PLAN FOR CHARACTERIZATION OF WATER IMPACT
BBSS COAL ASH RECLAMATION SITE

Introduction

This plan is submitted in response to paragraph 33 of the Consent Decree between Maryland Department of the Environment (MDE), Constellation Power Source Generation, Inc., and BBSS, Inc., effective October 1, 2007. The plan addresses characterization of the extent of groundwater and surface water impact related to the Waugh Chapel and Turner Pit ash fill areas, including additional proposed monitoring well locations, monitoring frequency and analytes, and methodology for evaluating the extent of contamination. This plan has been developed in conjunction with the response to Consent Decree paragraph 42 ("CD42") and refers to certain data presented in that response.

Proposed Additional Monitoring Wells

Water monitoring to characterize the extent of groundwater and surface water contamination related to the site will include groundwater monitoring at existing monitoring wells and surface water locations specified in the Pollution Prevention Plan dated October 11, 2007, submitted to MDE on that date in compliance with paragraph 45 of the Consent Decree.

In addition to those existing locations, eight additional monitoring wells are proposed, as follows:

Monitoring Well I.D.	Proposed Location	Rationale
MW-23	At eastern edge of BGE right-of-way between MW-3 and MW-12, contingent on access approval from owner BGE.	To assist in evaluating extent of groundwater impact from Waugh Chapel Pit and source of possible impact to MW-12.
MW-27	In Rt 3 median, down-gradient of MW-7, contingent on access approval from owner State Hwy Admin.	To assist in evaluating extent of groundwater impact from Turner Pit and effectiveness of hydraulic barrier in groundwater quality recovery.
MW-28	In Rt 3 median, down-gradient of MW-13, contingent on access approval from owner State Hwy Admin.	To assist in evaluating extent of groundwater impact from Turner Pit and effectiveness of hydraulic barrier in groundwater quality recovery.
MW-29	West of Rt 3, on inside of bend in Evergreen Rd, location to be	To assist in evaluating extent of groundwater impact from Turner

	coordinated with owner BBSS.	Pit..
MW-30	North side of Evergreen Rd, between MW-10 and MW-11, location to be coordinated with owner BBSS.	To clarify groundwater flow direction and to assist in evaluating extent of groundwater impact from Turner Pit.
MW-31	North side of intersection of Jackson Rd and Evergreen Rd, location to be coordinated with owner BBSS.	To serve as sentinel well for any groundwater impact in that direction.
MW-32	At eastern edge of BGE right-of-way between MW-12 and MW-11, contingent on access approval from owner BGE.	To assist in evaluating possible groundwater impact from treatment ponds or other sources west of Turner Pit.
MW-33	In Rt 3 median, between Turner Pit and Rt 3 private wells, contingent on access approval from commercial owner.	To serve as sentinel well for potential impacts on Rt 3 private wells and to assist in evaluating extent of groundwater impact from Turner Pit.

These proposed new well locations are illustrated in Figure 1.

These locations are proposed based on the assumption that legal access to the properties can be obtained for well installation and periodic monitoring. If legal access cannot be arranged, it will be attempted to obtain legal access to a nearby location that will serve a similar purpose.

The well screen at each new well location will extend to a depth approximately 10 to 15 feet below encountered water level, to allow for seasonal fluctuation in water levels. Each well screen will be 10 feet long and of slot size of 0.010 inch.

In addition to the new monitoring wells, it is proposed to monitor three existing residential wells in the vicinity of Waugh Chapel Pit, to observe groundwater quality variation over time. The wells at 1188 Summerfield Road and 2530 and 2544 Brickhead Road are proposed for this purpose, if legal access for periodic monitoring can be obtained. If access to the 1188 well cannot be arranged, then periodic sampling will be performed instead at the existing well at 1187 Summerfield Road, presently owned by BBSS. Temporary public water is presently being supplied to homes on Summerfield and Brickhead Roads, and a permanent water line is planned for installation in early 2008. After connection to the permanent line is completed, Constellation will coordinate with the well owners with the goal of converting the wells to monitoring wells.

It is also proposed to monitor private water supply wells at 1058 Route 3 N, 1085 Route 3 N, and 2482 Lee Street, down-gradient from Turner Pit and beyond the sentinel well MW-33, to observe groundwater quality variation over time, if legal access to these wells for periodic monitoring can be obtained.

Monitoring Frequency and Analytes

All monitoring frequency is subject to the availability of access to the wells proposed for monitoring. In the new monitoring wells, as in the monitoring wells described in the Pollution Prevention Plan, groundwater levels will be measured and sampling will be performed quarterly.

Samples will be analyzed for the inorganic chemicals included in COMAR 26.04.01.06 – Maximum Contaminant Levels for Inorganic Chemicals in Drinking Water (not including asbestos). Samples will also be analyzed for pH and for ash leachate indicator parameters described in the response to CD42 (sulfate, boron, chloride, lithium, total dissolved solids (TDS), calcium, sodium, magnesium, and potassium).

For proposed well locations MW-23, MW-27, MW-28, MW-29, and MW-30, if an exceedance of the levels defined in the Remedial Response Contingency Plan occurs in any of these wells, the well will be resampled within 30 days of receipt of the results that exceed the levels. If the exceedance is confirmed by the re-sampling results, the monitoring and reporting frequency for that well will be increased to monthly until the Department agrees that the sampling frequency may be reduced. (Note: This proposed frequency is consistent with the protocol under the Pollution Prevention Plan for down-gradient perimeter wells.)

The three converted residential wells in the Waugh Chapel area and the three wells down-gradient of the Turner Pit would be sampled and analyzed quarterly for two years (subject to access).

After two years of sampling, the frequency of sampling of these new monitoring wells and residential wells will be evaluated and changes will be proposed if needed, subject to Department approval.

Monitoring of existing wells is ongoing. Installation and monitoring of these proposed wells will be initiated within a reasonable period of time after approval by the Department. Monitoring of the residential wells described above will be initiated by June 2008, within 60 days after connection of the permanent water line to the houses (which will then allow conversion of the wells to monitoring wells), or within 30 days after obtaining access permission, whichever is later.

Characterization of Extent of Impact

Water levels and water quality results from all the sampled wells and the surface water monitoring points will be used to evaluate groundwater flow directions and extent of impact from the site. The data will also be used to evaluate feasibility and design of remedial options for the site.

The methodology for initial and ongoing characterization of the extent of contamination from the site will take into account ash leachate characteristics and temporal and spatial variability of water quality constituents. The characterization methodology will include the following components:

- Monitoring the water quality at a number of locations on a periodic basis, as described above, to provide data on spatial and temporal variability.
- Using the monitoring data for the primary and secondary ash leachate constituents (described in the response to CD42) to conduct graphical and statistical analyses of each monitoring well to determine extent of ash leachate migration. If the primary indicator constituents exceed the criteria concentrations defined in the response to CD42, then the secondary indicator constituents are utilized to confirm the inference derived from the primary indicator constituents. If primary indicator constituents do not exceed the criteria concentrations, secondary indicator constituents are not utilized for evaluation.
- Using the monitoring data for preparing spatial plots for each sampling event utilizing a set of monitoring wells along three representative groundwater flow paths to examine increases/decreases in concentrations of the indicator constituents and the spatial extent of ash leachate migration.
- Using the monitoring data to observe temporal variability and potential increasing/decreasing trends at a given location over time.Using the primary and secondary indicators, in addition to other information such as well locations, and other possible contaminant sources, to evaluate whether data from a particular location indicates the presence of ash leachate. No single indicator shall be considered determinative. Due to the presence of black soils that also significantly contribute sulfate and TDS to the groundwater quality in the area, it is required that chloride, boron, and lithium be included as primary indicator constituents for robustness for identification of ash leachate impacts. The available site-specific data show that boron and lithium are generally absent or present at very low levels in the ambient groundwater and are present in leachate at much higher concentrations, providing robust and reliable measures for identifying ash impact. Similarly, chloride is present in orders of magnitude higher in the leachate than in the ambient groundwater making it a reliable indicator for ash leachate impact. Chloride is not readily contributed by the black soils, which avoids misidentification of ash impacts.

The detailed methodology for evaluating and characterizing the extent of contamination is presented in the following sections.

Monitoring of Spatial Variability

The rationale used in this methodology is to monitor and evaluate time series data for the concentrations in groundwater of the indicator chemicals beginning from the well that defines leachate concentration, then progressively moving further down-gradient from the source to several locations that may experience leachate migration, and finally establishing a sentinel well that is not experiencing leachate impact, as defined by the indicator parameters. The sentinel well ideally is located along a groundwater flow path from the site but at a point as yet unimpacted by the ash leachate, and up-gradient of private water supply wells that are utilized for drinking water without treatment.

Waugh Chapel Pit: To evaluate the extent of Waugh Chapel Pit impacts, two groundwater flow paths are proposed. The first flow path is identified as A-A' and the second flow path is identified as B-B' in Figure 2. The specific wells proposed for flow path A-A' are MW-24 (leachate well), near-field down-gradient well MW-21, successively further down-gradient wells MW-3, MW-23 (proposed) , MW-12, MW-32 (proposed), MW-11, and MW-30 (proposed). A new sentinel well MW-31 (proposed) will be installed and monitored to confirm that there is no leachate migration towards the Jackson Road private water supply wells. The specific wells on the flow path B-B' identified for monitoring are MW-24 (as leachate well), near-field down-gradient well MW-21, and successively further down-gradient private water supply wells at 1188 Summerfield and 2544 and 2530 Brickhead. MW-15 is the sentinel monitoring well on this flow path.

Turner Pit: To identify the extent of Turner Pit impacts, one flow path is identified as C-C' in Figure 2. The specific wells proposed for the flow path C-C' are MW-14 (leachate well), near-field down-gradient well MW-13, successively further down-gradient wells MW-8, MW-29 (proposed), and MW-33 (sentinel, proposed). In addition three private water supply wells (i.e., 1058 and 1085 Route 3 and 2482 Lee Street) further down-gradient of new well MW-33 will be monitored to establish time and spatial variability. MW-8 possibly is a down-gradient well from Turner Pit but the groundwater hydrology may have been modified because of the recovery wells already installed and more to be installed in the near future. Therefore this well may show a water quality recovery response due to groundwater pumping.

Monitoring of Temporal Variability

The methodology requires that groundwater quality be monitored for the indicator parameters for the identified wells on a quarterly basis so that time trends for the indicator parameters can be defined. For the first two years it is proposed to monitor the wells on the three flow paths on a quarterly basis so that a minimum of eight quarters of data are available for graphical and statistical analyses. Following the two years of quarterly data collection and evaluation of the data by the analysis methods described herein, MDE may approve reduced monitoring to a semi-annual frequency for the long term assessment and monitoring of potential increasing/decreasing time trends for the indicator parameters, based on the evaluation of the monitoring data collected in the first two years of the monitoring program.

Indicator Parameters for Determination of Extent of Impacts

Based on examination of the available leachate wells (MW-14 and MW-24) and water samples from temporary standpipes (W-03, W-04, W-05, W-11) data from the site, the constituent concentrations found in ash leachate are elevated in comparison with background ambient monitoring wells at the site (see Tables 1 and 2 in the response to CD42). These are proposed as primary indicator parameters: sulfate, boron, chloride, lithium. These are proposed as secondary indicator parameters: TDS, calcium, sodium, magnesium, and potassium.

These primary and secondary indicator parameters attenuate differently in groundwater. Sulfate, boron, chloride, and lithium are all very mobile constituents and attenuate by dilution caused by dispersion processes, whereas the remaining constituents can attenuate to varying extents by chemical reactions in combination with the dispersion processes and may retard somewhat during migration with groundwater flow. Therefore, sulfate, boron, chloride, and lithium would be expected to be found in down-gradient wells that are impacted by ash leachate migration based on the advection and dispersion processes of the groundwater flow system. Since TDS is the sum of dissolved constituents in groundwater including calcium, sulfate, chloride, sodium, potassium, and magnesium, it should also serve as a useful indicator parameter for leachate migration. However, it should be remembered that for the BBSS site, the black soils also contribute sulfate and therefore TDS to the groundwater levels and can be erroneously identified as impact from ash leachate migration.

Graphical and Statistical Analysis to Determine Ash Impacts on a Temporal Scale

For each monitoring location, the measured concentrations for each of the indicator parameters will be plotted on an x-y plot as given in the examples in Appendix A, which utilize the existing data for TDS, sulfate, chloride and boron. The time series graphs will be visually examined to qualitatively determine if there are significant time trends. A polynomial regression analysis will be performed using time as the independent variable and the measured concentrations of indicator chemicals as the dependent variable. This regression analysis assumes that the time series data for the well are not correlated with each other. Statistical testing of the regression coefficients will then establish if there are increasing time trends in the indicator parameters being analyzed for each of the spatial locations. This approach explicitly takes into account spatial variability with respect to the ash source area. Conceptually, the closest monitoring well would be impacted first and may show increasing concentrations of the indicator parameters before reaching an asymptote. Progressively down-gradient wells will start to show increasing concentrations of the indicator parameters allowing inference that leachate has migrated to that distance from the ash source. Presumably the sentinel well will never be impacted from leachate migration. Depending on the extent of impacted down-gradient wells, actions may be taken to prevent/control leachate migration by instituting appropriate remedial measures.

Graphical and Statistical Analysis to Determine Ash Impacts on a Spatial Scale

For each sampling event, the measured concentrations for each of the indicator parameters will be plotted on an x-y plot for the monitoring wells that lie on the groundwater flow path as given in the examples in Appendix B, which utilize the existing data for TDS, sulfate, chloride and boron. The spatial (longitudinal distance) graphs will be visually examined to qualitatively determine if there are any spatial trends indicating development of a groundwater plume from leachate migration utilizing the indicator parameters. An intrinsically linear or piecewise linear regression analysis will be performed using distance as the independent variable and the measured concentrations as the dependent variable. Statistical testing of the regression coefficients will then establish if there are increasing/decreasing spatial trends in the indicator parameters being analyzed. This approach explicitly takes into account spatial locations on the flow path to first establish the groundwater concentrations along the flow path. By plotting measured groundwater concentrations of the indicator parameters for sampling events (time), assessment may be made to determine if there are increases occurring in concentrations of the indicator parameters as a function of time and for some or all of the monitoring locations. Presumably the sentinel well which is farthest from the ash source will never be impacted from leachate migration.

Determining Extent of Ash Leachate Migration Down-gradient of Waugh Chapel and Turner Pits

The primary indicator parameters (sulfate, boron, chloride, and lithium) are the most mobile of all the indicator parameters and are equally mobile in groundwater. As discussed in the response to CD42, published literature has shown that sulfate, chloride, boron and lithium are very mobile in groundwater and are considered conservative (non-reactive) constituents. These constituents are transported by advection and dispersion processes in the groundwater. Calcium, sodium, magnesium and potassium may be somewhat retarded during their migration in groundwater because of ion exchange, adsorption and/or precipitation/complexation processes. Therefore, we would expect to see sulfate, chloride, boron and lithium as the parameters to establish the leading edge of the leachate plume. However, calcium, sodium, magnesium, and potassium would also be found at increased concentrations due to ash leachate migration down-gradient from the Waugh Chapel Pit and Turner Pit structural fills. Depending on the years of travel time and hydrodynamic dispersion involved, the dissolved concentrations of the indicator chemicals will undergo dilution and some attenuation during their migration from the release source.

The concentrations criteria presented in the response to CD42 have been developed based on ash leachate signature parameters to identify groundwater quality impact from ash leachate migration through advection, dispersion and possible chemical attenuation reactions. The proposed methodology employs the time and space domains to evaluate leachate migration for the primary and secondary indicator parameters as discussed in previous sections.

Appendices A and B present examples of the graphical and statistical analysis techniques to determine changes in temporal and spatial dimensions for the leachate indicator parameters. However, it should be recognized that due to forthcoming implementation of remedial measures at the BBSS site, leachate release and migration are likely to be greatly reduced, and the monitoring and evaluation methodology would then enable documentation of recovery of groundwater quality where leachate impacts were previously experienced.

Reporting

Once the data for all indicator parameters are collected for eight sampling events at the locations along the three flow paths, Constellation will perform the spatial and temporal graphing and quantitative statistical analyses as illustrated in Appendices A and B, and inferences will be drawn regarding the extent of ash leachate plume in the groundwater. Constellation will submit an assessment report to MDE within 60 days after the eighth quarters of data collection. On an annual basis thereafter, Constellation will prepare and submit to MDE a similar report assessing the extent of ash leachate impacts, until MDE approves discontinuing the assessments. After the initial eight quarters, modifications to the monitoring program may be proposed, if warranted, for acceptance and approval by MDE.

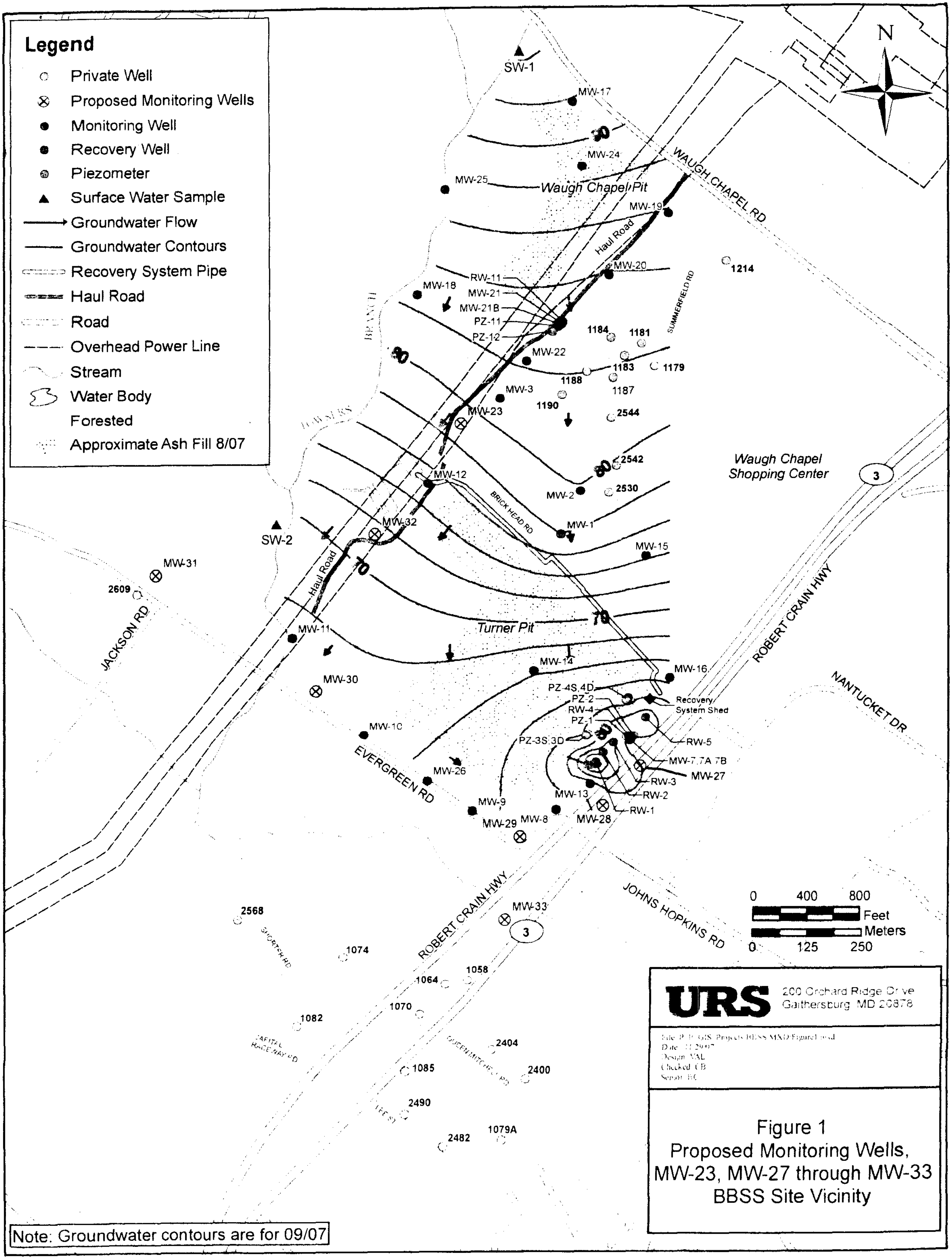

Figure 1
Proposed Monitoring Wells,
MW-23, MW-27 through MW-33
BBSS Site Vicinity

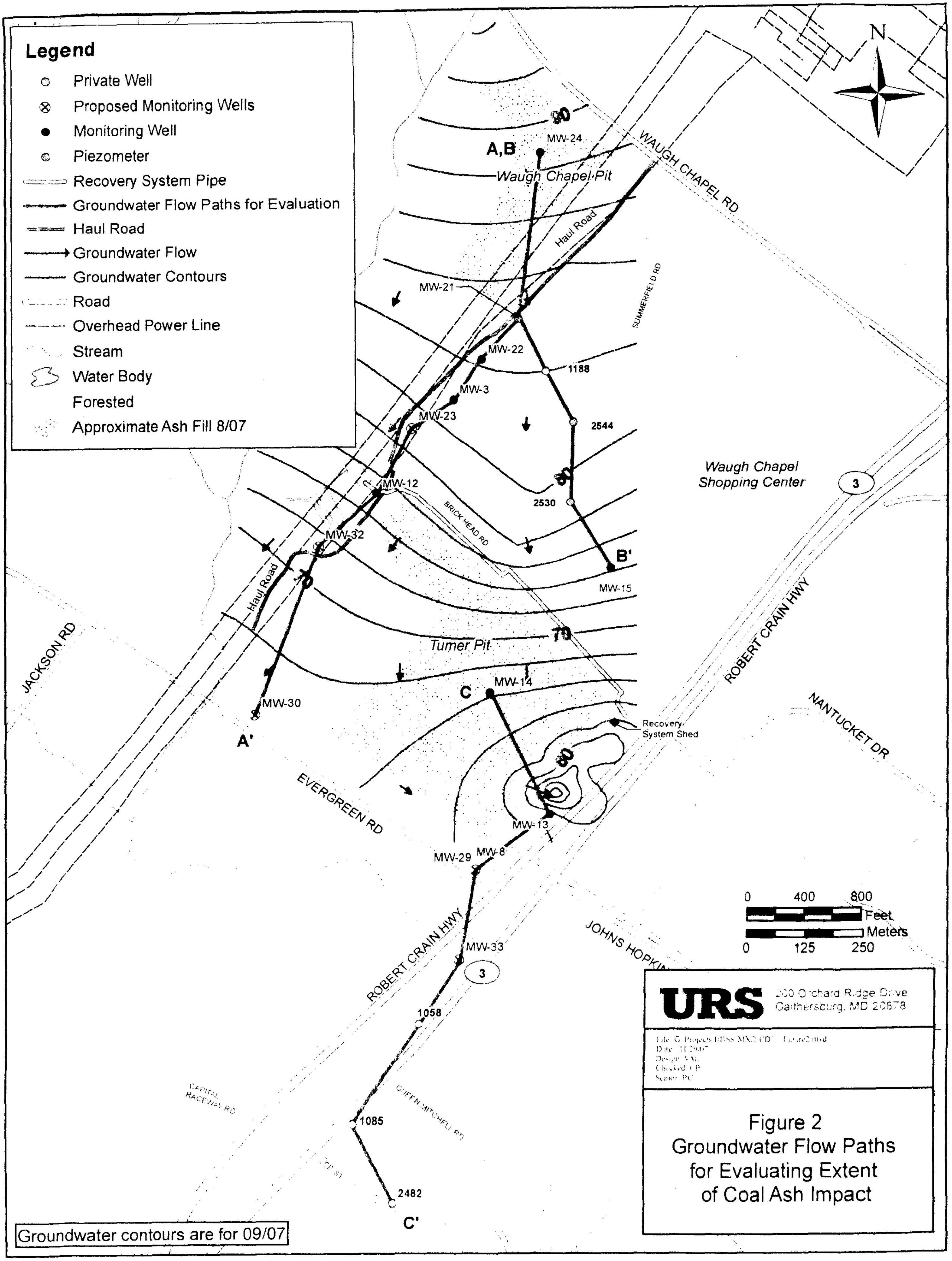

Figure 2
Groundwater Flow Paths
for Evaluating Extent
of Coal Ash Impact

APPENDIX A

Time Series Graphs and Regression Analysis (temporal analysis)

APPENDIX A
CONTENTS

Figures A-1 through A-3 are time series plots for indicator parameters in leachate well (MW-24) for Waugh Chapel Pit.

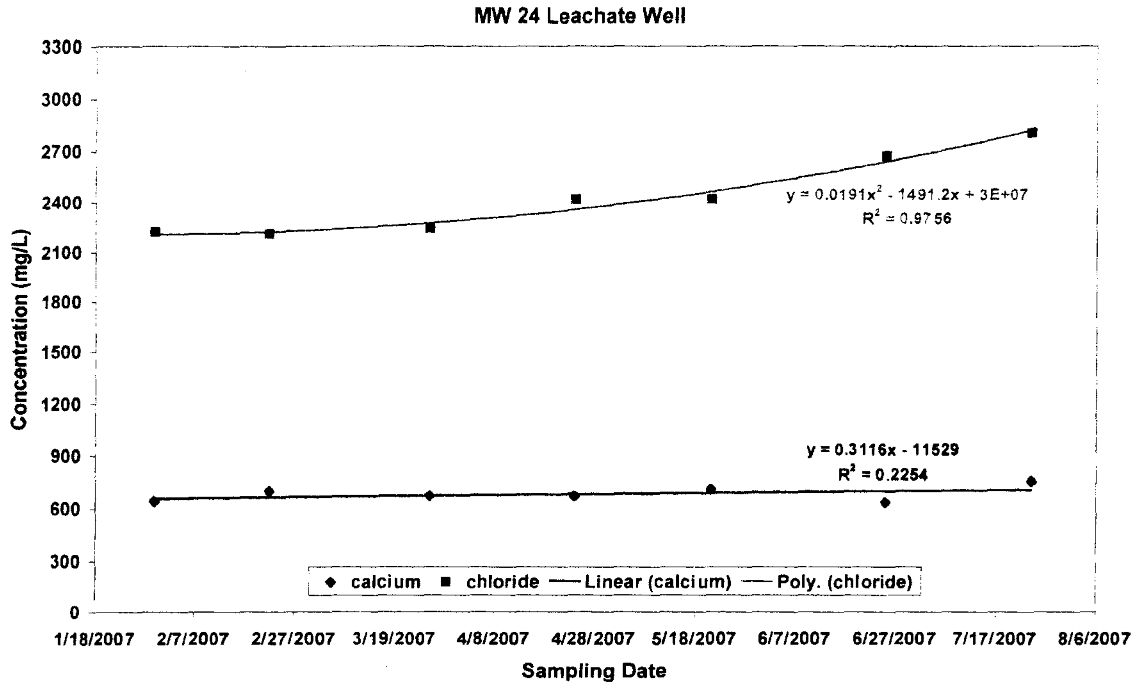

Figure A-1: Time series plots for ash leachate indicator parameters of calcium and chloride in MW-24

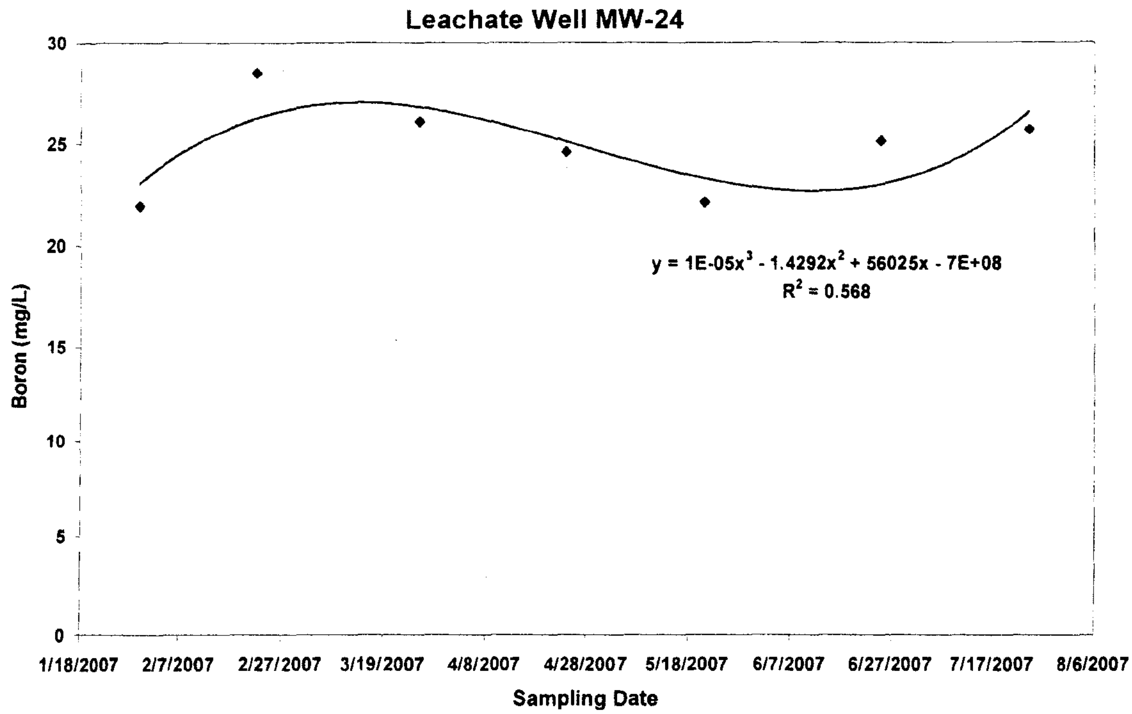

Figure A-2: Time series plot for ash leachate indicator parameter of boron in MW-24

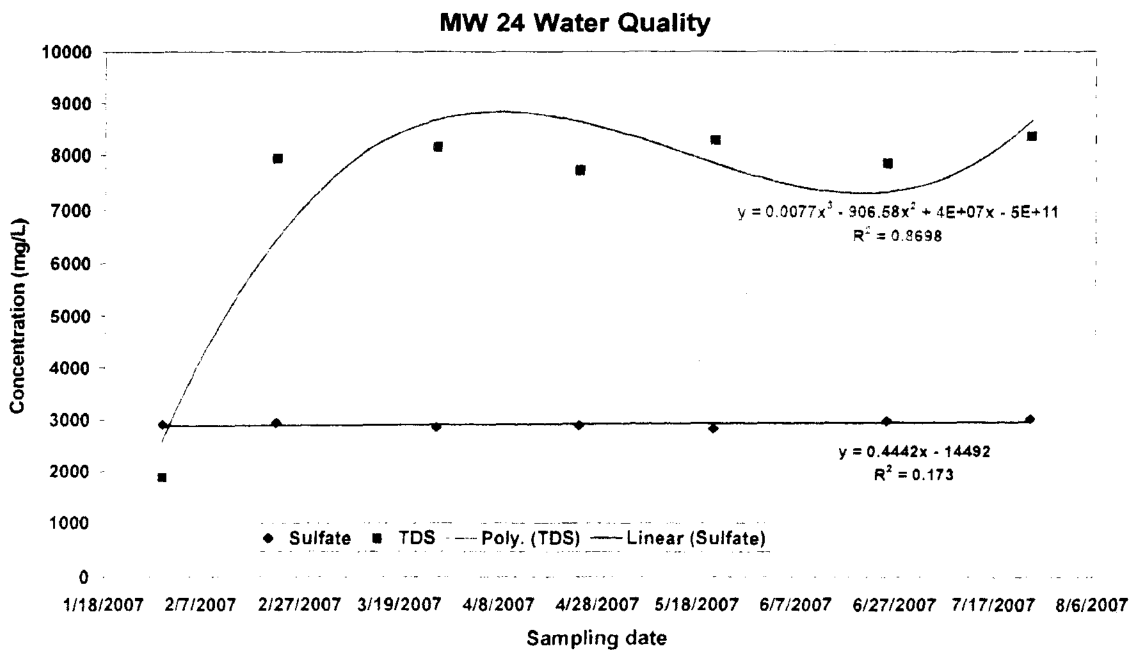

Figure A-3: Time series plot for ash leachate indicator parameters of sulfate and TDS in MW-24

Figures A-4 through A-9 are time series plots for indicator parameters near-field down-gradient monitoring wells (MW-21 and MW-22).

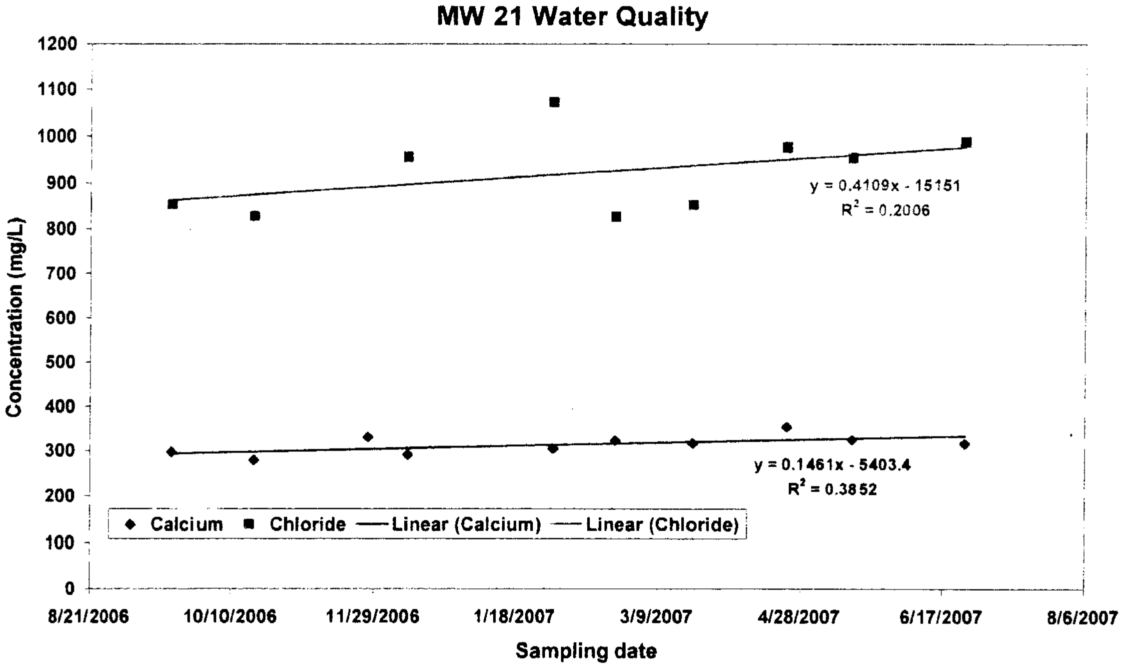

Figure A-4: Time series plots for calcium and chloride concentrations in near-field down-gradient well MW-21 from Waugh Chapel Pit area showing no time trends

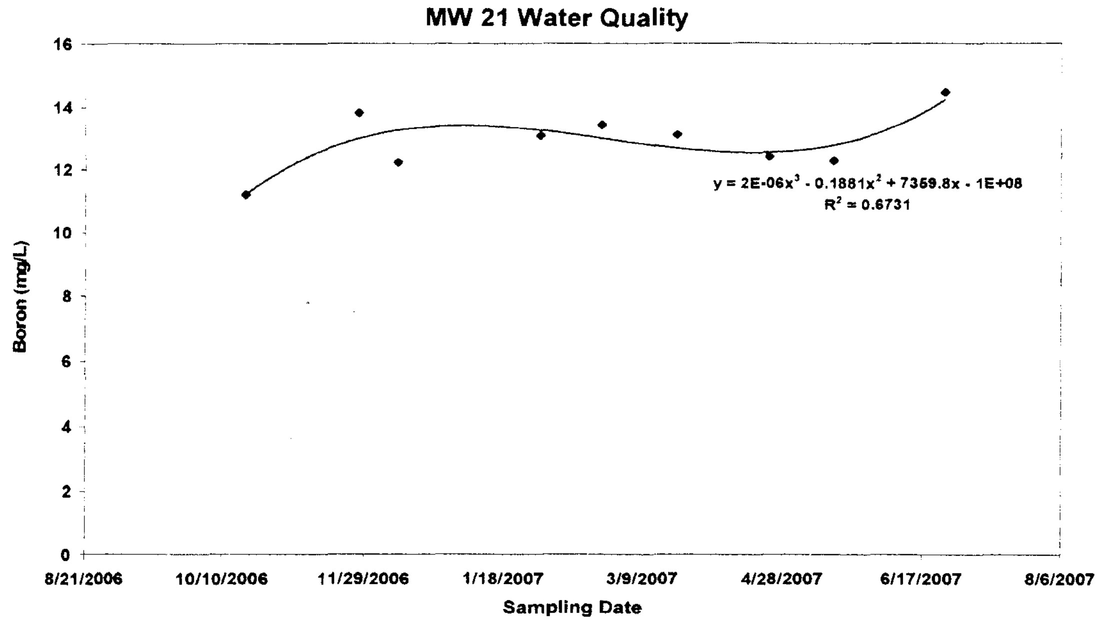

Figure A-5: Time series plot for boron concentrations in near-field down-gradient well MW-21 from Waugh Chapel Pit area showing some fluctuations

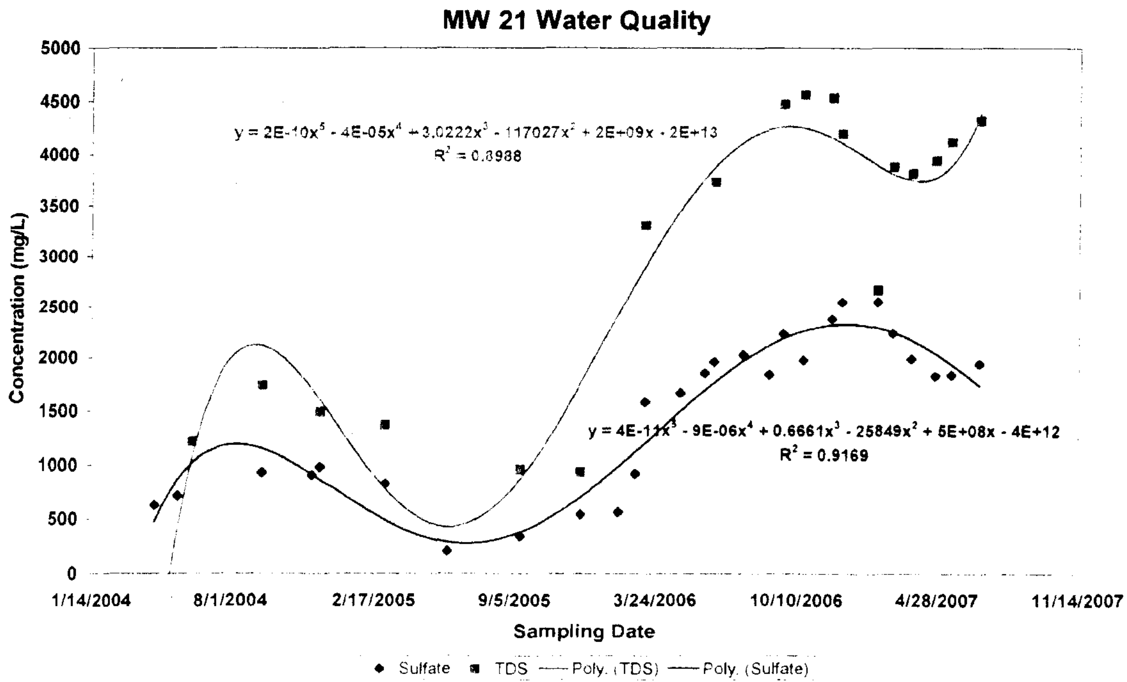

Figure A-6: Time series plots for sulfate and TDS concentrations in near-field down-gradient well MW 21 from Waugh Chapel Pit area showing increasing time trends

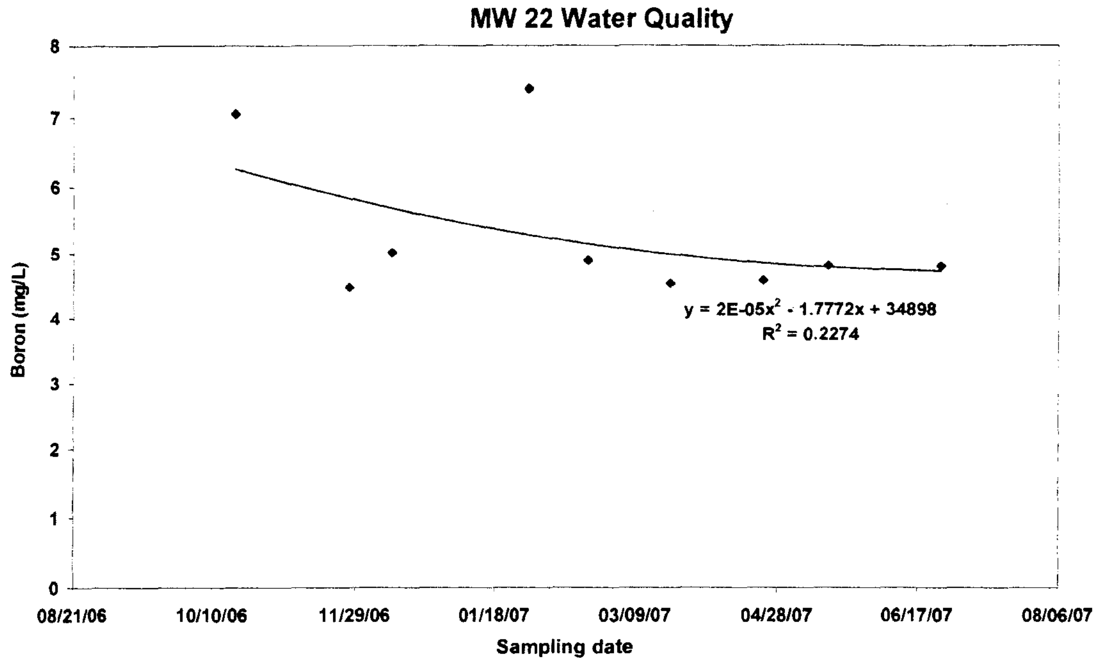

Figure A-7: Time series plot for boron concentration in near field ground water well MW 22 from Waugh Chapel Pit area showing some decreasing time trend

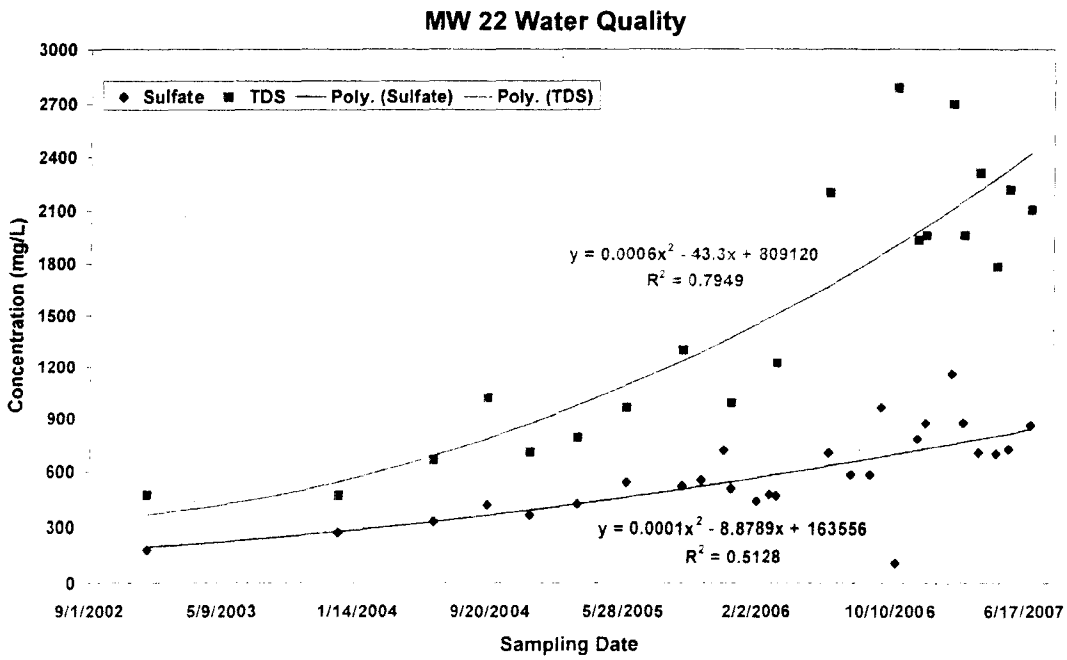

Figure A-8: Time series plots for sulfate and TDS concentrations in near field down-gradient well MW-22 from Waugh Chapel Pit area showing increasing time trends.

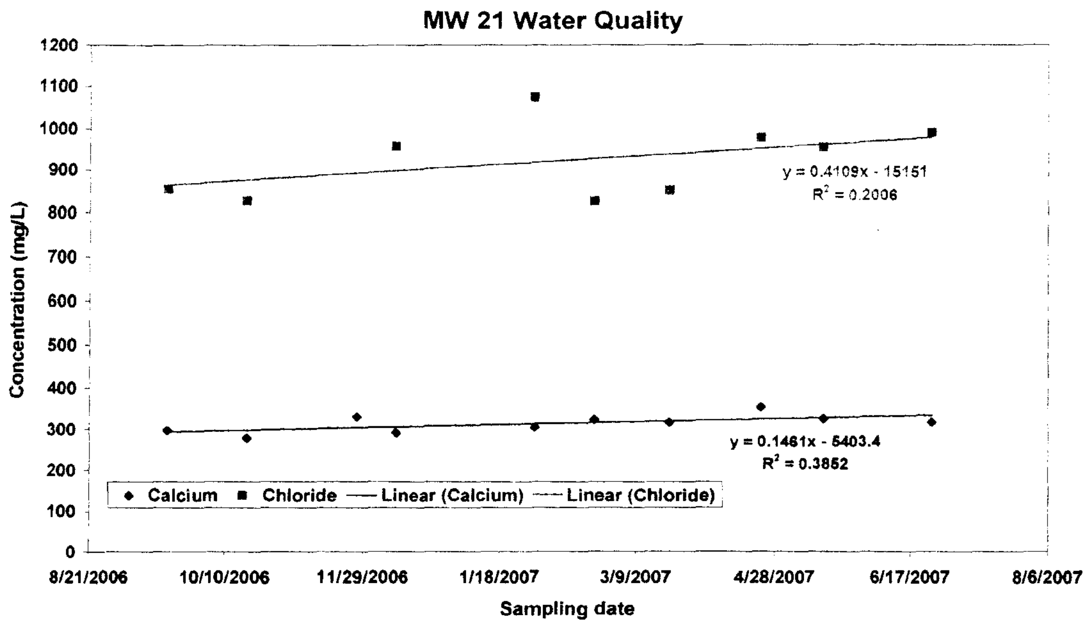

Figure A-9: Time series plots for calcium and chloride concentrations in near-field down-gradient well MW-22 from Waugh Chapel Pit

Figures A-10 through A-12 are for time series plots for indicator parameters for further down-gradient well (MW-3).

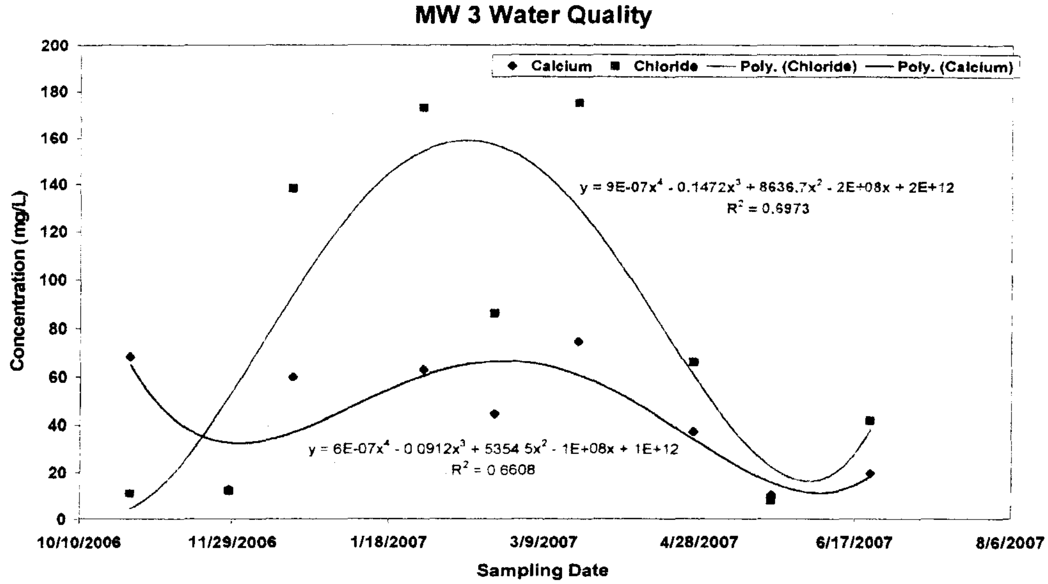

Figure A-10: Time series plots for calcium and chloride concentrations in further down-gradient well MW-3 from Waugh Chapel area showing a peak for calcium and chloride during the monitoring period

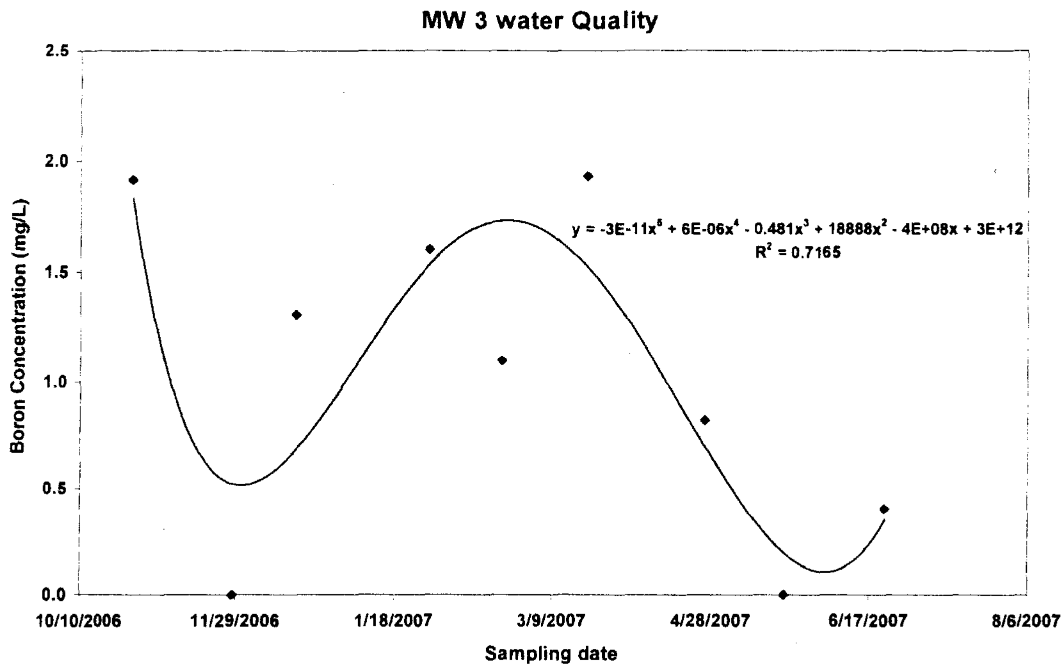

Figure A-11: Time series plot for boron concentrations in further down-gradient well MW-3 from Waugh Chapel Pit area showing oscillating but generally a downward time trend

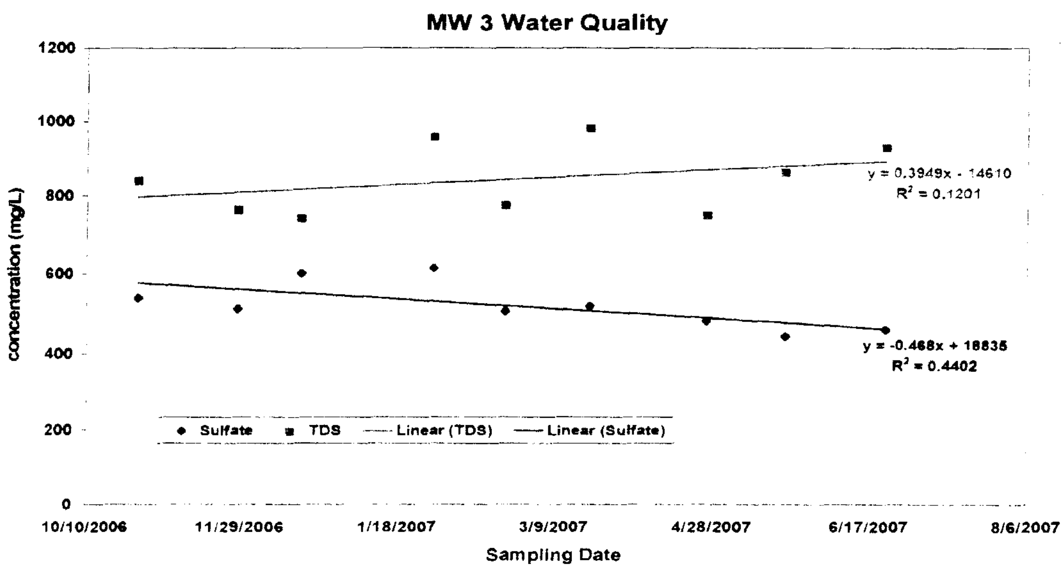

Figure A-12: ***Time series plots for sulfate and TDS concentrations*** **in further down-gradient well MW-3 from Waugh Chapel Pit area showing a downward time trend for sulfate and a slight upward trend for TDS**

Figures A-13 through A-14 are for time series plots for the ash indicator parameters for furthest down-gradient monitoring well (MW-11).

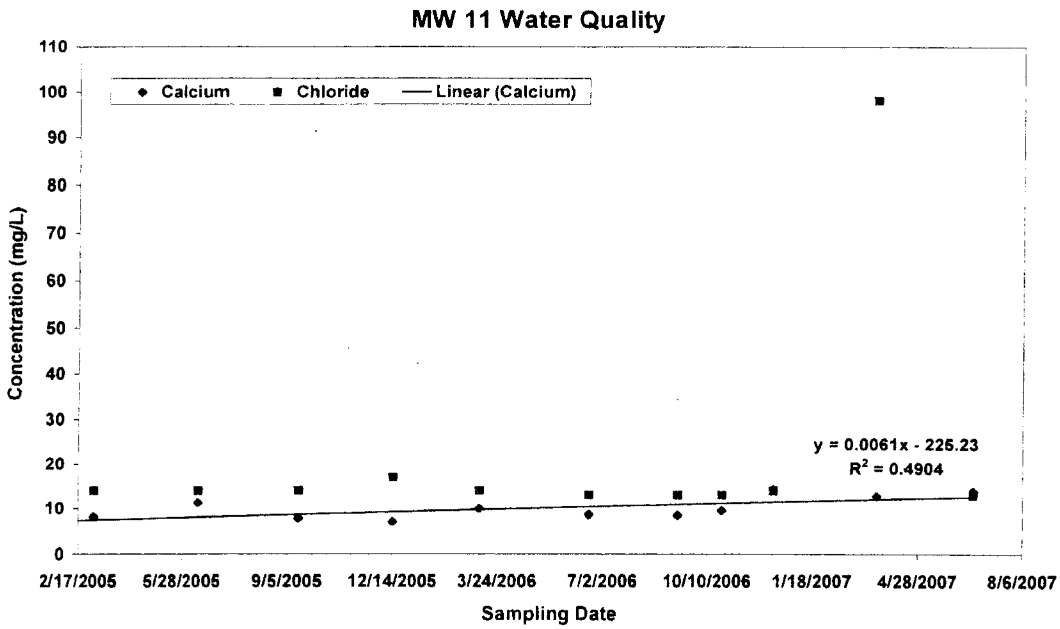

Figure A-13: Time series plots for calcium and chloride concentrations in furthest down-gradient well MW-11 from Waugh Chapel Pit area

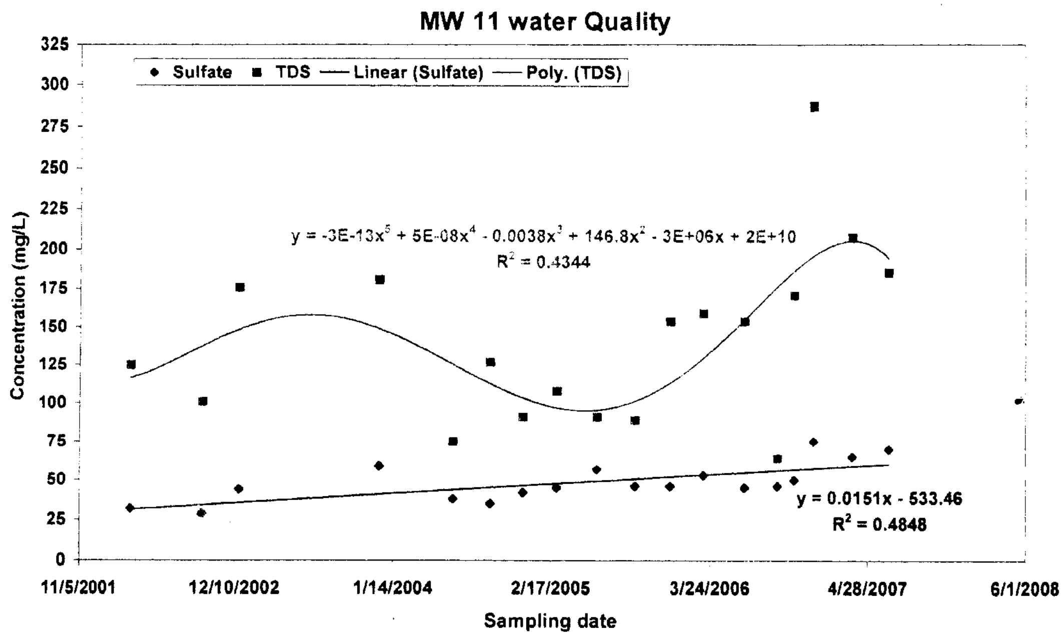

Figure A-14: Time series plots for sulfate and TDS concentrations in the furthest down-gradient well MW-11 from Waugh Chapel Pit area showing an increasing time trend

Figures A-15 through A-17 are for time series plots for indicator parameters for the near-field down-gradient monitoring well (MW-13) from Turner Pit.

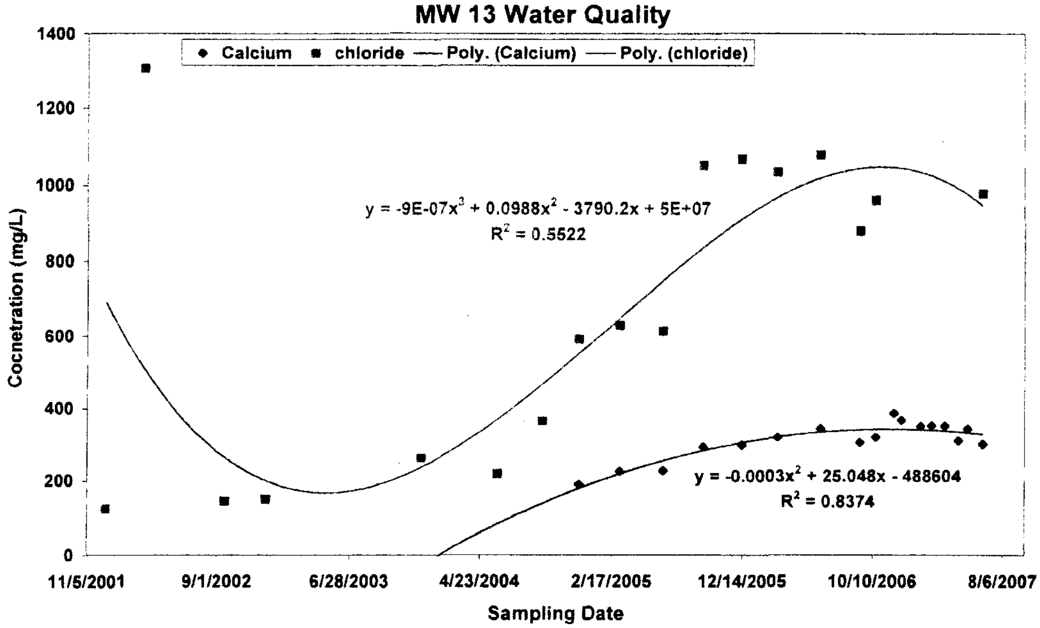

Figure A-15: Time series plots for calcium and chloride concentrations in the near field down-gradient well MW-13 from Turner Pit area showing an increasing time trend

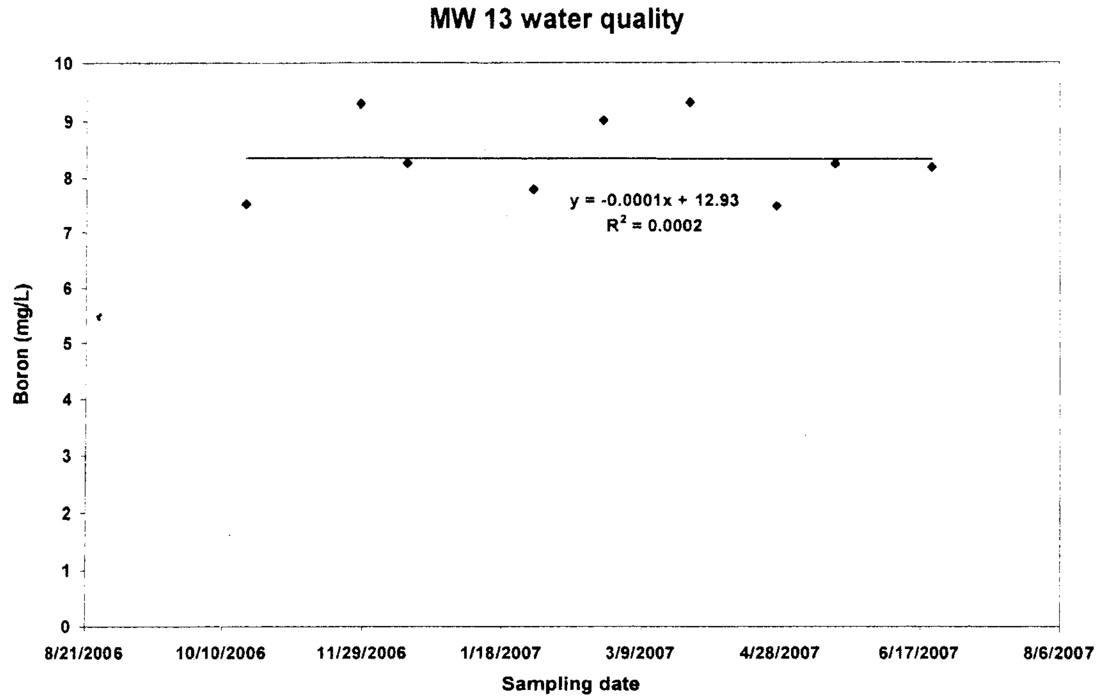

Figure A-16: Time series plot for boron concentrations in the near field down-gradient well MW-13 from Turner Pit area showing no time trend

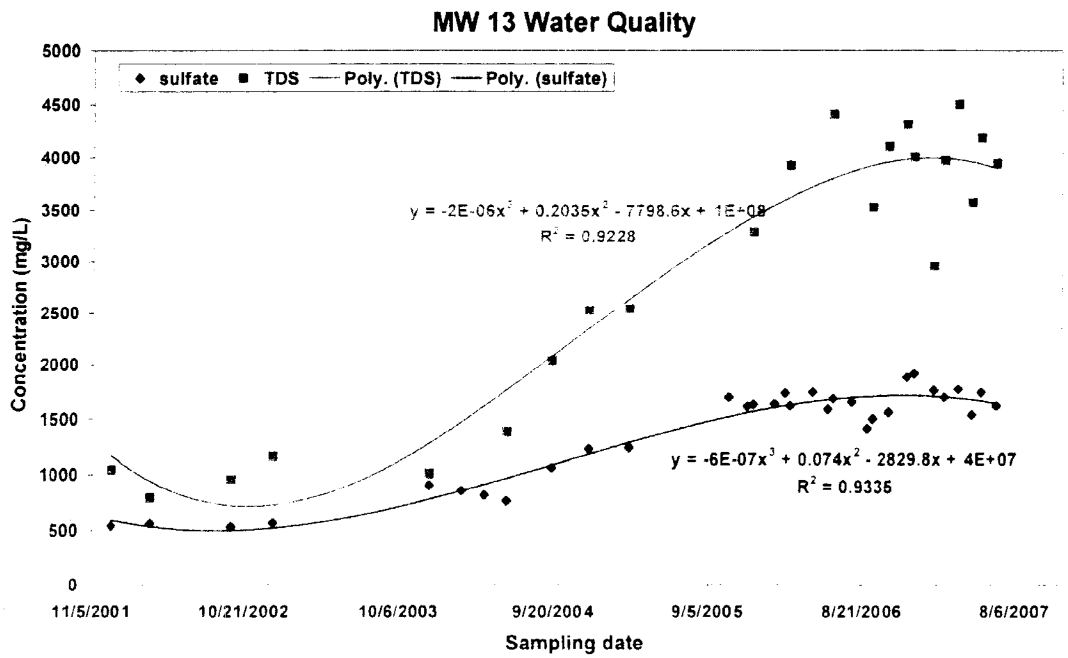

Figure A-17: Time series plots for sulfate and TDS concentrations in the near-field down-gradient well MW -13 from Turner Pit area showing an increasing time trend

Figures A-18 through A-20 are time series plots for indicator parameters for the further down-gradient monitoring well (MW-8) from Turner Pit.

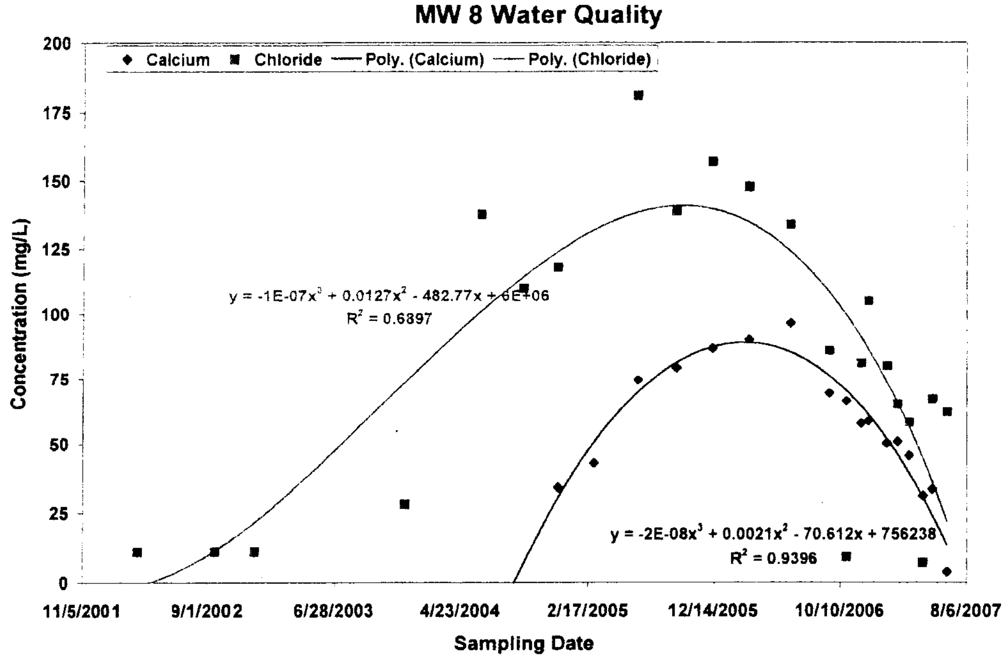

Figure A-18 Time series plots for calcium and chloride concentrations in the further down-gradient well MW-8 from Turner Pit area showing an increasing then decreasing time trend

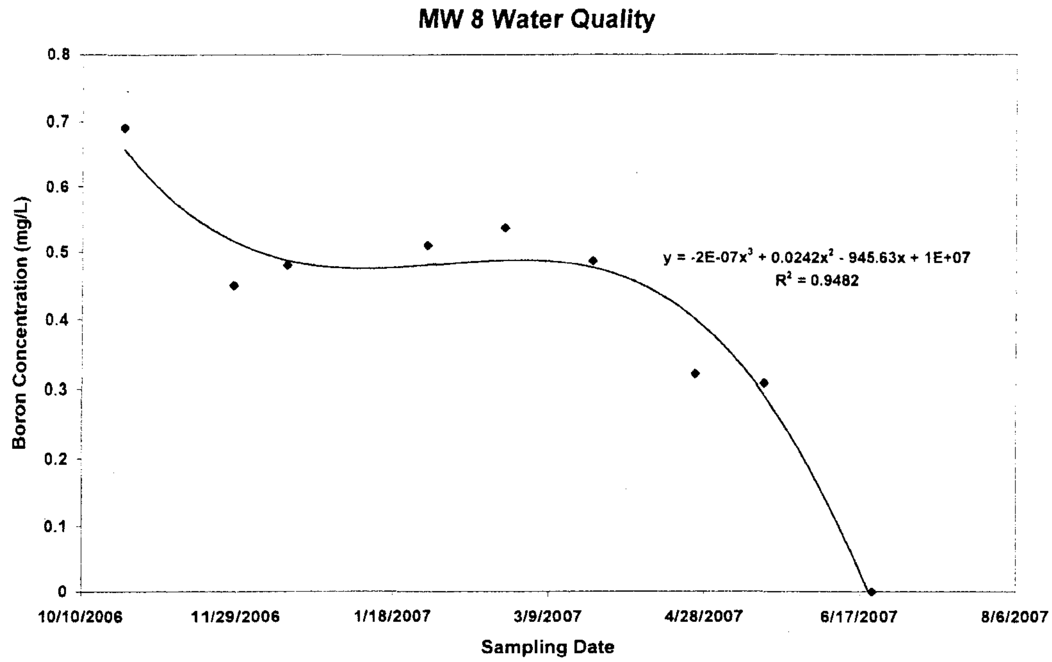

Figure A-19: Time series plots for boron concentrations in the further down-gradient well MW-8 from Turner Pit area showing a decreasing time trend

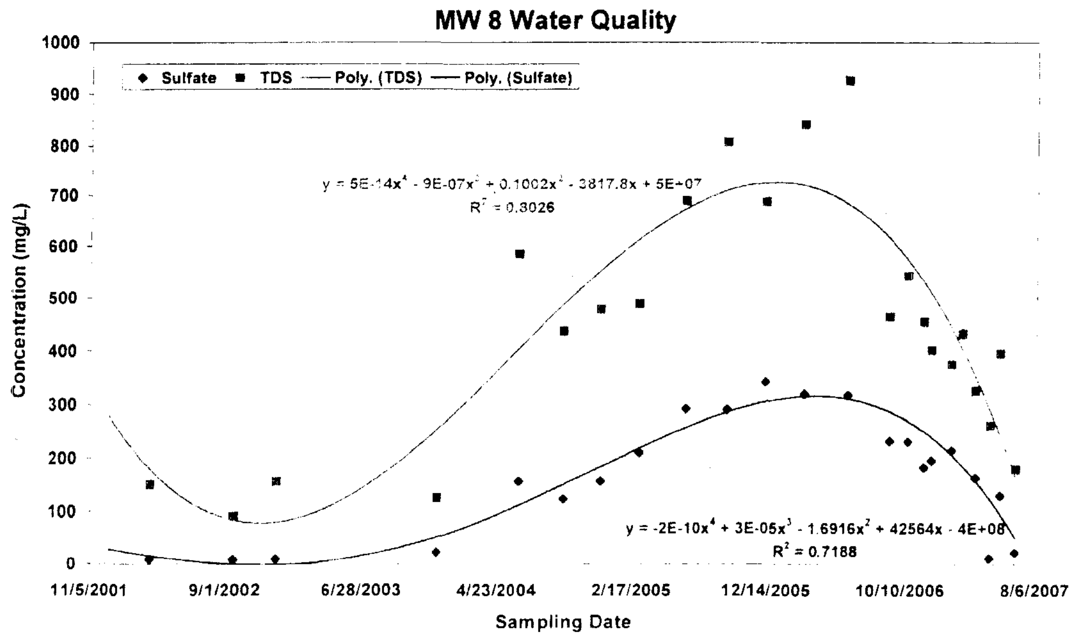

Figure A-20: Time series plots for sulfate and TDS concentrations in the further down-gradient well MW-8 from Turner Pit area showing an increasing and then decreasing time trends

APPENDIX B

Graphical presentation of concentrations of indicator parameters to identify migration of ash leachate from the Waugh Chapel and Turner Pits (spatial analysis)

APPENDIX B
CONTENTS

Figures B-1 through B-3 are spatial plots for sulfate and TDS along A-A' and B-B' for Waugh Chapel Pit.

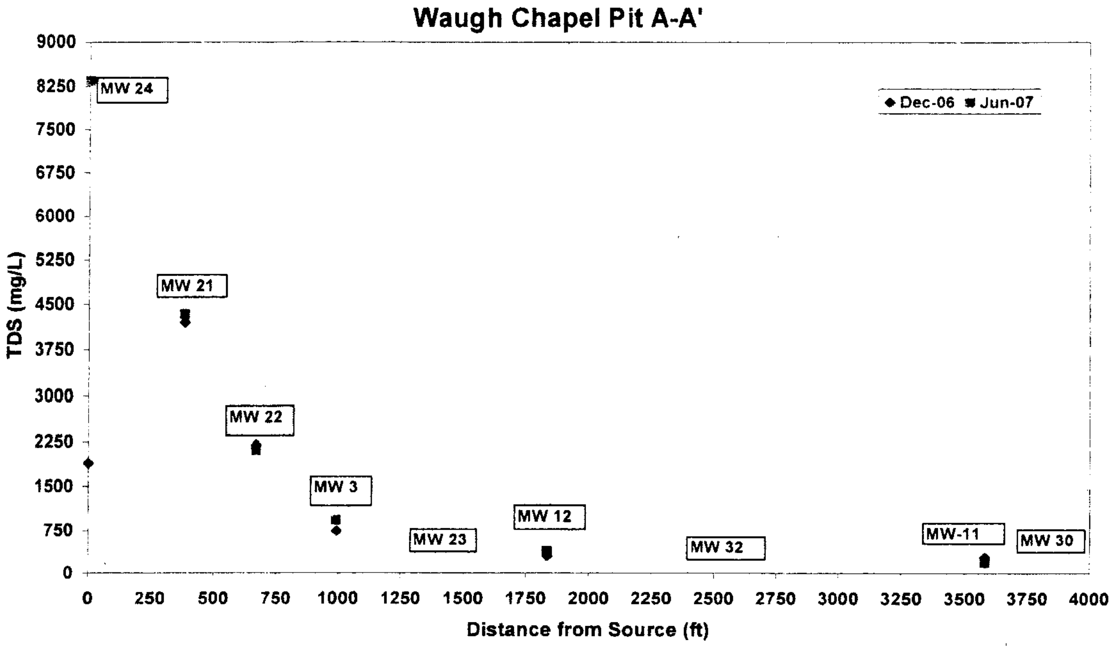

Figure B-1: Spatial distribution of TDS in leachate and groundwater from the Waugh Chapel Pit for December 2006 and June 2007 along flow path A-A'

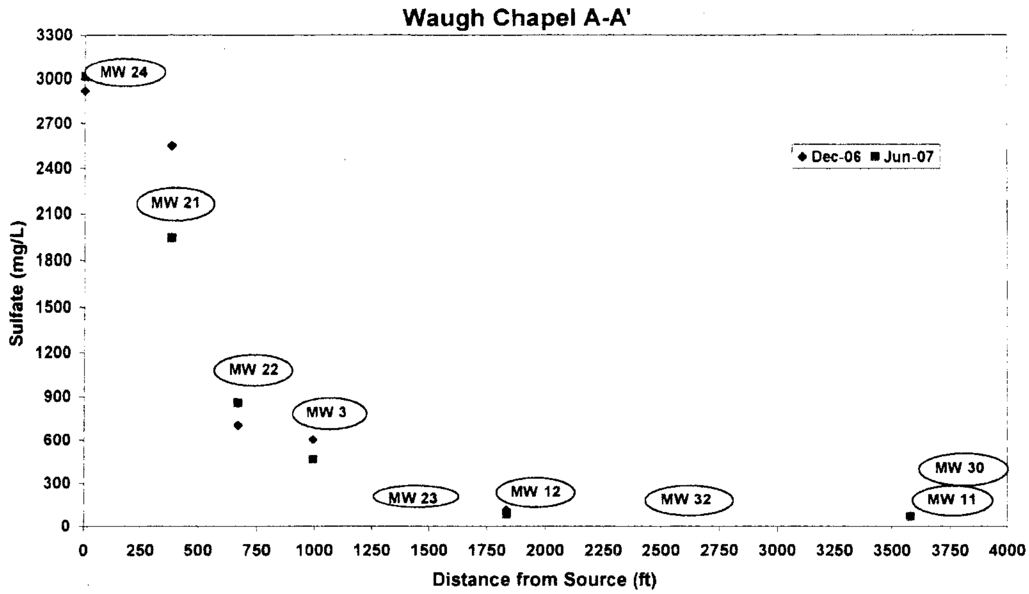

Figure B-2: Spatial distribution of sulfate in leachate and groundwater from the Waugh Chapel Pit for December 2006 and June 2007 along flow path A-A'

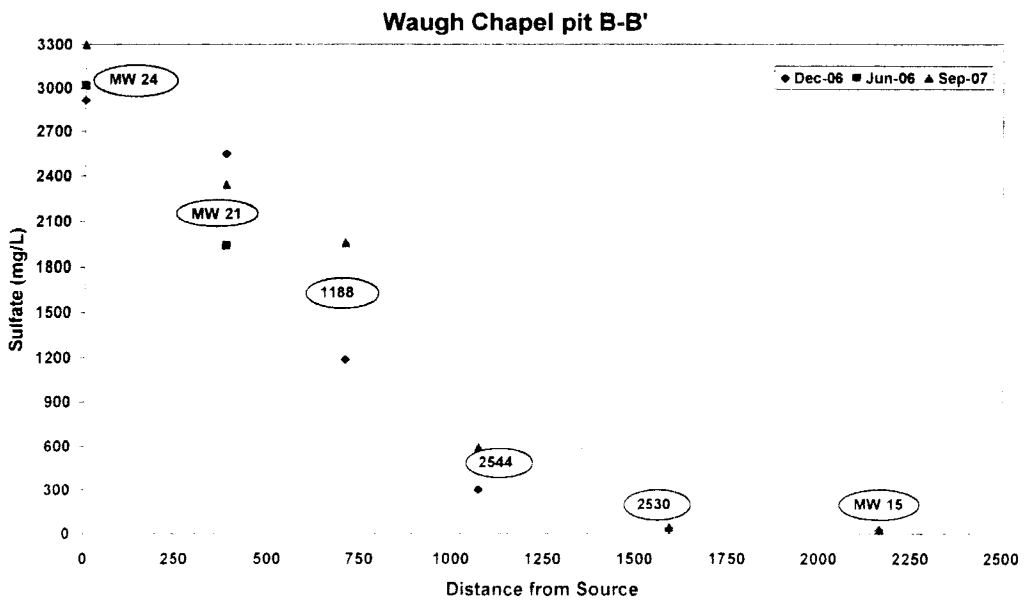

Figure B-3: Spatial distribution of sulfate in leachate and groundwater from the Waugh Chapel Pit for December 2006 and June 2007 along flow path B-B'

Figures B-4 and B-5 are spatial plots for sulfate and TDS along C-C' for Turner Pit.

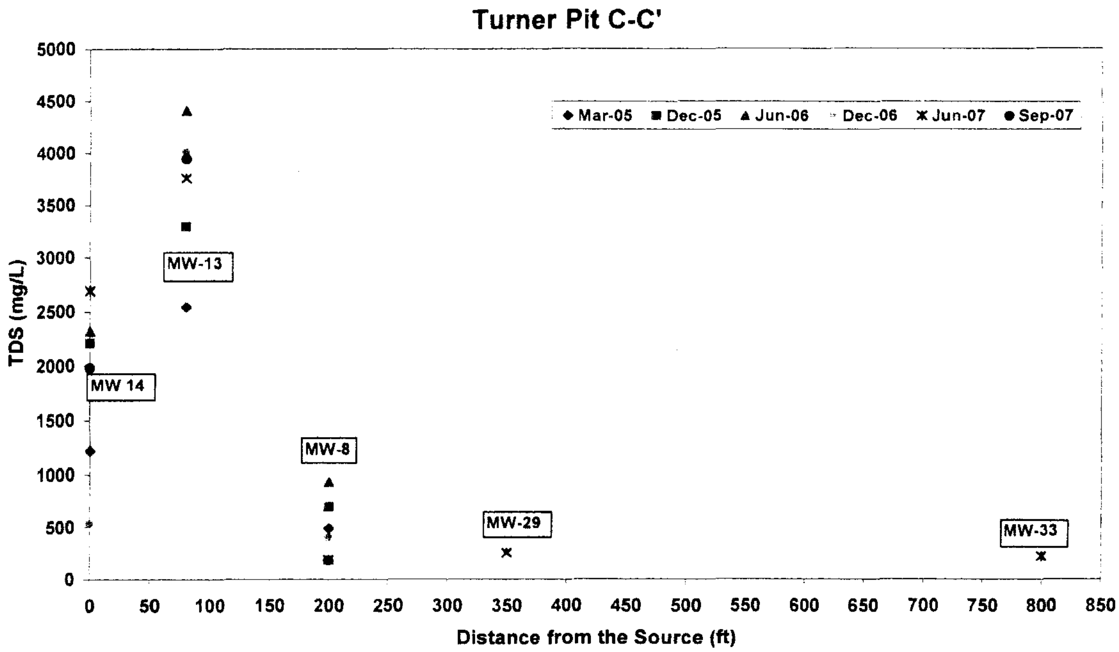

Figure B-4: Spatial distribution of TDS in leachate and groundwater from the Turner Pit for March 2005, December 2005, June 2006, December 2006, June 2007 and September 2007 along flow path C-C'. Data shown for MW-29 and MW-33 are for illustration purposes, not actual data.

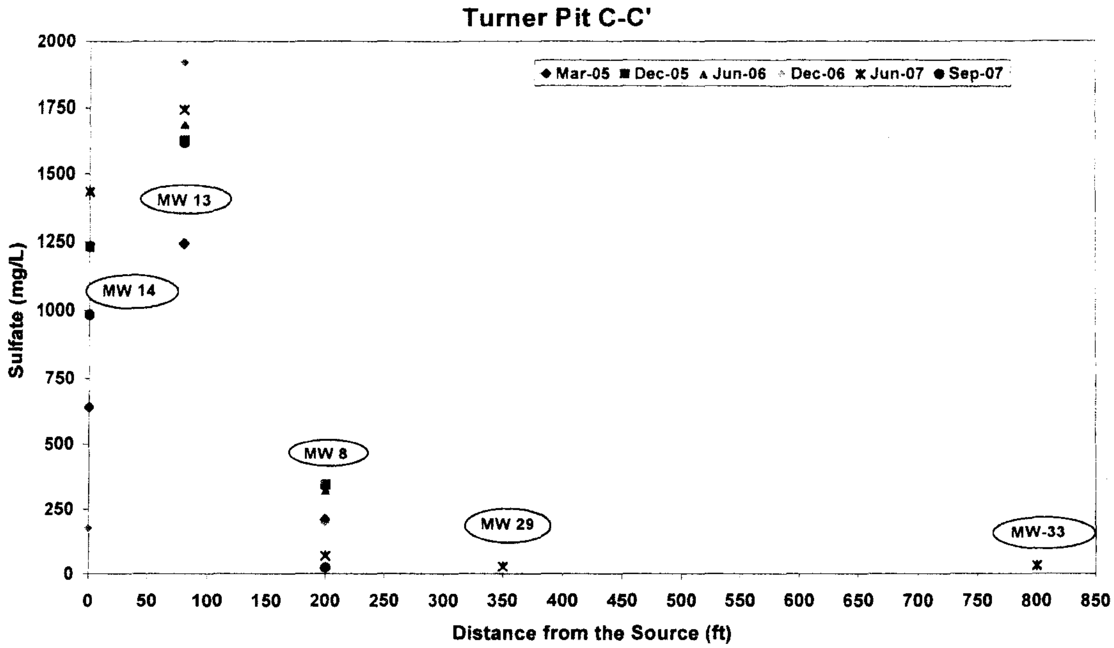

Figure B-5: Spatial distribution of sulfate in leachate and groundwater from the Turner Pit for March 2005, December 2005, June 2006, December 2006, June 2007 and September 2007 along flow path C-C'. Data shown for MW-29 and MW-33 are for illustration purposes, not actual data.