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January 6, 1997

Mr. Barney Chan, Hazardous Waste Specialist
Alameda County Health Care Services Agency
1131 Harbor Bay Parkway
Alameda, CA 94502

Subject: Quarterly Groundwater Monitoring Report For Hegenberger Maintenance Station

Dear Mr. Chan:

Enclosed is the groundwater monitoring report for the November 1996 sampling session at the referenced site in Oakland. The report covers the fourth quarter of sampling and analyses at the site after the installation and initial sampling of the monitoring wells in September/October 1995. This is the final scheduled quarter for the study, which was conducted under contract with Geocon.

Analytical results have shown that the gasoline constituent (i.e. BTEX and TPH-g) concentrations detected at the site are consistently declining over the past three quarters. As discussed in the "Analytical Results" section of the report, the attenuation of the contaminant levels at the site does not appear to be aided by intrinsic biodegradation when the groundwater's dissolved oxygen (D.O.) levels, as measured in each well, are compared to the corresponding dissolved BTEX concentrations detected in the water samples, which are dominated by benzene. The metabolization of hydrocarbons by subsurface microbes utilizes available dissolved oxygen to oxidize the hydrocarbons, which results in depleted D.O. levels within hydrocarbon plumes. The degree of D.O. depletion increases with higher concentrations of hydrocarbons, which yields an inverse relationship between D.O. levels and BTEX levels when intrinsic bioremediation is occurring.

As shown in the plot of D.O. levels versus benzene levels that I've enclosed along with the final quarterly report, there is a very poor regression correlation coefficient ($r^2 = 0.1552$) for these parameters at the Hegenberger site, which means there is no consistent relationship between D.O. and benzene concentrations and that bioremediation of the petroleum hydrocarbon contamination is likely not taking place. However, perhaps a more insightful analysis can accomplished by assuming a first order decay in the benzene concentrations detected in MW-1, MW-3, MW-4, and MW-5 over the last three quarters,

the time period when gasoline concentrations have been declining. Based upon this assumption, the change in contaminant concentrations, C, over time, t, is given by $\frac{dC}{dt} = -kC$, where k is the first order contaminant decay rate. The solution of this differential equation is given by $C = C_0e^{-kt}$, where C is the contaminant concentration at time t and C_0 is the initial contaminant concentration at time t = 0. The plot of an equation of this form on semi-log paper, with C as the logarithmic ordinate and t as the linear abscissa, yields a straight line of slope k. The semi-log plots of the benzene concentrations over time (where t = 0 is set as April 1, 1996) for wells MW-1, MW-3, MW-4, and MW-5 at the Hegenberger site show a strong correlation with an equation of the form $C = C_0e^{-kt}$: the regression correlation coefficients for the plots range between $r^2 = 0.8426$ and $r^2 = 0.9993$, which means the analytical results are very consistent with the mathematical theory. These graphs are also enclosed with this letter. *not that good*

Interestingly, there is quite a range in the benzene attenuation rates (k) derived for the wells. MW-1 and MW-5 both have attenuation rates below 0.8%/day, while MW-3 and MW-5 have attenuation rates greater than 2.5%/day. The higher attenuation rates correspond with the wells where depleted levels of D.O. (<1.5 mg/L) were measured in the groundwater and the lower attenuation rates were found in the wells with high levels of D.O. (>2.5 mg/L). The enclosed plot of D.O. versus benzene decay rates for each of the monitoring wells demonstrates this relationship.

The relationship between benzene attenuation rates and D.O. levels indicates that intrinsic biodegradation may actually be contributing to the mitigation of gasoline contaminants in the vicinity of monitoring wells MW-3 and MW-4, causing the higher contaminant attenuation rates and the depleted D.O. levels. It is not known why evidence of biodegradation has not been detected in the other wells where gasoline contamination has been found (MW-1 and MW-5). Determining whether bioremediation will become a factor contributing to the attenuation of gasoline contaminants in all the monitoring wells would require more sampling and analytical data.

Please recommend to our office if Alameda County Health Care Services Agency prefers that the monitoring program at the Hegenberger site be continued or if the evidence of declining concentrations is sufficient for site closure. If you have any questions or comments about this site investigation, please call me at 286-5647.
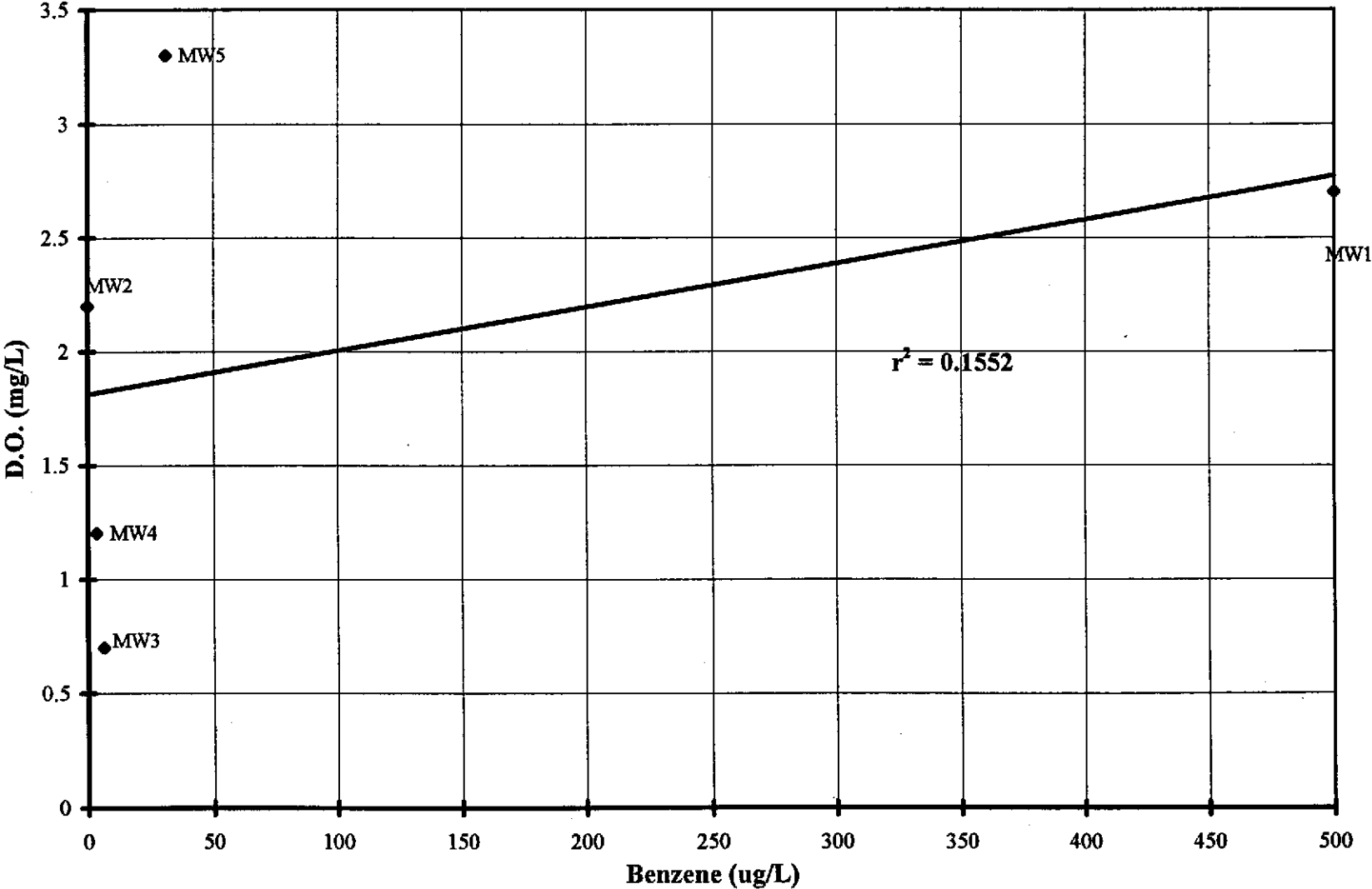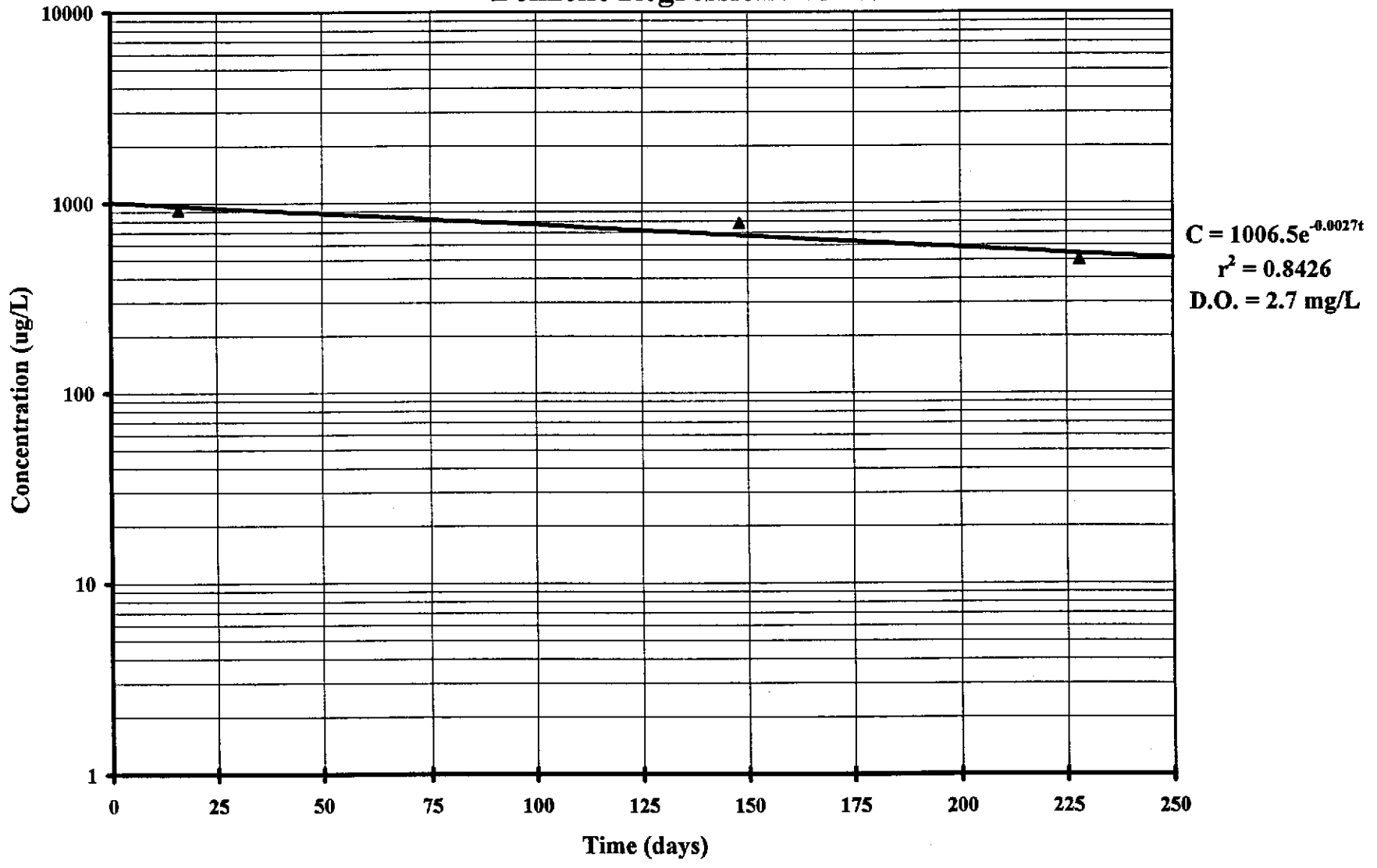
Sincerely,

Christopher R. Wilson

Christopher R. Wilson, P.E.
Office of Environmental Engineering

Enclosures
cc: file

D.O. Levels vs. Benzene Levels at Hegenberger Site

Scatter plot of D.O. (mg/L) on the y-axis versus Benzene (ug/L) on the x-axis. Data points: MW5 (≈25, 3.3), MW2 (≈0, 2.2), MW4 (≈5, 1.2), MW3 (≈5, 0.7), MW1 (≈500, 2.7). A linear trendline rises from about 1.8 at Benzene = 0 to about 2.8 at Benzene = 500. $r^2 = 0.1552$

Hegenberger Maintenance Station
Benzene Regression in MW-1

$C = 1006.5e^{-0.0027t}$
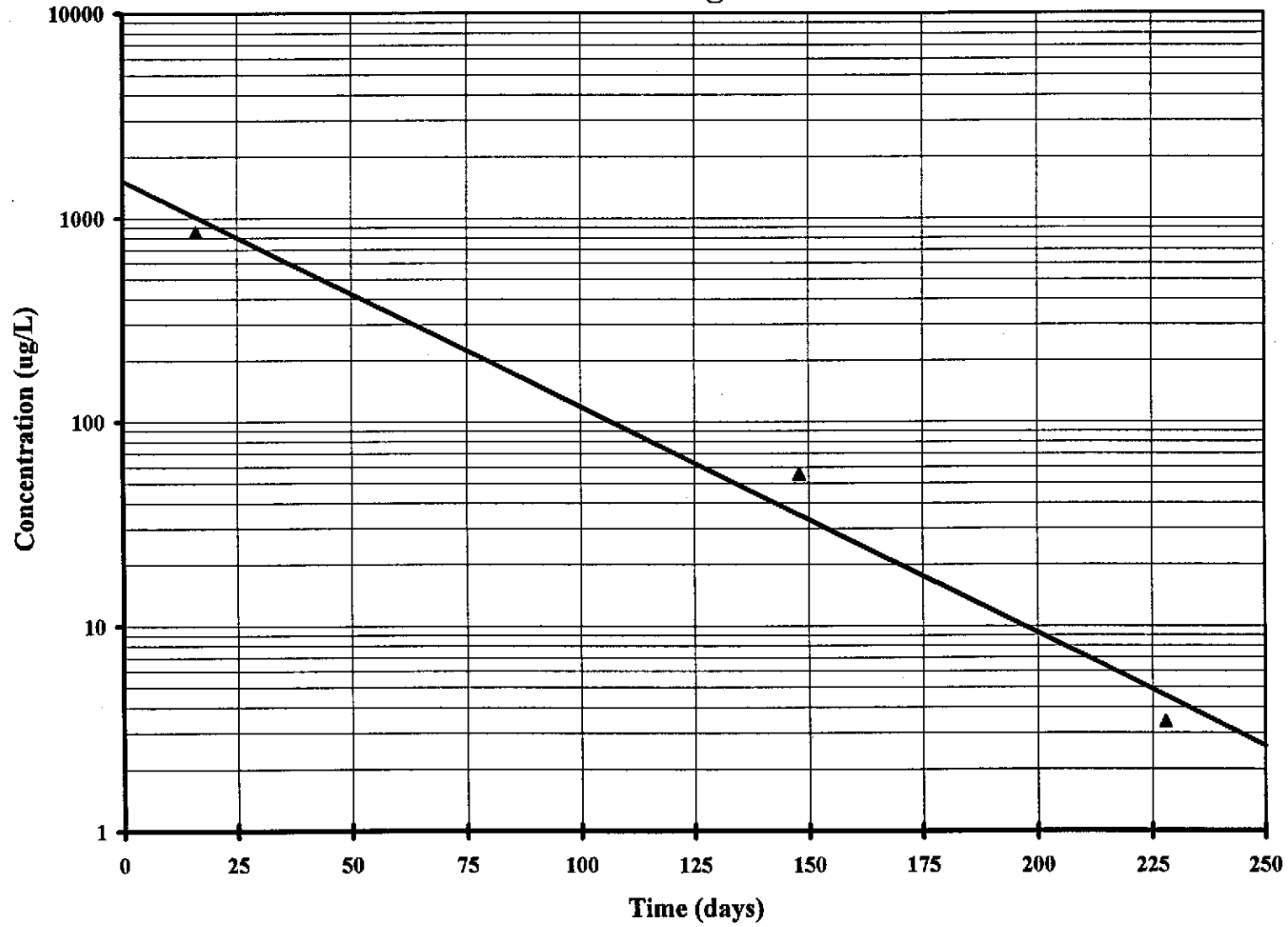
$r^2 = 0.8426$

D.O. = 2.7 mg/L

Hegenberger Maintenance Station
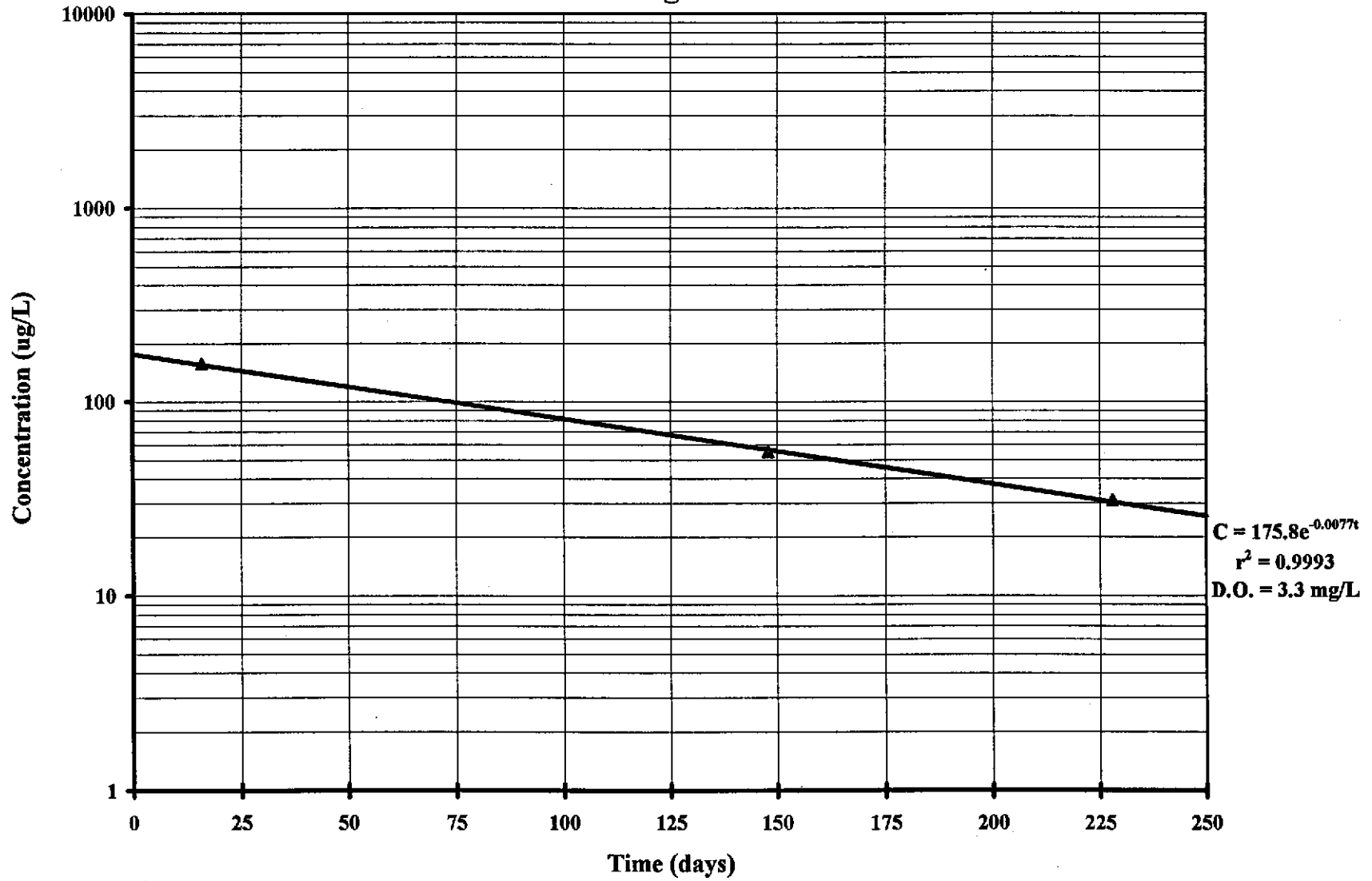## Benzene Regression in MW-3
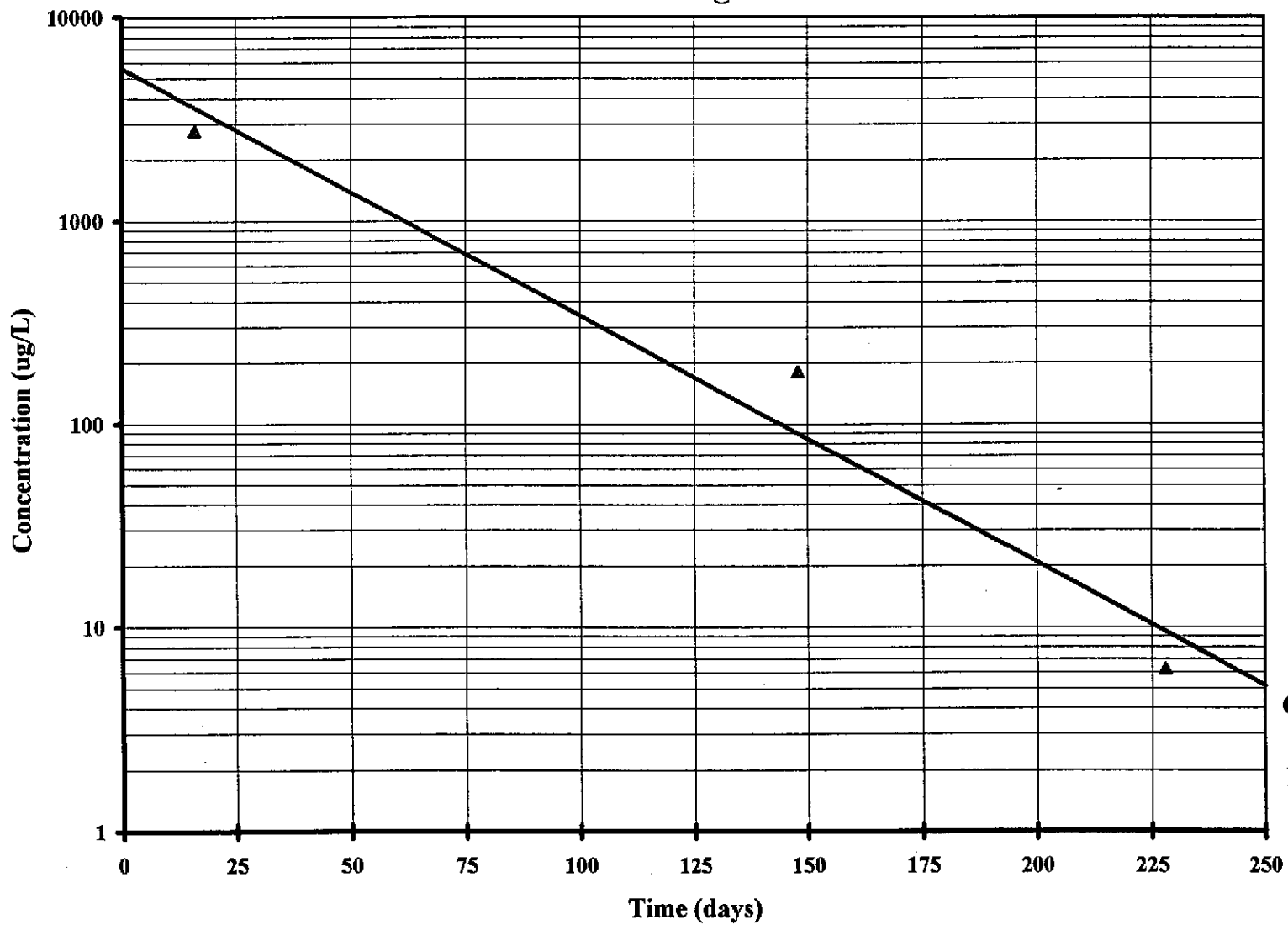
$$C = 5636.9e^{-0.0280t}$$
$$r^2 = 0.9603$$
$$D.O. = 0.7 \text{ mg/L}$$

Hegenberger Maintenance Station
Benzene Regression in MW-4

$C = 1521.2e^{-0.0255t}$
$r^2 = 0.979$
D.O. = 1.2 mg/L

Concentration (ug/L)

Time (days)

Hegenberger Maintenance Station
Benzene Regression in MW-5

$$C = 175.8e^{-0.0077t}$$
$$r^2 = 0.9993$$
$$D.O. = 3.3 \text{ mg/L}$$

Concentration (ug/L)

Time (days)

D.O. Levels vs. Benzene Decay Rates at Hegenberger Site