PROJECT MEMORANDUM

PROJECT: 191143; Ingersoll-Rand Corporation, 1944 Marina Blvd., San Leandro, CA

SUBJECT: Pilot Test - Enhanced Vacuum Recovery

TASK DATES: September 29 to October 2, 1992

Prepared By: William Schaal WCS, IT Corporation

PURPOSE

Because a pump and treat system appears imminent for the project site, the proposed pilot test was designed to examine the viability and efficiency of groundwater recovery using an enhanced vacuum procedure that eliminates pumps, timers, and downhole level switches. The pilot test also served to examine the potential for increasing water production from the low yield aquifer at the subject property.

METHODS

The selected recovery well was fitted with a specially designed head that provides control over negative pressure developed inside the well with a vacuum. Vacuum was applied to the recovery well through a one inch PVC stinger incorporated in the well head design. The stinger used to administer the vacuum also provided the conduit for water to be brought to the surface by entraining it with air. Vacuum applied to the well was generated by the RSI S.A.V.E.™ System used to treat the recovered groundwater. Vacuum pressure was measured at the well head using a magnehelic™ gauge.

Depth to groundwater at the selected recovery well at the time of the pilot test was 21.5 feet below surface grade. Combinations of drawdown levels and vacuum pressures were used to determine optimal parameters for maximizing groundwater recovery. Drawdown levels within the recovery well ranged from about 2.5 to 8.5 feet below static water level. Vacuum pressures at the well head ranged from 0 to 55 inches of water column.

To overcome lift problems associated with a solid stream or slug of water at system start-up, compressed air was blown down the jump start line incorporated within the stinger.

Water recovery rates were determined by timing the duration required to fill a unit volume container with water effluent discharged from the S.A.V.E.™ System.

To examine the effects of groundwater recovery on the formation, groundwater levels were recorded from observation wells in the vicinity of the recovery well. These wells were placed at the following distances from the recovery well: 5, 12, 20, and 40 feet. Measurements were collected using an electric-tape water level indicator at regularly timed intervals.

Pilot test duration was 72 hours.

RESULTS

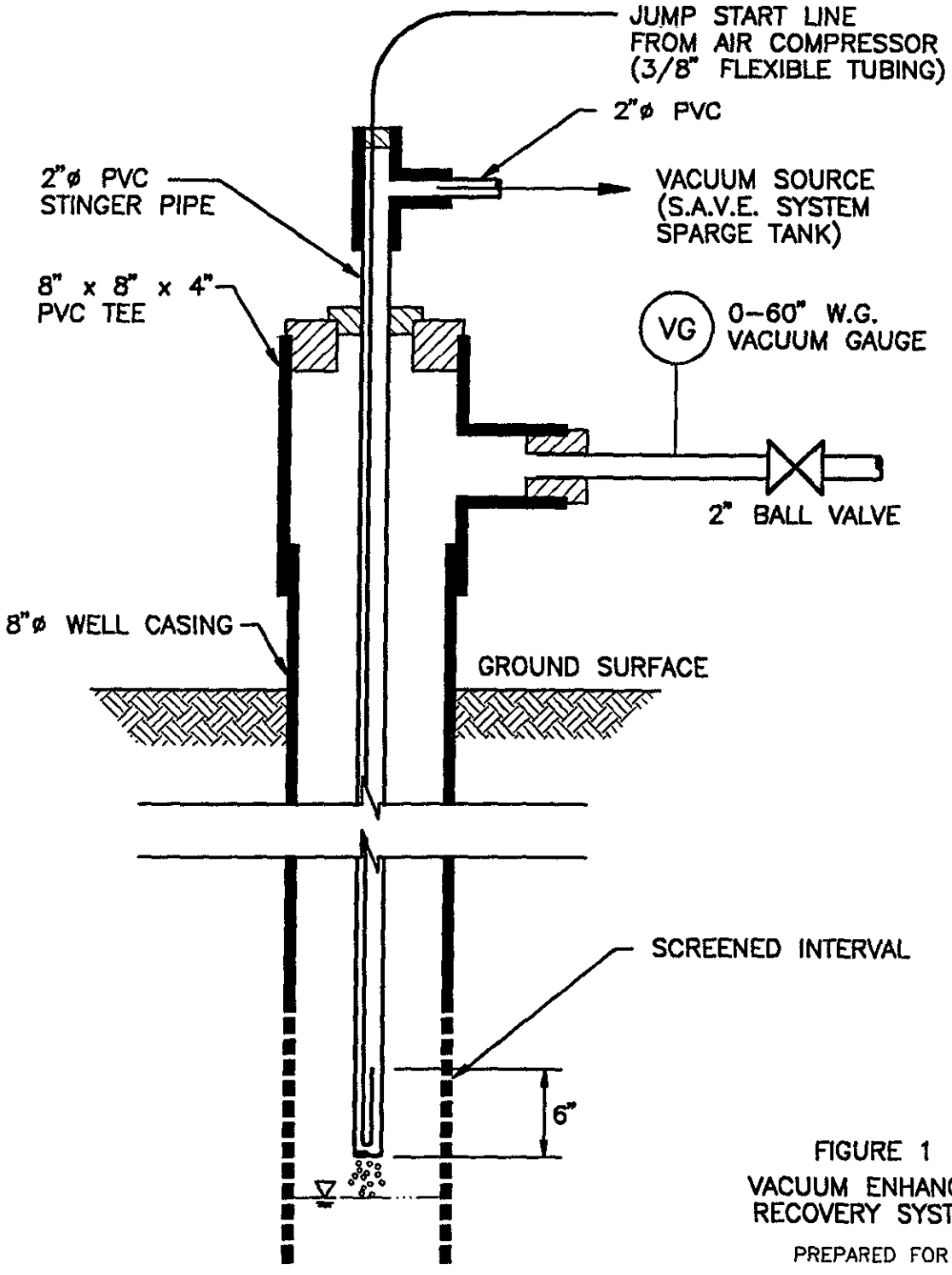
The pilot test effectively demonstrated that enhanced vacuum recovery in a low yield aquifer can increase formation yield; eliminate pumps, downhole level switches, and timers; and that the S.A.V.E.™ System used for treating water can also be used to recover it. Recovery using enhanced vacuum resulted in a sustained production of 1 gallon per minute (gpm). This represents a two-fold increase in groundwater recovery compared to standard pumping and non-enhanced vacuum techniques utilized previous to the 72 hour pilot test. Optimal drawdown and vacuum pressure at the recovery well were 8.5 feet below static water level and 45 inches of water column, respectively. It should be noted that in recovery tests conducted previously to the pilot test, recovery was not sustainable beyond 3 or 4 hours.

Groundwater levels monitored at adjacent observation wells showed very little deviation from static level throughout the pilot test. This was expected and anticipated. Expected because the water bearing formation was previously shown to be one of low yield and anticipated because vacuum applied in the manner described controls the groundwater potential. Experience has shown that vacuum control of groundwater potential is characterized by a relatively flat water table. small "cone" development ?

Utilization of the specified treatment system also as a water recovery device represents a new application for the system. Advantages provided or foreseen through the application of enhanced vacuum recovery include increased well recovery in low yield shallow aquifers, reduced number of wells required to achieve specific well filed production, reduced remediation durations, and elimination of labor and down time associated with operation /maintenance of pumps controlled by level switches or timers.

A figure of the enhanced vacuum recovery system well head, optimal recovery system settings, observation well construction diagrams, and selected groundwater level measurements gathered during the pilot test are included in the accompanying attachments.

DRAWING NUMBER	191143-A1
CHECKED BY	APPROVED BY
T.R.S.	11-2-92
DRAWN BY	



NOT TO SCALE

FIGURE 1
VACUUM ENHANCED
RECOVERY SYSTEM
PREPARED FOR
INGERSOLL-RAND
SAN LEANDRO, CALIFORNIA

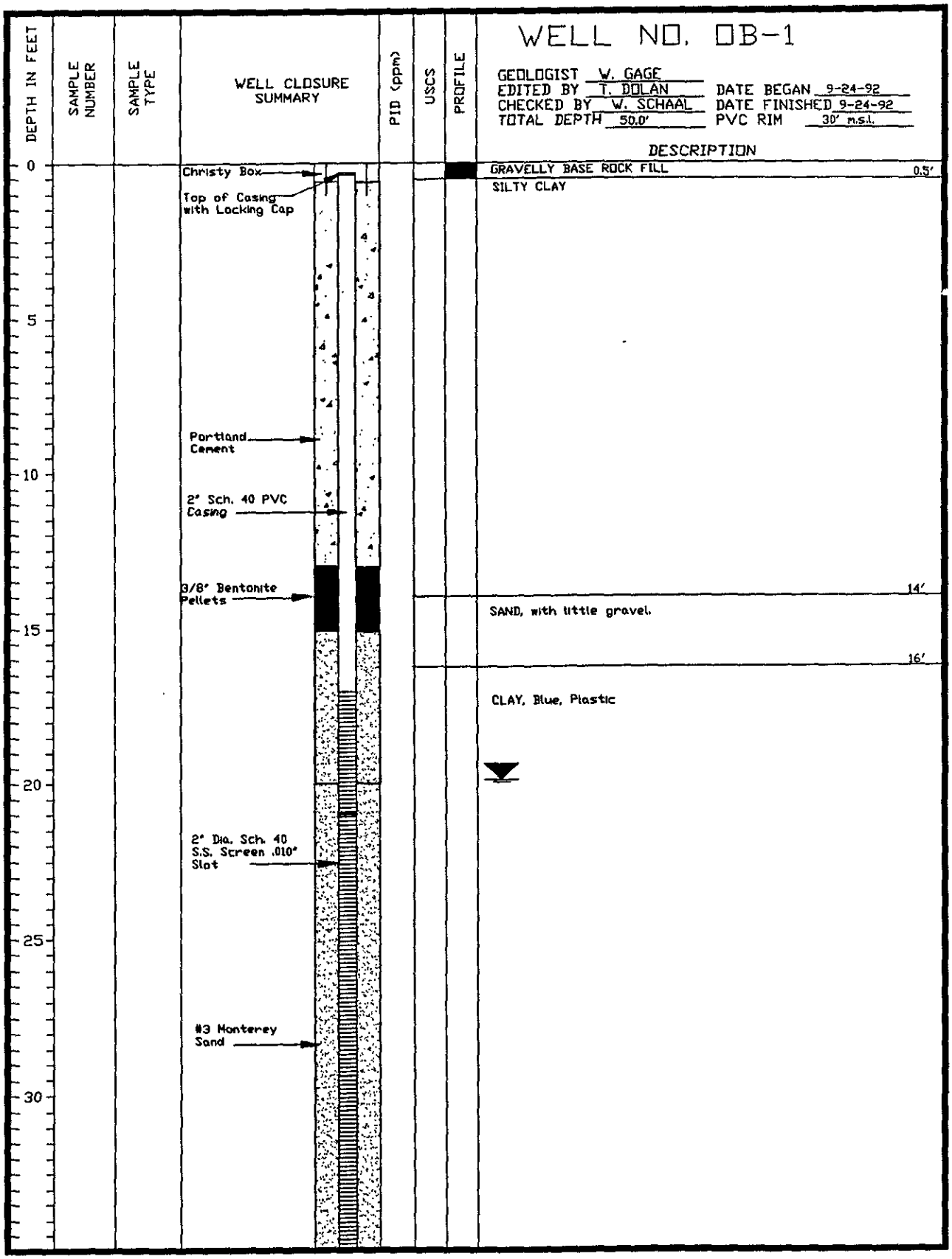
INTERNATIONAL
TECHNOLOGY
CORPORATION

IR-VERS(IR7)

Enhanced Vacuum Recovery Tables

Optimal System Settings

Tachometer	2300 RPM
Sparge Tank Vacuum	15 in. Hg
Intake Vacuum	20 in. Hg
Well Head Vacuum	45 in. Water
Air Flow From Sparge Tank	25 SCFM
Air Flow from Well	8 SCFM
Charging Voltage	14 V
Recirculation Temperature	130-140 F
Water Temperature	150-160 F
Oil Pressure	55 PSI
Recirculation Pressure	35-45 PSI
Fuel	Propane
Fuel Flow	110-135 SCFM
Groundwater Level	8.5 feet below static water level



DRILLING CO.: WEST HAZMAT DRILLING
DRILL METHOD: HOLLOW STEM ARGERS
SAMPLING METHOD: N/A

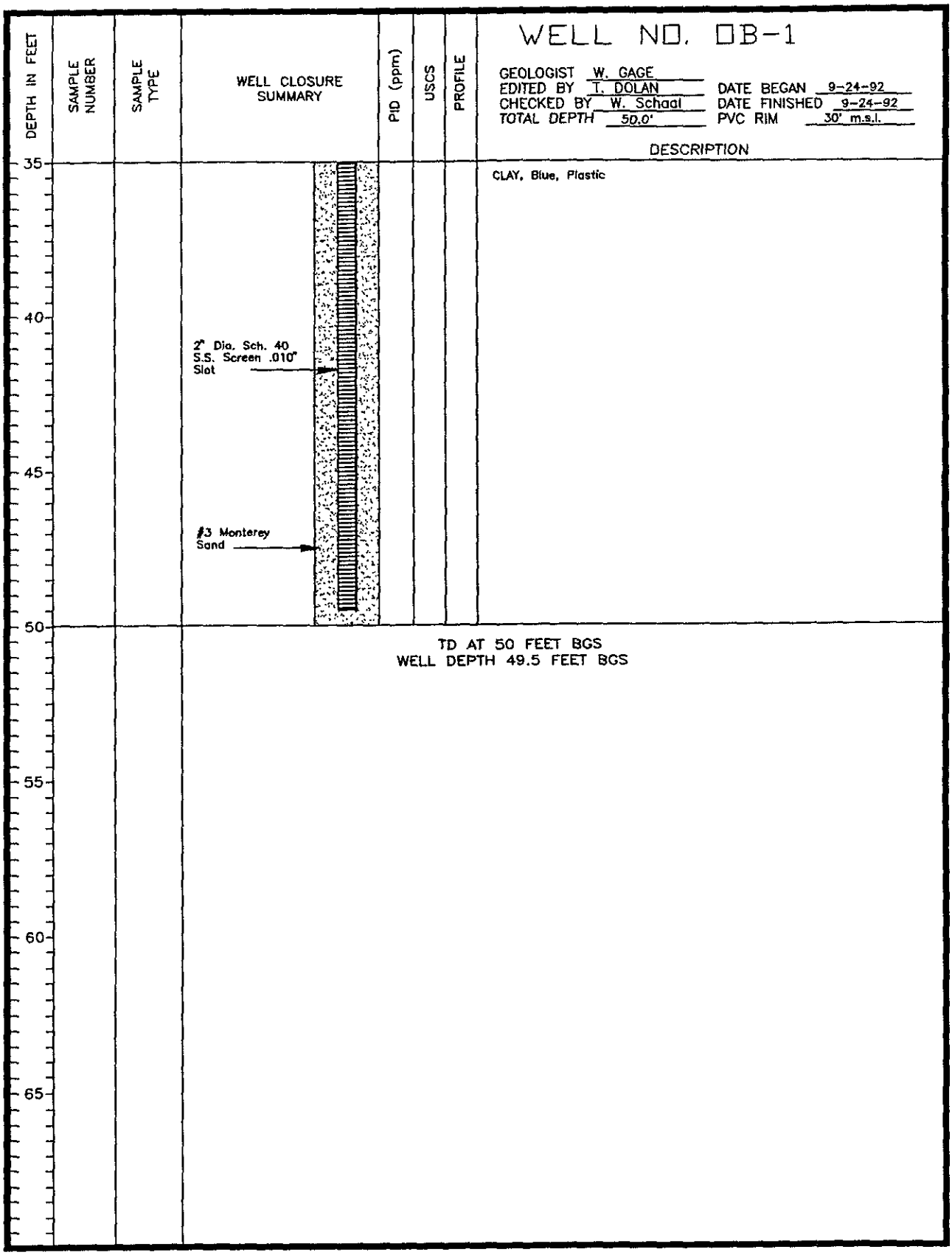
PROJECT NO.: 191143
CLIENT: INGERSOLL-RAND EQUIPMENT SALES
SITE ADDRESS: 1944 MARINA BOULEVARD
SAN LEANDRO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

WELL NO. OB-1

GEOLOGIST W. GAGE
EDITED BY T. DOLAN
CHECKED BY W. Schaal
TOTAL DEPTH 50.0'

DATE BEGAN 9-24-92
DATE FINISHED 9-24-92
PVC RIM 30' m.s.l.



DRILLING CO.: WEST HAZMAT DRILLING
DRILL METHOD: HELLOW STEM ARGERS
SAMPLING METHOD: N/A

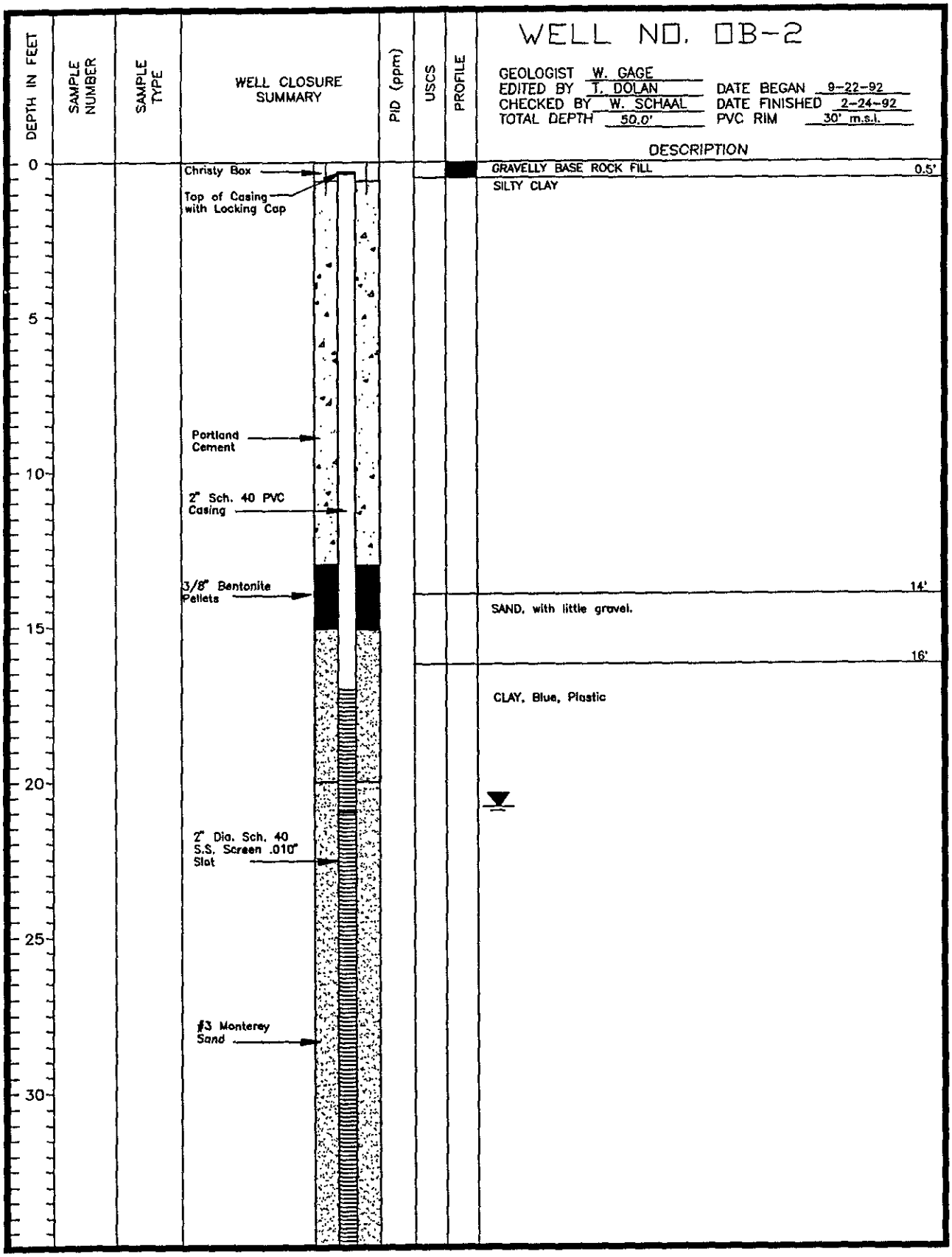
SHEET 2 OF 2

PROJECT NO.: 191143
CLIENT: INGERSOLL-RAND EQUIPMENT SALES
SITE ADDRESS: 1944 MARINA BOULEVARD
SAN LEANDRO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

WELL NO. OB-2

GEOLOGIST W. GAGE
EDITED BY T. DOLAN
CHECKED BY W. SCHAAL
TOTAL DEPTH 50.0'
DATE BEGAN 9-22-92
DATE FINISHED 2-24-92
PVC RIM 30' m.s.l.



DRILLING CO.: WEST HAZMAT DRILLING
DRILL METHOD: HOLLOW STEM AUGERS
SAMPLING METHOD: N/A

PROJECT NO.: 191143
CLIENT: INGERSOLL-RAND EQUIPMENT SALES
SITE ADDRESS: 1944 MARINA BOULEVARD
SAN LEANDRO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

WELL NO. OB-2

GEOLOGIST W. GAGE
EDITED BY T. DOLAN
CHECKED BY W. SCHAAL
TOTAL DEPTH 50.0'
DATE BEGAN 9-22-92
DATE FINISHED 9-22-92
PVC RIM 30' m.s.l.

DEPTH IN FEET	SAMPLE NUMBER	SAMPLE TPYE	WELL CLOSURE SUMMARY	PID (ppm)	USCS	PROFILE	DESCRIPTION
35							CLAY, Blue, Plastic
40			2" Dia. Sch. 40 S.S. Screen .010" Slot				
45			#3 Monterey Sand				
50							TD AT 50 FEET BGS WELL DEPTH 49.5 FEET BGS
55							
60							
65							

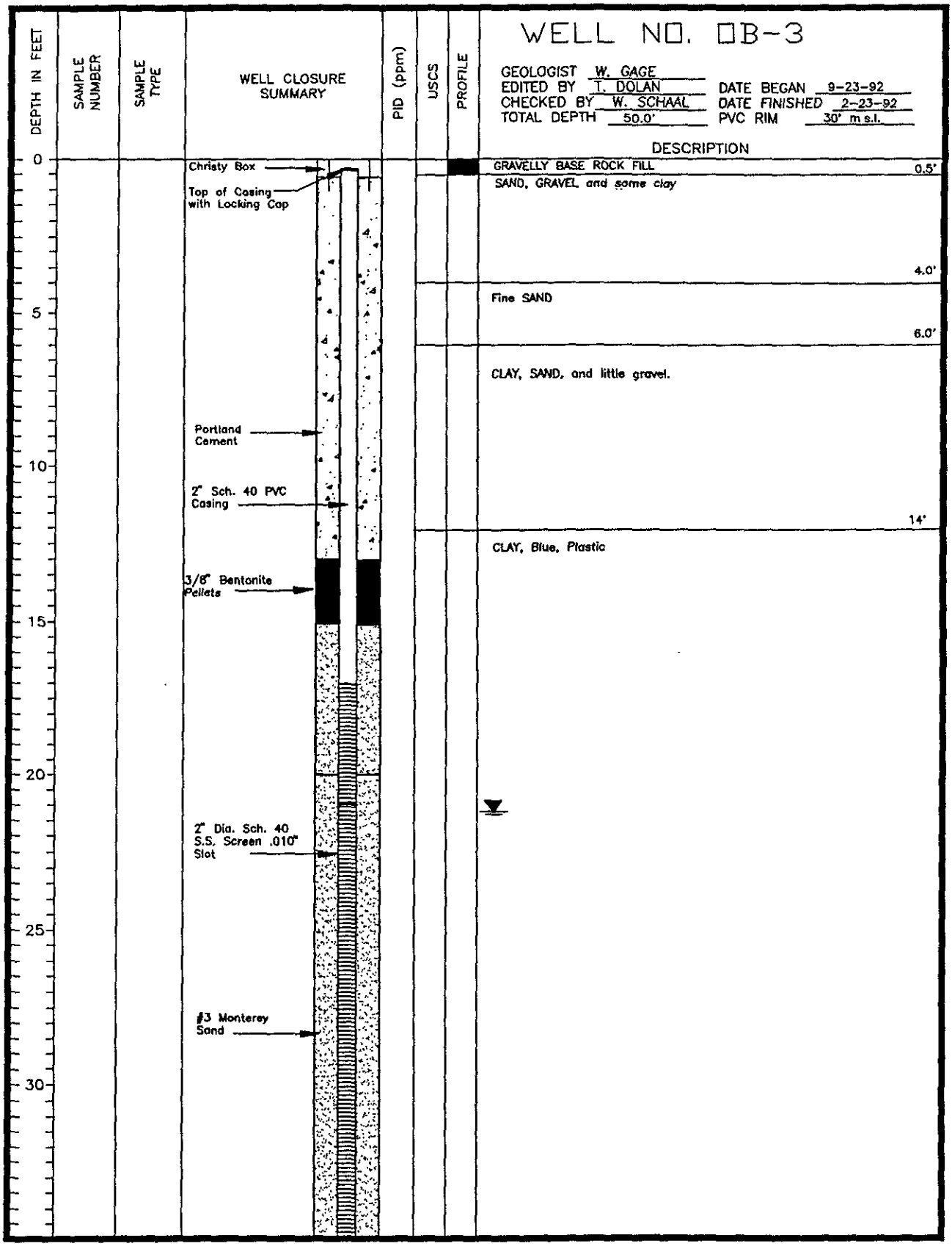
DRILLING CO.: WEST HAZMAT DRILLING
DRILL METHOD: HOLLOW STEM AUGARS
SAMPLING METHOD: N/A

PROJECT NO.: 191143
CLIENT: INGERSOLL-RAND EQUIPMENT SALES
SITE ADDRESS: 1944 MARINA BOULEVARD
SAN LEANDRO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

WELL NO. OB-3

GEOLOGIST W. GAGE
EDITED BY T. DOLAN
CHECKED BY W. SCHAAL
TOTAL DEPTH 50.0'
DATE BEGAN 9-23-92
DATE FINISHED 2-23-92
PVC RIM 30' m.s.l.



DRILLING CO.: WEST HAZMAT DRILLING
DRILL METHOD: HOLLOW STEM AUGARS
SAMPLING METHOD: N/A

SHEET 1 OF 2

PROJECT NO.: 191143
CLIENT: INGERSOLL-RAND EQUIPMENT SALES
SITE ADDRESS: 1944 MARINA BOULEVARD
SAN LEANDRO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

BORING NO. OB-3

GEOLOGIST W. GAGE
EDITED BY T. DOLAN
CHECKED BY W. SCHAAL
TOTAL DEPTH 50.0'
DATE BEGAN 9-23-92
DATE FINISHED 9-23-92
PVC RIM 30' m.s.l.

DEPTH IN FEET	SAMPLE NUMBER	SAMPLE TYPE	WELL CLOSURE SUMMARY	PID (ppm)	USCS	PROFILE	DESCRIPTION
35							CLAY, Blue, Plastic
40			2" Dia. Sch. 40 S.S. Screen .010" Slot				
45			#3 Monterey Sand				
50							TD AT 50 FEET BGS WELL DEPTH 49.5 FEET BGS
55							
60							
65							

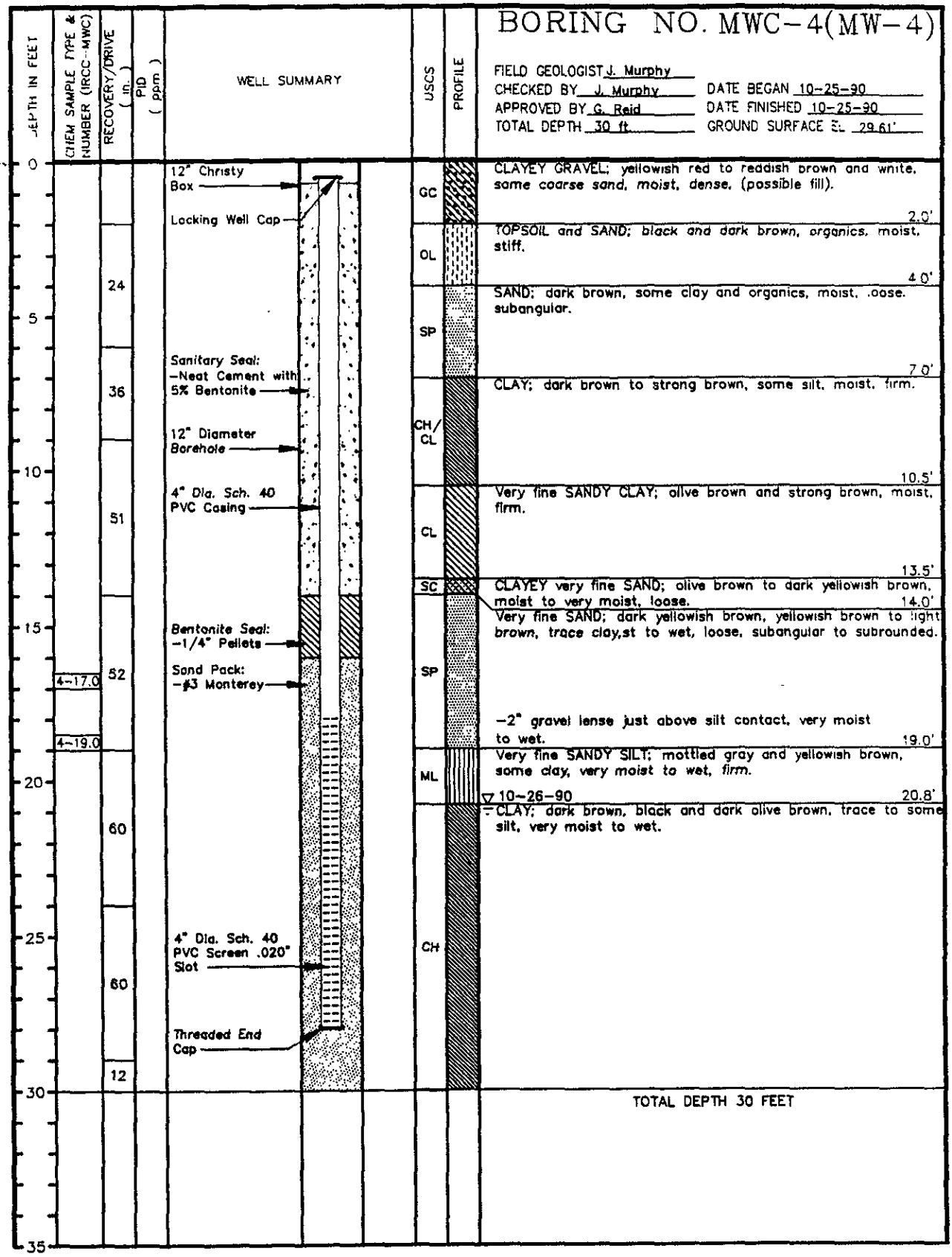
DRILLING CO.: WEST HAZMAT DRILLING
DRILL METHOD: HOLLOW STEM AUGARS
SAMPLING METHOD: N/A

PROJECT NO.: 191143
CLIENT: INGERSOLL-RAND EQUIPMENT SALES
SITE ADDRESS: 1944 MARINA BOULEVARD
SAN LEANDRO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

BORING NO. MWC-4(MW-4)

FIELD GEOLOGIST J. Murphy
CHECKED BY J. Murphy — DATE BEGAN 10-25-90
APPROVED BY G. Reid — DATE FINISHED 10-25-90
TOTAL DEPTH 30 ft — GROUND SURFACE EL. 29.61'



CLAYEY GRAVEL; yellowish red to reddish brown and white, some coarse sand, moist, dense, (possible fill). 2.0'

TOPSOIL and SAND; black and dark brown, organics, moist, stiff. 4.0'

SAND; dark brown, some clay and organics, moist, loose, subangular. 7.0'

CLAY; dark brown to strong brown, some silt, moist, firm. 10.5'

Very fine SANDY CLAY; olive brown and strong brown, moist, firm. 13.5'

CLAYEY very fine SAND; olive brown to dark yellowish brown, moist to very moist, loose. 14.0'

Very fine SAND; dark yellowish brown, yellowish brown to light brown, trace clay, st to wet, loose, subangular to subrounded.

-2" gravel lense just above silt contact, very moist to wet. 19.0'

Very fine SANDY SILT; mottled gray and yellowish brown, some clay, very moist to wet, firm.

▽ 10-26-90 20.8'

CLAY; dark brown, black and dark olive brown, trace to some silt, very moist to wet.

TOTAL DEPTH 30 FEET

DRILLING CO.: Water Development Corporation
DRILL METHOD: 3-1/4" I.D. Hollow Stem Auger – 5' Continuous Core
SAMPLING METHOD: Split Spoon Sampler

PROJECT NO.: 190678
CLIENT: Ingersoll Rand
LOCATION: 1944 Marina Boulevard
San Leandro, California

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

R-MWC-4(elR3)

Enhanced Vacuum Recovery Tables

Selected Groundwater Level

Well ID	Recovery Well	Observation Wells			
		OB1	OB2	OB3	MW-4
Distance from Recovery Well (Ft.)	0	5	12	20	40

Duration	Depth Below Grade (Ft.)				
t0	21.53	20.64	20.85	21.18	19.53
t1 (2 hr.)	23.48	20.75	20.93	21.23	
t2 (4 hr.)	26.23	20.88	21.00		
t3 (8.5 hr.)	30.22	21.04	21.11	21.34	19.53
t4 (24 hr.)	30.24	21.16	21.23	21.47	
t5 (45 hr.)	30.25	21.11	21.25	21.54	19.76
t6 (69 hr.)	30.27	21.18	21.28	21.54	19.75

PROJECT MEMORANDUM

PROJECT: 191143; Ingersoll-Rand Corporation, 1944 Marina Blvd., San Leandro, CA

SUBJECT: Pilot Test - RSI S.A.V.E™ (Spray Aeration/Internal Combustion) System

TASK DATES: September 29 to October 2, 1992

Prepared By: William Schaal, IT Corporation

PURPOSE

Because a pump and treat system appears imminent for the project site, the proposed pilot test was designed to examine the efficiency and viability of using the RSI S.A.V.E™ (spray aeration/internal combustion) System to recover and treat groundwater contaminated with dissolved-phase gasoline components. The S.A.V.E™ System is a relatively new product and selection of it for pilot testing was based on the claim that it is designed to treat recovered soil vapors and/or groundwater contaminated with volatile organic compounds (VOCs). This capability initially made the system interesting because the subject site has a temporary soil vapor extraction (SVE) system with carbon abatement established as an interim pro-active strategy to be replaced in the future by a system capable of treating both soil vapor and groundwater. Through examination of its design, the possibility of employing the S.A.V.E™ System to recover groundwater through an enhanced vacuum recovery procedure was identified. This represented a new application for the system.

The empirical study of treating water with the S.A.V.E™ System at the subject site is the focus of this Project Memorandum and employing the S.A.V.E™ System for enhanced vacuum recovery of groundwater is the focus of another Project Memorandum.

METHODS

Groundwater recovered from within the dissolved-phase gasoline plume was provided to the S.A.V.E™ System for treatment at a rate of 1 gallon per minute (gpm). The S.A.V.E™ System treats water in the following manner.

1. Heat the water to be treated using the exhaust manifold of the accompanying internal combustion engine.

2. Spray heated water in a thin film on the internal walls of a the aeration tank.

3. Strip the VOCs from the thin film of water by subjecting the aeration tank to vacuum.

4. Burn the VOCs in the internal combustion engine creating the vacuum that strips them from the heated thin film of water.

Approximately 2600 gallons of groundwater were treated during pilot testing. For comparison, samples of untreated and treated groundwater were analyzed for benzene, toluene, ethyl benzene, xylenes (BTEX) and total petroleum hydrocarbons as gasoline (TPH) using modified EPA methods 8015 and 8020, respectively. Chemical analysis were performed by a State certified mobile laboratory stationed on-site.

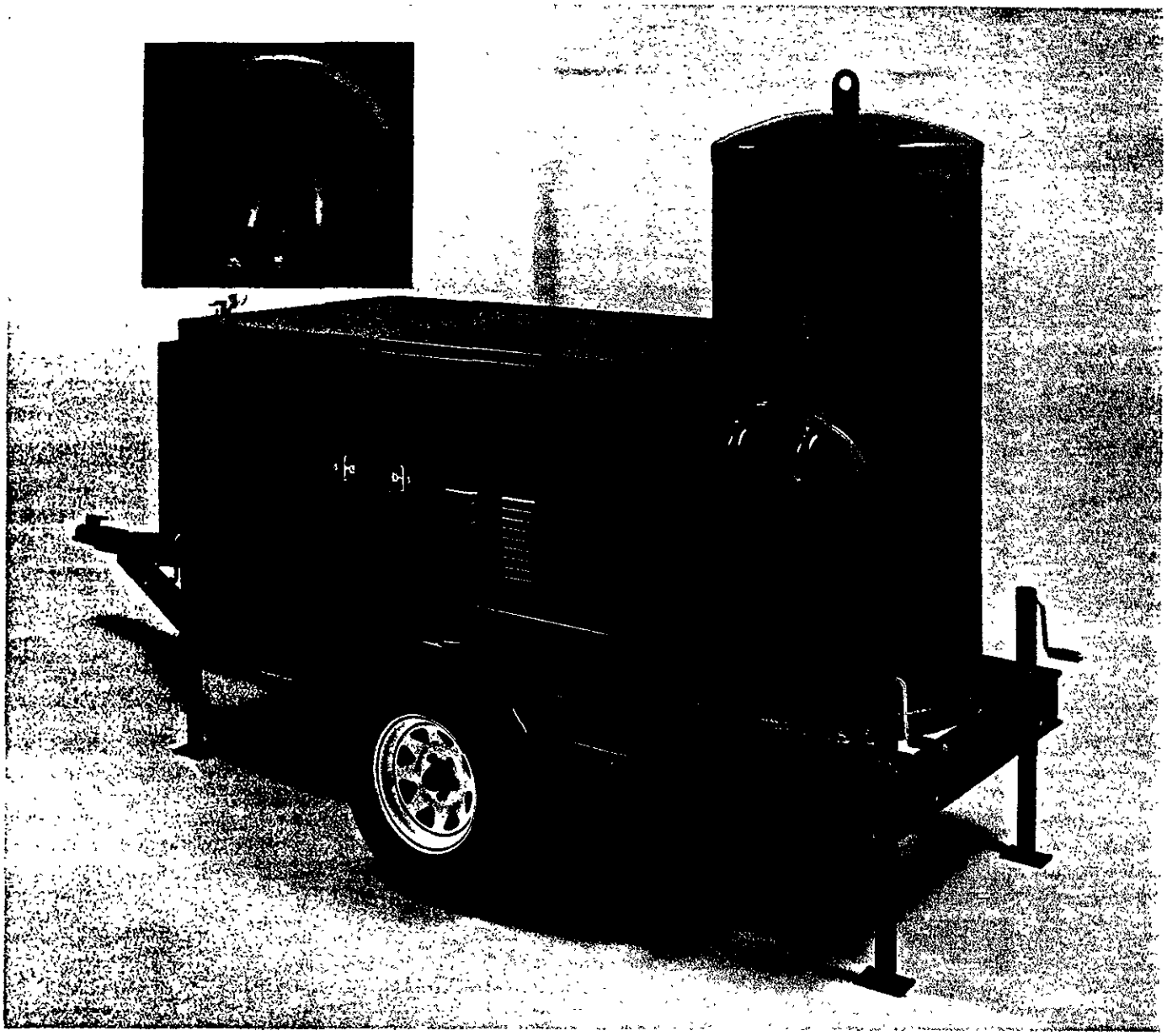
RESULTS

The pilot test effectively demonstrated that the S.A.V.E.™ System reduced the concentrations of BTEX and TPH in influent water to levels below detection.

A figure of the S.A.V.E™ System, optimal S.A.V.E™ System settings determined in the pilot test, and selected laboratory measurements gathered during the pilot test are included in the accompanying attachments.

The S.A.V.E.™ System

Combined Treatment for Contaminated Soil, Groundwater and Free Floating Product



U.S. Patent No. 4,979,886

AN ADVANCED SOLUTION

The RSI S.A.V.E. System combines air stripping, vacuum extraction and combustion technologies to provide a complete remediation package. Capable of treating contaminated soil, groundwater and free floating product, the S.A.V.E. System offers significant advantages over conventional remediation methods. Our process has been sited by the California Regional Water Quality Control Board as the best available technology economically achievable for the treatment of gasoline contaminated groundwater.

RSI®

Remediation Service, Int'l.

Enhanced Vacuum Recovery Tables

Optimal System Settings

Tachometer	2300 RPM
Sparge Tank Vacuum	15 in. Hg
Intake Vacuum	20 in. Hg
Well Head Vacuum	45 in. Water
Air Flow From Sparge Tank	25 SCFM
Air Flow from Well	8 SCFM
Charging Voltage	14 V
Recirculation Temperature	130-140 F
Water Temperature	150-160 F
Oil Pressure	55 PSI
Recirculation Pressure	35-45 PSI
Fuel	Propane
Fuel Flow	110-135 SCFM
Groundwater Level	8.5 feet below static water level

S.A.V.E. System Table

Selected Lab Measurements

Sample Type	Untreated Water #1	Untreated Water #2	Treated Water
Analyte			
Benzene (ug/l)	639.1	165.7	ND
Toluene (ug/l)	518.7	47.2	ND
Ethylbenz (ug/l)	93.0	8.6	ND
Xylene (ug/l)	578.5	39.4	ND
TPH Gass (ug/l)	5483.0	915.0	ND

Note: ND indicates not detected at detection limits.