Mabel Davis Park Groundwater Investigation

October 2011

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Abstract

Pollutant transport from municipal solid waste landfills is most often caused by water movement through waste to natural groundwater and is measured directly in landfill leachate collection systems and downgradient wells, seeps, and springs. These data indicate the source of groundwater and may dictate alternate management for pollutant attenuation. Following remediation, the Mabel Davis landfill was monitored through comparison of leachate volume, rainfall, and well water levels. In addition, water chemistry analyses were conducted including isotopic ratios related to source waters. Data collected from these investigations indicates the St. Elmo Terrace Deposit is the source of natural groundwater on the site. It also appears that this natural shallow groundwater is the source for Mabel Davis seep and the observed fluctuation in leachate volume. As a result, leachate volumes will continue to fluctuate with seasonal rainfall amount with large amount of leachate being generated during wet periods and low leachate amounts during drought conditions. Solid Waste Services may want to consider alternatives for management of remediated landfill cover to redirect infiltrating rainfall and ultimately reduce production of leachate to within design parameters.

Introduction

This report was prepared for the City of Austin's (City's) Solid Waste Services Department to document the results from several site investigations of groundwater issues at Mabel Davis Park with respect to increases in the volume of water discharging from the leachate collection system. Over the past three years, from April of 2007 to September of 2011, ERM staff conducted limited groundwater investigations of the occurrence, source and fluctuation of groundwater at the site and its effect on the amount leachate present within the leachate collection system for the closed landfill at the park.

Site Location and History

Mabel Davis Park is located at 3427 Parker Lane in Austin, Texas. The park is about 50-acres and is located east of Interstate 35, along Parker Lane, just north of Ben White Blvd. The park property was used as a gravel quarry until 1944. From 1944 to 1955, the site was used as a municipal waste landfill. The City purchased the property in 1974 and opened the park in 1979. The park was named after Mrs. Alden Davis a civic leader whose service to Austin spanned more than 60 years. Mrs. Davis was Life Chairman Emeritus of the Parks and Recreation Advisory Board, on which she served since its formation in 1951. From 1955 to 1974, no permitted activity occurred on the site; however, it is suspected that illegal dumping occurred after closure of the landfill.

Two well-defined intermittent headwater stream channels of the West Country Club Creek converge in the northeastern corner of the park. These streams traverse parts of the buried landfill. One stream runs west to east through the northern portion of the park and is referred to as the Parker Channel. The second stream flows from south to north along the eastern portion of the site and has a large pond at the headwaters of the tributary. The pond was constructed prior to 1944, when the site was operated as a gravel pit and it is believed to be spring fed from the St. Elmo Terrace Deposit. By the late-1990's, creek erosion began to expose some of the landfill. In early-2000 a site assessment revealed pesticide contamination suspected to be from a spill in 1979. Remediation of the spill met 1979 standards; however, it failed more stringent standards effective in early 2000 at the time of the site assessment.

In early 2004, the City designed and implemented a $7.3 million assessment and remediation project that included a landfill management component performed under the Texas Commission of Environmental Quality's Voluntary Cleanup Program. The project was completed in November 2005. The remediation consisted of excavation and off-site disposal of contaminated soil and installation of low-permeability soil cap or cover over the landfill area. The landfill improvements included removal of trees and woody vegetation from the landfill cap, re-grading the landfill cap to promote runoff and reduce infiltration, installation of an underground soil-bentonite cutoff wall downgradient of the on-site stock pond to minimize groundwater infiltration from the pond into the landfill. Also, the project involved installation of a leachate collection system and a landfill gas collection system. The park re-opened on December 3, 2005.

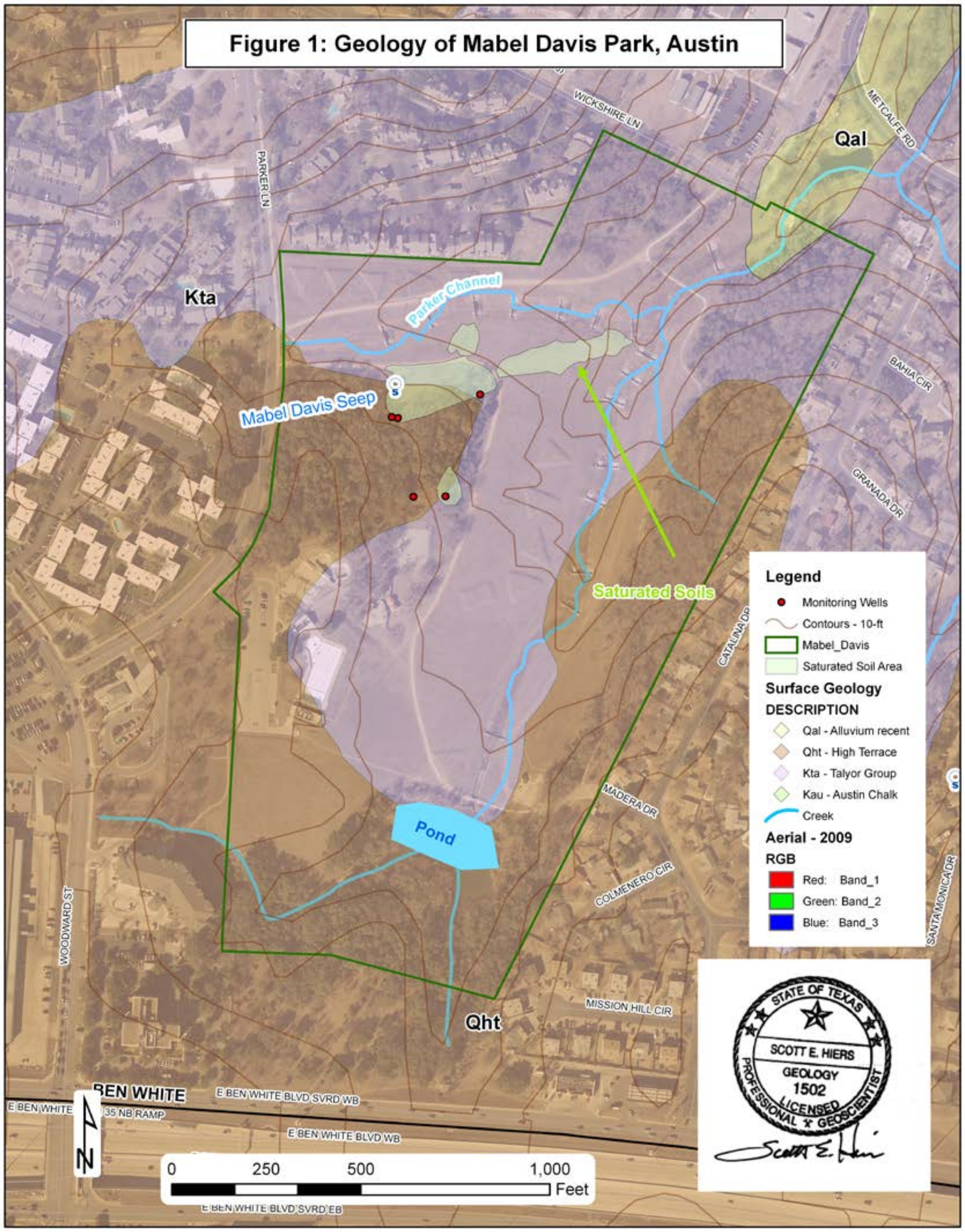
In early 2007, groundwater was observed along the wooded area south of Parker Channel discharging from a seep and saturated soils on the hillside and water was observed flowing across the landfill cap. In addition, monthly leachate volumes measured in the collection system were increasing from the landfill. To determine if groundwater might be causing the increase in leachate volume, the City installed five piezometers to monitor groundwater elevations up-gradient of the landfill and collected a water sample for water chemistry and isotope analysis. Preliminary source water investigations determined that the source of the groundwater was natural groundwater within the St. Elmo terrace deposit. However, urban leakage could not be ruled out as a source. During the drought of early 2008-2009, no groundwater was observed on site. In March of 2009, seeps and saturated conditions were once again observed on site. By this time, the leachate collection had been repaired, so the monitoring of groundwater elevation was resumed.

Groundwater elevation continued to be measured by ERM staff until fall of 2010. Using the data from the entire period of record, an Auto Regressive Integrated Moving Average Model (ARIMA) was used by ERM staff to determine whether there was a statistically significant relationship between rainfall and the leachate volume after the collection system was repaired. The results of ARIMA analysis indicated that about 60% of variability in leachate volume is explained by rainfall. This suggests that the rainfall and/or groundwater from St. Elmo Terrace Deposit is infiltrating into the leachate collect system.

Surface Geology and Groundwater Resources

The 1986 geologic map created by A.R. Trippet and L. E. Garner entitled "Geology of the Austin Area, Texas" indicates that Quaternary-age Colorado River High Terrace Deposits and Taylor Group (undivided) are exposed at the surface on the site (Figure 1). The oldest rock unit is the Taylor Group, which consists of alternating sandstone, mudstones and shales deposited in a deltaic or shallow-marine shelf environment during the Late-Cretaceous age. The alluvial terrace deposits of the Colorado River are also of Late-Quaternary age rock units. The alluvial deposits

Figure 1: Site Geology



Source: Bureau of Economic Geolgy; Geologic Map of Austin Area, Texaas 1986

have been the focus of many geologic investigations over the past 100-years by Hill and Vaughan, 1896-97; Baker and Penteado-Orellana, M.M., 1977; Blum and Valastro, 1994; Urbanec, 1963; and Weber, 1968. As a result of multiple studies over a long period of time, nomenclature of the terrace stratigraphic sequences varies. The Colorado River High Terrace

Deposit at Mabel Davis is referred to as the St. Elmo or Barton Creek Terrace by Weber (Weber, 1968). The St. Elmo Bench is about 6-miles along and 2.7-miles wide. It runs parallel to the Colorado River with an orientation in an easterly direction with slopes about 17-ft per mile eastward and elevations ranging from 700-ft on the western side to 500-ft to the east. The maximum thickness of the
deposit is about 30-ft (Urbance, 1963). The terraces are remnants of former floodplains of the Colorado River, when the river was flowing at higher elevations prior to an episode of downcutting (Weber, 1968).

Groundwater occurs in the upper portion of the Taylor unit within palochannels or weathered zones and is also perched within the terrace deposits. Since the underlying Taylor has lower permeability then the overlying alluvial terrace deposits, many springs and seep discharge near the contact between these two units. At least, fourteen mapped minor springs or seeps have been identified and mapped by the City of Austin Watershed Protection Department - Environmental Resource Management (ERM) division (Figure 2). The springs and seeps are important in maintaining base flow in creeks in the Austin area.

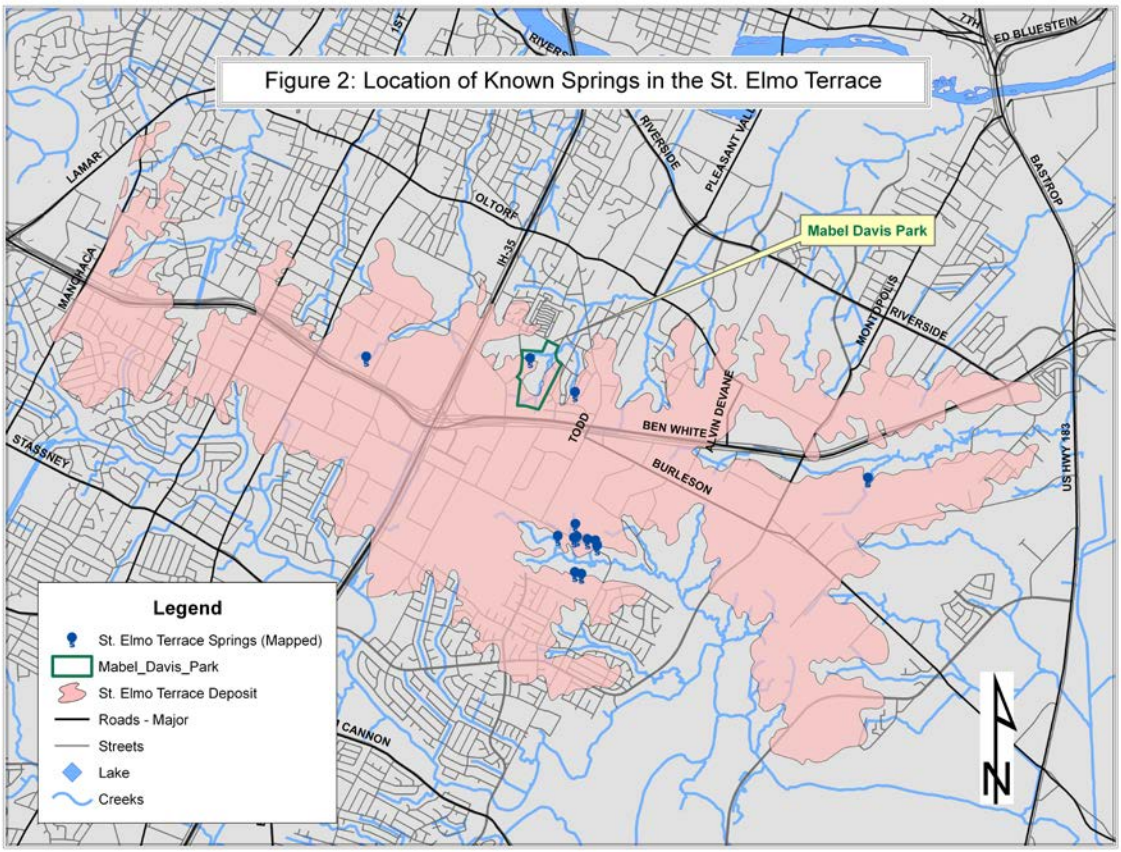


Figure 2: Location of Known Springs in the St. Elmo Terrace

Groundwater Elevation Monitoring and Modeling Results

Groundwater elevations, daily rainfall, and daily leachate volumes from the leachate collection system were monitored and analyzed to determine if groundwater was affecting leachate volumes and groundwater flow in the closed landfill at Mabel Davis Park.

Source Water Investigation - Strontium and Oxygen Isotope Evaluation

During periods of high rainfall, groundwater discharges were measured from an intermittent spring/seep, known as Mabel Davis Spring, along a wooded area south of Parker Channel (See Figure 1). In order to determine the water source of the discharge, ERM staff collected water samples from the seep and had them analyzed for physiochemical, ionic, and isotopic constituents. From data available in 2007, a natural groundwater source was suggested but urban leakage from water or wastewater lines could not be ruled out. However, continued analyses using isotopes as tracers for anthropogenic influences on surface and groundwater has strengthened the case that water discharging from up gradient of the Parker channel is natural groundwater.

In the Austin area, Christian, Banner, and Mack have used strontium isotope ratios (87Sr/86Sr) to determine sources of groundwater (Christian, unpublished). In general, waters from Cretaceous limestone in the Austin area have lower ratios than water from Colorado River and anthropogenic water (treated drinking water or wastewater also originating from the Colorado River). One way of separating natural stream water and groundwater is examine pH. Anthropogenic water will have higher pH values due to treatment chemicals; between about 8.0 and 9.6. Hauwert has also seen similar results with oxygen isotopes. Preliminary findings indicate that $18O_2/16O_2$ values of -3.0 are common for groundwater systems in the Austin area. Wastewater and tap water have more positive values ranging from -1.5 to 1.0 (Nico Hauwert, Personnel Communication).

In 2007 a water sample was collected from a seep in a wooded area near piezometer PZ-1 and analyzed for oxygen ($18O_2/16O_2$) and strontium isotope (87Sr/86Sr) ratios to help determine the source for the groundwater. Results are provided in Table 1. Three springs; Mable Davis, Winnebago, Laguna Spring, that discharge from the St. Elmo Terrace deposit have also been evaluated and the results are plotted in Figure 3. Due to a leaking waterline, Laguna Springs has a much higher pH compared to Mabel Davis and Winnebago Spring. If Mabel Davis Spring was directly influenced by leaking potable water or wastewater its pH should be higher than the 7.11 and isotopic ratios plotted similarly to Laguna Spring. However, if the leaking infrastructure is a long way away from the discharge point, the pH value might look chemically the same as natural groundwater due to buffering by contact with soil and rock along its flow path to the spring or seep.

All three springs have similar 87Sr/86Sr values ranging between 0.709000 and 0.709500, which suggest a similar water source. City of Austin water, Colorado River water, and Austin area soils have 87Sr/86Sr values at or near 0.7090. The preliminary 87Sr/86Sr results seem to indicate that springs in the Late Quaternary age alluvial terrace deposits of the Colorado River have higher strontium ratios compared to water originating from a limestone aquifer. This occurs due to higher silica content of the alluvium from quartz and chert pebbles, lower limestone content, and higher soil content within the deposits. Lithologic analysis of High Terrace deposits determined that limestone content was less than 6% (Weber, 1968). As a result, the High Terrace deposits should have 87Sr/86Sr ratios similar to the Colorado River water. In order to rule out leaking infrastructure as the source of the water at Mabel Davis seep, additional isotopic analysis (for oxygen isotope ratios) was completed on water a sample collected May 2007.

Table 1: Water Chemistry

SITE NO.	DATE	PARAMETER	VALUE	UNIT
4054	29-Mar-07	AMMONIA AS N	0.07	MG/L
4054	29-Mar-07	NITRATE/NITRITE AS N	1.58	MG/L
4054	29-Mar-07	FLUORIDE	0.14	MG/L
4054	16-Mar-07	DISSOLVED OXYGEN	1.76	MG/L
4054	16-Mar-07	PH	7.11	MG/L
4054	16-Mar-07	WATER TEMPERATURE	19.43	Deg. Celsius
4054	16-Mar-07	CONDUCTIVITY	933	uS/cm
4054	15-May-07	DELTA-18 OXYGEN SMOW (ISOTOPE)-STD MEAN OCEAN WATER	-3.5	Ratio to SMOW
4054	15-May-07	DELTA-18 OXYGEN SMOW (ISOTOPE)-STD MEAN OCEAN WATER	-3.4	Ratio to SMOW
4054	15-May-07	DEUTERIUM/PROTIUM RATIO	-23	Ratio to SMOW
4054	15-May-07	DEUTERIUM/PROTIUM RATIO	-24	Ratio to SMOW
4054	15-May-07	STRONTIUM-86/STRONTIUM-87 RATIO (STABLE ISOTOPE)	0.70928	Ratio

The oxygen isotope ratio in water aids in determining anthropogenic influences on groundwater. The oxygen isotope ratios ($18O_2/16O_2$) values that are below -3.0 are common for natural groundwater springs and wells (Hauwert, personnel communication). Wastewater and tap water influenced water typically have values ranging of -1.0 or greater. The strontium and oxygen isotope results for Mabel Davis spring collected in 2007 are shown on Figure 4. Additional strontium and oxygen isotope data is needed from alluvial springs to interpret the plot, but the oxygen isotope value of -3.5, is within the range observed for natural groundwater sources in the Austin Area.

Table 2: Strontium Isotope Ratios

Sample	Number of Samples	87Sr/86Sr Mean	87Sr/86Sr Range
West Bull Creek Water	2	0.70781	0.70778 - 0.70783
Barton Creek Water	9	0.70793	0.70785 - 0.70809
Onion Creek Water	21	0.70798	0.70788 - 0.70810
Bull Creek Water	5	0.70801	0.70778 - 0.70824
Slaughter Creek Water	7	0.70806	0.70794 - 0.70819
Williamson Creek Water	8	0.70822	0.70803 - 0.70870
Shoal Creek Water	10	0.70853	0.70814 - 0.70896
Waller Creek Water	65	0.70879	0.70818 - 0.70918
City of Austin Wastewater	2	0.70839	0.70810 - 0.70867
Soil Exchangeable Sr - Austin Area	35	0.70850	0.70786 - 0.70986
City of Austin Tap Water	10	0.70889	0.70878 - 0.70902
Colorado River - Downstream of Austin	2	0.70913	0.70886 - 0.70939

* *Source: Christian, L.N., Banner, J.L., and Mack, L.E., 2011*

Figure 3

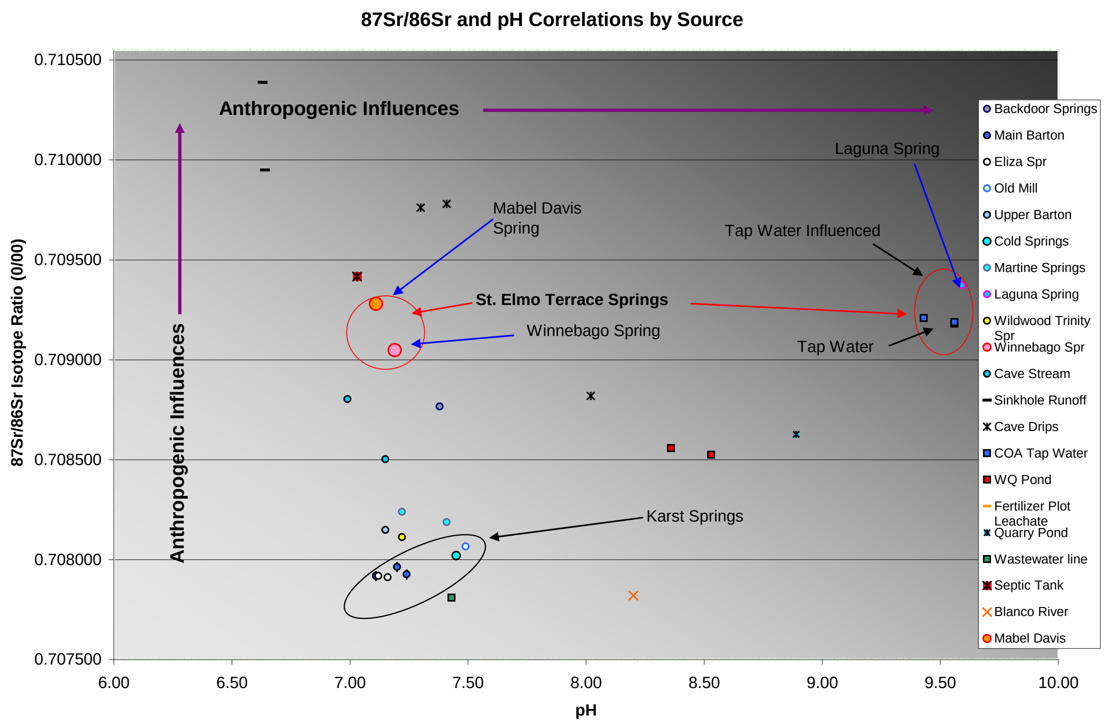
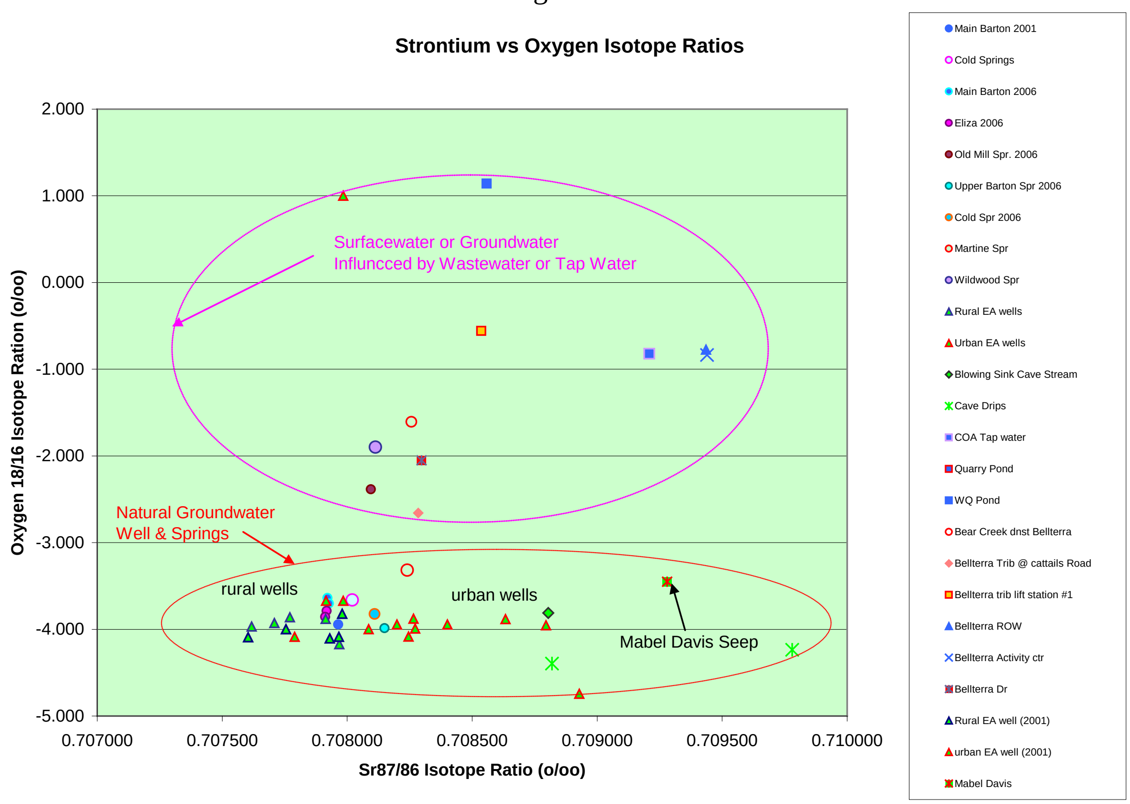


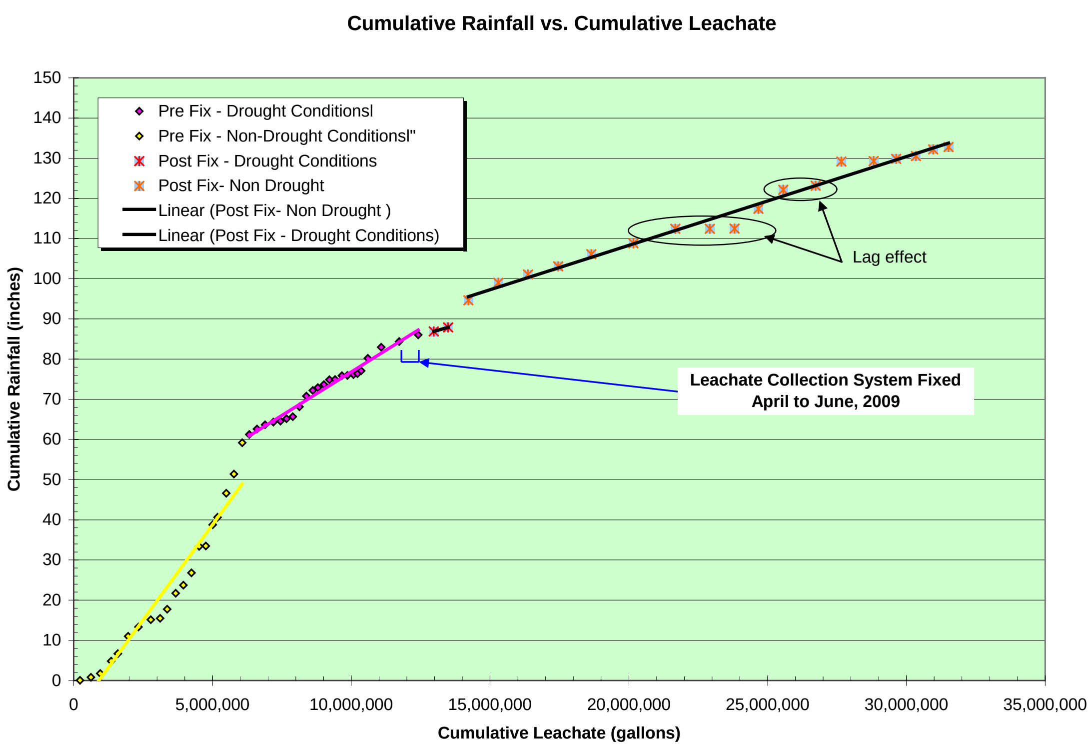
Figure 4



<u>*Rainfall versus leachate volume*</u>

A plot of cumulative monthly rainfall versus cumulative leachate volume was completed to evaluate infiltration through the landfill cover. Figure 5 plots the cumulative monthly rainfall data from Flood Early Warning System rain gauge No. 830 located 1800-ft west-southwest of Mabel Davis Park within the Internal Revenue Service's parking lot against the accumulated leachate volume measured at the lift station connected to the leachate collection system. Changes in the slope of cumulative plots indicate correspondence between leachate volume and rainfall. If no relationship existed between rainfall and leachate, then the slope of trend line would not change. A steep slope as seen in the period before collection system repair would indicate that rainfall had little to no influence on the leachate volume. The flatter the slope the more influence the same amount of rainfall has on leachate volume as seen in the period after the collection system was repaired. The plot data shows much flatter slopes in the trend line after June 2009, when the leachate collection system was repaired during drought and non-drought conditions. By looking at distance of points from the trend line, one can determine if there is lag or delay response between rainfall and leachate. Two lag responses are show on the graph when the monthly rainfall amount was near zero, but leachate volume increased. The lag response suggests slow infiltration of rainfall thru the cap or groundwater seepage into leachate collection system.

Figure 5



A time trend analysis of monthly leachate and rainfall amounts shows that once the leachate collection system was repaired, months with large rainfall amounts are follow by an increase in leachate volume (Figure 6). The duration of the lag time is dependent upon the soil moisture conditions, the frequency of rainfall, and the rainfall amount. The volume of leachate that is produced by the landfill is a function of the amount of water percolating through the waste. If an anthropogenic source of water is influencing leachate volume, then changes in the monthly leachate volume should not track with fluctuations in monthly rainfall amounts as seen prior to repair of leachate collection system. The relationship between rainfall and leachate volume seen in Figure 6 shows that there is a connection between surface water and groundwater via infiltration to the leachate collection system.

ARIMA Modeling

The Auto Regressive Integrated Moving Average Model (ARIMA) is a statistical method used to account for lag effects in the time series data. An ARIMA model was used to analyze the rainfall and leachate data. The model results indicate (Table 3) that the total amount of leachate present in the leachate collection system on the previous day and the amount of rainfall that day explains 58.5% of the variability in daily leachate amounts. This indicates that there is a fair connection between rainfall and leachate volume.

Figure 6: Leachate Volume

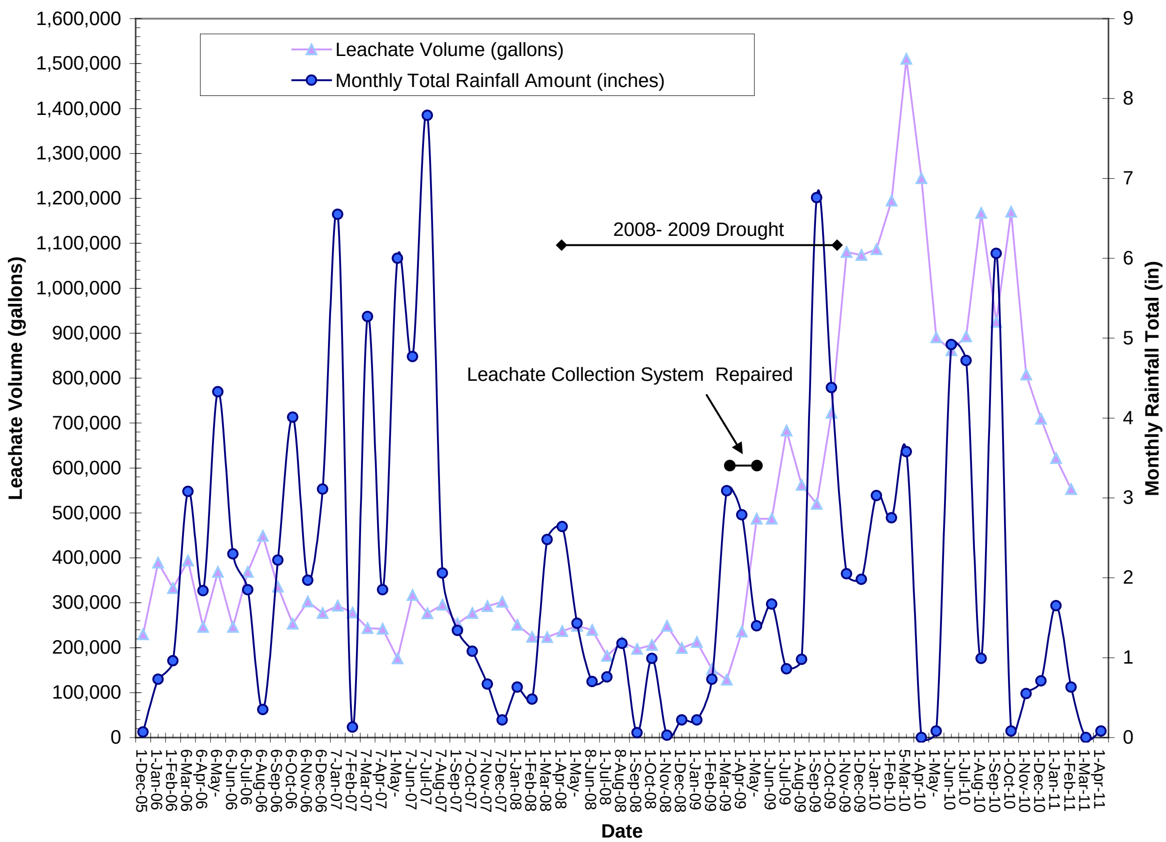


Table 3: Rainfall-Leachate Statistics

Parameter	Estimate	StdErr	tValue	Probt	Lag	Shift	R-square
Total Leachate MU	-2.05249	0.403375	-5.09	<.0001	0	0	**0.58352**
Total Leachate MA1,1	0.805727	0.03727	21.62	<.0001	1	0	
Total Leachate AR1,1	0.165339	0.059982	2.76	0.0058	1	0	
Rainfall Total (in)	19.14229	2.190506	8.74	<.0001	0	0	

Groundwater Elevations, Leachate Volume and Rainfall

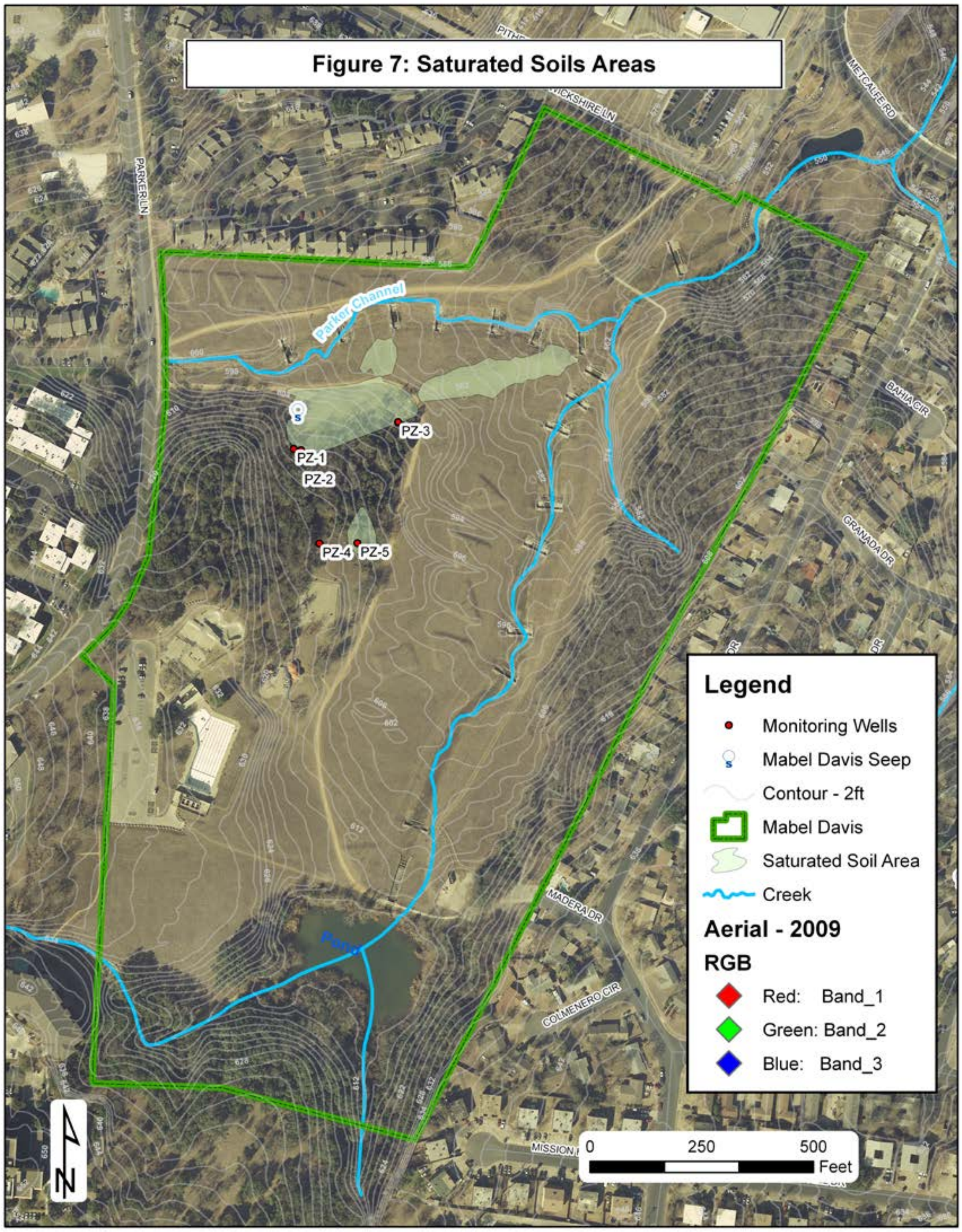
Shallow groundwater is perched within the St. Elmo Terrace deposit by the less permeable rock units of the Taylor Group. Minor amounts of groundwater are also present within upper weathered zone of the Taylor Group, which in the Austin area, is about 15 to 20-ft thick Groundwater discharging in the form of springs and seeps is common for these alluvial terrace deposits during periods of frequent and abundant rainfall. At Mabel Davis in 2007 and 2011 seeps and saturated soil areas were observed by ERM staff east of Parker Lane along a wooded area on the south side of the Parker channel (Figure 7). To better understand the shallow groundwater system, five piezometers wells; PZ-1, PZ-2, PZ-3, PZ-4 and PZ-5, were installed in early 2007 to a depth of about 14.5-ft. ERM staff monitored the groundwater elevations at the wells from November 2007 to September 2010 to determine if there was a connection between groundwater elevations and leachate volume. The groundwater elevations are reported in Table 4. For about an 8-month period; September 2008 to April 2009, the piezometers were dry. During this time, Central Texas was experiencing a drought due to the La Niña weather pattern. After June of 2008, PZ-2 was vandalized and no longer suitable as a monitoring well. The only other notable change in groundwater elevation measurements was that PZ-5 was dry until March of 2010, and then afterwards, consistent groundwater elevations were measured.

Time-series plot of monthly leachate volume and groundwater elevations are shown in Figure 8. As seen with the cumulative rainfall versus total leachate volume graph, after the leachate collection system was repaired in June of 2009, changes in leachate volume correlate to similar changes in groundwater elevation. Since all the piezometers are up gradient of the landfill, the corresponding response to fluctuations in leachate indicates a hydrologic communication between groundwater within the St. Elmo Terrace Deposit and Mabel Davis landfill leachate collection system. PZ-1 PZ-3, PZ-4, and PZ-5 track well with change in leachate volume. PZ-5, which was dry prior to June 2009, shows a much more dramatic decreasing response of leachate volume to groundwater elevations. The reason for this different response at PZ-5 is attributed to the well location and/or the porosity and permeability differences within the terrace deposit. If the PZ-5 was completed within a zone of high porosity and permeability, its response to dropping groundwater elevations would be more rapid than if it were completed in a less porous and permeable zone. A plot of same data on daily time-step also exhibits a stronger response to changes in the daily leachate volume with the repair of the leachate collection system. Figure 9 shows the daily rainfall amount and daily leachate volume from April of 2009 to April 2010.

A time-series plot of rainfall and groundwater elevations shows similar but not as striking responses to that between leachate volume and groundwater (Figure 10). In general, as the monthly rainfall amount decreases, a similar delayed decreasing response is seen in groundwater elevations. Again, as seen in the time series plot, PZ-5 shows a steeper slope for drought conditions. The reason for this different response of groundwater elevation to rainfall in drought conditions has not been determined. An explanation may partially be provided by well locations or porosity and permeability differences within the terrace deposit. Although the time-series plot of rainfall and groundwater is not as convincing as the time-series for leachate and groundwater, the ARIMA model results demonstrate that there is a relationship between rainfall and leachate volume.

Table 4: Piezometer Elevations

Well No.	PZ-1	PZ-2	PZ-3	PZ-4	PZ-5
Well Depth (ft)	15.0	16.0	16.0	16.0	16.0
Well Completeness Elevation (ft)	593.96	590.76	578.67	596.80	590.50
Surface Elevation (ft)	608.96	606.76	594.67	612.80	606.50
Well Elevation at top of Casing (ft)	613.42	611.15	598.20	616.88	609.93
5-Nov-07	606.53	606.50	*Well Dry*	606.69	*Well Dry*
12-May-08	600.98	601.14	590.32	600.94	*Well Dry*
19-Jun-08	601.08	601.33	585.10	601.14	*Well Dry*
26-Jun-08	600.60	600.84	582.28	600.34	*Well Dry*
2-Sep-08	*Well Dry*	*Well Dry*	*Well Dry*	*Well Dry*	*Well Dry*
26-Feb-09	*Well Dry*	*Well Dry*	*Well Dry*	*Well Dry*	*Well Dry*
22-Apr-09	*Well Dry*	*Well Dry*	*Well Dry*	*Well Dry*	*Well Dry*
15-Mar-10	607.72	*Well Damaged*	594.80	608.50	606.61
14-Apr-10	607.22	*Well Damaged*	594.76	607.63	604.49
21-Apr-10	607.34	*Well Damaged*	594.80	607.77	605.66
4-May-10	606.72	*Well Damaged*	594.24	606.97	602.74
8-Jun-10	606.07	*Well Damaged*	594.05	606.18	595.83
29-Jun-10	605.34	*Well Damaged*	592.49	605.41	592.56
5-Aug-10	607.17	*Well Damaged*	594.50	607.75	592.97
9-Aug-10	606.87	*Well Damaged*	594.26	607.15	592.38
15-Sep-10	606.86	*Well Damaged*	594.82	607.14	*Well Dry*



Source: City of Austin - GIS Image server - 2009 Aerials

Figure 8

Time Series Plot- Average Groundwater Elevation and Monthly Leachate Volume

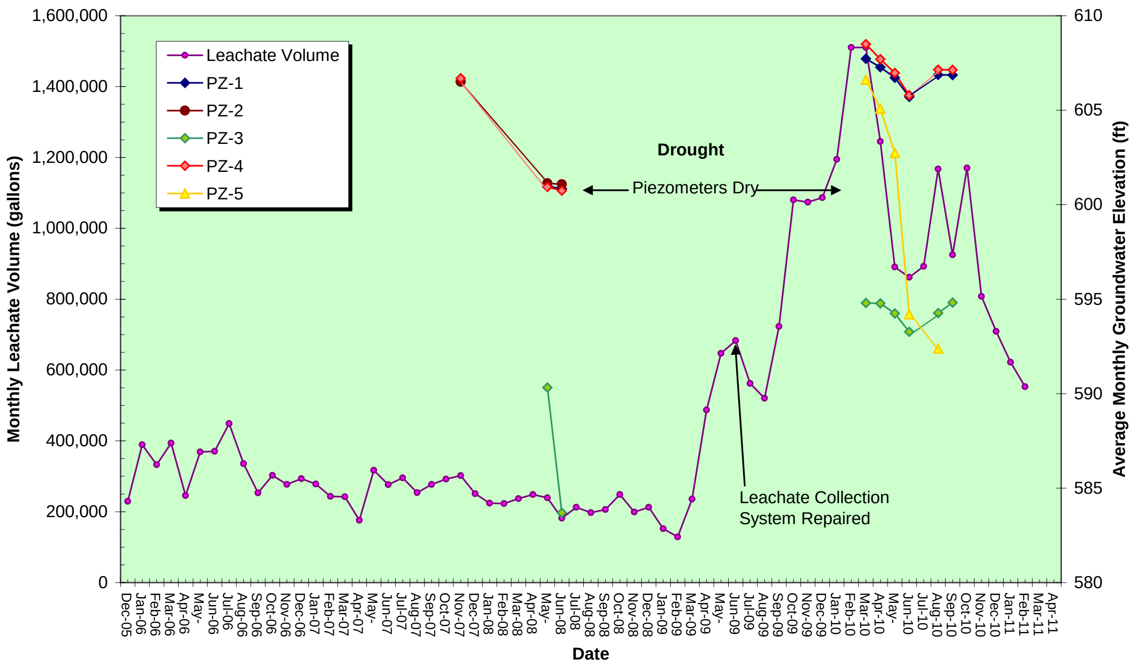


Figure 9

Time Series Plot – Groundwater Elevation and Daily Leachate Volume

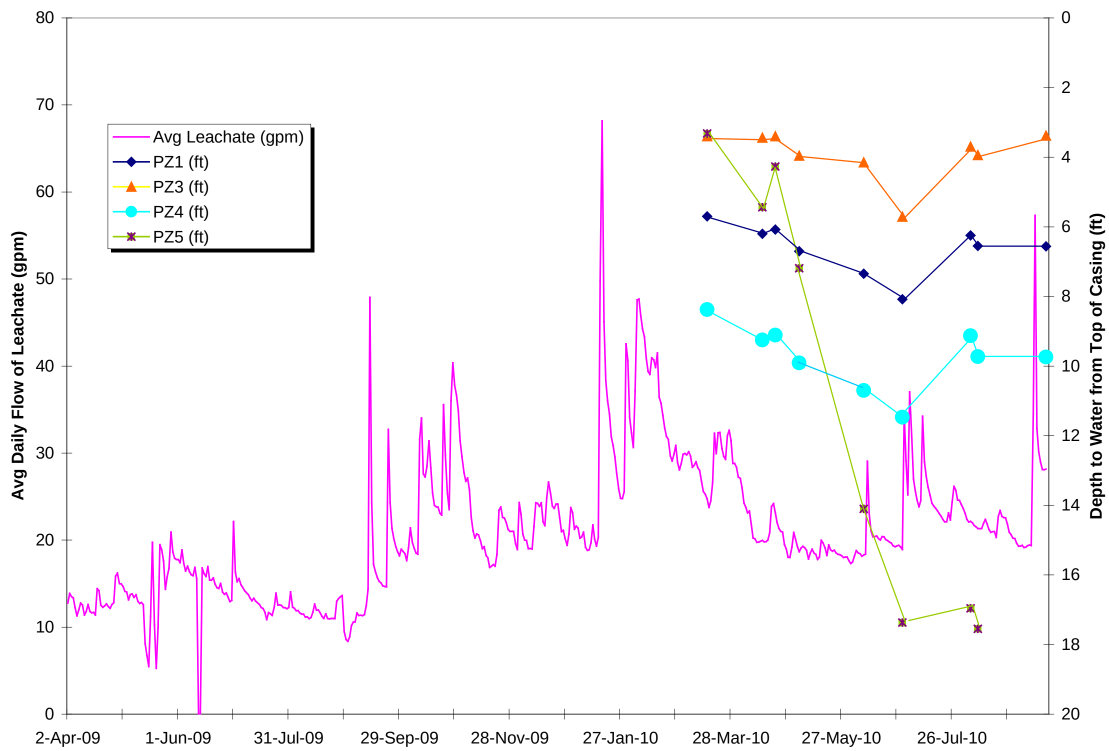
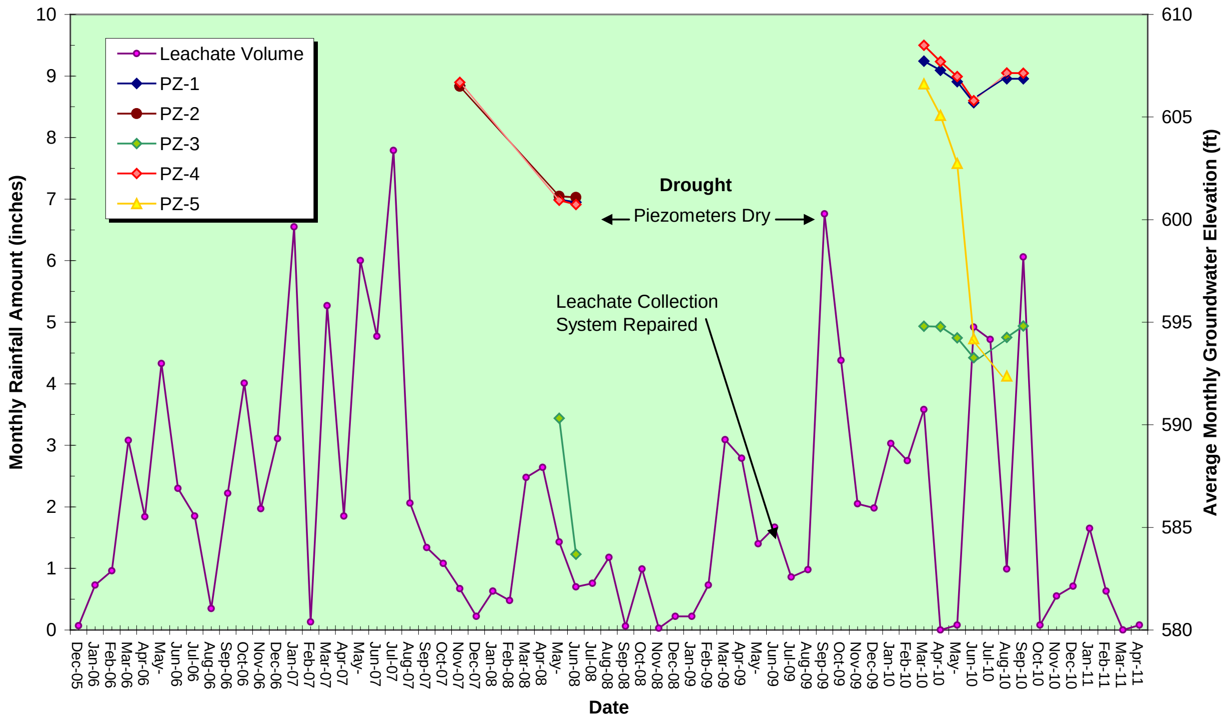


Figure 10

Time Series Plot- Average Groundwater Elevation and Monthly Rainfall Totals



Conclusions

Evaluation of the data collected from these investigations indicates St. Elmo Terrace Deposits are the source of natural groundwater on the site. The strontium and oxygen isotope values and pH values measured at Mabel Davis from a hillside seep suggest a natural groundwater. Both the pH and strontium isotope values observed are similar to other St. Elmo terrace springs. In addition, the oxygen isotope ratio is comparable to natural groundwater and not leaking infrastructure. Water chemistry data, leachate volumes, groundwater elevations, and rainfall indicate that groundwater is the source for Mabel Davis seep and the observed fluctuation in leachate volume. Fluctuations in leachate volume correlate to similar changes in groundwater elevation and suggest there is a hydrologic connection between the leachate collection system and shallow groundwater system. Since the amount of shallow groundwater present is dependent upon seasonal rainfall, a similar but less significant relationship is seen in time series plot of rainfall and leachate volume. Auto Regressive Integrated Moving Average Model (ARIMA) statistics support a connection between the total amount of leachate present in the leachate collection system on the previous day and the amount of rainfall that day. Taken together, these findings indicate a correspondence of groundwater leachate for the Mabel Davis landfill to rainfall. As a result, leachate volumes will continue to fluctuate with seasonal rainfall amount with large amounts of leachate generated during wet periods and low leachate amounts during drought conditions. If SWS can achieve lower infiltration rates through landfill cap improvements or drainage modifications, leachate generation may be disconnected from rainfall influences and be reduced to design criteria rates.

References

Baker, V.R. and Penteado-Orellana, M.M., 1977, Adjustment to Quaternery Climate Change by the Colorado River in Central Texas, The Journal of Geology, Vol. 85, No. 4, pp. 395-422.

Blum, M.D. and Valastro, S. Jr., 1994, Late Quaternary sedimentation, lower Colorado River, gulf Coastal Plain Texas, Geological Society of America Bulletin, No. 106, p. 1002-10016.

Christian, L.N., Banner, J.L., and Mack, L.E., 2011, Sr isotope as tracers of anthorpgenic influences on stream water in Austin, Texas, area,

Hauwert, N., 2011, (Personnel Communication) City of Austin- Watershed Protection Department, Austin , Texas.

Hill, R.T., and Vaughan, T.W., 1896-1897, Geology of the Edwards Plateau and Rio Grande Plain adjacent to Austin and San Antonio, Texas with reference to the occurrence of underground waters: U.S. Geological Survey Annual Report, No. 18, part II, p. 195-321.

Trippet, A.R. and Garner, L. E., 1986, Guide to Points of Geologic Interest in Austin, Bureau of Economic Geology – the University of Texas at Austin, Guidebook 16, 37 p.

Urbanec, D.A., 1963, Stream terraces and related deposits in the Austin area, Texas, [M.S. thesis]: Austin, University of Texas at Austin, 93 p.

Weber, G.E., 1968, Geology of the fluvial deposits of the Colorado River Valley, central Texas [M.S. thesis]: Austin, University of Texas at Austin, 119 p.