NYE COUNTY NUCLEAR WASTE REPOSITORY PROJECT OFFICE

TEST PLAN

TITLE:	REVISION: **0**
Cross-Hole, Multiple-Well Tracer Test at Site 22	DATE: **11-18-04**
	PAGE: **1 of 22**

TEST PLAN NUMBER:	SUPERSEDES:
TPN-9.3	**None**

APPROVAL

11-22-04

Project Manager Date

CONCURRENCE

Dale Hammond 11/23/04

On-Site Geotechnical Represeptative Date

Dale Hammond for John Campanella 11/23/04

Principal Investigator Date

18 Nov 2004

Quality Assurance Officer Date

1.0 INTRODUCTION

This test plan (TPN) provides detailed instructions for a Nye County Nuclear Waste Repository Project Office (NWRPO) cross-hole, multiple-well tracer test to be conducted in 2005 at Early Warning Drilling Program (EWDP) site 22. This TPN supplements work plan WP-9, *Work Plan for Tracer Testing*, which provides the background, purpose, and objectives of the test.

Wells NC-EWDP-22S, -22PA, -22PB and –22PC shall be referred to in this TPN as 22S, 22PA, 22PB and 22PC, respectively.

2.0 WELL INFORMATION

Table 1 lists well casing and water level information for 22S.

Table 1
Well Information

Description	Elevation	
	feet above mean sea level (amsl)	feet below ground surface (bgs)
Measuring point	2,851.51	
Static water level in Screen 2 (472.94 feet to fluid)	2378.57	
6⅝-inch outside diameter (OD) steel casing (6.05-inch inside diameter [ID])		1,190.1
5-inch Schedule 80 PVC pipe (4.768-inch ID)		515
Westbay MP55 casing (2.25-inch ID)		1,185.81
Connection between 5-inch PVC pipe and MP55 casing		515

3.0 COMPLETION INFORMATION

Table 2 summarizes well screen intervals and Westbay port depths for 22S. Completion diagrams for 22S, 22PA, 22PB and 22PC are shown on Figures 1, 2, 3 and 4, respectively.

Table 2
Westbay Completion Information

Screen	Screen Interval (feet bgs)	Measurement Port (feet bgs)	Pumping Port (feet bgs)
1	521.5 – 581.3	559.6	569.8
2	661.2 – 760.6	742.6	752.9
3	880.2 – 980.0	960.1	970.4
4	1140 – 1180	1148.0	1158.3

Source: Westbay completion report.

4.0 EQUIPMENT LIST

Table 3 lists the equipment required for the multiple-well tracer test and the amount specified for each item.

Table 3
Multiple-Well Tracer Test Equipment

Item (In Alphabetical Order)	Amount
Barrel (50-gallon)	1
Carboy (5–gallon, empty)	13
Carboy containing concentrated 2,4,5-trifluorobenzoate (245-TFBA)	1+
Carboy containing concentrated 2,5–difluorobenzoate (25-DFBA)	1+
Carboy containing concentrated 2,6-difluorobenzoate (26-DFBA)	1+
Carboy containing concentrated lithium bromide (LiBr)	1+
Carboy containing concentrated lithium chloride (LiCl)	1+
Carboy containing microspheres	1+
Cone-bottom water tank (1,500-gallon)	2
Datalogger with cable (for SAMs and MOSDAX probes)	2 or 3
Fittings and nipples for surface equipment (2- and 1.25-inch)	Assorted
Flat-bottom water tank (1,550-gallon)	2
Flat-bottom water tank (305-gallon)	1
Gate valve (2-inch, for 1,550-gallon flat-bottom water tank)	2
Generator	1
Hand sprayer (one or two gallon)	1
ISCO Autosampler® and associated sample pump on loan from Los Alamos National Laboratory (LANL)	1
MOSDAX™ (Westbay) probe with centralizer	4
Motor for submersible pump (4-inch 10-horsepower (hp) Franklin®, or alternative)	1
Personal protective equipment	2 sets
Portable staircase	1
Pressure gauge (160 pounds-per-square-inch-gauge [psig])	1
PVC hose (1.25-inch, braided, flexible)	100 feet
PVC pipe (2-inch)	50 feet
Quarter-turn ball valve (2-inch)	4
SAM - 250-psia (with spider centralizer provided by rig contractor)	1
Sample bottles (240-milliliter [ml] amber glass bottles)	~2000
Sample bottles (40-ml glass vials)	~1400
Scientific notebook	1
Stand-alone module (SAM) and MOSDAX pressure transducer probes (30 pounds-per-square-inch-absolute [psia])	6
Steel pipe and associated pup joints (2-inch, galvanized)	510 feet
Stopwatch (for barrel flow rate test)	1
Submersible pump (Myers® S100-40, or alternative)	1
Variable-speed pump	1
Water meter (1-inch Turbine, with totalizer, on loan from USGS)	1
Well sounder (500-foot minimum)	2

5.0 PROCESS

5.1 Borehole Equipment and Instrument Installation

5.1.1 Sounders

1. Measure water levels with a sounder (i.e., 500-foot or greater) in all screens of wells 22S, 22PA, 22PB, and 22PC, referring to technical procedure TP-9.9, *Measurement of Groundwater Levels Using Electric Well Sounders*. Record the measurements in the scientific notebook.

5.1.2 30-psia SAMs and MOSDAX Probes

1. Install the six 30-psia pressure transducer probes in the upper and lower piezometer screens of wells 22PA, 22PB and 22PC, referring to TP-9.2, *Operation of Westbay MOSDAX® Groundwater Monitoring Equipment In Nye County Wells*. These probes generate temperature as well as pressure data. Run the probes approximately 25 feet below the water table (i.e., approximately 500 feet bgs) in each piezometer. Gauges should read approximately 24 psia.

2. Set the dataloggers to obtain readings from the pressure probes every 60 seconds. Monitor background readings overnight.

5.1.3 MOSDAX Probes in 22S

1. Open the pumping port for Screen 2 in well 22S. Install the MOSDAX probes in Screens 1, 3, and 4, removing the centralizer from the probe used in Screen 1. If deemed appropriate by the PI, install a probe, without a centralizer, in Screen 2.

2. Ensure that all probes and dataloggers are synchronized.

3. Set the dataloggers to obtain probe readings every 10 seconds. 10-second readings shall be taken immediately prior, during, and immediately after pumping. Monitor background readings overnight. Readings shall be taken at 60-second intervals at all other times to avoid datalogger memory overflow.

5.1.4 250-psia SAM

1. Direct the pumping contractor to lift the submersible pump and motor with the pumping rig.

2. Tape the 250-psia SAM as close as physically possible to the top of the 5-foot-long pump. The SAM must be less than 7 feet above the pump intake. Protect the SAM with the spider centralizer.

3. Record the distance between the midpoints of the pump intake and SAM in the scientific notebook.

4. Run the submersible pump into well 22S on the 2-inch galvanized steel pipe, being careful to avoid damaging the SAM cable. As it is being fed into the hole, tape the

SAM cable to the pipe above and below each collar. Set the bottom of the pump 3 feet above the top of the existing PVC pipe/MP55 casing connection to maximize the available drawdown for the pump. Cap the galvanized pipe at the wellhead.

5. Record all depth control information on a Tubing and Casing Record (TP-7.0, Drill Site Management).

6. Ensure that the pumping contractor remains onsite until the submersible pump has been started in 22S.

5.2 Site, Plumbing, Chase-Water, and Tracer Preparation

5.2.1 Carboys

1. Obtain carboys filled with the tracers listed in Table 4 and Material Safety Data Sheets (MSDSs) for each tracer from the University of Nevada, Las Vegas, Harry Reid Center (UNLV/HRC), and purchase 13 empty 5-gallon carboys. One tracer, 25-DFBA, is referred to as qualitative tracer in this TPN; the remaining tracers are referred to as quantitative.

Table 4
Tracer Names and Types

Tracer Name	Abbreviation	Injection Location	Tracer Mass (kg)	Tracer Injection Concentration Target (mg/l)	Type
2,4,5-trifluorobenzoate	245-TFBA	22PA lower screen	8.5	8500	Quantitative
lithium bromide	LiBr		25	25,000	
lithium chloride	LiCl		97	97,000	
2,6–difluorobenzoate	26-DFBA	22PC lower screen	8.5	8500	
2,5–difluorobenzoate	25-DFBA	22PA upper screen	1.5	1,500	Qualitative
Microspheres	none	22PA or 22PC lower screen	0.01- 0.02	0.01- 0.02	Quantitative

5.2.2 Cone- and Flat-Bottom Tanks

1. Connect the first 1,500-gallon cone-bottom tank to the 1,550 gallon flat-bottom tank shown in Figure 5 using the 2-inch galvanized steel pipe with the 1-inch water meter and the variable speed pump.

2. Record the water meter reading in the scientific notebook. Start the variable-speed pump and begin filling the tank.

3. Record the water meter total again when water first enters the tank.

4. Fill the cone-bottom tank with produced water from the flat-bottomed tank until the water meter reading equals the volume recorded in step 3 plus 214 gallons.

5. Simultaneously close the tank valve and turn off the pump. Record both the water meter total and the tank water level (i.e., height of the water) in the scientific notebook.

6. Connect and fill the second 1,500-gallon cone-bottom tank, following steps 1 through 3. Fill the tank with produced water until the water meter reading equals the volume recorded in step 3 plus 228 gallons, then repeat step 5.

5.2.3 Quantitative Tracer Dilution

1. Contact UNLV/HRC at 702 895-4450 before diluting the tracers so an analyst can be on location when the initial diluted tracer sample is taken (step 8).

2. Connect the variable-speed pump inlet to the outlet of the first 1,500-gallon cone-bottom tank (i.e., the tank containing 214 gallons of water) as shown on Figure 6. Attach the 1.25-inch braided PVC hose to the pump outlet. Place one end of the hose inside the tank through the access hole in the top of the tank. Tape the hose to the portable staircase for support.

3. Open valve on the tank and start the pump. Repair any leaks. Roll the tank with the pump.

4. Fill the 13 empty carboys with produced water from the tank using the PVC hose and set them aside. This water will be used for rinsing.

5. Put on personal protective equipment (PPE), as specified in the MSDSs.

6. Empty the carboys containing the quantitative tracers 245-TFBA, LiBr, and LiCl into the tank while continuing to roll the tank.

7. When empty, rinse the tracer carboys, using two of the reserved carboys containing the rinse water obtained in step 4. Add the rinsate to the tank and continue to roll the tank. Label the tank with the tracer name.

8. Using the PVC hose, fill a labeled sample bottle with diluted tracer water from the tank. Seal the bottle and ship the sample to UNLV/HRC for immediate analysis.

9. UNLV/HRC will contact Nye County personnel immediately after completion of the tracer analyses described in step 8 to report the tracer concentrations. Target tracer concentrations are listed in Table 4 and found in Attachment F-1 of the Nevada Underground Injection Control Permit UNEV200310.

10 Dilute the quantitative tracer 26-DFBA in the second 1,500 gallon cone-bottom tank (i.e., the tank containing 228 gallons of water) by following steps 2 through 9, skipping step 4, and substituting 26-DFBA for the tracers listed in step 6.

5.2.4 Qualitative Tracer Dilution (25-DFBA)

1. Contact UNLV/HRC at 702 895-4450 before diluting the tracers so an analyst can be on location when the initial diluted tracer sample is taken in step 7 below.
2. Connect the variable-speed pump inlet to the outlet of the 305-gallon flat-bottom tank. Attach the 1.25-inch braided PVC hose to the pump outlet. Place one end of the hose inside the tank through the access hole in the top of the tank.
3. Open the valve on the tank and start the pump. Repair any leaks. Roll the tank with the pump.
4. Put on PPE, as specified in the MSDSs.
5. Empty the carboy(s) containing the qualitative tracer 25-DFBA into the tank while continuing to roll the tank with the pump. Label the tank with the tracer name.
6. When empty, rinse the carboy(s), using water from one of the reserved carboys containing the rinse water obtained in step 4 of section 5.2.3. Add the rinsate to the tank and continue to roll the tank.
7. Using the PVC hose, fill a labeled sample bottle with diluted tracer from the tank. Seal the bottle and ship the sample to UNLV/HRC for immediate analysis.
8. UNLV/HRC will contact Nye County personnel immediately after completion of the tracer analyses described in step 8 of Section 5.2.3 to report the tracer concentrations. Target tracer concentrations are listed in Table 4 and found in Attachment F-1 of the Nevada Underground Injection Control Permit UNEV200310.

5.2.5 Injection Line

1. Plumb the injection line as shown on Figure 7. Use quarter-turn valves adjacent to each tank to control flow from the tanks and a variable-speed pump between the injection tanks and 22PA to aid injection, as necessary. Attach a section of braided PVC hose at the end of the pipe system. This hose will be placed approximately 10 feet into the existing 2-inch PVC casing of the lower piezometer in 22PA to inject the tracers.

5.3 Discharge Line Connection

1. Connect a 2-inch galvanized steel pipe and discharge line to the submersible pump at the wellhead as shown on Figure 8. Ensure that the water meter is in a straight run of pipe at least 3 feet from any upstream or downstream flow disturbance, such as bends or valves, and upstream from the control gate valve. Place the 160-psig pressure gauge upstream from the gate valve.
2. Record the flow meter volume in the scientific notebook.
3. Photograph the discharge line to comply with permit regulations.
4. Place the 50-gallon barrel near the discharge point for the barrel flow rate test.

5.4 Sampling Preparation

Personnel from the U.S. Department of Energy (DOE) Sample Management Facility (SMF) shall work with Nye County personnel to collect water samples for tracer analysis. SMF personnel shall be responsible for supplying correctly labeled bottles to sample collection point(s) and transporting filled bottles according to DOE quality assurance requirements.

1. Ensure that probes and dataloggers are synchronized and that the generator is fueled and running properly.
2. Connect the LANL ISCO Autosampler to the discharge line (Figure 8).
3. Fill the Autosampler with clean, labeled bottles. Program the Autosampler to obtain samples as soon as pumping starts according to the schedule in Table 5.
4. The minimum number of samples to be analyzed by UNLV/HRC is also listed in Table 5. Turnaround time for sample analyses by UNLV/HRC (i.e., time from receipt of samples to delivery of preliminary results to Nye County) should be 2 to 3 days, when possible. Analyzed samples should be approximately equally spaced with regards to time in order to generate a useable tracer concentration versus time curve.

Table 5
Autosampler Sampling Schedule

Elapsed Time	Frequency	Total Number of Samples	Minimum Number of Analyses
Hours 0 – 24	Every 10 minutes	144	12
Days 1 – 5	Every 30 minutes	192	10
Days 5 – 14	Every hour	216	18
Days 14 –120	Every 2 hours	1272	92

5. Manual samples shall be taken for replication and quality control according to the schedule in Table 6. If the Autosampler is offline for any reason, a manual sample shall be taken at the frequency stated in Table 5.

Table 6
Manual Sampling Schedule

Time	Frequency	Total Number of Samples
Hours 0 – 5	Every 20 minutes	15
Hours 5 – 12	Every hour	7
Hours 12 – 24	Every 2 hours	6
Days 1 – 14	Every 8 hours	39
Days 14 –120	Every day	106

6. If Nye County has decided to inject microspheres, sampling preparation shall differ slightly. Immediately before injecting the microspheres, obtain both a 40-ml split of each Autosampler sample and a manual sample. These samples shall be shipped to LANL. Microsphere injection is described in section 5.8.

   If microspheres are injected, injections will likely begin more than 14 days after the start of the tracer injection described in sections 5.5 and 5.6. As a result, the sampling schedule for microspheres shall be once per day for manual sampling and once per 2 hours for the Autosampler (Tables 5 and 6).

5.5 Quantitative Tracer Injection

5.5.1 Injection of 245-TFBA, LiBr, and LiCl

1. Stop recording readings from the 30-psia pressure probe in the lower piezometer in 22PA. Pull the probe out of the well.

2. LANL personnel shall deploy a YSI multiprobe in the lower piezometer in 22PA to a depth of approximately 770 feet bgs and take continuous electrical conductivity readings.

3. Open the control gate valve fully on the discharge line and start the submersible pump in 22S. The pump rate should be approximately 40 to 50 gpm. Monitor the drawdown and pinch back with the gate valve, if required.

4. Start the Autosampler to ensure that it is functional before tracer injection.

5. Record the time and water level of the cone-bottom tank containing 245-TFBA, LiBr, and LiCl in the scientific notebook. Check that the 1.25-inch braided PVC hose is inserted approximately 10 feet into the lower piezometer in 22PA, as shown on Figure 7.

6. Note the time on the multiprobe datalogger and start the gravity feed of quantitative tracers 245-TFBA, LiBr, and LiCl from the cone-bottom tank by opening the quarter-turn ball valve, taking care not to exceed the capacity of the well to take the tracers.

7. After approximately 50 gallons of tracer have been injected into the lower piezometer in 22PA, or after an increase in the multiprobe electrical conductivity has been observed, LANL personnel shall do the following:

   a. Pull the multiprobe uphole 5 to 10 feet.

   b. Stop and record conductivity for approximately 1 minute, or until the reading has stabilized.

   c. Continue moving up 5-foot intervals, stopping for approximately 1 minute to collect multiprobe readings.

d. After reaching the top of the screen (i.e., at approximately 660 feet bgs), reverse direction and start lowering the multiprobe, again stopping at 5-foot intervals and collecting readings to a depth of 770 feet bgs.

e. Repeat multiprobe logging runs between approximately 770 and 660 ft bgs as long as either tracer or chase water is being injected into the lower 22A piezometer or as determined by the PI after consultation with LANL personnel onsite.

8. Stop the tracer injection before emptying the tank. A possible stop point is when the tracer level in the tank reaches the bottom of the cone. Record the fluid level and time in the scientific notebook.

9. Rinse and flush the tank into the injection line with the rinse water from two of the remaining reserved carboys. Use the hand sprayer to rinse the tank walls.

10. After the flush water has drained from the tank, turn off the quarter-turn ball valve to isolate the tank.

11. Record the time and water level of the 1,550-gallon flat-bottom tank (Figure 7) in the scientific notebook. Open the valve slowly and gravity feed 86 gallons of chase water (i.e., twice the displacement volume of the piezometer) into the lower screen interval of 22PA, taking care not to exceed the capacity of the well to take water.

12. Record the time and tank water level (i.e., height of the water) in the scientific notebook immediately after closing the valve and stopping the water displacement.

13. LANL personnel shall then remove the multiprobe at the PI's discretion.

14. Re-install the 30-psia pressure probe in the lower piezometer screen of 22PA at the depth it was originally set in step 1 in Section 5.1.2, referring to TP-9.2.

15. Set the datalogger to obtain readings from the pressure probe every 60 seconds.

5.5.2 Injection of 26-DFBA

1. Within 24 hours of starting the pump at 22S, begin injecting quantitative tracer 26-DFBA into the lower piezometer in 22PC.

2. Record the time and water level of the 1,500-gallon cone-bottom tank containing 26-DBFA in the scientific notebook. Place the 1.25-inch braided PVC hose approximately 10 feet into the lower piezometer of 22PC, as shown on Figure 9.

3. Start the gravity feed of the tracer from the cone-bottom tank by opening the quarter-turn ball valve, taking care not to exceed the capacity of the well to take the tracers.

4. Stop the tracer injection before emptying the tank. A possible stop point is when the tracer level in the tank reaches the bottom of the cone. Record the fluid level and time in the scientific notebook.

5. Rinse and flush the tank into the injection line with the rinse water from two of the remaining reserved carboys. Use the hand sprayer to rinse the tank walls.

6. After the flush water has drained from the tank, turn off the quarter-turn ball valve to isolate the tank.

7. Record the time and water level of the 1,550-gallon flat-bottom tank (Figure 9) in the scientific notebook. Open the valve slowly and gravity feed approximately 86 gallons of chase water (i.e., twice the displacement volume of the piezometer) into the lower screen interval of 22PC, taking care not to exceed the capacity of the well to take water.

8. Record the time and water level of the tank (i.e., height of the water) in the scientific notebook immediately after closing the valve and stopping the chase water gravity feed.

5.6 Qualitative Tracer Injection

1. Within 24 hours of starting the pump at 22S, cap off the lower piezometer in 22PA and place the braided PVC hose into the upper piezometer in 22PA.

2. Carefully gravity feed qualitative tracer 25-DFBA from the 305-gallon flat-bottom tank into the piezometer.

3. When the tank is nearly empty, rinse and flush the tank into the injection line with the water from one of the remaining carboys. Use the hand sprayer to rinse the tank walls.

4. Displace the tracer into the formation by gravity feeding 32 gallons (i.e., twice the calculated displacement requirement) of chase water from the 1,550-gallon flat - bottom tank.

5. Record the beginning and ending times and tank water levels (i.e., heights of the water) in the scientific notebook.

5.7 Microsphere Preparation and Dilution

1. If Nye County determines that quantitative tracers, injected as described in section 5.5, break through rapidly in 22S and it is therefore likely that microsphere tracers will also break through rapidly, microspheres shall be injected into the lower piezometer in either 22PA or 22PC, depending upon which piezometer is most likely to produce the fastest breakthrough in 22S.

The following steps shall be followed to prepare microspheres for injection:

1. Connect one of the 1,500-gallon cone-bottom tanks to the 1,550 gallon flat-bottom tank shown on (Figure 5).

2. Record the water meter reading in the scientific notebook. Start the variable-speed pump and begin filling the tank.

3. Record the water meter total again when water first enters the tank.
4. Fill the cone-bottom tank until the water meter reading equals the volume recorded in step 3 plus 264 gallons.
5. Connect the variable-speed pump inlet to the outlet of the 1,500-gallon cone-bottom tank. Attach the 1.25-inch braided PVC hose to the pump outlet. Place one end of the hose inside the tank through the access hole in the top of the tank. Tape the hose to the portable staircase for support (Figure 6).
6. Open valve on the tank and start the pump. Repair any leaks. Roll the tank with the pump.
7. Put on PPE, as specified in the MSDSs.
8. Empty the carboys containing the microspheres into the tank while continuing to roll the tank.
9. When empty, rinse the tracer carboys, using one of the reserved carboys containing the rinse water. Add the rinsate to the tank and continue to roll the tank.
10. Using the PVC hose, fill a labeled 40-ml sample vial with diluted tracer from the tank. Seal the vial and ship the sample to LANL for immediate analysis.
11. LANL will contact Nye County personnel immediately after completion of the tracer analyses described in step 10 to report tracer concentrations. Target tracer concentrations are listed in Table 4 and found in Attachment F-1 of the Nevada Underground Injection Control Permit UNEV200310.

5.8 Microsphere Injection

1. Assuming that 22PA is selected for microsphere injection, connect the tracer and chase-water tanks to 22PA, as shown in Figure 7.
2. Record the time and water level of the cone-bottom tank containing microspheres in the scientific notebook. Place the 1.25-inch braided PVC hose approximately 10 feet into the lower screen of 22PA.
3. Start the gravity feed of the microspheres from the cone-bottom tank by opening the quarter-turn ball valve, taking care not to exceed the capacity of the well to take the microspheres.
4. Stop the microsphere injection before emptying the tank. A possible stop point is when the microsphere level in the tank reaches the bottom of the cone. Record the fluid level and time in the scientific notebook.
5. Rinse and flush the tank into the injection line with the rinse water from two of the remaining reserved carboys. Use the hand sprayer to rinse the tank walls.
6. After the flush water has drained from the tank, turn off the quarter-turn ball valve to isolate the tank.

7. Record the time and water level of the 1,550-gallon flat-bottom tank in the scientific notebook. Open the valve slowly and gravity feed 86 gallons of chase water (i.e., twice the displacement volume) into the lower screen of 22PA, taking care not to exceed the capacity of the well to take water.

8. Record the time and tank water level (i.e., height of the water) in the scientific notebook immediately after closing the valve and stopping the water displacement.

5.9 Sample Collection

1. Start the Autosampler as soon as pumping begins. Collect groundwater samples from the discharge line according to Tables 5 and 6.

2. Pump the well until tracer levels are at or below requirements by the state of Nevada. (i.e., Nevada Underground Injection Control Permit UNEV200310). Pumping is anticipated to take from 90 to 120 days.

3. Record water meter with totalizer readings in the scientific notebook at the same frequency as manual sampling.

4. Take barrel flow rate measurements daily. Use the stopwatch to determine the time required to fill the barrel. Record the measurements in the scientific notebook.

5. Check pressure transducer probes and dataloggers daily. Download the datalogger to clear its memory as often as necessary. Data collection at a 10-second frequency is preferred; however, adjust frequency to between 10 and 60 seconds to match manpower availability. Note that 10-second frequency requires daily downloads while 60-seconds requires downloads approximately every 5 days.

6. Additional sampling of the injection zones by a Bennett pump or other method may be requested and shall be at the PI's discretion.

7. If pressure transducer probes are non-functioning, take manual water level measurements daily.

8. If the pump accidentally shuts down, restart it, record the time in scientific notebook, and notify the PI for a possible temporary sample frequency increase.

9. When tracer sample collection is stopped, shut down the pump.

10. Monitor recovery with probes for 12 hours at a 10-second frequency. The PI may specify a longer monitoring period.

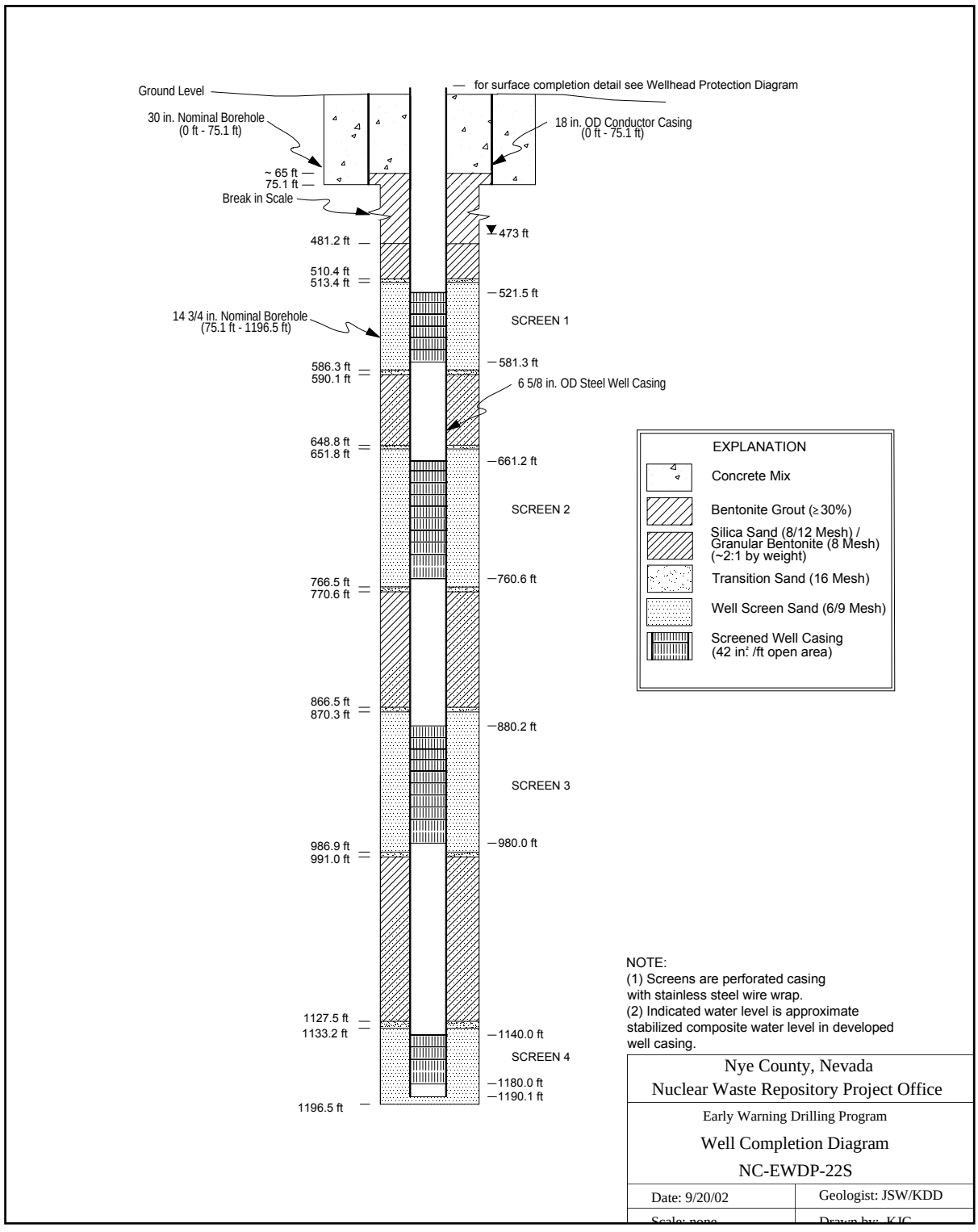

Figure 1
Completion Diagram for Well NC-EWDP-22S

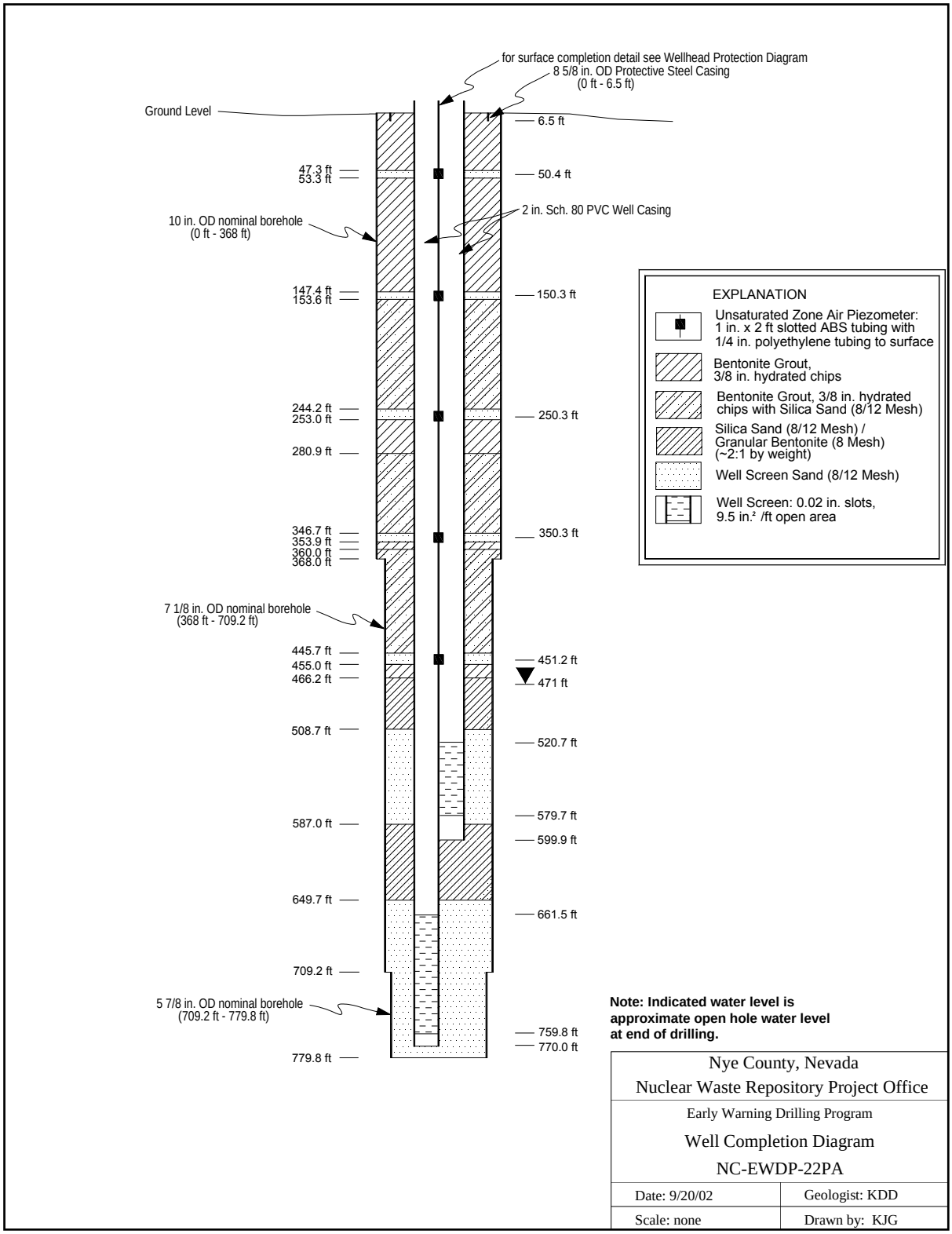

Figure 2
Completion Diagram for Well NC-EWDP-22PA

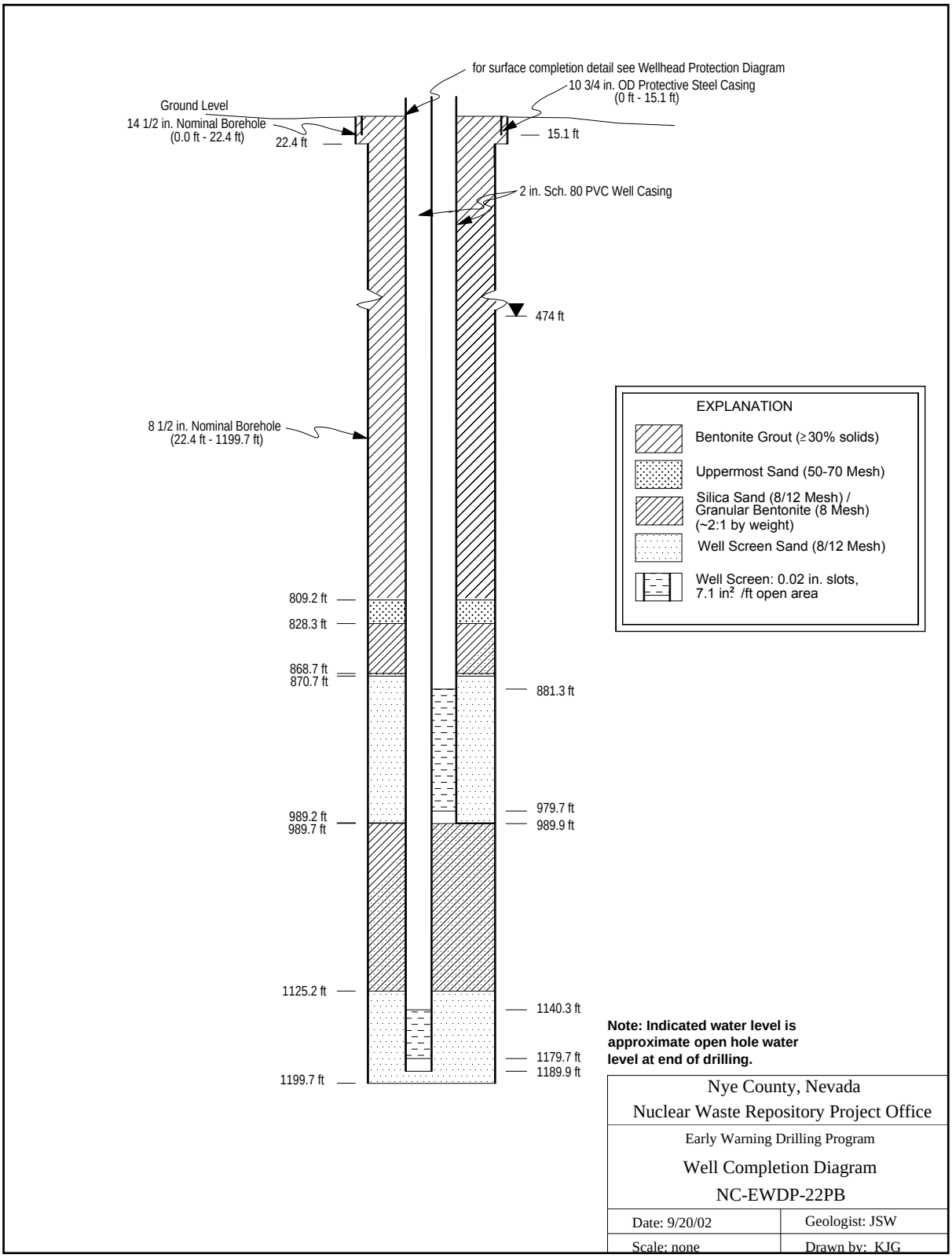

Figure 3
Completion Diagram for Well NC-EWDP-22PB

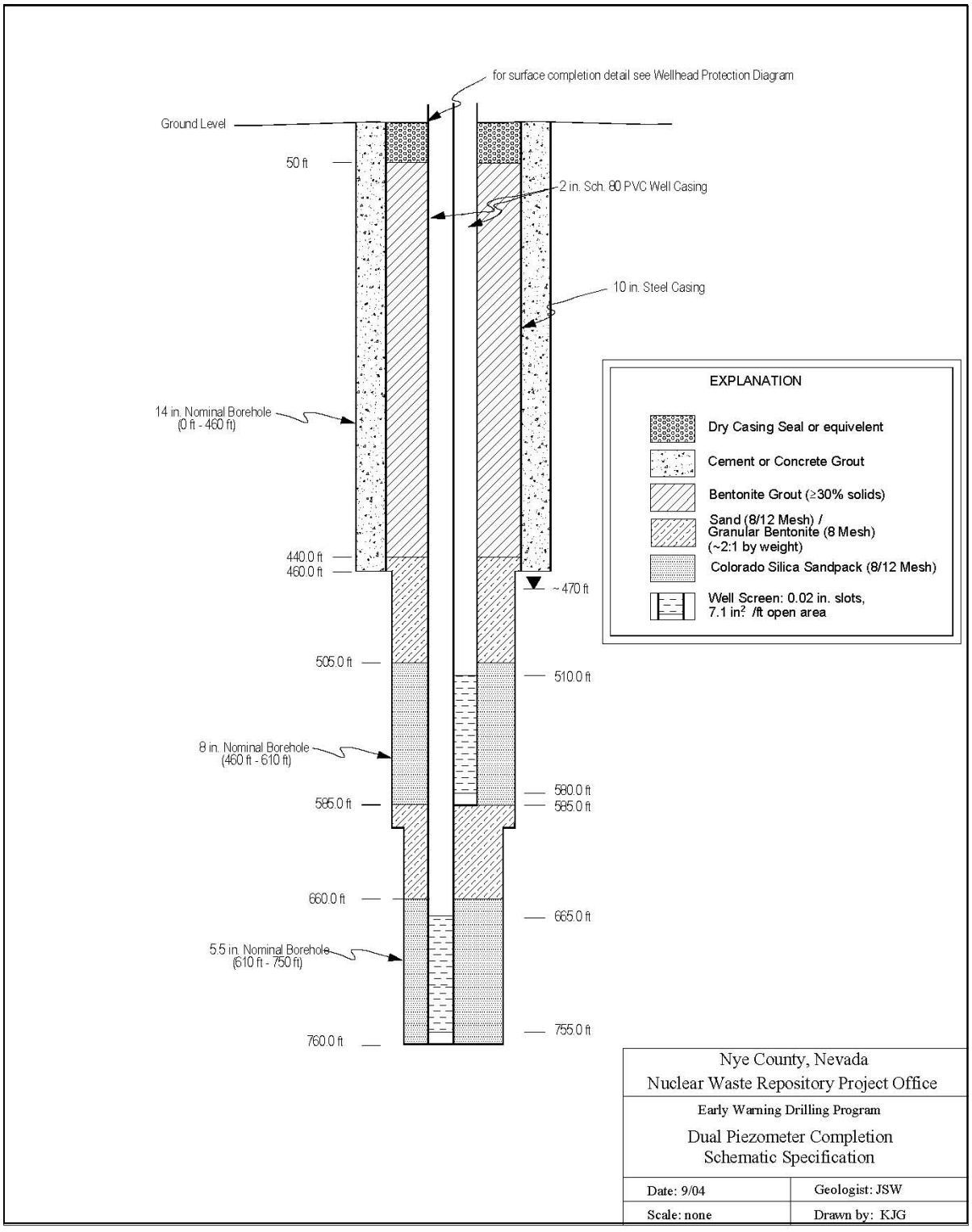

Figure 4
Proposed Completion Diagram for Well NC-EWDP-22PC

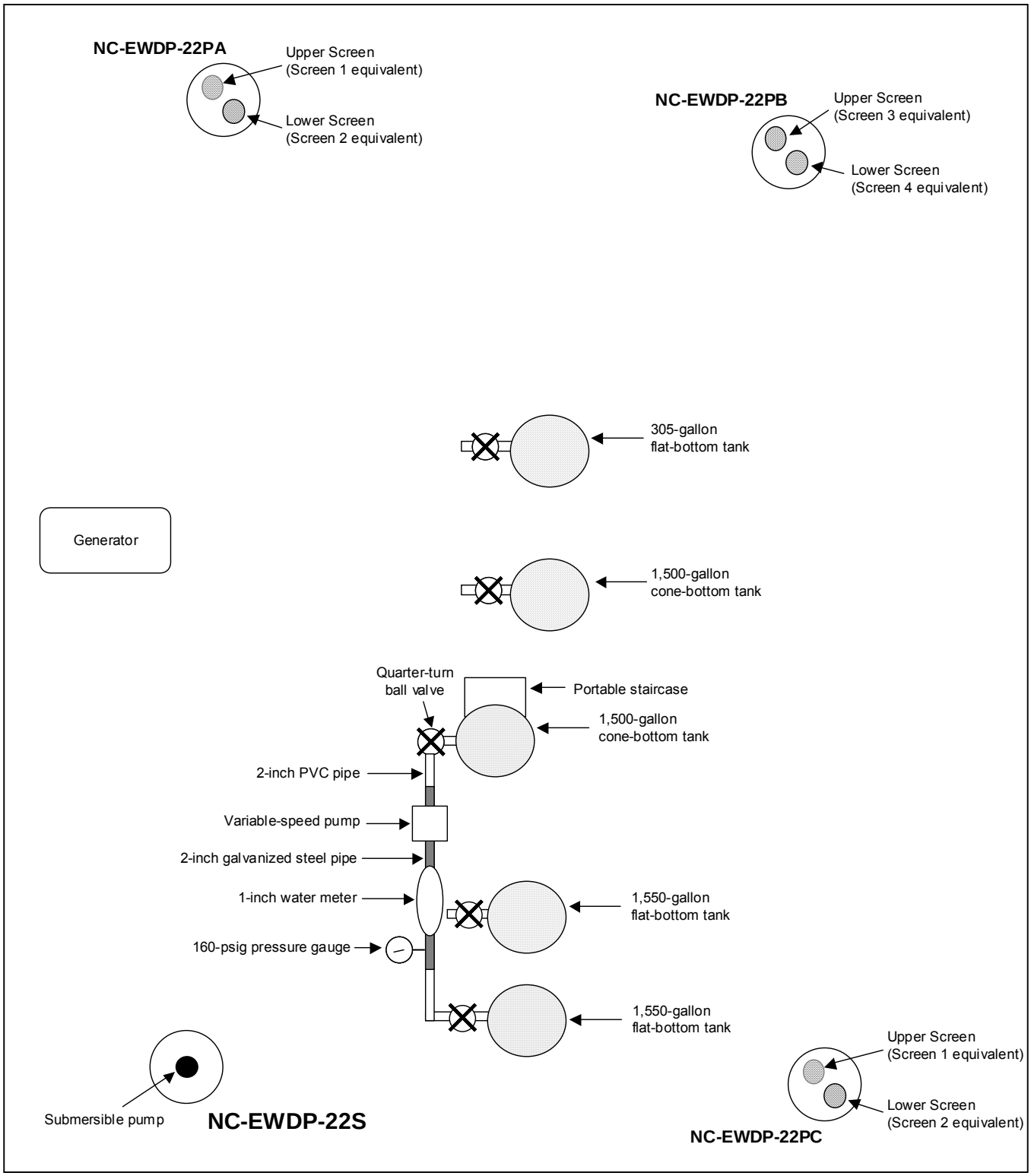

Figure 5
Piping Schematic for Cross-Hole, Multiple-Well Tracer Injection and Pumping at Site 22
Filling of One of Two 1,500 Cone-Bottom Tracer Injection Tanks

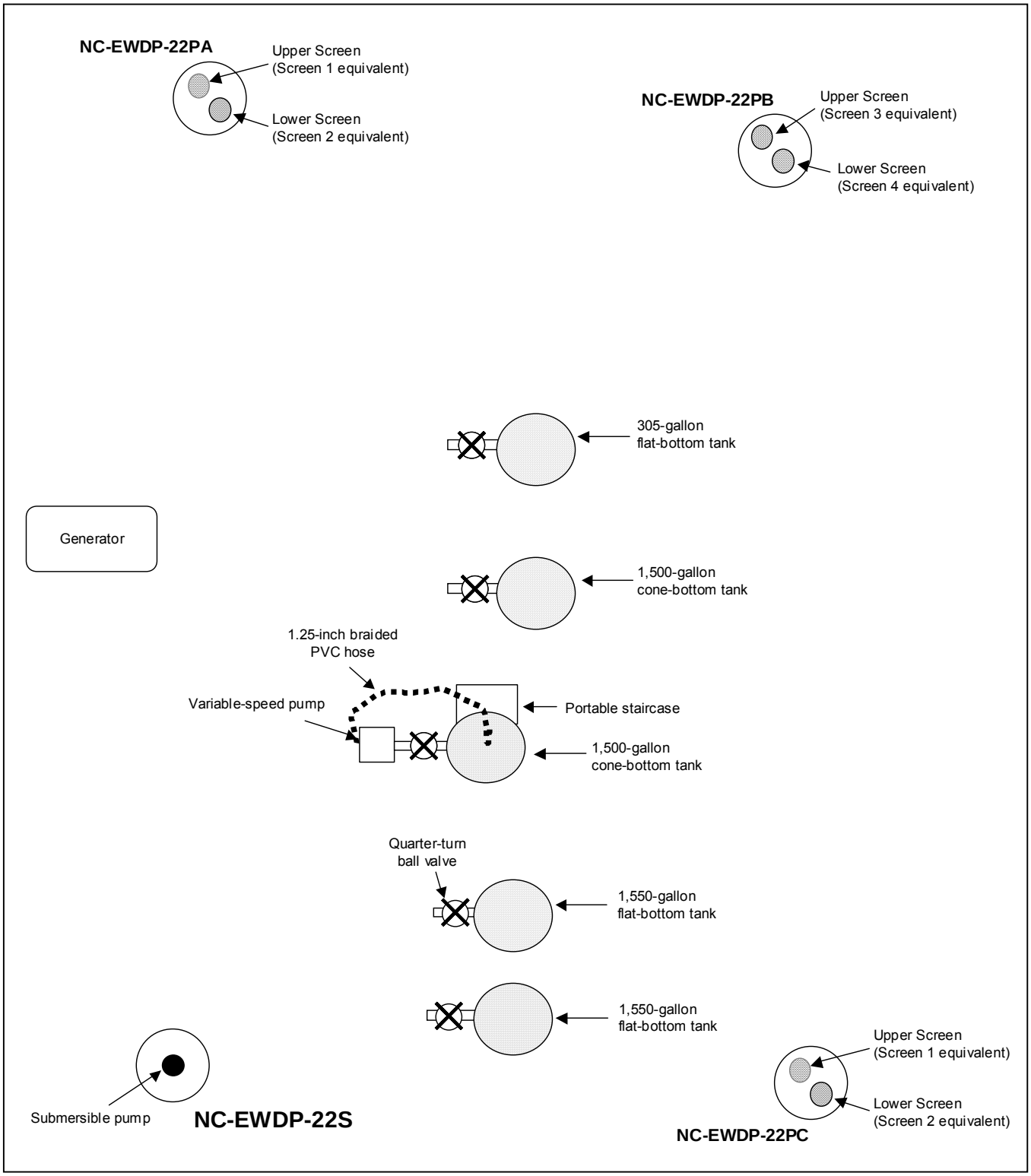

Figure 6
Piping Schematic for Cross-Hole, Multiple-Well Tracer Injection and Pumping at Site 22
Quantitative Tracer Dilution

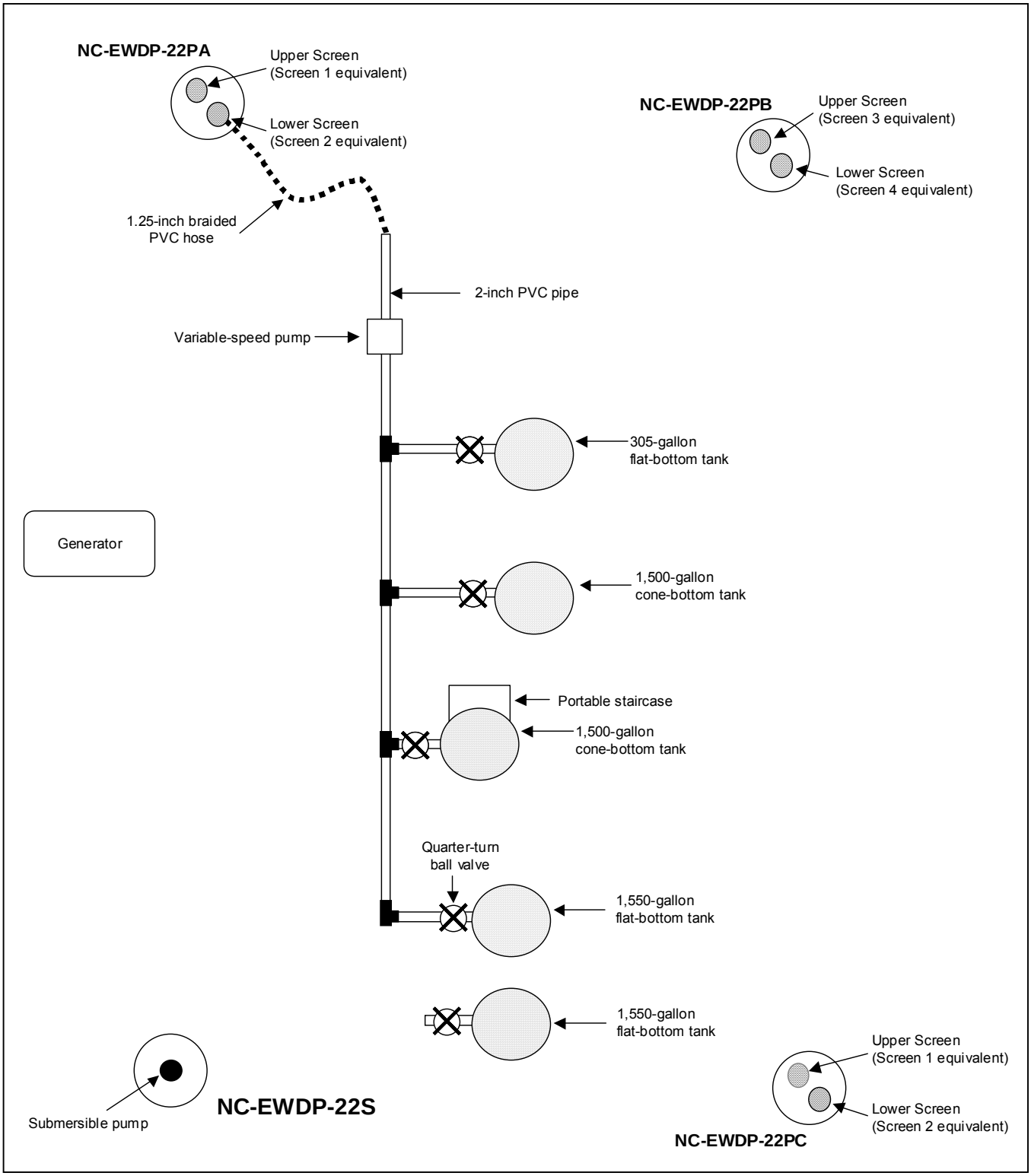

Figure 7
Piping Schematic for Cross-Hole, Multiple-Well Tracer Injection and Pumping at Site 22
Injection Line Connection to 22PA

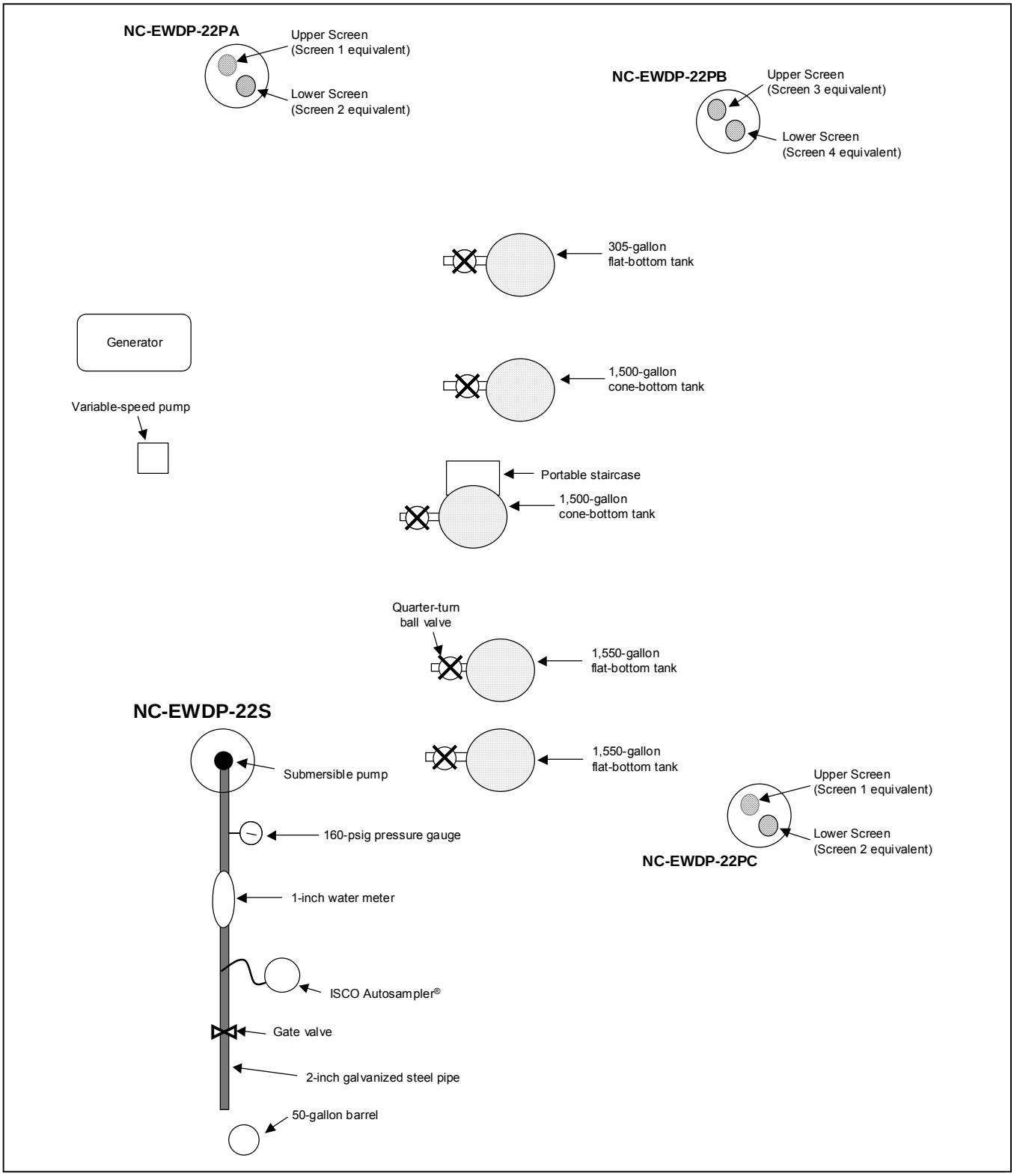

Figure 8
Piping Schematic for Cross-Hole, Multiple-Well Tracer Injection and Pumping at Site 22
Discharge Line Connection

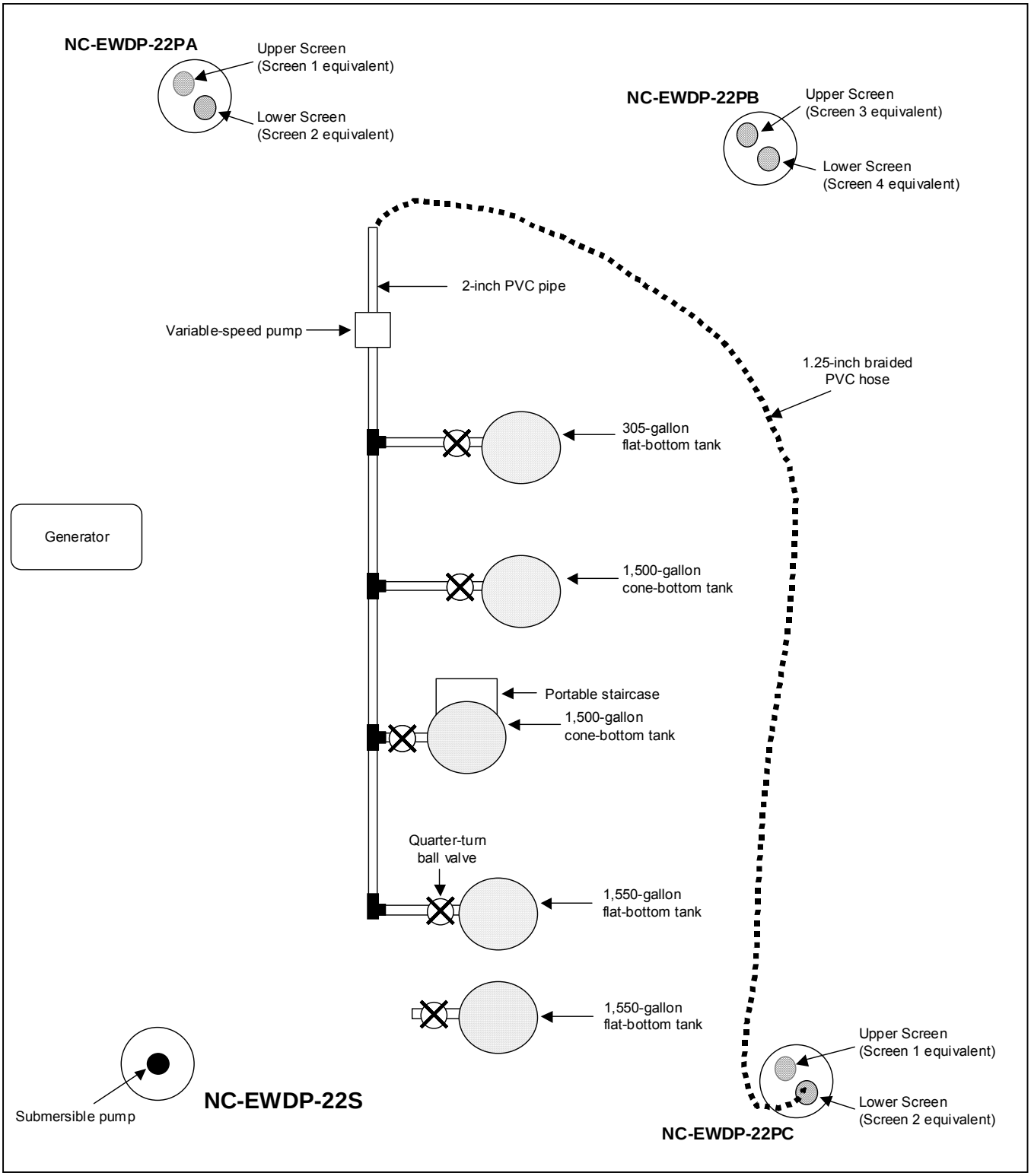

Figure 9
Piping Schematic for Cross-Hole, Multiple-Well Tracer Injection and Pumping at Site 22
Injection Line Connection to 22PC