Groundwater Baseline Monitoring Program – Swan

Scope of Work: Shell Western Exploration and Production Incorporated (SWEPI LP) has elected to implement a baseline groundwater monitoring program (Program) for its exploration and production facilities included in the Swan Project Area in northwest Colorado. The program is a combination of the Colorado Oil & Gas Association (COGA) Voluntary Baseline Groundwater Quality Sampling Program dated November 15, 2011 and COGCC baseline groundwater monitoring requirements for the Dawson Creek 1-25 permitted drilling location. Where elements of the two monitoring programs differ, the more stringent element is being followed.

Task 1 – Identification of Sampling Locations

Using the Colorado State Engineer's Permitted Water Well database, SWEPI LP will identify the two closest private water wells or springs/seeps within a one-mile radius of the proposed drilling locations. SWEPI LP will plot the identified well and/or spring/seep locations on USGS Topographic maps. If numerous wells or springs/seeps are located in the target area, SWEPI LP's preference for downgradient domestic water wells at locations will be used to select the two wells or springs/seeps to be sampled. SWEPI LP staff will secure access to the locations to be monitored and will contact the landowner directly and make arrangements to visit their property and access their well(s) for sampling purposes. If access cannot be secured, SWEPI LP will note that access could not be secured and will attempt to secure access to another appropriate sampling location(s).

Task 2 - Preparation of Sampling and Analysis Plan

SWEPI LP will prepare a Sampling and Analysis Plan (SAP) to meet the program elements of both COGCC and COGA.

Task 3 – Sample Collection

3rd party qualified field staff will visit each sampling location and collect water samples from the private water well(s)/alternate sources, and will measure field water quality parameters at the time of collection. The field scientist will note odor, water color and effervescence during the sampling process. Each water sample will be field screened for conductivity, temperature and pH. The location of the water well or spring/seep will be determined using a global positioning system (GPS) datalogger.

The samples will be analyzed for the constituents listed in Table 1.

An additional one-liter plastic sample bottle with appropriate preservatives will be filled at the time of sampling and held, pending the results of the dissolved methane analysis, for analysis of Fixed Gases C1-C6 by US EPA Method RSK175 and Stable Isotopic Concentration of the Carbon and Hydrogen in Methane by US EPA Method NG-1.

Task 4 - Sample Analysis

The water samples will be submitted to the appropriate 3rd-party laboratory under strict chain-of-custody documentation. If dissolved methane is detected above 1.0 milligrams per liter (mg/L), SWEPI LP will submit the additional sample bottle to another 3rd party laboratory for analysis of gas composition and analysis of the carbon and hydrogen isotope ratios of methane.

Task 5 - Data Evaluation and Report Preparation

SWEPI LP will prepare a brief report that will include the following:

- A summary of the water quality data for all wells/sources sampled;
- Comparison of the laboratory analytical results to established federal drinking water standards and other water quality criteria established in the State of Colorado for private water wells/alternate sources. The locations of all wells sampled will be shown on an area map;
- Photographs of each well location (identified by location); and
- A description of the field sampling methods and laboratory analytical methods utilized.

Upon completion of the sampling program, SWEPI LP will deliver to the COGCC a CD-ROM containing the data collected, including the laboratory reports. A separate stand-alone report will also be prepared and submitted to each water well/alternate source owner. All reports will be completed and provided to the appropriate parties within 90 days of the sampling event.

Monitoring After Completion of Production Well

SWEPI LP will perform post-completion monitoring of the selected locations at the following frequencies:

- Within 12 months of completion of the production well
- Within 3 years of completion of the production well
- Within 6 years of completion of the production well

Additional post-completion monitoring may be performed if changes in water quality are identified during follow-up testing. If, after the production well is drilled, water sample testing indicates any abnormalities or petroleum hydrocarbon-related impact, SWEPI LP will notify the COGCC within 10 days of receipt of sample results and initiate discussions to determine appropriate corrective actions to be undertaken.

Table 1
Groundwater Baseline Monitoring Program

Analytes	Analytical Method	COGA Program Required Analysis	COGCC Required Analysis	Additional Shell Required Analysis
Field Measurements				
Conductivity	SM2510B	**x**	**x**	
Temperature	Field Measurement	**x**	**x**	
Flow	Field Measurement	**x**	**x**	
pH (field)	Field Measurement	**x**	**x**	
Odor	Field Observation	**x**	**x**	
Water Color	Field Observation	**x**	**x**	
Effervescence	Field Observation			**x**
Volatile Organic Contaminants				
Benzene	EPA Method 8021 or 8260	**x**	**x**	
Toluene	EPA Method 8021 or 8260	**x**	**x**	
Ethylbenzene	EPA Method 8021 or 8260	**x**	**x**	
Xylenes (o- and m- + p- varieties)	EPA Method 8021 or 8260	**x**	**x**	
TPH-GRO	EPA Method 8015			**x**
TPH-DRO	EPA Method 8015			**x**
Dissolved Gases				
Ethane	EPA Method RSK-175	**x**	**x**	
Methane*	EPA Method RSK-175	**x**	**x**	
Propane	EPA Method RSK-175	**x**	**x**	
Lower Explosive Limit (LEL)	Field Measurement			**x**
Metals				
Arsenic	M200.8 ICP-MS			**x**
Barium	M200.7 ICP			**x**
Boron	M200.7 ICP	**x**	**x**	
Cadmium	M200.8 ICP-MS			**x**
Calcium	M200.7 ICP	**x**	**x**	
Chromium (Total)	M200.7 ICP			**x**
Copper	M200.7 ICP			**x**
Iron	M200.7 ICP	**x**	**x**	
Lead	M200.8 ICP-MS			**x**
Magnesium	M200.7 ICP	**x**	**x**	
Manganese	M200.7 ICP	**x**	**x**	
Mercury	M245.1 CVAA			**x**
Potassium	M200.7 ICP	**x**	**x**	
Selenium	M200.8 ICP-MS	**x**	**x**	
Silver	M200.7 ICP			**x**
Sodium	M200.7 ICP	**x**	**x**	
Strontium	M200.7 ICP	**x**	**x**	
General Chemistry				
Alkalinity (total as $CaCO_3$)	SM 2320B	**x**	**x**	
Bromine/Bromide	EPA 200.7or 200.8/SW846 6010C or SW846 6020	**x**	**x**	
Carbonate /Bicarbonate	M300.0 - Ion Chromatography			**x**
Cation-Anion Balance	M300.0 - Ion Chromatography			**x**
Chlorine / Chloride	SM2340B - Calculation	**x**	**x**	
Fluorine/Fluoride	SM2320B - Titration			**x**
Hardness	M353.2 - H_2SO_4 preserved			**x**
Methylene Blue Active Substances	ASTM D2330-88(1995)e1			**x**
Nitrate and Nitrite as total N	SM2540C	**x**	**x**	
Phosphorus	USGS - I1738-78	**x**	**x**	
SAR (Sodium Absorption Ratio)	Calculation	**x**	**x**	
Silica	M200.7 ICP			**x**
Sulfate (SO_4)	Calculation	**x**	**x**	
Total Dissolved Solids	SM2540C	**x**	**x**	