F30, M10	32.8 ft., 10 m	± 0.032 ft., 1.0 cm

NOTE

To use the Levelogger Junior with Software Version 4.3.0, ensure you are using version 2.007 firmware.

NOTE

The Levelogger Junior looks very similar to the newer Levelogger Junior Edge. To determine the difference, look at the serial number on the body of the Levelogger. If the fourth number in the serial number is 1, it is a Levelogger Junior. If the fourth number is a 2, it is a Levelogger Junior Edge.

1.1.10 LTC Levelogger Junior

The LTC Levelogger Junior provides an inexpensive and convenient method to measure level, temperature and conductivity all in one probe.

LTC Levelogger Junior Technical Specifications	
Level Sensor:	Piezoresistive Silicon with Hastelloy Sensor
Ranges:	30, 100 ft. (10, 30 m)
Accuracy	± 0.1% FS
Normalization:	Automatic Temperature Compensation
Temp Comp. Range:	10ºC to 40ºC
Temperature Sensor:	Platinum Resistance Temperature Detector (RTD)
Accuracy:	± 0.1ºC
Resolution:	0.1ºC
Conductivity Sensor:	4-Electrode Platinum
Full Range:	0 to 80,000 µS/cm
Calibrated Range:	500 to 50,000 µS/cm
Accuracy:	± 2% of reading or 20 µS/cm
Resolution:	1 µS
Normalization:	Specific Conductance normalized to 25ºC for full range
User Calibration Points:	1413, 5000, 12,880 µS
Battery Life:	5 years (based on 1 reading/ 5 minutes)
Clock Accuracy:	± 1 minute / year
Operating Temperature:	-20ºC to 80ºC
Memory:	Non-volatile EEPROM, FRAM back-up, Slate mode only
Maximum Readings:	16,000
Communication Speed:	9600 bps
Com Interface:	Optical Infrared: USB, RS-232, SDI-12
Size:	7/8" x 7.5" (22 mm x 190 mm)
Weight:	200 g (7.05 oz.)
Wetted Materials:	Hastelloy, Delrin®, Viton®, 316L Stainless Steel, Platinum
Sampling Mode:	Linear, Future Start, Real Time View
Measurement Rates:	5 seconds to 99 hours
Altitude Input:	-980 to 16,400 ft. (-300 to 5,000 m)
Barometric Compensation:	High accuracy, air-only, Barologger

LTC Models	Full Scale (FS)	Accuracy
F30, M10 C50	32.8 ft., 10 m	± 0.032 ft., 1.0 cm
F100, M30 C50	98.4 ft., 30 m	± 0.098 ft., 3 cm

! NOTE

Solinst recommends using the most recent firmware, Version 2.005, when using a LTC Levelogger Junior with Software Version 4.3.0.

1.1.11 Rainlogger

The Rainlogger is designed for use with most standard tipping-bucket rain gauges with a reed switch output. It records each tip time from the tipping-bucket, and outputs the amount of rainfall per programmed time period (based on rainfall calibration constant).

Rainlogger Technical Specifications	
Battery Life:	10 years (logging 2 parameters/10 minutes)
Clock Accuracy:	± 1 minute/year
Operating Temperature:	-20˚C to 80˚C
Maximum # Readings:	Up to 60,000 tip times
Memory:	Non-volatile EEPROM, Slate mode only
Communication:	Optical infra-red: USB, RS-232, SDI-12
Measurement:	Records each tip by the tipping-bucket rain gauge and outputs the amount of rainfall
Sampling Mode:	Event Based, Future Start, Real TIme View
Size:	7/8" x 7" (22 mm x 175 m)
Weight:	4.8 oz (135 grams)
Materials:	316L Stainless Steel, Delrin®, Viton®
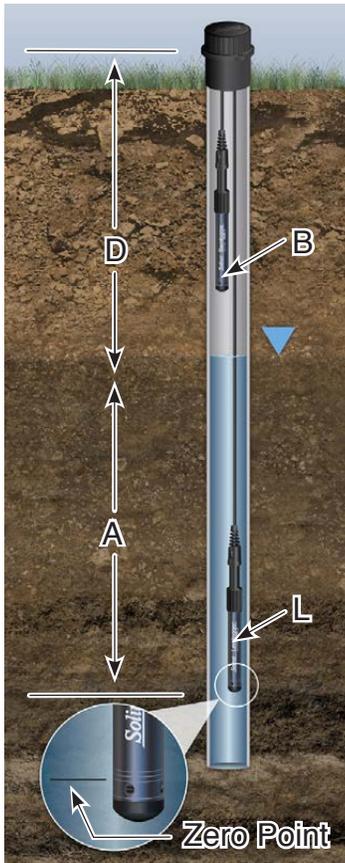
A = L - B

Figure 1-1
Levelogger Measurement Fundamentals

> ⚠ **NOTE**
>
> Leveloggers measure the pressure of air plus water column above their sensor (zero point). To adjust the level readings after data collection, for example to water level depths below top of casing **(D)**, refer to the Advanced options within the software Data Wizard.

> ⚠ **NOTE**
>
> The Levelogger Gold, Levelogger Junior and LTC Levelogger Junior models convert pressure readings to the water level equivalent above the datalogger's pressure zero point of 950 cm (31.17 ft). The Levelogger Edge, Levelogger Junior Edge and LTC Levelogger Edge have no zero point offset. As such, water level data will appear different, although measuring the same amount of pressure. Barometric Compensation using the Data Wizard, automatically considers this zero point offset difference when compensating a mix of Models.

1.2 Measurement Parameters

1.2.1 Level

All Leveloggers measure total (absolute) pressure. When submerged, the Levelogger is recording the combination of barometric pressure and water pressure. The actual pressure of just water **(A)** above the sensor is obtained by subtracting barometric pressure **(B)** from the total pressure **(L)** (see Figure 1-1).

The best method to compensate for barometric pressure is to employ a Barologger above the water level, to obtain records of barometric pressure. The Levelogger Software includes a Data Wizard, which guides you through the automated process of barometric compensation. Manual methods can be employed to determine the absolute water level using barometric records collected on-site or available from a local weather station (i.e. airport). Water level readings from Leveloggers are automatically temperature-compensated.

A = Actual water column height

B = Barometric pressure

L = Levelogger total pressure readings

D = Depth to water level, below reference datum

Note: the Levelogger Gold, Levelogger Junior and LTC Levelogger Junior models convert pressure readings to the water level equivalent above the datalogger's pressure zero point of 950 cm (31.17 ft). The Levelogger Edge, Levelogger Junior Edge and LTC Levelogger Edge have no zero point offset. As such, water level data will appear different, although measuring the same amount of pressure (i.e. Levelogger Edge data will appear to be reading 950 cm (31.17 ft) higher than a Levelogger Gold. Barometric Compensation using the Data Wizard, automatically considers this zero point offset difference when compensating a mix of Models.

1.2.1.1 Pressure Calibration

The Levelogger Edge is calibrated against a range of set reference points to an accuracy of 3 decimal places. During the calibration procedure, the Levelogger is fully submerged in a highly accurate water bath. The bath is allowed to stabilize. The pressure is then calibrated to six separate pressure points covering the entire range of pressure to check for any non-linearity. The process is repeated again at two different temperatures to check for temperature effects. Once done, the Levelogger is approved after all specifications for accuracy, precision, stability and hysteresis have been met. The Levelogger should be calibrated for the lifetime of the instrument, as long as it is used within its specified range.

1.2.2 Barometric Pressure

The Barologger is designed for use in air only. It has a specific range and firmware algorithms based on air pressure rather than water pressure. This makes the Barologger less accurate if used in water, but more accurate if used as intended in air. Using a Barologger is the most accurate and convenient method of obtaining atmospheric pressure and air temperature measurements, which are then synchronized to the Levelogger. The Data Wizard in the Levelogger Software simplifies the adjustment of the level measurements for barometric pressure changes, by using the synchronized data from all Leveloggers on site and the site Barologger.

1.2.3 Temperature

Leveloggers record temperature compensated water levels. Groundwater and surface water temperature measurements are particularly important in situations where temperatures may fluctuate significantly, and when temperature is used in determining liquid level, viscosity and hydraulic conductivity. Temperature monitoring is vital in the calculation of certain temperature dependent contaminant reaction rates. A Platinum Resistance Temperature Detector is used to accurately compensate for temperature changes within the range of 0 to +50°C for the Levelogger Edge and LTC Levelogger Edge, -10°C to +50°C for the Barologger Edge, and 0 to +40°C for the Levelogger Junior Edge. The Levelogger will record temperature in its thermal range of -20 to +80°C, but outside the range, compensation will be less accurate.

1.2.4 Conductivity

The LTC Levelogger Edge and Junior models provide the added feature of electrical conductivity measurement; they measure the actual conductivity at the current temperature. Conductivity measurement is particularly useful in monitoring saltwater intrusion, surface water infiltration and mixing, as well as the monitoring of certain pollutants and contaminant parameters. Conductivity is measured via a platinum 4-electrode sensor, which produces highly stable and consistent readings. Conductivity calibration is performed by using a liquid solution, with a known conductivity value, and the Calibration Wizard in the Levelogger Windows Software. The Data Wizard allows you to convert conductivity readings to Specific Conductance (at 25°C), or Salinity expressed in Practical Salinity Units (PSU). A Practical Salinity Unit (PSU) is a dimensionless descriptor for the Practical Salinity Scale (PSS). The PSS defines salinity as the ratio of a water sample's conductivity to that of a standard KCL solution. The Data Wizard uses the equation given in the UNESCO Technical Paper "Algorithms for computation of fundamental properties of seawater", to convert Conductivity readings to Salinity. For more information, see: Fofonoff, N. P. and R.C. Millard, Jr. Algorithms for computation of fundamental properties of seawater, UNESCO, Tech. Pap. Mar. Sci.,44.

1.2.4.1 Calibration of the Conductivity Sensor

The conductivity sensor of an LTC Levelogger is a highly sensitive device requiring regular calibration by the user. The conductivity calibration frequency is dependent on the water quality of the Levelogger's monitoring environment. To determine whether an LTC Levelogger should be re-calibrated, test the unit in a solution with a known electrical conductivity value at a reference temperature. In Real Time View, observe current readings by using the Read Now function. If this reading varies from the known Specific Conductance of the solution by greater than the stated accuracy of the conductivity measurement, the unit should be re-calibrated using the Conductivity Calibration Wizard procedure outlined in Section 6. As a minimum, calibrate your LTC Levelogger at least twice a year. Ensure that a conductivity calibration is performed when the LTC Levelogger is being set up for its initial use and after long periods of dry storage.

1.2.5 Total Rainfall

Solinst Rainloggers are designed to record the number of tips of an external tipping-bucket rain gauge, and output the amount of rainfall per tip.

⚠ NOTE

For every degree change in temperature, there is approximately a 2% change in conductivity. To convert raw conductivity measurements to Specific Conductance measurements, you can use the following equation:

Specific Conductance = Conductivity / (1 + 0.02 * (temp(C) - 25))

You can also perform this calculation automatically using the Data Wizard.

1.3 Software Communication

Levelogger Software is Windows based, and is therefore used with a desktop or laptop PC. Dataloggers connect to a laptop or desktop PC with an Optical Reader cable. The Optical Reader cable uses an infrared data reader/port connected to the datalogger and a USB or RS-232 (Serial) Com Port to transfer information between the datalogger and computer.

If you are programming dataloggers in the office, or have deployed your datalogger using a wireline or cord, an Optical Reader is most commonly used for communication with a PC (see Figure 1-2).

If a datalogger is deployed in the field using a Direct Read Cable, a PC Interface Cable is used for communication with the PC, without removing it from the well (see Figure 1-3).

Optical Reader

Figure 1-2 Levelogger Connected to a PC Using an Optical Reader

PC Interface Cable

Datalogger Down Well

Figure 1-3
Levelogger and Direct Read Cable Connected to PC Using a PC Interface Cable

1.3.1 Backwards Compatibility

The Levelogger Edge is not backwards compatible with previous versions of Levelogger Software. Only Levelogger Software Version 4 and up can be used to program the Levelogger Edge and Barologger Edge. The Levelogger Junior Edge is only compatible with Levelogger Software Version 4.0.2 and up. The Rainlogger Edge is only compatible with Software Version 4.1 and up. The LTC Levelogger Edge is only compatible with 4.3.0 and up.

The Levelogger Junior, LTC Levelogger Junior, Rainlogger, and Leveloader are compatible with Levelogger Software Version 4.3.0. If used with previous software versions, they will not have some of the features gained with the release of Version 4.3.0 Software. The Levelogger Gold and Barologger Gold are also compatible with Version 4.3.0 Software, and previous versions.

To use your Leveloggers with Version 4.3.0 Software, ensure your firmware is upgraded to the following versions:

Datalogger	Firmware Version
Levelogger Edge	3.003
Barologger Edge	3.003
Levelogger Junior Edge	3.003
LTC Levelogger Edge	1.000
Rainlogger Edge	3.001
Leveloader Gold	2.002
Levelogger Gold	2.007
Barologger Gold	2.007
Levelogger Junior	2.007
LTC Levelogger Junior	2.005
Rainlogger	2.000

For more information on previous software and firmware versions, visit www.solinst.com to view **3001 Levelogger Series: Hardware Compatibility**, located on the Downloads page.

2 System Requirements

The minimal hardware and software requirements for software installation and operation are:

Hardware	Software
Memory: 32 MB or more	OS: Windows 7, 8 or 10
Display: VGA: 800 x 600 pixels, 256 colour	
Ports: USB or RS-232 Serial Port	

Communication Port Setting for Levelogger Communications:

Bits per second	9600
Data bits	8
Stop bits	1
Flow control	None

3 Software Installation

Web Download

Download the newest version of Levelogger Software by visiting www.solinst.com/downloads/

CD Installation

1) Insert the software CD provided.

2) If the installer does not automatically start, to activate the software install click on the 'setup.exe' file located on the software CD.

3) The Software Installation Wizard will guide you through the remaining installation process. Figure 3-1 shows the Levelogger Installation Wizard.

4) Restart the computer after installation is completed. Default Directory is C:\Program Files\Solinst\Levelogger4_3
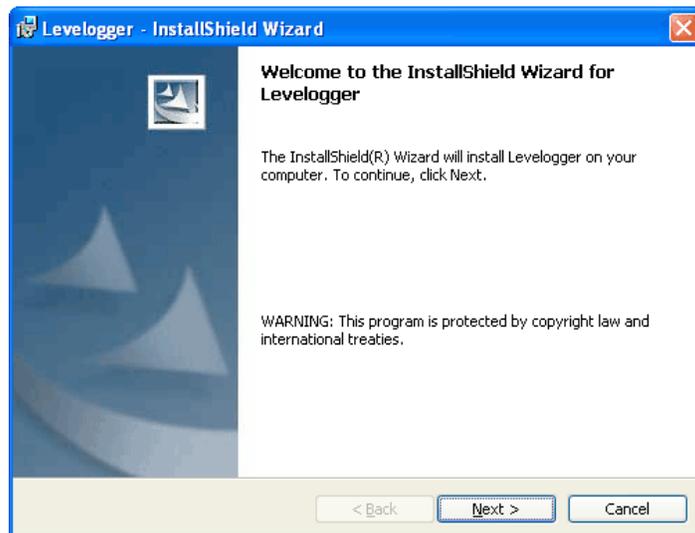
Figure 3-1 Software Installation Wizard

4 Startup, Configurations and Settings

4.1 Startup

If using a USB port, plug in the USB cable before starting the Levelogger Software. If plugging in the USB device for the first time, the driver for the device will have to be installed, see Section 4.1.3 for USB driver installation instructions.

To start the Levelogger Software, click ![icon], or click the Start button and select:

Programs > Solinst > Levelogger 4 > Levelogger 4.3.0

Once the program is started, you can set up the parameters for the Software.

4.1.1 Software/Firmware Update Checks

Each time the software is opened, it automatically checks for software updates. If there is an update, "Software Update Available" will appear in the top right of the menu bar. When you click the message, it will open a web page where you can download the software update.

The Software also checks for firmware updates once you have retrieved settings from a connected Levelogger (see Section 5). "Firmware Update Available" will appear in the top right menu bar. Clicking the message will open a web page where you can download the firmware update. See Section 12 for firmware update instructions.

4.1.2 Communicating with a USB Port

USB port communication requires the installation of USB driver software and the setting up of a virtual com port. The user will either:

1) Connect a Levelogger Optical Reader or PC Interface Cable to the USB port
2) Use a USB to RS-232 Adapter

If 1, during the installation of Levelogger Software, the **Virtual Com Port Driver** will be installed automatically. The Levelogger Software Installation Wizard also copies a folder to the Levelogger folder containing all the Solinst USB drivers. When you plug in the Solinst USB device, check the com port designation after installing the device (see Section 4.2.1).

If 2, Solinst strongly recommends the use of either Keyspan™ or IO Gear™ USB to RS-232 Serial Adapters. These adapters have a sufficiently large buffer to accommodate the size of data bundle and bit transfer rate of the Levelogger. Follow the manufacturer's USB Driver and Com port setup installations found on the CD accompanying the adapter.

If you have installed another brand-name adapter, but cannot communicate with the Levelogger, in most cases the problem is that the adapter does not have a large enough internal memory buffer. The minimum buffer size should be 96 bytes.

⚠ NOTE

Your PC must have an internet connection to check for software and firmware updates.

You can also check for updates using the Help menu.

⚠ NOTES

To check the Com port assigned to a USB device after installation, open the Device Manager. Expand "Ports (COM & LPT)" to show the Com Port that has been assigned. To change the assigned Port, see Section 4.2.1.

You may have to restart your computer after adding a new USB device, before that port will be detected by the Levelogger Software

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4.1.3 Installing USB Drivers for Levelogger 4 Software

Levelogger Software Version 4.3.0, for use with Solinst USB Optical Reader, PC Interface Cable and Leveloader, comes equipped with USB drivers for: Windows 7 and 10.

Windows 8 can also be used, see Section 4.1.3.2 for instructions to enable Windows 8 USB installation.

4.1.3.1 USB Installation for Windows 7

Plug the USB Device into the PC. The system will automatically detect the connected unit. Windows 7 should automatically install the driver for the device.

If no driver is automatically found, and the 'Found New Hardware Wizard' fails to start, the following steps should be taken:

1) Press the Windows start button to bring up the start menu, select 'Control Panel', then 'Hardware and Sound', then 'Device Manager'.

2) Under 'Other Devices' there will be a Solinst device shown with a yellow warning symbol. Right click on this device, and select 'Update Driver Software'.

Figure 4-1 Windows 7 Device Manager

3) Select 'Browse my computer for driver software'.

Figure 4-2 Update Driver Software

Figure 4-3 Browse for Driver Software

4) Click the Browse button and point the navigation window to the provided USB drivers located within the Levelogger4_3 folder. Default destination is:

C:\Program Files\Solinst\Levelogger4_3\USB Drivers

Select the actual USB Drivers folder, not a sub file from the folder.

5) Select Next. A window may appear stating 'Windows can't verify the publisher of this driver software', select 'Install this driver software anyway'.

Figure 4-4 Update Complete

6) Windows will confirm when the installation is complete. Press Close to close the window, then go back to the 'Device Manager'.
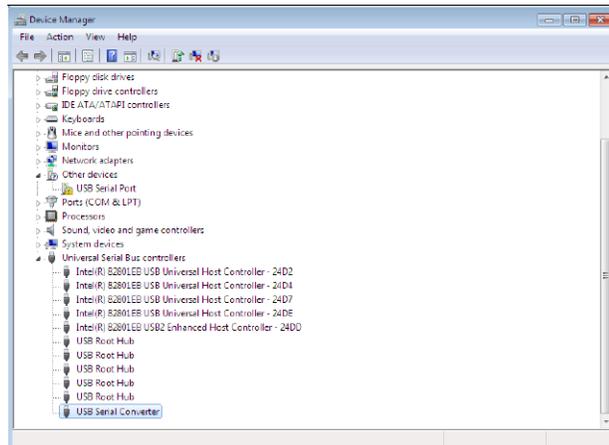
Figure 4-5 Update Serial Port

7) You may have to repeat steps 2-6 to update the USB Serial Port. This would be shown under 'Other Devices' with a yellow warning symbol.

8) Once installation is complete, a window will confirm the COM port assigned to the device.

4.1.3.2 Enabling USB Installation for Windows 8

1) Press Win + C on your keyboard to bring up the Charms Bar. Click on "Settings".

2) Click on "Change PC settings" to open the Modern Control Panel.
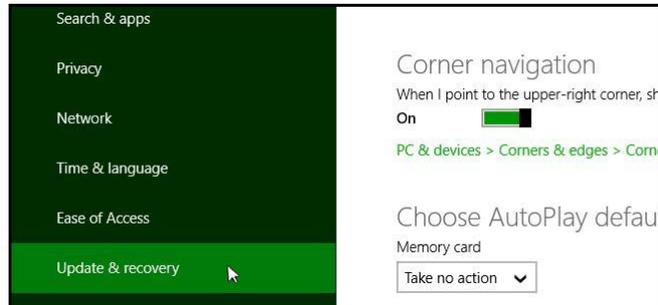
Figure 4-6 Windows 8 Control Panel

3) In the Control Panel, switch over to the "Update & recovery" section.

4) Click on the "Recovery" option.

Figure 4-7 Restart Windows 8 PC

5) In the Advanced startup section, click the "Restart now" button. This will restart your PC.
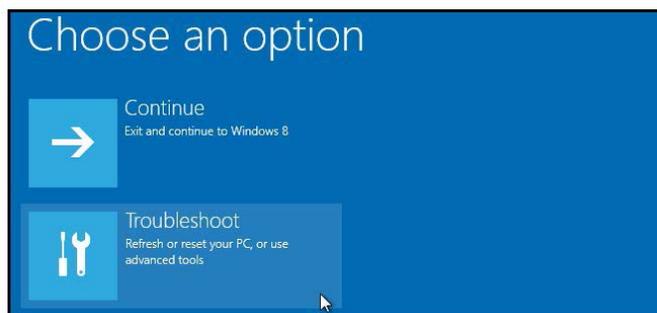
Figure 4-8 Troubleshoot Windows 8 PC

6) Once your PC has rebooted, select the "Troubleshoot" option.

7) Select "Advanced options".

8) Select "Startup Settings".

9) Select "Restart" to reboot your PC once more. This will allow modification to the boot time configuration settings.

Startup Settings

Press a number to choose from the options below:

Use number keys or functions keys F1-F9.

1) Enable debugging
2) Enable boot logging
3) Enable low-resolution video
4) Enable Safe Mode
5) Enable Safe Mode with Networking
6) Enable Safe Mode with Command Prompt
7) Disable driver signature enforcement
8) Disable early launch anti-malware protection
9) Disable automatic restart after failure

Press F10 for more options
Press Enter to return to your operating system

Figure 4-9 Windows 8 Startup Settings

10) A list of settings that can be changed will be shown. The setting you are looking for is "Disable driver signature enforcement". To choose this setting, press the F7 key.

11) After the PC automatically restarts, you will be able to install the USB drivers, as described in Section 4.1.3.1.

4.1.3.3 USB Installation for Windows 10

Plug the USB device into the PC. The system will automatically detect the connected unit. Windows 10 should automatically install the driver for the device.

If no driver is automatically found, and the 'Found New Hardware Wizard' fails to start, the following steps should be taken:

1. Open the Windows Start Menu and click on "Settings". Click on "Devices".

2. In Devices, click on "Connected Devices". You should see your connected Solinst USB device listed under Other Devices. It should indicate that the device's setup is incomplete.
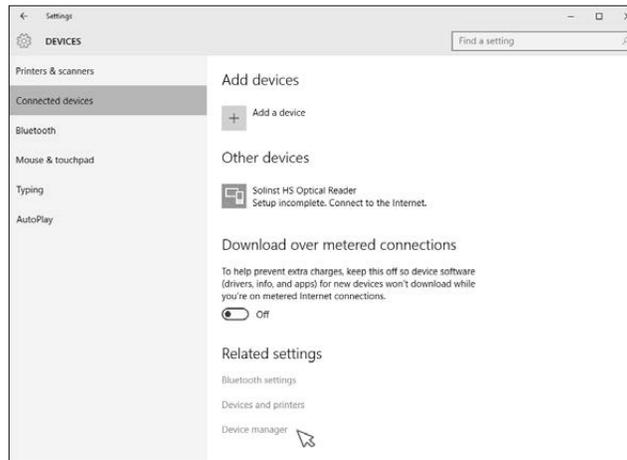
Figure 4-10 Windows 10 Connected Devices

3. Under Related settings, click on "Device Manager".
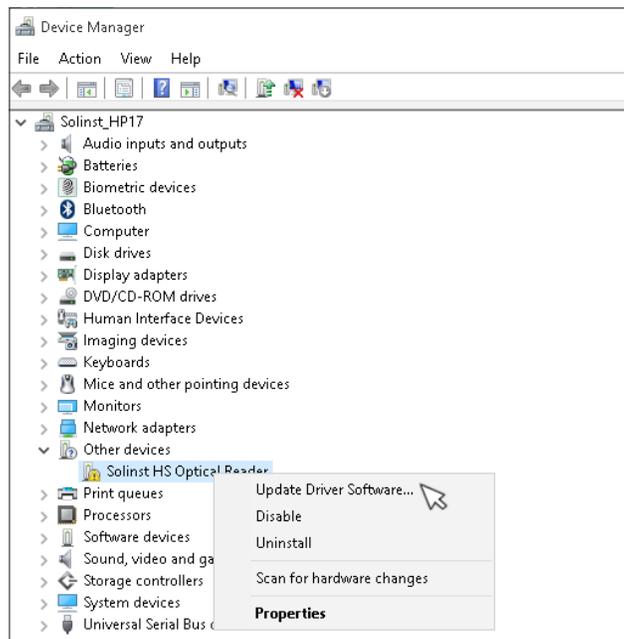
Figure 4-11 Windows 10 Device Manager

4. Under Other devices, there will be a Solinst device shown with a yellow warning symbol. Right click on this device, and select "Update Driver Software...".
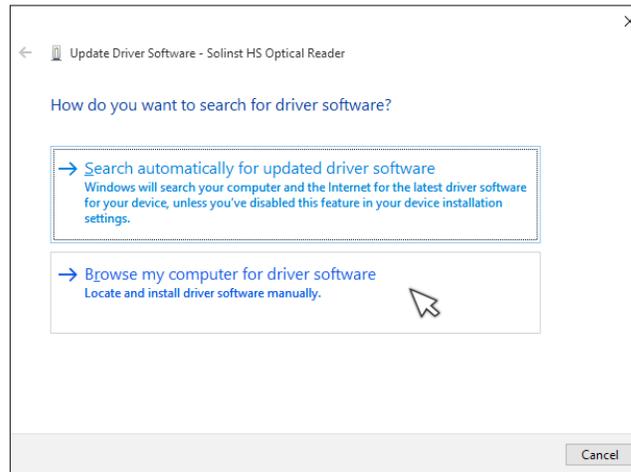
Figure 4-12 Update Driver Software

5. Select "Browse my computer for driver software".

6. Click the Browse button and point the navigation window to the provided USB drivers located within the Levelogger4_3 folder. Default destination is:

   C:\Program Files\Solinst\Levelogger4_3\USB Drivers

   Select the actual USB Drivers folder, not a sub file from the folder.

⚠ NOTE

Make sure you only select the USB Drivers folder when browsing for the driver location. Do not choose a sub file from the folder.
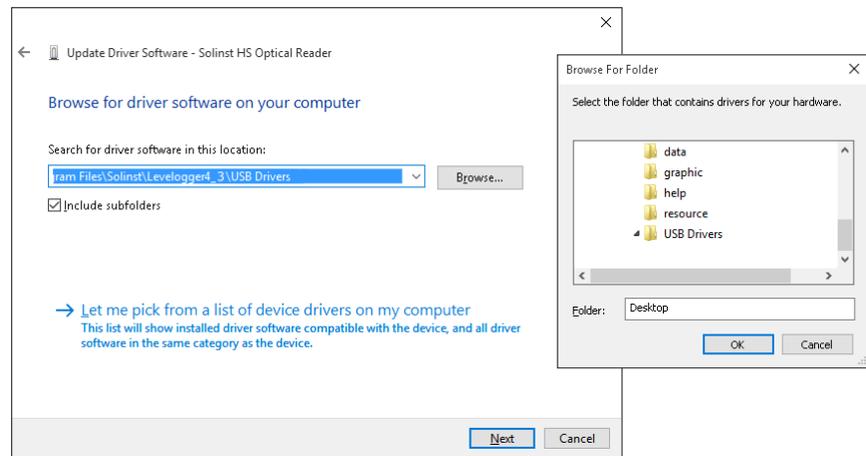
Figure 4-13 Browse for Driver Software

7. Select Next. A Window may appear stating "Windows can't verify the publisher of this driver software", select "Install this driver software anyway".

If you encounter the following error: "Windows encountered a problem installing the driver software for your device. Windows found driver software for your device but encountered an error..." Then please proceed with the instructions to **Disable Driver Signature Enforcement** in Section 4.1.3.4.
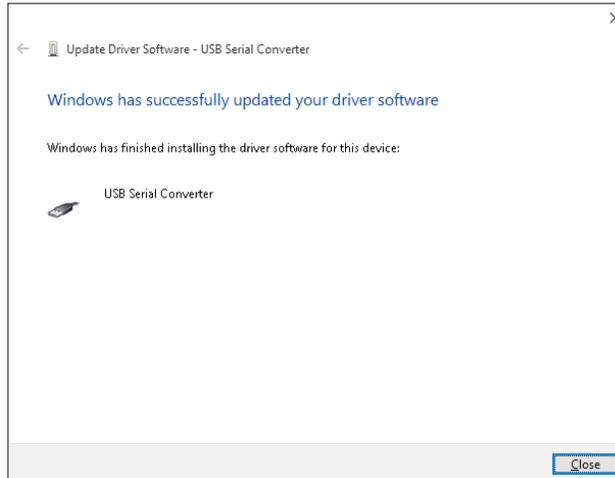
Figure 4-14 Update Complete

8. Windows will confirm when the installation is complete. Press Close, then go back to the Device Manager.
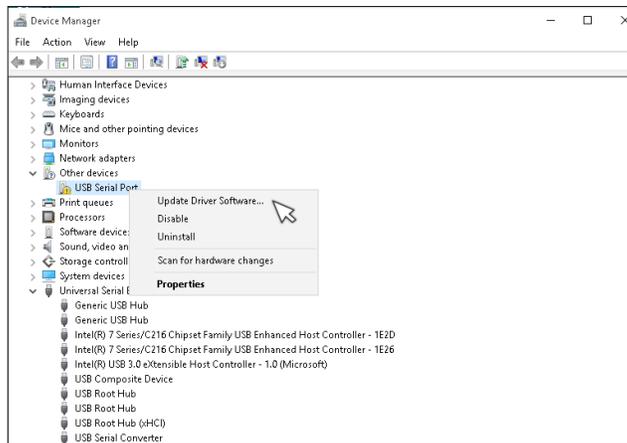
Figure 4-15 Update USB Serial Port

9. Follow Steps 4-8 to update the USB Serial Port, shown under Other devices with a yellow warning symbol.
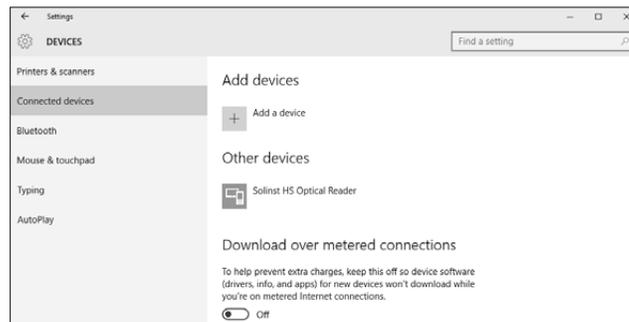
Figure 4-16 Installed Solinst USB Device

10. Once the installation is complete, this will be shown in the Devices > Connected devices Window. See Figure 4-16.

4.1.3.4 Disable Driver Signature Enforcement for Windows 10

1.   Open the Windows Start Menu and click on "Settings".

2. In Settings, click on "Update & security".
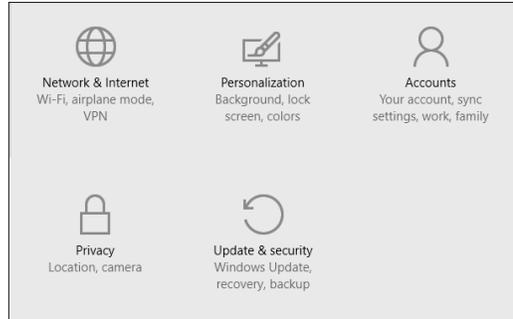
Figure 4-17 Windows 10 Settings

3.   Then click on the Recovery option on the left hand side.

4.   Once selected, you will see an Advanced startup section appear on the right hand side. Click on the "Restart now" button.
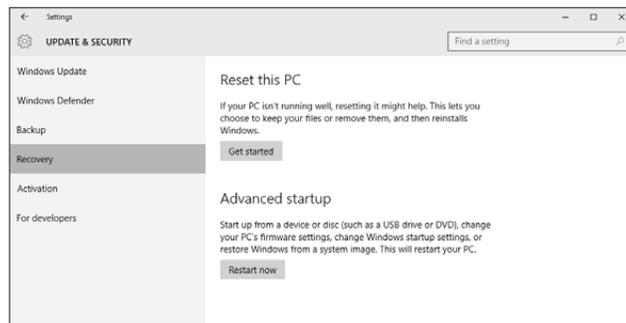
Figure 4-18 Windows 10 Advanced Startup

5.   Once your Computer has rebooted, choose the "Troubleshoot" option.

Figure 4-19 Windows 10 Troubleshoot

6. Select "Advanced options".

7. Select "Startup Settings".

Advanced options

System Restore
Use a restore point recorded on your PC to restore Windows

Startup Settings
Change Windows startup behavior

Startup Repair
Fix problems that keep Windows from loading

Figure 4-20 Windows 10 Advanced Options

8. Select "Restart" to reboot your PC once more. This will allow modification to the boot time configuration settings.

9. A list of settings that can be changed will be shown. The setting you are looking for is "Disable driver signature enforcement". To choose this setting, press the F7 key.

Startup Settings

Press a number to choose from the options below:

Use number keys or functions keys F1-F9.

1) Enable debugging
2) Enable boot logging
3) Enable low-resolution video
4) Enable Safe Mode
5) Enable Safe Mode with Networking
6) Enable Safe Mode with Command Prompt
7) Disable driver signature enforcement
8) Disable early launch anti-malware protection
9) Disable automatic restart after failure
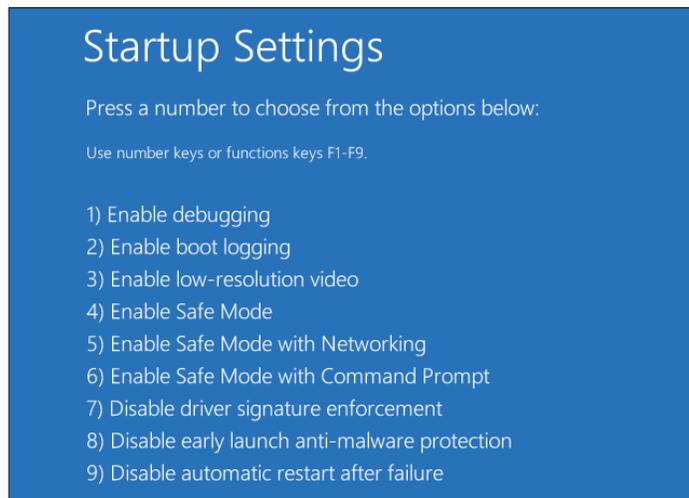
Figure 4-21 Windows 10 Startup Settings

10. After the PC automatically restarts, you will be able to install the USB drivers, as described in Section 4.1.3.3.

4.2 Configuration and Settings

4.2.1 Com Port Designation Set Up

After installing a USB device, should the Com Port number assigned to the device conflict with your existing devices, it is possible to change the Com Port designation number:

1) Click Start > Settings > Control Panel
2) Click Systems to open the System Properties
3) Click the Hardware tab and click 'Device Manager'
4) Double Click the Ports Icon and select the 'USB Serial Port'
5) Right click and select Properties
6) Click the 'Port Settings' tab and click 'Advanced'
7) Select the Com Port Number and click 'OK'

Note: the path to the 'Port Settings' tab may be different for each Windows operating system. The above is just a guideline.

4.2.2 Data Directory

The program will save data downloaded to the following default directory: <C:\Program Files\Solinst\Levelogger4_3\Data> unless otherwise specified in the Default Directory field of the Application Settings window (Figure 4-22).

Click the Configuration menu at the top of the program window, select Application Settings and input or navigate to a different folder destination. After completing the Application Settings, click the OK button to confirm and save the settings.
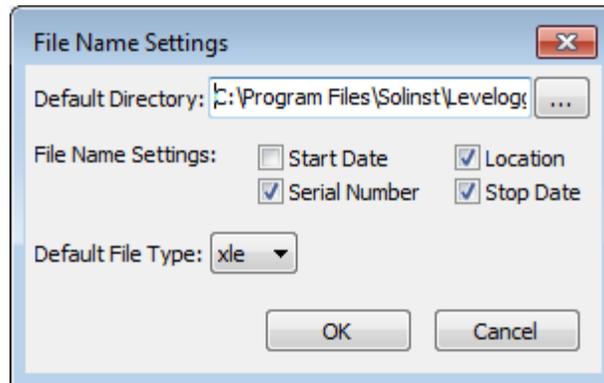
Figure 4-22 Application Setting Window

4.2.3 File Name Settings

From the Application Settings window in the Configuration menu, you can set what information will be included in your default file names of downloaded data (see Figure 4-22). You can include Start Date, Stop Date, Serial Number, and Location. Check-off the information you would like included.

After completing the Application Settings, click the OK button to confirm and save the settings.

4.2.4 Default File Type

From the Application Settings window in the Configuration menu, you can set what default file type you would like to use for downloaded, saved and exported data files. You can select between either *.xle (default) or *.lev file types (see Figure 4-22). For more information about the two file types, see Section 7.1.1.

After completing the Application Settings, click the OK button to confirm and save the settings.

5 Levelogger Edge Series Setup

After you start the Levelogger Software, the main Levelogger Software window will appear, with the Datalogger Settings tab open.

Figure 5-1 Datalogger Settings Tab

Select the appropriate COM or USB Port for the connected communications device from the centre drop-down menu.

Click [icon] to retrieve the current settings from the connected datalogger.

5.1 Datalogger Settings

After you have retrieved the settings of the connected datalogger, the Datalogger Settings tab will identify the Instrument Type, Serial Number, Firmware Version, Project ID, Location, and the Channel Settings.

- **Instrument Type**: will display the model of the attached datalogger, i.e.: M30, Barologger, Rainlogger.
- **Serial Number:** the unique serial number of the attached datalogger will be displayed.
- **Firmware Version**: shows the firmware version of the attached datalogger.
- **Project ID:** input your own identification system. The Project ID is limited to 32 characters.
- **Location**: input specific site / location information. The location is limited to 32 characters.

5.1.1 Setting Up Channel Information

In the lower left portion of the Datalogger Settings tab is the area for setting channel parameters (level, temperature, conductivity, rainfall). The software will detect the available channels when the datalogger settings are retrieved.

5.1.1.1 Level Channel (Ch1)

- **Identification** describes the measurement parameter of the channel and has already been configured as 'LEVEL'. The channel can be re-named to suit each project. The channel monitors water column equivalent pressure. The Identification field will be the channel heading, data column heading and graph line name when viewing the data. Identification is limited to 32 characters.
- **Unit** refers to the channel's unit of measurement. There are six options when using a Levelogger: m (default), cm, ft, kPa, bar, and psi. When using a Barologger Edge, the options are kPa (default), mbar, and psi.
- **Offset** refers to an adjustment, such as the distance between the tip of the Levelogger and the monitoring well cap or static water level. It is recommended that the value of 0.00 be used, as this keeps all subsequent readings relative to the tip of the Levelogger. The reference range is -1000 to 16,400 ft or -300 m to 5000 m.
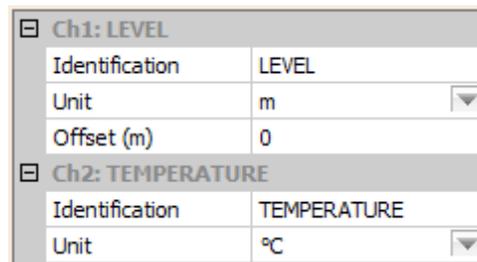
Figure 5-2 Levelogger Edge Channel Setup

The LTC Levelogger Junior also has inputs for:

- **Altitude** in feet or meters above sea level, at which the logger is actually deployed, is input in the altitude field. You can enter an elevation between -1000 ft below sea level and 16,400 ft (or -300 m and 5000 m) above sea level. The readings will then be automatically compensated for elevation.
- **Density** is used to adjust the range of the Levelogger based on the sample fluid density. The range for the density adjustment is from 0.9 kg/L to 1.1 kg/L.

5.1.1.2 Temperature Channel (Ch2)

- **Identification** describes the measurement parameter of the channel and has already been configured as 'TEMPERATURE'. The channel can be re-named to suit each project. The Identification field will be the channel heading, data column heading and graph line name when viewing the data. Identification is limited to 32 characters.
- **Unit** refers to the channel's unit of measurement. For the Levelogger and Barologger, the temperature channel can be set to °C (default) or °F.

5.1.1.3 Conductivity Channel (Ch3)

- **Identification** describes the measurement parameter of the channel and has already been configured as 'CONDUCTIVITY'. The channel can be re-named to suit each project. The Identification field will be the channel heading, data column heading and graph line name when viewing the data. Identification is limited to 32 characters.

- **Unit** refers to the channel's unit of measurement. There are two units of measure available for the user to select: mS/cm or µS/cm.
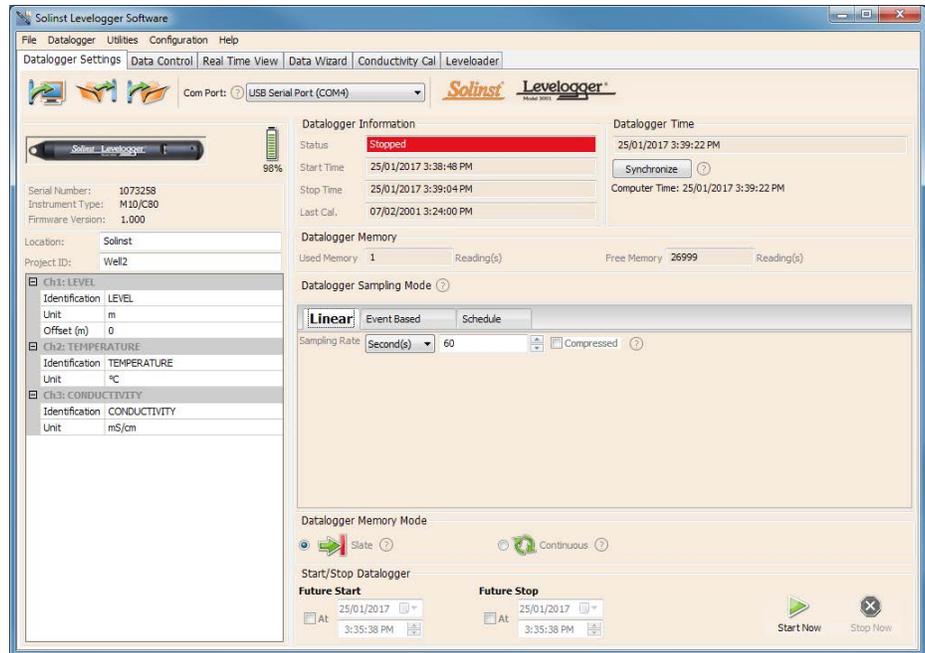
Figure 5-3 Conductivity Channel Setup

5.1.1.4 Rainloggers

There is one channel of measurement for the Rainlogger Edge and Rainlogger. The **RainFall** Channel records each tip time by the connected tipping-bucket and outputs the amount of rainfall per tip (input Rainfall Cal Constant).

- **Identification** describes the measurement parameter of the channel and has already been configured as 'RainFall'. The channel can be re-named to suit each project. The Identification field will be the channel heading, data column heading and graph line name when viewing the data. Identification is limited to 32 characters.

- **Units** refers to the channel's unit of measurement. There are two units of measure available for the user to select: mm or in.

- **The Rainfall Cal Constant** field allows you to enter the calibration factor for the tipping-bucket you will be using. The calibration factor is the amount of rainfall depth (mm, in) per tip. The calibration factor should be indicated on a label on the tipping-bucket device or in the manufacturer's documentation. Input the calibration factor in mm or inches.
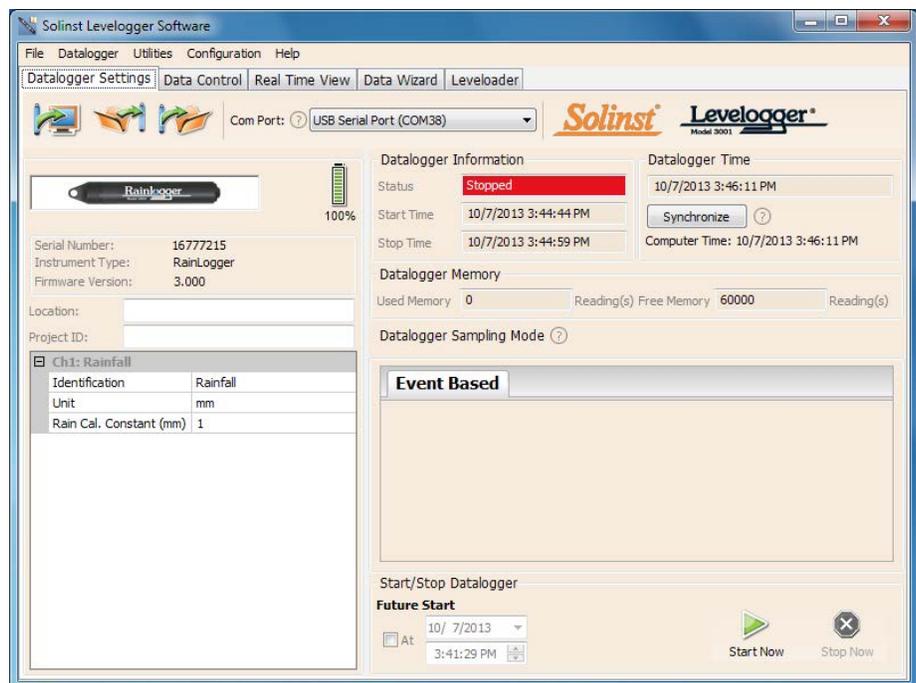
Figure 5-4 Rainlogger Channel Setup

5.2 Datalogger Information

The Datalogger Information section shows the Status of the attached datalogger (i.e.: Started, Stopped, Future Start) and the Start Time and Stop Time of the datalogger. When a Future Start and/or Stop time is set (see Section 5.8), the Start Time and Stop Time fields will fill in. The fields will update each time the datalogger is stopped and started.
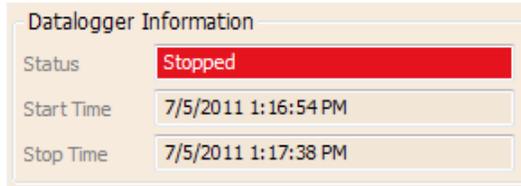
Figure 5-5 Datalogger Information

5.3 Datalogger Memory

The Datalogger Memory section shows the amount of memory used, and the amount of memory remaining (number of readings).
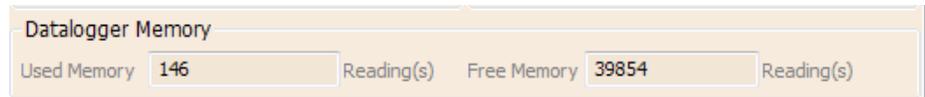
Figure 5-6 Datalogger Memory Remaining

If the Data Compression option is selected (see Section 5.5), the amount of free memory shown is approximated as a visual status bar.
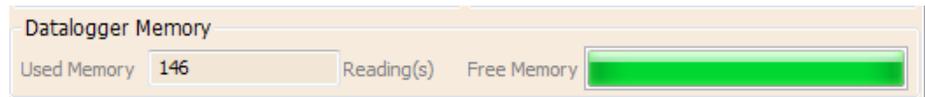
Figure 5-7 Datalogger Compressed Memory

5.4 Datalogger Time

The Datalogger Time section provides the controls for setting the datalogger clock. If you want to synchronize the datalogger's clock to the computer clock, click Synchronize to set the time in the datalogger.

If you start the datalogger without synchronizing the clock and the time difference between the datalogger and the PC is more than 3 seconds, the software will give you a message asking 'Do you want to synchronize the logger time to system time?'. Click Yes to synchronize the clock.

It can be very useful to synchronize the clocks of all the Leveloggers and Barologgers when it comes to Barometric Compensation.
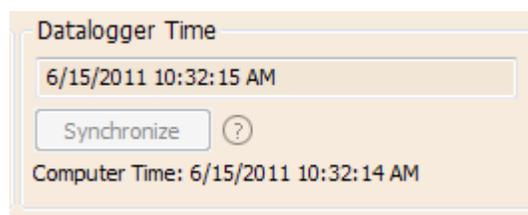
Figure 5-8 Datalogger Time

⚠ NOTE

It is very useful to synchronize the clocks of all the Leveloggers and Barologgers for use on the same project.

⚠ NOTE

To synchronize to a different time/ time zone you first must adjust the computer time using the Windows Operating System Date and Time Settings menu. Then re-start the Solinst Levelogger Software and synchronize your Dataloggers to the new time.

5.5 Datalogger Sampling Mode

The Datalogger Sampling Mode section allows you to choose the sampling measurement type. Options for the Levelogger Edge, Barologger Edge and LTC Levelogger Edge are Linear, Event Based and Schedule.

Linear refers to a set time interval between collection of readings. Sample Rate can be any number from 0.125 seconds to 99 hours for the Levelogger Edge and 2 seconds to 99 hours for the LTC Levelogger Edge.

There is a data compression option available for the Levelogger Edge. This increases the memory capacity of the Levelogger Edge from 40,000 readings to up to a maximum of 120,000. Check the Data Compression box to allow data compression.

Data Compression works by only saving data changes in memory. For example, if you have linear sampling set to record each second, and your water level varies a little for 60 seconds, the memory will only record incremental values for the 60 seconds. When your data is exported, it will display all 60 intervals with the corresponding level data.

Figure 5-9 Linear Sampling Setup

Event Based sample collection is the most memory efficient means of data collection. In Event mode, the Levelogger will be activated at every defined 'Sample Rate' to check if readings have changed by the selected 'Change' from the last recorded reading.

For the Levelogger Edge, 'LEVEL' or 'TEMPERATURE' is the selected parameter where change is monitored. You can also select 'CONDUCTIVITY' for the LTC Levelogger Edge. The Levelogger will record a new reading only if the specified change in the parameter has occurred, at the specific point in time, as defined by the 'Sample Rate'.

A default reading will also be stored in the datalogger memory, every 24 hours from the last recording, if no 'Change' occurs.

Figure 5-10 Event Based Sampling Setup

Schedule Sampling allows you to select a logarithmic style sampling schedule adapted to the needs of each application.

Schedule Sampling is set by using the plus and minus buttons to add or subtract line items in the Schedule window. The maximum number of line items in a schedule is 30, each with its own sampling interval of seconds, minutes or hours and duration of seconds, minutes, hours, days or weeks. A 'Pause' interval can also be selected, which stops the Levelogger from recording for the specified duration.

Running totals of the number of readings still available, from the total possible 40,000 (27,000 readings for the LTC Levelogger Edge), and the run time to date are shown. If the number of readings selected exceeds the Leveloggers memory capacity an error message appears.

By checking Repeat, the Levelogger will continue to run through the schedule until its memory is full, or it is stopped.
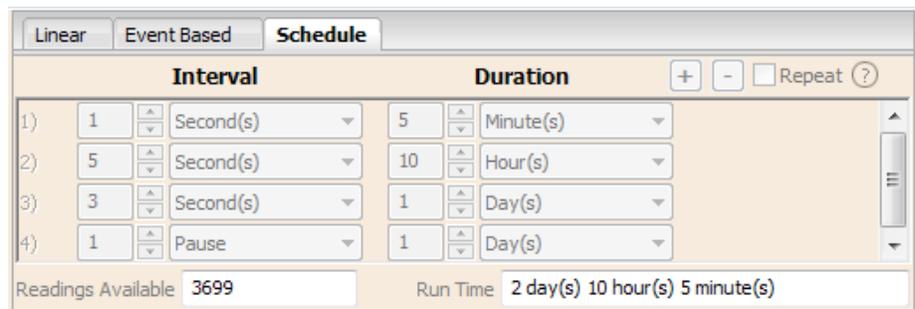
Figure 5-11 Schedule Sampling Setup

5.6 Datalogger Memory Mode

Datalogger Memory Mode selection will only appear when **Linear** sampling mode is selected. When using a Levelogger Edge in Linear Mode, there is a choice of **Continuous** Logging (wrap around) or **Slate** Logging .

Compressed Linear, Event Based and Schedule sampling modes can only use the Slate Mode option.

In Continuous Logging, the new log is started at the end of any previous log and continues logging, eventually recording over the first logged data. As one of the download options is to 'Append Data', Continuous Logging can be a preferred choice when logging long-term (see Section 7.1.2).

In Slate Logging, the new log is also started at the end of any previous log, but will stop recording after 40,000 readings (or up to 120,000 readings), so that the beginning of the current log will not be written over.

Figure 5-12 Datalogger Memory Mode

5.7 Saving and Retrieving Levelogger Settings Files

To store settings as defaults, click . It will store the settings of the Levelogger into an *.dtf file as a series of defaults. The *.dtf file will save the Project ID, Location, Sample Mode, Sample Rate, Channel ID, Unit, and Offset.

To retrieve settings from defaults, click from a selected *.dtf file. This is particularly useful if programming several Leveloggers with similar identical settings. Keep in mind that Project ID and Location identification information will be identical and should be distinguished from logger to logger or monitoring point to point.

5.8 Starting and Stopping the Datalogger

Starting the Datalogger

There are two ways to start logging: **Start Now** or by programming a **Future Start** time.

To start logging immediately, do not fill in a Future Start time and click, . It should say Start Now below the icon to indicate an immediate start. Any changed settings will automatically be applied to the datalogger, and it will start logging. Datalogger Status will change from Stopped to Started.

After the datalogger is started, and begins collecting readings, the Start icon will be greyed out, and only the Stop icon and Future Stop settings will be active.
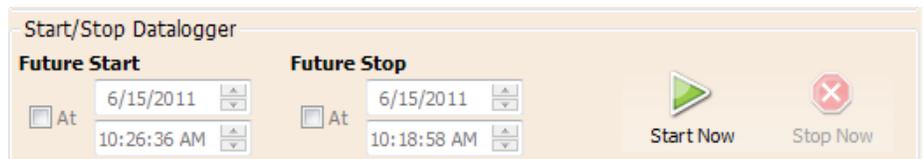
Figure 5-13 Starting the Datalogger Immediately

Check **Future Start** 'At' to set logging to start at a later date and/or time. This Start mode is referred to as Future Start in the Status field. Click to apply the Future Start time and any changes to the datalogger settings.

When the Future Start time is reached, the datalogger will start logging and the Status will change from Future Start to Started.
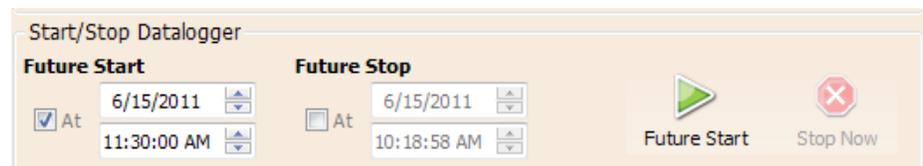
Figure 5-14 Future Start Setting

Stopping the Datalogger

There are two ways to stop logging: Stop Now or at a programmed Future Stop time for the Levelogger Edge and Barologger Edge.

To stop the datalogger immediately when it is logging, click ⊗ , (it should say Stop Now below the icon).

The Levelogger can be stopped at any time before it reaches the maximum reading capacity. **Starting again begins a new recording session and clears previously stored data readings.**

Figure 5-15 Stopping the Datalogger Immediately

To program a **Future Stop** time for your datalogger, check Future Stop 'At' and fill in the desired stop time. The Future Stop time will be applied to the datalogger once ▷ is selected for an immediate or future start.

You can also program a Future Stop time after you have started the datalogger, by checking Future Stop 'At' and filling in the desired stop time. Select ⊗ to apply the Future Stop time (it should say Future Stop below the icon).
The Stop Time should be shown in the Datalogger Status section.

Figure 5-16 Future Stop Setting

It is critical to note that when Leveloggers log data in Slate mode, it means they will record data until stopped or their memory is full. When the memory fills, the datalogger will stop recording. For this reason, it is important to determine, based on your start time and sampling rate, the date and time at which the memory will be full and the datalogger will stop recording. Levelogger Edge units record in Slate mode if Event, Schedule, or Compressed logging, but in standard Linear mode they can be set to Slate or to Continuous logging.

! NOTE

You can not set a Future Stop time for the Levelogger Junior Edge, LTC Levelogger Junior, or Rainlogger.

! NOTE

If you have set a Future Stop time, but wish to stop the datalogger immediately, uncheck the Future Stop 'At' box, and the Stop icon should say Stop Now. Click the icon to stop logging.

5.9 Levelogger Gold Series Setup

This section briefly describes the Levelogger Gold, Barologger Gold and Levelogger Junior setup.
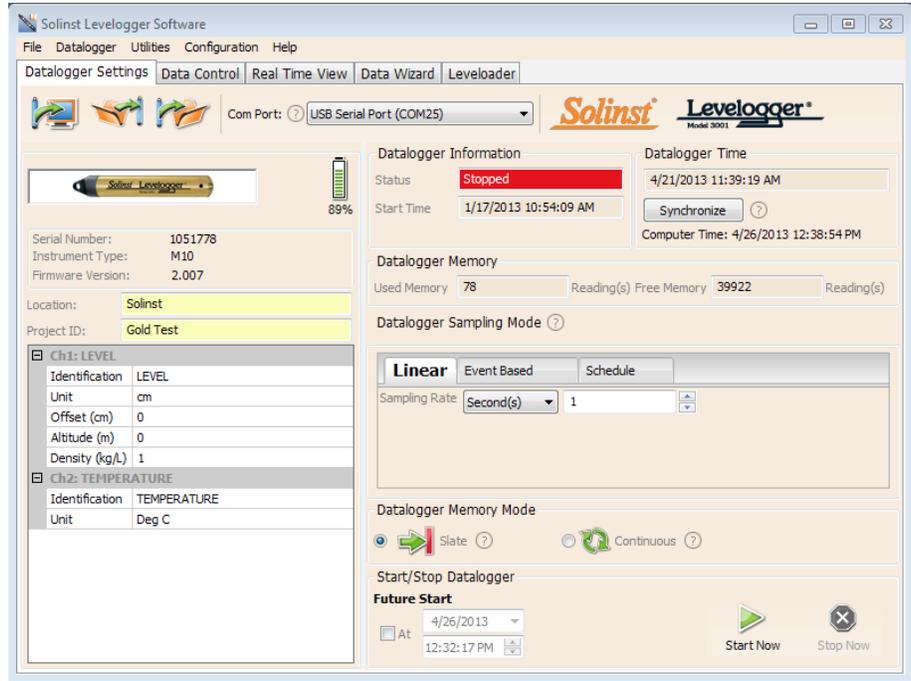
Figure 5-17 Levelogger Gold Settings

Select the appropriate COM or USB Port for the connected communications device from the centre drop-down menu.

Click [icon] to retrieve the current settings from the connected datalogger.

Channel Information

Level Channel (Ch1)

- **Identification** describes the measurement parameter of the channel and has already been configured as 'LEVEL'. The channel can be renamed to suit each project. The channel monitors water column equivalent pressure. The Identification field will be the channel heading, data column heading and graph line name when viewing the data. The Identification is limited to 32 characters.
- **Units** refers to the channel's units of measurement. There are three units of measure available for the user to select: cm, m or ft. When the user changes the unit, the value of the range and altitude will change according to the Unit Conversion formula. Note that when a metric unit is used, the unit of altitude is meters. When feet are the level channel units, feet are the units of altitude.

- **Offset** refers to an offset correction, such as the distance between the tip of the Levelogger and the monitoring well cap or static water level. It is recommended that the value of 0.00 be used for offset as this keeps all subsequent readings relative to the tip of the Levelogger. The offset range for Levelogger Gold and Barologger Gold units is -1000 to 16400 ft or -300 m to 5000 m.

- **Altitude** in feet or meters above sea level, at which the logger is actually deployed, is input in the altitude field. Water column equivalent pressure decreases with altitude at a rate of approximately 1.2:1000 in the lower atmosphere below 5000 m. You can compensate for this by entering an elevation between -1000 ft below sea level and 16,400 ft (or -300 m and 5000 m) above sea level. The readings will then be automatically compensated for elevation.

- **Density Adjustment** is used to adjust the range of the Levelogger based on the sample fluid density. The range for the density adjustment is from 0.9 kg/L to 1.1 kg/L.

Temperature Channel (Ch2)

- **Identification** describes the measurement parameter of the channel and has already been configured as 'TEMPERATURE'. The channel can be re-named to suit each project. The Identification field will be the channel heading, data column heading and graph line name when viewing the data. Identification is limited to 32 characters.

- **Unit** refers to the channel's unit of measurement. The Levelogger Gold and Barologger Gold measure in °C only.

Sample and Memory Modes

Sample Mode, allows you to choose the sampling measurement type. Options are Linear, Event Based and Schedule.

- **Linear** refers to a set time interval between collection of readings. Sample Rate can be any number from 0.5 seconds to 99 hours. The Levelogger Gold and Barologger Gold can store 40,000 readings of level and temperature.

- **Event Based** sample collection is the most memory efficient means of data collection. In Event mode, the Levelogger will activate every sampling interval defined and check if readings have changed by the selected threshold (Change) from the last recorded reading. For the Levelogger Gold, 'LEVEL' or 'TEMPERATURE' is the selected parameter where change is monitored. The Levelogger will record a new reading only if the specified change in the parameter has occurred.

- **Schedule Sampling** allows you to select a logarithmic style sampling schedule adapted to the needs of each application. Schedule Sampling is set by using the plus and minus buttons to add or subtract line items in the Schedule window. The maximum number of line items in a schedule is 30, each with its own sampling interval of seconds, minutes or hours and duration of seconds, minutes, hours, days or weeks.

⚠ NOTE

The Levelogger Junior records using Linear sampling mode only.

⚠ NOTE

In Event Based sampling mode, the Levelogger Gold has a total memory of 25,000 readings of level and temperature

⚠ NOTE

An important reminder for Event Based sampling is that, although actual memory usage in stable water level conditions may be relatively small, battery power consumption is partially a function of the sample reading rate. Therefore, a small sample reading interval will consume battery power at a higher rate whether readings are stored or not.

Memory Mode selection will be grayed-out if not in Linear Mode sampling. When using a Levelogger Gold in Linear Mode, there is a choice of **Continuous** logging (wrap around) or **Slate** logging. In Continuous logging the new log is started at the end of any previous log and continues logging, eventually recording over the first logged data. As one of the download options is to 'Append Data', Continuous logging can be a preferred choice when logging long-term. In Slate logging the new log is also started at the end of any previous log, but will stop recording after 40,000 readings, so that the beginning of the current log will not be written over.

Starting and Stopping the Levelogger

There are two ways to start logging: **Start Now** or by programming a **Future Start** time.

To start logging immediately, do not fill in a Future Start time and click, ▷ . It should say Start Now below the icon to indicate an immediate start. Any changed settings will automatically be applied to the datalogger, and it will start logging. Datalogger Status will change from Stopped to Started.

After the datalogger is started, and begins collecting readings, the Start icon will be greyed out, and only the Stop icon and Future Stop settings will be active.

Check **Future Start** 'At' to set logging to start at a later date and/or time. This Start mode is referred to as Future Start in the Status field. Click ▷ to apply the Future Start time and any changes to the datalogger settings.

When the Future Start time is reached, the datalogger will start logging and the Status will change from Future Start to Started.

To stop the datalogger immediately when it is logging, click ✖ , (it should say Stop Now below the icon).

The Levelogger can be stopped at any time before it reaches the maximum reading capacity. **Starting again begins a new recording session and clears previously stored data readings.**

It is critical to note that when Leveloggers log data in Slate mode, it means they will record data until stopped or their memory is full. When the memory fills, the datalogger will stop recording. For this reason, it is important to determine, based on your start time and sampling rate, the date and time at which the memory will be full and the datalogger will stop recording. Levelogger Gold units record in Slate mode if using Event, or Schedule sampling mode, but in standard Linear mode they can be set to Slate or to Continuous logging.

Figure 6-1
LTC Levelogger Edge and Junior

> **⚠ NOTE**
>
> If you know the approximate conductivity range of the water that you will be measuring, best accuracy when calibrating your unit is to select two calibration points - one above, and one below that range. If you are measuring in water less than 1,413 µS/cm or above 12, 880 µS/cm or 80,000 µS/cm, use just one calibration solution.

6 Conductivity Calibration

The LTC Levelogger Edge and LTC Levelogger Junior conductivity sensors must be calibrated for reliable conductivity measurements. Calibrate for conductivity at the start of each new monitoring project or at a minimum each new monitoring season (twice a year).

Calibrating the LTC Levelogger directly after the monitoring project or season will provide information on the degree of conductivity deviation during the project or season. If necessary, readings can be corrected for any conductivity deviation in a spreadsheet program after the data has been exported.

The process of conductivity calibration is performed automatically by use of the Calibration Wizard. You place the LTC Levelogger in a specified calibration solution and follow the steps provided by the wizard. Conductivity calibration solutions are available from Solinst or any laboratory supply outlet.

The LTC Levelogger Edge has an 100,000 µS/cm conductivity range and a calibrated range from 50 to 80,000 µS/cm. It can be calibrated to 4 calibration standard points:

- 1,413 µS/cm
- 5,000 µS/cm
- 12,880 µS/cm
- 80,000 µS/cm

The LTC Levelogger Junior has an 80,000 µS/cm conductivity range and a calibrated range from 500 to 50,000 µS/cm. It can be calibrated to 3 calibration standard points:

- 1,413 µS/cm
- 5,000 µS/cm
- 12,880 µS/cm

If you know the approximate conductivity range of the water that you will be measuring, best accuracy when calibrating your unit is to select two calibration points - one above, and one below that range. If you are measuring in water less than 1,413 µS/cm or above 12,880 µS/cm or 80,000 µS/cm, use just one calibration solution.

The solution(s) must be between 10°C and 30°C during actual calibration. Temperature should remain stable during the 10 - 20 seconds it takes to perform each calibration.

For best accuracy, it is recommended you use calibration solutions that have a temperature error of ±2% or better. You should also keep the solution as close to the stated temperature on the bottle as possible (i.e. 25°C). The closer you get to the temperature extremes of 10°C and 30°C, the less accurate your calibrations may be.
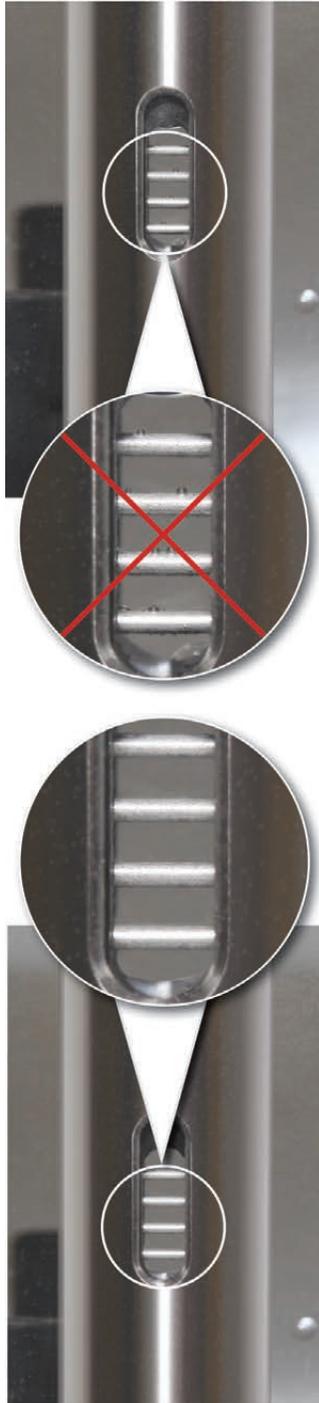
Retrieve the settings from the attached LTC Levelogger by clicking .

Stop the LTC Levelogger by clicking .

Start the Calibration Wizard by clicking the Conductivity Cal tab. The wizard will guide you through the calibration process. You can exit the wizard after any step to cancel the calibration session.

Introduction: The LTC Levelogger must be connected to the computer with an Optical Reader during the entire calibration process and **must be in the stopped mode**. Ensure you use fresh calibration solution and allow thermal equilibration of the solution during the process. Also ensure no air bubbles are present on the sensor and that the pins are clean. See Section 10.2 for recommended methods to clean the sensor pins. See Section 10.1.5.3 for protection against biofouling conditions.

Figure 6-2 LTC Levelogger Calibration Wizard Introduction

1) **Setting the Temperature Coefficient:** The default setting for the Temperature Coefficient is 2.00. If the conductivity solution you are using to calibrate the LTC Levelogger states a different temperature coefficient on the label, please input that number into the Temperature Coefficient field.
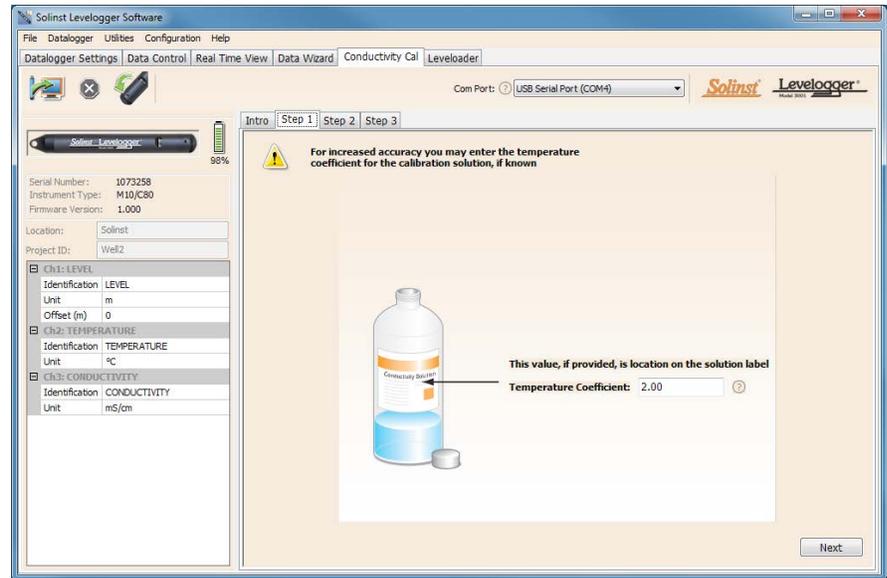
Figure 6-3 LTC Levelogger Calibration Wizard Step 1

2) **Setup:** The Levelogger Software requires the user to choose the calibration solutions. You can choose up to four (three for the LTC Levelogger Junior) solutions for a multipoint calibration of the LTC Levelogger. Ensure the solutions are ready in the calibration beaker or container. Start the calibration by selecting Next.

> **⚠ NOTE**
>
> To obtain the highest accuracy, choose the calibration solution(s) closest to your expected conductivity.
>
> Use a two point calibration for waters between 1,413 µS/cm and 12,880 µS/cm.
>
> Use a one point 1,413 µS/cm calibration for waters less than 1,413 µS/cm.
>
> Use a one point 12,880 µS/cm/80,000 µS/cm calibration for waters greater than 12,880 µS/cm/80,000 µS/cm.
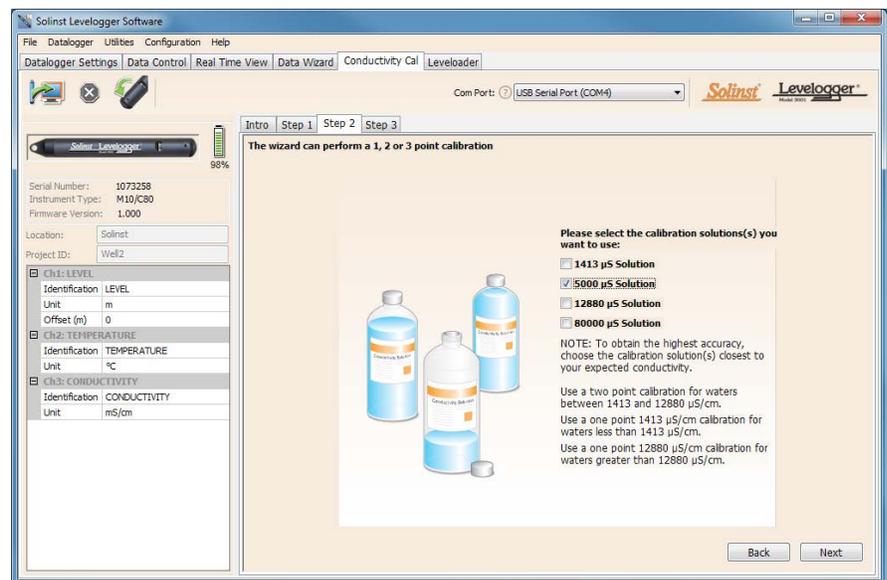
Figure 6-4 LTC Levelogger Calibration Wizard Step 2

3) **LTC Levelogger Rinsing Process:** Use DI water to rinse the LTC Levelogger first and then rinse the LTC Levelogger with the displayed calibration solution. Use fresh solution for calibration, and immerse the LTC Levelogger. Lightly tap the Levelogger to remove any bubbles from the sensor. Allow 2-3 minutes to stabilize, then select next to calibrate.

Figure 6-5 LTC Levelogger Calibration Wizard Step 3
(example of window calibrating with 5,000 µS/cm solution)

! NOTE

Always remember to use fresh solution, remove all bubbles from the sensor pins, and allow for thermal equilibration of the sensor before proceeding.

Calibration: Since most standard calibration solutions state conductivity at a standard temperature of 25°C, the LTC Levelogger an account for temperature differences between 10 to 30°C when you calibrate the unit. The LTC Levelogger will compare the current temperature and conductivity readings against the temperature corrected standard solution.

! NOTE

Once the calibration is complete for the first solution of a multipoint calibration, the Calibration Wizard will then go back to the beginning of Step 3 to start the rinsing process for the next solution selected.
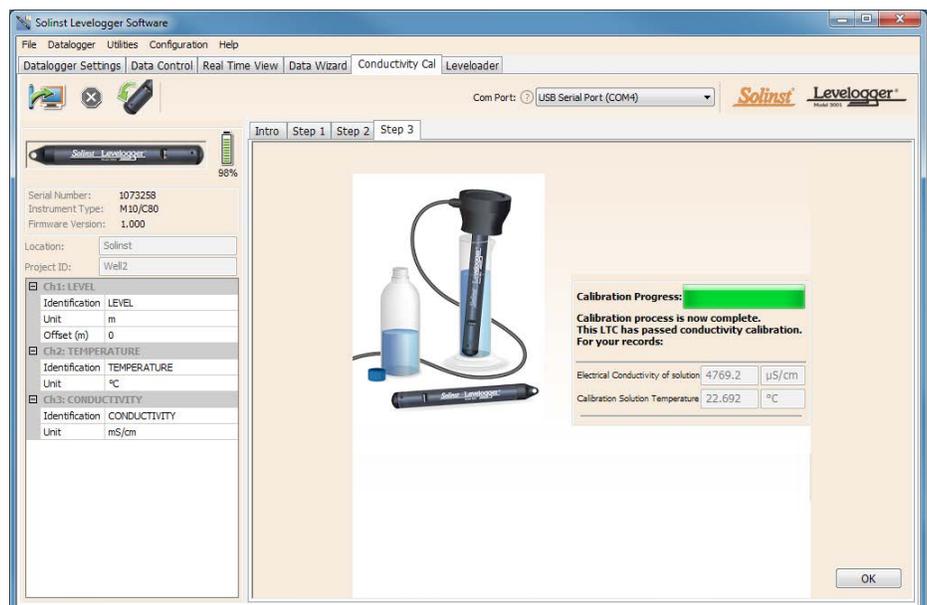
Figure 6-6 LTC Levelogger Calibration Successful

When a single-point calibration is successful, the process is complete. Once the calibration is complete for the first solution of a multipoint calibration, a message will appear stating that the calibration was successful. When you select 'Okay', the Calibration Wizard will go back to the beginning of Step 3 to start the rinsing process for the next solution selected. The calibration process will proceed automatically until completed for all solutions.

If a failure occurs at any point during calibration, a message will appear asking you to clean and check your probe, then start the calibration process over for that current solution by selecting 'Yes' (Figure 6-7). If performing a multipoint calibration, any previous successful calibration points will remain.
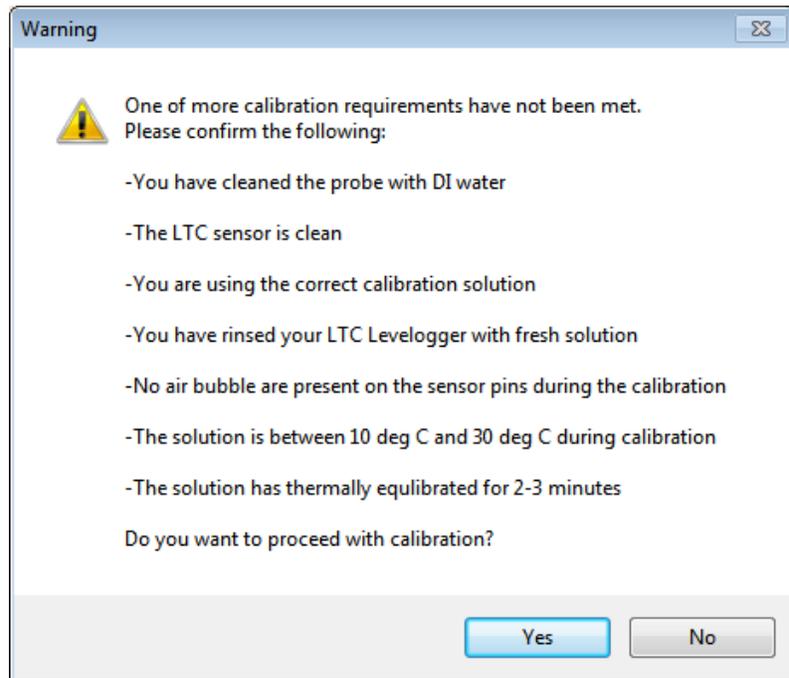
Figure 6-7 LTC Levelogger Calibration Warning 1

If a second failure occurs during calibration, a warning message will appear indicating that your probe may still be dirty, or damaged. This may occur if your LTC Levelogger conductivity sensor has been affected by dirt, mineral build-up, etc., so it no longer responds like it did when it was first factory calibrated. This step allows your sensor to be calibrated within a wider range of the standard solution value.
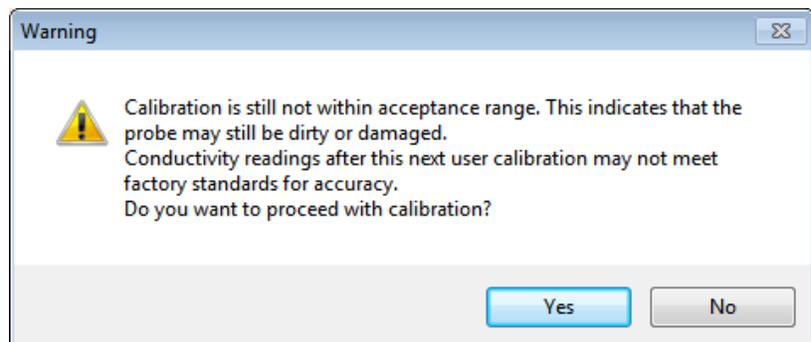
Figure 6-8 LTC Levelogger Calibration Warning 2

If you select 'Yes' to accept the larger tolerance, the calibration process will start over for that current solution (Figure 6-8). If performing a multipoint calibration, any previous successful calibration points will still remain. If you select 'No', the LTC Levelogger will default back to the last pre-calibrated state. You can retry the calibration using the normal tolerance range.

If a third calibration error occurs, or the results of the calibration are outside the error tolerance range, a warning message will appear asking you to contact Solinst for more options (Figure 6-9).
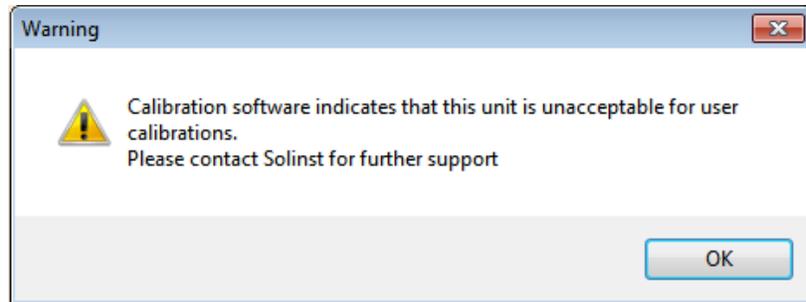
Figure 6-9 LTC Levelogger Calibration Warning 3

6.1 Restore Factory LTC Levelogger Calibration

An LTC Levelogger can be set back to original factory calibration settings for conductivity at any time, using this function. If you suspect that user calibrations are not working properly, you can restore the LTC Levelogger to its original factory settings and then perform a "first-time" conductivity user calibration to maximize accuracy.

To execute this function, simply click the Restore Factory LTC Calibration button, with the LTC Levelogger connected to the PC.

7 Data Control
(Downloading and Viewing Data)

Click the Data Control tab on the Main window. From the Data Control tab you can download data from a Levelogger, display data in tabular or graphic format, and save and export data files.
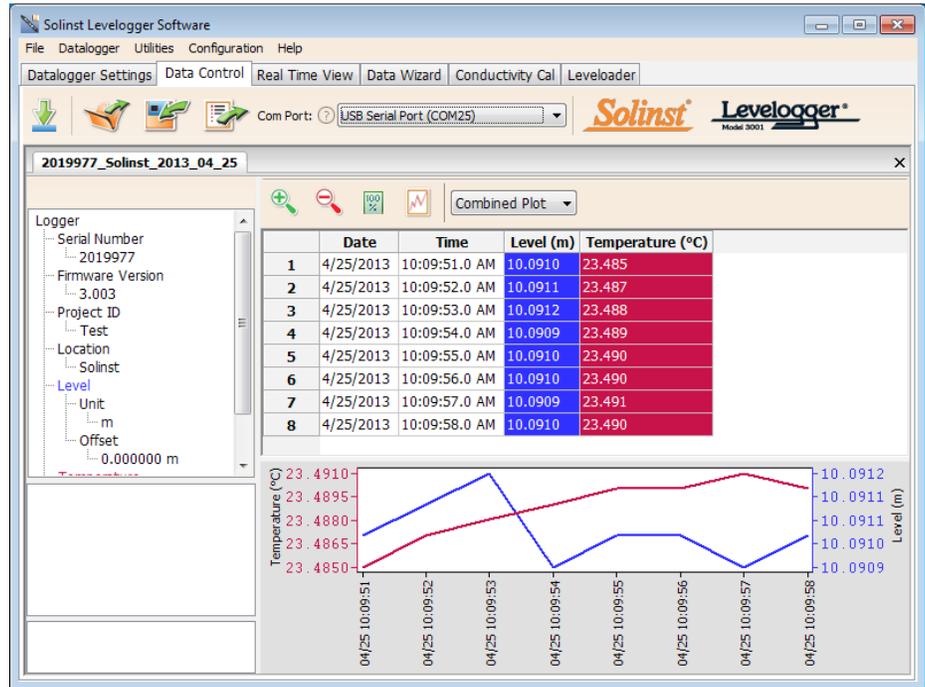
Figure 7-1 Data Control Tab

Click [icon] to open a *.xle or *.lev file. Multiple files can be opened at the same time and are available for viewing by clicking the File Name Tab on top of the data table.

All the Levelogger settings and the channel information effective during data collection are shown on the top left of the window.

The bottom left sections of the window are used to display information after a data compensation has been performed. The middle section displays information from a Barologger, if a barometric compensation is performed, and the bottom section includes information from other conversions, such as offsets or conductivity conversions (see Section 8).
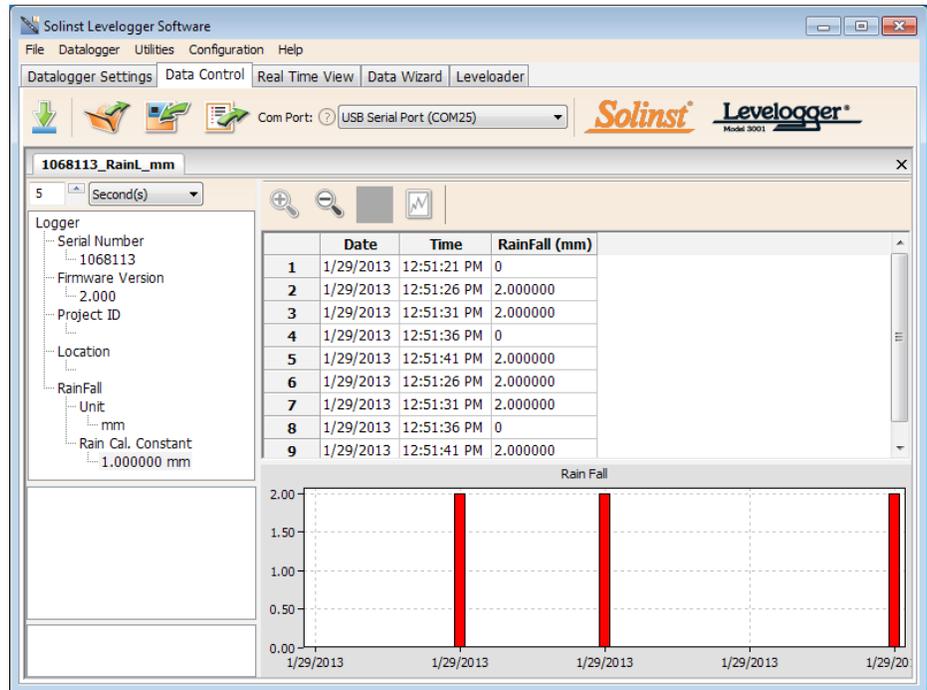
Figure 7-2 Rainlogger Data

When you view data downloaded from a Rainlogger, the RainFall data will be shown in a table and in a bar graph. A drop-down menu appears that allows you to select the time interval at which you would like the data shown, from 1 to 99 seconds, minutes, hours, days, or weeks (this acts like a zoom function). Figure 7-2 shows the data every 5 seconds from the start date and time.

7.1 Downloading Options and Saving Data Files

7.1.1 Default File Format

The default file type for Levelogger Software Version 4 and up is *.xle, unless changed to *.lev in the Application Settings (see Section 4.2.4). Previous Levelogger Software used *.lev files as the default. The *.xle file type is a *.xml format, which allows for enhanced functionality. The *.xle files can be exported as *.xml files, which can be integrated into external database programs.

The *.lev files of previous Levelogger downloads are compatible with Levelogger Software Version 4 and up, however, *.xle files are not compatible with previous software versions. To ensure compatibility, all Levelogger Software versions allow data to be exported as *.csv files for use in external spreadsheet programs. See Section 7.3 for Export options.

NOTE

The default file type is *.xle, unless changed in the Application Settings (see Section 4.2.4).

7.1.2 Downloading Data

Click [icon] from the Data Control tab to download data from a connected datalogger. There are four options for downloading data. They are: **All Data, Append Download, Partial Download and Recover Previous Log**.

If you select **All Data**, the program will download all the data from the current logging session of a datalogger into a *.xle file.

The default directory for saved data is in the 'Data' folder: <C:\Program\Files\Solinst\Levelogger4_3\Data>.

If you select **Append Download**, the program will append the data in an opened *.xle file from the datalogger. The opened *.xle file and the attached datalogger should have the same serial number and start time, otherwise an error will occur.
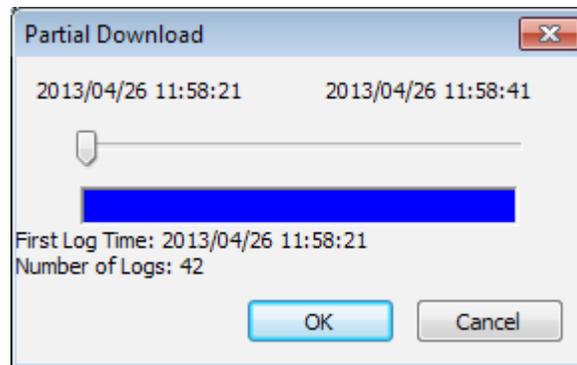
Figure 7-3 Partial Download Window

If you select **Partial Download**, a Partial Download Selection Window will open. The window shows the time stamp of the first and last reading in the logging session. Use the slider to select the time interval you would like data from. Once you click OK, all the data within that time will be downloaded to a *.xle file.

If you select **Recover Previous Log**, the software will try to recover the data from the previous log session and download the data to a *.xle file.

Once the data is downloaded from a Levelogger, it is automatically saved in a temporary file.

7.1.3 Saving Data

Click ![save icon] to save the data in a specific *.xle file.

The default directory for saved data is in the 'Data' folder: <C:\Program\Files\Solinst\Levelogger4_3\Data>.

However, the default directory for saved files can be changed by clicking the Configuration menu at the top of the program window, selecting 'Application Settings' and inputting or navigating to a different folder destination. If an error is experienced in saving your first data file such as depicted in Figure 7-4, you may not have file writing privileges to the default directory. In this case, create and set as the default file save folder, a new Levelogger data folder within the My Documents folder and attempt the file save procedure again.
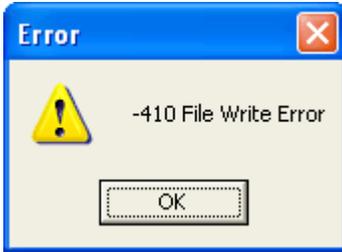
Figure 7-4 File Write Error Message

NOTE
As there is only one channel of data for Rainloggers, there are no graphing options.

NOTE
Right click, and drag the mouse to scan the data graph.

7.2 Graph Manipulation and Zoom Function

To perform the Zoom In function on the graph, click ![zoom in icon] .

To perform a Zoom Out function on the graph click ![zoom out icon] . Click ![100% icon] to undo all the zoom functions.

The Zoom functions can also be used for data selections in the graph.

Click ![graph icon] to open the Graph Option Dialog. The Graph Dialog is shown in Figure 7-5.
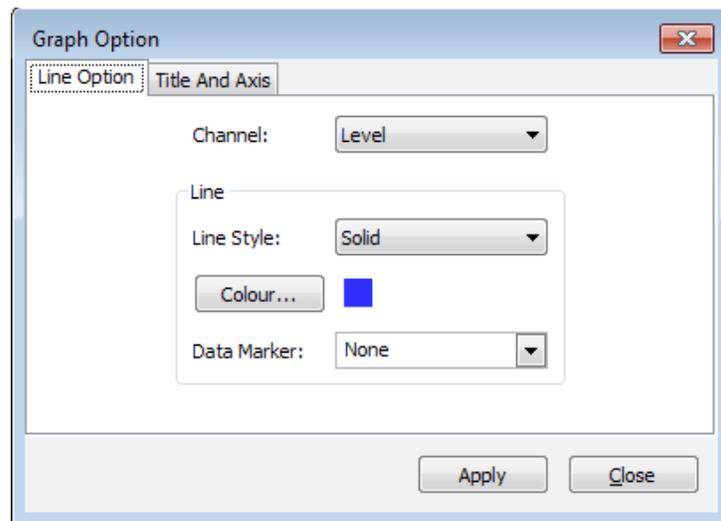
Figure 7-5 Line Option Window

The Line Option is used to adjust the style and colour of the line in the graph for each channel. The user can also select the shape of the data marker or remove the data marker.
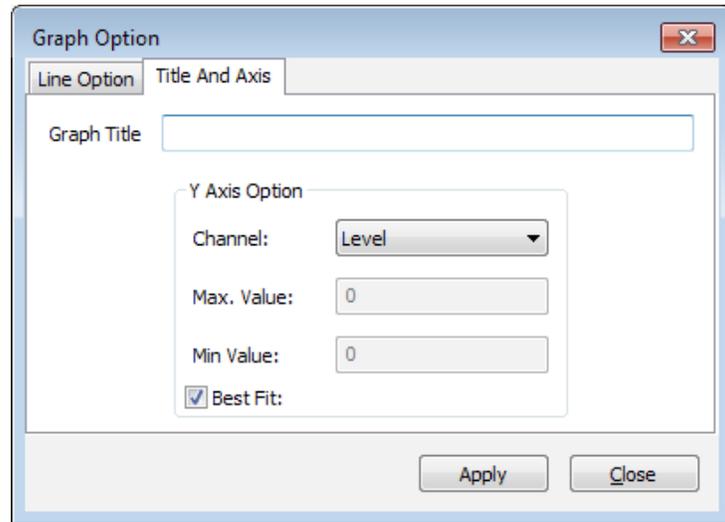
Figure 7-6 Title and Axis Option Window

The Title and Axis Option is used to enter the title of the graph and change the Y axis label or user selected scale. Check the Best Fit box to enable the software to determine the best fit scale. If the Best Fit box is not checked, the user has to enter a maximum and minimum value of the selected channel. The X axis is logging time.

There is the option to show Combined Plot graphs or Separated Plot graphs of the data. Choosing a Combined Plot will show the data from each of the channels in one graph. The Separated Plot option will show a separate graph for each data channel.
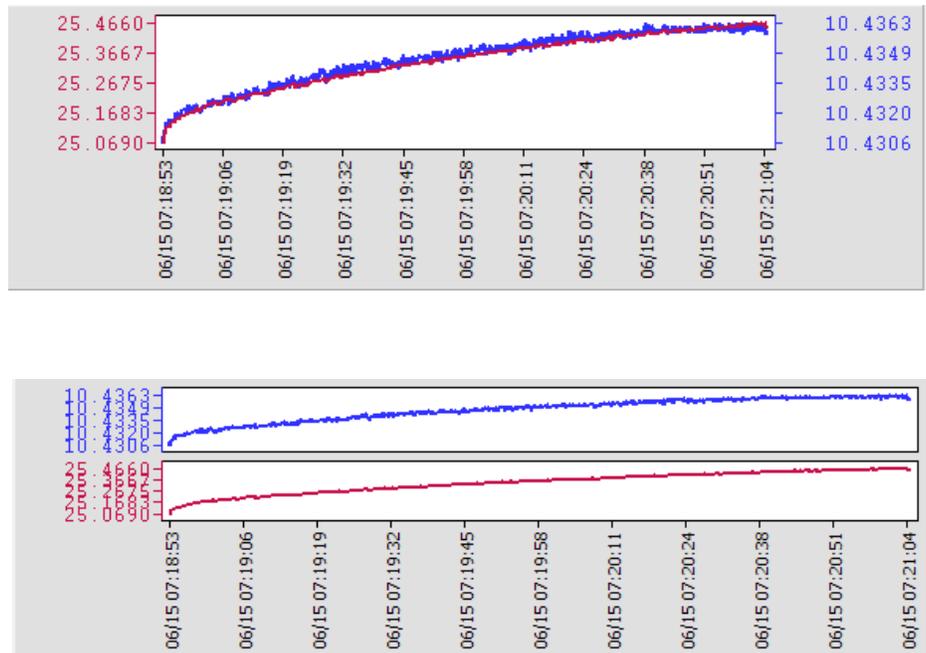
Figure 7-7 Combined and Separated Plot Graphs

There is also the option to view more than one graph at a time. Click and drag a File Name Tab and drop it when you see a shaded area on the window to open a separate graph of that data file. You can view any number of graphs at one time by re-sizing your window as required.
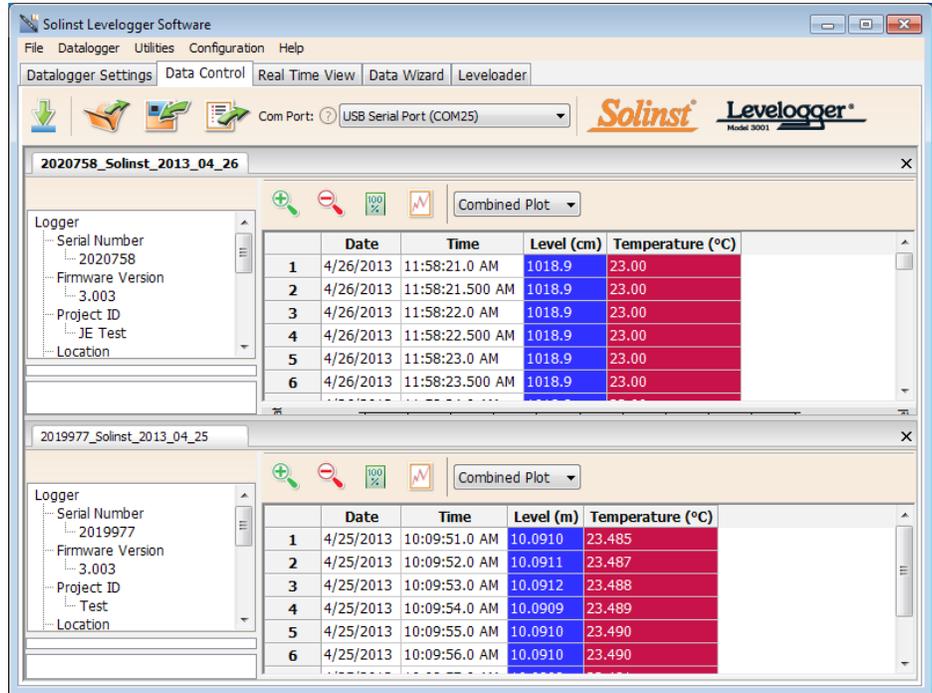
Figure 7-8 Viewing Two Graphs

7.3 File Export and Print Function

Data can be exported in *.csv (comma separated value) file format or *.xml (extensible markup language) file format by clicking File > Export > Data or

The *.csv and *.xml file formats are supported and can be imported by most spreadsheet and database programs.

Also, the data graph can be exported to a *.bmp file or a *.png file by clicking File > Export > Graph.

The Datalogger Settings, data table and data graph can be printed. Click File > Print Preview, to open the Print Preview window. Figure 7-9 shows the print preview of the Datalogger Settings. The Datalogger Settings are always on the first page of the document. The data graph is on the second page of the document and the rest of the document is the data table.

Click Print…, to open the print dialog. You can choose to print the entire document or just a selection. You can also click File > Print, to open the print dialog.
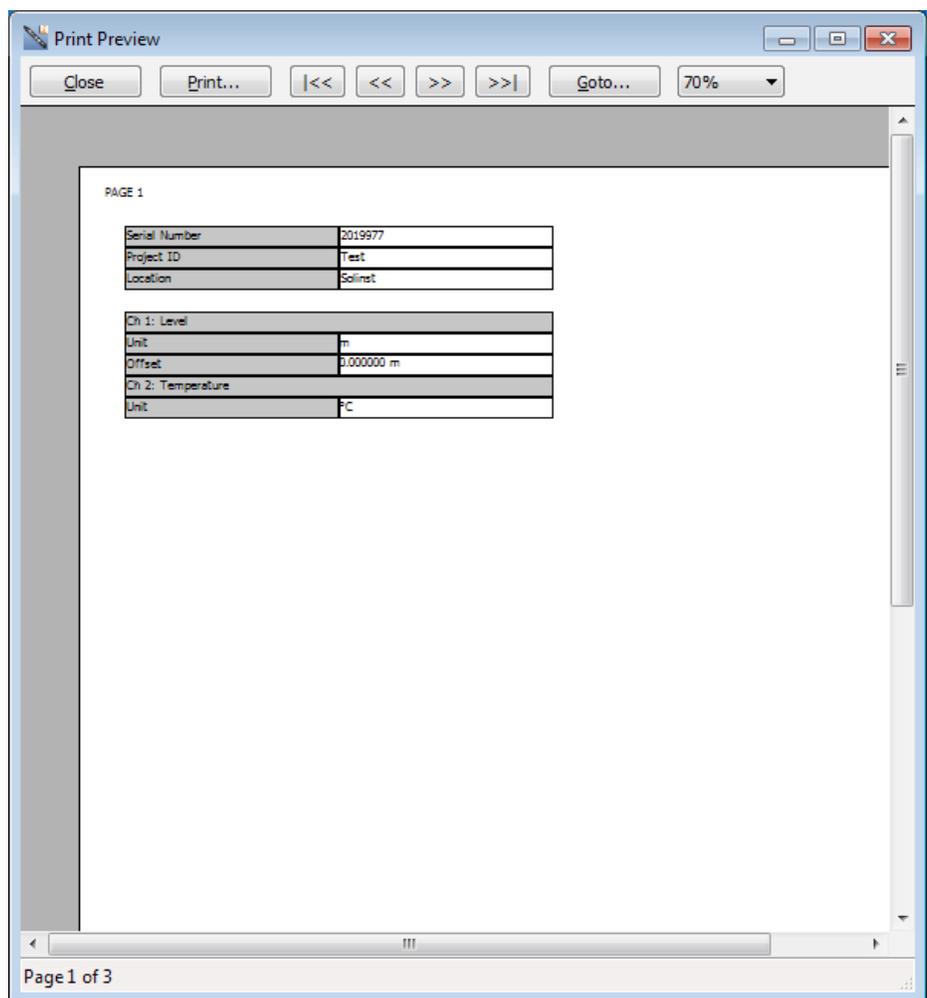
Figure 7-9 Print Preview Window

8 Data Compensation

Data Compensations, such as Barometric Compensation, Manual Data Adjustments and Parameter Adjustments can be performed automatically using the Levelogger Software Data Wizard, or manually, by exporting data to an external spreadsheet program.

8.1 Data Wizard

Open the Data Wizard tab. The first step is to select your Data Compensation Path. The choices for Leveloggers are **Basic** or **Advanced**.

Choosing **Basic** allows you to do a simple Barometric Compensation of Levelogger data only.

The **Advanced** option allows you to perform Barometric Compensation, Manual Data Adjustments and Parameter Adjustments, including adjustments to Rainlogger data.

> ⚠ **NOTE**
>
> Multiple datalogger files can be compensated at once.

Figure 8-1 Data Wizard

Barometric Compensation simply subtracts the barometric reading from the corresponding Levelogger reading(s), to give true water level measurements.

Manual Data Adjustment allows you to enter a manual water level measurement or reference point as a field zero, which all Levelogger water level readings can then be adjusted to. There is the option to convert readings to Depth to Water Level measurements (e.g. from the top of a well casing to water level), or Elevation of Water Level measurements (e.g. above sea level).

Parameter Adjustments allow you to change Levelogger, Barologger or Rainlogger data to different units of measurements, add an offset, correct data for elevation differences, convert conductivity to Salinity or Specific Conductance, adjust density, or adjust barometric efficiency. Only the options available for your opened datalogger file types will be active (e.g. Conductivity Conversion is only available for LTC Levelogger Edge and LTC Levelogger Junior data files).

Standard Adjustments:

- **Unit** conversion allows you to convert level readings in a Levelogger file to different units (m, cm, ft, kPa, bar or psi), a Barologger file to kPa, mbar, or psi, temperature readings to °C or °F, conductivity readings to μS/cm or mS/cm, or rainfall values to mm or inches.
- **Offset** allows you to enter any value, positive or negative, which will be added to each reading in the selected Levelogger file to be offset by that amount. It is recommended to stay with the default zero value, unless a known offset has been determined (e.g. to correct for pressure sensor drift. See Solinst Technical Bulletin: Understanding Pressure Sensor Drift).
- **Elevation** is used to correct for altitude differences between Levelogger or Barologger locations. Water column equivalent pressure decreases with altitude at a ratio of approximately 1.21/1000 in the lower atmosphere below 5000 m. You can compensate for this by entering an elevation between -1000 ft below sea level and 16,400 ft (or -300 m and 5000 m) above sea level.
- **Conductivity Conversion** allows you to convert raw Conductivity readings from an LTC Levelogger Edge or Junior, to Specific Conductivity (conductivity that is temperature compensated to the standard of 25°C). The Temperature Coefficient default for Specific Conductivity is 2.00. The Temperature Coefficient should not be adjusted, unless you know the value specific to the solution you are measuring. You can also convert Conductivity readings to Salinity expressed in Practical Salinity Units (PSU) (See Section 1.2.4).
- **Rainfall Cal. Constant** allows you to enter a different rainfall calibration constant for a Rainlogger Edge or Rainlogger data file (amount of rainfall per tip of the tipping-bucket rain gauge).

Additional Adjustments:

- **Density Adjustment** corrects the range of the level channel in the Levelogger data file based on a user input adjustment of fluid density. The range of the density adjustment is from 0.9 kg/L to 1.1 kg/L.
- **Barometric Efficiency** adjustment is used to proportionally adjust Barologger data in relation to a particular Levelogger. Barometric efficiency is often expressed as a percentage or proportion. The input field is proportional and has a default value of 1.00. For more information about Barometric Efficiency, see Section 10.1.3.1. The barometric efficiency can be set from 0.01 to 3.00.

8.1.1 Basic Compensation

When you choose **Basic** compensation, the next step is to select the Barologger file you want to use for compensation, then select the Levelogger file(s) you want to compensate. You can only select one Barologger file to compensate multiple Levelogger files.

For best accuracy, the Levelogger file(s) and Barologger file should have the same start time and logging interval. (The Future Start option in the Datalogger Settings tab is a convenient way to start all of your loggers at the same time.) If there is an inconsistency of the time stamp between the Barometric file and the Levelogger file(s), a linear approximation on the barometric data will be performed.

Figure 8-2 Selecting Files for Barometric Compensation

Any files you have open in the Data Control tab will be listed.

Use the directory on the left of the window or click [icon] to open any other Levelogger data files you would like to compensate. Ensure the files you want to compensate are highlighted in the list. **Both the Barologger file and Levelogger file(s) must be highlighted.** Do this by clicking the file name. To de-select a file, click it again. Multiple Levelogger files can be selected at once.

Select Next to complete the compensation.

The compensated data will automatically be saved in a new *.xle file. The default file name will be the <original Levelogger file name> with the word <compensated> added to the file name prefix. Alternatively, the user can rename the compensated file by saving it in the Data Control tab. Do not change or delete the file extension. All data files are saved to the default location: <C:\Program Files\Solinst\Levelogger4_3\Data>.

The next window will show the results of the compensation. If the compensation was unsuccessful, there will be an explanation in the Reason column (e.g. time stamp of Levelogger and Barologger files were not close enough to perform an accurate compensation). You can still view the compensated file in the Data Control tab by clicking 'Open' in the Action column. If the compensation is successful, select 'Open' to view the compensated file in the Data Control tab.

Figure 8-3 Barometric Compensation Results

From the Data Control tab, you can view the data, save the compensated file with a new filename and/or export the data (see Section 7).

All the original Levelogger settings and the channel information effective during data collection are shown on the top left of the window. The bottom left sections of the window are used to display the compensation information. The middle section displays information from the Barologger.
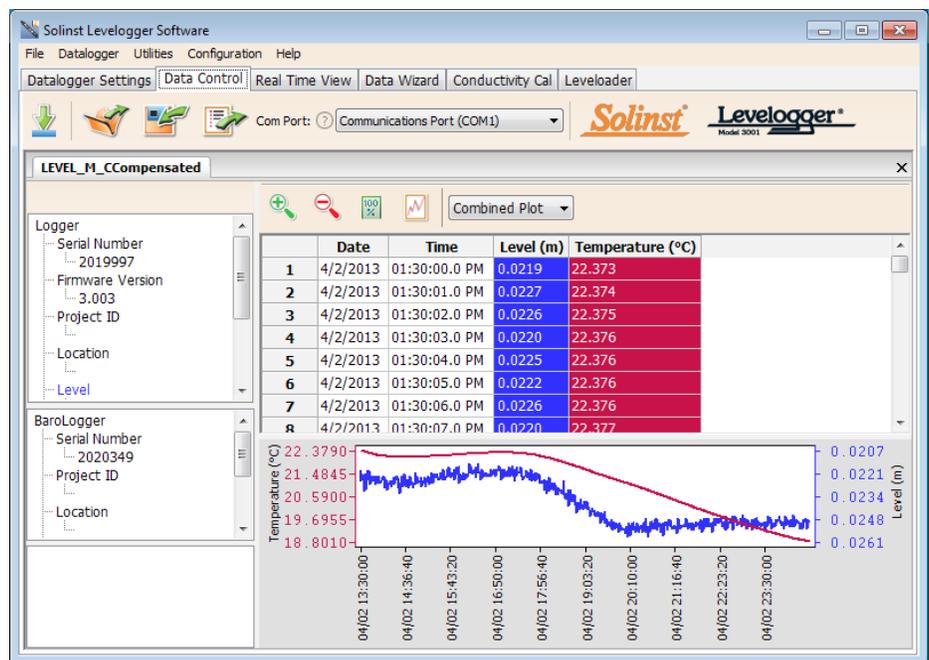

Figure 8-4 Viewing Compensated Files in the Data Control Tab

8.1.2 Advanced Compensation

When you select **Advanced** compensation, the Data Compensation Options window will open.
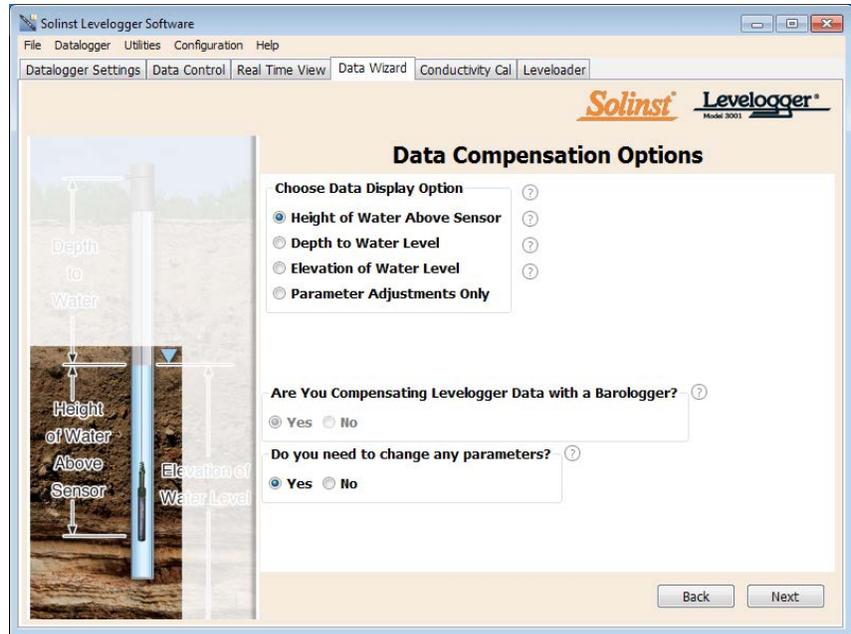
Figure 8-5 Advanced Data Compensation Options

First, you will select how you want your data displayed (Manual Data Adjustment):

- **Height of Water Above Sensor** is the default display option. Select this option to perform a Barometric Compensation and/or Parameter Adjustments to one or more data files, while keeping the sensor diaphragm (zero point) as the reference point.

- **Depth to Water Level** adjusts water level data to represent depth to water level readings (from the top of a well casing or other reference point) by entering a field zero, such as a manual depth to water level measurement. Adjustments can be made to one or more data files.

- **Elevation of Water Level** adjusts water level data to represent elevation of water level readings (above sea level or other reference point) by entering a measuring point elevation, and a field zero, such as a staff gauge measurement from that point. Adjustments can be made to one or more data files.

- **Parameter Adjustments Only** allows you to adjust one or more data files to different units, elevation, etc., while keeping the sensor diaphragm (zero point) as the reference point for Leveloggers. It also allows you to change Rainlogger data file parameters.

> **! NOTE**
>
> Parameter Adjustments Only, is the only option for compensating Rainlogger data.

Next, you will select Yes or No to **Barometrically Compensating** the data (will not be active if you selected Parameter Adjustments Only).

Next, you will select Yes or No to performing any **Parameter Adjustments** on the data files (will not be active if you selected Parameter Adjustments Only).

Click Next, after you have selected all of your Data Compensation options.

In the next window, you will choose the Levelogger file(s), Rainlogger file(s), and Barologger file(s) you would like to use in the compensation. Any files you have open in the Data Control tab will be listed.

Use the directory on the left of the window or click [icon] to open any other data files you would like to compensate. Ensure the files you want to compensate are highlighted in the list. **If doing a Barometric Compensation, ensure the Barologger file is highlighted.** Do this by clicking the file name. To de-select a file, click again. Select Next to continue.
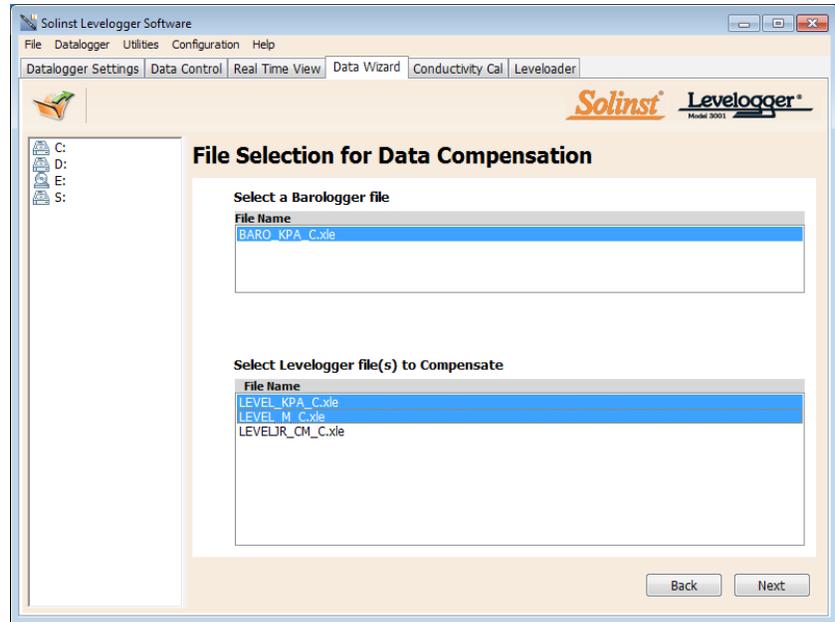
Figure 8-6 Selecting Files for Compensation

If you have selected yes to **Parameter Adjustments**, or selected the **Parameter Adjustments Only** option, in the next window you will enter these. You can expand the window by clicking ">>" to show additional adjustment options. If you did not select to change any parameters, this window will not be shown.
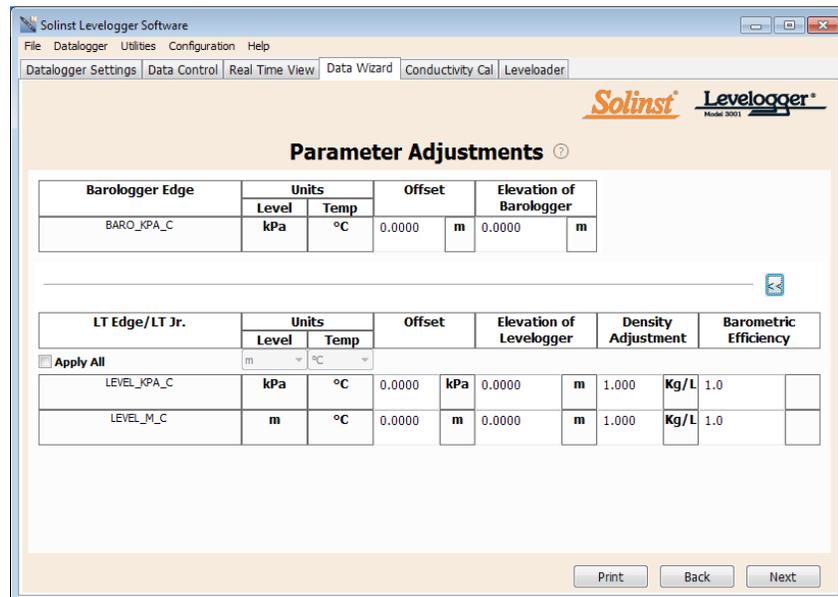
Figure 8-7 Parameter Adjustments

Next, for each selected Levelogger file, you will enter the Field Zero(s) you would like to use to manually adjust your Levelogger data. (If you have selected **Height of Water Above the Sensor or Parameter Adjustments Only**, this window will not be shown.)

For **Depth to Water Level** adjustments, enter a **Field Zero (A)**. If the static water level is below your Field Zero measurement, the Field Zero is input as a positive value (e.g. a manual water level meter measurement taken from the top of a well casing. See Example 8.1). If the static water level is above your Field Zero, the Field Zero is input as a negative value (such as in an artesian condition).

The Time the Field Zero measurement was taken must replace an actual reading in the Levelogger file. This is selected from the drop-down menu showing all time stamps in the Levelogger file. Click 'Add' to apply the adjustment. If you need to change a Field Zero, click 'Update' after any edits.
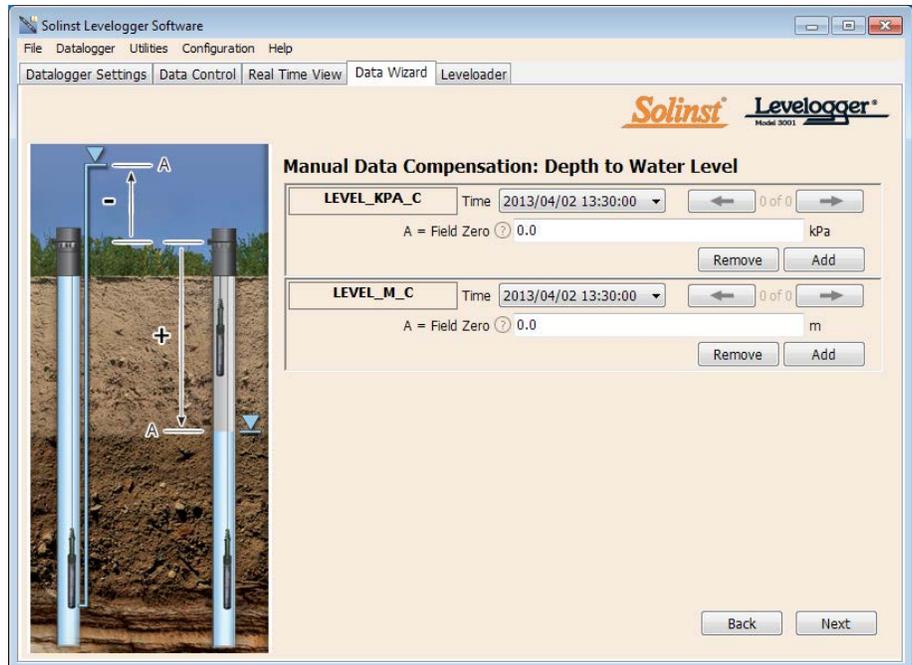
Figure 8-8 Manual Data Adjustment - Depth to Water Level
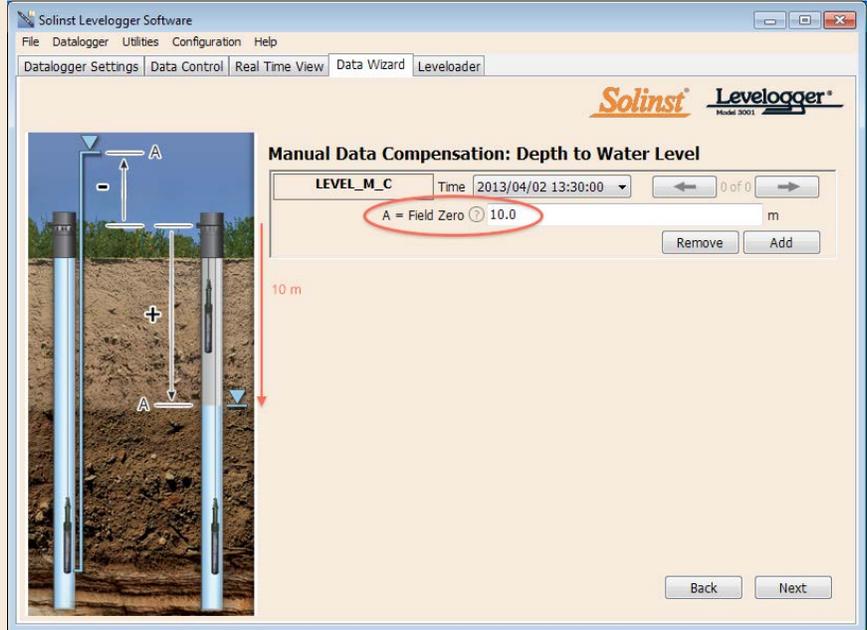
Example 8.1 Depth to Water Level Adjustment

When using a manual depth to water measurement taken from the top of a well casing as a Field Zero, enter it as a positive value (e.g. 10 m).

In your adjusted data file, your readings will increase in value as the water level decreases. This is because the depth to static water level from the top of the well casing is increasing. The adjusted readings will decrease in value as the static water level rises.

Original Levelogger Data (barometrically compensated height of water above sensor)	8.75 m	8.50 m	8.75 m	9.0 m	9.25 m
Adjusted Levelogger Data (depth to water)	(A) 10.0 m	10.25 m	10.0 m	9.75 m	9.50 m

For **Elevation of Water Level** adjustments, enter a **Measuring Point Elevation (A)** and a **Field Zero (B)** from that Measuring Point.

If the static water level is below your Measuring Point, the Field Zero is input as a positive value (e.g. if you are using a manual depth to water measurement as a Field Zero, from the top of a well casing as the Measuring Point).

If the static water level is above your Measuring Point, the Field Zero is input as a negative value (such as an artesian condition). The Measuring Point elevation may also be entered as a negative value.
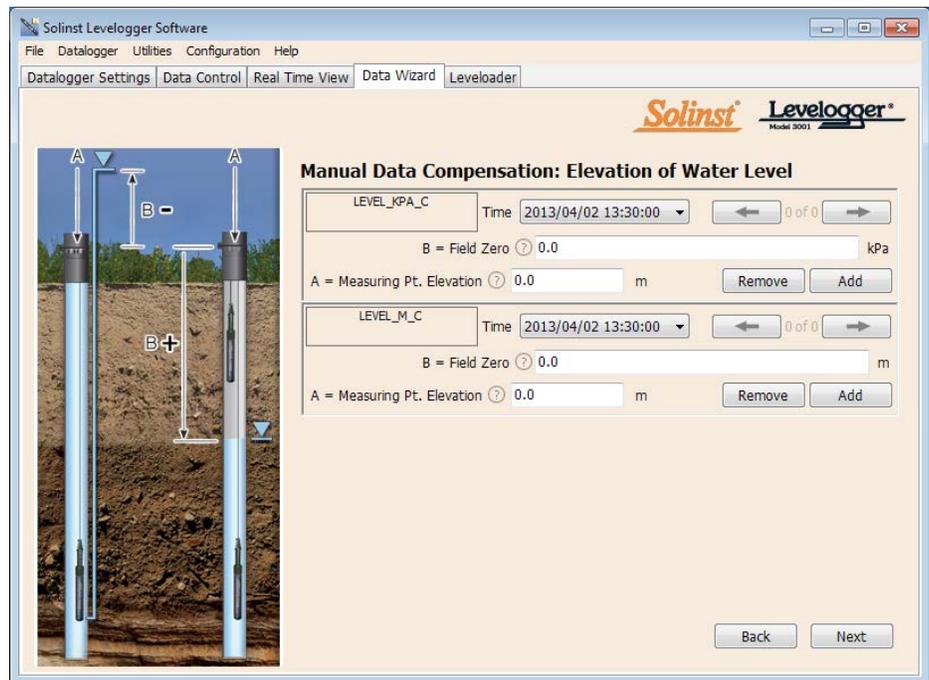
Figure 8-9 Manual Data Adjustment - Elevation of Water Level

The Time the Field Zero measurement was taken, must replace an actual reading in the Levelogger file, and is selected from the drop-down menu showing all time stamps in the Levelogger file. Click 'Add' to apply the adjustment. If you need to change a Field Zero, click 'Update' after any edits.

You can make multiple adjustments to one data file by selecting 'Add' again to enter another Field Zero. All readings after this Time, will be adjusted to this second measurement. You can add as many adjustments to one Levelogger data file as you would like (as long as it doesn't exceed the total number of readings in that file).

Select Next to complete the compensation.

> **⚠ NOTE**
>
> The date and time of measurement of the Field Zero must be recorded to complete the adjustment. The Field Zero must replace an actual reading the Levelogger file. I.e. take a manual measurement immediately after starting the Levelogger, and note that time.

The compensated data will automatically be saved in a new *.xle file. The default file name will be the <original Levelogger file name> with the word <compensated> added to the file name prefix. Alternatively, the user can rename the compensated file by saving it in the Data Control tab. Do not change or delete the file extension. All data files are saved to the default location: <C:\Program Files\Solinst\Levelogger4_3\Data>.

The next window will show the results of the compensation. If the compensation was unsuccessful, there will be an explanation in the Reason column (e.g. time stamp of Levelogger and Barologger files were not close enough to perform an accurate compensation). You can still view the compensated file in the Data Control tab, by clicking 'Open' in the Action column. If the compensation is successful, select 'Open', to view the compensated data file in the Data Control tab.
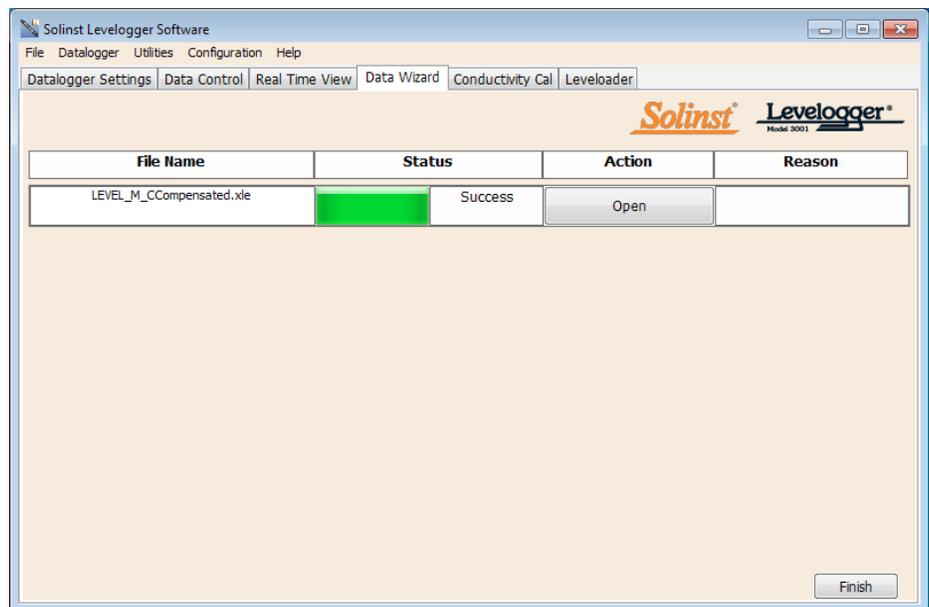
Figure 8-10 Advanced Data Compensation Results

From the Data Control tab, you can view the data, save the compensated file with a new filename and/or export the data (see Section 7).

All the original Levelogger settings and the channel information effective during data collection are shown on the top left of the window. The bottom left sections of the window are used to display the compensation information. The middle section displays information from the Barologger, and the bottom section includes information about manual data and parameter adjustments.
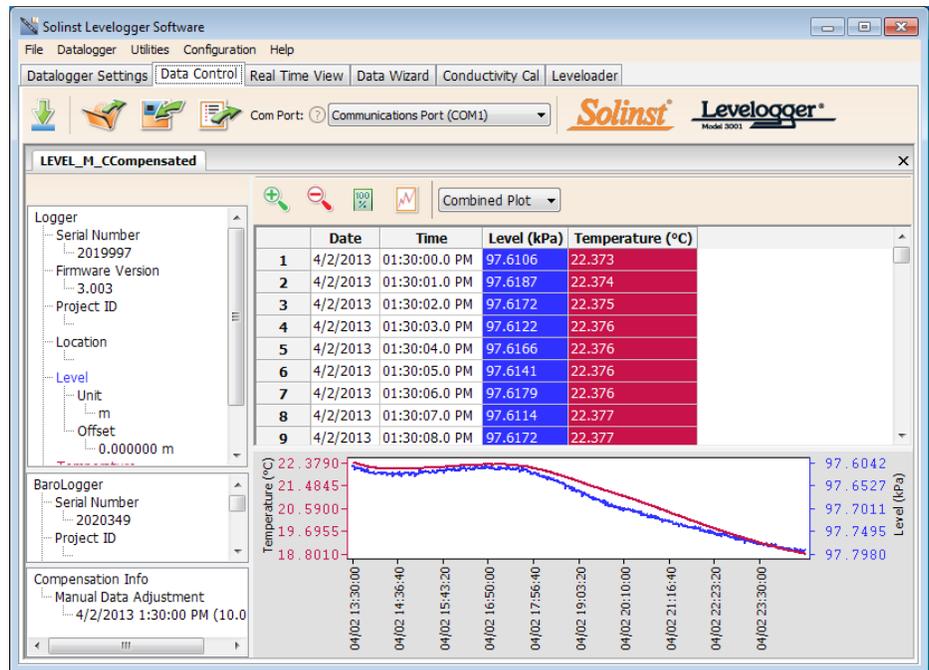
Figure 8-11 Viewing Compensated Files in the Data Control Tab

NOTE

When analyzing barometric data it is important to keep in mind that storm events commonly reduce total atmospheric pressure by about 1.7% from pre-existing high pressure conditions. 1.7% converts to approximately 0.6 ft or 0.2 m of water level equivalent barometric fluctuation.

NOTE

For Manual Barometric Compensation instructions for the Levelogger Gold and Levelogger Junior, visit: www.solinst.com and see the Levelogger Software Version 3.4.1 User Guide in the Downloads Section.
Or view " Automatic or Manual Barometric Compensation of Your Levelogger Data" in the Technical Bulletin Section at:
http://www.solinst.com/Prod/3001/Datalogger-Technical-Bulletins.html

NOTE

You can also convert the Levelogger Edge data units to match the Barometric units using the Data Wizard.

NOTE

It is important to remember that weather station barometric data will often contain an offset or normalization (i.e. normalization to sea level). Manual data conversation and barometric compensation should account for any variation of the normalization or offset used between the barometric data sourced and Solinst Leveloggers.

8.2 Manual Barometric Compensation

This section describes how to perform manual barometric compensation on Levelogger Edge, Levelogger Junior Edge, and LTC Levelogger Edge data files when a Barologger was not dedicated as a barometric recorder.

For short term tests during which the barometric pressure varies insignificantly, the collection of continuous barometric data may be unnecessary. In this event, take a reading from an open air exposed Levelogger prior to running the short term test and record this level. This level represents the barometric pressure. Similarly, at the end of your test, take another barometric reading and record this measurement. After the submerged Levelogger data has been exported to a spreadsheet program, compensate your submerged Levelogger data files for barometric pressure. If no appreciable change in barometric reading occurred, you may write in the first cell of a new column, a simple calculation that subtracts your barometric reading from the submerged data file, then copy and paste this calculation to all the cells in that new column. The new column will represent the barometrically compensated liquid level.

Barometric data can be collected on site using a recording barometer or from a local weather station. To accomplish an accurate manual barometric compensation, the atmospheric pressure station should not be greater than 20 miles (30 km) away and within an elevation change of 1000 ft (300 m). In addition, the date and time of the barometric data should cover the range of data collected by the Levelogger. If setting up the barometer, set the recording interval to that of the Levelogger sampling interval or some multiple of the Levelogger interval. To compensate submerged Levelogger data using barometric data collected from an on site barometric datalogger or a nearby weather station, these steps must be taken:

1) Export both the Levelogger data file and the barometric file to a spreadsheet.

2) In the spreadsheet, ensure both files are using the same units. If your Levelogger data was recorded in m, cm, or ft, convert the barometric data column from its barometric measurement units (typically atm, mm Hg, psi, mbar or kPa) to feet or meters of water column equivalent using the conversion factors in Table 8-1. (There is also the option to initially set up your Levelogger to record in psi, kPa, or bar. This makes compensation using other atmospheric pressure devices easier.)

Table 8-1		
Common barometric units to water column equivalent conversions		
Barometric unit	**Water column equivalent (ft)**	**Water column equivalent (m)**
1 psi	2.307	0.703
1 kPa	0.335	0.102
1 mbar	0.033	0.0102

Table 8-1 Common Barometric Units to Water column Equivalent Conversions

3) Once the units for each column are the same, subtract the barometric column from the Levelogger data to get the true net water level recorded by the Levelogger Edge.

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9 Real Time View

Click the Real Time View tab from the main software window (Figure 9-1). The purpose of this tab is to provide on-screen measurement as data is being recorded by the connected datalogger. The data is displayed in tabular and graphical format. All the channel information and Levelogger settings are displayed on the left of the window.

First, select a non-logged view rate `seconds ▾ 1 ▴▾` . This rate can be set independently of the logging period of the Levelogger and does not interfere with any logging taking place in the Levelogger itself.

Checking, **Enable Manual Data Adjustment**, allows you to enter a datum/ field zero (e.g. depth to water level) to which the change in Real Time View level measurements are then adjusted against. This is only available when you are taking readings in m, cm, or ft.

Real Time View readings can be displayed as a graph or in tabular format. The same graphing options as the Data Control tab are available for Real Time View readings. Real Time View readings are being recorded within the Levelogger Software and prior to closing the window, they can be saved by exporting the data into a *.csv file, by choosing the file export option 📇 .

To start the current readings, click ▶ . Immediately the readings will be displayed.

To take a reading at any specific time, click the ✓ button and that reading will be added to the displayed data. To turn the Real Time View monitoring off, decide if you want to save the data as described above, and simply click ⊗ .
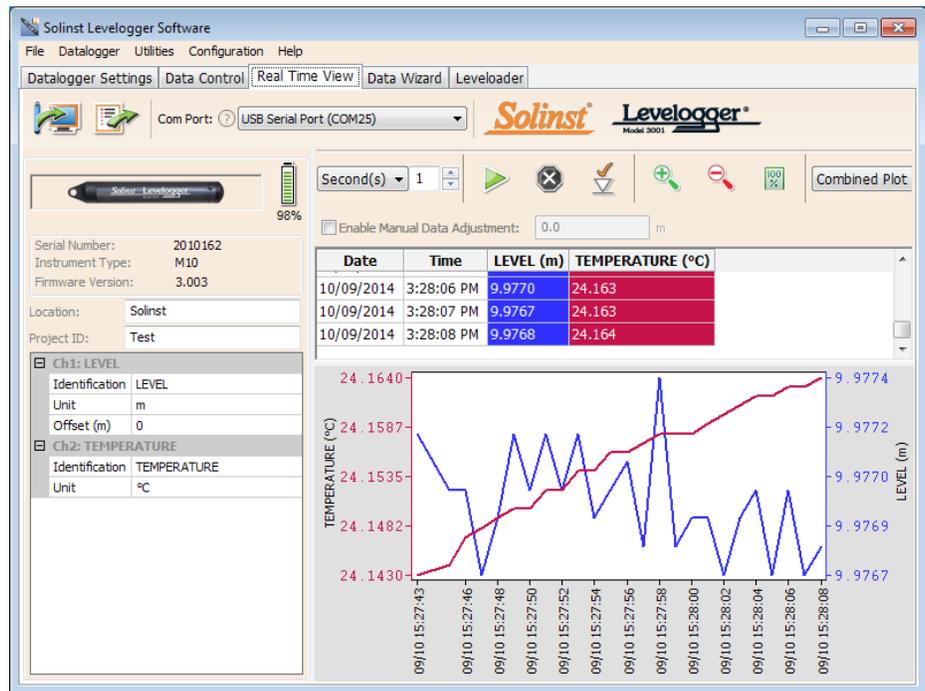
Figure 9-1 Real Time View Window

10 Installation and Maintenance of Leveloggers

10.1 Installation

Many options exist for installation of the Levelogger, but essentially these installation methods can be classified into two broad categories: free suspended or fixed installations.

1) In free suspended installations, the Levelogger is hung via suspension wire or Direct Read Cable from a well cap, or some fixed tie-off location, at the well head.

2) In fixed installations the Levelogger is fixed in place by a compression fitting, a clamping mechanism or simple metal straps.

It is recommended that the Levelogger be installed in a vertical orientation. However, inclined or horizontal installation is acceptable. The level sensor in the Levelogger is indicated by the machined line about the body of the logger just above the pressure access holes. The pressure transducer is oriented in a plane normal to the long axis of the body and detects pressure directed along the plane of the long axis (Figure 10-1). In vertical orientations, the sensor detects pressure above the pressure transducer line, where as in non-vertical orientations, the pressure zero point is proportional to the angle of inclination.

Care should be taken to avoid dropping the Levelogger against a hard surface. Leveloggers should always be installed with the installation cap on (if not using a Direct Read Cable), whether it is being suspended by it or not. This prevents unnecessary battery drainage and protects the optical eyes.

Make sure you properly estimate the maximum and minimum expected water levels during the monitoring period. You need to install your Levelogger so it remains submerged at all times, and ensure that its maximum submergence depth throughout the monitoring period remains within its specified range. The pressure transducer can be damaged if the datalogger is over-pressurized by submergence greater than its level range. The Levelogger Edge, Levelogger Junior Edge, and LTC Levelogger Edge are warranted to pressures up to 200% of their full scale level range (150% for the Levelogger Gold, Levelogger Junior and LTC Levelogger Junior Models), however accuracy can not be guaranteed beyond its full scale.

Other important considerations when installing the Levelogger in pressurized or intermittently pressurized locations such as pressure vessels, pressurized pipes, pulse flow conditions, drop structures or near hydraulics works, is to keep in mind the potential effect of water or steam hammer and hydraulic jump. Water hammer is caused by an abrupt alteration of flow direction resulting in pressure surges. Steam hammer occurs when steam enters a cold pipe partially filled with water. The hammer effect has the potential to significantly increase hydraulic pressure possibly exposing the pressure sensor to pressures beyond its maximum rating. Hydraulic jump is a phenomenon that occurs when water is 'lifted' or 'ramped' by velocity or flow obstructions. Hydraulic jump causes turbulence and creates non-representative head conditions in the water column. Care should be taken to avoid logger installation at points susceptible to hydraulic jump.

Levelogger Edge/
LTC Levelogger Edge
Measurement Line

Levelogger Junior Edge
/LTC Levelogger Junior
Measurement Line

Levelogger Gold
Measurement Line
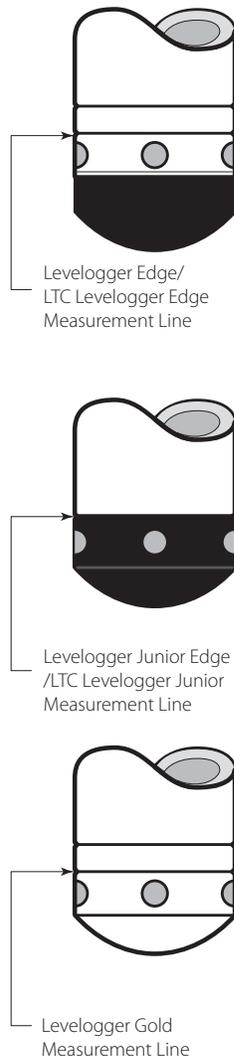
Figure 10-1

Figure 10-2
Solinst 2" Locking Well Cap
for Wireline or Kevlar Cord

Coil 1
Coil 3
Coil 2

Diagram 1

Coil 1
Coil 3
Wireline
Coil 2

Diagram 2

Coil 1
Coil 3
Wireline
Coil 2

Diagram 3

Coil 1
Wireline
Coil 3
Coil 2
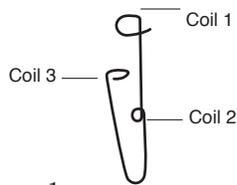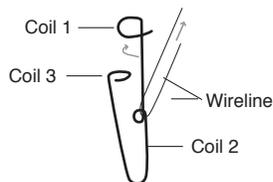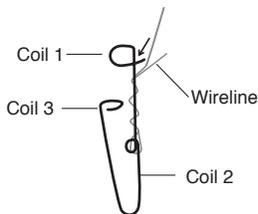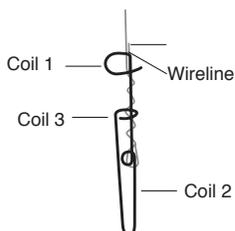
Diagram 4

Figure 10-3 Wireline Hook Installation

10.1.1 Free Suspended Installations

10.1.1.1 Suspension Wire/Cord Installation

When installing on a suspension wire or cord, the Levelogger is pre-programmed and started using the software. It is then deployed with the suspension wire or cord connected to the installation cap of the Levelogger to the underside of a well cap. The data is retrieved manually, by withdrawing the Levelogger, removing the installation cap and attaching an Optical Reader (or Direct Read to Optical Adaptor) directly to the datalogger. Data is downloaded to a desktop or laptop PC, or by using a DataGrabber, Levelogger App & Interface, or Leveloader (see separate instructions). This type of installation is applicable to both submerged and barometric record applications.

Solinst supplies stainless steel suspension wire assemblies including SS stranded wire and hooks available in a variety of lengths from 50 ft (15 m) to 500 ft (150 m), and Kevlar cord assemblies to 500 ft (150 m). Solinst also supplies the Model 3001 2" Well Cap Assembly from which the Levelogger can be suspended. An Adaptor for 4" wells also available (see Section 10.1.1.3).

Follow these steps to install the Levelogger using **stainless steel wire and hooks**:

1) Loop the cable through the coil 2 of the hook assembly, then wind the looped strands several times around the hook shaft and pass through coil 1.

2) Pass coil 3 through the Well Cap eyelet or Levelogger/Barologger eyelet and snap coil 3 to the hook shaft.

3) If the Well Cap is not used then some secure tie-off point should be used or installed.

4) If installing a Barologger, ensure the suspension level is above the highest expected water level.

5) When retrieving data and/or reprogramming the Levelogger, extract it from the monitoring location, un-thread the installation cap, interrogate and re-suspend the unit rechecking the security of the wireline clamps each time.

Figure 10-4 Kevlar Cord
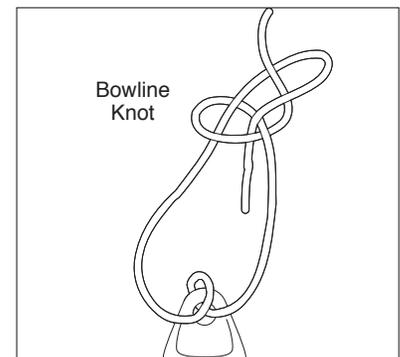
Bowline
Knot

Figure 10-5 Bowline Knot Used to Connect Kevlar Cord to the Levelogger

It is recommended that the **Kevlar cord** be connected to the Levelogger and well cap using a bowline knot (see Figure 10-5). The Kevlar cord is comprised of multiple Kevlar strands braided with black polyester, and has break strength of 150 lbs. Kevlar is very suitable for underwater applications in freshwater and marine environments, as the material resists rusting.

Single Well Cap Option

Dual Well Cap Option

Figure 10-6
Solinst 2" Locking Well Caps for
Direct Read Cable Installation

Figure 10-7
Solinst Direct Read Cable

10.1.1.2 Direct Read Cable Assembly Installation

When installing using a Direct Read Cable Assembly, the Levelogger can be deployed before it is programmed and started with the software. The Levelogger is installed using a Direct Read Cable to a Direct Read Wellhead, where a PC Interface Cable is connected allowing the Levelogger to communicate with a desktop or laptop PC. Alternatively, you can connect a Levelogger App Interface, DataGrabber, or Leveloader for communication (see separate instructions).

The Direct Read Cable system is composed of the ordered length of Direct Read Cable, the Model 3001 Well Cap Assembly (see Section 10.1.1.3) and the PC Interface Cable. The Direct Read cable threads to the Levelogger, while the socket at the opposite end of the Direct Read Cable fits into the specially designed Well Cap insert. The PC Interface Cable connects to the Direct Read socket at surface and to either a USB or RS-232 port on the PC. While use of the Model 3001 Well Cap is recommended and convenient, it is optional as long as a satisfactorily secure alternative tie-off point is found for the Direct Read Cable. Follow these steps to install a Direct Read Cable Assembly to the Levelogger:

1) Remove the installation cap from the Levelogger, align and connect the optical socket (two glass 'eyes' using the alignment pin) of the Direct Read cable to the Levelogger by threading the coupling onto the Levelogger tightly.

2) The Levelogger and optical socket will fit through the hole in the Well Cap insert.

3) Remove the protective cap from the non-optical socket at the wellhead end of the Direct Read Cable, seat the socket in the Well Cap Insert and align and thread it to the round socket of the PC Interface Cable.

4) Connect the USB or RS-232 socket of the PC Interface Cable to the USB or RS-232 Com Port on your PC.

5) The two plugged holes in the Well Cap can be opened to provide an access port for a Barologger, as well as a water level meter probe.

> When removing a Direct Read Cable from a Levelogger, ensure you only twist the coupling. To avoid possible damage, do not twist the strain relief on the Direct Read Cable.

Strain Relief

Coupling

Figure 10-8 Proper way to remove a Direct Read Cable from a Levelogger

10.1.1.3 Model 3001 Well Cap Assembly

The Model 3001 Well Cap Assembly is designed to fit 2" wells, and provides options for installing Leveloggers with wireline, Kevlar cord, or using a Direct Read Cable.

The well cap base provides a tight friction fit onto the well casing. The cap is secured to the base with a twist lock. For further security, a 3/8" (9.5 mm) shackle diameter lock can be used. The Well Cap is vented to allow for the equalization of barometric pressure in the well. Users can choose to permanently secure the PVC Well Cap to the well casing, using three screw points on the inner shoulder of the Well Cap Base.

For wireline or Kevlar cord suspension, simply use the suspension hook on the underside of the insert to secure the Levelogger to the Well Cap (see Section 10.1.1.1). To install using a Direct Read Cable, lower the Levelogger with the Direct Read Cable through one opening in the insert (see Section 10.1.1.2).

Figure 10-9 Model 3001 Well Cap Assembly (#110099).
If installing Leveloggers in a 4" well, a reducer adaptor is available. (#110235)

A Support Hanger Bracket is available for use with the Well Cap Assembly. When installed, it provides an option for supporting and organizing down well cables or cords, or for coiling extra Direct Read Cable if the full length is not required. It is inserted through the top of the well cap base and hangs from the shoulder.

Figure 10-10 Support Hanger Bracket (#112764)

> **NOTE**
>
> The insert has openings to hold two Direct Read Cables in the same well. If only one Direct Read Cable is used, the other hole (0.89" ID) provides access for Solinst Water Level Meters.

> **NOTE**
>
> There are three holes in the top of the Support Hanger Bracket that can be used to secure it in the well cap base with screws.

Figure 10-11
Artesian Well Fitting Assembly

> **⚠ NOTE**
>
> The Artesian Well Fitting Assembly is not recommended for pressures in excess of 30 psi (66 ft (20 m) of water column).

10.1.2 Fixed Installations

10.1.2.1 Flowing Artesian Monitoring

Monitoring of flowing artesian conditions using Leveloggers can be quite straight forward. Continuous artesian conditions infer that the piezometric surface never drops below the level of the ground surface, or particularly the top of casing elevation, and the casing is sealed with a wellhead. In this case, where freezing is not a concern, the Levelogger need only be installed on the wellhead itself by means of an Artesian Well Fitting Assembly, as illustrated in Figure 10-11. This same fitting allows the use of a Direct Read Cable to install the Levelogger at depth in a well, for cases when the piezometric surface falls below top of casing. See separate installation instructions.

When conducting artesian monitoring with Leveloggers, a number of issues should be considered. First, ensure that the maximum hydraulic pressure the datalogger will encounter at its installation point, will not exceed the specified range of the datalogger. Second, artesian conditions do not preclude the necessity for barometric compensation of Levelogger data. Artesian conditions are caused by aquacludes forming confined aquifers. Confined aquifers, while not acted on by barometric pressure to the same extent as unconfined aquifers, are typically subject to barometric pressure at some barometric efficiency (See Section 10.1.3.1).   Finally, bear in mind that the total pressure and subsequent water column equivalent depth measured by the Levelogger after barometric compensation may not represent the actual water level within the artesian well. Sealed intermittent artesian wells can be pressurized when artesian, but can also be de-pressurized when non artesian. The Levelogger's reading after barometric compensation represent the height of the piezometric surface.

10.1.2.2 Vacuum Monitoring

Vacuum monitoring is usually conducted by first installing pressure transducers such as the Levelogger in monitoring wells and then shutting-in or sealing those wells to the atmosphere with pressure sealed wellheads. Air is pumped out from an extraction well amongst the cluster or matrix of monitoring wells, theoretically dropping air pressure in the vicinity of the extraction well. For short-term tests in which data is not required during the extraction event, the Leveloggers can be programmed and simply suspended from hooks or eyelets on the underside of the sealed wellheads, the test run and the data collected at the end of the test by extraction and downloading of the loggers. However, if ongoing data from the Leveloggers is required during the extraction event, the loggers must be installed in a manner similar to the artesian monitoring scenarios described previously in this section. Leveloggers or Barologgers can be used to monitor the drop in pressure.

Figure 10-12 Levelogger and Barologger in Well

10.1.3 Barologger Installation

The Barologger is a Levelogger with a small range adequate to monitor the fluctuations that occur in barometric pressure. The Barologger's readings are used to barometrically compensate Levelogger readings. As a rule of thumb, a Barologger can be used to compensate all the Leveloggers in a 20 mile (30 km) radius and/or with every 1000 ft. (300 m) change in elevation.

To monitor barometric pressure correctly, the Barologger should never be submerged. In well installations, it is recommended that the Barologger be suspended in one of the monitored wells above the high water point (the well must be vented). For best reading accuracy, the Barologger should be installed in a similar thermal environment to that of the Levelogger. In groundwater wells, the Barologger should be suspended beyond the frost line and deep enough to avoid large temperature fluctuations. In surface water applications, the Barologger is best deployed in a dry well – a well embedded in the bottom of the water body, but sealed at the base from water entry and vented to the atmosphere. If a dry well cannot be installed, the Barologger can be installed on a float in the stilling well. Further information on the Barologger and barometric pressure can be found in Section 8.2.

10.1.3.1 Barometric Efficiency

The influence of barometric pressure on a groundwater surface can follow three scenarios. In confined aquifers with capillary or vadose head space, increased atmospheric pressure can tighten the pore spaces in the overlying soil and produce a capillary effect as the water level rises in response to having nowhere else to go but up. Second, some deeper aquifer systems can be quite barometrically isolated from the relatively small change in level that barometric influences can produce. The third scenario occurs in an unconfined aquifer, with high barometric efficiency, in which a barometric pressure change results in an equivalent or highly proportional drop or rise in groundwater pressure. In essence, depending on the aquifer type and depth, increased barometric pressure can result in either increased, static or decreased water levels. Barometric efficiency, the relationship of a barometric change on groundwater pressure, in confined aquifers generally ranges from 20 to 75%, whereas in unconfined aquifers the efficiency can range from 80 - 100%.

A second important element of Barometric efficiency is time lag – the time differential between a unit change in barometric at the surface to the time of transmission of that change to the aquifer. Calculating general barometric efficiency should not be done on a single barometric event, but rather on a statistically significant number of events. As a result, it may take a month or more of submerged Levelogger and Barologger data to determine barometric efficiency and time lag. As Barometric pressure fluctuates over time in excess of 60 cm water column equivalent pressure and as barometric efficiency can be such an important factor in accurately monitoring groundwater levels, it is vital that barometric compensation of the Levelogger data be performed.

The absolute pressure method used in the Levelogger and Barologger provide the user with the data necessary to determine barometric efficiency and time lag. If a barometric efficiency value has been determined from the Levelogger and Barologger data, that value can be applied to Barologger data in the Data Wizard.

Wells puncturing an aquifer have a negligible to non-existent effect on directly transmitting barometric changes to the larger aquifer. Barometric pressure is transmitted through overlying layers. To obtain the best and most accurate long term water level readings from Leveloggers, the user must first understand how the Levelogger calculates a depth of water above the transducer and second whether barometric efficiency should be considered in barometric compensation.

10.1.4 Rainlogger Installation

Solinst Rainloggers (Figure 10-13) are designed to log the tip times of an external tipping-bucket rain gauge, and output the amount of rainfall per tip.

The Rainlogger Edge housing is made of ABS, while the Rainlogger housing is made of stainless steel. Direct exposure to rainfall should be avoided, and Rainloggers should not be submerged. The Rainlogger Edge ABS housing provides extra electrostatic discharge (ESD) protection.

The rain gauge connected to the Rainlogger is supplied by the customer and is a normally-open style reed-switch type gauge most commonly known as a tipping-bucket rain gauge. The Rainlogger rain gauge connector (Figure 10-14) connects to the 2 m (6.5 ft.) cable supplied with the Rainlogger. The Rainlogger Edge and Rainlogger are supplied with different connector cables, which can not be interchanged. The connector cables have two wires, which are connected to the tipping-bucket by splicing to the tipping-bucket cable. As the tipping-bucket is just an electrical switch, for most models, the wires can be connected to either cable wire. Refer to the manufacturer's operating instructions. Longer, exposed cables should be protected from rodents and vandalism by cable armoring or installation within electrical conduit.

Figure 10-13 Solinst Rainloggers

Rain Gauge
Connector

Figure 10-14
The Tipping-bucket Rain Gauge Connector
of the Rainlogger Edge

⚠ NOTE

The Rainlogger Edge and Rainlogger are supplied with different connector cables, which can not be interchanged.

Figure 10-15 Rainlogger Edge Connected to Tipping-bucket

Stilling well

Non toxic
sealing tape

Thick
balloon

Non corrosive/
non toxic
antifreeze
solution

Figure 10-16
Installation in Freezing Liquid

> **⚠ NOTE**
>
> Although precautions can be taken,
> placing a Levelogger in a situation
> where the water may freeze solid
> can permanently damage the
> sensor.

10.1.5 Installation in Extreme Environments

10.1.5.1 Freezing or High Temperature Conditions

Levelogger installation at submerged depths that may be at risk of freezing during the monitoring session is not recommended without taking adequate precautions to avoid transducer damage. When water freezes it expands approximately 9% by volume. A 9% expansion can equate to extreme pressure as demonstrated in Example 10.1. Therefore, solid freezing has the potential to damage the pressure transducer, which is rated to withstand up to 200% (150% for the Levelogger Gold and Junior Models) of its depth fluctuation range. Pressures beyond this threshold may damage the transducer. As such, care should be taken when choosing the appropriate pressure transducer range for your application.

> **Example 10.1 Solid Freezing Effects**
>
> The pressure exerted by the physical expansion or ice crystallization process on a retaining or enclosing contact surface is related to the temperature gradient over which the process occurs, i.e. the speed at which freezing occurs. For example, liquid freezing at -22°C, can create expansion pressures of 22 kg/cm^2 or 313 psi or the equivalent of 721 ft or 220 m water column depth.

With precautions, the Levelogger can be used in freezing liquid environments. If monitoring shallow water bodies or groundwater zones susceptible to freezing, the easiest way to avoid transducer damage is to lower the transducer to a point in the water column below the frost line or ice formation depth. In water bodies such as shallow streams, wetlands or ponds where freezing may penetrate to the bottom, install the Levelogger in a vented stilling well imbedded into the bottom of the water body beyond the frost line.

In cases where the above noted precautions cannot be taken and the Levelogger must be installed in the freezing zone, it is recommended that the logger be placed inside two elongated silicon, rubber or latex balloons, the balloons can be filled with a non-toxic, non-corrosive anti-freeze solution and sealed (Figure 10-16). Place the balloons in a section of perforated, 1.25" (30 mm) ID pipe and install the logger in the monitored water. The antifreeze solution will protect the Levelogger from ice expansion at the pressure transducer, yet transmit any pressure fluctuations that occur. However, it should be noted that even if these precautions are taken, there is still the risk that placing a Levelogger in a situation where the water may freeze solid can permanently damage the sensor (see Example 10.1).

Please note that a similar installation protection can be used when the Levelogger is monitoring liquids which are incompatible with its wetted materials.

The operating temperature range for Leveloggers is -20° to 80°C (-4° to 180°F). At the opposite end of the thermal scale, exposing the Levelogger to temperatures beyond 80°C may damage the thermistor and otherwise affect the Levelogger.

10.1.5.2 Marine or Brackish Installations

When installing the Levelogger in salt or brackish water or in a liquid having a specific gravity (density) different than fresh water, the density difference is compensated for by inputting the density of the monitored fluid in the Datalogger Settings window for the LTC Levelogger Junior and the Levelogger Gold Series (see Section 5.1). Also, see Section 8 for details in compensating the Levelogger Edge, Levelogger Junior Edge, and LTC Levelogger Edge for fluid density differences.

The Levelogger Edge and LTC Levelogger Edge can be used for monitoring in salt or brackish water. However, long term use of the stainless steel body Levelogger Junior Edge, LTC Levelogger Junior, Levelogger Junior and first generation LTC and LT Leveloggers in salt or brackish water is not recommended, as the salt or other pollutants may cause pitting which can lead to perforation of the Levelogger's casing. To minimize this effect, regularly lift the Levelogger from the liquid; within seconds a thin protective layer will be formed by oxidation. Again, this precaution applies to the Levelogger Junior Edge, LTC Levelogger Junior, Levelogger Junior, and first generation LTC and LT Leveloggers.

If using these dataloggers in a continuous salt/brackish monitoring scenario, the stainless steel body of the datalogger can be protected in a manner similar to the freezing protection method described in Section 10.1.5.1. The Levelogger can be placed in balloons and the balloons filled with non-corrosive/ non-toxic fluid. As pressure changes, the fluid encasing the loggers will transmit the pressure differential to the datalogger's pressure transducer. Care must be taken in the selection of the balloon material or filling fluid such that the balloon material prevents diffusion of salts across the concentration gradient or that the filling fluid is comprised of polymeric molecules too large to diffuse out of the balloon material.

10.1.5.3 Biofouling Conditions

Biofouling is the unwanted buildup of microorganisms, plants, algae, or organisms such as barnacles and muscles on a wetted surface. When a Levelogger is deployed for an extended period of time, especially in a saltwater environment, there is the risk of biofouling. Biofouling on the pressure sensor and conductivity cell can compromise the accuracy of the measurements.

A Solinst Biofoul Screen can be used to protect the Levelogger from biofouling. The copper-coiled Delrin screen naturally reduces biofouling, and lengthens the time a Levelogger can be deployed before maintenance is required. The Biofoul Screen simply slips onto the sensor end of the Levelogger where it is held in place with its compression fitting. It adds about 3/4" (19 mm) to the length of the Levelogger. It allows water to freely enter the conductivity cell, as well as the pressure transducer inlets. It is replaced as required.

1.65"
(42 mm)

4 1/8"
(105 mm)

Figure 10-17 Biofoul Screen Dimensions

Figure 10-18 Solinst Biofoul Screen for the Levelogger

10.2 Levelogger Maintenance

Levelogger maintenance consists of cleaning the outside casing, the circulation holes and the optical infrared eyes. The required frequency of cleaning is dependent on several aspects of the monitored water quality. In freshwater with good to excellent water quality, the Levelogger cleaning requirements will be very minimal; amounting to a seasonal or even annual maintenance inspection.

In most cases cleaning can be accomplished by rinsing the Levelogger and using mild, non-residual, non-abrasive household cleaners using a very soft-plastic, bristled, pipe-cleaner type brush. Do not insert any object through the circulation holes at the sensor end of the Levelogger.

In some cases simple cleaners are insufficient to properly clean the Levelogger. Several commonly occurring water conditions require specific maintenance methods, these include hard water, high suspended solids loading, biological or chemical fouling and salt or brackish water conditions.

Hard water monitoring can result in the precipitation of calcium and magnesium deposits on the pressure transducer as well as other components of the Levelogger. These deposits can be safely dissolved using a diluted solution (typically ≤ 10% strength) of acetic or phosphoric acid. Commercially available products for dissolving hard water scaling are also available and can be used if designed for household use. Some industrial strength hard water scaling removers are much higher strength and are not recommended for cleaning the Levelogger.

High suspended solids load may block the circulation ports or clog the internal pressure cell of the Levelogger. The potential clogging effect of solids deposition can be minimized by placing the Levelogger in zones of flow. To remove solids build up, rinse the Levelogger under a low flow of tap water until particles have been washed away.

Bacteriological or chemical fouling can be an important consideration in many ground and surface water monitoring projects. Sessile bacteria will often utilize installed instrumentation as an attachment substrate. Chemical deposit can be the result of electrical charge differential between the instrumentation of the monitored liquid or the result of biological or algal activity. Both forms of fouling can result in difficult to remove deposits on the Levelogger transducer, the conductivity wires and the Levelogger casing. To remove fouling use a diluted (≤ 10%) solution of sulfuric acid. Persistent material may require soaking for several hours.

Cleaning LTC Levelogger sensor pins is recommended before calibrating the unit prior to starting a project. The pins of the LTC Levelogger sensor are platinum-coated, therefore they should not be roughly cleaned or touched with any metal. They can be cleaned with a soft bristle brush, Q-tip, or cloth. Almost any acid solution can be selected to clean the sensor, provided it is highly diluted (generally less than 10% acid). The "soaking" time should be monitored and kept to a minimum.

! NOTE

It is important to ensure the installation cap or a Direct Read Cable is attached to the Levelogger during storage to prevent unnecessary battery drain and to protect the optical eyes.

! NOTE

To clean the optical infrared eyes on a Levelogger, use a clean, soft cloth or cotton swab to gently wipe away any debris and dry the eyes. Avoid soap or cleaners, as it may leave a residue. Compressed air may also be used to clear away any debris.

! NOTE

The Levelogger installation cap should be left on when you are soaking a Levelogger.

11 Diagnostics Utility

The Levelogger Diagnostics Utility can be used for troubleshooting Leveloggers and obtaining information about that Levelogger that can assist the Solinst Technical Support representative to identify and fix any problems you may encounter with your Levelogger. The Diagnostics Utility can be launched from the Utilities menu at the top of the software. The utility can be used to run a self-test, do a Memory Dump and create and email reports.

11.1 Run Diagnostics

The Run Diagnostics function reads the following information from the Levelogger:

1) Serial Number
2) Model Number
3) Firmware Version
4) Battery Voltage
5) Charge Level
6) Current Level Reading
7) Current Temperature Reading
8) Max/Min Pressure Reading
9) Max/Min Temperature Reading
10) Max/Min Conductivity Reading
11) Total Number of Logs

> **⚠ NOTE**
>
> If an LTC Levelogger fails the Conductivity Sensor Test, this could mean that you have not calibrated your LTC in a while (~1 year). It is recommended that you perform a conductivity calibration, then 'Run Diagnostics' again.

This information can be used to identify firmware, battery and/or temperature/pressure/conductivity sensor problems. This function also performs a series of self-tests on the Levelogger to check for problems with the battery, memory, pressure/temperature/conductivity sensors. If an LTC Levelogger fails the Conductivity Sensor Test, this could mean that you have not calibrated your LTC in a while (~1 year). It is recommended that you perform a conductivity calibration, then 'Run Diagnostics' again. If any of these tests fail then a report should be created and emailed to Solinst Technical Support. To execute this function simply click the 'Run Diagnostics' button.
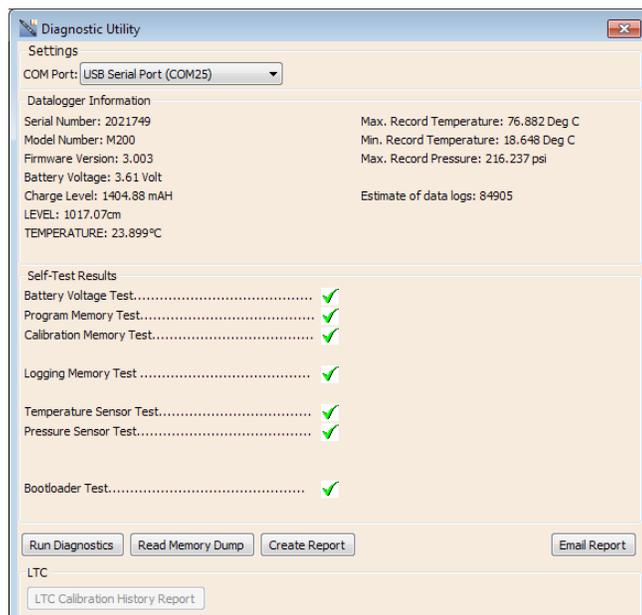
Figure 11-1 Run Diagnostics

11.2 Read Memory Dump

This function creates a complete dump of the Levelogger's memory, which can then be sent to Solinst Technical Support for analyzing.

To execute this function simply click the Read Memory Dump button. Performing a memory dump will create a *.xle file of the data to save.
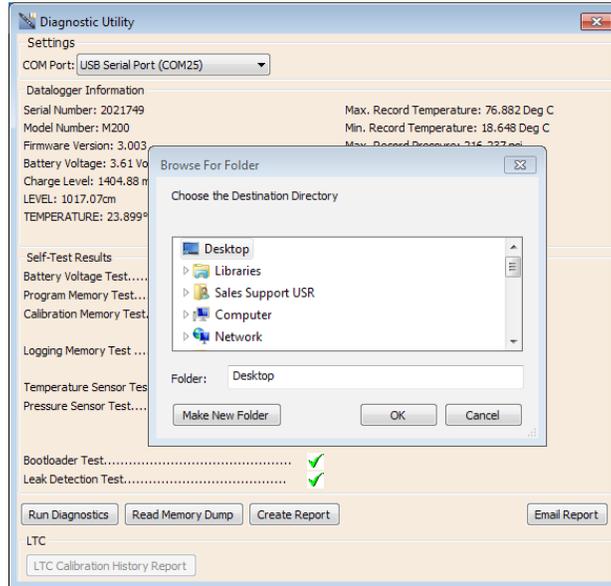
Figure 11-2 Read Memory Dump

11.3 Create Report

This function simply creates a text file containing the information obtained from the Run Diagnostics function. When you click the Create Report button, a window will pop up asking you to fill out your company information. Simply fill this out and the resulting report can be saved or sent to Solinst Technical Support for troubleshooting. If creating a report for an LTC Levelogger, the LTC Calibration History Report will be included.

Figure 11-3 Customer Info Input Window

Figure 11-4 Report Example

11.4 Email Report

Clicking Email Report will guide you through the process of creating a Diagnostics Report, and it will automatically attach the report to an email to send to Solinst Technical Staff for troubleshooting. If you are emailing a report for an LTC Levelogger, the LTC Calibration History Report will be included.

11.5 LTC Calibration History Report

This function creates a report of all previous user calibrations performed on the LTC Levelogger. Use it to send a history report to Solinst for analysis if the LTC Levelogger readings are irregular and/or the unit does not maintain its calibration. To execute this function simply click the LTC Calibration History Report button. This creates a text file that can be sent to Solinst Technical Support.
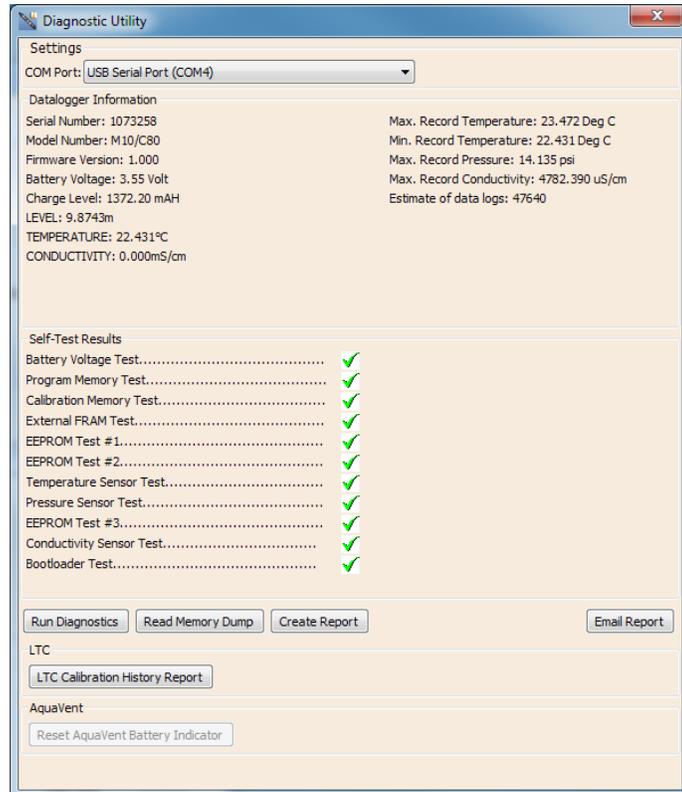
Figure 11-5 LTC Calibration History Report

11.6 Software/Firmware Updates

Each time the Diagnostic Utility is opened, it automatically checks for software updates. If there is an update, "Software Update Available" will appear in the top right of the window. When you click the message, a web page will open, allowing you to download the software update.

The Utility also checks for firmware updates. "Firmware Update Available" will appear in the top right of the window. Clicking the message will open a web page where you can download the firmware update. See Section 12 for firmware update instructions.

12 Firmware Upgrade Utility

The Firmware Upgrade Utility is used to upload new firmware files to a Levelogger. The zipped firmware file can be obtained from: http://www.solinst.com/downloads/

Make sure to unzip the firmware file after you have downloaded it, so you can access the *.ssf file.

To upload new firmware to a Levelogger, follow these steps:

1) Open the Solinst Firmware Upgrade Utility from the Utilities menu in the main Levelogger Software. Pick the Com Port to which the Levelogger is connected and make sure the Baud Rate is set to 9600.

2) Click the 'Open' button ![icon], which should open a file dialog asking for the firmware file (*.ssf) to upload. Navigate to the directory where the firmware file was saved on your PC, then click on the file and click 'Open'.

3) Check the 'Firmware File Information' box to make sure that the opened file is the right one.

4) Click the 'Upload Firmware' button ![icon], to start the firmware upload process.

5) If a communication error occurs and is indicated in the Levelogger Information Window (Figure 12-1) either before the 'Verified Program Checksum' message or after the 'Program Information Section', then restart the upgrade process.

6) If, however, a communication error occurs between the 'Verified Program Checksum' and the 'Program Information Section' messages, then please contact Solinst. You will need to give the Levelogger Serial Number and explain the exact positioning of the error message.
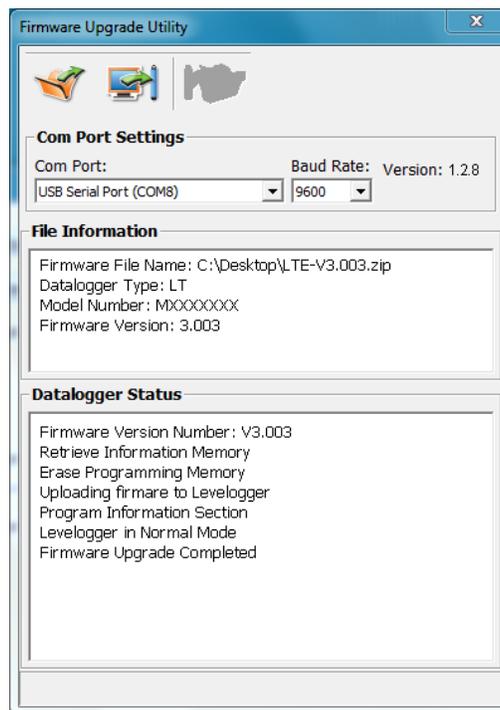
Figure 12-1
Firmware Upgrade Utility Window

13 Trouble Shooting

13.1 Problems During Installation of Levelogger Software

'Class not Registered' or 'DLL not found' or 'Access violation'

1) You may not have Administrator Rights to install the software in the Windows 7/8/10 environment.

 - Ask your System Administrator for assistance.

2) Some files got corrupted during installation of the Levelogger software. Use 'Add/Remove Programs' to uninstall then re-install Levelogger software.

13.2 Error During Software Uninstall Process

The 'Add/Remove Program' cannot locate the Levelogger <setup.exe> file of the software or the link between the software and the 'Add/Remove Program' is damaged.

The record in the Registry Table must be removed:

1) Ask your System Administrator to remove this.

2) Refer to the following link from Microsoft Website for instructions: http://support.microsoft.com/default.aspx?scid=kb;en-us;247501

13.3 Problems During Installation of RS-232 to USB Converter

Unable to install the RS-232/USB converter from Keyspan or IO Gear

> **⚠ NOTE**
>
> Solinst recommends Keyspan or IO Gear. For problems with converters from other manufacturers, please contact the manufacturer.

1) After plugging in the RS-232/USB Converter, a Hardware Installation Wizard will open. Follow the instruction from the Wizard and make sure to select the RS-232/USB Converter Driver from the Keyspan or IO Gear Installation CD.

2) If the Hardware Installation Wizard does not open after plugging in the RS-232/USB Converter, follow the steps below to open the Hardware Installation Wizard:

 a. Select Control Panels

 b. Double click on System

 c. Select the Device Manager Tab

 d. Double click on Other devices

 e. Right click on USB Serial Converter

 f. Select Update Driver...

13.4 Data Has Been Erased Accidentally

If Levelogger has been restarted and old data has not been saved, go to Download Options and choose Data Recovery. It downloads the immediately previous log.

13.5 Error Messages During Use of Software

'Communication Time Out' or 'Communication Error' or
'The Command that is sent to the Levelogger Edge is not defined'

1) Try communicating with another Levelogger, Optical Reader or Direct Read Cable. The communication cable, Optical Reader or Levelogger may be damaged.

2) Clean the optical 'eyes' on the Levelogger and the cable, with a soft cloth.

3) Check that the communication cable is connected to the same Com Port that is chosen in the upper middle of the Main Window of the Levelogger software.

4) Check the Com port settings. They should be as follows:

   - Bits per second: 9600
   - Data bits: 8
   - Parity: None
   - Stop bits: 1
   - Flow control: None
     (This may have been set to Xon/Xoff – change it to None, Select [OK] and back out of this pathway.)

The route to view your Com port settings is as follows:

   a. Select Control Panels
   b. Double click on System
   c. Select the Device Manager Tab
   d. Double click on Ports
   e. Double click on Communications Port(s)
   f. Choose the Port Settings Tab

5) Try using a different computer, to see if this is the cause of the problem.

6) If using a laptop (especially in conjunction with a Direct Read Cable) your Com Port may not be powered adequately to receive/transmit data. Try using a desktop computer to test this, or contact Solinst to obtain a PC Interface Booster Cable.

7) If problem persists, contact Solinst.

'Port Cannot Open'

1) If using a USB device, ensure you plugged it in before starting the Levelogger Software.

2) Ensure the correct Com Port is selected in the upper middle of the Main Window of the Levelogger software.

3) If the correct Com Port is not available, a USB Driver installation or update may be required.

4) Check if some other software is using the same Com Port in the background. Shut that software down or choose another Com Port if available. Such background software may be anti-virus software or PDA software.

5) Make sure your Com Port has been enabled:
   a. Select Control Panel
   b. Double click on System
   c. Select the Device Manager Tab
   d. Double click on Ports
   e. Double click on Communications Port(s)
   f. Choose General
   g. Uncheck 'Disable in this hardware profile box'

6) If you are using a virtual Com Port, like a USB optical reader or USB/RS-232 converter, refer to the 'Problems During Installation of RS-232 to USB Converter' section to make sure they are installed properly.

'File Create Error' and 'File Write Error'

1) If you do not have file-writing privileges to the Levelogger default data folder, change the folder as follows: in the Levelogger software, click 'Configuration' then 'Application Settings'. Under 'Default Directory', enter a new destination folder, to which you have file writing privileges, e.g. 'My Documents'. Follow the same procedure if you have the same problem when you export the data file in csv format.

2) Ask your System Administrator for assistance.

'File Open Error' and 'File Read Error'

1) Shut down or disable any other software that is active and using the same file.

2) In Notepad or Wordpad, open the <*.xle> or <*.lls> file to check for corruptions in the file. How are the Levelogger files ended?

3) If problems persist contact Solinst for assistance.

'Time Span Error, some data cannot be compensated'

1) Find another barometric data file that has the same time stamp as the Levelogger.

2) Perform the compensation (a simple subtraction) in a spreadsheet program for any missing time stamps.

'A different type of Levelogger is detected'

Try clicking the Retrieve Settings icon again, or replace the Levelogger currently in the Optical Reader with the one that was previously being worked on, and complete the operation.

'The selected file is not a barometer'

Select a Barologger for the compensation process.

'Data Corrupted'

Contact Solinst for assistance. Use Levelogger Diagnostic Utility to do a memory dump and sent the dump file to Solinst for further analysis.

'Internal Error'

Contact Solinst for assistance.

'Fail to append data - A different Levelogger has been detected!' or 'Fail to append data - A different start time has been detected!' or 'Fail to append data - New data is not available in the Levelogger!'

The Levelogger software can only append data to a file that has the same serial number and start time as the connected Levelogger. Find the correct file, or use 'All Data' to download the complete file.

'Only Levelogger Gold/Edge supports this function'

The 'Append Data', 'Partial Download' and 'Data Recovery' functions are only supported by the Levelogger Gold/Edge loggers, not previous version Leveloggers.

'Schedule cannot be empty'

When using the 'Schedule' sampling option in a Levelogger Gold/Edge, the schedule must contain at least one item.

'Readings in schedule exceed the maximum'

The number of readings in a schedule should not result in more than 40,000 individual readings.
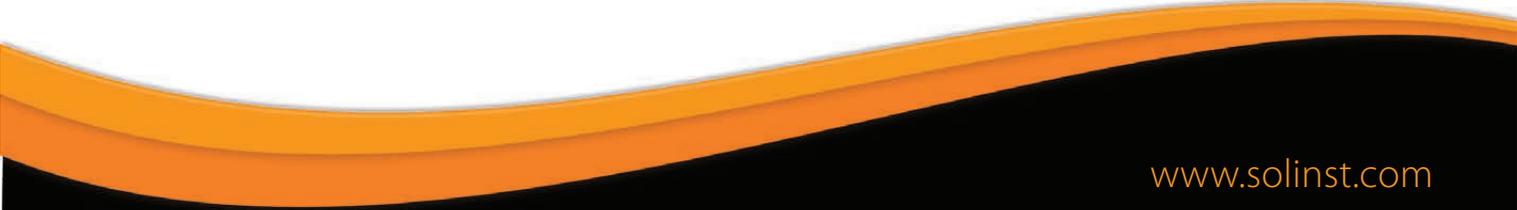
RAE Systems, Inc. Portable ppb VOC Monitor

ppbRAE

Hand-held PID Monitor Capable of Detecting VOCs in the Parts-Per-Billion (ppb) Range

The most sensitive handheld VOC monitor in the world with true parts per billion (ppb) detection of extremely low level, low vapor pressure and highly toxic Volatile Organic Compounds (VOCs) such as nerve agent, pesticide residues and low level permeation breakthrough detection.

Benefits
- New patented planar, dual channel PID detector
- New super bright UV lamp
- Increased sensitivity down to 1 ppb
- Reduced humidity interference
- Improved linearity
- Easily accessible lamp and sensor
- Strong, built-in sample draw pump with pump stall feature
- Prevents liquid flow into the monitor
- Snap-in, field replaceable NMH rechargeable battery 10 hours of continuous monitoring
- Smart battery charging
- Alkaline battery holder supplied
- Automotive charger available
- Large keys operable with 3 layers of gloves
- Large easy to read back light display
- Alarm activated
- LCD backlight is low light or manually activated
- Preset alarm thresholds for STEL, TWA, low and high level peak values
- Audio buzzer and flashing LED display will be activated when the limits are exceeded
- 15,000 point data logging storage capacity for data download to PC
- Rubber protective boot
- 102 built-in correction factors from a RAE list of 250+ chemicals
- User selectable hygiene and survey modes
- Protected from portable radios

Applications:
- Weapons of Mass Destruction – chemical warfare agents, rocket propellants
- Breath sampling
- Personal monitoring of very toxic compounds -TDI, Methyl isocyanate, Vinylcyclohexene, Hydrazines

- **Personal monitoring of low volatile toxic compounds, for example**
- **Heat exchange fluids**
- **Pesticides and pesticide residues**
- **Hypo-allergenic studies in chemical clean rooms**
- **Laboratory fume hood breakthrough**
- **Personal protective equipment (PPE)-Breakthrough, Decision making**
- **Environmental Survey instrument**
- **Leak detection, Residue studies**
- **Drug detection**

Model PGM-7240 Monitor
ppb RAE unit with 10.6 eV PID detector
Nickel metal hydride batteries
Alkaline battery holder
Rubber Boot
Inlet probe and water trap filter
Operation and maintenance manual
Soft carry case
Pro-RAE Suite software (datalogging version)

Model PGM 7240 KIT
Items included with Monitor Plus:
Calibration Gas
Calibration Regulator with flow controller
Porous metal filter & O-ring kit
Gas outlet port and tubing
Tool kit
Hard transport case

Accessories
Automotive charging adapter
9.8 eV lamps
Collapsible remote sampling probe
Vibration alarm

Series 2000
Magnehelic® Differential
Pressure Gage

Indicate Positive, Negative or Differential,
Accurate within 2%

Range - Inches of Water ▼

	Model Number	Description	Price
	2000-00N	Differential pressure gage, range .05-0-.2" w.c., minor divisions .005, calibrated for vertical scale position.	$77.45
	2000-00	Differential pressure gage, range 0-0.25" w.c., minor divisions .005, calibrated for vertical scale position.	$73.00
	2000-0	Differential pressure gage, range 0-0.50" w.c., minor divisions .01, calibrated for vertical scale position.	$63.50
	2001	Differential pressure gage, range 0-1.0" w.c., minor divisions .02.	$63.50
	2002	Differential pressure gage, range 0-2.0" w.c., minor divisions .05.	$63.50

EMISSIVITY

The IR1000 is set to an emissivity of 0.95. This applies to most applications and will provide a reliable accurate measure of the surface temperature.

Shiny bright surfaces (i.e. chrome, new copper, white boards) have a much lower emissivity, and will not read accurately. A common solution to measuring on these types of surfaces is to first apply a small piece of masking tape. The tape has an emissivity much closer to 0.95, and will quickly take on the temperature of the surface to which it is applied.

BATTERY REPLACEMENT

1. **Open** the battery compartment by pulling the compartment lid at the indentations, away from the trigger (see *Thermometer Attributes* section).
2. **Remove** and recycle exhausted batteries.
3. **Replace** 2 x AAA alkaline batteries observing the polarity indicated on the inside markings.
4. **Return** compartment lid and make sure it locks into place.

ACCURACY

Ambient Temperature	Target Temperature	Accuracy
77°F	59~95°F(15~35°C)	±1.8°F(1.0°C)
68~79°F (20~26°C)	32~1000°F (0~538°C)	±2% of reading or 4°F(2°C) whichever is greater
68~79°F (20~26°C)	-58~32°F (-50~0°C)	±(4°F+0.1 degree/degree) ±(2°C+0.05 degree/degree)

WARRANTY

This product is warranted to be free from defects in materials and workmanship for a period of two years from the date of purchase. During this warranty period, Klein Tools has the option to repair or replace or refund the purchase price of any unit which fails to conform to this warranty under normal use and service. This warranty does not cover damage which occurs in shipment or failure which results from alteration, tampering, accident, misuse, abuse, neglect, or improper maintenance. Batteries and damage resulting from failed batteries are not covered by warranty. A purchase receipt or other proof of original purchase date will be required before warranty repairs will be rendered.

Any implied warranties, including but not limited to implied warranties of merchantability and fitness for a particular purpose, are limited to the express warranty. Klein Tools shall not be liable for loss of use of the instrument or other incidental or consequential damages, expenses, or economic loss, or for any claim or claims for such damage, expenses or economic loss.

Some states or countries laws vary, so the above limitations or exclusions may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state. If your Klein product requires repair or for information on how to exercise your rights under the terms of this warranty, please contact Klein Tools at 1-877-775-5346.

CLEANING

Clean the instrument by using a damp cloth. Do not use abrasive cleaners or solvents.

Take care to keep the sensor lens clean at all times. Clean the lens using a soft cloth or cotton swab with water or rubbing alcohol only, and allow the lens to dry before use.

STORAGE

Remove the batteries when instrument is not in use for a prolonged period of time. Do not expose to high temperatures or humidity. After a period of storage in extreme conditions exceeding the limits mentioned in the Specifications section, allow the instrument to return to normal operating conditions before using it.

DISPOSAL / RECYCLE

Caution: This symbol indicates that equipment and its accessories shall be subject to a separate collection and correct disposal.

Instruction Manual

IR1000

ENGLISH

- **-58° TO 1000°F MEASUREMENT RANGE**
- **12:1 SPOT RATIO**
- **LASER TARGETING**
- **MAX/MIN/ AVG/DIFF**
- **BACKLIT DISPLAY**
- **AUTO SHUT OFF**
- **°F / °C BUTTON**

$C\epsilon$

KLEIN TOOLS®

www.kleintools.com

For Professionals...Since 1857®
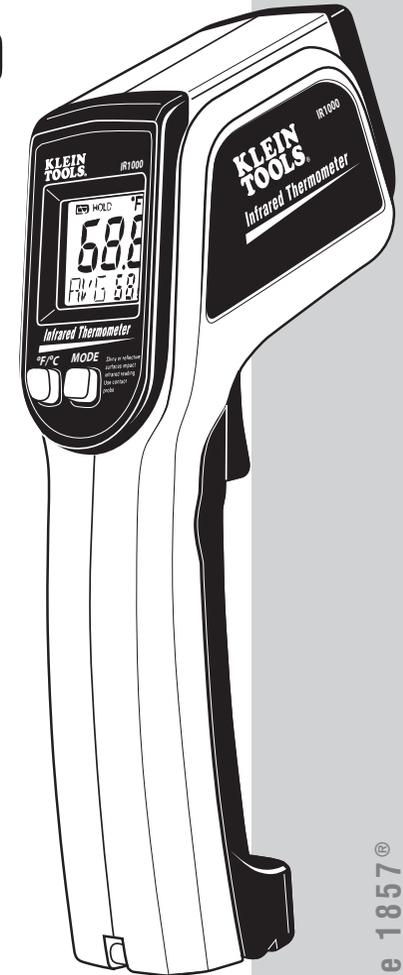
IR1000
Instruction Manual

GENERAL SPECIFICATIONS

The Klein Tools IR1000 is a professional series infrared thermometer. It features a wide measurement range, a tight distance-to-spot ratio, and several calculation modes to assist you in making the best possible measurements.

- **Operating Altitude:** 2000 meters
- **Relative Humidity:** 75% max
- **Operating Temperature:** 32~122°F (0~50°C)
- **Storage Temperature:** -4~140°F (-20~60°C)
- **Accuracy Temperature:** 22.8°C ± 1.7°C (73°F ± 3°F)
- **Emissivity:** 0.95 fixed
- **Optical Resolution (Distance: Spot):** 12:1
- **Dimensions:** 3.25 x 7 x 1.74"
- **Weight:** 3.9 oz.
- **Battery Type:** 2 x AAA alkaline batteries
- **Battery Life:** 14.5 hours
- **Display Resolution:** 0.1°
- **Display Hold:** Auto
- **Calibration:** Accurate for one year
- **Laser:** FDA and IEC Class II
- **Certifications:** CE and RoHS

⚠ WARNINGS

To ensure safe operation and service of the tester, follow these instructions. Failure to observe these warnings can result in severe injury or death.

- Do not direct laser beam into eyes, as this can cause permanent eye damage.
- Do not use instrument if the case is damaged in any way.
- Replace the batteries as soon as low battery indicator appears.
- Have the instrument serviced immediately if it is acting abnormally.
- Be cautious of readings of reflective materials as they may be indicated by the instrument as cooler than they actually are (see *Emissivity* section).
- Avoid using the instrument around strong electromagnetic fields.

SAFE PRACTICES

This instrument is designed for professionals who know the hazards associated with their trade. While this instrument offers no foreseeable dangers beyond its laser sight, the equipment you are servicing, as well as the environment you're working in, can be hazardous. These are a few common safety practices for those working around temperature critical environments:

- Follow the manufacturer's maintenance procedures when servicing equipment.
- Before using this instrument to determine if an area is safe to touch or enter, verify your readings are reasonably accurate by comparison with known measurements.
- Properly maintain your infrared thermometer and calibrate it regularly.

SYMBOLS

☀	Laser	⚠	Warning or Caution
⌧	Follow safe disposal procedures	⚡	Dangerous levels
🔋	Battery		

THERMOMETER ATTRIBUTES
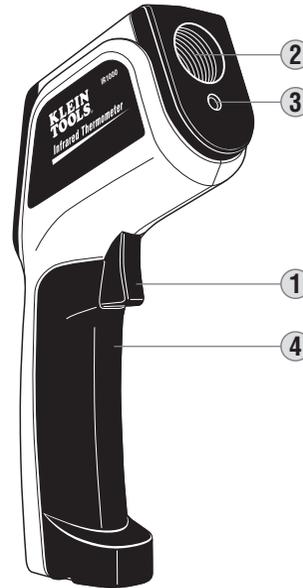
1. **Trigger:**
   Initiates measurement.
2. **IR Sensor:**
   Collects temperature data.
3. **Laser Pointer:**
   Assists in aiming the sensor.
4. **Battery Compartment:**
   Pops forward to store 2 x AAA batteries.
5. **°F /°C Button:**
   Changes the measurement scale.
6. **Mode Button:**
   Changes the calculation mode.
7. **LCD Screen:**
   Displays measurement and additional information.
   - **A.** Most recent measurement.
   - **B.** Low battery indicator.
     - 🔋 Battery OK
     - 🔋 Battery Low
     - ⬜ Battery Exhausted
   - **C.** Calculation display.
   - **D.** Temperature scale (°F/°C)
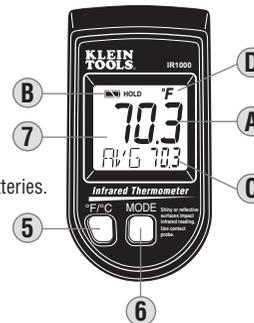
OPERATING INSTRUCTIONS

Temperature Measurement

To take measurements with your IR1000, aim the instrument at the object to be measured and pull the trigger. The unit has an auto off after releasing the trigger of 15 seconds.

Min /Max /Avg /Differential

Press the MODE button to select minimum, maximum, average or differential. Press the trigger and scan the area being measured.

- **Min**: Displays the lowest temperature measured while scanning.
- **Max**: Displays the highest temperature measured while scanning.
- **Avg**: Displays an average of the temperature as you are scanning.
- **Diff**: Displays the difference between the highest and lowest temperatures measured while scanning.

Selecting Temperature Scale

Press the °F/°C button to alternate between Fahrenheit and Celsius. You can select either scale during or after measurement, when viewing any of the held values.

Auto Hold

The IR1000 will hold the last temperature measured for 15 seconds after the trigger is released. To recall this value press the MODE key to activate the display to show the held temperature.

DISTANCE TO SPOT RATIO

The distance-to-spot ratio is a representation of how focused the IR sensor is on the measurement area. The closer you are to the surface you are measuring, the smaller the area of measurement is.

The IR1000 has a 12:1 distance-to-spot ratio. This means that if you are 12 feet away from an air vent, the vent should be 1 foot or less in diameter in order to resolve the most accurate measurement.

Below is an illustration of other example measurements.

Diameter of Spot

Distance to Object
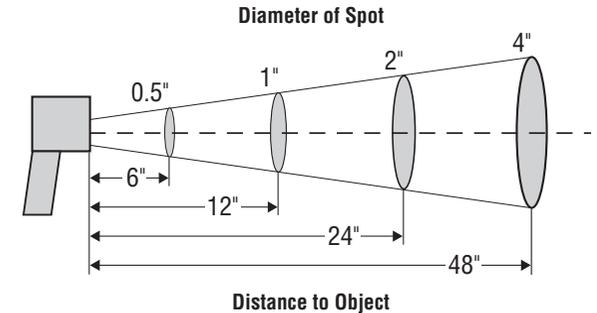
EMISIVIDAD

El IR1000 está ajustado a una emisividad de 0,95. Esto se aplica a la mayoría de aplicaciones y proporcionará una medida precisa y confiable de la temperatura en la superficie.

Las superficies brillantes y resplandecientes (es decir, cromo, cobre nuevo, tablas blancas) tienen una emisividad mucho más baja y no darán lecturas precisas. Una solución común para medir estos tipos de superficies es aplicar primero un pequeño pedazo de cinta de enmascarar. La cinta tiene una emisividad mucho más cercana a 0,95 y alcanzará rápidamente la temperatura de la superficie sobre la que esté aplicada.

REEMPLAZO DE LAS PILAS

1. **Abra** el compartimiento de las pilas jalando la tapa del compartimiento en las indentaciones, alejándola del gatillo (vea la sección "*Atributos del termómetro*").
2. **Retire** y recicle las pilas agotadas.
3. **Reemplácelas** con 2 pilas alcalinas AAA, observando la polaridad indicada en las marcas interiores.
4. **Reponga** la tapa del compartimiento y asegúrese de que quede bloqueada en su sitio.

PRECISIÓN

Temperatura Ambiente	Temperatura del Objetivo	Precisión
77 °F	59~95 °F (15~35 °C)	±1,8 °F (1,0 °C)
68~79 °F (20~26 °C)	32~1000 °F (0~538 °C)	±2% de la lectura ó 4 °F (2 °C), lo que sea mayor
68~79 °F (20~26 °C)	-58~32 °F (-50~0 °C)	±(4 °F + 0,1 grados/grados) ±(2 °C + 0,05 grados/grados)

GARANTÍA

Se garantiza que este producto estará libre de defectos de materiales y fabricación durante un período de dos años a partir de la fecha de compra. Durante este período de garantía, Klein Tools tiene la opción de reparar, reemplazar o reembolsar el precio de compra de cualquier unidad que no cumpla con esta garantía bajo uso y servicio normales. Esta garantía no cubre los daños que ocurran en el envío o las fallas que ocurran debido a alteración, manipulación indebida, accidente, uso incorrecto, abuso, negligencia o mantenimiento inapropiado. Las pilas y los daños que ocurran por causa de pilas que fallen no están cubiertos por esta garantía. Se requerirá un recibo de compra u otro comprobante de la fecha de compra original antes de que se realicen las reparaciones bajo garantía.

Todas las garantías implícitas, incluyendo pero sin estar limitadas a las garantías implícitas de comerciabilidad e idoneidad para un propósito específico, están limitadas a la garantía expresa. Klein Tools no será responsable por la pérdida de uso del instrumento u otros daños incidentales o emergentes, gastos o pérdida económica, ni por cualquier reclamo o reclamos por dichos daños, gastos o pérdida económica.

Las leyes de algunos estados o países varían, por lo que es posible que las limitaciones o exclusiones que anteceden no tengan aplicación en el caso de usted. Esta garantía le confiere a usted derechos legales específicos y es posible que usted tenga también otros derechos que varían de un estado a otro. Si su producto Klein requiere reparación, o para obtener información sobre cómo ejercer sus derechos bajo los términos de esta garantía, sírvase contactar a Klein Tools llamando al 1-877-775-5346.

LIMPIEZA

Limpie el instrumento utilizando un paño húmedo. No utilice limpiadores abrasivos ni solventes.

Tenga cuidado de mantener limpio el lente del sensor en todo momento. Limpie el lente utilizando un paño suave o una bolita de algodón con agua o alcohol desinfectante solamente, y deje que el lente se seque antes de utilizarlo.

ALMACENAMIENTO

Retire las pilas cuando el instrumento no se vaya a usar durante un período prolongado. No lo exponga a altas temperaturas o humedad. Después de un período de almacenamiento en condiciones extremas que excedan los límites mencionados en la sección Especificaciones, deje que el instrumento regrese a las condiciones de funcionamiento normales antes de utilizarlo.

ELIMINACIÓN / RECICLAJE

Precaución: Este símbolo indica que el equipo y sus accesorios estarán sujetos a recogida y desecho correcto por separado.

SERVICIO AL CLIENTE

KLEIN TOOLS, INC.
450 Bond Street
Lincolnshire, IL 60069

1-877-775-5346
www.kleintools.com

Rev. 05/10

139585T

Manual de Instrucciones

IR1000

ESPAÑOL

- **INTERVALO DE MEDICIÓN DE -58° A 1000 °F**

- **RELACIÓN DE PUNTO 12:1**

- **ENFOQUE CON LÁSER**

- **MAX / MIN / PROM (AVG) / DIF**

- **PANTALLA CON LUZ DE FONDO**

- **AUTOAPAGADO**

- **BOTÓN DE °F / °C**

Para Profesionales... Desde 1857®

KLEIN TOOLS.

www.kleintools.com

IR1000
Manual de Instrucciones

ESPECIFICACIONES GENERALES

El IR1000 de Klein Tools es un termómetro infrarrojo de serie profesional. Cuenta con un amplio intervalo de medición, una relación de distancia a punto muy ajustada y varios modos de cálculo para ayudarle a realizar las mejores mediciones posibles.

- **Altitud de funcionamiento:** 2000 metros
- **Humedad relativa:** 75% máx
- **Temperatura de funcionamiento:** 32~122 °F (0~50 °C)
- **Temperatura de almacenamiento:** -4~140 °F (-20~60 °C)
- **Temperatura de precisión:** 22,8 °C ± 1,7 °C (73 °F ± 3 °F)
- **Emisividad:** 0,95 fija
- **Resolución óptica (Distancia: Punto):** 12:1
- **Dimensiones:** 3,25 x 7 x 1,74 pulgadas
- **Peso:** 3,9 onzas
- **Tipo de pilas:** 2 pilas alcalinas AAA
- **Vida útil de las pilas:** 14,5 horas
- **Resolución de la pantalla:** 0,1°
- **Retención de la pantalla:** Automática
- **Calibración:** Precisa durante un año
- **Láser:** FDA e IEC Clase II
- **Certificaciones:** CE e RoHS

⚠ ADVERTENCIAS

Para asegurar un funcionamiento y un servicio seguros del probador, siga estas instrucciones. Si no se hace caso de estas advertencias, el resultado puede ser lesiones graves o la muerte.

- No dirija el rayo láser hacia los ojos, ya que esto puede causar daños oculares permanentes.
- No utilice el instrumento si la carcasa está dañada de alguna manera.
- Reemplace las pilas en cuanto aparezca el indicador de pila baja.
- Haga que le den servicio de mantenimiento al instrumento si se está comportando de manera anormal.
- Tenga cuidado con las lecturas de materiales reflectantes, ya que es posible que el instrumento las indique como más frías de lo que realmente son (vea *Emisividad*).
- Evite utilizar el instrumento cerca de campos electromagnéticos fuertes.

PRÁCTICAS SEGURAS

Este instrumento está diseñado por profesionales que conocen los peligros asociados con su actividad. Aunque este instrumento no ofrece peligros previsibles más allá de su mira láser, el equipo al que usted esté haciendo servicio de mantenimiento, así como el entorno en el que esté trabajando, pueden ser peligrosos. Éstas son unas pocas prácticas de seguridad comunes para las personas que trabajan cerca de entornos de temperatura críticos:

- Siga los procedimientos de mantenimiento del fabricante cuando haga servicio de mantenimiento de equipos.
- Antes de utilizar este instrumento para determinar si es seguro tocar un área o entrar en ella, verifique que sus lecturas son razonablemente precisas en comparación con mediciones conocidas.
- Mantenga apropiadamente su termómetro infrarrojo y calíbrelo regularmente.

SÍMBOLOS

⚠ Láser

☒ Siga los procedimientos de eliminación segura

🔋 Pila

⚠ Advertencia o precaución

⚡ Niveles peligrosos

ATRIBUTOS DEL TERMÓMETRO
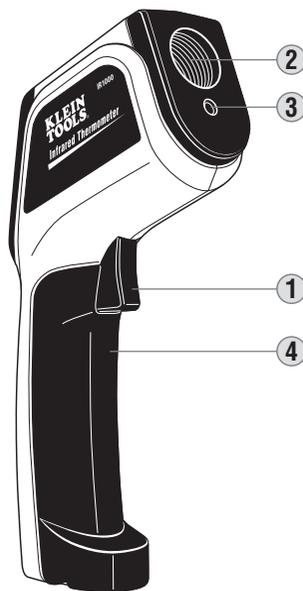
1. **Gatillo:**
   Inicia la medición.

2. **Sensor IR:**
   Recoge datos de temperatura.

3. **Indicador láser:**
   Ayuda a apuntar el sensor.

4. **Compartimiento de las pilas:**
   Salta hacia delante para almacenar 2 pilas AAA.

5. **Botón de °F/°C:**
   Cambia la escala de medición.

6. **Botó de modo:**
   Cambia el modo de cálculo.

7. **Pantalla LCD:**
   Muestra la medición e información adicional.
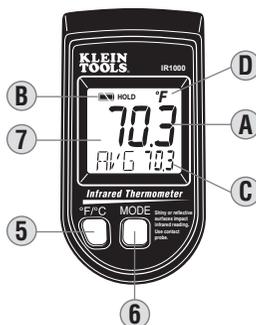
   A. Medición más reciente.

   B. Indicador de pila baja.
      🔋 Pila OK
      🔋 Pila baja
      🔋 Pila agotada

   C. Pantalla de cálculo.

   D. Escala de temperatura (°F/°C)

INSTRUCCIONES DE UTILIZACIÓN

Medición de temperatura

Para tomar medidas con su IR1000, apunte el instrumento hacia el objeto que vaya a medir y jale el gatillo. La unidad tiene una función de apagado automático después de soltar el gatillo de 15 segundos.

Min /Max /Prom(Avg) /Diferencial

Presione el botón de MODO para seleccionar mínimo, máximo, promedio o diferencial. Presione el gatillo y escanee el área que esté midiendo.

- **Min**: Muestra la temperatura más baja medida mientras se está escaneando.
- **Max**: Muestra la temperatura más alta medida mientras se está escaneando.
- **Prom (Avg):** Muestra un promedio de la temperatura mientras usted está escaneando.
- **Dif**: Muestra la diferencia entre las temperaturas más alta y más baja medidas mientras se está escaneando.

Selección de la escala de temperatura

Presione el botón de °F/°C para alternar entre grados Fahrenheit y centígrados.

Puede seleccionar cualquiera de las dos escalas durante o después de la medición, cuando esté viendo cualquiera de los valores retenidos.

Retención automática

El IR1000 retendrá la última temperatura medida durante 15 segundos después de soltar el gatillo. Para recuperar este valor, presione la tecla de MODO para activar la pantalla y mostrar la temperatura retenida.

RELACIÓN DE DISTANCIA A PUNTO

La relación de distancia a punto es una representación de qué tan enfocado está el sensor IR en el área de medición. Cuanto más cerca esté usted de la superficie que esté midiendo, más pequeña será el área de medición.

El IR1000 tiene una relación de distancia a punto de 12:1. Esto significa que si usted está a 12 pies de un respiradero de aire, dicho respiradero debe tener 1 pie o menos de diámetro para resolver la medición más precisa.

A continuación se muestra una ilustración de otras medidas de ejemplo.

Diámetro del punto

Distancia al objeto
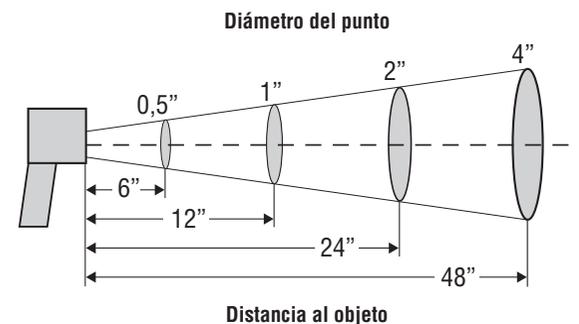
ÉMISSIVITÉ

L'instrument IR1000 est réglé sur une émissivité de 0,95. Ceci s'applique à la plupart des applications et fournira une mesure fiable et précise de la température à la surface.

Les surfaces brillantes et réfléchissantes (p. ex., le chrome, le cuivre nouveau, les panneaux blancs) ont une émissivité beaucoup plus faible et ne permettent pas une lecture précise. Une solution couramment utilisée pour effectuer des mesures sur ces types de surfaces consiste à appliquer d'abord.

REMPLACEMENT DES PILES

1. **Ouvrez** le compartiment des piles en tirant sur le couvercle de ce compartiment au niveau des indentations dans le sens opposé à la gâchette (voir la section *Attributs du thermomètre*).
2. **Retirez** et recyclez les piles complètement déchargées.
3. **Remplacez** 2 piles alcalines AAA en tenant compte de la polarité indiquée par les repères à l'intérieur du compartiment.
4. **Remettez en place** le couvercle du compartiment et assurez-vous qu'il est solidement en place.

PRÉCISION

Température Ambiante	Température de la cible	Précision
77 °F	59~95 °F (15~35 °C)	±1,8 °F (1,0 °C)
68~79 °F (20~26 °C)	32~1000 °F (0~538 °C)	±2 % de la lecture ou 4 °F(2 °C) selon la plus élevée de ces valeurs
68~79 °F (20~26 °C)	-58~32 °F (-50~0°C)	±(4 °F+0,1 degré/degré) ±(2 °C+0,05 degré/degré

GARANTIE

Ce produit est garanti sans défauts de matériau ou de fabrication pendant une période de deux ans à compter de la date de l'achat. Pendant cette période de garantie, à son choix, Klein réparera ou remplacera tout produit qui ne serait pas conforme à cette garantie dans des conditions normales d'utilisation et de service, ou en remboursera le prix d'achat. Cette garantie ne couvre pas les dommages qui surviennent pendant l'expédition ou les défaillances qui résultent d'une altération, d'une falsification, d'un accident, d'une utilisation non conforme ou abusive, de négligence ou d'une maintenance incorrecte. Les piles et les dommages résultant de piles défectueuses ne sont pas couverts par la garantie. Un reçu d'achat ou un autre justificatif indiquant la date de l'achat initial sera exigé avant que des réparations ne soient effectuées dans le cadre de la garantie.

Toutes garanties implicites, y compris, entre autres, les garanties implicites de qualité marchande et d'adéquation à un but particulier, sont limitées à la garantie expresse. Klein Tools n'assumera aucune responsabilité au titre de la perte d'utilisation de l'instrument ou pour d'autres dommages, frais ou pertes économiques secondaires ou accessoires, ou en cas de réclamation ou de réclamations pour de tels dommages, frais ou pertes économiques.

Étant donné que les lois de certains États, de certaines provinces ou de certains pays varient, les limitations ou exclusions ci-dessus ne s'appliquent peut-être pas à vous. Cette garantie vous confère des droits particuliers, et vous pouvez aussi avoir d'autres droits qui varient selon l'État ou la province où vous résidez. Si votre produit Klein nécessite des réparations ou pour connaître la façon de faire valoir vos droits en vertu des termes de la présente garantie, veuillez contacter Klein Tools au 1-877-775-5346.

NETTOYAGE

Nettoyez l'instrument en utilisant un chiffon humide. N'utilisez pas de produits de nettoyage abrasifs ou de solvants.

Prenez soin de toujours garder la lentille du capteur propre. Nettoyez la lentille en utilisant un chiffon doux ou un coton-tige avec de l'eau ou de l'alcool à friction seulement, et laissez la lentille sécher avant de l'utiliser.

RANGEMENT

Retirez les piles lorsque l'instrument ne va pas être utilisé pendant une période prolongée. N'exposez pas à une température ou une humidité élevée. À la suite d'une période de rangement dans des conditions extrêmes dépassant les limites mentionnées dans la section consacrée aux spécifications, laissez l'instrument retourner dans des conditions de mesure normales avant de vous en servir à nouveau.

MISE AU REBUT/RECYCLAGE

Mise en garde: Ce symbole indique que l'équipement et ses accessoires doivent faire l'objet d'une élimination distincte et d'une mise au rebut conforme aux règlements.

SERVICE À LA CLIENTÈLE

KLEIN TOOLS, INC.
450 Bond Street
Lincolnshire, IL 60069

1-877-775-5346
Rev. 05/10   **www.kleintools.com**   139586T

Mode d'Emploi

IR1000

FRANÇAIS

- **PLAGE DE MESURE : DE -58 ° À 1 000 °F**
- **RAPPORT OPTIQUE 12 :1**
- **CIBLAGE LASER**
- **MAX / MIN / MOYENNE / DIFFÉRENCE**
- **RÉTROÉCLAIRAGE**
- **EXTINCTION AUTOMATIQUE**
- **BOUTON °F / °C**

CE

KLEIN TOOLS.

www.kleintools.com

Pour les Professionnels...Depuis 1857®
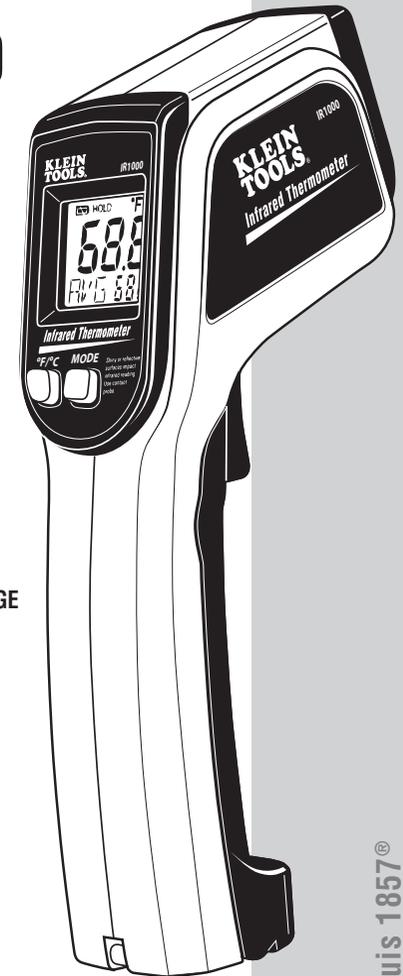
IR1000
Mode d'Emploi

SPÉCIFICATIONS GÉNÉRALES

L'instrument Klein Tools IR 1000 est un thermomètre à infrarouges de la série professionnelle. Il a une plage de mesure étendue, un excellent rapport de distance au point et plusieurs modes de calcul pour vous aider à prendre les meilleures mesures possibles.

- **Altitude de fonctionnement :** 2 000 mètres
- **Humidité relative :** 75 % max.
- **Température de fonctionnement :** 32~122 °F (0~50 °C)
- **Température de stockage :** -4~140 °F (-20~60 °C)
- **Précision de la température :** 22,8 °C ± 1,7 °C (73 °F ± 3 °F)
- **Émissivité :** 0,95, fixe
- **Résolution optique (distance au point) :** 12 :1
- **Dimensions :** 3,25 x 7 x 1,74 po
- **Poids :** 3,9 oz
- **Type de piles :** 2 piles alcalines AAA
- **Durée de vie des piles :** 14,5 heures
- **Résolution à l'affichage :** 0,1°
- **Maintien de l'affichage :** Auto
- **Calibrage:** Précision garantie pendant un an
- **Laser :** FDA et IEC Classe II
- **Certifications:** CE et RoHS

⚠ AVERTISSEMENTS

Pour assurer un fonctionnement sans danger et correct de l'instrument de mesure, suivez ces instructions. Le non-respect de ces avertissements pourrait entraîner des blessures graves ou même la mort.

- Ne dirigez pas le rayon laser directement dans les yeux car ceci pourrait causer une lésion permanente aux yeux.
- Ne vous servez pas de cet instrument si son étui est endommagé de quelque façon que ce soit.
- Remplacez les piles dès que l'indicateur de décharge des piles s'allume.
- Faites inspecter l'instrument immédiatement par un spécialiste si son fonctionnement vous semble anormal.
- Faites particulièrement attention lorsque vous faites des lectures de la température de matériaux réfléchissants car ils risquent d'être indiqués par l'instrument comme étant moins chauds qu'ils ne le sont réellement (voir *Émissivité*).
- Évitez d'utiliser l'instrument à proximité de puissants champs électromagnétiques.

PRATIQUES DE SÉCURITÉ

Cet instrument est conçu à l'intention de professionnels qui connaissent les risques de leur métier. Bien que cet instrument ne présente aucun danger prévisible en dehors du rayon laser, les équipements sur lesquels vous travaillez, ainsi que l'environnement dans lequel vous travaillez, peuvent être dangereux. Voici quelques pratiques de sécurité ordinaires pour les personnes qui travaillent dans des environnements où la température peut présenter des dangers.

- Suivez les procédures de maintenance du fabricant lorsque vous effectuez des opérations d'entretien.
- Avant de vous servir de cet instrument pour déterminer si une surface est à une température adéquate pour la toucher ou si vous pouvez entrer quelque part, assurez-vous que vos lectures sont raisonnablement comparables aux mesures connues par ailleurs.
- Entretenez correctement votre thermomètre infrarouge et calibrez-le à intervalles périodiques.

SYMBOLES

⚠ Laser

☒ Suivez des procédures d'élimination sans danger.

🔋 Piles

⚠ Avertissement ou Mise en garde

⚡ Niveaux dangereux

ATTRIBUTS DU THERMOMÈTRE
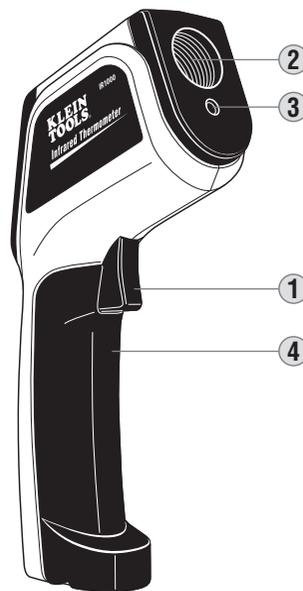
1. **Gâchette :**
   Déclenche la mesure.

2. **Capteur IR :**
   Recueille les données sur la température.

3. **Pointeur laser :**
   Aide à pointer le capteur.

4. **Compartiment des piles :**
   S'ouvre d'un seul coup vers l'avant; rangement de 2 piles AAA.

5. **Bouton °F / °C :**
   Change l'échelle de mesure.

6. **Bouton de mode :**
   Change le mode de calcul.

7. **Écran ACL :**
   Affiche la mesure ainsi que d'autres informations.

   A. Mesure la plus récente.

   B. Indicateur de décharge des piles.
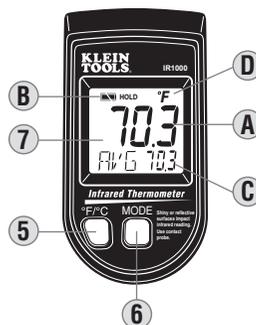
      🔋 Piles OK
      🔋 Piles partiellement déchargées
      ☐ Piles totalement déchargées

   C. Affichage des calculs.

   D. Échelle des températures (°F/°C)

INSTRUCTIONS POUR LE FONCTIONNEMENT

Mesure de la température

Pour faire des mesures avec votre instrument IR1000, pointez l'instrument sur l'objet à mesurer et tirez sur la gâchette. L'instrument est doté d'un mécanisme d'extinction automatique qui se déclenche 15 secondes après que vous ayez tiré sur la gâchette.

Min / Max / Moyenne / Différence

Appuyez sur le bouton MODE pour sélectionner minimum, maximum, moyenne ou différentiel. Appuyez sur la gâchette et balayez la surface à mesurer.

- **Min**: Affiche la mesure de température la plus basse lue pendant le balayage.
- **Max**: Affiche la mesure de température la plus élevée lue pendant le balayage.
- **Avg (Moyenne) :** Affiche une moyenne des températures lues pendant le balayage.
- **Diff :** Affiche la différence entre les températures les plus élevées et les plus basses lues pendant le balayage.

Sélection de l'échelle de température

Appuyez sur le bouton °F/°C pour alterner entre les degrés Fahrenheit et les degrés Celsius. Vous pouvez sélectionner n'importe laquelle de ces échelles pendant ou après la mesure lorsque vous regardez n'importe quelle valeur mise en mémoire.

Maintien automatique de l'affichage

L'instrument IR1000 maintiendra la dernière température mesurée affichée pendant 15 secondes après que vous aurez relâché la gâchette. Pour rappeler cette valeur, appuyez sur la touche MODE afin d'activer l'écran d'affichage pour montre la température ainsi mise en mémoire.

RAPPORT DE DISTANCE AU POINT

Le rapport de distance au point est une représentation de la façon dont le capteur IR est pointé sur la zone à mesurer. Plus vous êtes près de la surface que vous mesurez, plus la surface de mesure est petite.

L'instrument IR1000 a un rapport de distance au point de 12 :1. Cela signifie que si vous êtes à 12 pieds (4 m) d'une grille d'aération, la grille doit avoir un diamètre d'un pied (30 cm) ou moins pour que vous puissiez obtenir la mesure la plus précise.

Voici ci-dessous une illustration d'autres mesures à titre d'exemple.

Diamètre du point

Distance par rapport à l'objet
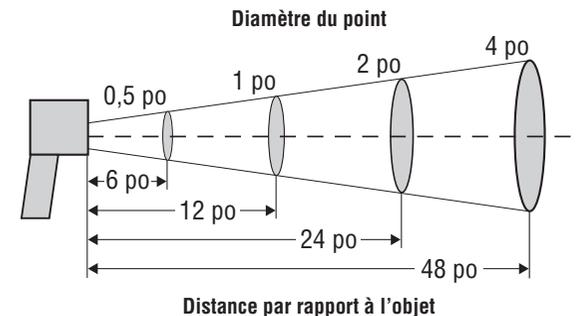
EW-10323-11
TESTOTHERMOANEMOMETER
WITH COMPACT VANE

$640.00 / each (USD)   .

Ergonomic designed meter with compact probe for hard-to-reach areas

 Display's flow and volume (cfm) in English or metric units

 3 1/2 ft telescopic handle

This compact multi-function Anemometer makes airflow measurement easy and effortless. The super compact vane is designed to measure air velocity (flow) and volume flow (cfm). To calculate
volume flow (cfm), just enter the air duct size (either circular diameter or rectangular length and width) and the meter automatically calculates and displays the volume flow. Timed and multi-point mean flow calculations allow easy flow analysis,
volume accumulation estimates. Min/Max values are one-button simple, while the Hold function freezes the current readings in the display for easy data recording. Meter features an auto-off function.

What's Included:

9 V battery and calibration documentation.

Specifications	
Air velocity range	118 to 8000 ft/min (0.6 to 40 m/sec)
Air velocity resolution	0.1 ft/m (0.1 m/sec)
Display	two-Line LCD
Air velocity accuracy	± 40 ft/m +1.5% of reading (±0.2 m/sec ±1.5% m.v.)
Dimensions	2 1/2"W x 7 "H x 1 1/2"D
Power	one 9 V battery (included)

APPENDIX C

FIELD FORMS FOR AS/SVE/SSD MONITORING

Air Sparge Blower, Air Sparge Wells, Extraction Laterals, Extraction Blower, Subslab Depressurization

Technician:						Day/Date:
Weather Condition: (temp, barometer, wind, etc)						
Monitoring Point	**Time**	**Valves** (% Open)	**Flow** (m/s)	**Temp.** (°C/ °F)[b]	**Pressure** (in H$_2$O +/-)[c] (psig)[c]	**Comments**
Air Sparge Blower	Time On:_____			Time Off:_____		
AS Blower Vault						
Air Sparge Wells						
11574-ASW-1						
11574-ASW-2						
Extraction Blower Suction						
11574-SVE-BS-1						
11574-SVE-BS-2						
Extraction Blower Exhaust (11574-SVE-BE-1)	Always 100%			**VOCs by PID** (ppbv/ppmv)[d]		
Sub-slab Probe Pressures	**SSD-S1 (SE)** (in W.C.)	**SSD-S2 (SW)** (in W.C.)	**SSD-N1 (NE)** (in W.C.)	**SSD-N2 (NW)** (in W.C.)	**SSD-3 (inside)** (in W.C.)	
Comments (e.g. Duration of KO drum draining, Valve Position Changes, Samples, etc.						
					Signature:	

Notes:
a: Identify phase of testing, AS and SVE valve positions, etc.;   b: Identify temperature units.
c: Identify negative or positive pressure. (in H$_2$O for SVE blower, psig for sparge blower).   d. Identify units of measurement.

Sealaska Environmental Services

Soil Vapor Migration and Subslab Depressurization Monitoring

Project Phase/ Operating Condition[a]:							
Technician:							
Weather Conditions: (wind, barometer, temp, etc. Data source)							
Monitoring Point[b]	**Date**	**Time**	**Port Pressure** (in H_2O +/-)	**Pressure Differential** (in H_2O)	**VOC by PID** (ppb/ppm)	**Lab Sample** (Summa/Tedlar) **Sample ID**	**Comments**
Parking Lot Soil Vapor Probes							
11574-SVP--1a							
11574-SVP--1b							
11574-SVP--2a							
11574-SVP--3a							
11574-SVP--4a							
11574-SVP--5a							
11574-SVP--5b							
11574-SVP--6a							
11574-SVP--7a							
11574-SVP--7b							
Building Subslab Monitoring Port							
11574-SSD-N1							
11574-SSD-N2							
11574-SSD-S1							
11574-SSD-S2							
11574-SSD-3							

Notes:
a: Identify blower and compressor status, AS and SVE valve positions, etc.
b: Soil Vapor Probe "a" installed at shallow depth. Soil Vapor Probe "b" installed at greater depth. Depths calculated based on calculated cone of expansion of extraction system. Depths decrease with distance from building.

Sealaska Environmental Services

SUMMA CANISTER SAMPLING

Day/Date: _____	

Project Phase and Operating Condition:_AS blower on/off; SVE blower on/off; SVE valve positions (% open): _____

Technician:

Weather Conditions: (wind, barometer, temp, etc. Data source)

Time	Summa Canister Number	Sampling Cane Number	Canister Sampling Location	Initial Canister Vacuum (in Hg)	Final Canister Vacuum (in Hg)	Comments

Sealaska Environmental Services

Site Log-In Sheet
JBLM AOC 9-2, Air Sparge/ Soil Vapor Extraction System
Lewis North, America's Credit Union, JBLM Building 11574

Day & Date	Time	Technician	Purpose of Site Visit/ Observations

Sealaska Environmental Services

SEALASKA ENVIRONMENTAL SERVICES, LLC, (SES)

CONFINED SPACE ENTRY PRE-ENTRY BRIEFING CHECKLIST

Project Name: _____ **Project Location:** _____

Date: _____ **Time:** _____

Completed By: _____

Attendee(s): _____

_____

☐ Hazard Communication (including the signs, symptoms, and modalities of chemical overexposure.

☐ Physical hazards present.

☐ All hazard controls.

☐ Acceptable entry conditions.

☐ Emergency procedures.

☐ Rescue procedures.

☐ Duties of entrants and attendants during routine and emergency operations.

☐ Frequency and Types of Monitoring.

☐ Communications system backup to be used.

☐ Review of work to be accomplished during entry.

☐ Decontamination procedures (if necessary).

☐ PPE disposal

☐ Potential emergencies that may occur outside the confined space.

SEALASKA ENVIRONMENTAL SERVICES, LLC (SES)
CONFINED SPACE ENTRY PERMIT

PERMIT VALID FOR ONE SHIFT ONLY. ALL PERMIT COPIES REMAIN AT SITE UNTIL JOB COMPLETED. A PERMIT IS TO BE POSTED FOR ALL CONFINED SPACE ENTRIES REGARDLESS OF THE TYPE OF SPACE ENTERED. HOWEVER, ONLY SECTIONS OF THE PERMIT APPLICABLE TO THE SPECIFIC TYPE OF CONFINED SPACE (PERMIT vs NON-PERMIT) NEED BE COMPLETED.

DATE:_____ SITE LOCATION/DESCRIPTION:_____

PURPOSE OF ENTRY:_____

SUPERVISOR(S) IN CHARGE OF CREWS/TYPE OF CREW/PHONE #:_____

COMMUNICATION PROCEDURES:_____

RESCUE PROCEDURES AND PHONE NUMBERS:_____

Name of Emergency Service (ES)	Phone# of ES	Date/Time ES contacted	ES Available? Y or N	Date/Time ES Response Made		Comments/Problems with Service
				Before Confined Space	After Confined Space	

REQUIREMENTS COMPLETED	DATE	TIME	REQUIREMENTS COMPLETED	DATE	TIME
Breathing Apparatus			Line(s) Broken-Cappe Blank		
Emergency Escape/Fall Retrieval Equipment			Protective Clothing		
			Purge-Flush and Vent		
Fire Extinguishers			Respiratory Protection		
Full Body Harness w/ "D" Ring			Secure Area (Post and Flag)		
Lifelines			Standby Safety Personnel		
Lighting (Explosive Proof)			Ventilation		

Note: For items that do not apply, enter N/A in the blank. See page 2 to add any special requirements..

RECORD MONITORING RESULTS EVERY 1/4 HOUR

TEST(S) TO BE TAKEN	Permissible Entry Level	Time(s)
PERCENT OF OXYGEN	19.5% to 22.0%	
LOWER FLAMMABLE LIMIT	Under 10 %	

Note: Initial air monitoring is mandatory for all confined spaces.

REMARKS:_____

CONFINED SPACE ENTRY PERMIT

GAS TESTER NAME & CHECK #	INSTRUMENT(S) USED	MODEL &/OR TYPE	SERIAL &/OR UNIT #
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

SUPERVISOR AUTHORIZATION—ALL CONDITIONS SATISFIED:_____   DEPT/PHONE_____

PRINT NAME: SIGNATURE: FUNCTION (i.e., entrant, attendant, or supervisor)

_____

_____

_____

_____

_____

_____

_____

_____

SPECIAL REQUIREMENTS:

_____

_____

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_____

COMMENTS:

_____

_____

_____

_____

_____