A. AREA OF REVIEW METHOD

Give the methods and, if appropriate, the calculations used to determine the size of the area of review (fixed radius or equation). The area of review shall be a fixed radius of 6.11 miles from the well bore unless the use of the equation is approved in advance by the director.

The area of review (AOR) for the EGT site consists of the cone of influence (COI), defined below. This area is larger than the default two-mile radius around the EGT wells that is required by regulation. All wells except shallow test borings have been mapped and tabulated in Table C-1. No corrective action is necessary for this site.

For consistency with "No-migration" petition application, the AOR has been calculated by determining the distance from the centers of the two wells to the boundary of the critical pressure buildup. The critical pressure is the reservoir pressure at the top of injection interval that would support a column of brine far enough above the injection interval to enter the base of the underground source of drinking water (USDW). The column of fluid in a wellbore will move if the upward-directed pressure at the base of the fluid column overcomes the downward-directed hydrostatic pressure of the fluid column. This method of defining critical pressure makes the conservative assumption that, in worst case, hypothetical brine-filled wellbore exists that connects the injection interval to the USDW. The critical pressure was calculated in EGT Wells #1-12 and #2-12 based on the specific gravity of the fluid in the injection interval, the depth of the top of the injection interval below the base of the USDW, and the height of the fresh water above the base of the USDW.

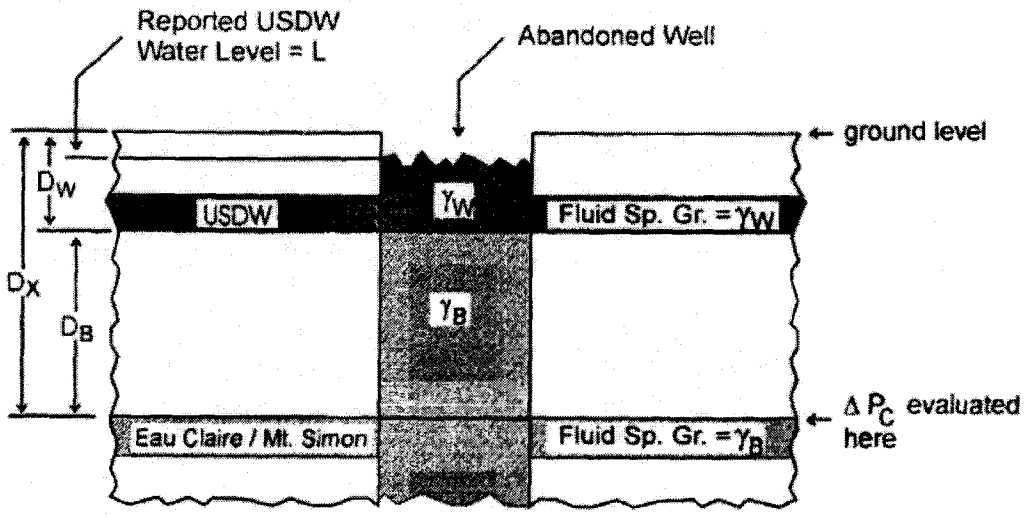
The hydrogeologic Atlas of Michigan (1981) indicates that glacial drift deposits in northwest Wayne County are approximately 100 feet deep. The glacial drift deposit in Wayne County is characterized in the Hydrogeologic Atlas of Michigan (1981) as "generally not an aquifer".

The USDW in the vicinity of EGT is limited to the surgical and glacial drift deposits, and, the Detroit River Formation. This is indicated by the Dual Induction Focused log of the surface whole in EGT Well #2-12. This log indicates that formation fluids below a depth of 387 feet (RKB) have concentrations of total dissolved solids (TDS) that are greater than 10,000 mg/l. The base of the USDW is considered to be at 387 feet RKB.

EGT proposes that an acceptable surrogate measurement of water level in the USDW is the water level of Lake Erie, which is (presumably) hydrologically connected to the shallow aquifers. The mean elevation of the surface of Lake Erie is 571.33 feet (International Great Lakes Datum, 1985; IGLD85). This IGLD85 elevation is referenced to a slightly different datum from North American Vertical

Datum of 1929 (NAVD29) to which ground levels at EGT are referenced. The correct lake elevation is 571.80 feet, NAVD29. This is 54.8 feet below the surveyed ground level at EGT.

A schematic drawing of a hypothetical wellbore is shown below.



Critical pressure buildup was calculated using the following equation:

$$\Delta P_C = (H_W \times \gamma_W + H_B \times \gamma_B) \times 0.433 \text{ psi/ft} - P_i \qquad \text{Equation A-1}$$

where:

ΔP_c = critical pressure buildup

H_W = height of freshwater column above base of USDW (D_W - L = 387 - 55 = 332 feet)

D_W = depth to base of USDW (387 feet BGL)

L = depth to the USDW water table (55 feet BGL)

γ_W = specific gravity of fresh water (1.0)

H_B = height of brine column below base of USDW (D_X - D_W = 3537 feet)

D_X = depth to top of the injection interval (3937 feet RKB - 13 feet KB or 3924 feet BGL)

γ_B = specific gravity of natural brine in the injection interval (1.153)

and

P_i = original reservoir pressure (correcting from an original measurement of 1983.5 psi at -3626 feet msl)

= 1983.5 + (-3298 - (-3626)) x (-0.433) x 1.153)

= 1820 psi

Substituting the above values to estimate ΔP_c for a hypothetical abandoned brine-filled wellbore near the location of EDS #2-12:

ΔP_c = (332 x 1.0+3537 x 1.153) x 0.433-1820

= 89.6 psi

Equation A-2

The edge of the cone of influence is set at the 89.6-psi pressure buildup contour.

Calculation of the Radius of the Cone of Influence

The primary objective of pressure modeling is to establish the worst case location of the COI for EGT Wells #1-12 and #2-12, for the projected operational life of the wells. It is desirable to utilize rezervior rock properties and fluid properties that will result in calculated pressures which are conservative, i.e higher, when compared to actual future reservoir pressures.

Pressure buildup calculations for the injection interval have been performed using parameters derived from interference test between EGT Wells #1-12 and #2-12, conducted June 12 through 15, 2002. This testing indicated that the reservoir encompasses two distinguishable hydraulic units, one with permability of 400 md, and thickness of 33 feet, and the other with a permeability of 63.4 md and thickness

of 190 feet,. The permeability-thickness products of these intervals are quit similar, so it is assumed that approximately half of the total injected flow will enter each unit.

The model utilized to project pressurization represents a single layer. Consequently, preliminary modeling was conducted to identify whether modeling the 33-foot or the 190-foot interval would lead to the more conservative estimate of the COI. The INTERACT model was utilized to make this comparison, and the results are in Figure VI.E(a)ii-1 of the petition document submitted to Region 5 of the Environmental Protection Agency (EPA). This figure depicts pressure at the end of the 20 years service life of the wells, as a function of distance from the wellbore. The critical pressure of 89.6 psi is also shown. The COI is 23,275 feet for the 33-foot interval, and 10,865 feet for the 190-foot interval.

As a result of this analysis, the 33-foot interval was selected for modeling. The viscosity of the reservoir brine used in the pressure modeling for the injection interval is 1.34 centipoise. The porposity φ, was set at 11%. The total compressibility, c_t, was set at 6.6×10^{-6} psi^{-1}

All pressure calculations for the injection interval were performed using the analytical (exponential integral) method as implemented in the PHIST and INTERACT computer programs. A discussion of the mathematical basis of the pressure buildup modeling presented in the petition is included in Section VI.A.1(a) of the petition document.

Each of the sets of model input/output which are discussed in the following section have been reproduced in the attachment VI.E.1(a)iii-1(INTERACT projections of Cone of Influence) or Attachment VI.E.1(a)iii (PHIST projections of Wellbore Pressure) of the petition document. Each set of results is referenced to a corresponding model run that is labeled in one of the above attachments.

Pressure modeling represented a single 33-foot thick layer, receiving half of the total flow of 166 gpm for the first 19 years and 11 months of the service life. During the last month of the service life, injection was increased to the maximum short-term rate of 270 gpm.

The isobaric contour from the INTERACT code depicting reservoir pressure rise at the end of high-rate injection, within the last month of a 20- year operational life , is depicted in figure VI.E(a)iii-1 of the petition document. The average radius of the 89.6-psi critical pressure contour is at a distance of 23,275 feet. Computer input and output from the INTERACT programs are reproduced in Attachment VI.E.1(a)iii-1 of the petition document.

The sensitivity analysis presented in section VI.D.3(a) of the petition document indicates that the COI in the composite interval representing the 33- and 190-foot sections could extend to a radius of 32,280 feet. This radius is based on setting the

net thickness of the composite interval at the minimum for the range of uncertainty. For this reason, the AOR is conservatively set at the larger radius of 32,280 feet.

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