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CITY OF TUCSON

MEMORANDUM

DATE: July 12, 2012

TO: Andrew Quigley
Assistant City Manager
City Manager's Office

Nancy Petersen
Interim Director
Environmental Services

FROM: Molly Collins
Project Coordinator
Environmental Services

SUBJECT: Silverbell Landfill WQARF Site Proposed Pump and Treat System: Cost Estimate and Schedule

The updated conceptual design and engineer's cost estimate for the proposed pump and treat system Silverbell Landfill Water Quality Revolving Fund Site (WQARF) from SCS Engineers is complete and attached to this memo. This proposed pump and treat system is designed to treat chlorinated solvents, primarily tetrachloroethene (PCE), at the Silverbell Landfill by extraction, air stripping and reinjection.

Also attached is an analysis of the degradation of methyl-tert-butyl ether (MTBE) into tert-butyl alcohol (TBA) and tert-amyl methyl ether (TAME), which was completed by Clear Creek Associates in order to predict the concentrations of these compounds that may be drawn into the extraction wells and affect the proposed treatment system in the future. The MTBE, TBA and TAME are from the Silvercroft Wash Release Site. This site is the responsibility of Kinder Morgan Energy Partners (KM), and is upgradient of the Silverbell Landfill.

A project schedule for the proposed treatment system and a summary of the engineer's cost estimate showing the estimated capital costs and operations and maintenance for a period of 20 years is also attached. The entire project is broken into two phases based on the time expected for arrival of MTBE, TBA and TAME at the southernmost extraction well, and the potential treatment mechanisms for the three contaminants. Each Phase is described in more detail in the SCS Conceptual Design Report. The 2011 engineer's cost estimate from Malcom Pirnie, for a conceptual design which did not account for MTBE, TBA or TAME, is also attached for reference. Tucson Water has reviewed and provided comments on this package.

Phase I addresses the system construction, and operations to treat PCE from the Silverbell Landfill, which is the primary purpose of the proposed pump and treat system. The design and construction of Phase I is expected to be completed, and the system to begin operation, in the third quarter of 2014. The cost for final design and construction of Phase I is estimated at

$6,039,000. The annual cost for operation of Phase I is estimated at $690,000. The total 20 year annualized cost, including a 30% contingency, is estimated at $1,217,000. Table 1 also shows the estimated annualized cost without the 30% contingency. Environmental Services will issue a Request for Proposal (RFP) to contract a firm to provide the capital to design, construct and begin operations of the Phase I system. The selected firm will be repaid over the 20 year period based on the Phase I 20 year annualized costs with the 30% contingency.

MTBE, TBA and TAME are not regulated under Federal or State drinking water regulations, although the Federal Environmental Protection Agency is currently reviewing MTBE. Under the Arizona Department of Water Quality (ADEQ) Underground Storage Tank (UST) regulations, MTBE has a Tier 1 remedial level of 94 ug/L if no drinking water receptor will be affected by the release. The May 7, 2012 *Draft Remedial Investigation Report, Silvercroft Wash Release Site, Tucson, Arizona*, prepared for KM by Arcadis, states that the MTBE will not require additional treatment by KM when it reaches the proposed treatment system wells because KM believes the concentrations of MTBE will not likely exceed 94 ug/L after 1) treatment by the air stripping unit, 2) mixing with groundwater recharged by the Sweetwater Recharge Facility (SRF), and 3) uptake by the SRF extraction wells for use in the reclaimed water system. According to the RI, the SRF reclaimed water system is a non-drinking water receptor and therefore, MTBE at concentrations less than 94 ug/L in the reclaimed water system would not pose a risk to human health. TBA and TAME were not discussed in the RI report because they do not have remedial guidance levels under the ADEQ UST regulations. ADEQ has not yet approved the RI, and therefore; whether KM will be required to provide groundwater treatment of these contaminants is unknown at this time.

Environmental Services requested SCS Engineers to incorporate treatment of MTBE, TBA and TAME into the conceptual design of the proposed treatment system in order to remove these contaminants to below 1 ug/L, if necessary. Tucson Water has also indicated a willingness to remove MTBE, TBA and TAME at the SRF, if necessary, but this option has not yet been explored.

In order to cover the event that KM contaminants will require treatment if they reach the southernmost extraction well, SCS Engineers separated the design, construction and cost of treatment for these into a separate Phase. In the SCS Engineers conceptual design and engineer's estimate, Phase IIA addresses the addition of two air stripper trays in the proposed treatment system in order to remove MTBE to the detection limit if it impacts the southernmost extraction well. Phase IIB covers the addition of an as yet unknown treatment unit to address the TBA and TAME, if and when they impact the southernmost extraction well. These contaminants are expected to travel at the same rate as MTBE, and may be detected in higher concentrations than MTBE; however, most treatment systems for these two contaminants are currently in pilot phase. Estimated costs for the Phase II activities are shown on Table 1. If and when it becomes necessary to initiate Phase II activities at the proposed treatment system, the annual repayment to the selected firm will be renegotiated.

Jeff Drumm and I met with Procurement on June 7th to discuss the process to contract a firm to design, build, and operate this system for a 20 year period. A draft RFP was provided to the Procurement Team (Victoria Cortinas, Cheri Odeski, Matt Hausman and Lisa Rotello) at that meeting.

I also met with Blake Ashley and Joel Peterson on June 25th to determine the legal requirements (land ownership, environmental liability, etc…) for such a contract. Blake and Joel's suggestions will be incorporated into the RFP and contract for Phase I. Based on the current schedule, we plan to issue the RFP to the Procurement Team in July 2012.

Installation of five groundwater monitoring and testing wells as recommended by Clear Creek Associates in the October 2011 groundwater flow and fate and transport model report is scheduled to begin July 9th. The wells will be completed, pump tested and sampled by the end of August 2012. The information from the well testing and sampling will be included in the RFP for use in the final extraction well design and the operation of Phase I.

If you have any questions concerning this memorandum, please contact me at 837-3703, or Jeffrey Drumm at 837-8313.

MC/cj

cc: Alan Forrest, Tucson Water
Wally Wilson, Tucson Water (email copy)
Bruce Prior, Tucson Water (email copy)
Jeffrey Drumm, Environmental Services (email copy)
Molly Collins, Environmental Services (email copy)
Silverbell Landfill File

ENCLOSURES

SCS Engineers *TECHNICAL MEMORANDUM Recommended Conceptual Design Modifications Silverbell Landfill WQARF Site Pump and Treat System Phase 1 and II,* June 4, 2012
Clear Creek and Associates: *Silverbell Landfill TBA Simulation,* June 4, 2012
Malcom Pirnie *Silverbell Landfill Conceptual Design Cost Update,* January 2011
Project Schedule: Silverbell Landfill Pump and Treatment Phase I and Phase II
Table 1: Silverbell Landfill Proposed Treatment System Cost Summary

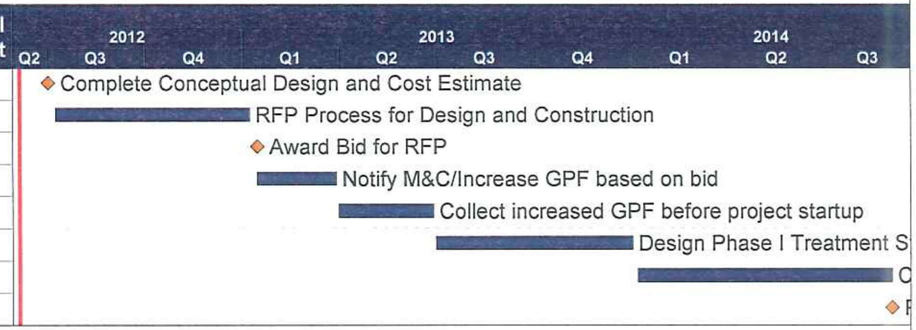
TABLE 1
Silverbell Landfill
Proposed Treatment System Cost Summary

ITEM	CAPITAL COST	O&M COST PER YEAR	Years of Operation	ANNUALIZED COST (without 30% Contingency)	ANNUALIZED COST (with 30% Contingency)	Comments
Phase I Design, Construction and Operation	$ 6,039,000	$ 690,000	20	$ 851,900	$ 1,217,000	Costs expected annually years 1-5 and years 15-20.
Phase II Design, Construction and Operation	$ 2,491,000	$ 389,000	10	$ 509,600	$ 728,000	Expected cost years 5-15 to treat MTBE, TBA and TAME.

See SCS Engineering Report Table 4. SCS annualized Costs include 6% inflation rate
Phase I is to treat PCE only for 20 years
Phase II is to treat MTBE, TBA and TAME in addition to PCE (assumes concentrations increase in year 5 and fall off after year 15)
TBA and TAME treatment is based on best available technology in 2012 (assumes concentrations increase in year 5 and fall off after year 15)
Costs based on RS Means 2009, 2010
15% is included as contractor overhead and profit

SILVERBELL PUMPAND TREATMENT PHASE I

Act ID	Description	Orig Dur	Rem Dur	Early Start	Early Finish	Total Float
1000	Complete Conceptual Design and Cost	0	0	02JUL12 A		
1010	RFP Process for Design and Construction	1d	0	09JUL12 A	07JAN13 A	
1020	Award Bid for RFP	0	0		14JAN13 A	
1021	Notify M&C/Increase GPF based on bid	1d	0	14JAN13 A	29MAR13 A	
1025	Collect increased GPF before project startup	1d	0	01APR13 A	28JUN13 A	
1030	Design Phase I Treatment System	1d	0	01JUL13 A	01JAN14 A	
1040	Construct & Startup of Phase I Treatment	1d	0	06JAN14 A	01SEP14 A	
1050	Phase I Starts Operation	0	0		01SEP14 A	



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Summary bar
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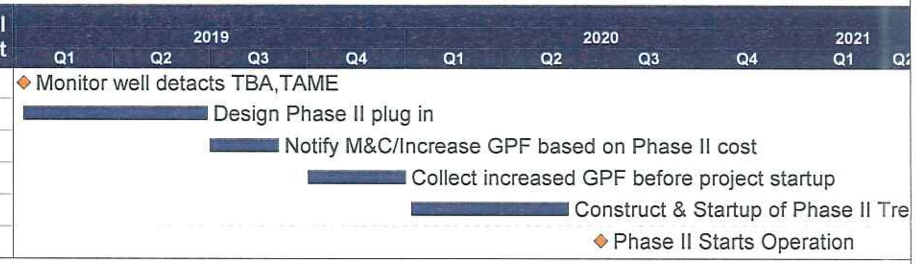
Finish milestone point

SILVERBELL PUMPAND TREATMENT PHASE II

Act ID	Description	Orig Dur	Rem Dur	Early Start	Early Finish	Total Float
1000	Monitor well detacts TBA,TAME	0	0	07JAN19 A		
1010	Design Phase II plug in	1d	0	07JAN19 A	28JUN19 A	
1021	Notify M&C/Increase GPF based on Phase	1d	0	01JUL19 A	03SEP19 A	
1025	Collect increased GPF before project startup	1d	0	01OCT19 A	31DEC19 A	
1040	Construct & Startup of Phase II Treatment	1d	0	06JAN20 A	01JUN20 A	
1050	Phase II Starts Operation	0	0		01JUL20 A	



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SCS ENGINEERS

July 3, 2012
File No. 01211313.02

TECHNICAL MEMORANDUM

TO: Molly Collins, City of Tucson

FROM: Brad Johnston, SCS Engineers

SUBJECT: Recommended Conceptual Design Modifications
Silverbell Landfill WQARF Site Pump and Treat System Phase 1 and 2

INTRODUCTION

The following is a description of key elements of the conceptual design for the groundwater pump and treat system proposed for the Silverbell Landfill WQARF site. The conceptual design includes two Phases: Phase 1 is intended to address the perchlorethylene (PCE) plume that currently exists at the site. Phase 2 is intended to address an off-site methyl tertiary butyl ether (MTBE), tertiary butyl alcohol (TBA), and tertiary amyl methyl ether (TAME) plume that may in the future be drawn into the remediation system from the Kinder Morgan pipeline release southeast of the site. It should be noted that these Phases are not equivalent to the two phases that were described in the January 2010 *Remedial Action Plan Implementation - Evaluation of Remedial Alternatives* report.

This conceptual design for Phase 1 is a revision of the original conceptual design that was developed by Malcolm Pirnie as described in Section 4 (dated November 2009) of the above-referenced report, and subsequently modified by the *Remedial Action Plan Implementation – Updated Modeling Study for Phase 1 Implementation Alternatives* dated October 2011. Extraction and injection well designs were verified by Clear Creek Associates in May 2012.

The Phase 2 conceptual design is based on groundwater fate and transport modeling that was performed by Clear Creek Associates as summarized in a letter report dated June 4, 2012. The model predicts that MTBE and TBA will arrive at the southern extraction well within 5 years of system startup. The MTBE concentration in the combined water from the two extraction wells is predicted to reach a maximum of 30 to 40 µg/L, and the maximum TBA concentration is predicted to reach a maximum of 300 to 400 µg/L. These maximum concentrations are anticipated to occur within 5 to 10 years after startup, and should decrease significantly by approximately 15 years after startup.

Based on limitations of the model, the actual concentrations of MTBE, TBA, and TAME that may be drawn into the system are uncertain. The model is based on best available information, but site-specific information regarding degradation of MTBE and generation of TBA is not available at this time. Therefore, contractors should be aware that the design parameters for MTBE and TBA/TAME are considered assumptions at this time. These parameters should be reevaluated and if necessary modified prior to final design and installation of Phase 2.

The recommendations described below are not intended to be project specifications. Contractors should feel free to recommend alternatives or modifications if they will improve the efficiency of the proposed system.

PHASE 1

As described below, the proposed Phase 1 system includes the following:

- An initial groundwater pump-and-treat system which will have a capacity of 1,000 gallons per minute (gpm), and which will have the capability of removing PCE to less than 1 ug/l.

As previously discussed, the Phase 1 design is based on an existing conceptual design prepared by Malcolm Pirnie. Table 1 below provides a summary of changes and additions to the original conceptual design, and these changes are discussed in more detail in the following text.

Table 1. Phase 1 Summary of Design Changes

Component	Changes to Original Design
Phase 1 - 1,000 gpm, PCE is Primary COC, MTBE will be addressed as it appears	
Extraction Wells	Decrease number of wells from 4 to 2; no changes in design details
Extraction Well Pumps	Increase capacity from 200 gpm per well to 400 and 600 gpm
Injection Wells	Increase number of wells from 3 to 4 (add backup well)
Injection Pumps	Increase capacity from 400 gpm per unit to 500 gpm per unit
Pretreatment	No changes
Air Strippers	Increase capacity from 2 units at 400 gpm/2,400 scfm to 2 units at 500 gpm/3,600 scfm.
Duct Heater	Increase capacity from 5,000 scfm to 7,500 scfm.
Vapor Phase GAC	Increase capacity from 5,000 scfm to 7,500 scfm (5,000# carbon to 10,000# carbon).
Electrical	Decrease in load for initial system, but possible increase in total load if MTBE modification is implemented. Decrease in total wiring/conduit amounts.
Piping	Decrease in linear footage due to changed layout

Extraction Wells

The modeling performed in the October 2011 Updated RAP assumed injection and extraction wells were screened through the three upper layers, to a total well depth of 320 feet below ground surface (bgs), which is approximately 160 feet below the water table. However, the Updated RAP also indicates that the final design may need to be modified as follows: "The well depths for the extraction wells, while necessary for well operational performance, could create an opportunity for cross-aquifer contamination during non-pumping periods. Design of the individual extraction wells should consider incorporating features such as annular seals and blank casing sections to aid in limiting potential cross aquifer groundwater flow." Evaluation of vertical flow issues was not included in this conceptual design scope of work.

Final design of the extraction wells should confirm well diameter and screen type/size based on increased flow from 200 gpm to 400 and 600 gpm, and evaluate potential casing design to control vertical flow if indicated by recent monitoring well installation and testing.

Although the final design should address the issues discussed above, this conceptual design assumes that the extraction wells will be constructed as described in the November 2009 RAP (Figure 14), which is consistent with model parameters used in the Updated RAP.

Table 2. Extraction Well Parameters

Depth	320 feet
Borehole Diameter	17.5 inches
Casing Diameter	12.75 inches
Blank Casing Type	Low Carbon Steel
Screen Type	High Strength Low Alloy, Louvered
Screen Slot Size	0.050 inches
Screen Interval	175-300 feet

Extraction Well Pumps

The original design was based on a pumping rate of 200 gpm from each extraction well. Based on the modeling in the Updated RAP, the per-well pumping rates were increased to 400 and 600 gpm, and extraction well pump capacities have been increased accordingly.

Table 3. Extraction Well Pump Parameters

	Well EXT-N	Well EXT-S
Type	submersible	submersible
Capacity	600 gpm	400 gpm
Total Dynamic Head	210 ft water	210 ft water
Horsepower	60	40
RPM	3,450	3,450
Outlet Size	6 inches	4 inches
Drive Type	variable speed	variable speed
Volts/Phase/Hertz	460/3/60	460/3/60
Preliminary Specification	Grundfos 625S600-3A or equivalent	Grundfos 385S400-5 or equivalent

Injection Wells

As discussed under Extraction Wells, the injection wells are assumed to be screened through the three upper layers, to a total well depth of 320 feet. This differs from the original design in the November 2009 RAP, which included a screened interval from 200 to 400 feet. The per-well injection rate will increase from 200 to 333 gpm, so casing and screen specifications should be confirmed.

For this conceptual design, it is assumed that the injection wells will be constructed as described in the November 2009 RAP (Figure 15), except that the total well depth will be decreased from 420 to 320 feet, and glass beads will be used as the filter pack material instead of silica sand.

Table 4. Injection Well Parameters

Depth	320 feet
Borehole Diameter	17.5 inches
Casing Diameter	10 inches
Blank Casing Type	Low Carbon Steel
Screen Type	Stainless Steel Wire Wrap
Screen Slot Size	0.060 inches
Screen Interval	100-300 feet

Injection Pumps

The injection well pumps have been increased in capacity from the original design flow of 800 gpm total to 1,000 gpm total. Configuration is the same as the original conceptual design.

Table 5. Injection Pump Parameters

Type	end suction centrifugal
Quantity	2
Design Flow	500 gpm (1,000 gpm total)
Total Dynamic Head	265
Horsepower	50
RPM	3,550
Net Positive Suction Head	9 ft of water
Drive Type	variable speed
Volts/Phase/Hertz	460/3/60
Preliminary Specification	Goulds Series SSH or equivalent

Pretreatment

Pretreatment of extracted groundwater is assumed to be the same as the original conceptual design, except for a slightly higher feed rate based on the increased system flow rate. This reduces the days of storage provided by the three chemical storage totes; if a longer storage capacity is desired, additional totes or a permanent aboveground storage tank should be considered.

Table 6. Pretreatment Parameters

Sequestering Agent	
Type	liquid
Concentration	33%
Specific Gravity	1.35
Design Flow	1,000 gpm
Dose	3.3 mg/l
Feed Rate	Approx 0.45 gph
Preliminary Specification	H2OSmart SeqQuest or equivalent
Storage	
Tote Capacity (gal)	
# of Totes	3 (1 + 2 backup)
Days of Storage	93
Metering Pumps	

Type	diaphragm
Quantity	2 (1 + 1 backup)
Feed Rate	12 gph
Preliminary Specification	Neptune PZi-31 or equivalent

Air Stripper

For the initial system, the air stripper capacity has been increased from the original design to accommodate the increase in total system flow from 800 to 1,000 gpm. The power rating of the blower motor is higher than the stock specification to accommodate potential back pressure from the carbon vapor treatment system.

Table 7. Air Stripper Parameters

Type	low profile
Quantity	2
Design Liquid Flow Per Unit	500 gpm (1,000 total)
Trays Per Unit	6
Air Inlet Flow	3,600 scfm
Air-Water Ratio	54:1
Blowers (1 per stripper):	
Design Air Flow	3,600 scfm @ 34" water
Horsepower	60
Volts/Phase/Hertz	460/3/60
Preliminary Specification	BISCO 61251 or equivalent

Duct Heater

Due to the increased airflow from the air strippers (original design 5,000 scfm, revised design 7,200 scfm), the duct heater capacity has been increased. Telemetry control capability has also been added.

Table 8. Duct Heater Parameters

Type	finned tubular, stainless steel
Quantity	1
Flow	7,200 scfm
Max Influent Temp	76°F, dry bulb
Max Influent Relative Humidity	100%
Effluent Relative Humidity	40%
Heating Load	335,000 BTU/hr
Volts/Phase/Hertz	460/3/60
Kilowatts	101
Preliminary Specification	Brasch

Vapor Phase GAC Contactor

The original design for a single vessel contactor has been increased in capacity to accommodate the increased airflow. The unit can be charged with less carbon if desired and still meet performance standards, but using 10,000 pounds as specified will prolong the time between carbon changes.

Table 9. Vapor Phase GAC Contactor Parameters

Flow (scfm)	7,200 scfm
Carbon Type	VC 4x8 coconut
Capacity (# carbon)	10,000 pounds carbon
Max Influent Temp	120^{O}F
Max Influent Relative Humidity	50%
Preliminary Specification	Siemens RB10 or equivalent

Electrical

Electrical plans and specifications are assumed to be the same as those described by Malcolm Pirnie in the November 2009 RAP, except for the number of wells and length of wiring runs from the treatment compound to the wells. General load calculations and the length of wiring runs were revised accordingly, using the spreadsheets that were developed by Malcolm Pirnie in the November 2009 RAP and subsequent revisions. Electrical requirements must be verified during final design due to variables in the proposed system.

Table 10. General Electrical Parameters

Load for Initial (PCE only) System (KVA/AMP)	381/458
Load for MTBE System Modification (KVA/AMP)	198/238
Total Load for Phase I System (KVA/AMP)	579/697

Telemetry

Remote telemetry has been added. This would consist of a broadband modem connected to the processor located at PLC-SB (Figure 24 of November 2009 RAP). The broadband modem would be connected to the internet over a broadband or DSL communications network. The modem would be assigned a dedicated IP address by the local provider which would be accessible by the Operator Work Station (OWS). The OWS would include Graphical User Interface (GUI) software, programmed to depict the system variables, setpoints, and alarms as detailed on Figure 24 of the November 2009 RAP. The GUI software will have pop-up windows for each piece of process equipment which will show status and setpoints, and will allow control of the equipment based on operator adjustable inputs. The OWS will also include reporting software and Microsoft Office.

Piping

The original design specified 10” piping for extraction wells and 8” piping for injection wells. These parameters result in header flow velocities of approximately 4 and 6 feet per second respectively at the increased flow of 1,000 gpm, which is within typical limits. However, this specification and associated pump sizes should be verified during final design.

The proposed remediation system piping alignment crosses existing underground utilities in at least one area. For example, an existing sewer line associated with the nearby Estes development is present at approximately 2.5 feet below ground surface, so remediation system piping will need to cross beneath or over this feature. Contractor must verify any such crossings and the method of crossing them. Furthermore, pump and piping sizes that may be affected by elevation changes should be verified during final design.

Based on the previous design, it is assumed that a common header pipe will be used for the injection wells, and a common header pipe will be used for the extraction wells.

Archaeological Clearance

Archaeological clearance may be required for all or portions of the area that will be disturbed by construction activities. Contractor is responsible for verifying and performing such clearances.

PHASE 2

As discussed above, Phase 1 system is intended to remediate PCE at the present time. Phase 2 of the system may include modification(s) of the system to treat the off-site MTBE, TBA, and TAME plume when/if the plume is drawn into the extraction system. The Phase 1 conceptual design is laid out in such as manner as to facilitate addition of components, and this flexibility should be included in the final design and construction of Phase 1.

Any system modifications for MTBE, TBA, and TAME should be based on whether the on-site monitoring well network confirms movement of the off-site plume toward the extraction system. At that time, actual site-specific concentrations of MTBE, TBA, and TAME should be used to confirm whether these assumed system modifications are necessary and appropriate. These assumed modifications include the following:

- Modification of the initial system to treat MTBE. The actual concentration of MTBE that will be treated is not known, but current information indicates that the predicted concentration of MTBE can be adequately treated by doubling the air-water ratio of the air stripping system. Therefore, it is assumed that the modification will include the addition of two more air stripping units while maintaining a total system throughput of 1,000 gpm.

- Modification of the system to treat TBA and TAME. Current proven air stripping technologies are not effective for removing associated TBA and TAME and site-specific concentrations of these compounds are not known. Based on information available at the present time, technologies that have been proposed by equipment vendors for this site include a modified air stripping method that is currently in development; a fluidized bed bioreactor; and a high-performance adsorption technology that is currently in development. The technology needed to remove TBA/TAME should be reevaluated after the migration and behavior of the TBA/TAME plume is better understood at the Silverbell Landfill site. However, for cost estimating purposes at this time, it is assumed that the fluidized bed bioreactor will be used to treat TBA and TAME.

Technologies that were considered and are potentially capable of treating MTBE, TBA, and TAME are discussed below.

Air Stripping

Based on modeling performed by Bisco Environmental Inc. (using recent modeling results provided by Clear Creek), the proposed initial air stripper system (two units operating at 500 gpm each) should be capable of reducing MTBE from 40 ppb to 13 ppb, which is a 67% removal rate. TBA would be reduced from 400 ppb to 389 ppb, and TAME would be reduced from 300 ppb to 284 ppb; these removal rates are only 2.7% to 5.2%. If two additional air strippers of the same model are added to the Phase 1 system so that flow through the individual units was reduced to 250 gpm, modeling indicates that MTBE would be reduced to less than 1 ppb, TBA to 285 ppb, and TAME to 155 ppb. These figures represent removal rates of 98%, 28%, and 48%, respectively.

For the MTBE plume, it is assumed that two additional air stripper units with the same design parameters as Phase 1 will be added to the system while maintaining the same total system liquid flow rate of 1,000 gpm. This is intended to increase the air-water ratio to 108:1 in each unit to provide better removal effectiveness for MTBE. It is also assumed that one additional duct heater and one additional vapor phase GAC contactor with the same design parameters as Phase 1 will be added to the MTBE remediation system. Electrical requirements must also be verified.

Bisco Environmental is currently testing a modified air stripping method which may be capable to achieving better removal rates for TBA and TAME. They will reportedly be obtaining preliminary test results in the coming weeks, and they have expressed interest in using the Silverbell Landfill site as a pilot test for the system. This technology should be investigated when Phase 2 design is performed.

High-Performance Adsorption

Envirogen Technologies, Inc. indicated that they are currently developing a "high-performance adsorption" technology that should be effective for removal of TBA and TAME. Adsorptive technologies for TBA and TAME are generally considered to be most effective when other oxygenates and fuel components are first removed by other means. Therefore, if development of this product indicates it will be effective for TBA and TAME, the Phase 2 design should evaluate using it as a "polishing" step after the air strippers.

Fluidized Bed Bioreactor

Two firms were contacted regarding fluidized bed bioreactors. Envirogen Technologies indicated that they believed the technology would not be efficient because anticipated contaminant concentrations will be low, and would not sustain biomass without constant addition of TBA or TAME. However, Cardno ERI proposed a system which they claim will reduce MTBE, TBA, and TAME to less than 10 ppb. The system consists of four 12-foot diameter vessels, each with a throughput flow capacity of 250 gpm. If the system is shut down for more than one day, an auxiliary feed of MTBE would be required to support the biomass in the bioreactor. This technology should be investigated when Phase 2 design is performed.

The following table summarizes Phase 2 design elements and potential alternatives.

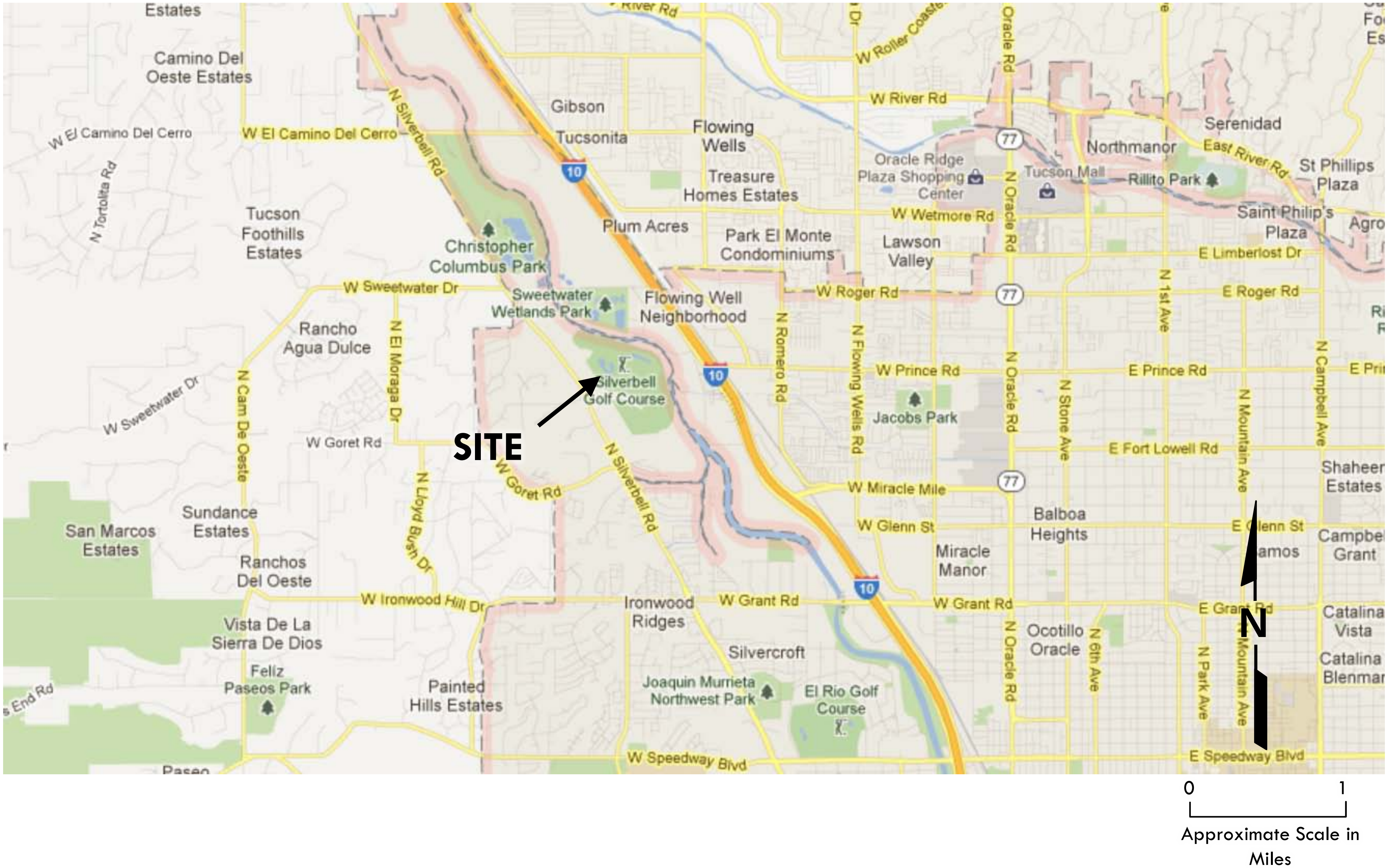
Table 11. Phase 2 Summary of Design Elements

Component	Changes to Phase 1 Design
Phase 2 - 1,000 gpm, will address MTBE, TBA, and TAME if/when they appear	
Extraction Wells	No changes to proposed Phase 1 system
Extraction Well Pumps	No changes to proposed Phase 1 system
Injection Wells	No changes to proposed Phase 1 system
Injection Pumps	No changes to proposed Phase 1 system
Pretreatment	No changes anticipated, but will depend on final technology selection (e.g. pH stabilization could be necessary for bioreactor)
Piping	Additional piping in treatment compound, depends on final technology selection
Electrical	Probable need for increased capacity at treatment compound depending on final technology selection
Air Strippers	If necessary for MTBE, assume add 2 more 3,600 scfm units so that individual throughput will be 250 gpm per unit. Technology pending for TBA/TAME; possible alternative.
Duct Heater	If necessary for MTBE, assume add second 7,500 scfm capacity unit. If additional or different air strippers are added for TBA/TAME, may require additional heater.
Vapor Phase GAC	If necessary for MTBE, assume add second 7,500 scfm capacity unit. If additional or different air strippers are added for TBA/TAME, may require additional vessel or a vessel with greater capacity.
Adsorption Technology for GW Polishing	Technology pending for TBA/TAME; possible alternative. May require additional pump(s) to maintain flow from air strippers into adsorption vessel(s).
Fluidized Bed Bioreactor	May require surge and equalization tanks, additional pump(s) to maintain flow into bioreactors, and filters. Assumed alternative for cost estimates.

CLOSING

This memo and associated cost opinions represent SCS Engineers' recommendations and opinions based on information available at this time. Due to potentially changing site conditions, uncertainty regarding contaminant fate and transport, emerging technologies, and other factors, the information herein should be verified by potential bidders and the Contractor performing the final design.

SCS appreciates the opportunity to assist the City of Tucson with this project.



City of Tucson
Silverbell Landfill WQARF Site
Tucson, Arizona

Figure 1
Site Location

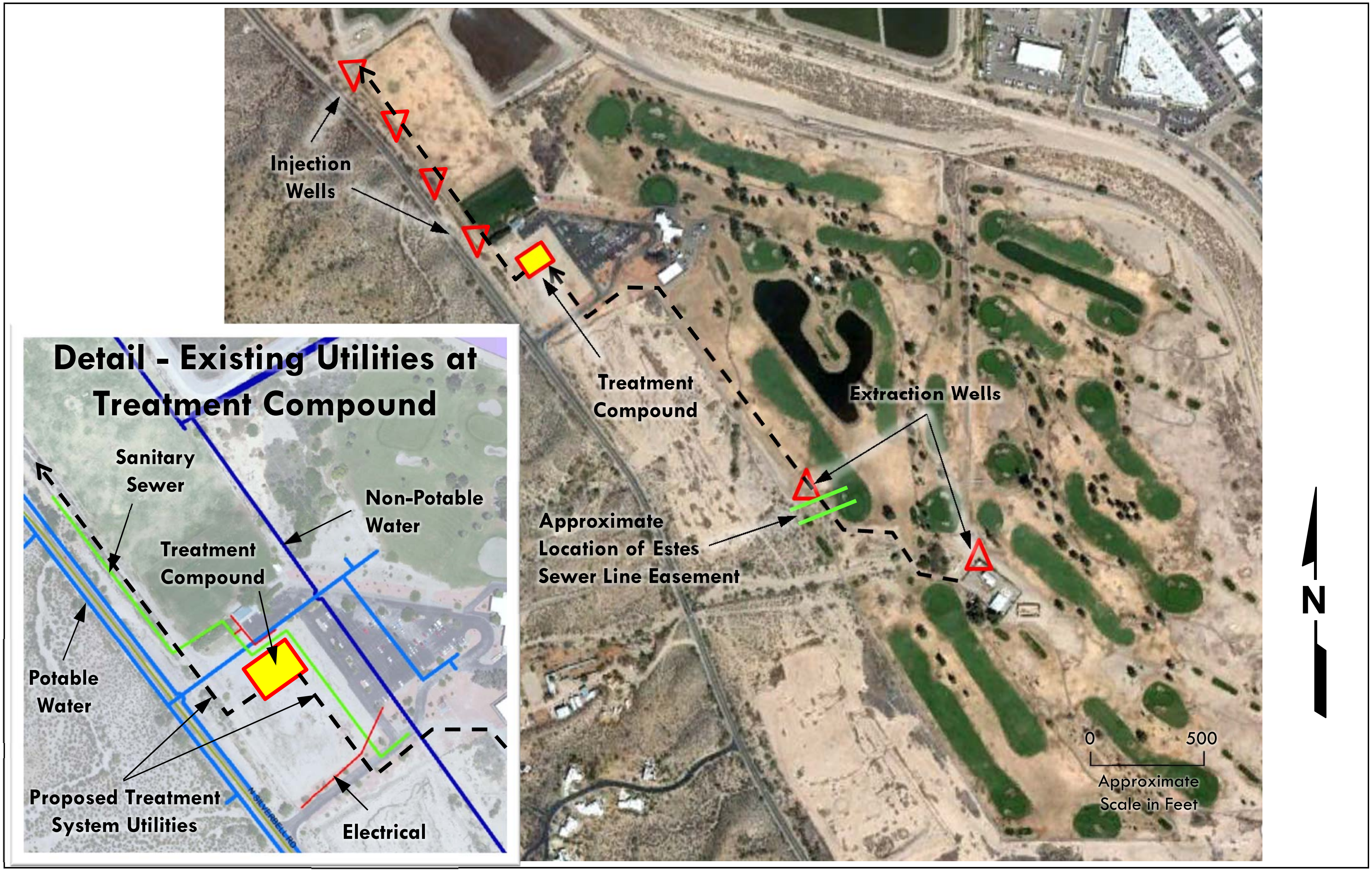
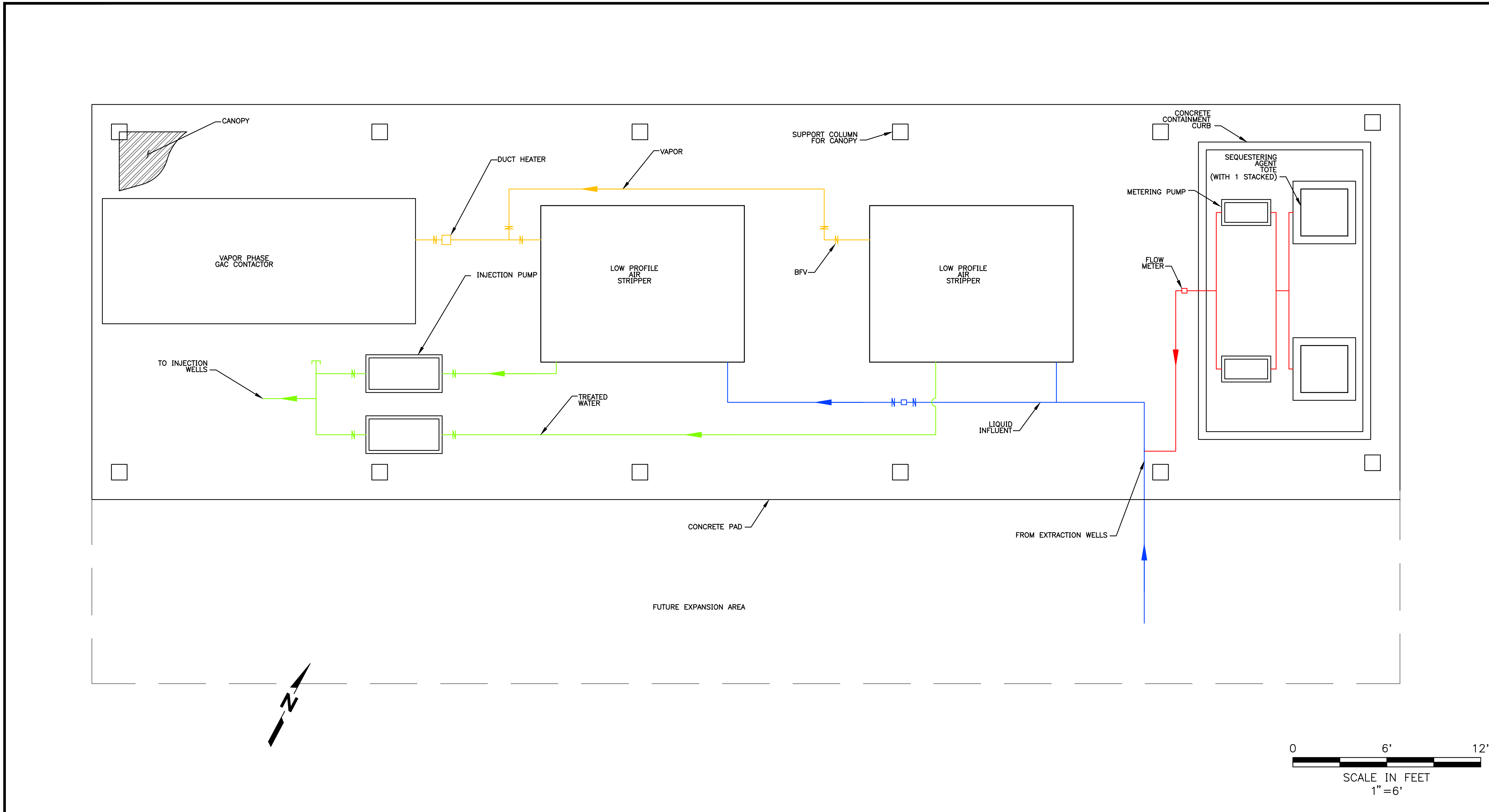


Figure 2
Overall System Layout



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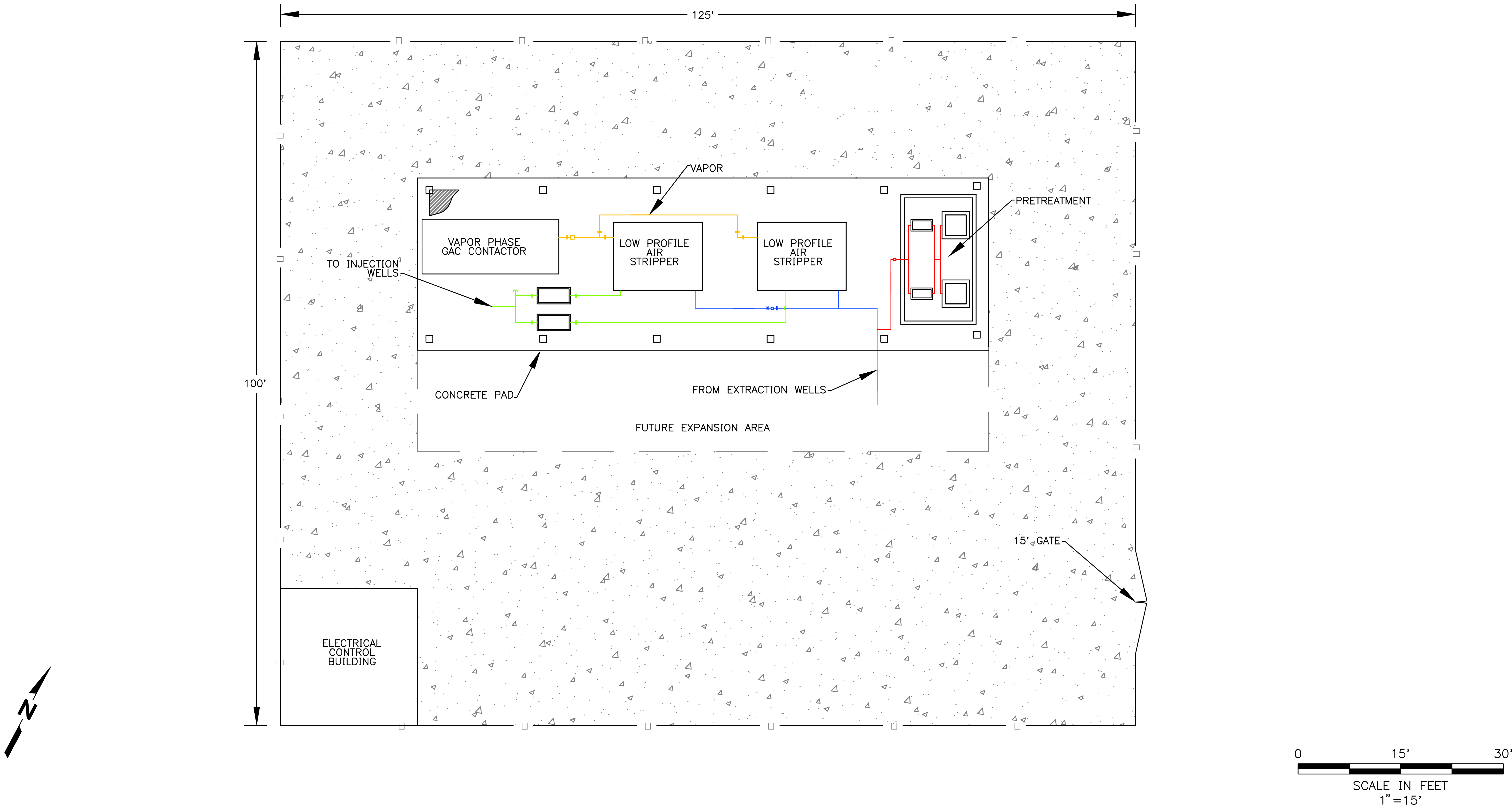
City of Tucson
Silverbell Landfill
WQARF Site
Tucson, Arizona

Figure Number 3
TREATMENT PROCESS



City of Tucson
Silverbell Landfill
WQARF Site
Tucson, Arizona

Figure Number 4
TREATMENT COMPOUND LAYOUT

TABLE 1
REVISED COST OPINION
PHASE 1 SILVERBELL LANDFILL PUMP AND TREAT SYSTEM
CAPITAL COSTS

Cost Items	Quantity	Unit	Unit Cost	ENR CCI	Materials[6]	Labor[2]	Item Subtotal	References/Comments
CONSTRUCTION COSTS								
Wells								
Extraction Wells (includes 2 extraction wells)	2	LS	$ 150,000	9290	$ 300,000	$ 75,000	$ 300,000	Yellow Jacket May 2012
Injection Wells (includes 4 injection wells)	4	LS	$ 150,000	9290	$ 600,000	$150,000	$ 600,000	Yellow Jacket May 2012
				Subtotal Well Construction Cost:			**$ 900,000**	
Well Pumps								
400 gpm Extraction Well Submersible Pump	1	EA	$ 20,000	9273	$ 20,037	$ 5,009	$ 25,100	Grand Canyon Pump & Supply April
600 gpm Extraction Well Submersible Pump	1	EA	$ 28,600	9273	$ 28,652	$ 7,163	$ 35,900	Grand Canyon Pump & Supply April
1" Sounding Tube, PVC	1800	LF	$ 0.72	8574	$ 1,404	$ 351	$ 1,800	Ryan Herco (MP)
1" Transducer Tube, PVC	1800	LF	$ 0.72	8574	$ 1,404	$ 351	$ 1,800	Ryan Herco (MP)
Transducers	6	EA	$ 2,500	8574	$ 16,253	$ 4,063	$ 20,400	Malcolm Pirnie (MP)
4" Galvanized Steel Extraction Well Piping	540	LF	$ 86	9290	$ 46,170	Incl.	$ 46,200	RS Means 2012 22 11 13.44 1400
4" Galvanized Steel Injection Well Piping	1,240	LF	$ 86	9290	$ 106,020	Incl.	$ 106,100	RS Means 2012 22 11 13.44 1400
Inflatable Packer	4	EA	$ 17,000	8574	$ 73,679	Incl.	$ 73,700	Baski (MP)
8" Flow Control Valve (motor-operated)	4	EA	$ 7,530	8574	$ 32,635	$ 8,159	$ 40,800	Dezurik (MP)
Extraction Well Heads								
Pre-fabricated Utility Box (5'x10'x6')	2	EA	$ 3,900	9290	$ 7,800	Incl.	$ 7,800	RS Means 2012 33 05 16.13 0050
Aluminum checkered Man-way Plate Cover (4'x6'; 24 SF)	2	EA	$ 742	9290	$ 1,484	Incl.	$ 1,500	RS Means 2012 05 54 13.20 0300
Excavation (7'x12'x6')	1,008	CY	$ 10	9290	$ 9,647	Incl.	$ 9,700	RS Means 2012 31 23 16.16 6060
Compacted Fill, 12"	160	CY	$ 3	8952	$ 437	Incl.	$ 500	RS Means 2010 31 23 23 2000 (MP)
Combination Air/Vacuum Release Valve Assembly with Tee	2	EA	$ 1,050	8185	$ 2,384	$ 596	$ 3,000	Malcolm Pirnie (MP)
4" Check Valve	2	EA	$ 1,387	9290	$ 2,774	Incl.	$ 2,800	RS Means 2012 23 05 23.80.1460
4" PVC Ball Valve	2	EA	$ 750	9290	$ 1,499	$ 375	$ 1,900	RS Means 2012 22 05 23.60 5910
4" Flow Meter	2	EA	$ 1,400	8185	$ 3,178	$ 795	$ 4,000	Micrometer (MP)
Site Work								
Gravel Driveway (6" thick)	802	SY	$ 7.19	9290	$ 5,766	Incl.	$ 5,800	RS Means 2012 32 11 23.23 0100
Chain Link Fence, 3-strand barbed wire (6 ft)	456	LF	$ 17	7942	$ 9,020	Incl.	$ 9,100	SAVSARP - cost opinion (MP)
10-in Ductile Iron Pipe - from extraction wells to treatment plant	3,000	LF	$ 21	8952	$ 65,534	$ 16,384	$ 82,000	ACIPCO Jan 2011 (MP)
8-in Ductile Iron Pipe - from treatment system to injection wells	1,500	LF	$ 16	8952	$ 25,373	$ 6,343	$ 31,800	ACIPCO Jan 2011 (MP)
Trench Excavation (for 10-in Ductile Iron Pipe)	964	CY	$ 5.09	9290	$ 4,909	Incl.	$ 5,000	RS Means 2012, 31 23 16.13 0090
Trench Excavation (for 8-in Ductile Iron Pipe)	429	CY	$ 5.09	9290	$ 2,186	Incl.	$ 2,200	RS Means 2012, 31 23 16.13 0090
Backfill (for 10-in Ductile Iron Pipe)	904	CY	$ 4.63	8952	$ 4,343	Incl.	$ 4,400	RS Means 2010, 31 23 23.13 1900 (MP)
Backfill (for 8-in Ductile Iron Pipe)	399	CY	$ 4.63	8952	$ 1,918	Incl.	$ 2,000	RS Means 2010, 31 23 23.13 1900 (MP)
Electrical and Instrumentation & Controls Site Work								
Electrical utility service to plant	1	LS	$ 100,000	8952	$ 103,776	Incl.	$ 103,800	Malcolm Pirnie/2009 RS Means (MP)
Service Entrance Switchboard (480V, 1200A, NEMA 3R)	1	EA	$ 50,000	8952	$ 51,888	Incl.	$ 51,900	Malcolm Pirnie/2009 RS Means (MP)
Motor Control Center (480V, 1200A, NEMA 12)	1	EA	$ 100,000	8952	$ 103,776	Incl.	$ 103,800	Malcolm Pirnie/2009 RS Means (MP)
Variable Frequency Drives (for Extraction Wells, incl in pump price)		EA					$ -	Malcolm Pirnie/2009 RS Means (MP)
Variable Frequency Drives (50HP for Injection Wells)	2	EA	$ 40,000	8952	$ 83,021	Incl.	$ 83,100	Malcolm Pirnie/2009 RS Means (MP)
Miscellaneous Loads (lighting, grounding, receptacles)	1	LS	$ 50,000	8952	$ 51,888	Incl.	$ 51,900	Malcolm Pirnie/2009 RS Means (MP)
Flow Control Valve Disconnect Switches	4	EA	$ 1,000	8952	$ 4,151	Incl.	$ 4,200	Malcolm Pirnie/2009 RS Means (MP)
Treatment Plant Conduit and Wire	1	LS	$ 100,000	8952	$ 103,776	Incl.	$ 103,800	Malcolm Pirnie/2009 RS Means (MP)
Site Conduit and Wire	1	LS	$ 457,000	8952	$ 474,255	Incl.	$ 474,300	Table 2
Injection Concrete Hand Holes	10	EA	$ 2,500	8952	$ 25,944	Incl.	$ 26,000	Malcolm Pirnie/2009 RS Means (MP)
Extraction Concrete Hand Holes	10	EA	$ 2,500	8952	$ 25,944	Incl.	$ 26,000	Malcolm Pirnie/2009 RS Means (MP)
Instrumentation								
Ultrasonic Level Transmitter	3	EA	$ 1,000	8952	$ 3,113	Incl.	$ 3,200	Malcolm Pirnie/2009 RS Means (MP)
Level Switch - Float	3	EA	$ 500	8952	$ 1,557	Incl.	$ 1,600	Malcolm Pirnie/2009 RS Means (MP)
Propeller Flowmeter	9	EA	$ 2,000	8952	$ 18,680	Incl.	$ 18,700	Malcolm Pirnie/2009 RS Means (MP)
Magnetic Flowmeter	1	EA	$ 5,000	8952	$ 5,189	Incl.	$ 5,200	Malcolm Pirnie/2009 RS Means (MP)
Differential Pressure Transmitter	1	EA	$ 500	8952	$ 519	Incl.	$ 600	Malcolm Pirnie/2009 RS Means (MP)
Pressure Indicator	2	EA	$ 500	8952	$ 1,038	Incl.	$ 1,100	Malcolm Pirnie/2009 RS Means (MP)
Pressure Switch	2	EA	$ 500	8952	$ 1,038	Incl.	$ 1,100	Malcolm Pirnie/2009 RS Means (MP)
Diaphram Seal	2	EA	$ 500	8952	$ 1,038	Incl.	$ 1,100	Malcolm Pirnie/2009 RS Means (MP)
Relative Humidity Analyzer	1	EA	$ 5,000	8952	$ 5,189	Incl.	$ 5,200	Malcolm Pirnie/2009 RS Means (MP)
Local Control Panel LCP-SB	1	EA	$ 75,000	8952	$ 77,832	Incl.	$ 77,900	Malcolm Pirnie/2009 RS Means (MP)
Local Control Panel LCP-CHEM	1	EA	$ 25,000	8952	$ 25,944	Incl.	$ 26,000	Malcolm Pirnie/2009 RS Means (MP)
Remote Telemetry	1	EA	$ 12,000	9273	$ 12,022	$ 3,005	$ 15,100	Telemetry Process and Controls April
Broadband Connection to Treatment Compound	1	EA	$ 5,000	9273	$ 5,009	$ 1,252	$ 6,300	SCS 2012
Concrete (Bldg Foundation & Structures)								
Excavation	119	CY	$ 13	9290	$ 1,562	Incl.	$ 1,600	RS Means 2012 31 23 16.16 6070
Compacted Fill, 6"	60	CY	$ 2	8952	$ 132	Incl.	$ 200	RS Means 2010 31 23 23 2000 (MP)
Concrete Slab on Grade, 12"	119	CY	$ 156	9290	$ 18,581	Incl.	$ 18,600	RS Means 2012 03 30 53.40 4700
Equipment Pads, (i.e. air stripper and chemical totes), 6" thick	392	SF	$ 11	9290	$ 4,404	Incl.	$ 4,500	RS Means 2012 03 30 53.40 5210
Building								
Canopy	1750	SF	$ 31	9290	$ 54,635	Incl.	$ 54,700	RS Means 2012 10 73 16.20.7750
Secondary Containment Curb for Totes (Concrete)	60	LF	$ 13	9290	$ 753	Incl.	$ 800	RS Means 2012 32 16 13.13 0400
Electrical Building	1	LS	$ 20,000	7942	$ 23,395	$ 5,849	$ 29,300	Tucson Water - control building cost (MP)
Air Conditioner	1	EA	$ 1,317	9290	$ 1,317	Incl.	$ 1,400	RS Means 2012 23 81 13.10 0260
PROCESS EQUIPMENT								
Anti-scale treatment								
Chemical pumps for sequstering agent injection	2	EA	$ 365	8528	$ 795	$ 199	$ 1,000	Pollard Water
Aeration Equipment - Phase 1 for PCE only								
Shallow Tray Aerator (stripper, blower, controls, delivery) - Initial	2	EA	$ 95,000	9290	$ 190,000	$ 47,500	$ 237,500	BISCO Environmental, Inc. May 2012
Sound Enclosure for Air Stripper Blowers - Initial System	1	EA	$ 9,000	8952	$ 9,340	$ 2,335	$ 11,700	BISCO Environmental, Inc. (MP)
Air Filter for Blower Inlet - Initial System	1	EA	$ 2,000	8952	$ 2,076	$ 519	$ 2,600	BISCO Environmental, Inc. (MP)
Vapor Phase Carbon Contactor - Initial System	1	EA	$ 52,000	9273	$ 52,095	$ 13,024	$ 65,200	Siemens RB10 quote April 2012
Duct (36"x36") - Initial System	1	LS	$ 11,830	8952	$ 12,277	$ 3,069	$ 15,400	Perry Fiberglass Products (MP)
Electric Duct Heater	1	EA	$ 9,000	9273	$ 9,016	$ 2,254	$ 11,300	Brasch - Moore Mechanical April 2012
Duct Insulation	1	LS	$ 2,083	8952	$ 2,162	Incl.	$ 2,200	RS Means 2012 23 07 13.10 0100
Process Piping and Valves	1	LS	$ 26,200	8952	$ 27,189	$ 6,797	$ 34,000	Malcolm Pirnie (10% of equipment costs)
Transfer pumps - Initial System	2	EA	$ 12,413	8574	$ 26,898	$ 6,725	$ 33,700	Grand Cayon Pumps April 2009 (MP)

TABLE 1
REVISED COST OPINION
PHASE 1 SILVERBELL LANDFILL PUMP AND TREAT SYSTEM
CAPITAL COSTS

Cost Items	Quantity	Unit	Unit Cost	ENR CCI	Materials[6]	Labor[2]	Item Subtotal	References/Comments
SYSTEM STARTUP								
Start-up Plan Development								
Engineer	60	HR	$ 120	8952	$ 7,472		$ 7,500	Malcolm Pirnie
Senior Engineer	4	HR	$ 220	8952	$ 913		$ 1,000	Malcolm Pirnie
Project Manager	16	HR	$ 180	8952	$ 2,989		$ 3,000	Malcolm Pirnie
Adminstrative	16	HR	$ 65	8952	$ 1,079		$ 1,100	Malcolm Pirnie
Materials	1	LS	$ 1,000	8952	$ 1,038		$ 1,100	
Start-up Plan Implementation and Reporting[3]								
Field Technician	120	HR	$ 80	8952	$ 9,962		$ 10,000	Malcolm Pirnie
Engineer	40	HR	$ 160	8952	$ 6,642		$ 6,700	Malcolm Pirnie
Project Manager	16	HR	$ 180	8952	$ 2,989		$ 3,000	Malcolm Pirnie
Adminstrative	16	HR	$ 65	8952	$ 1,079		$ 1,100	Malcolm Pirnie
Laboratory								
Water Samples (VOCs 8260)	34	EA	$ 150	8952	$ 5,293		$ 5,300	Malcolm Pirnie
Air Samples (VOCs TO-15)	51	EA	$ 170	8952	$ 8,997		$ 9,000	Malcolm Pirnie
Materials	1	LS	$ 1,000	8952	$ 1,038		$ 1,100	Malcolm Pirnie
Subtotal Phase I Treatment Facility and Well Equipment Construction Cost:							**$ 2,293,000**	

PHASE 1 TOTALS - PCE ONLY			
	Subtotal Construction Cost (Wells):		**$ 900,000**
	Subtotal Phase 1 Construction Cost (PCE only):		**$ 2,293,000**
	Contractor Overhead and Profit	15%	**$ 479,000**
City of Tucson Sales Tax: 9.60%	**Tax (65% of local rate)**	**6.24%**	**$ 199,000**
	SUBTOTAL INCLUDING OH&P AND TAX:		**$ 3,871,000**
	Engineering & Administration (Design and Construction Services):	20%	**$ 774,000**
	SUBTOTAL INCLUDING ENGINEERING AND ADMINISTRATION:		**$ 4,645,000**
	Contingency:	30%	**$ 1,394,000**
	TOTAL CAPITAL COST OPINION (PHASE 1 PCE ONLY):		**$ 6,039,000**

ABBREVIATIONS:
CF = cubic foot
CY = cubic yard
DIP = ductile iron pipe
GAL = gallon
Incl. = included
kWh = kilowatt-hour
LF = linear foot
SF = square foot
SY = square yard

NOTES:
1. Spreadsheet source Malcolm Pirnie, January 27, 2010, modifications by SCS June 5, 2012.
2. A factor of 25% of material costs was used for installation and commissioning labor for items where labor is not included in the unit cost.
3. Start-up monitoring including daily water and vapor phase sampling for seven days, weekly sampling for four weeks, and monthly sampling for six months.
4. This option provided only for budgetary purposes; other alternatives may be used.
5. (MP) indicates reference is same as cited in January 27, 2012 Cost Opinion spreadsheet.
6. Costs in this column have been adjusted for inflation since quotes were received using ENR Construction Cost Index (CCI)

TABLE 2
REVISED COST OPINION
SILVERBELL LANDFILL PUMP AND TREAT SYSTEM
WIRING AND CONDUIT

Item	Qty	Cost	Per	Reference	Subtotal
#4/0 XHHW	19600	$1,011	100	2009 RS Means 26 05 19.90 3220	$198,156
#3/0 XHHW	11600	$820	100	2009 RS Means 26 05 19.90 3200	$95,120
#2/0 XHHW	0	$665	100	2009 RS Means 26 05 19.90 3180	$0
#1/0 XHHW	0	$539	100	2009 RS Means 26 05 19.90 3160	$0
#1 XHHW	0	$439	100	2009 RS Means 26 05 19.90 3140	$0
#2 XHHW	0	$352	100	2009 RS Means 26 05 19.90 3120	$0
#4 XHHW	0	$243	100	2009 RS Means 26 05 19.90 3100	$0
#6 XHHW	0	$169	100	2009 RS Means 26 05 19.90 3080	$0
#8 XHHW	15600	$122	100	2009 RS Means 26 05 19.90 3060	$19,032
#10 XHHW	0	$87	100	2009 RS Means 26 05 19.90 3040	$0
#12 XHHW	0	$66	100	2009 RS Means 26 05 19.90 3020	$0
#14 XHHW	0	$51	100	2009 RS Means 26 05 19.90 3000	$0
STP	32900	$115	100	2009 RS Means 26 05 19.90	$37,671
CAT 5E (X)	0	$200	100	2009 RS Means 26 05 19.90	$0
3/4" PVC-RS Conduit	0	$13.95		Malcolm Pirnie 2009	$0
1" PVC-RS Conduit	0	$17.70		Malcolm Pirnie 2009	$0
1-1/2" PVC-RS Conduit	0	$24.00		Malcolm Pirnie 2009	$0
2" RGS Conduit	0	$31.50		Malcolm Pirnie 2009	$0
2-1/2" RGS Conduit	0	$32.00		Malcolm Pirnie 2009	$0
3" RGS Conduit	0	$41.50		Malcolm Pirnie 2009	$0
4" RGS Conduit	0	$55.50		Malcolm Pirnie 2009	$0
5" RGS Conduit	0	$96.00		Malcolm Pirnie 2009	$0
3/4" PVC Conduit	0	$2.56		Malcolm Pirnie 2009	$0
1" PVC Conduit	0	$3.14		Malcolm Pirnie 2009	$0
1-1/2" PVC Conduit	0	$4.34		Malcolm Pirnie 2009	$0
2" PVC Conduit	11400	$5.30		Malcolm Pirnie 2009	$60,420
2-1/2" PVC Conduit	0	$6.75		Malcolm Pirnie 2009	$0
3" PVC Conduit	4900	$8.95		Malcolm Pirnie 2009	$43,855
4" PVC Conduit	0	$13.05		Malcolm Pirnie 2009	$0
5" PVC Conduit	0	$18.10		Malcolm Pirnie 2009	$0
Trenching, backfill, concrete encasement	500	$5.00			$2,500

Sub-Total	$456,754
Contingency	$0
Total	$456,754

NOTES:

1. Spreadsheet source and cost references from Malcolm Pirnie, January 27, 2010. Number of units and other modifications by SCS June 5, 2012.

TABLE 3
REVISED COST OPINION
PHASE 1 SILVERBELL LANDFILL PUMP AND TREAT SYSTEM
ANNUAL OPERATIONS AND MAINTENANCE

Cost Items	Quantity	Unit	Unit Cost	ENR CCI	Amount	Subtotal[5]	References[1]
ANNUAL SYSTEM OPERATIONS[2]							
Labor							
System Operator	690	HR	$ 90	8952	$ 62,100	$ 64,500	Malcolm Pirnie
Engineer	60	HR	$ 120	8952	$ 7,200	$ 7,500	Malcolm Pirnie
Project Manager	96	HR	$ 180	8952	$ 17,280	$ 18,000	Malcolm Pirnie
Administrative	144	HR	$ 65	8952	$ 9,360	$ 9,800	Malcolm Pirnie
Power - Phase 1 PCE only							
Extraction Well Pump - 40 Hp	261,298	kWh	$ 0.10	8952	$ 26,130	$ 27,200	Calculated
Extraction Well Pump - 60 Hp	391,946	kWh	$ 0.10	8952	$ 39,195	$ 40,700	Calculated
Shallow Tray Aerator - Blower	522,595	kWh	$ 0.10	8952	$ 52,260	$ 54,300	Calculated
Duct Heater	525,600	kWh	$ 0.10	8952	$ 52,560	$ 54,600	Calculated
Chemicals and Carbon - Phase 1 PCE only							
Sequestering Agent	20,830	LBS	$ 3.00	8952	$ 62,491	$ 64,900	H2O Smart, SeaQuest
Granular Activated Carbon	12,500	LBS	$ 2.00	8952	$ 25,000	$ 26,000	10,000 lb, change every 9 mo
			Subtotal Annual System Operations			**$ 367,500**	
ANNUAL SYSTEM MAINTENANCE[3]							
Labor							
Field Technician	200	HR	$ 65	8952	$ 13,000	$ 13,500	Malcolm Pirnie
Instrumant Technician	192	HR	$ 120	8952	$ 23,040	$ 24,000	Malcolm Pirnie
Project Manager	48	HR	$ 180	8952	$ 8,640	$ 9,000	Malcolm Pirnie
Subcontractor							
Injection Well Back-flush (1/3 years)	0.33	LS	$ 80,000	8952	$ 26,400	$ 27,400	Malcolm Pirnie
Extraction Well Maintenance (1/5 years)	0.2	LS	$ 80,000	8952	$ 16,000	$ 16,700	Malcolm Pirnie
Well Pump Replacement (1/7 years)	0.14	LS	$ 153,400	8952	$ 21,914	$ 22,800	Malcolm Pirnie
			Subtotal Annual System Maintenance			**$ 113,400**	
ANNUAL COMPLIANCE MONITORING AND REPORTING[4]							
Field Technician	100	HR	$ 80	8952	$ 8,000	$ 8,400	Malcolm Pirnie
Engineer	160	HR	$ 120	8952	$ 19,200	$ 20,000	Malcolm Pirnie
Project Manager	40	HR	$ 180	8952	$ 7,200	$ 7,500	Malcolm Pirnie
Adminstrative	24	HR	$ 65	8952	$ 1,560	$ 1,700	Malcolm Pirnie
Laboratory							
Water Samples (VOCs 8260)	8	EA	$ 150.00	8952	$ 1,200	$ 1,300	
Air Samples (VOCs TO-15)	12	EA	$ 170.00	8952	$ 2,040	$ 2,200	
		Subtotal Annual Compliance Monitoring and Reporting				**$ 41,100**	
EXPENSES (5% of labor)				8952	$ 8,829	**$ 9,200**	

PHASE 1 TOTALS - PCE ONLY		
SUBTOTAL :		**$ 531,000**
Contingency:	30%	**$ 159,000**
TOTAL O&M COST OPINION (PHASE 1 PCE ONLY):		**$ 690,000**

NOTES:

1. Spreadsheet source and cost references from Malcolm Pirnie, January 27, 2010. Number of units and other modifications by SCS June 5, 2012.
2. Operations include system start-up and shut down, chemcial delivery management, etc.
3. System maintenance assumes blower (lubrication and belts) and valve maintenance, back-wash injection wells, and extraction well maintenance.
4. Compliance monitoring assumes quarterly sampling of raw and treated water and air, data review and reduction, and monitoring report preparation.
5. Costs in this column have been adjusted for inflation since the quotes were received using ENR Construction Cost Index (CCI)

TABLE 4
REVISED COST OPINION
PHASE 1 SILVERBELL LANDFILL PUMP AND TREAT
SUMMARY

PHASE 1 - PCE ONLY

Total Capital Cost	20-year Annualized Capital Cost	Annual O&M Cost	Total Annual Cost	20-Year Present Worth
$ 6,039,000	$ 527,000	$ 690,000	$ 1,217,000	$ 13,954,000

Rate (i) = 6%
Phase 1 Years (n) = 20
All numbers in 2012 $

TABLE 1A
REVISED COST OPINION
PHASE 2 SILVERBELL LANDFILL PUMP AND TREAT SYSTEM
CAPITAL COSTS

Cost Items	Quantity	Unit	Unit Cost	ENR CCI	Materials	Labor[1]	Item Subtotal	References/Comments
POTENTIAL PHASE 2 MODIFICATION FOR MTBE/TBA/TAME								
Aeration Equipment - Phase 2 for MTBE addition								
Shallow Tray Aerator (stripper, blower, controls, delivery) - MTBE	2	EA	$ 95,000	9290	$ 190,000	$ 47,500	$ 237,500	BISCO Environmental, Inc. May 2012
Sound Enclosure for Air Stripper Blowers - MTBE Addition	1	EA	$ 9,000	8952	$ 9,340	$ 2,335	$ 11,700	BISCO Environmental, Inc. (MP)
Air Filter for Blower Inlet - MTBE Addition	1	EA	$ 2,000	8952	$ 2,076	$ 519	$ 2,600	BISCO Environmental, Inc. (MP)
Vapor Phase Carbon Contactor - MTBE Addition	1	EA	$ 52,000	9273	$ 52,095	$ 13,024	$ 65,200	Siemens RB10 April 2012
Duct (36"x36") - MTBE Addition	1	LS	$ 11,830	8952	$ 12,277	$ 3,069	$ 15,400	Perry Fiberglass Products (MP)
Electric Duct Heater	1	EA	$ 9,000	9273	$ 9,016	$ 2,254	$ 11,300	Brasch - Moore Mechanical April 2012
Duct Insulation	1	LS	$ 2,083	8952	$ 2,162	Incl.	$ 2,200	RS Means 2012 23 07 13.10 0100
Process Piping and Valves	1	LS	$ 26,200	8952	$ 27,189	$ 6,797	$ 34,000	Malcolm Pirnie (10% of equipment costs)
Transfer pumps - MTBE Addition	2	EA	$ 12,413	8574	$ 26,898	$ 6,725	$ 33,700	Grand Cayon Pumps April 2009 (MP)
Fluidized Bed Bioreactor - Phase 2 for TBA/TAME[2]								
Design (modify Phase I piping, electrical, etc.)	1	EA	$ -	9290	$ -	$ 20,000	$ 20,000	SCS 2012
Bioreactor Vessels	4	EA	$ 140,000	9290	$ 560,000	$ 140,000	$ 700,000	Cardno ERI May 2012
Shipping and Site Delivery	4	EA	$ 7,600	9290	$ 30,400		$ 30,400	Cardno ERI May 2012
Assembly	4	EA	$ 12,550	9290	$ 50,200		$ 50,200	Cardno ERI May 2012
Startup and 60 days O&M	1	EA	$ 40,000	9290	$ 40,000		$ 40,000	Cardno ERI May 2012
Materials (pumps, filters, tanks)	1	EA	$ 50,000	9290	$ 50,000	$ 12,500	$ 62,500	SCS 2012
						Subtotal Potential Phase 2 Modification Cost:	**$ 1,317,000**	

	Subtotal Phase 2 Construction Cost with Allowances (Assume Fluidized Bed Bioreactor):		**$ 1,317,000**
	Contractor Overhead and Profit	**15%**	**$ 198,000**
City of Tucson Sales Tax: 9.60%	**Tax (65% of local rate)**	**6.24%**	**$ 82,000**
	SUBTOTAL INCLUDING OH&P AND TAX:		**$ 1,597,000**
	Engineering & Administration (Design and Construction Services):	**20%**	**$ 319,000**
	SUBTOTAL INCLUDING ENGINEERING AND ADMINISTRATION:		**$ 1,916,000**
	Contingency:	**30%**	**$ 575,000**
	TOTAL CAPITAL COST OPINION (PHASE 2):		**$ 2,491,000**

NOTES:

1. A factor of 25% of material costs was used for installation and commissioning labor for items where labor is not included in the unit cost.
2. This option provided only for budgetary purposes; other alternatives may be used.

TABLE 3A
REVISED COST OPINION
PHASE 2 SILVERBELL LANDFILL PUMP AND TREAT SYSTEM
ANNUAL OPERATIONS AND MAINTENANCE

Cost Items	Quantity	Unit	Unit Cost	ENR CCI	Amount	Subtotal	References
POTENTIAL PHASE 2 MODIFICATION FOR MTBE/TBA/TAME							
Power - Phase 2 MTBE addition							
Shallow Tray Aerator - Blower (MTBE add)	522,595	kWh	$ 0.10	8952	$ 52,260	$ 54,300	Calculated
Duct Heater (MTBE add)	525,600	kWh	$ 0.10	8952	$ 52,560	$ 54,600	Calculated
Injection Pumps (50 Hp)	653,244	kWh	$ 0.10	8952	$ 65,324	$ 67,800	Calculated
Chemicals and Carbon - Phase 2 MTBE addition							
Granular Activated Carbon (MTBE add)	12,500	LBS	$ 2.00	8952	$ 25,000	$ 26,000	10,000 lb, change every 9 mo
Bioreactor - Phase 2 TBA/TAME addition (assume 10 years of operation)							
Bioreactor Maintenance and Cleaning	12	MO	$ 8,000	9290	$ 96,000	$ 96,000	Cardno ERI
					Subtotal Phase 2 O&M	**$ 298,700**	
					SUBTOTAL :	**$ 299,000**	
				Contingency:	**30%**	**$ 90,000**	
					TOTAL O&M COST OPINION:	**$ 389,000**	

TABLE 4A
REVISED COST OPINION
PHASE 2 SILVERBELL LANDFILL PUMP AND TREAT
SUMMARY

Total Capital Cost	10-year Annualized Capital Cost	Annual O&M Cost	Total Annual Cost	10-Year Present Worth
$ 2,491,000	$ 339,000	$ 389,000	$ 728,000	$ 5,355,000

Rate (i) = 6%
Years (n) = 10
All numbers in 2012 $

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June 4, 2012

Ms. Molly Collins, R.G.
Project Coordinator
City of Tucson Environmental Services
Price Service Center
4004 South Park Ave., Bldg. #1
Tucson, Arizona 85714

Silverbell Landfill TBA Simulation

Dear Ms. Collins:

In accordance with our proposal dated March 27, 2012, Clear Creek Associates (Clear Creek) conducted a reevaluation of methyl-tertiary butyl ether (MTBE) and a preliminary evaluation of tertiary butyl alcohol (TBA) concentrations at the Silverbell Landfill Water Quality Assurance Revolving Fund (WQARF) site. The City of Tucson is planning to construct and operate a groundwater treatment system for chlorinated hydrocarbons, primarily tetrachloroethene (PCE), associated with the former landfill. However, TBA and other hydrocarbons are present in a groundwater contaminant plume which originated at the ruptured Kinder Morgan gasoline pipeline near Silvercroft Wash (Figure 1) and subsequently migrated off of the Silvercroft Wash site. This plume has impacted monitor wells at the South Cell of the Silverbell Landfill, and may be drawn in by the proposed groundwater treatment system.

Clear Creek previously generated an estimate of future MTBE concentrations at the Silverbell Landfill proposed treatment system using the contaminant fate and transport model developed to evaluate remedial alternatives for the PCE plume at the WQARF site (Clear Creek Associates, 2011; Clear Creek Associates, 2010). The preferred remedial alternative, based on the PCE simulation results, includes three injection wells and two extraction wells at the locations shown on Figure 1.

Recent sampling results for TBA in the Silvercroft Wash plume (including an October 2011 result of 23,000 µg/L at monitor well MW-16 and a January 2012 result of 40,000 µg/L at monitoring well WR-359A) prompted City of Tucson Environmental Services to request an evaluation of TBA using the same model previously used to simulate PCE (Clear Creek Associates, 2011; Clear Creek Associates, 2010) and MTBE (Clear Creek Associates, 2011).

The previous MTBE simulation (Clear Creek Associates, 2011) included the simplifying assumption that MTBE would not degrade significantly over time. However, previous studies have shown that MTBE degrades to TBA, and the concentration of TBA in groundwater contaminated by gasoline spills is significantly increased by the biodegradation of MTBE. In fact, EPA has stated that the major portion of TBA at a gasoline spill site is produced by biodegradation of MTBE once it is dissolved in groundwater (Wilson and Adair, 2007). Therefore, in order to predict future concentrations of TBA at the Silverbell Landfill proposed extraction wells, it was necessary to revise the 2011 model and run a combined MTBE / TBA transport simulation which included the effects of biodegradation. In addition to providing a prediction of future TBA concentrations, the revised model is likely to yield a more accurate simulation of future MTBE concentrations.

The revised transport simulation was linked to the same groundwater flow model previously used to evaluate MTBE and PCE at Silverbell Landfill (Clear Creek Associates, 2011; Clear Creek Associates, 2010). For the new MTBE/TBA simulation, Clear Creek applied the contaminant transport modeling package RT3D ver. 2.5 and added a sequential decay reaction to simulate the breakdown of MTBE, the generation of TBA, and the breakdown of TBA. The Visual Modflow ver. 2009.1 Premium interface was used to develop the model and evaluate the results.

Model input data and their sources are presented below:

MTBE Initial Concentrations

Simulated plume bounded approximately by WR-242A (downgradient) and MW-15 (upgradient); maximum concentration of 200,000 µg/L around Kinder-Morgan monitoring well MW-26. Data sources: City of Tucson (2012a); City of Tucson (2012b); Arcadis (2012).

<u>The simulation assumes that there is no continuing source of MTBE.</u> This is likely an optimistic assumption, because the soil vapor extraction system remains in operation at the Silvercroft Wash release site (Arcadis, 2012), which suggests that a source is still present in the vadose zone. The assumption of no continuing source yields simulated future concentrations of MTBE and TBA that are lower than they would be if a continuing source was simulated. However, there is no practical way to simulate a source without more information regarding its size, the concentrations of the contaminants within it, and the length of time it is likely to be present.

TBA Initial Concentrations

Simulated plume bounded approximately by WR-242A (downgradient) and MW-15 (upgradient); maximum concentration of 40,000 µg/L around WR-359A. Data sources: City of Tucson (2012a); City of Tucson (2012b); Arcadis (2012).

<u>The simulation assumes that there is no continuing source of TBA, except for the decay of MTBE.</u> This is a reasonable assumption, because the direct contribution of TBA from a continuing source is likely to be minor compared to the contribution from MTBE decay.

First-Order Decay Rate for MTBE	0.0011 per day (McHugh et al., 2012)
First-Order Decay Rate for TBA	0.0005 per day (McHugh et al., 2012). This value is lower than values reported in some of the available literature. If a higher value was used, the simulated future TBA concentrations would be lower. However, this value is based on recent field data from several hundred sites, and Clear Creek believes it is the best value available for this model at this time.
Retardation Factors for MTBE and TBA	Retardation Factor = 1; i.e., MTBE and TBA move at approximately the same velocity as groundwater (ITRC, 2005)
Dispersion	Longitudinal Dispersion = 50 feet Ratio of longitudinal to transverse dispersivity = 0.25 Unchanged from previous model (Clear Creek Associates, 2011)

Clear Creek re-ran the model to evaluate the potential impact of the MTBE/TBA plume on the recommended Silverbell Remedial Action Plan alternative (Clear Creek Associates, 2011). The recommended alternative consists of two continuously-operating extraction wells located west of the north landfill cell and three continuously operating injection wells located northwest of the Silverbell golf course (Figure 1). In this alternative, the north extraction well operates at 600 gpm and the south extraction well operates at 400 gpm; each injection well operates at 333.3 gpm.

Simulation Results

The results of the MTBE/TBA simulation from the revised model are shown on Figures 2 through 5 (attached) for Scenario 1 (the anticipated scenario), which assumes a decay rate of 0.0011 per day for MTBE and a decay rate of 0.0005 per day for TBA. Additional simulations were run for two alternative scenarios. The results for Scenario 2, which assumes an MTBE decay rate of 0.0011 per day and a TBA decay rate of 0.005 per day, are shown on Figure 6. The results for Scenario 3, which assumes a decay rate of 0.01 per day for both MTBE and TBA, are shown on Figure 7. The various scenarios are summarized on Table 1 below.

TABLE 1. SUMMARY OF MODEL RESULTS FOR VARIOUS SCENARIOS

SCENARIO	*FIGURE(S)*	*DECAY CONSTANTS USED IN MODEL***	*MAXIMUM SIMULATED MTBE CONCENTRATION* (TIME AFTER SYSTEM STARTUP)*	*MAXIMUM SIMULATED TBA CONCENTRATION* (TIME AFTER SYSTEM STARTUP)*
Original Model (Clear Creek, 2011) {No Degradation}	4	-	1,200 µg/L (8-10 years)	-
1. MTBE Decays Faster Than TBA	2, 3, 4, 5	MTBE 0.0011 day^{-1} TBA 0.0005 day^{-1}	40 µg/L (7-8 years)	340 µg/L (8-9 years)
2. TBA Decays Faster Than MTBE	6	MTBE 0.0011 day^{-1} TBA 0.005 day^{-1}	40 µg/L (7-8 years)	10 µg/L (7-8 years)
3. MTBE and TBA Decay Quickly and at Equal Rates	7	MTBE 0.01 day^{-1} TBA 0.01 day^{-1}	0.000009 µg/L (2-3 years)	0.00009 µg/L (2-3 years)

* In combined flow from both extraction wells, assuming continuous operation for 25 years

** The values in Scenario 1 are believed to be the most appropriate to use in the model, based on a review of available literature. The values in Scenarios 2 and 3 were selected to determine a reasonable estimate of potential concentration ranges for MTBE and TBA, based on wide variations in reported decay rates from laboratory and field studies at other locations.

For the anticipated scenario (Scenario 1), the model predicts that MTBE and TBA will arrive at the southern extraction well within 5 years of system startup and at the northern extraction well between 5 and 10 years after system startup (Figures 2 and 3). The results indicate migration of MTBE and TBA away from the source, and thus an increase in the length of the Silvercroft Wash plume, which contrasts with a statement by McHugh et al. (2012) that MTBE plumes typically stabilize at relatively short lengths from the source area within a few years. However, the startup of the extraction wells at the Silverbell Landfill WQARF site is a significant factor in the model, and it is reasonable to expect that operation of the extraction wells would enhance the migration of upgradient contaminants.

The model results for Scenario 1 indicate that the combined water delivered from the extraction wells to the treatment system will reach a maximum MTBE concentration in the range of 30 to 40 µg/L between five and ten years after startup, and then decline to below 10 µg/L in less than 15 years after startup (Figure 2). Maximum simulated MTBE concentrations at the south well are in the range of 60 to 70 µg/L between five and ten years after startup. Maximum MTBE concentrations at the north well are predicted to be about 1 µg/L roughly ten years after startup. As shown on Figure 4, the predicted MTBE concentrations in this simulation are lower than those reported previously by Clear Creek (2011), because the new model incorporates a sequential decay reaction simulating biodegradation of MTBE to TBA, whereas the original model (Clear Creek Associates, 2011) included an assumption that MTBE would not degrade. The original model (Clear Creek Associates, 2011) predicted a maximum MTBE concentration of approximately 1,200 µg/L for the combined flow from both extraction wells. The revised model provides a more detailed simulation of MTBE fate and transport.

The model results for Scenario 1 indicate that the combined water delivered from the extraction wells to the treatment system will reach a maximum TBA concentration in the range of 300 to 400 µg/L between five and ten years after startup, and then decline to below 100 µg/L in less than 15 years (Figure 3). Maximum simulated TBA concentrations at the south well are in the range of 500 to 600 µg/L between five and ten years after startup. Maximum TBA concentrations at the north well are predicted to be in the range of 10 to 20 µg/L between ten and fifteen years after startup.

Limitations

1. A very important limitation of this model is that it was not based on site specific decay rates for MTBE and TBA. The decay values used in the simulation for Scenario 1 were taken from a paper that compiled data for several hundred sites in California (McHugh et al., 2012). However, published values for MTBE and TBA decay rates vary significantly, and are highly dependent on the presence of electron acceptors including oxygen, nitrate, Iron (III) and sulfate in local groundwater. For example, EPA (Wilson and Adair, 2007), citing research by Schirmer et al. (2003) at the Borden field site, reported first order removal rates under aerobic conditions of 0.12 per day for TBA and 0.03 to 0.15 per day for MTBE; they also noted that rates of TBA biodegradation under anaerobic conditions vary by over two orders of magnitude. We chose the values reported by McHugh et al (2012), because they are based on recent field data from several hundred sites.

It is possible, however, that the TBA value in particular is conservative. If TBA decays at a faster rate than what is assumed in the model, then the actual concentrations of TBA will be lower than predicted. If, as some literature suggests, TBA decays faster than MTBE, then TBA would not be expected to accumulate anywhere downgradient from the release site. To illustrate the effect of a faster TBA decay rate, Clear Creek ran a second simulation using a TBA decay rate of 0.005, which is higher by a factor of 10 than the initial scenario, and also higher than the MTBE decay rate (Figure 6). Clear Creek also ran a third simulation using a decay rate of 0.01 per day for both MTBE and TBA, which represents very fast degradation of both contaminants (Figure 7). The model results for Scenario 1 and the two alternative scenarios (Scenarios 2 and 3) are shown on Figures 5 through 7, and summarized on Table 1.

2. The Silverbell model (Clear Creek Associates, 2011; Clear Creek Associates, 2010) was not designed to replicate the Silvercroft Wash plume. Concentrations of MTBE and TBA in groundwater downgradient from the Silvercroft Wash release site vary substantially over small distances and short time intervals. For example, the MTBE results for quarterly samples from Kinder-Morgan monitoring well MW-26 in 2011 varied from 75,000 µg/L to 230,000 µg/L. During the same time period, MTBE results for MW-25, located less than 300 feet to the west, ranged from 40 µg/L to 180 µg/L. The variations appeared to be random, without a consistent trend toward increasing or decreasing values, and the data table compiled by Arcadis (2012) did not provide any indication of laboratory error in the results. The initial concentrations used in the model are a highly simplified interpretation of what is actually a very complex distribution of contaminants.

Summary and Recommendations

The contaminant fate and transport model described above demonstrates the potential for MTBE and TBA in groundwater impacted by the Kinder-Morgan pipeline rupture to reach extraction wells that the City of Tucson is planning to install to pump and treat groundwater at the Silverbell Landfill WQARF site. The maximum concentrations of these contaminants when they reach the extraction wells is not known at this time. However, based on reasonable assumptions and decay constants of 0.0011 per day for MTBE and 0.0005 per day for TBA, the model predicts maximum concentrations 40 µg/L and 340 µg/L for MTBE and TBA, respectively, in the combined outflow from the extraction wells. MTBE and TBA will reach the extraction wells within 5 years, based on the model results.

Although there is significant uncertainty in the choice of a TBA decay rate to use in the model, and despite the fact that some literature suggests that TBA could decay faster than MTBE and thus not accumulate in groundwater impacted by the MTBE plume, Clear Creek believes that the decay rate of 0.0005 per day for TBA is the most appropriate value available at this time, and we believe that TBA will accumulate and impact the proposed extraction wells. This interpretation is supported by data for monitor well MW-16, where the TBA concentration increased to 23,000 µg/L in October 2011 after consistently being below 12,000 µg/L in previous sampling events. It is also supported by January 2012 data for WR-359A, where the TBA concentration (40,000 µg/L) was nearly as high as the MTBE concentration (43,000 µg/L).

The arrival of MTBE and TBA at the Silverbell WQARF site extraction wells would affect the City's approach to treating and re-injecting groundwater impacted by PCE and other chlorinated hydrocarbons. Accordingly, Clear Creek recommends that the City establish a sentinel well network southeast of the extraction wells to monitor the approach of MTBE and TBA, and to provide a better estimate of the concentrations of both contaminants when they arrive at the treatment system. To the extent possible, existing wells should be used for this purpose. However, additional monitoring wells might be necessary. The wells should be in locations that provide sufficient time for the City to modify the treatment system to ensure that MTBE and TBA are removed before the water is reinjected farther downgradient. A more detailed transport model, based on a more complete set of data for the existing MTBE and TBA plume, may be necessary to establish the optimal configuration of the sentinel well network.

Clear Creek appreciates the opportunity to assist City of Tucson Environmental Services with this project. Please call me at 622-3222 if you have any questions.

Sincerely,
CLEAR CREEK ASSOCIATES, PLC

Greg Hess, R.G.
Senior Hydrogeologist

REGISTERED GEOLOGIST
CERTIFICATE NO.
50994
GREGORY S.
HESS
DATE SIGNED 6/28/12
ARIZONA U.S.A.
Expires 6 / 30 / 13

Attachments:
Figures 1 through 7
References

Cc: Michael Alter, R.G.

References

Arcadis, 2012. Fourth Quarter 2011 Groundwater Monitoring Report - Silvercroft Wash Release Site, Tucson, Arizona

City of Tucson, 2012a. XENCO Laboratories analytical reports for samples collected in January 2012.

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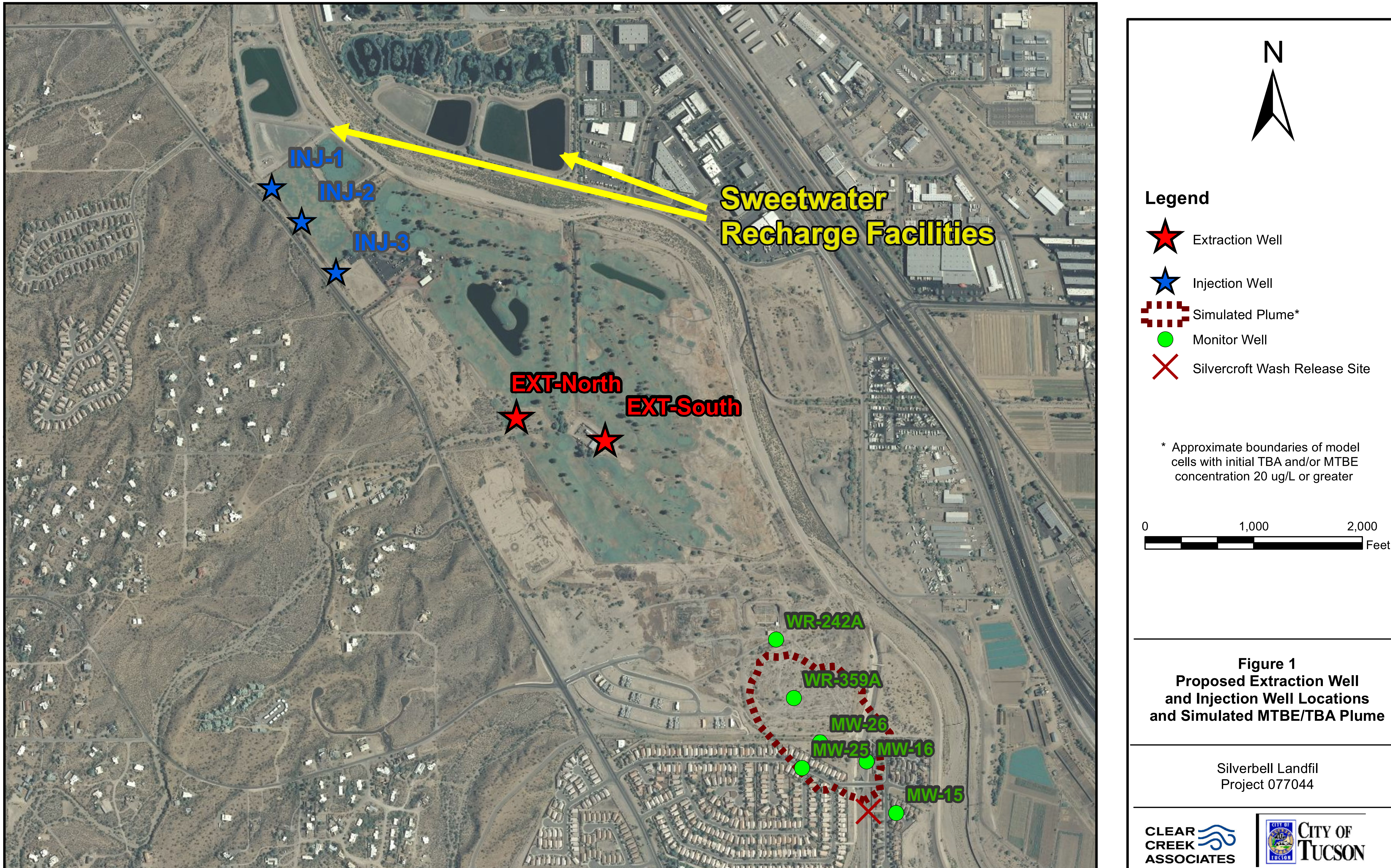


Figure 1
Proposed Extraction Well and Injection Well Locations and Simulated MTBE/TBA Plume

Silverbell Landfil
Project 077044

CLEAR CREEK ASSOCIATES
CITY OF TUCSON

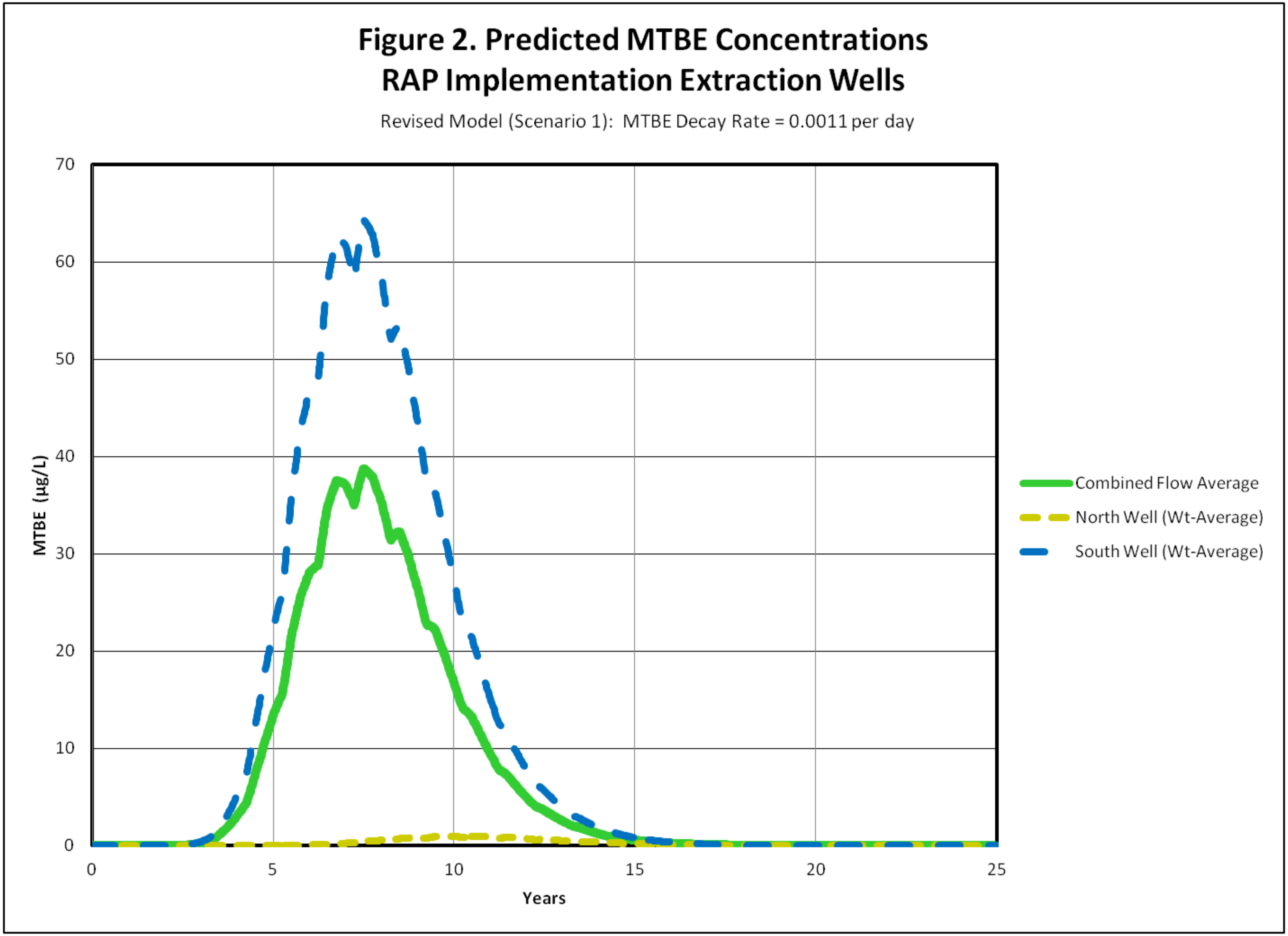


Figure 2. Predicted MTBE Concentrations
RAP Implementation Extraction Wells
Revised Model (Scenario 1): MTBE Decay Rate = 0.0011 per day
MTBE (µg/L)
70
60
50
40
30
20
10
0
0
5
10
15
20
25
Years
Combined Flow Average
North Well (Wt-Average)
South Well (Wt-Average)

Figure 3. Predicted TBA Concentrations RAP Implementation Extraction Wells

Revised Model (Scenario 1): MTBE Decay Rate = 0.0011 per day; TBA Decay Rate = 0.0005 per day

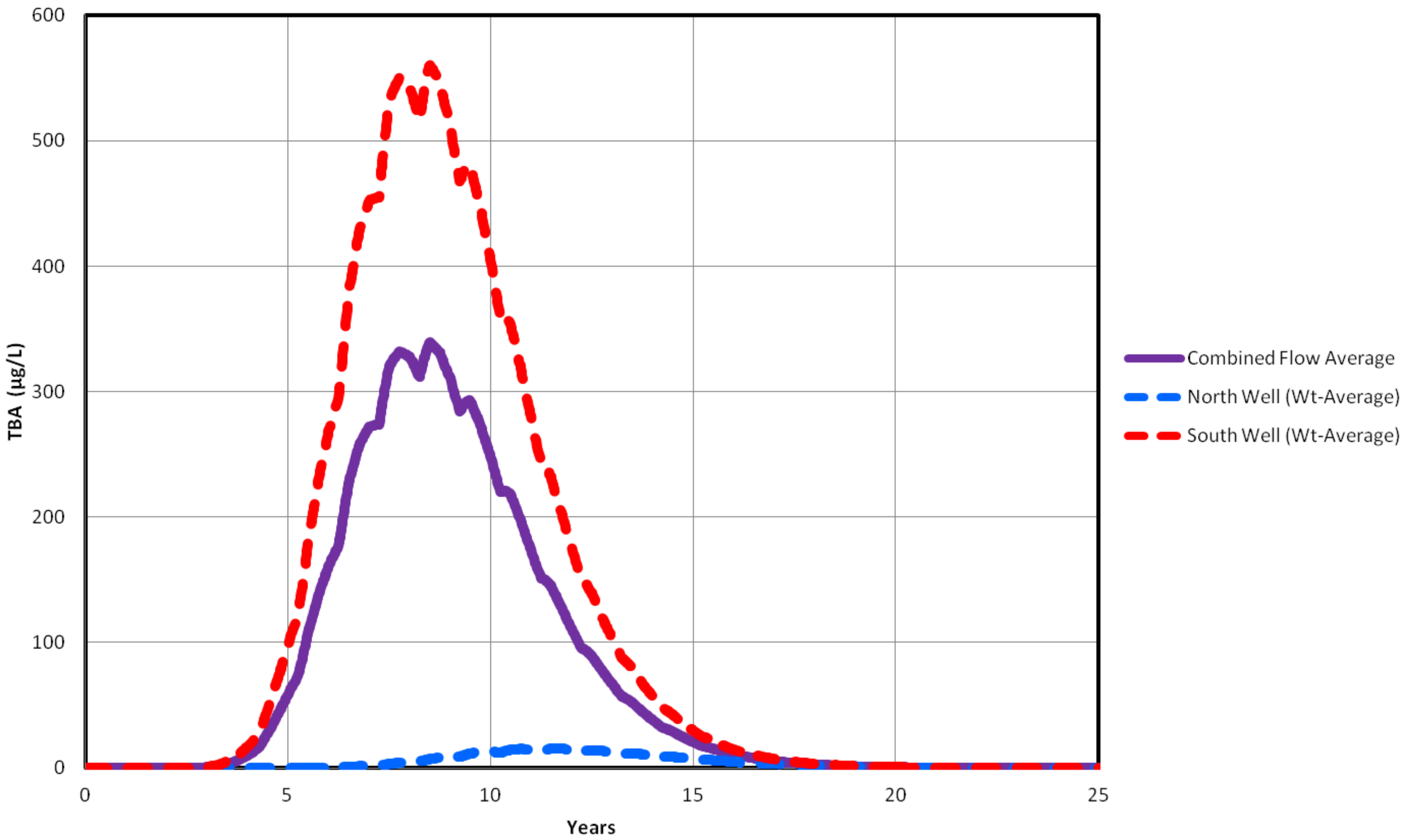


Figure 4. Predicted MTBE Concentrations Combined Flow From Both Extraction Wells With and Without Simulation of Decay

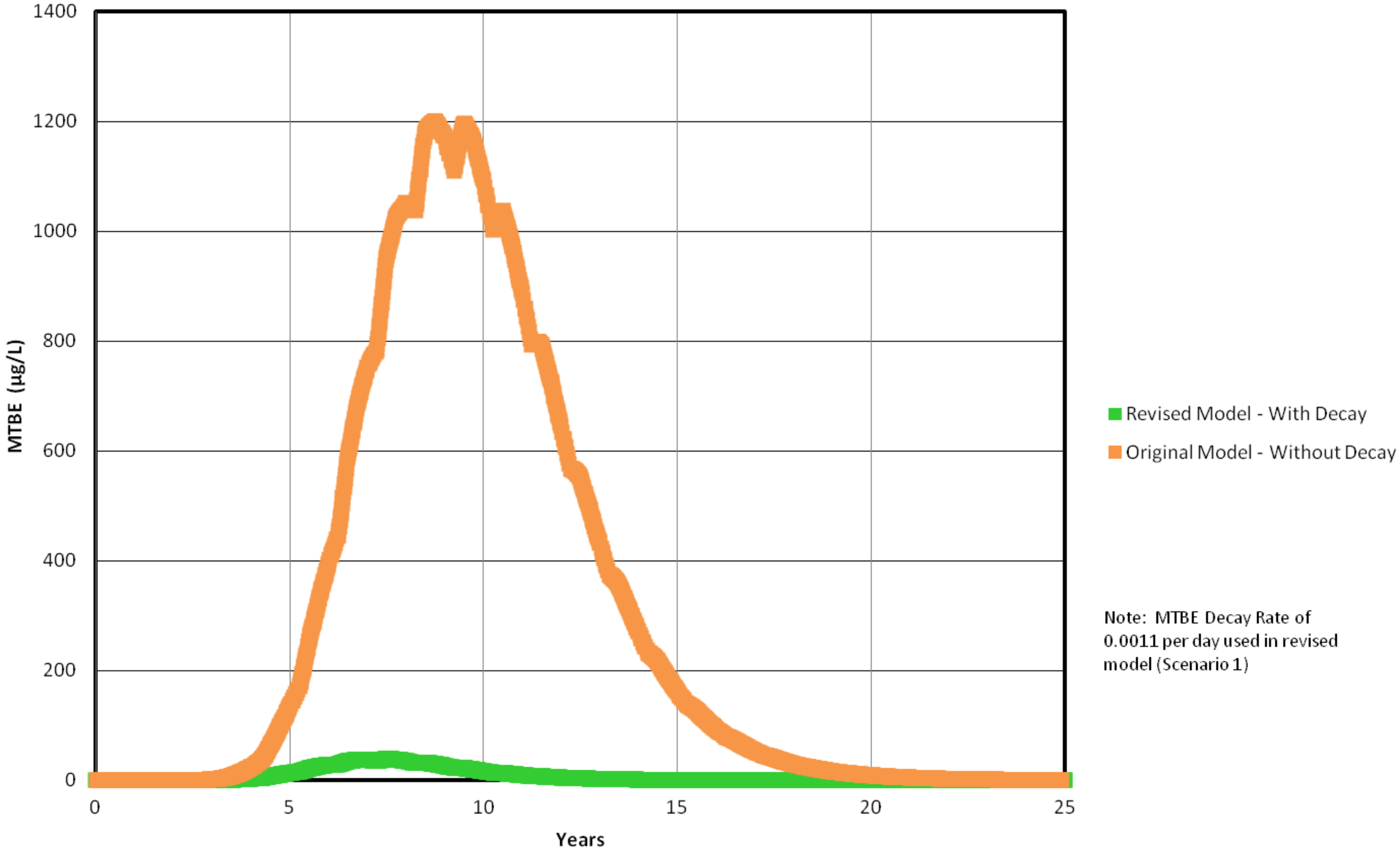


**Figure 5. Predicted MTBE and TBA Concentrations in Revised Model
Combined Flow From Both Extraction Wells
Scenario 1 - MTBE Decays Faster Than TBA**

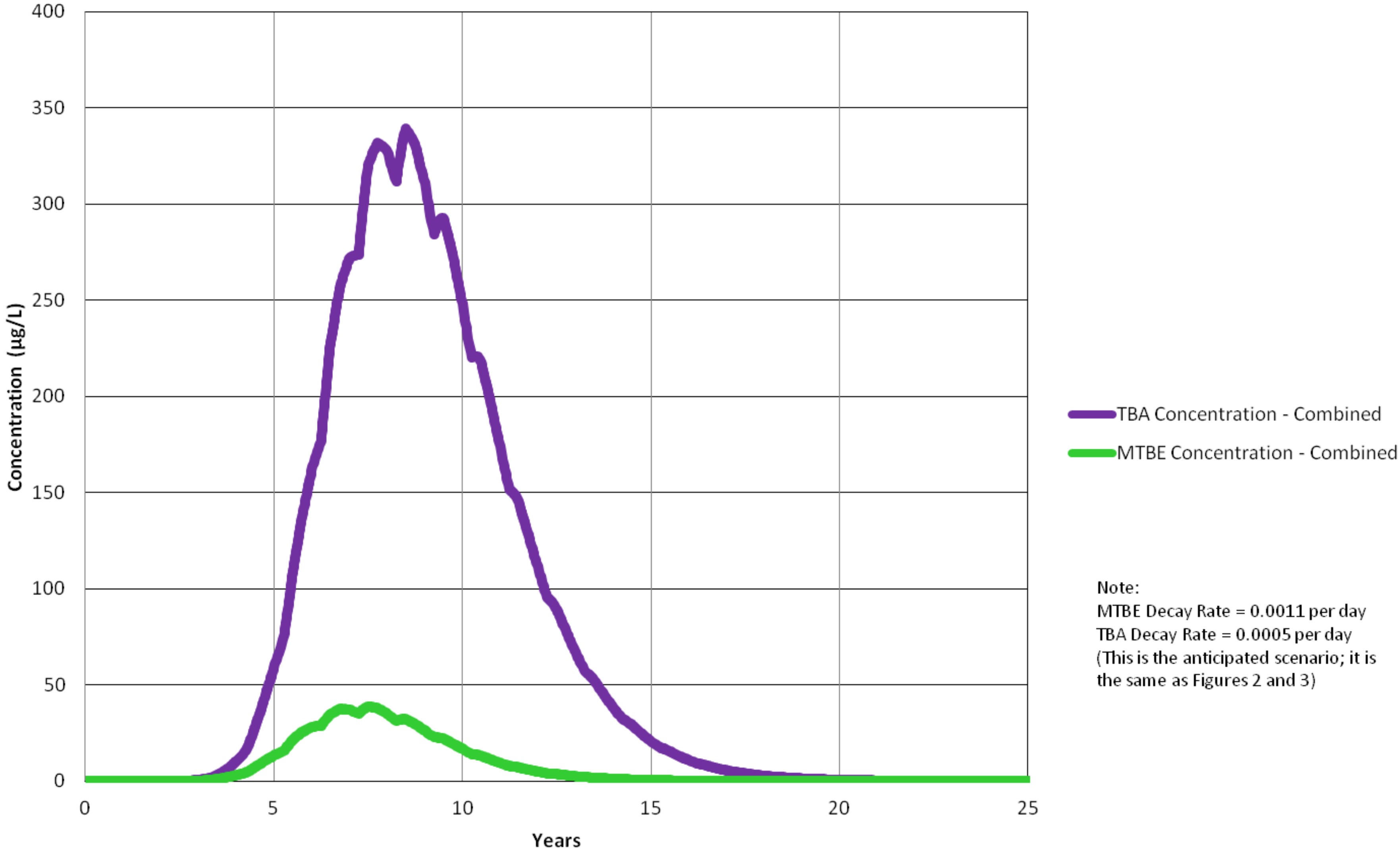


Figure 6. Predicted MTBE and TBA Concentrations in Revised Model Combined Flow From Both Extraction Wells Scenario 2 - TBA Decays Faster Than MTBE

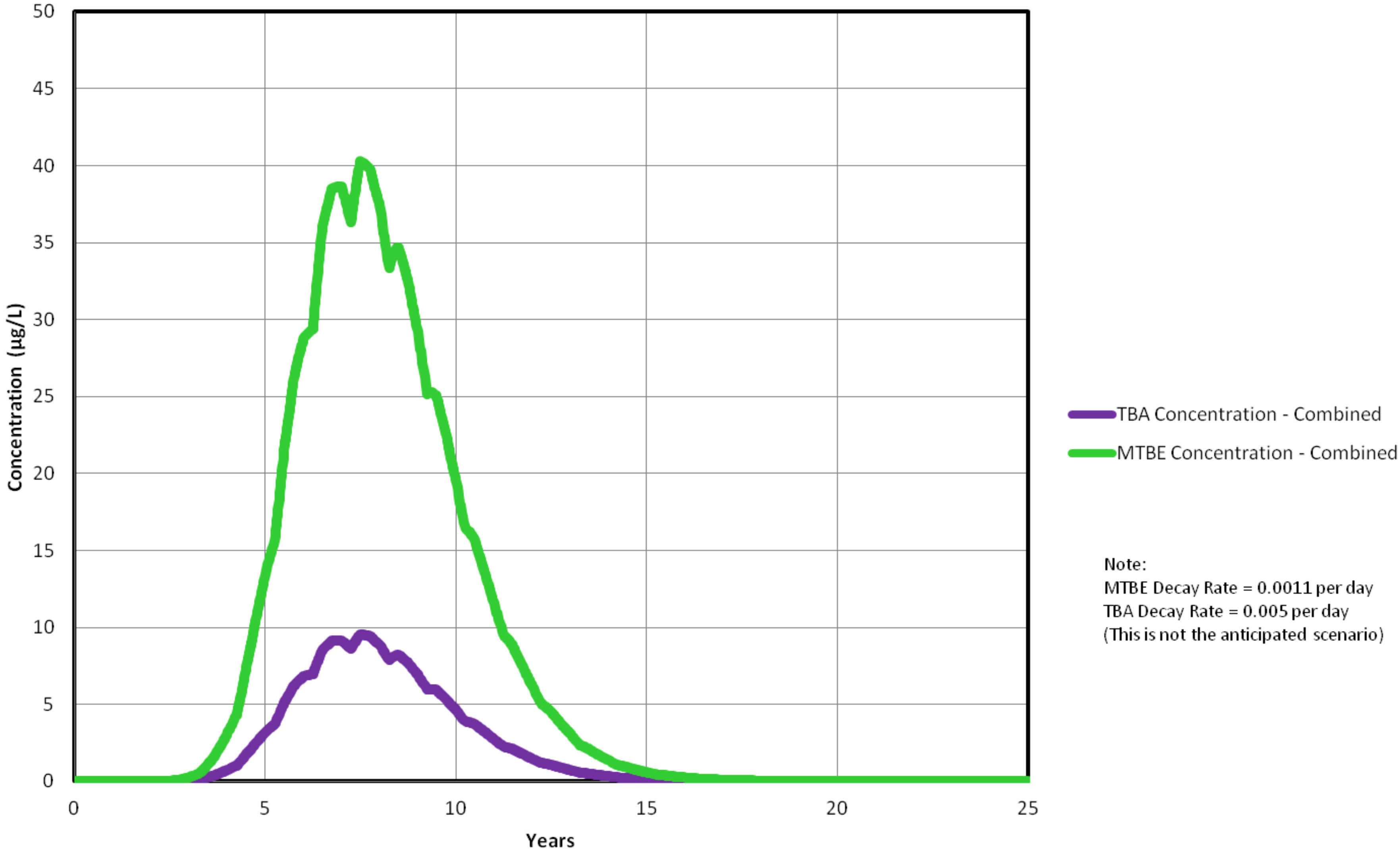
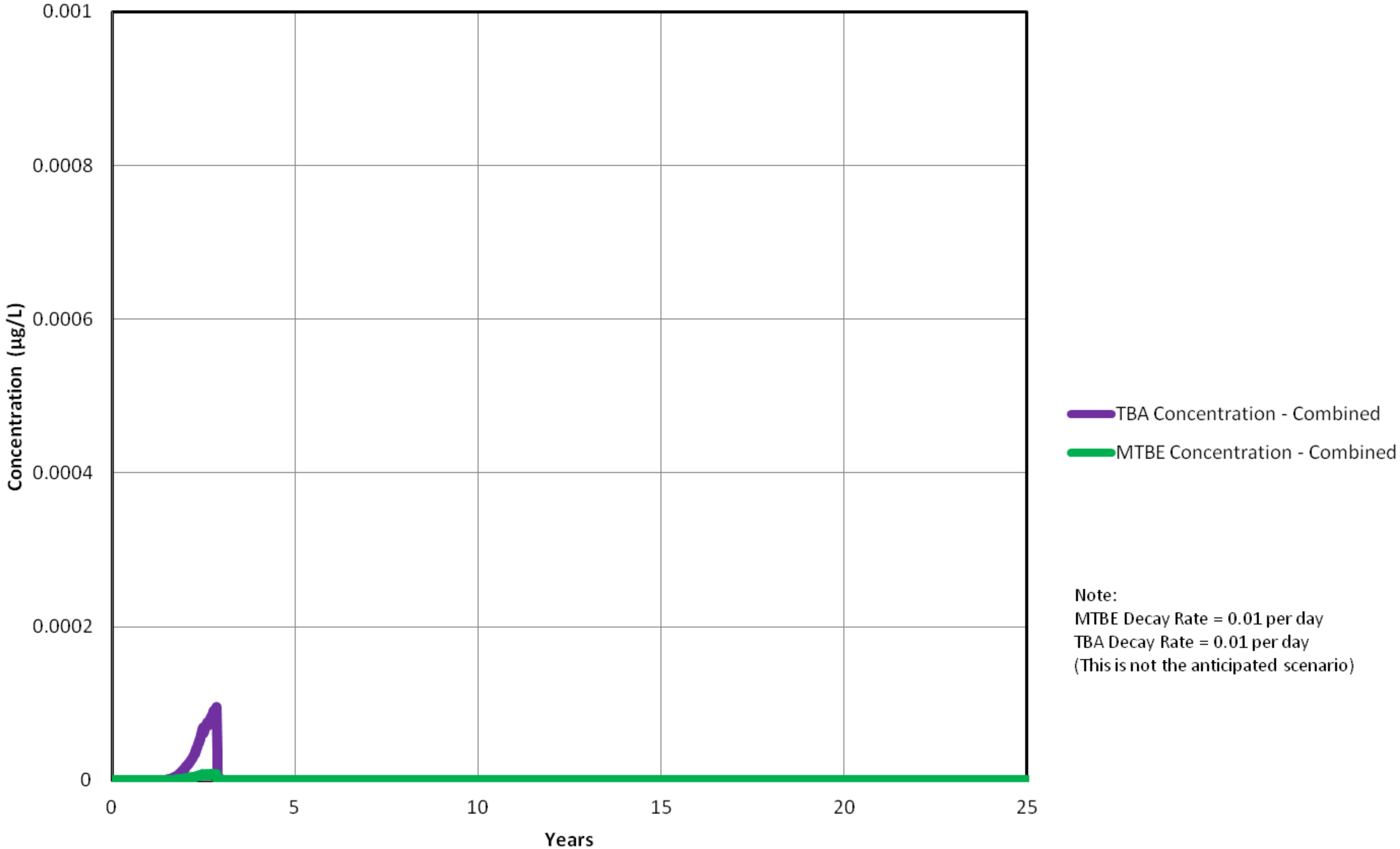


Figure 7. Predicted MTBE and TBA Concentrations in Revised Model
Combined Flow From Both Extraction Wells
Scenario 3 - MTBE and TBA Decay Quickly, At Equal Rates



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January 27, 2011

Ms. Molly Collins
Environmental Manager
City of Tucson, Environmental Services
4004 S. Park Avenue, Bldg 1 and Bldg 2
Tucson, AZ 85726-7210

RE: SILVERBELL GROUNDWATER REMEDIATION SYSTEM COST OPINION UPDATE

Dear Ms. Collins:

Malcolm Pirnie, the Water Division of ARCADIS, is pleased to submit this letter report updating the cost opinion for the groundwater remediation system at the Silverbell Landfill Water Quality Revolving Fund (WQARF) Site originally prepared by Malcolm Pirnie, Inc. in November 2009 as a subcontractor to Clear Creek Associates and presented in the *Silverbell Landfill WQARF Site - Remedial Action Plan Implementation Evaluation of Remedial Alternatives* (Clear Creek Associates 2010). The City of Tucson – Environmental Services (COTES) is actively engaged in implementing the recommendations presented in the Clear Creek Associates (2010) remedial action plan implementation report. The update to the engineer's conceptual cost opinion presented in the remedial action implementation plan evaluation is based on costs developed in 2009 and includes the baseline assumption that COTES staff would operate, monitor, and maintain the remediation systems. The purpose of this project is to update the conceptual cost opinion to December 2010 prices, as well as update operations costs assuming a non-city contractor will be responsible for operations. The Cost Opinion Update has been prepared in conjunction with the On-Call Environmental Design and Construction Services and Operations Support contract (Contract No. 062063-04, Amendment 4) between the City of Tucson and Malcolm Pirnie.

Project Approach

Malcolm Pirnie updated unit costs for materials to 2010 pricing levels as presented in the 2010 RS Means Construction Cost Data and contacted vendors to update equipment costs. Review of the 2010 RS Means Electrical Cost Data indicated that costs for electrical equipment and materials decreased by approximately 10 to 20 percent compared to general cost data presented in the 2009 RS Means Electrical Cost Data. It is assumed the decrease in electrical equipment cost data from 2009 to 2010 is largely related to economic factors in 2009 and pricing of material costs at that time. Cost for copper rose to over four dollars per pound ($4.00/lb) in late 2010. Copper prices are projected to continue rising during 2011. Copper prices were most recently over $4.00/lb during the summer of 2008. Copper prices plummeted in late 2008 from more than $4.00/lb to less than $1.60/lb (source: http:/Investinmetal.com). The RS Means 2009 Electrical Cost Data was based on the high material costs for electrical equipment in mid-2008, while the greatly reduced material cost data for electrical equipment presented in the RS Means 2010 Electrical Cost Data was based on the lower copper prices prevalent during 2009 and 2010. Based on current trends for 2011 and beyond, material costs for electrical equipment and electrical equipment costs are increasing and are expected to approach 2009 costs. Based on the current economic environment and engineering judgment, the conceptual cost opinion for electrical and instrumentation are based on 2009 RS Means Cost Data.

Regulatory permitting and monitoring requirements were not available for the evaluation report (Clear Creek Associates, 2010) and regulatory compliance costs, therefore, were not included in the conceptual cost opinion. Since January 2010, COTES has been in discussions with the Arizona Department of Water Resources (ADWR) and the Arizona Department of Environmental Quality (ADEQ) to determine permitting requirements for operating the groundwater remediation system as described in the evaluation report. ADWR will require a Poor-quality Groundwater-withdrawal Permit. The permit requires the operator to monitor groundwater withdrawals and prepare two semi-annual monitoring reports and one annual withdrawal report. Initial design, construction, and startup of remediation systems would require regulatory oversight costs, which are conceptually addressed in this updated cost opinion strictly based on assumptions presented in this memorandum. It is assumed that the regulatory agencies will require a facility startup plan, which will include monitoring of treatment plant influent and effluent. It is assumed that daily monitoring will be required the first week of operation, weekly monitoring will be require for the first full month of operation, and monthly sampling for the next six months. Any additional regulatory costs will be dependent on agency requirements for system operations, which will be developed as part of the design and permitting process.

All operation and maintenance (O&M) costs were updated assuming third-party pricing levels for operation, maintenance, and reporting and added to the updated cost opinion on a conceptual level to address potential costs. It was assumed that operations of the system will include routine startup and shutdown of the system, equipment and well maintenance, chemical delivery and management, quarterly sampling of water treatment system (influent and effluent sampling) and air treatment (exhaust), and operations reporting will be performed as part of this contract.

Capital Costs

The updated conceptual capital cost opinion was developed based on the conceptual design for the extraction wells, treatment facility, and injection wells presented in the *Silverbell Landfill WQARF Site - Remedial Action Plan Implementation Evaluation of Remedial Alternatives* (Clear Creek Associates 2010). The conceptual design drawings from the 2010 evaluation report are attached to this technical memorandum for reference. The updated conceptual capital cost estimates presented herein are based on available existing studies, recent projects with similar components, manufacturer's budget estimates, standard construction cost estimating manuals, and engineering judgment. Process equipment costs include an allowance of 5 percent for both piping and site work. All capital costs include a 20 percent factor for engineering and administrative costs, a 30 percent factor for contingencies, and 15 percent for contractor overhead and profit. The 30 percent contingency is required to account for the level of detail normally associated with conceptual-level design.

Cost opinions are expressed in December 2010 dollars (20 Cities Average Engineering News Record Construction Cost Index = 8952). The level of accuracy for the cost estimates corresponds to the Class 4 estimate as defined by the Association for the Advancement of Cost Engineering (AACE) International. This level of engineering cost estimating is approximate and generally made without detailed engineering data and site layouts, but is appropriate for preliminary budget-level estimating. The accuracy range of a Class 4 estimate is minus 30 percent to plus 50 percent. All of the cost assumptions that were made in the development of the original equipment list and conceptual cost opinion in the *Silverbell Landfill WQARF Site - Remedial Action Plan Implementation Evaluation of Remedial Alternatives* (Clear Creek Associates 2010).

The equipment list and the conceptual-level capital cost opinion for the treatment system are provided in Table 1. The updated cost opinion is based on vender quote updates for major equipment for the treatment processes, cost scaling from May 2009 (ENR CCI = 8547) to December 2010 (ENR CCI = 8952) for extraction well and injection well installation, and RS Means Cost Data evaluations for general construction and electrical elements. As previously stated, general construction components are based on 2010 RS Means Building Construction Cost Data and electrical components are based on 2009 RS Means Electrical Cost Data.

The material costs for electrical components are discussed in detail in the *Project Approach* on the first page of this letter report. The construction cost associated with electrical requirements for the remediation system conceptual design at the Silverbell Landfill WQARF Site account for over 50 percent of the capital construction cost of the entire system. In the conceptual design (Clear Creek, 2010), a new electrical service was assumed for the treatment site location at the south cell of the landfill adjacent to the former police small arms range. Individual services at each well site were determined to be infeasible due to the locations of these well sites within the Silverbell Golf Course. The COTES had discussions with Tucson Electric Power (TEP) and determined that power drops to individual extraction well sites within the golf course would be cost prohibitive. The wiring and conduits for power delivery and well controls are assumed to run from the treatment site to the individual well locations. The extensive underground wiring and conduit runs are detailed in Table 2 and are largely responsible for the relatively high electrical cost. Costs for development, production, and implementation of the start-up plan are included in the capital costs, for these are one-time costs associated with capital system start-up rather than routine operations.

O & M Conceptual Cost Opinion

The conceptual O&M cost opinion has been updated to identify potential items that will affect operations and maintenance of the proposed groundwater remediation system at the Silverbell Landfill. The O&M cost opinion is presented in Table 3 in three general categories:

1) Remediation system start-up, shut-down, and operations
2) Remediation system maintenance
3) Remediation system monitoring and reporting

The basis of the cost opinion for each of these categories is described below.

1) *Conceptual Cost Opinion for Operations* – The cost opinion for the operations of the Silverbell Landfill groundwater remediation system is based on the following assumptions:
    - Operator hours based on one-third full-time operator time (assuming 2,080 hours per year)
    - Project manager time at 8 hours per month and invoicing and administrative time of 12 hours per month.
    - Engineering time at 5 hours per month for responding to miscellaneous project specific needs.
    - Cost rates based on engineer's judgment.
    - Power usage based on pump, blower, and duct heater demands at $0.10 per kilowatt-hour.
    - Chemical usage based on vendor estimate of approximately 36 pounds (lbs) sequestering agent per day at 800 gallons per minute (gpm) flow rate.
    - Granular Activated Carbon (GAC) change-outs of 5,000 lbs capacity every 9 months. The nine-month carbon life estimate is based on early operations of the Tucson International Airport Groundwater Remediation Project (TARP) from 1994 through 2005. More recent GAC change-outs have been on an approximate annual basis.
2) *Conceptual Cost Opinion for Maintenance* –The conceptual design in the remedial action plan implementation evaluation (Clear Creek Associates 2010) does not include estimates of maintenance schedules for equipment. The conceptual cost opinion presented herein is only for the purpose of identifying typical maintenance issues that may arise in operations of air-stripping treatment systems, groundwater extraction wells, and groundwater injection wells. The assumptions used to develop maintenance costs are as follows:
    - Field technician time for equipment lubrication, blower maintenance, and field calibration of instruments as well as general site maintenance activities.
    - Instrument technician time based on 16 hours per month, operations of the TARP demonstrate that calibration and maintenance of instruments are generally the most labor-intensive portion of the maintenance program for the water treatment plant.

- Injection well design is based on minimizing requirements for injection well maintenance; however, back-flushing events should be planned for. Back-flushing is assumed to occur every 3 years at a cost of $20,000 per well based on engineering judgment from costs associated with Aquifer Storage and Recovery (ASR) wells.
- Extraction well maintenance including pulling well pumps and piping, swabbing casing, and purging would be performed on a 5-year cycle. This interval is consistent with the current maintenance cycle for the TARP South Well Field (SWF) wells, which have a similar submersible pump design. Well maintenance events are assumed to cost approximately $20,000 per event.
- Extraction well pump replacement program assumes replacement of submersible well pumps once every 7 years. Replacement costs are based on initial well installation costs.
- Maintenance on blowers (lubrication and belts) and maintenance of flow control and check valves.

3) *Conceptual Cost Opinion for Monitoring and Reporting* – The monitoring and reporting cost opinion is based on quarterly sampling of influent and effluent water at the shallow-tray air stripping unit and air samples of the influent, effluent, and carbon bed of the GAC contactor. The updated O&M conceptual cost opinion is based on the quarterly monitoring of water and vapor-phase treatment systems. The system start-up and shake-down monitoring is assumed to be part of the capital construction cost presented in Table 1. Water samples for both programs are assumed to be analyzed for volatile organic compounds (VOCs) by EPA Method 8260 and air samples by EPA Method TO-15. Reporting is assumed to include data reduction and validation and quarterly monitoring reports to the City of Tucson and ADEQ to determine whether system operation is achieving the remedial action objectives. Two semi-annual monitoring reports are assumed to be prepared for distribution to ADWR and ADEQ and one annual withdrawal report to ADWR based on requirements of the Poor-quality Groundwater-withdrawal Permit.

Summary

Table 4 provides a summary of the updated cost opinion for the implementation of the Silverbell Landfill WQARF site Remediation Action Plan. The total capital cost is estimated at approximately $7.3 million and the annual operation costs at approximately $692,000 per year. The annualized capital cost estimate and the present worth estimate of combined capital and O&M costs are based on a 20-year term at an annualized 6 percent interest rate. We appreciate the opportunity to work with COTES updating this conceptual cost opinion.

Very truly yours,

MALCOLM PIRNIE
The Water Division of ARCADIS U.S., Inc.

James W. Dettmer, P.E., BCEE
Principal Engineer

Registered Professional Engineer (Sanitary)
CERTIFICATE NO.
27864
JAMES W.
DETTMER
Date Signed 1/27/2011
ARIZONA, U.S.A.

Expires: 3/31/2012

c. Glenn Hoeger, ARCADIS-US/Malcolm Pirnie
George Maseeh, ARCADIS-US/Malcolm Pirnie

Attachments
00949059.0000

TABLES

Table 1
Engineer's Conceptual Opinion of Probable Capital Costs
Pump and Treat Only / Year Round

					Materials		Labor *(Note 1)*	
						Total Materials		Item Subtotal
	References	Quantity	Unit	**Unit Cost**	ENR CCI	December 2010[2]	25%	(December 2010)[2]
CONSTRUCTION COSTS								
Wells								
Extraction Wells (includes 4 extraction wells)	Clear Creek / Layne	1	LS	$ 652,000	8574	$ 680,745	Incl.	$ 680,800
Injection Wells (includes 4 injection wells)	Clear Creek / Layne	1	LS	$ 780,800	8574	$ 815,223	Incl.	$ 815,300
						Subtotal Well Construction Cost:		**$ 1,496,100**
Well Pumps								
6-in Extraction Well Pump w/VFD	Grand Canyon Pump & Supply	4	EA	$ 6,222	8952	$ 24,888	$ 6,222	$ 31,200
1" Sounding Tube, PVC	Ryan Herco	1940	LF	$ 0.72	8574	$ 1,458	$ 365	$ 1,900
1" Transducer Tube, PVC	Ryan Herco	1940	LF	$ 0.72	8574	$ 1,458	$ 365	$ 1,900
Transducers	Malcolm Pirnie	8	EA	$ 2,500	8574	$ 20,882	$ 5,220	$ 26,200
4" Galvanized Steel Extraction Well Piping	RS Means 2010 22 11 13.44 1400	1,080	LF	$ 73	8952	$ 78,840	Incl.	$ 78,900
4" Galvanized Steel Injection Well Piping	RS Means 2010 22 11 13.44 1400	1,240	LF	$ 73	8952	$ 90,520	Incl.	$ 90,600
Inflatable Packer	Baski	4	EA	$ 17,000	8574	$ 70,998	Incl.	$ 71,000
8" Flow Control Valve (motor-operated)	Dezurik	4	EA	$ 7,530	8574	$ 31,448	$ 7,862	$ 39,400
Extraction Well Heads								
Pre-fabricated Utility Box (5'x10'x6')	RS Means 2010 33 05 16.13 0050	4	EA	$ 3,675	8952	$ 14,700	Incl.	$ 14,700
Aluminum checkered Man-way Plate Cover (4'x6'; 24 SF)	RS Means 2010 05 54 13.20 0300	4	EA	$ 641	8952	$ 2,564	Incl.	$ 2,600
Excavation (7'x12'x6')	RS Means 2010 31 23 16.16 6060	2,016	EA	$ 10	8952	$ 19,555	Incl.	$ 19,600
Compacted Fill, 12"	RS Means 2010 31 23 23 2000	336	CY	$ 3	8952	$ 884	Incl.	$ 900
Combination Air/Vacuum Release Valve Assembly with Tee	Malcolm Pirnie	4	EA	$ 1,050	8185	$ 4,594	$ 1,148	$ 5,800
4" Check Valve	RS Means 2010 23 05 23.80.1460	4	EA	$ 1,375	8952	$ 5,500	Incl.	$ 5,500
4" PVC Ball Valve	RS Means 2009 22 05 23.60 5910	4	EA	$ 425	8574	$ 1,775	$ 444	$ 2,300
4" Flow Meter	Micrometer	4	EA	$ 1,400	8185	$ 6,125	$ 1,531	$ 7,700
Site Work								
Gravel Driveway (6" thick)	RS Means 2010 32 11 23.23 0100	134	CY	$ 7.86	8574	$ 1,098	Incl.	$ 1,100
Chain Link Fence, 3-strand barbed wire (6 ft)	SAVSARP - cost opinion	456	LF	$ 17	7942	$ 8,692	Incl.	$ 8,700
10-in Ductile Iron Pipe - from extraction wells to treatment plant	ACIPCO	3,683	LF	$ 21	8952	$ 77,527	$ 19,382	$ 97,000
8-in Ductile Iron Pipe - from treatment system to injection wells	ACIPCO	4,645	LF	$ 16	8952	$ 75,714	$ 18,928	$ 94,700
Trench Excavation (for 10-in Ductile Iron Pipe)	RS Means 2010, 31 23 16.13 0090	1,184	CY	$ 4.74	8952	$ 5,612	Incl.	$ 5,700
Trench Excavation (for 8-in Ductile Iron Pipe)	RS Means 2010, 31 23 16.13 0091	1,330	CY	$ 4.74	8952	$ 6,303	Incl.	$ 6,400
Backfill (for 10-in Ductile Iron Pipe)	RS Means 2010, 31 23 23.13 1900	1,110	CY	$ 4.63	8952	$ 5,138	Incl.	$ 5,200
Backfill (for 8-in Ductile Iron Pipe)	RS Means 2010, 31 23 23.13 1900	1,236	CY	$ 4.63	8952	$ 5,723	Incl.	$ 5,800
Electrical and Instrumentation & Controls Site Work								
Electrical utility service to plant	Malcolm Pirnie/2009 RS Means	1	LS	$100,000	8952	$ 100,000	Incl.	$ 100,000
Service Entrance Switchboard (480V, 1200A, NEMA 3R)	Malcolm Pirnie/2009 RS Means	1	EA	$50,000	8952	$ 50,000	Incl.	$ 50,000
Motor Control Center (480V, 1200A, NEMA 12)	Malcolm Pirnie/2009 RS Means	1	EA	$100,000	8952	$ 100,000	Incl.	$ 100,000
Variable Frequency Drives (20HP for Extraction Wells)	Malcolm Pirnie/2009 RS Means	4	EA	$20,000	8952	$ 80,000	Incl.	$ 80,000
Variable Frequency Drives (50HP for Injection Wells)	Malcolm Pirnie/2009 RS Means	2	EA	$40,000	8952	$ 80,000	Incl.	$ 80,000
Miscellaneous Loads (lighting, grounding, receptacles)	Malcolm Pirnie/2009 RS Means	1	LS	$50,000	8952	$ 50,000	Incl.	$ 50,000
Flow Control Valve Disconnect Switches	Malcolm Pirnie/2009 RS Means	4	EA	$1,000	8952	$ 4,000	Incl.	$ 4,000
Treatment Plant Conduit and Wire	Malcolm Pirnie/2009 RS Means	1	LS	$100,000	8952	$ 100,000	Incl.	$ 100,000
Site Conduit and Wire	Table 2	1	LS	$669,535	8952	$ 669,535	Incl.	$ 669,600
Injection Concrete Hand Holes	Malcolm Pirnie/2009 RS Means	10	EA	$2,500	8952	$ 25,000	Incl.	$ 25,000
Extraction Concrete Hand Holes	Malcolm Pirnie/2009 RS Means	10	EA	$2,500	8952	$ 25,000	Incl.	$ 25,000

Table 1
Engineer's Conceptual Opinion of Probable Capital Costs
Pump and Treat Only / Year Round

	References	Quantity	Unit	Unit Cost	Materials ENR CCI	Amount	Labor *(Note 1)* 25%	Item Subtotal (December 2010)[2]
Instrumentation								
Ultrasonic Level Transmitter	Malcolm Pirnie/2009 RS Means	3	EA	$1,000	8952	$ 3,000	Incl.	$ 3,000
Level Switch - Float	Malcolm Pirnie/2009 RS Means	3	EA	$500	8952	$ 1,500	Incl.	$ 1,500
Propeller Flowmeter	Malcolm Pirnie/2009 RS Means	9	EA	$2,000	8952	$ 18,000	Incl.	$ 18,000
Magnetic Flowmeter	Malcolm Pirnie/2009 RS Means	1	EA	$5,000	8952	$ 5,000	Incl.	$ 5,000
Differential Pressure Transmitter	Malcolm Pirnie/2009 RS Means	1	EA	$500	8952	$ 500	Incl.	$ 500
Pressure Indicator	Malcolm Pirnie/2009 RS Means	2	EA	$500	8952	$ 1,000	Incl.	$ 1,000
Pressure Switch	Malcolm Pirnie/2009 RS Means	2	EA	$500	8952	$ 1,000	Incl.	$ 1,000
Diaphram Seal	Malcolm Pirnie/2009 RS Means	2	EA	$500	8952	$ 1,000	Incl.	$ 1,000
Relative Humidity Analyzer	Malcolm Pirnie/2009 RS Means	1	EA	$5,000	8952	$ 5,000	Incl.	$ 5,000
Local Control Panel LCP-SB	Malcolm Pirnie/2009 RS Means	1	EA	$75,000	8952	$ 75,000	Incl.	$ 75,000
Local Control Panel LCP-CHEM	Malcolm Pirnie/2009 RS Means	1	EA	$25,000	8952	$ 25,000	Incl.	$ 25,000
Concrete (Bldg Foundation & Structures)								
Excavation	RS Means 2010 31 23 16.16 6070	119	CY	$ 13	8952	$ 1,550	Incl.	$ 1,600
Compacted Fill, 6"	RS Means 2010 31 23 23 2000	60	CY	$ 2	8952	$ 127	Incl.	$ 200
Concrete Slab on Grade, 12"	RS Means 2010 03 30 53.40 4700	119	CY	$ 153	8952	$ 18,226	Incl.	$ 18,300
Equipment Pads, (i.e. air stripper and chemical totes), 6" thick	RS Means 2010 03 30 53.40 5210	392	SF	$ 11	8952	$ 4,134	Incl.	$ 4,200
Building								
Canopy	RS Means 2010 10 73 16.20.7750	1750	SF	$ 31	8952	$ 54,390	Incl.	$ 54,400
Secondary Containment Curb for Totes (Concrete)	RS Means 2010 32 16 13.13 0400	60	LF	$ 13	8952	$ 804	Incl.	$ 900
Electrical Building	Tucson Water - control building cost	1	LS	$ 20,000	7942	$ 22,543	$ 5,636	$ 28,200
Air Conditioner	RS Means 2010 23 81 13.10 0260	1	EA	$ 1,164	8952	$ 1,164	Incl.	$ 1,200
PROCESS EQUIPMENT								
Anti-scale treatment								
Chemical pumps for sequstering agent injection	Pollard Water	2	EA	$ 365	8528	$ 766	$ 192	$ 1,000
Aeration Equipment								
Shallow Tray Aerator (incl. air stripper, blower, control panel, delivery)	BISCO Environmental, Inc. - NEEP Systems quote - 2 required for ND scenario	2	EA	$ 83,000	8952	$ 166,000	$ 41,500	$ 207,500
Sound Enclosure for Air Stripper Blowers	BISCO Environmental, Inc. - NEEP Systems	2	EA	$ 9,000	8952	$ 18,000	$ 4,500	$ 22,500
Air Filter for Blower Inlet	BISCO Environmental, Inc. - NEEP Systems	2	EA	$ 2,000	8952	$ 4,000	$ 1,000	$ 5,000
Vapor Phase Carbon Contactor	Siemens RB5 quote - max capacity 5,000	1	EA	$ 31,650	8952	$ 31,650	$ 7,913	$ 39,600
Duct (36"x36")	Perry Fiberglass Products	1	LS	$ 11,830	8952	$ 11,830	$ 2,958	$ 14,800
Electric Duct Heater	Brasch	1	EA	$ 6,000	8528	$ 6,298	$ 1,575	$ 7,900
Duct Insulation	RS Means 2010 23 07 13.10 0100	1	LS	$ 1,783	8952	$ 1,783	Incl.	$ 1,800
Process Piping and Valves	Malcolm Pirnie (10% of equipment costs)	1	LS	$ 22,565	8952	$ 22,565	$ 5,641	$ 28,300
Transfer pumps	Grand Cayon Pumps April 2009	2	EA	$ 12,413	8574	$ 25,919	$ 6,480	$ 32,400
Start-up Plan Development								
Engineer	Malcolm Pirnie	60	HR	$ 120	8952	$ 7,200		$ 7,200
Senior Engineer	Malcolm Pirnie	4	HR	$ 220	8952	$ 880		$ 900
Project Manager	Malcolm Pirnie	16	HR	$ 180	8952	$ 2,880		$ 2,900
Adminstrative	Malcolm Pirnie	16	HR	$ 65	8952	$ 1,040		$ 1,100
Materials		1	LS	$ 1,000.00	8952	$ 1,000		$ 1,000
Start-up Plan Implementation and Reporting[3]								
Field Technician	Malcolm Pirnie	120	HR	$ 80	8952	$ 9,600		$ 9,600
Engineer	Malcolm Pirnie	40	HR	$ 160	8952	$ 6,400		$ 6,400
Project Manager	Malcolm Pirnie	16	HR	$ 180	8952	$ 2,880		$ 2,900
Adminstrative	Malcolm Pirnie	16	HR	$ 65	8952	$ 1,040		$ 1,100
Laboratory								
Water Samples (VOCs 8260)		34	EA	$ 150.00	8952	$ 5,100		$ 5,100
Air Samples (VOCs TO-15)		51	EA	$ 170.00	8952	$ 8,670		$ 8,700
Materials		1	LS	$ 1,000.00	8952	$ 1,000		$ 1,000
Subtotal								**$ 46,900**
							Subtotal Treatment Facility and Well Equipment Construction Cost:	**$ 2,562,000**

Table 1
Engineer's Conceptual Opinion of Probable Capital Costs
Pump and Treat Only / Year Round

	Subtotal Construction Cost with Allowances (Treatment Facility and Well Equipment):		**$**	**2,562,000**
	Subtotal Construction Cost (Wells):		**$**	**1,496,100**
	Contractor Overhead and Profit	**15%**	**$**	**384,000**
City of Tucson Sales Tax: 9.60%	**Tax (65% of local rate)**	**6.24%**	**$**	**253,000**
	SUBTOTAL INCLUDING OH&P AND TAX:		**$**	**4,695,100**
	Engineering & Administration (Design and Construction Services):	**20%**	**$**	**939,000**
	SUBTOTAL INCLUDING ENGINEERING AND ADMINISTRATION:		**$**	**5,634,100**
	Contingency:	**30%**	**$**	**1,690,000**
	TOTAL CAPITAL COST OPINION:		**$**	**7,324,100**

ABBREVIATIONS:
CF = cubic foot
CY = cubic yard
DIP = ductile iron pipe
GAL = gallon
Incl. = included
kWh = kilowatt-hour
LF = linear foot
SF = square foot
SY = square yard

NOTES:
1. A factor of 25% of material costs was used for installation and commissioning labor for items where labor is not included in the unit cost.
2. ENR CCI December 2010 = 8952
3. Start-up monitoring including daily water and vapor phase sampling for seven days, weekly sampling for four weeks, and monthly sampling for six months.

Table 2
Engineer's Conceptual Opinion of Probable Conduit and Wire Costs
Pump and Treat Only / Year Round

Item	Qty	Cost	Per	Reference	Subtotal
#4/0 XHHW	10800	$1,011	100	2009 RS Means 26 05 19.90 3220	$109,188
#3/0 XHHW	19200	$820	100	2009 RS Means 26 05 19.90 3200	$157,440
#2/0 XHHW	0	$665	100	2009 RS Means 26 05 19.90 3180	$0
#1/0 XHHW	4800	$539	100	2009 RS Means 26 05 19.90 3160	$25,872
#1 XHHW	0	$439	100	2009 RS Means 26 05 19.90 3140	$0
#2 XHHW	0	$352	100	2009 RS Means 26 05 19.90 3120	$0
#4 XHHW	1600	$243	100	2009 RS Means 26 05 19.90 3100	$3,888
#6 XHHW	0	$169	100	2009 RS Means 26 05 19.90 3080	$0
#8 XHHW	62000	$122	100	2009 RS Means 26 05 19.90 3060	$75,640
#10 XHHW	0	$87	100	2009 RS Means 26 05 19.90 3040	$0
#12 XHHW	0	$66	100	2009 RS Means 26 05 19.90 3020	$0
#14 XHHW	0	$51	100	2009 RS Means 26 05 19.90 3000	$0
STP	78700	$115	100	2009 RS Means 26 05 19.90	$90,112
CAT 5E (X)	0	$200	100	2009 RS Means 26 05 19.90	$0
3/4" PVC-RS Conduit	0	$13.95		Malcolm Pirnie 2009	$0
1" PVC-RS Conduit	0	$17.70		Malcolm Pirnie 2009	$0
1-1/2" PVC-RS Conduit	0	$24.00		Malcolm Pirnie 2009	$0
2" RGS Conduit	0	$31.50		Malcolm Pirnie 2009	$0
2-1/2" RGS Conduit	0	$32.00		Malcolm Pirnie 2009	$0
3" RGS Conduit	0	$41.50		Malcolm Pirnie 2009	$0
4" RGS Conduit	0	$55.50		Malcolm Pirnie 2009	$0
5" RGS Conduit	0	$96.00		Malcolm Pirnie 2009	$0
3/4" PVC Conduit	0	$2.56		Malcolm Pirnie 2009	$0
1" PVC Conduit	0	$3.14		Malcolm Pirnie 2009	$0
1-1/2" PVC Conduit	0	$4.34		Malcolm Pirnie 2009	$0
2" PVC Conduit	34100	$5.30		Malcolm Pirnie 2009	$180,730
2-1/2" PVC Conduit	0	$6.75		Malcolm Pirnie 2009	$0
3" PVC Conduit	2700	$8.95		Malcolm Pirnie 2009	$24,165
4" PVC Conduit	0	$13.05		Malcolm Pirnie 2009	$0
5" PVC Conduit	0	$18.10		Malcolm Pirnie 2009	$0
Trenching, backfill, concrete encasement	500	$5.00			$2,500

Sub-Total		$669,535
Contingency		$0
Total		$669,535

Table 3
Engineer's Conceptual Opinion of Probable Annual O&M Costs
Pump and Treat Only / Year Round

	References	Quantity	Unit	**Unit Cost**	Materials ENR CCI	Amount	Item Subtotal
Annual System Operations[1]							
Labor							
System Operator	Malcolm Pirnie	690	HR	$ 90	8952	$ 62,100	$ 62,100
Engineer	Malcolm Pirnie	60	HR	$ 120	8952	$ 7,200	$ 7,200
Project Manager	Malcolm Pirnie	96	HR	$ 180	8952	$ 17,280	$ 17,300
Administrative	Malcolm Pirnie	144	HR	$ 65	8952	$ 9,360	$ 9,400
Power							
Extraction Well Pumps (20 Hp)	Calculated	522,595	kWh	$ 0.10	8952	$ 52,260	$ 52,300
Shallow Tray Aerator - Blower	Calculated	522,595	kWh	$ 0.10	8952	$ 52,260	$ 52,300
Duct Heater	Calculated	525,600	kWh	$ 0.10	8952	$ 52,560	$ 52,600
Injection Pumps (50 Hp)	Calculated	653,244	kWh	$ 0.10	8952	$ 65,324	$ 65,400
Chemicals and Carbon							
Sequestering Agent	H2O Smart, SeaQuest Product	13,331	LBS	$ 3.00	8952	$ 39,994	$ 40,000
Granular Activated Carbon (GAC)	Siemens RB5 quote - 5,000 pound maximum, Calgon price per pound quote	7,500	LBS	$ 2.00	8952	$ 15,000	$ 15,000
Subtotal							**$ 373,600**
Annual System Maintenance[2]							
Labor							
Field Technician	Malcolm Pirnie	200	HR	$ 65	8952	$ 13,000	$ 13,000
Instrumant Technician	Malcolm Pirnie	192	HR	$ 120	8952	$ 23,040	$ 23,100
Project Manager	Malcolm Pirnie	48	HR	$ 180	8952	$ 8,640	$ 8,700
Subcontractor							
Injection Well Back-flush (1/ 3 years)	Malcolm Pirnie	0.33	LS	$ 80,000	8952	$ 26,400	$ 26,400
Extraction Well Maintenance (1/5 years)	Malcolm Pirnie	0.2	LS	$ 80,000	8952	$ 16,000	$ 16,000
Well Pump Replacement (1/7 years)	Malcolm Pirnie	0.14	LS	$ 119,600	8952	$ 17,086	$ 17,100
Subtotal							**$ 104,300**
Annual Compliance Monitoring and Reporting[3]							
Field Technician	Malcolm Pirnie	100	HR	$ 80	8952	$ 8,000	$ 8,000
Engineer	Malcolm Pirnie	160	HR	$ 120	8952	$ 19,200	$ 19,200
Project Manager	Malcolm Pirnie	40	HR	$ 180	8952	$ 7,200	$ 7,200
Adminstrative	Malcolm Pirnie	24	HR	$ 65	8952	$ 1,560	$ 1,600
Laboratory							
Water Samples (VOCs 8260)		8	EA	$ 150.00	8952	$ 1,200	$ 1,200
Air Samples (VOCs TO-15)		12	EA	$ 170.00	8952	$ 2,040	$ 2,100
Subtotal							**$ 39,300**
Expenses (5 percent Labor)					8952	$ 15,152	**$ 15,200**
						SUBTOTAL :	**$ 532,000**
					Contingency:	**30%**	**$ 160,000**
						TOTAL O&M COST OPINION:	**$ 692,000**

NOTES:

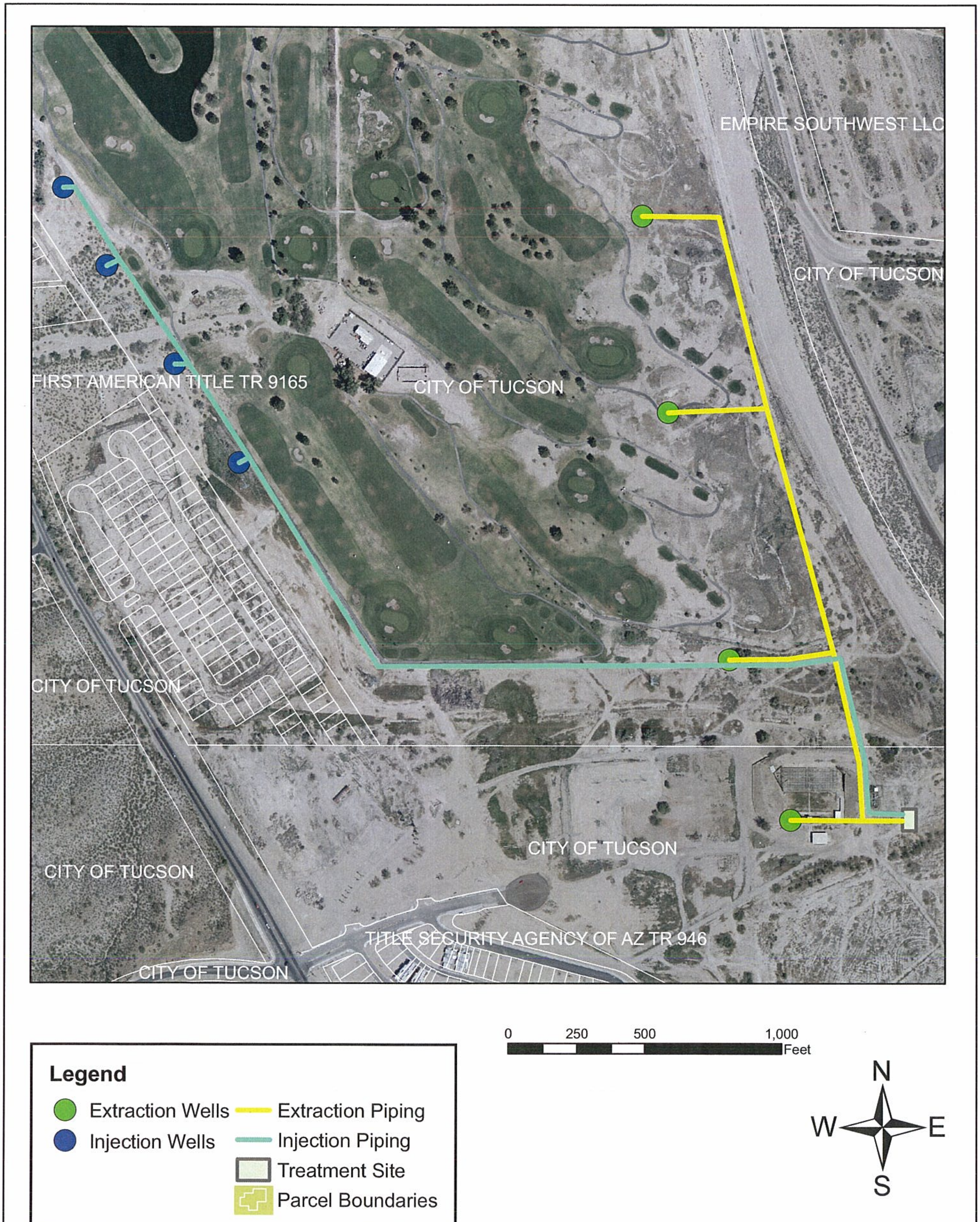
1. Operations include system start-up and shut down, chemcial delivery management, and .
2. System maintenance assumes blower (lubrication and belts) and valve maintenance, back-wash injection wells and extraction well maintenance once every three years, and pump replacement once every 7 years.
3. Compliance monitoring assumes quarterly sampling of raw and treated water and air, data review and reduction, and monitoring report preparation.
4. ENR CCI December 2010 = 8952

Table 4
Summary of Cost Opinion Data for Remdial Alternatives of Groundwater at the Silverbell Landfill WQARF Site

Remediation Alternative	Total Capital Cost	20-year Annualized Capital Cost	Annual O&M Cost	Total Annual Cost	20-Year Present Worth
	2010 $	2010 $	2010 $	2010 $	2010 $
Alternative 1	$ 7,324,100	$ 639,000	$ 692,000	$ 1,331,000	$ 15,262,000

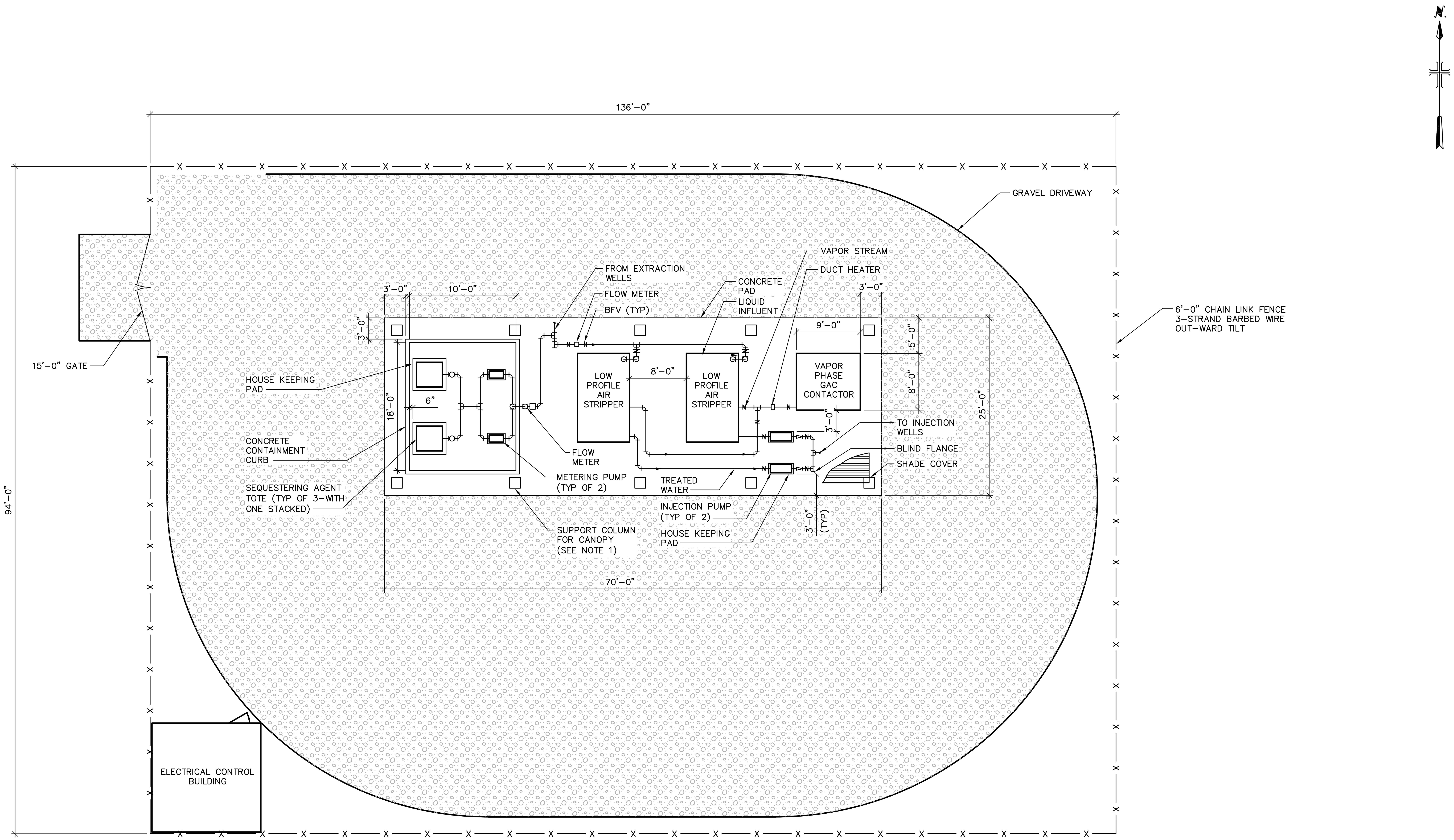
Assumptions: *Rate (i) = 6%*
Years (n) = 20

CONCEPTUAL DESIGN FIGURES FROM SILVERBELL LANDFILL WQARF SITE REMEDIAL ACTION PLAN IMPLEMENTATION – EVALUATION OF REMEIDAL ALTERNATIVES (CLEAR CREEK ASSOCIATES 2010)



MALCOLM PIRNIE	City of Tucson Environmental Services Silverbell RAP Implementation Well and Piping Conceptual Layout	Malcolm Pirnie, Inc. FIGURE 19

P:\4182004\R-1 Deliverables\Final Report\Figure 19 - Piping Layout.mxd



NOTE:
1. SIZE AND LOCATIONS OF SUPPORT COLUMNS ARE FOR ILLUSTRATION ONLY, AND SHALL BE DETERMINED DURING DETAILED DESIGN.

MALCOLM PIRNIE

CITY OF TUCSON
ENVIRONMENTAL SEVICES
SILVERBELL RAP IMPLEMENTATION

TREATMENT FACILITY LAYOUT

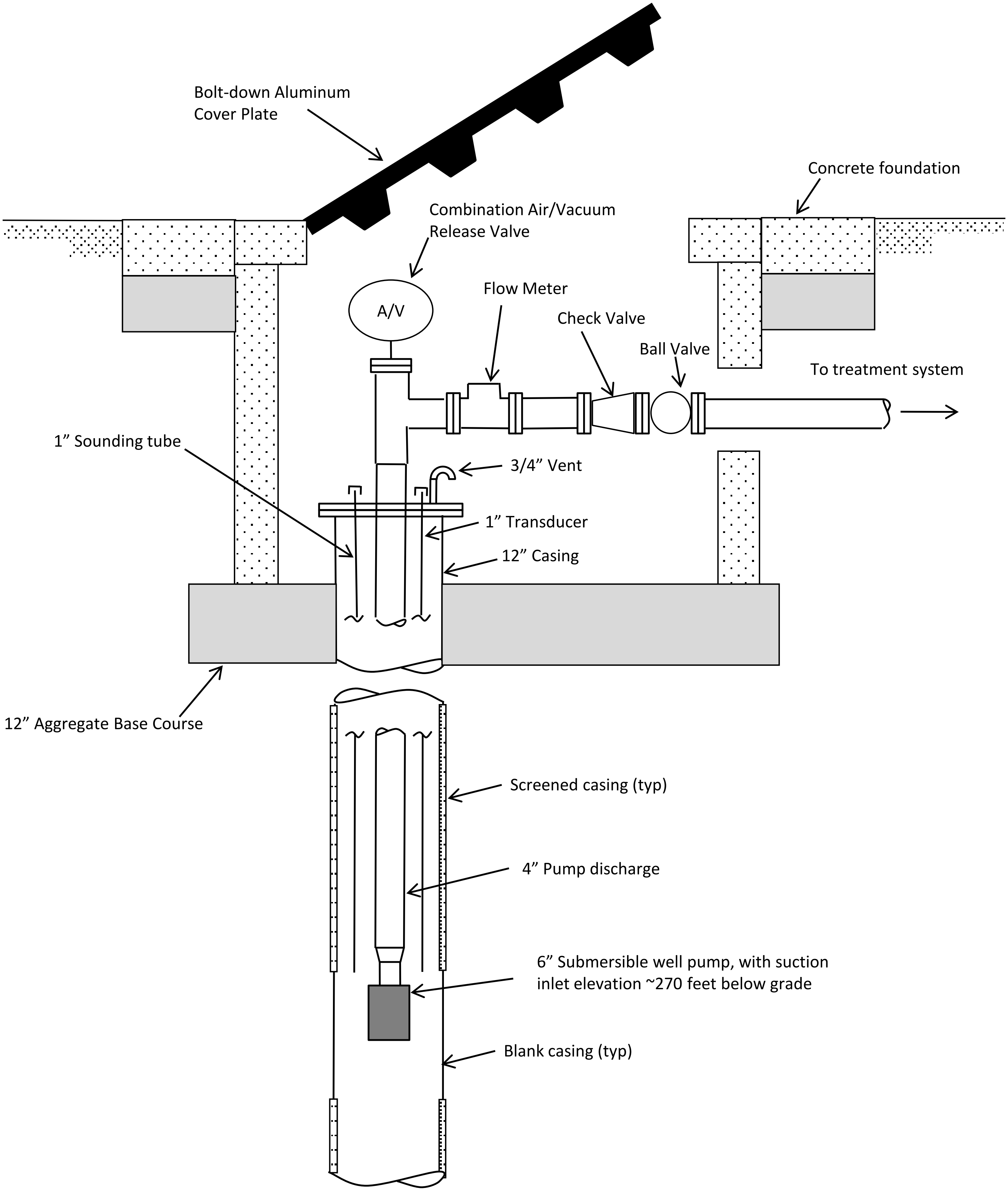
SCALE: 1/16" = 1'-0"

MALCOLM PIRNIE, INC.

NOVEMBER 2009

FIGURE 20

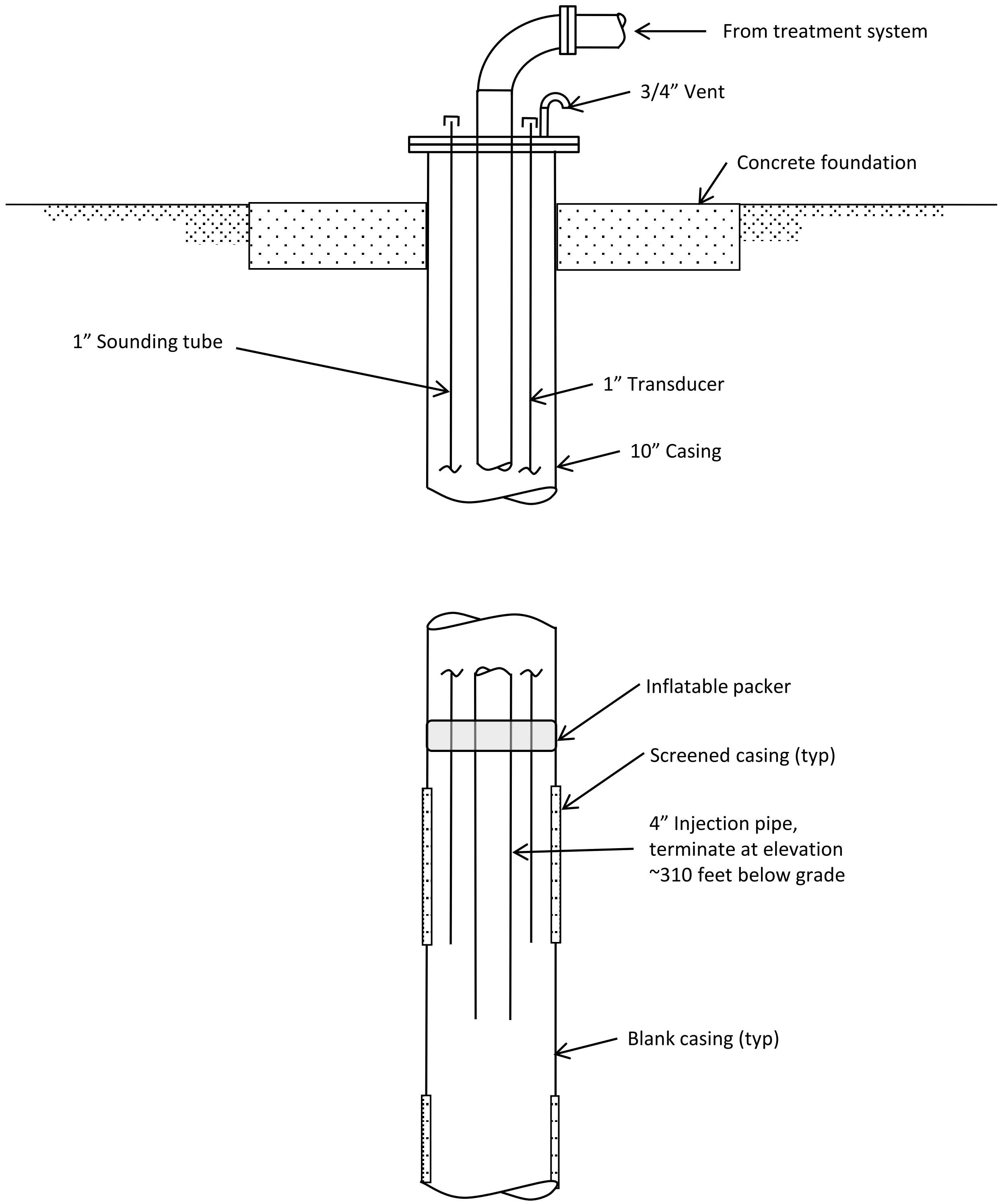
PRELIMINARY-NOT FOR CONSTRUCTION



PRELIMINARY – NOT FOR CONSTRUCTION

Not to Scale

MALCOLM PIRNIE	City of Tucson Environmental Services Silverbell RAP Implementation	MALCOLM PIRNIE, INC.
		NOVEMBER 2009
	Extraction Well Equipment	FIGURE 21



PRELIMINARY – NOT FOR CONSTRUCTION

Not to Scale

MALCOLM PIRNIE

City of Tucson Environmental Services
Silverbell RAP Implementation

Injection Well Equipment

MALCOLM PIRNIE, INC.

NOVEMBER 2009

FIGURE 22

DEVICE IDENTIFICATION LEGEND

	FIRST LETTER(S)		SUCCEEDING LETTERS		
	MEASURED OR INITIATING VARIABLE	MODIFIER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	ANALYSIS		ALARM		
B	BURNER , COMBUSTION				
C	CONDUCTIVITY			CONTROL	
D	DENSITY	DIFFERENTIAL			
E	VOLTAGE		PRIMARY ELEMENT		
F	FLOW RATE	RATIO (FRACTION)			
G	GAUGE		GLASS, VIEWING DEVICE		
H	HAND (MANUAL)				HIGH
I	CURRENT (ELECTRICAL)		INDICATE		
J	POWER	SCAN			
K	TIME, TIME SCHED.	TIME RATE OF CHANGE		CONTROL STATION	
L	LEVEL		LIGHT		LOW
M	MOISTURE	MOMENTARY			MIDDLE
N	INTRUSION				NORMAL
O			ORIFICE, RESTRICTION		
P	PRESSURE, VACUUM		POINT CONNECTION		
Q	QUANTITY	INTEGRATE, TOTALIZE			
R	RADIATION		RECORD OR PRINT		
S	SPEED, FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMIT	
U	MULTIVARIABLE		MULTIFUNCTION	MULTIFUNCTION	MULTIFUNCTION
V	VIBRATION			VALVE, LOUVER	
W	WEIGHT, FORCE		WELL		
X	UNCLASSIFIED	X AXIS	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED
Y	EVENT, STATE OR PRESENCE	Y AXIS		RELAY, COMPUTE, CONVERT	
Z	POSITION	Z AXIS		DRIVER, ACTUATOR, FINAL CONTROL ELEMENT	

ONE LINE DIAGRAM SYMBOLS

TVSS — TRANSIENT VOLTAGE SURGE SUPPRESION DEVICE

POTENTIAL TRANSFORMER AND FUSES AS SHOWN

CURRENT TRANSFORMER

DELTA–WYE GROUNDED POWER TRANSFORMER WITH GROUNDED SECONDARY

AT/AF — THERMAL–MAGNETIC MOLDED CASE CKT BREAKER, TOP NUMBER INDICATES FRAME RATING; LOWER NUMBER INDICATES TRIP RATING; TYPICAL FOR OTHER TYPES OF BREAKERS. BREAKER TO BE 3 POLE UNO AS "2P" OR "1P" FOR 2 POLE OR 1 POLE RESPECTIVELY.

EO 600/800 — DRAWOUT LOW–VOLTAGE POWER BREAKER EO INDICATES ELECTRICALLY OPERATED; UPPER NUMBER INDICATES TRIP RATING; LOWER NUMBER INDICATES FRAME SIZE. FUSE IS CURRENT LIMITER (IF REQUIRED)

AT/MCP FVNR 1 — COMBINATION MOTOR STARTER WITH MOTOR CIRCUIT PROTECTOR AND THERMAL OVERLOAD PROTECTION. NUMBER INDICATES NEMA STARTER SIZE. FVNR = FULL VOLTAGE NON–REVERSING, FVR = FULL VOLTAGE REVERSING, 2S = TWO SPEED. RVNR = REDUCED VOLTAGE NON–REVERSING. AT = AUTO TRANSFORMER

MTR OR 5 — ELECTRIC MOTOR, NUMBER INDICATES HORSEPOWER

M OR MOV — MOTOR OPERATED CONTROL VALVE OR GATE

X, F X/Y, CB X/Y — DISCONNECT SWITCH; F INDICATES FUSED DISCONNECT SWITCH CB INDICATES ENCLOSED CIRCUIT BREAKER. X – INDICATES DISCONNECT RATING IN AMPERES Y – INDICATES FUSE SIZE OR CIRCUIT BREAKER SETTING IN AMPERES

PANELBOARD. RATINGS AS SHOWN ON PANEL SCHEDULE.

INSTRUMENT AND FUNCTION SYMBOLS

FIELD MOUNTED

MOUNTED ON FACE OF PANEL

MOUNTED ON INTERIOR OF PANEL

INSTRUMENTS SHARING COMMON HOUSING

AL # / YL # / UL # — ALARM OR PILOT LIGHT

HS # XX — HAND SELECTOR SWITCH OR PUSHBUTTON XX DENOTES FUNCTION

ACK	ACKNOWLEDGE
E–STP	EMERGENCY STOP
FSR	FORWARD–STOP–REVERSE
HOA	HAND–OFF–AUTO
JOG	JOG OR PULSE
LOR	LOCAL–OFF–REMOTE
SLOS	START LOCK–OUT STOP
OC	OPEN–CLOSE
OCA	OPEN–CLOSE–AUTO
OO	OFF–ON
OSC	OPEN–STOP–CLOSE
POT	POTENTIOMETER
RS	RESET
SS	START PUSHBUTTON AND STOP PUSHBUTTON (SHOWN AS ONE DEVICE FOR CLARITY)
STP	STOP
STR	START

FY # XX — INSTRUMENT RELAY MOUNTED IN REAR OF PANEL (BROKEN LINE). ACTIVATES AND DEACTIVATES CONTROL AND/OR ALARM SWITCHES AT PRESET SIGNAL VALUES. SEE BELOW FOR FUNCTIONS (X).

>	HIGH SELECTOR
<	LOW SELECTOR
I/I	CURRENT/CURRENT CONVERTER
R/I	RESISTANCE/CURRENT CONVERTER
△	DIFFERENCE
AV	AVERAGE
%	RATIO

AE # XX — ANALYZING ELEMENT XX DENOTES MEASURED SUBSTANCE/CONCENTRATION

CG	COMBUSTIBLE GAS
DO	DISSOLVED OXYGEN
FCl2	FREE CHLORINE RESIDUAL
H2S	HYDROGEN SULFIDE
ORP	OXIDATION REDUCTION POTENTIAL
PC	PARTICLE COUNTER
pH	HYDROGEN ION CONCENTRATION (LOG10)
TCl2	TOTAL CHLORINE RESIDUAL
NTU	TURBIDITY (NEPHELOMETRIC TURBIDITY UNITS)

DISPLAY AT OPERATOR INTERFACE COMPUTER STATION AND/OR AT THE OPERATOR INTERFACE TERMINAL

PRIMARY ELEMENT SYMBOLS

FIT # / M — MAGNETIC FLOWMETER, FLOWTUBE TYPE

FIT – — FLOW ELEMENT (ROTAMETER TYPE)

LT # — SUBMERSIBLE PRESSURE LEVEL ELEMENT

LS ## — FLOAT SWITCH

LE ## — ULTRASONIC ELEMENT

PI – / PSH – — PRESSURE GAUGE AND SWITCH WITH ANNULAR PRESSURE ISOLATOR

PROCESS SYMBOLS

M — BLOWER

M — CENTRIFUGAL OR SPLIT CASE HORIZONTAL PUMP

SP M ST — METERING PUMP W/ MANUAL STROKE POSITIONER (SP) SPEED TACHOMETER (ST)

M — SUBMERSIBLE PUMP

M — ELECTRIC MOTOR ACTUATOR SEE ELECTRICAL DWGS FOR DIAGRAMS

S — SOLENOID ACTUATOR

CALIBRATION COLUMN

GATE VALVE

GLOBE VALVE

PLUG VALVE

DIAPHRAGM VALVE

BUTTERFLY VALVE

BALL VALVE

BALL VALVE

PINCH VALVE

NEEDLE VALVE

CHECK VALVE

3–WAY VALVE

BACKFLOW PREVENTER

AIR RELIEF VALVE

PRESSURE REDUCING VALVE (SELF CONTAINED)

BACK PRESSURE REGULATOR VALVE (SELF CONTAINED)

BLIND FLANGE

MALCOLM PIRNIE

CITY OF TUCSON
ENVIRONMENTAL SERVICES
SILVERBELL RAP IMPLEMENTATION

ELECTRICAL AND INSTRUMENTATION LEGEND

NOT TO SCALE

MALCOLM PIRNIE, INC.
NOVEMBER 2009
FIGURE 23

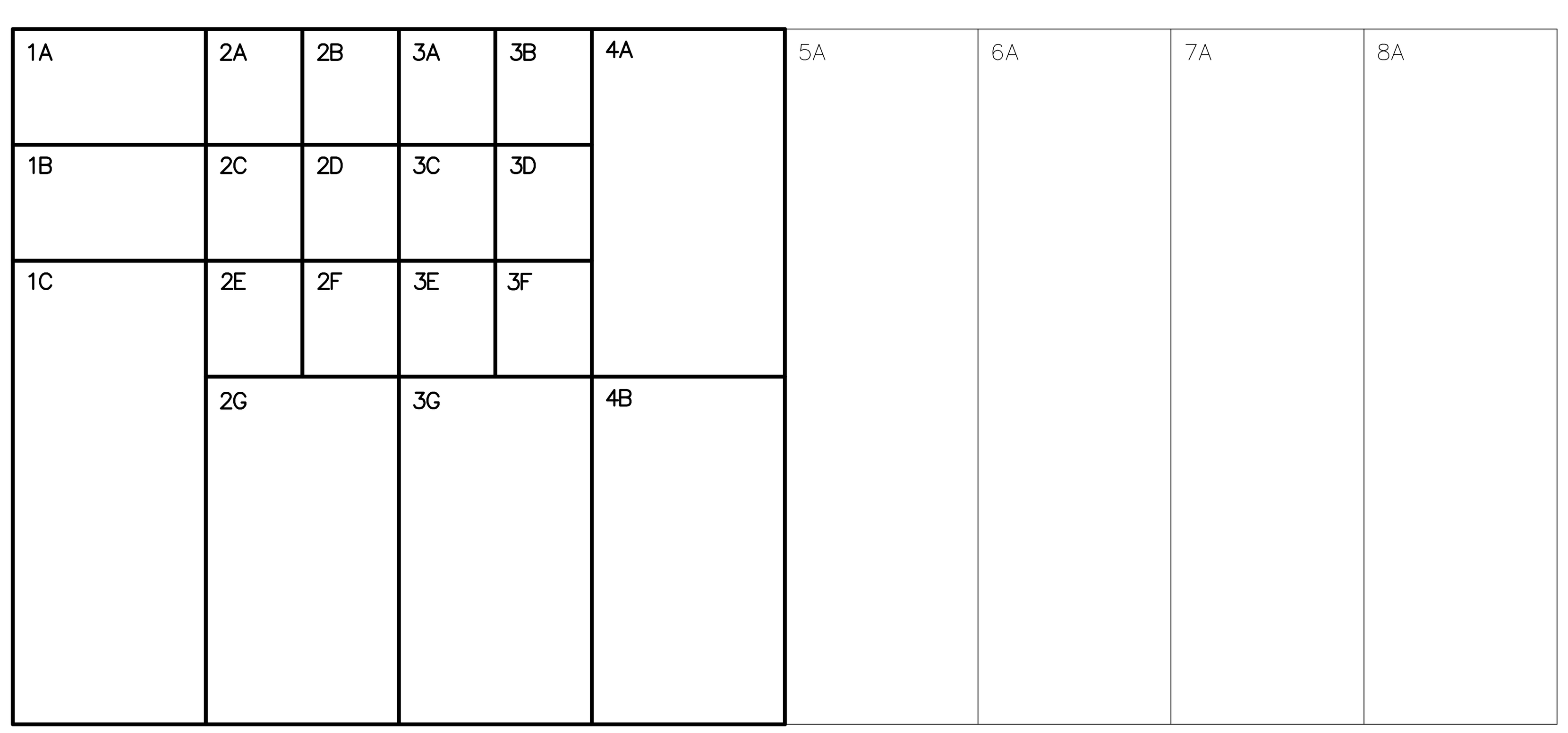
PRELIMINARY–NOT FOR CONSTRUCTION

NOTES:

1. ALARMS FOR AUTO DIALER TO BE DETERMINED BY OWNER.

MALCOLM PIRNIE	CITY OF TUCSON ENVIRONMENTAL SERVICES SILVERBELL RAP IMPLEMENTATION	SILVERBELL WQARF P&ID NOT TO SCALE	MALCOLM PIRNIE, INC. NOVEMBER 2009 FIGURE 24

PRELIMINARY—NOT FOR CONSTRUCTION



MCC–SB ELEVATION

1A CUSTOM METERING
1B TVSS
1C MAIN LUGS ONLY
2A EXTRACTION WELL PUMP VFD 1
2B EXTRACTION WELL PUMP VFD 2
2C EXTRACTION WELL PUMP VFD 3
2D EXTRACTION WELL PUMP VFD 4
2E DUCT HEATER 1
2F AIR CONDITIONER
2G AIR STRIPPER BLOWER 1
3A FCV–1
3B FCV–2
3C FCV–3
3D FCV–4
3E INJECTION WELL PUMP 1
3F INJECTION WELL PUMP 2
3G AIR STRIPPER BLOWER 2
4A XFMR T–SB
4B LP–SB
5A FUTURE
6A FUTURE
7A FUTURE
8A FUTURE

NOTES:

1. LIGHTER LINES INDICATE FUTURE ELEMENTS. HEAVIER LINES INDICATE WORK TO BE DONE UNDER THIS CONTRACT.

MCC-SB			
480V LOAD SUMMARY			
LOAD DESCRIPTION	KVA	HP	AMP
PHASE 1			
EXTRACTION WELL 1 (VFD)		20	27
EXTRACTION WELL 2 (VFD)		20	27
EXTRACTION WELL 3 (VFD)		20	27
EXTRACTION WELL 4 (VFD)		20	27
AIR STRIPPER BLOWER 1		50	65
AIR STRIPPER BLOWER 2		50	65
DUCT HEATER 1	60		72
CHEMICAL METERING PUMPS		2	3
INJECTION WELL PUMP 1 (VFD)		50	65
INJECTION WELL PUMP 2 (VFD)		50	65
FLOW CONTROL VALVES (1-4)		2	3
MISCELLANEOUS	30		36
AIR CONDITIONER FOR BUILDING	25		30
PHASE 1 TOTAL LOAD	**425**		**512**
PHASE 2			
EXTRACTION WELL 5 (VFD)		20	27
EXTRACTION WELL 6 (VFD)		20	27
EXTRACTION WELL 7 (VFD)		20	27
EXTRACTION WELL 8 (VFD)		20	27
AIR STRIPPER BLOWER 3		50	65
AIR STRIPPER BLOWER 4		50	65
DUCT HEATER 2	60		72
CHEMICAL METERING PUMPS		2	3
INJECTION WELL PUMP 3 (VFD)		50	65
INJECTION WELL PUMP 4 (VFD)		50	65
FLOW CONTROL VALVES (5-8)		2	3
PHASE 2 TOTAL LOAD	**371**		**446**
GRAND TOTAL LOAD	**796**		**959**

MALCOLM PIRNIE

CITY OF TUCSON
ENVIRONMENTAL SERVICES
SILVERBELL RAP IMPLEMENTATION

ELECTRICAL ONE LINE DIAGRAM

MALCOLM PIRNIE, INC.

NOVEMBER 2009

FIGURE 25

PRELIMINARY–NOT FOR CONSTRUCTION