WORK PLAN
GROUNDWATER MONITORING IN THE NORTH FORK RANCH DEVELOPMENT RATON BASIN, COLORADO

Submitted to:
PIONEER NATURAL RESOURCES USA, INC
WESTERN DIVISION,
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1 INTRODUCTION

Pioneer Natural Resources USA Inc, (Pioneer) is planning to develop Coalbed Methane (CBM) in their held leases within the Spanish Peaks Unit area of the Raton Basin in Colorado. Part of the development will occur within and adjacent to the North Forks Ranch (NFR), a former ranch that has been converted to 35 acre ranchettes. The NFR covers an area of approximately 5.1 square miles. There are forty (40) landowner wells located within or on the border of the NFR, although eighteen (18) of these wells are located in the southern part of the NFR more than ½ mile beyond any of Pioneer's proposed CBM well locations. In addition, there are eight (8) wells located outside of the NFR but within ½ mile of the NFR boundary and a proposed CBM well location. Pioneer has currently drilled three (3) CBM wells within the NFR and eight (8) wells outside of the NFR but within ½ mile of the NFR boundary.

The goal of the monitoring program is to obtain water quality and water level data prior to and during future CBM development from the same aquifers used for water supply by landowners in the NFR. To accomplish this, Norwest Applied Hydrology (NAH) will install monitoring wells into the shallow aquifer system. The new shallow monitoring wells will be completed in the same hydrostratigraphic zone as nearby landowner wells. Where feasible, monitoring wells will be located between the CBM and landowner wells to provide a bellwether of changes to the shallow aquifer from CBM activity. NAH will also sample homeowner wells for baseline water quality characterization.

This work plan describes the tasks that will be performed to establish and maintain a shallow groundwater monitoring program for the North Fork Ranch area. Along with the North Fork Ranch Sampling and Analysis Plan (NAH 2006), it outlines the procedures that will be used to assure that the data obtained from the monitoring program meets the data quality objectives described herein.

2 OBJECTIVES OF PROPOSED MONITORING PROGRAM

The objectives of the monitoring program are to:

- Obtain water quality and water level data from the shallow aquifer prior to and during CBM development. By initiating the monitoring program prior to CBM development Pioneer will be able to document pre-development baseline conditions.
- Monitor water quality and potentiometric levels in the shallow aquifer, including any diagnostic parameters that can help distinguish changes related to CBM activities from the effects of homeowner wells, septic tank systems and other land use activities.

3 MONITORING PROGRAM

Shallow monitoring wells will be installed and water level measurements and water quality sampling and analysis will be conducted, at the shallow monitoring wells and at homeowner wells, prior to and during CBM development. The procedures described below are further detailed in the North Fork Ranch Sampling and Analysis Plan (NAH 2006).

3.1 INSTALLATION OF SHALLOW MONITORING WELLS

Proposed Monitoring Well Locations

The North Fork Ranch Study Area is located in the Raton Basin northeast of the town of Stonewall. The Poison Canyon Formation overlies most of the Study Area. The Poison Canyon Formation consists of interbedded coarse grained conglomerate sandstone, and mudstone and contains little coal but some carbonaceous shale (Johnson and Finn 2001). The Poison Canyon Formation overlies and intertongues with the Raton Formation The geologic strata dip gently to the east as the Study Area lies to the west of the Raton Basin synclinal axis. Most of the water supply wells in the North Fork Ranch Study Area are screened in the Poison Canyon Formation.

The preliminary monitoring well locations shown in Figure 1 were selected to monitor the aquifer used by landowners in the NFR. Most of the sixteen proposed wells are located between proposed CBM wells and homeowner well(s). The locations for the proposed CBM wells identified on the map are approximate and will change based on field inspection of access options, slopes and site conditions. Likewise, the monitoring well locations will also change based on final CBM well locations, access, site conditions and landowner approvals. Table 1 lists the proposed wells and provides the basis for including the wells in the monitoring program. It is anticipated that the eight wells in Table 1 that are listed as medium or highest priority will be installed first.

Monitoring Well Completions

The monitoring wells will be permitted with the Colorado State Engineer's Office (SEO) and will comply with the Water Well Construction Rules issued by the SEO. Screened casing will be set at the major producing zone of the aquifer, with blank casing above this zone. The selection of the production zone will be determined in the field during drilling based on water production, geologic logs and elevations of the well screen intervals in nearby homeowner wells(s). The monitoring wells will be at least four inch in diameter to accommodate down-hole data loggers and sampling pumps.

A sand pack will be installed along the entire screened interval. A bentonite seal, at least two-feet thick, will be installed above the sand pack to provide a proper seal. The remainder of the annulus will be filled with cement or bentonite. The wells will be completed above-grade with protective casing set in a concrete well pad and fitted with a locking cap.

Monitoring wells will be developed by bailing, air lifting and/or surging. Monitoring well development has two objectives:

- To repair damage done to the formation by drilling of the monitoring wells so that natural hydraulic properties are restored.
- To remove any fluids introduced into the formation that might interfere with analysis of the groundwater sample.

Monitoring wells will be developed until pH, temperature, and conductivity have stabilized and turbidity has been reduced to the greatest extent possible. Documentation of the steps taken to develop wells will be recorded in the log book, including pH, temperature, and conductivity measurements, and turbidity observations during well development.

During drilling and well completion, several types of information will be recorded, either on the well completion log or in the field book. Information will include the following:

- Name and/or job number and location of job,
- Name of crew,
- Type and make of drilling rig,
- Weather conditions,
- Surface conditions,
- Date and Time of start and finish of drilling and well completion,
- Monitoring well number and location, including GPS coordinates
- Geologist log and basis for selection of screened interval
- Well completion information
- Well development information

3.2 MONITORING AND SAMPLING OF SHALLOW MONITORING WELLS

Potentiometric Level Data Acquisition

A pressure transducer and data logger will be installed, calibrated, and set to collect potentiometric (water level) data. The data logger will be calibrated using a manual water level indicator. The data logger will be programmed to take a reading every 6 hours. The data loggers

may also be used to record field water quality parameters, including pH, conductance, and temperature, as described below.

A water level reading will be taken manually and pressure data from the data logger will be downloaded during each sampling event. Prior to taking water level measurements or sampling of monitoring wells, the well identification will be verified the field ID tag and a GPS reading of the well location taken and recorded in the field log book. The capped well head will be opened and a gas meter will used to measure head space for combustible gas, hydrogen sulfide, and CO_2. No respiratory hazards are expected. Any unusual odor will be noted in the log book and reported to the NAH project manager immediately.

Water level measurements will be taken from a consistent point marked on the top of the protective well casing. To take a water level measurement, the water level probe is lowered into the well until either the audible or visual alarm activates. Two consecutive readings shall be obtained to verify the measurement and one recorded in the Field Sampling Logbook.

Well Sampling

Baseline water quality samples will be taken after the well has been developed and allowed to fully recover. The analytical parameters for baseline samples are provided in Table 2. The parameter list may be modified or reduced for future sampling events depending on the results of the baseline sampling.

In addition, samples may be collected and sent to a laboratory specializing in stable isotope analysis. The samples will be analyzed for: δD and $\delta^{18}O$ of water, $\delta^{13}C$ of carbon dioxide, and $\delta^{13}C$ and δD of methane, if present. The purpose of these specialized data is to provide information to help in determining the source(s) of groundwater and origin of dissolved methane (COGCC 2003).

Operational water quality sampling will be conducted weekly or as needed during CBM well drilling and well development/fracing, and quarterly thereafter. Additional samples will also be collected following redevelopment or fracing of a nearby CBM well. Operational water samples will be analyzed for field parameters, total metals, major cations and anions, fluoride, bromide, TDS, TSS, sulfides, TPH, and dissolved methane. The field parameters of temperature, specific conductance, and pH will be measured in the field using portable monitoring equipment. In addition, as described below, selected wells may be equipped with water quality sampling probes for continuous measurement of these field parameters.

Well sampling will include the following procedures:

Each day prior to sampling the pH and conductivity meters will be checked for calibration and any actions taken (i.e., calibrated meter or no action required) recorded on the daily field logbook.

Prior to sampling each well, an inspection will be made of the following:

- Monitoring well identification.
- Condition and security of the casing and well cap
- Integrity of lock or seal
- Well pad: cracks, signs of deterioration, erosion, settling, and/or animal and insect burrowing

These observations will be recorded in the log book along with:

- Project name and location (well number);
- Field sample identification;
- Date and time sample was collected;
- Preservative (if applicable);
- Sampler's initials; and
- Analysis type.

Sample Collection

All wells will be equipped with dedicated sample pumps or will be pumped with a portable pump that has been thoroughly cleaned between each well. Before pumping, the depth to water and total well depth will be measured in each well and recorded in the field log book. Each well will purged sufficiently before sampling to ensure representative samples can be collected. After at least 3 well volumes have been removed, samples will be collected periodically and tested for temperature, pH, conductance, and turbidity until these field parameters have stabilized. The pump rate will then be reduced so that samples can be collected with minimum disturbance.

The following procedures will be used to obtain groundwater samples:

(1) Label sample bottles. Fill each sample bottle carefully and avoid overfilling to prevent loss of preservative, if applicable.

(2) Fill BTEX sample vials first. To prevent volatilization, fill the bottle slowly. Make sure there are no bubbles or headspace in the sample bottle and ensure that a meniscus has developed before capping.

(3) For dissolved gas samples (dissolved methane and CO_2 analysis) follow appropriate procedures as described in Norwest Applied Hydrology's sampling and analysis plan (NAH 2006).

(4) Seal sample bottles with evidence (custody) tape. Chain-of-custody documentation is required for all samples shipped to a laboratory for analysis.

(5) Place sample bottles under ice in a cooler and transport to the laboratory.

In addition, all equipment that is reused between sampling locations will be thoroughly decontaminated in the field. At least one rinsate sample will be collected to document adequate equipment decontamination each day.

Handling of hydrocarbons (e.g., fuel containers) will be minimized but, if necessary, will be performed wearing Nitrile gloves that are discarded after such handling. Fresh Nitrile gloves will be donned whenever there is a chance of contact with groundwater at the site. Gloves will be changed between each well to reduce the risk of cross-contamination of samples.

Post-sampling Activities and QA/QC

A blind duplicate sample will be collected from one monitoring well during each sampling event or for each ten wells sampled. The sample bottles will be labeled with an identifier that will not allow the laboratory to determine which well was sampled. Results from the blind duplicate samples will be compared with those collected from the same well to confirm laboratory consistency.

One trip blank will accompany each shipment to the laboratory for VOCs (BTEX). Trip blanks provide a check on sample handling and analytical procedures to ensure that chemicals are not introduced into water samples by outside factors or laboratory procedures. These blanks consist of VOA vials filled with distilled water that are analyzed for BTEX. Trip blanks are typically prepared by the lab, but are sometimes created on site. Each trip blank is individually sealed in bubble pack and placed in coolers along with groundwater samples.

Samples will be delivered with their proper Chains of Custody (COC).

After sampling each well will be secured with its locking well cap replaced and locked.

3.3 SAMPLING OF HOMEOWNER WELLS

Pioneer voluntarily offered to sample any water wells of property owners in the NFR who had concerns about their drinking water supply. As part of this work plan, additional wells will be sampled, with homeowner's permission, in areas near where CBM development is planned.

Preparation for Sampling

Prior to sampling, the well identification will be verified and a GPS reading of the well location taken and recorded in the field log book. If the well head can be opened, a gas meter will used to measure head space for combustible gas, and hydrogen sulfide, and CO_2. Any unusual odor will be noted in the log book and reported to the NAH project manager immediately.

If possible, a water level reading will be taken manually prior to sampling. Water level measurements will be taken from a consistent point marked on the top of the protective well casing. To take water level measurement, the water level probe lowered into the well until either the audible or visual alarm activates. Two consecutive readings shall be obtained to verify the measurement and one recorded in the Field Sampling Logbook.

Well Sampling

Initially, Homeowner water supply wells will be sampled for baseline water quality characterization. The analytical parameters for baseline samples are provided in Table 2. Additional samples will be obtained if there is a homeowner complaint or a nearby monitoring well shows changes that may be related to CBM drilling or production activities.

Prior to collecting water samples, water will be allowed to run for a sufficient period of time to represent typical homeowner daily use. Specific conductance, pH, and temperature will be measured periodically and recorded in the field data book. Samples will be collected in accordance with the procedures described in Section 3.2 for sampling of shallow monitoring wells.

3.4 EQUIPMENT REQUIREMENTS

The list of equipment required for the testing program and the responsibility for installation or acquisition are summarized in Table 3. The monitoring wells will be equipped, at a minimum, as follows:

- NAH will install a submersible pump, pressure transducer, and data logger in each of the monitoring wells. The pump intake will be set near the base of the well casing, just above the top of the target aquifer. Transducers with a suitable range to cover the anticipated bottom-hole pressure will be installed approximately 20 feet above the pump in each well. The transducers are equipped with vented cable so that no compensation for barometric pressure will be necessary.

- Pressure transducers will be equipped with a data logger, which will be programmed by the field personnel for the type of test being performed. Data from the logger will be downloaded using a laptop computer.

- NAH will ensure that appropriate connections are available at the wellhead for the pressure transducers and manual water level measurements. The pressure transducer cable is typically run through a 1" I.D. male NPT fitting.

The position of the transducer with respect to the wellhead elevation datum will be accurately recorded. This will allow the recorded pressure (in psi) to be converted to equivalent head, and expressed as a water level elevation. Data will be converted to actual water level elevation in the well by subtracting the head indicated by the wellhead pressure gauge (in psi converted to feet of water).

Measurement accuracy for the transducers is approximately 0.1% of total range. For a 50 psi transducer, this equates to 0.05 psi or about 0.11 feet. The precision of the transducer measurements is approximately 0.01% of full range, or 0.005 psi (about 0.011 feet). This will allow water level changes of about 0.011 feet to be recorded accurately. Transducers will be periodically checked against manual measurements to see if there has been any significant instrument drift over time. Corrections will be applied to the data to account for any transducer drift.

Selected wells may also be equipped with probes to measure field water quality parameters including pH, specific conductance, and temperature. The data from these probes would be recorded by the data logger and downloaded periodically to provide further, real-time indications of changes in groundwater quality. The feasibility and potential benefit of installing water quality probes in the monitoring wells will be evaluated once the wells are installed and equipped with pressure transducers, data loggers, and sampling pumps.

4 DATA MANAGEMENT

All manual field data readings, data collected from the data loggers, and data collected by the pumping contractor at the pumping well will be reduced to digital format that can be input into various analytical and numerical software. The data will be stored, along with electronic data from the laboratory, in a relational database maintained by NAH. The database will be reviewed periodically to assure that the appropriate data are being collected and stored. NAH will provide Pioneer with copies of all raw and reduced data and will produce reports and analysis of the data whenever needed.

5 REFERENCES

NAH, 2006. Sampling and Analysis Plan, North Fork Ranch, *in preparation.* Norwest Applied Hydrology, Denver, Colorado

Johnson and Finn, 2001. Potential for a Basin-Centered Gas Accumulation in the Raton Basin, Colorado and New Mexico. *In* U.S. Geological Survey Bulletin 2184-B. U.S. Geological Survey, Reston, Virginia

COGCC, 2003. COGCC Raton Basin Baseline Study Staff Report, October 27, 2003. Colorado Oil and Gas Conservation Commission, Denver, Colorado

TABLE 1
PROPOSED MONITORING WELLS

Well ID number	Proposed location	Estimated surface elevation	Nearest water well depth (ft)	Nearest CBM Well	CBM well status	Discussion
1	T32S,R68W,Sec 22,SE,NE	8500	?	Shining 31-21	Current Proposed	Highest priority, near planned CBM and water wells
2	T32S,R68W,Sec 35,NW,NW	8000	110	Keystone 11-35	Current Proposed	Highest priority, CBM well drilling planned nearby
3	T32S,R68W,Sec 35,NW,SE	8000	170	Niagara 23-35	Current Proposed	Highest priority, CBM well drilling planned nearby
4	T32S,R68W,Sec 35,NE,NE	8200	1000	Sanchinator 11-36	Current Proposed	Highest priority, CBM well drilling planned nearby
5	T32S,R68W,Sec 35,SE,NE	8000	140	Molokai 13-36	Well drilled	Highest priority, alleged well impacts
6	T32S,R68W,Sec 27, NE,NW	8200	?	Flashback 32-27	Well drilled	Medium priority, CBM well near drainage
7	T32S,R68W,Sec 25,SW,NW	8300	1000	Magnum 43-26	Current Proposed	Medium priority, between three planned CBM wells
8	T32S,R68W,Sec 26,NE,SW	8200	140	Home Run 32-26	Current Proposed	Medium priority, near planned CBM and water wells
9	T32S,R68W,Sec 35,SW, NE	8000	110	Reef 42-35	Future Proposed	Lowest priority, future CBM well area
10	T32S,R68W,Sec23,SW,NW	8420	117	Mother Earth 11-33	Future Proposed	Lowest priority, future CBM well area
11	T32S,R68W,Sec 26,SW,SE	8300	?	Whistler 24-23	Current Proposed	Lowest priority, no water wells near planned CBM well
12	T32S,R68W,Sec 35,NW,SE	7700	?	NFRA_7 33-35	Future Proposed	Lowest priority, future CBM well area
13	T32S,R68W,Sec 26,NE,SW	8100	140	Volunteer 32-26	Future Proposed	Lowest priority, future CBM well area
14	T32S,R68W,Sec 35,SW,SW	7700	507	NFRA_6 41-35	Future Proposed	Lowest priority, future CBM well area
15	T32S,R68W,Sec 26,SE,SW	8200	?	Divide 13-26	Current Proposed	Lowest priority, no water wells near planned CBM well
16	T32S,R68W,Sec 26, SW,NW	8100	?	NFRA_3 43-27	Future Proposed	Lowest priority, future CBM well area

TABLE 2
BASELINE ANALYTICAL PARAMETERS

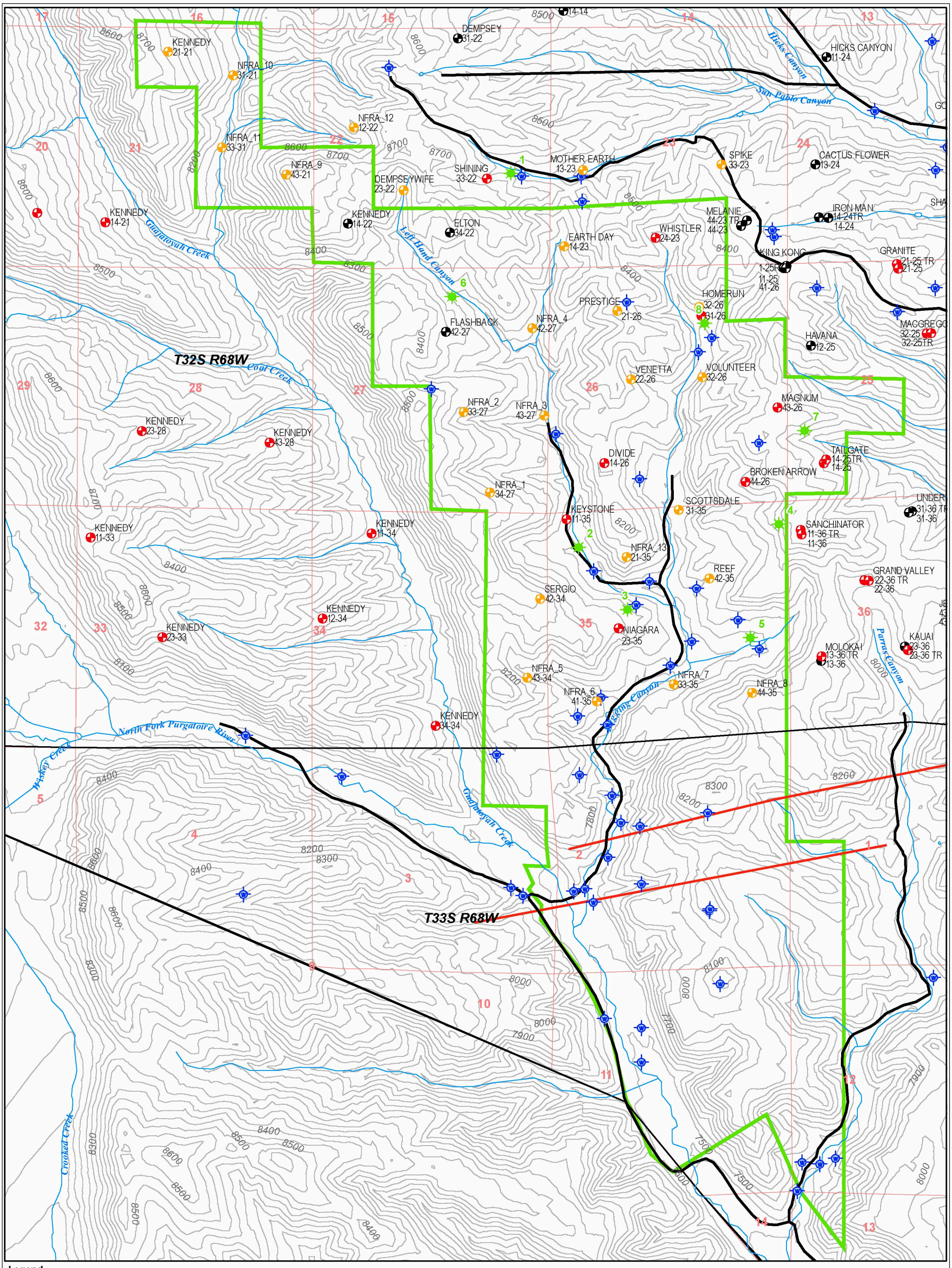
Analyte	Reporting Limit	Units	Methods
MAJOR IONS			
Fluoride	0.2	mg/L	EPA 300.0
Chloride	1.0	mg/L	EPA 300.0/325.2
Nitrite	0.1	mg/L	EPA 300.0
Bromide	0.2	mg/L	EPA 300.0
Nitrate	0.1	mg/L	EPA 300.0
Sulfate	5.0	mg/L	EPA 300.0
Carbonate	5.0	mg/L	EPA 310.1
Bicarbonate	5.0	mg/L	EPA 310.1
Alkalinity	5.0	mg/L	EPA 310.1
Sulfide	0.05	mg/L	EPA 376.2
Sodium	250	*u*g/L	EPA 200.8
Potassium	250	*u*g/L	EPA 200.8
Magnesium	250	*u*g/L	EPA 200.8
Calcium	250	*u*g/L	EPA 200.7
METALS			
Arsenic	2.5	*u*g/L	EPA 200.8
Barium	5	*u*g/L	EPA 200.8
Boron	5	*u*g/L	EPA 200.8
Cadmium	5	*u*g/L	EPA 200.7
Chromium	10	*u*g/L	EPA 200.7
Copper	2.5	*u*g/L	EPA 200.8
Iron	100	*u*g/L	EPA 200.8
Lead	1.5	*u*g/L	EPA 200.8
Manganese	5	*u*g/L	EPA 200.8
Selenium	4	*u*g/L	EPA 200.8
Silver	10	*u*g/L	EPA 200.7
Zinc	20	*u*g/L	EPA 200.7

Analyte	Reporting Limit	Units	Methods
PHYSICAL PROPERTIES			
pH	0.1		EPA 150.1
Temperature			
Specific Conductance			
TDS (Total Dissolved Solids)	10	mg/L	EPA 160.1
TSS (Total Suspended Solids)	4	mg/L	EPA 160.2
DISSOLVED GASES			
Methane	5	*u*g/L	RSK SOP-175
Ethane	5	*u*g/L	RSK SOP-175
Ethene	5	*u*g/L	RSK SOP-175
HYDROCARBONS			
Diesel Range Organics	250	*u*g/L	SW846 8015B
Benzene	0.5	*u*g/L	SW846 8021B
Toluene	0.5	*u*g/L	SW846 8021B
Ethylbenzene	0.5	*u*g/L	SW846 8021B
Total Xylenes	0.5	*u*g/L	SW846 8021B

TABLE 3
EQUIPMENT REQUIREMENTS AND STATUS

Equipment	Responsibility
Field meters (pH, Temp., Conductance)	Contractor/AHA
Gas meter (combustible gas, H_2S, CO_2)	Contractor/AHA
Portable GPS unit	Contractor/AHA
Sampling pumps	Pioneer/AHA
Data loggers, pressure transducers, and Divers	Contractor/AHA
Laptop computers with software	Contractor/AHA
500' Water water level meter	Contractor/AHA
Pick-up truck	Contractor
Cell phone	Contractor

FIGURE 1
LOCATION OF PROPOSED MONITORING WELLS



Legend

- Proposed Monitoring Well
- Current Proposed CBM Well
- Future Proposed CBM Well
- Drilled CBM Well
- Water Well
- Topographic Contours
- Streams
- Dikes
- Roads
- North Fork Subdivision
- Townships
- Sections

Figure 1 - Monitoring Well Locations

North Fork Ranch Subdivision

Date:10/11/2006
Magdaléna Dohnalová

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0 0.25 0.5 1
Miles

Projection Information:
Universal Transverse Mercator
North American Datum 1927
Zone 13 N
meters

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