# ADEQ

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Department of Environmental Quality

AFIN: ______ Permit No.: ______
Date: 11/30/07 By: ______
Project: El Dorado Chemical Company
Remedial Action Workplan
Sheet ___ of ___



1. Executive Summary, page i: The third bullet states "Periodic review of off-site domestic wells". Explain/Clarify. Does this "review" include or consist of sampling or monitoring of the off-site domestic wells? What is meant by periodic? Semi-annually? Annually? Bi-annually?

   What is the relationship (depth, stratigraphy, i.e., hydrogeology) between the ammonia contamination, groundwater recovery system, and the off-site domestic wells?

2. 1.1 Purpose and Objectives, page 1 and 1.2 Risk Assessment Findings, page 2: What is/was the concentration of ammonia in the groundwater?

   What is the extent of ammonia contamination in the groundwater (i.e., what is the size of the plume?)?

3. 2.3 Selected Remedy, pages 6-7: What is the pumping rate (i.e., gpm) of the recovery wells?

   What is the size (extent) of the capture zones for the recovery wells?

# Remedial Action Workplan

Prepared for:

**El Dorado Chemical Company**
**4500 North West Avenue**
**El Dorado, AR 71730**

Prepared by:

**GBM$^c$ & Associates**
**219 Brown Lane**
**Bryant, AR 72022**

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# EXECUTIVE SUMMARY

El Dorado Chemical Company (EDCC) has performed a Human Health and Ecological Risk Assessment (HHERA) on shallow groundwater and determined that there are no current receptors for site groundwater, therefore there are no current risks associated with the groundwater.

One of the purposes of the HHERA was to identify constituents that pose excessive risk, thus guiding the remedial actions to mitigate those risks. Because there are no current receptors, the HHERA used hypothetical future exposure pathways to assess if any significant risks could exist for any of the parameters evaluated. The results of the hypothetical evaluation indicated a potential need to establish a proposed monitoring end-point for the one constituent (ammonia) that may become a potential human health risk should an off-site residential exposure scenario be completed.

Several remediation methods have been considered to complement the continued operation of the existing groundwater recovery system, initiated in November 2006. Site conditions are favorable for monitored natural attenuation, most importantly because ammonia contamination is not currently affecting or threatening potential down-gradient receptors and additional contaminant loading is being eliminated at the source zone. Thus, the Remedial Action Workplan (RAP) proposed for the EDCC site consists of the following elements:

- Continued operation/maintenance of the groundwater recovery system
- Semi-annual groundwater monitoring to support assessment of natural attenuation processes
- Periodic review of off-site domestic wells

The EDCC property has been used for industrial purposes since 1943. Current and future industrial use and/or control of the property were considered in the selection of the site remedy.

# 1.0 INTRODUCTION

EDCC manufactures basic agricultural chemicals, including sulfuric acid, nitric acid, low-density and high-density ammonium nitrate prills used in fertilizers and explosives, and industrial grade ammonium nitrate solution. The facility is located at 4500 North West Avenue in El Dorado, Union County, Arkansas. The Plant is located on a total area of approximately 1,300 acres and the manufacturing area covers approximately 150 acres.

This document presents the proposed remedial actions to address potential risks identified as a result of the human health and ecological risk assessment (HHERA) for groundwater impacted by industrial activity at El Dorado Chemical Company (EDCC). The risk assessment was completed in accordance with the requirements of Consent Administrative Order (CAO) LIS No. 06-153 and submitted to ADEQ on August 9, 2007. The HHERA findings are the basis for development of the Remedial Action Workplan (RAP) for mitigation of potential risks associated with site groundwater.

## 1.1 Purpose and Objectives

The HHERA determined there are no completed exposure pathways for site groundwater, therefore no risks to human or ecological receptors. Nevertheless, the HHERA quantified hypothetical risks assuming an off-site exposure to groundwater were to occur. The purpose of the RAP is to propose corrective actions to reduce or eliminate human health and/or ecological risks; in this case, measures that will maintain the current incomplete exposure pathways in the future. The objectives of the RAP include:

a) identify a remediation strategy to address hypothetical risks resulting from site groundwater, and
b) establish preliminary monitoring and/or remediation endpoints in site groundwater based on the findings of the HHERA.

During implementation of the RAP, there may be a need to implement procedures for the systematic evaluation and enhancement of site remediation processes to ensure that human health and the environment are being protected over the long term at minimum risk and cost. The need to review and update the RAP may arise based on additional groundwater monitoring data, revised site information, scientific advances, regulatory changes, evaluation of remediation technologies, or other site specific information that becomes available as remediation strategies are implemented.

This will allow for consideration to be given to the reevaluation of remediation goals and a way that potentially inapplicable or unattainable goals can be updated.

## 1.2 Risk Assessment Findings

The potential exposure pathways were evaluated for human health and ecological effects at the EDCC property boundary. This exposure is purely hypothetical as there is no evidence that contaminated groundwater has migrated off the EDCC property. Based on the hypothetical exposure, the HHERA (Section 5.5.3) identified ammonia as the constituent that may need to be addressed in the RAP.

# 2.0 REMEDIAL ACTION

Remedial action may be necessary where the threat of human or ecological exposure to a constituent presents an unacceptable risk. EDCC has determined that only hypothetical future groundwater exposure scenarios exist at the El Dorado site and thus there is no unacceptable risk to potential receptors. Nevertheless, actions to monitor the status of groundwater contaminants and prevent future completion of exposure pathways are necessary to ensure maintenance of the minimal risk associated with site groundwater.

## 2.1 Remediation Strategy

The strategy for corrective action at the EDCC site is based on protection of the current status of no onsite or off-site groundwater receptors that could be exposed to chemicals of potential concern evaluated in the HHERA. Because there are no off-site residential receptors and no ecological pathway has been identified, the remedial approach should be proportional to the actual health or ecological risk. The proposed remedial measures will consist of continuation of the existing groundwater treatment system, institutional controls to prevent the potential for on site exposure, continued groundwater monitoring at the property boundary and periodic assessment of off site groundwater use to ensure that the risk to off site receptors continues to be excluded, and monitored natural attenuation as a long term remediation strategy. Natural attenuation will be assessed through continued monitoring of key onsite groundwater indicators.

## 2.2 Remedial Alternatives

Remedial alternatives considered for ammonia in the EDCC groundwater included active and passive technologies, *in-situ* as well as extraction and recovery/treatment. A brief overview of treatment alternatives that are potentially applicable to ammonia remediation is provided in the following sections.

### 2.2.1 Monitored Natural Attenuation

Natural subsurface processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions may reduce contaminant concentrations to acceptable levels. The goal of a monitored natural attenuation program is to confirm that the plume is shrinking or stable, and that contaminant degradation is proceeding at rates consistent with meeting cleanup objectives.

As the term Monitored Natural Attenuation implies, passive processes that result in the reduction of contaminants in groundwater are assessed through periodic analyses to statistically determine if the reduction is occurring and if so, at a rate suitable to prevent potential risk to receptors. Typically, the constituent of concern and its daughter products or other indicator parameters are routinely monitored and evaluated after a sufficient period of time (three to five years) has elapsed to establish statistical trends for the parameters. The statistical assessment performed upon completion of the monitoring period may be used to guide a determination of "no further action required" or direct additional investigation at that time.

### 2.2.2 *In-situ* Bionitrification

Enhanced *in-situ* bioremediation systems stimulate the biodegradation of certain contaminants by manipulating conditions that affect microbial populations in the subsurface. Microbes responsible for bioremediation generally require a source of carbon, an electron donor, an electron acceptor, appropriate nutrients, and a suitable temperature and pH range.

Enhanced *in-situ* bionitrification is a remediation technology where oxygen is introduced to a ammonia contaminated aquifer. Indigenous aerobic bacteria convert ammonium ions ($NH_4^+$) to cell mass during aerobic respiration. Ammonium ion is the most readily usable form among all inorganic forms of nitrogen. Its use does not require an oxidation-reduction reaction because its nitrogen atom is at the same oxidation level as the nitrogen atom of amino acids, purines, and pyrimidines, precursors for proteins and nucleotides. Ammonia-nitrogen can be considered as 100% available for nutritional use by bacteria. As oxygen in the aquifer becomes depleted from nitrification, levels may be replaced through extraction, aeration and reinjection of aerated groundwater.

## 2.2.3 Phytoremediation

The US EPA's Phytoremediation Resource Guide defines six types of phytoremediation mechanisms, including phytoaccumulation, phytodegradation, phytostabilization, phytovolatilization, rhizodegradation, and rhizofiltration. The phytoremediation mechanisms applicable to ammonia remediation include phytodegradation, phytostabilization, and rhizodegradation.

- Phytodegradation, also called phytotransformation, is the breakdown of contaminants taken up by plants through metabolic processes within the plant, or the breakdown of contaminants external to the plant through the effect of compounds, such as enzymes, produced by the plants. Pollutants are degraded, used as nutrients, and incorporated into plant tissues.

- Phytostabilization is the use of certain plant species to immobilize contaminants in soil and groundwater through absorption and accumulation by roots, adsorption onto roots or precipitation within the root zone, and physical stabilization of soils. This process reduces the mobility of the contaminant and prevents migration in groundwater. Depending on the type of trees, climate, and season, trees can act as organic pumps and establish hydraulic control of the groundwater.

- Rhizodegradation, also called phytostimulation, is the breakdown of contaminants in the soil through microbial activity that is enhanced by the presence of the rhizosphere. Natural substances released by the plant roots (e.g., sugars, alcohols, and acids) contain organic carbon that is utilized by microorganisms. Rhizodegradation is aided by the way plants loosen the soil and transport oxygen and water to the area. The plants also enhance biodegradation by other mechanisms such as breaking apart clods and transporting atmospheric oxygen to the root zone.

## 2.2.4 Permeable Reactive Barrier

A permeable reactive barrier (PRB) is a continuous, *in-situ* permeable treatment zone designed to intercept and remediate a contaminant plume. The treatment zone may be created directly using reactive materials or indirectly using materials designed to stimulate secondary processes, such as by adding carbon substrate and nutrients to enhance microbial activity. The "barrier" is not intended to convey the idea of a barrier to groundwater flow but as a barrier to contaminants. PRBs are designed to be more permeable than the surrounding aquifer materials so that contaminants are treated as groundwater readily flows through without significantly altering groundwater hydrogeology.

PRBs may be used as a containment remedy or as a source zone remedy. For example, a PRB installed near the down-gradient site boundary may be designed to protect down-gradient properties or receptors such as surface waters or potable wells. Alternatively, a PRB installed near the source zone may be designed to reduce the mass of contaminant by a given percent with the idea that natural attenuation or some other remedy will address the down-gradient residual contamination.

PRBs are installed as permanent, semi-permanent, or replaceable units across the ground water flow path of a contaminant plume. PRBs can be installed as a funnel-and-gate system, trench system, or a series of injection points. The funnel-and-gate system has impermeable walls that direct the contaminant plume through a gate containing the reactive media. A trench is installed across the entire path of the plume and is filled with the reactive media. A series of injection points may be set up to create a treatment zone for groundwater to flow through.

### 2.2.5 *Ex-situ* Treatment

*Ex-situ* treatment includes any process wherein groundwater is extracted from the subsurface. The main advantage of *ex-situ* treatment is that it generally requires a shorter time period, and there is potentially more certainty about the uniformity of treatment because of the ability to monitor and continuously mix the groundwater that is pumped to the surface for treatment. However, *ex-situ* treatment requires pumping of groundwater, leading to increased costs and engineering for equipment, possible permitting issues, and material handling, and therefore may not exclusively be the most cost-effective remedy.

Table 2.1. Treatment alternative advantages and disadvantages.

| Treatment Alternative | Advantages | Disadvantages |
|---|---|---|
| Monitored Natural Attenuation | • Less intrusive than most remediation technologies as few surface structures are required<br>• May be applied to all or part of a given site, depending on-site conditions and cleanup objectives<br>• Natural attenuation may be used in conjunction with, or as a follow-up to, other remedial measures<br>• Overall cost will potentially be lower than other remediation technologies, depending on monitoring time frame and parameters that are required to be analyzed | • Time frames for complete remediation may be long<br>• Responsibility must be assumed for long-term monitoring and its associated cost, including the possibility of implementing institutional controls<br>• Natural attenuation is subject to natural and anthropogenic changes in hydrogeologic conditions<br>• Aquifer heterogeneity may complicate site characterization<br>• Intermediate products of biodegradation can be more toxic than the original compound (e.g., nitrite) |
| Enhanced *In-situ* Biodenitrification | • Less intrusive than most remediation technologies as few surface structures are required<br>• May be applied to all or part of a given site, depending on-site conditions and cleanup objectives | • Clogging of injection wells may occur due to excessive growth of microorganisms (i.e., biofouling)<br>• Preferential flow paths may decrease contact between injected fluids and contaminants throughout the contaminated zone<br>• Intermediate products of biodegradation can be more toxic than the original compound |
| Phytoremediation | • Relatively low installation and maintenance costs<br>• May provide hydraulic control as well as contaminant degradation<br>• Plants and/or trees are aesthetically acceptable | • Time frame for plants to reach mature age<br>• Limited effective depth of treatment, depth of the treatment zone is determined by the type of plant used<br>• High concentrations of contaminants may be toxic to plants<br>• Intermediate products of biodegradation can be more toxic than the original compound |
| Permeable Reactive Barrier | • May be applied in the source zone or at down-gradient locations<br>• Hydraulic control may be possible | • Installation and maintenance costs<br>• Operational problems may arise due to difficulty of controlling groundwater hydrology |
| Groundwater Recovery Wells | • Hydraulic control may be possible<br>• Potential for shorter cleanup time frame<br>• Utilize in process or existing wastewater treatment system | • Groundwater must be pumped to surface<br>• Possible permitting issues<br>• Capital cost for pumping and material handling equipment<br>• Operation and maintenance |

## 2.3 Selected Remedy

EDCC proposes a combination of *ex-situ* treatment and monitored natural attenuation to address site groundwater contamination. An important factor for implementing monitored natural attenuation is elimination of additional contaminant loading at the source zone. In November 2006, EDCC constructed and began operation of two (2) groundwater recovery wells in the area exhibiting the highest concentrations of ammonia in groundwater at the site. Water from the recovery wells is utilized in the manufacturing processes. Continued operation of the recovery wells is expected to reduce the source of ammonia in the site groundwater as well as the potential for off-site migration of groundwater containing elevated ammonia levels. Also, EDCC has implemented significant source reduction activities through institutional controls and process management improvements.

Site conditions are favorable for monitored natural attenuation as part of the remedial action, most importantly because ammonia contamination is not currently affecting or threatening potential down-gradient receptors. Also, ammonia is an excellent candidate for monitored natural attenuation because it is degraded biologically through nitrification/denitrification under conditions commonly encountered in shallow groundwater aquifers.

Historical groundwater monitoring data in some site wells indicate a trend of decreasing ammonia concentrations which supports a conclusion that natural attenuation is occurring at EDCC. However, the decreasing concentration trend is not universal at the site and collection of adequate monitoring data subsequent to implementation of source reduction activities is necessary to support the statistical analyses of natural attenuation and its reduction or elimination of the hypothetical risk associated with site groundwater. Additional monitoring parameters (alkalinity, nitrite, dissolved manganese, dissolved iron, total phosphorus, and Total Organic Carbon) were included in the EDCC monitoring program in October 2005 to enable evaluation of the natural attenuation process for nitrogen compounds. At this time, insufficient data has been collected since the indicator parameters were added (October 2005) and the groundwater recovery system implemented (November 2006) to predict the time frame for achieving a specific concentration end point, or the precise final concentration end point that can be expected from natural attenuation processes. Existing and future data will be used to develop a model to assist in making a statistical evaluation of the performance of the selected remedy for the EDCC site.

### 2.3.1 Groundwater Monitoring

As presented in the HHERA, groundwater at the EDCC facility was delineated into four representative groundwater areas (units). These units are delineated mostly by density of industrial activities and the groundwater characteristics, and are described in Table 2.2. Figure 2.1 provides a view of the physical location of each well; the well's groundwater unit is indicated by color code.

Table 2.2. EDCC Groundwater Units described in the HHERA.

| Groundwater Area (Units) | Description | Well #'s |
|---|---|---|
| Up-gradient Unit | Wells up-gradient of facility influences, representing natural background groundwater quality. | ECMW 1-3 |
| Production Unit | Wells located in the most concentrated area of industrial activities at the facility and generally representing the highest potential groundwater contamination. | ECMW 4-11 |
| Midgradient Unit | Wells located near the wastewater treatment ponds and representing a lower level of industrial activity. | ECMW 14-16 |
| Down-gradient Unit | Wells near the property line of the facility, Down-gradient of industrial activities, and representative of the groundwater quality that could potentially be leaving the site. | ECMW 17-22 |

The target monitoring value for ammonia (0.55 mg/l at the property boundary) as presented in the HHERA provides a management goal that may be used to identify if or when further consideration of site conditions is warranted. EDCC shall continue to monitor groundwater semi-annually from the existing monitoring and recovery wells in accordance with Condition No. 3 of CAO LIS 06-153. Information collected from the semi-annual monitoring will be submitted to ADEQ according to CAO LIS 06-153 Condition No. 4, annually by April 1.

Included in each annual report will be an analysis of the groundwater in the Down-gradient Groundwater Unit (DGU), which is along the property boundary, to assess progress towards attainment of the ammonia goal of 0.55 mg/L. The analysis will include the required elements for groundwater monitoring programs as outlined in previous reports with emphasis on analysis of ammonia trends over time, analysis of variance (ANOVA), and calculation of ammonia averages in the DGU.

Monitoring will continue on a semi-annual basis until 5 years of "post recovery well" data has been collected (on or about November 2011). At this time the annual report will include a detailed analysis and discussion of the ammonia data in the DGU to determine if the following criteria are met: 1) has the 0.55 mg/l goal been attained; 2) is the ammonia data from the DGU statistically significantly less than or equal to (at an alpha of 0.05) that of the background wells (Up-gradient Groundwater Unit (UGU)); 3) have the ammonia levels in the DGU stabilized (not increased) or decreased over time.

The remedy will be deemed complete at such time as either criteria 1 or criteria 2 has been achieved. At such time as criteria 3, outlined above, has been attained (i.e. the ammonia trend indicates stabilized concentration levels and no statistically significant increase over time) the continuation of the recovery well operation may no longer be required. After cessation of the recovery well operation, and prior to completion of the remedy, the monitoring frequency will be reduced to once per year to assess the progress of natural attenuation processes. Should the ammonia levels in the DGU be found to be increasing at a statistically significant level (alpha=0.05) then the RAP will be revised to further characterize and delineate the plume (determining if the ammonia levels have indeed increased or if the plume has expanded) and/or to evaluate the need for additional remedial measures to address containment.

### 2.3.2 Aquifer Assessment

Potentiometric maps of the Cockfield Formation aquifer will be prepared and submitted with the annual groundwater monitoring report. Hydraulic gradient for the site may be derived from the water elevation contours and evaluated to determine if changes in the gradient have occurred that may adversely impact the rate and/or direction of groundwater flow.

### 2.3.3 Off-site Well Survey

The potential for exposure to Cockfield Formation groundwater exists only if off-site wells are constructed in the future. No wells have been previously identified within a 1.5 mile radius of the EDCC property (Woodward-Clyde, "Development of Risk-Based Target Monitoring Levels", December 1997) nor are any new domestic wells likely to be installed. To support the proposed remedy, EDCC will conduct a survey of the area within a 1.5 mile radius of the property every 5 years to determine if any wells have been constructed. The findings of the off-site well survey will be submitted to ADEQ in the annual groundwater report.

# 3.0 FUTURE PROPERTY USE

The EDCC site has been used for industrial purposes since its initial operation in 1943. Industrial use of the property in the future is probable. Potential exposure to groundwater by site workers has been addressed by site-wide administrative controls by EDCC. These controls have been integrated into the EDCC Environmental Health and Safety (EHS) program. Specifically, activities such as maintaining the groundwater recovery system components, sampling monitoring wells or constructing additional wells are monitored by site EHS personnel and appropriate PPE employed to prevent dermal contact, inhalation, or ingestion of groundwater. Exposure to groundwater by other construction and repair workers is not anticipated due to the depth to groundwater (>10 feet), but will nevertheless be controlled by the site-wide administrative controls.

The protections proposed by the RAP will continue until EDCC documents that site controls and natural attenuation preclude any hypothetical on or off-site risk or such time that the ADEQ determines no further action is necessary. Thus, implementation of the selected remedy will ensure that the hypothetical risk from ammonia concentrations in EDCC site groundwater are contained within the property boundary and adequately controlled.

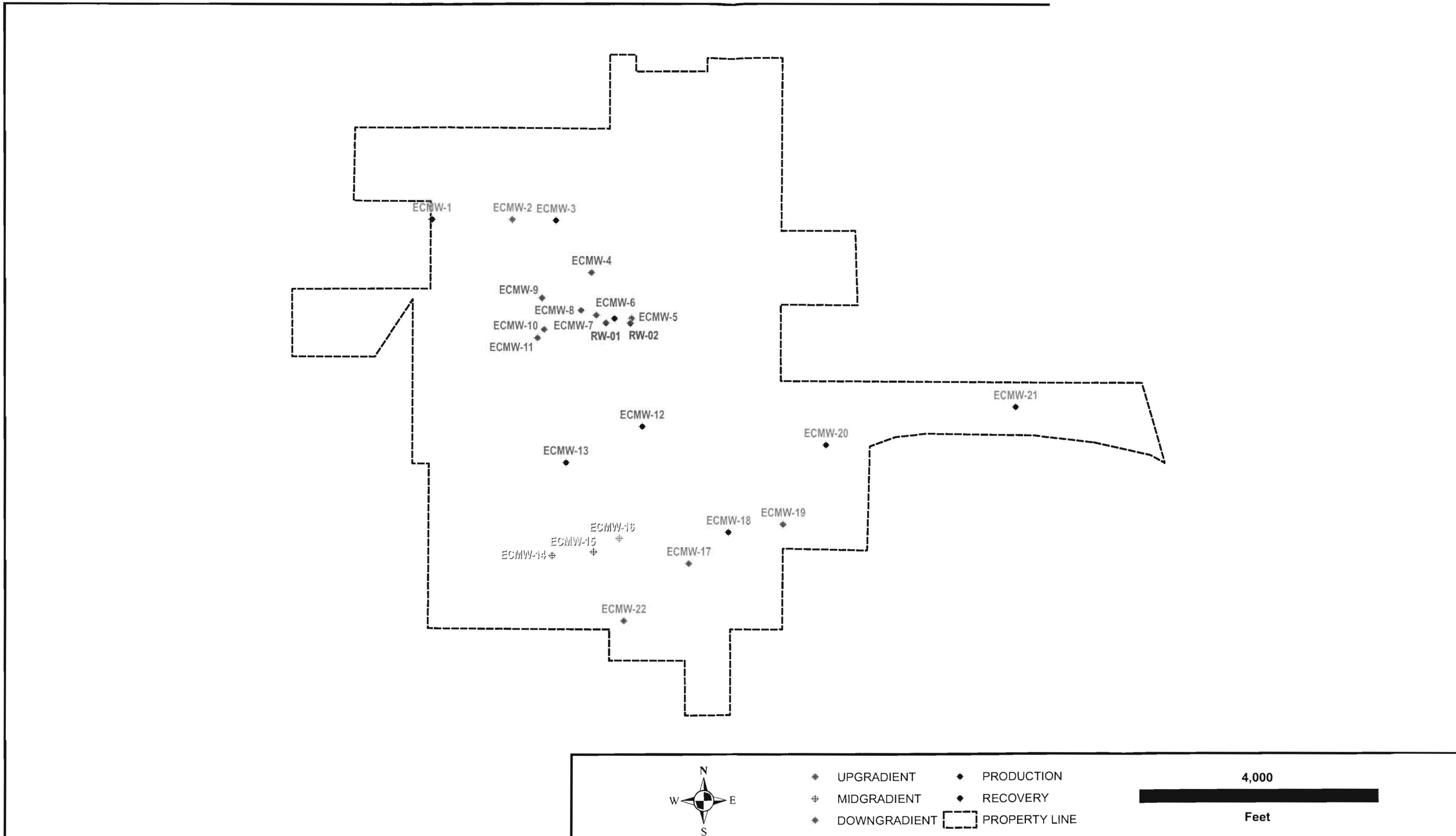


Figure 2.1. Monitoring/Recovery Well location map.