Reducing 2-Methylisoborneol (MIB) and Geosmin in the Metropolitan-Phoenix Area Water Supply

A Cooperative Research and Implementation Program among

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Central Arizona Water Services Department Conservation District (CAWCD)
City of Tempe
City of Peoria

For calendar year 2003

EXECUTIVE SUMMARY

The goal of this project is to continue advancing the state-of-knowledge and implementation activities regarding algae-related water quality issues in the metro-Phoenix water supply systems. ASU wants to build upon the results and momentum of the previous T&O project, which have been ongoing since 1998. The specific tasks proposed and corresponding objectives are as follows:

- **Task 1 – Monitoring Program**
  - To provide early-warning and near real-time information on T&O levels for local municipalities
  - To continue building a long-term database on algae-related parameters for the metro-Phoenix water supply system
  - To document water quality changes in Saguaro Lake related to forest fires in the Salt River watershed
- **Task 2 – Implementation Activities**
  - To recommend preventative and/or responsive actions for controlling T&O production (modifying water supplies, canal treatments and in-plant treatments)
  - To provide information updates (T&O Newsletter) during traditional periods of T&O problems
- **Task 3 – Applied Research Products**
  - To develop correlations between FPA and GC/MS analysis for T&O compounds
  - To calibrate a commercially available model for determining Powdered Activated Carbon (PAC) doses to be fed at the WTPs
  - To field-test emerging techniques for T&O monitoring and control
  - To better understand mechanisms responsible for T&O production
  - To facilitate collaboration between municipalities in obtaining external research funds to better understand and respond to T&O problems

Task 1 – Monitoring Program

A refined monitoring sampling schedule and analytical load was developed based upon recommendations from our previous 3-year study and available funding. Sampling frequency was monthly from January through June at all sites, twice per month for June through December in the reservoirs, and weekly June through December for the canal and WTP sites. Field measurements were taken in canals and reservoirs (temperature, pH). Taste and odor compounds (MIB, geosmin, cyclocitral), microcystin algae toxin, organic carbon, nitrogen, phosphorous, and conductance were the primary analytical measurements; most notable from prior studies was elimination of algae counting and identification. The goal of the monitoring was to provide data for water management, canal treatments, and in-plant treatment modifications.

T&O levels in the reservoirs was average in Saguaro Lake, and almost non-existent in Lake Pleasant or Bartlett Lake. The observed seasonal trends since 1998 indicate Saguaro Lake consistently has T&O, while Lake Pleasant and Bartlett lake are almost on cycles of every other year for high T&O levels – this could indicate that 2004 would have high T&O levels in these reservoirs. *We recommend monitoring the thermal stratification of reservoirs to predict when elevated T&O compounds may be released, and timing the use of water supplies based upon*

thermal destratification.

The most significant deviation from prior years is that MIB levels in the hypolimnion (deeper water) in Saguaro Lake contained higher MIB levels than the epilimnion (top 10 m of water). Usually algae grow in the epilimnion and this is where MIB is observed at highest levels. One explanation for the high MIB levels in the hypolimnion is export of MIB from upstream reservoirs (Canyon Lake). During a synoptic sampling event to all the Salt River reservoirs – Canyon lake water had very high MIB levels. Waters released from Canyon Lake are cold and would "sink" in Saguaro Lake. *We recommend that SRP undertake hydraulic modeling of the Saguaro (and other) lakes to understand the thermal mixing environments.*

T&O production in the Arizona canal occurred in both upper (Highway 87 to Hayden Road) and lower (24th Street to 29th Avenue) sections. Both attached periphytic algae and actinomycetes were confirmed to be present and potential contributors to T&O production in the canals. During approximately 3 months of 2003 when MIB levels increased by as much as 30 to 40 ng/L (from 20 ng/L up to 70 ng/L) along the length of the Arizona Canal. In some cases Deer Valley WTP was off-line so no canal treatment was implemented. In other cases, proper canal treatment could have significantly reduced the need for PAC addition at 24th Street WTP and Deer Valley WTPs. Tables E.1 and E.2 breakdown MIB occurrence in raw and finished waters from the six WTPs studied.

Table E.1– Percentage samples in different MIB concentration ranges (Phoenix WTPs)

MIB Range (ng/L)	24th Street		Deer Valley		Val Vista		Union Hills	
	Raw	Fin.	Raw	Fin.	Raw	Fin.	Raw	Fin.
<50	89%	100%	81%	100%	100%	100%	100%	100%
<30	63%	96%	44%	92%	93%	100%	100%	100%
<20	48%	76%	33%	67%	70%	91%	100%	100%
<15	33%	52%	33%	50%	44%	83%	100%	100%
<10	22%	32%	26%	29%	33%	61%	100%	100%
<5	11%	20%	7%	8%	7%	13%	93%	96%
<2	7%	12%	0%	4%	0%	9%	86%	54%
# 2003 Samples	27	25	27	24	27	23	28	28

Table E.2 –Percentage samples in different MIB concentration ranges (Tempe&Peoria WTPs)

MIB Range (ng/L)	N. Tempe		S. Tempe		Greenway	
	Raw	Fin.	Raw	Fin.	Raw	Fin.
<50	83%	100%	100%	100%	92%	100%
<30	58%	92%	100%	100%	80%	100%
<20	42%	79%	100%	100%	52%	100%
<15	25%	67%	100%	100%	48%	100%
<10	25%	33%	88%	88%	36%	96%
<5	4%	8%	40%	40%	20%	96%
<2	4%	4%	8%	8%	12%	84%
# 2003 Samples	24	24	25	25	25	25

Forest fires in the Salt River watershed in 2002 resulted in significant loading of organic matter (nitrogen, phosphorous, carbon) into Roosevelt Lake in August and September 2002 during the first major runoff event after the fires (Figure E.1). Most of this loading was particulate in nature, and as Roosevelt Lake fills in the future these sediments will potentially leach these materials into the water column. Spring runoff in 2003 was essentially non-existent due to low snowpack, so additional loadings were minimal. The forest fires will have long lasting effects on the Salt River watershed, but may be more pronounced during runoff from rainfall events than from snowmelt events, as most of the "snowshed" was not in the burned areas.

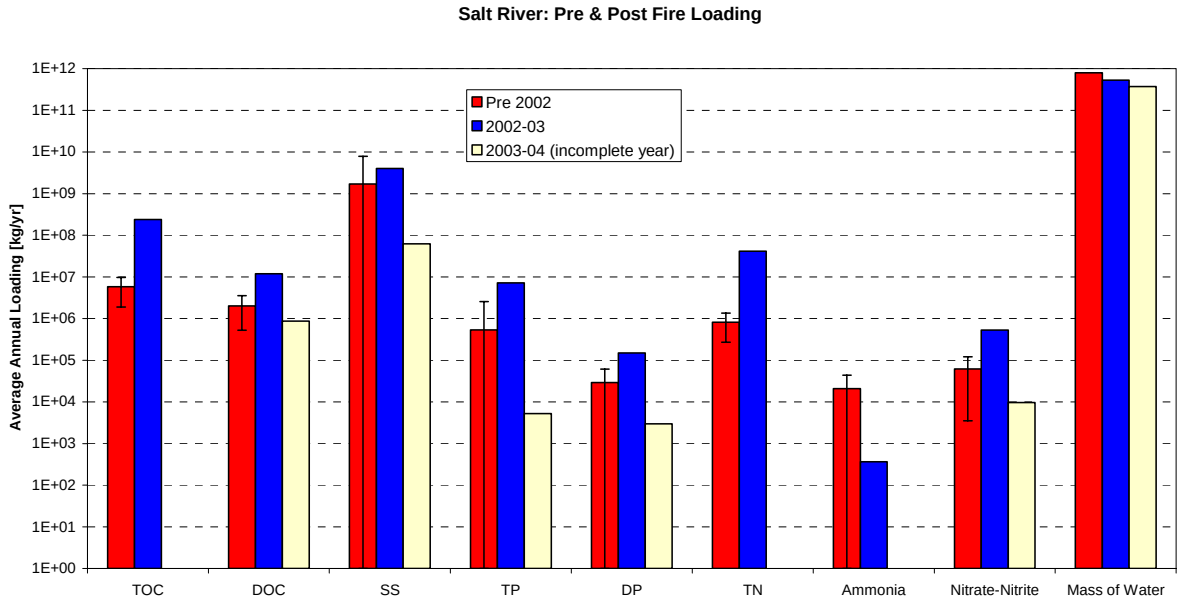

Figure E.1 Loading analysis for the Salt River above Roosevelt Reservoir. Annual loading analysis taken as July 1 through June 30th to correspond with timing of forest fire.

A simple hydraulic model for the Salt River reservoirs was developed to aid in understanding potential effects from pulse runoff-loading events in the Salt River after the forest fires. Because of pumpback energy-related operations of two reservoirs, we believe the reservoir systems act similar to CSTRs in series, and were modeled accordingly.

Task 2 – Implementation Activities

ASU produced T&O Newsletters to disseminate MIB data, summarize plant performance, provide occasional special issues on regional water quality, and provide recommendations for in-plant changes, canal treatments, or blending scenarios. An example T&O Newsletter is provided as an appendix. Implementation activities also included:

- ASU meet with CAWCD and SRP to modify water supply (surface and ground water) to reduce T&O levels in water entering the canal systems. For example, the feasibility of changing the timing of CAWCD water by-pass pumping around Lake Pleasant could offset release of MIB and Geosmin from Lake Pleasant.
- ASU recommended implementing canal management (mechanical brushing and/or

copper addition) or water supply management activities (e.g., shifting WTP production).

- ASU provided **T&O Forecasts** for two and four weeks into the future, providing guidance for purchasing of canal treatment equipment by SRP and PAC supplies by WTPs.

ASU coordinated **two workshops** (March and September 2003) to continue dissemination of T&O information, gather input and lead an integrated approach for improving regional water quality related to algae T&O and biotoxin issues.

ASU recommended and evaluated the effectiveness of Mechanical brushing and chemical treatments. Figure 2.10 illustrates the gain in MIB across different reaches of the Arizona canal. Arrows on these graphs indicate timing of specific canal treatments. Overall, the following conclusions can be made:

- Brushing was effective when thick/dense biomass present
- Copper was effective when less dense/thinner biomass present
- Both very effective in minimizing in-canal MIB production
- Reduced MIB production lasted for 2-4 weeks
- Treatments effectively controlled MIB, geosmin and cyclocitral
- Constant pro-active treatments throughout summer season can avoid MIB spikes due to in-canal MIB production

Task 3 – Applied Research Products

Flavor Profile Analysis Correlations. FPA intensity was successfully predicted with the MIB and Geosmin Weber-Fechner plots and a three component (MIB, Geosmin, Cyclocitral) multivariate non-linear relationship. However, plots and regressions may lack of significance as variability was high and a lot of outliers were eliminated during the analysis. High variability may be attributed to the fact that approximately one third of the samples originated from UH WTP, which is located in the CAP Canal, a canal that does not present T&O problems during summer and has low T&O levels through the year. A better reproducibility of FPA results may be obtained if more samples with higher T&O are used during FPA.

Powder Activated Carbon Kinetic Model. An Excel-based model was developed based upon extensive laboratory studies of MIB removal in different source waters with different PAC brands. The model predicts a recommended PAC dose to achieve a fixed effluent MIB concentration based upon the following input parameters: type of PAC, dissolved organic carbon (DOC) content of raw water for WTP (estimated from blending ratios if not directly available), influent MIB concentration, WTP flowrate and contact basin sizes (i.e., PAC contact time), and target effluent MIB concentration. A copy of the model is available to participating agencies.

Biocide/Algaecide Coatings. Previous ASU research indicated that biocide (algaecide) coatings applied to the canal may be effective at reducing algae growth and T&O production. A titanium-oxide paint is currently being reformulated for better attachment to concrete. The biocide paint was tested in an existing device built by ASU and SRP, and at larger field scale levels. The main findings of this research are:

- EP2000 had better periphytic algae inhibitor than Sun Wave.
- EP2000 and Sun Wave reduced periphytic algae growth by 99 % and 35 % for up to 3 months when compared to control substrates.
- The antifouling Coatings EP 2000 and Sun Wave leached H_2O_2 and zinc as result of the photocatalytic action of sunlight.
- Algal growth was inhibited in cement samples with algaecide additives as their zinc oxide concentration increased.

Culprit Algae – Role of Conductance on MIB Release. ASU's research suggests that the production of T&O compounds by culprit algae may be influenced by the dissolved salts or ion content of the water. Coincidentally with increasing specific conductance (a measure of total ion in solution), both reservoir and canal MIB and geosmin concentrations frequently also increase, suggesting that the culprit organisms may be responding either by exhibiting accelerated growth or through a metabolic shift that results in greater production and release of these compounds.

Culprit Algae Early Warning Detection. ASU continued on-going attempts to genetically fingerprint the culprit T&O producers in the water system so that they can be more readily pinpointed for removal or mitigation efforts. A molecular fingerprinting technique was applied to probe for the presence of cyanobacteria that have the genetic potential to produce MIB and geosmin. This method involved denaturing gradient gel electrophoresis (DGGE) analysis of PCR-amplified 16S rDNA fragments. When analyzed by this method, the phylogenetic composition of periphyton cyanobacterial communities in the Arizona Canal differed substantially, with generally higher richness and diversity of cyanobacterial species at upstream sites compared to downstream sites in the Canal. Direct relationships were observed between specific DNA fingerprints, and episodes and intensity of MIB/geosmin production in specific sections of the Arizona Canal. This suggests that the method, along with GC/MS analysis, could serve as a reliable method for detection and possibly forecasting taste/odor episodes so that mitigation measures may be applied in advance of significant production. ASU plans to continue research along this line with the ultimate goal of implementing this molecular gene probe technology to improve T&O prevention or mitigation practices. This work is funded by Salt River Project, and a final report can be made available separately upon request.

Ozone-Enhanced Biofiltration for MIB and Geosmin Removal. ASU has been successful in obtaining funds for algae-related research, and that effort would be expected to continue. ASU finished its project: AWWARF – Solicited RFP#2775: PIs: P. Westerhoff, Z. Chowdhury, S. Summers. "Ozone-enhanced Biofiltration for MIB and Geosmin Removal" February 2002-2004 ($350,000). A draft final report has been submitted. This work included pilot plant analysis at Chandler and Phoenix. A draft executive summary is attached as an appendix.

Other Research Collaborations. ASU continues to collaborate through conducting pipeloop experiments on AWWARF – Tailored Collaboration Project: Cities of Phoenix, Scottsdale, and Tempe plus Arizona State University. "Developing a Customer-Driven Response Strategy for Dealing with Public Perception (taste and odors at the tap) and Potential Health Concerns (algal biotoxins)" April 2002-2004 (PIs: R. Gottler, P. Westerhoff) (>$150,000). Milt Sommerfeld has continued T&O monitoring, recommendations and research with the City of Chandler.

Recommendations

Continuous and ongoing process control monitoring can avoid undesirable T&O events which would cause consumers to be dissatisfied with the taste and odor quality of their water. This dissatisfaction may lead consumers to perceive their drinking water as being unsafe. Therefore it is imperative that local agencies continue T&O monitoring to prevent serious T&O episodes. As a continuing goal of reducing T&O levels to below the threshold levels, it is important that water providers (CAP & SRP) work together with cities and WTP operators to provide raw water at the WTPs with the lowest T&O levels possible. This can occur through blending of source waters, managing groundwater pumping, and treating periphytic algae growth in the canals. WTPs must consider optimization of PAC selection and dosing, and plan to upgrade treatment processes (e.g., GAC adsorption systems).

The intensive monitoring (weekly in canals and WTPs from June through December) in 2003 was probably not necessary. With exception of two WTPs (24th Street (aka Squaw Peak) and Deer Valley WTPs), T&O levels changed rather slowly and sampling every other week would probably be sufficient. Likewise sampling the reservoirs twice per month could be reduced to just monthly. These recommendations have already been implemented as part of the 2004 monitoring program.

In many cases T&O production occurs in the Salt and Verde River reservoirs. We recommend that SRP undertake hydraulic modeling of the Saguaro (and other) lakes to understand the thermal mixing environments. This is critical to the evolution of T&O over time in these reservoirs. Because periphytic algae in the canals also contribute to T&O production we recommend testing algaecide coatings on a scale of 100 meter test sections, after the coating manufacturer receives NSF approval. In addition, the Arizona canal was not dried-up in 2003 by SRP and no sediment removal undertaken. We strongly recommend removing sediment above the siphon on the Arizona canal (near Hayden Road) and between 24th Street and 29th Avenue as a means of improving water quality.

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CHAPTER 1 - BACKGROUND

In June 2002, Arizona State University (ASU) completed a 3-year project for the City of Phoenix (COP) that researched the role of algae on operational and water quality issues (taste and odor, dissolved organic carbon (DOC), disinfection by-products (DBPs), and in-plant algae growth). During the last year of the project, the focus was on the implementation of activities in the watershed and in the water treatment plants (WTPs) to minimize taste and odor (T&O) levels reaching consumers. By all measures the project has been successful. Some of the major outcomes were:

- Improved understanding and predictive capabilities for T&O compounds in the watershed, canal system, and WTPs
- Laboratory- and field-proven effectiveness of implementation measures that remove algae and reduce T&O levels. *Proactive controls* were developed to minimize the growth of T&O-producing algae. *Responsive controls* were developed to treat T&O compounds if proactive measures were not effective.
- Reduced T&O levels entering and leaving WTPs, as quantified by consumer days below various T&O thresholds (e.g., MIB concentration below 10 ng/L)
- Development of an implementation guide for COP
- Verification that MIB & Geosmin were the dominant T&O compounds
- Improved understanding of DOC and DBP sources in reservoirs
- Peer-reviewed publication of results, and award of two related AWWARF Projects
- Recognition of Phoenix by metro-Phoenix cities, Arizona Department of Environmental Quality (ADEQ), Salt River Project (SRP), and Central Arizona Water Services Department Conservation District (CAWCD) as a leader in T&O control
- Effective rapid response communication network between ASU and COP (and others) regarding T&O problems and solutions

Motivation for Continued Monitoring and Implementation

ASU, COP, SRP and CAWCD have developed an integrated communication network capable of detecting emerging T&O problems and providing proactive and responsive controls that reduce T&O levels for consumers. After three years of research and implementation, a network of monitoring sites has been identified that will yield high quality data on T&O occurrence and provide opportunities to control algae production of T&O compounds at the sources. Based on discussions with COP staff and representatives from other entities, during the previous project, ASU proposed continued monitoring and implementation guidance for 2003. ASU also continued applied research to aid COP in optimizing T&O control strategies.

Goals and Objectives

The goal of this project is to continue advancing the state-of-knowledge and implementation activities regarding algae-related water quality issues in the metro-Phoenix water supply systems. ASU wants to build upon the results and momentum of the previous T&O project. The specific tasks proposed and corresponding objectives are as follows:

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CHAPTER 2 - RESULTS

Task 1 - Monitoring Program

Sampling locations and justification for the sites is described in Table 2.1. Parameters analyzed at each site varied based upon frequency and analytical significance. Table 2.2 summarizes the general analytical approach. The appendix to this report provides data on all analyses, and is available in an electronic format (ACCESS). The T&O Newsletters were used as a tool to disseminate much of the collected data in an immediate fashion. The schedule for the T&O Newsletter was monthly (January through June) and then approximately weekly (July through December). This section will graphically summarizes key trends in selected parameters.

Microcystin, an algal toxin, was monitored throughout 2003 using ELISA. In all cases concentrations of dissolved microcystin was < 1 ug/L. Cellular-associated microcystin toxin was present in reservoir and some canal waters but not in finished water samples. Chlorine effectively destroys microcystin toxins.

MIB and Geosmin

Lakes

Figure 2.1 shows the long-term trends in MIB for the three reservoirs serving metro-Phoenix with raw drinking water. Saguaro Lake exhibits MIB production every year, while Bartlett and Pleasant appear to experience higher MIB events only two out of the four years of record. MIB levels are higher in the upper layers of the reservoir (epilimnion). Upon thermal destratification (September for most reservoirs in 2003), MIB concentrations were uniform with depth. Water withdrawn from the reservoirs during and immediately after thermal destratification will cause a change, over the course of 1-2 weeks, in MIB and other water quality being released downstream. MIB concentrations quickly decrease in the months after destratification due partially to dilution, but mainly through biodegradation of the MIB by bacteria naturally occurring in the reservoirs. Geosmin concentrations generally paralleled MIB concentrations, but geosmin concentrations were lower than MIB concentrations in the reservoirs. *We recommend monitoring the thermal stratification of reservoirs to predict when elevated T&O compounds may be released, and timing the use of water supplies based upon thermal destratification.*

The most significant deviation from prior years is that MIB levels in the hypolimnion (deeper water) in Saguaro Lake contained higher MIB levels than the epilimnion (top 10 m of water). Usually algae grow in the epilimnion and this is where MIB is observed at highest levels. One explanation for the high MIB levels in the hypolimnion is export of MIB from upstream reservoirs (Canyon Lake). During a synoptic sampling event to all the Salt River reservoirs – Canyon lake water had very high MIB levels. Waters released from Canyon Lake are cold and would "sink" in Saguaro Lake. *We recommend that SRP undertake hydraulic modeling of the Saguaro (and other) lakes to understand the thermal mixing environments.*

Several **biological models** were evaluated. The Redfield ratio of nitrogen to phosphorous is a general indicator for algae productivity of lakes, but lack of significant seasonal variations in N/P

ratios could not explain seasonal algae patterns in the local reservoirs. More advanced USEPA models require many rate constants, field data, and hydraulic modeling of reservoirs – as this data was not available the food-chain related models could not be utilized. Numerous correlative models were considered, but lacked the ability to predict temporal MIB patterns. Therefore neural network modeling was considered the best approach to predicting MIB patterns in the reservoirs. A MS thesis was conducted on neural network modeling for prediction of MIB events. The following abstract summarizes this thesis work conducted by Mari Rodriguez (Factors Influencing the Occurrence of MIB in Three Water Supply Reservoirs), which is available upon request:

> The objective of this research was to investigate the factors that influence the occurrence of Methylisoborneol (MIB) in three water supply reservoirs that serve the Phoenix Metropolitan area. Modeling analyses were conducted based upon physical, biological, and chemical data collected over a three-year period from the reservoirs. The results provide a better understanding of the factors that affect the net production and degradation of MIB.
>
> MIB is an algae metabolite that occurs in surface water supplies and is responsible for taste and odor (T&O) complaints. Monitoring the reservoirs revealed that MIB concentrations peaked during late summer in the epilimnion during maximum water temperatures and prior to thermal destratification. Mass balance analyses on MIB concluded that destratification mixing and hydraulic flushing / dilution alone did not account for observed rapid declines in MIB concentrations during the fall season. Net rates of MIB loss (biodegradation, volatilization, photolysis) in the field ($R_{F,max}$) ranged from 0.4 to 1.0 ng/L/d. Using lake water in laboratory experiments, bacterial biodegradation of MIB occurred at a calculated rate (R_L) on the order of 0.8 to 1.2 ng/L/d.
>
> Artificial neural network models were developed to quantify the interactions between several parameters and MIB occurrence in the epilimnion of two Metro-Phoenix reservoirs. Results showed that the timing and magnitude of the MIB occurrence could be successfully predicted in Lake Bartlett using only total and dissolved nitrogen, total and dissolved phosphorus, dissolved oxygen, total and dissolved organic carbon, and specific UV absorbance. Training results for Saguaro Lake showed that conductance, epilimnion temperature, reservoir depth, and Secchi disk depth could sufficiently predict the MIB concentrations. Validation testing of these networks found that the network for Lake Bartlett was likely overtrained while the network for Saguaro Lake could sufficiently predict MIB concentrations in the reservoir. Sensitivity analyses were conducted on individual parameters for both reservoirs. Results for Lake Bartlett showed that nutrients, light intensity, and algal biomass have the strongest impact on MIB occurrence, while epilimnion temperature had the strongest affect on MIB concentrations in Saguaro Lake.

Table 2.1 – Location and Justification of monitoring sites
Sampling will be conducted by CAWCD, SRP, and ASU

Monitoring Site	Justification	Sampling Team
Terminal Lakes Havasu Pleasant (R2A, R2B) Bartlett (R6A, R6B) Saguaro (R9A, R9B)	Algae growth in the lakes is a primary source of T&O entering WTPs; monitoring reservoirs and predicting the duration of T&O occurrence will allow COP to order PAC supplies, etc.	CAWCD SRP
Rivers Verde River at Beeline Hwy (R25) Salt River at Bluepoint Bridge (R10)	These sites are downstream of terminal lakes and represent influent water to the SRP canal system; storm runoff affects T&O in rivers	 ASU ASU
CAWCD Canal Wadell Canal (R3) Above SRP cross-connect (R11)	CAWCD canal provides water to Union Hills WTP and to the head of the SRP canals; historically T&O levels are lower in CAWCD water than SRP water and offer opportunities to blend sources to control T&O	 ASU ASU ASU
Arizona Canal Above & Below CAWCD cross-connect (R12& R13) At Beeline Highway (Hwy87) Pima Road (Pima) 56th Street (R22) Central Street (R21)	For the past three years three different "hot spots" for T&O production have been identified. Frequent monitoring has localized "hot spots" and allowed for copper treatment or canal brushing by SRP to reduce in-canal T&O production	All by ASU
South Canal Below CAWCD cross-connect (SOCA) South Canal at head of Consolidated and Tempe Canal (HTC)	Different blends of SRP and CAWCD surface water enter the Arizona and South canals, and downstream of Val Vista WTP groundwater is pumped into the canal	ASU
WTPs (Influent and Effluent samples) <u>City of Phoenix</u> Union Hills WTP (UH In/UH Out) 24th Street WTP (R15/R16) Deer Valley WTP (R16/R17) Val Vista WTP (R18/R19) <u>City of Tempe</u> Martinez WTP (NP In/NP Out) South WTP (SPT In/ SPT out) <u>City of Peoria</u> Greenway WTP (Green In/Green Out)	Influent T&O concentrations allow optimization of treatment conditions (e.g., PAC type and doses); finished water is quality perceived by customers	All by ASU

Table 2.2 – Sampling frequency and water quality parameters to be measured

Monitoring Site	Sampling Frequency	Water Quality Parameters
Terminal Lakes	1x per month[a] 1x-2x per month[b]	Field: Depth profiles of temp, pH, DO; secchi disk depth Lab (Epi- and hypo-limnion samples): MIB, Geosmin, DP, DN/NO3/NH3, chl-a, cyanophytes, conductance, DOC (Grab sample at Havasu Lake, only), Microcystins
Rivers	Monthly[a] Weekly[b]	Field: temperature Lab: MIB, Geosmin, Dissolved Phosphorous, DN/NO3/NH3, chl-a, cyanophytes, conductance, DOC, Microcystins (reduced number of sites[c])
CAWCD Canal		
Arizona Canal		
South Canal		
Water Treatment Plants		

[a]Winter-Spring 2003
[b]Summer-Fall 2003
[c]Microcystins measured in the influent and effluent of two WTPs, those located at the lower reaches of the Arizona Canal (e.g. Deer Valley WTP) and the South Canal system (e.g. Tempe South WTP)

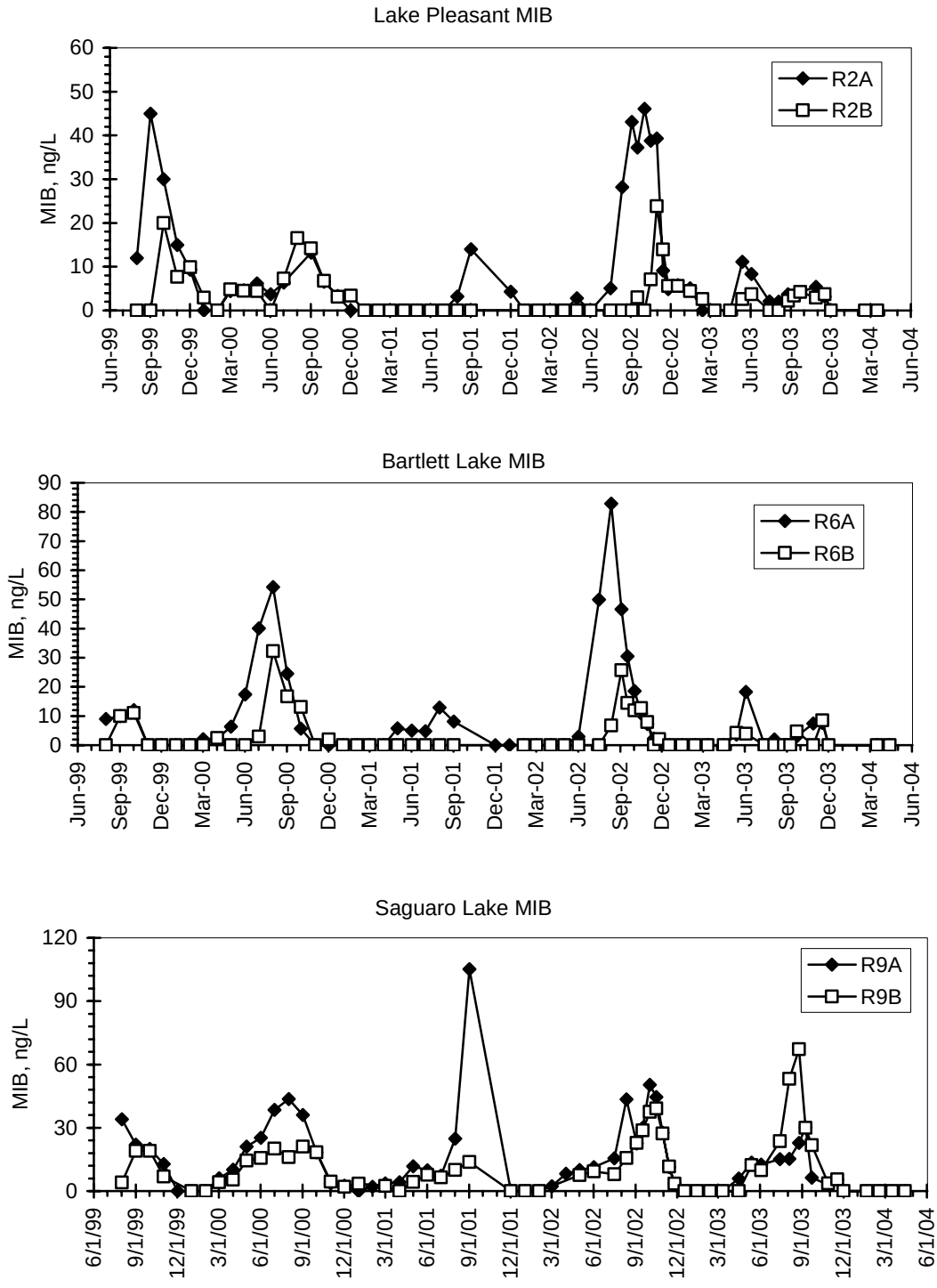


Figure 2.1 Trends in MIB concentration in epilimnion (R2A, R6A, R9A) and hypolimnion (R2B, R6B, R9B) of terminal reservoirs for the metro Phoenix region

Canals

MIB production in the canal system occurred noticeably only in the Arizona Canal during the warmer months of 2003 (Figures 2.2 and 2.3). Two regions of MIB and geosmin production were observed. These included the reach from Highway 87 to the siphon near Hayden Road and between 24th Street and 29th Avenue. Over the same time period SRP funded a genetic fingerprinting project to identify culprit periphytic algae that grow on the canal walls (Hu, Sommerfeld, Westerhoff). Final reports for this two-year study are available. Culprit algae are present and genetic analysis can be an early warning approach for timing of chemical or mechanical treatments.

In both sections of the Arizona canal blue-green algae were the suspected cause for MIB and geosmin production along the length of the canal. However, in late 2003 sediment samples collected from the Arizona canal between Pima and Hayden indicated the presence of actinomycetes, some of which can also produce MIB and geosmin. Above the siphon on the Arizona canal (near Hayden Road) rich organic sediment was present in the canal and would be ideal for actinomycete growth. Above Pima the canal sediment was limited to more inorganic materials (sand, gravel), but actinomycetes were still present.

The geometry of these two canal sections are much different, and hence the ability to treat the canals also differs. The lower reaches of the Arizona canal have the walls cleaned mechanically using the SRP brushing device. The upper reaches of the Arizona canal has steeper side banks and deeper water and is more amenable to chemical algaecide treatments than brushing.

The Arizona canal was not dried-up in 2003 by SRP and no sediment removal undertaken. We strongly recommend removing sediment above the siphon on the Arizona Canal (near Hayden Road) and between 24th Street and 29th Avenue as a means of improving water quality.

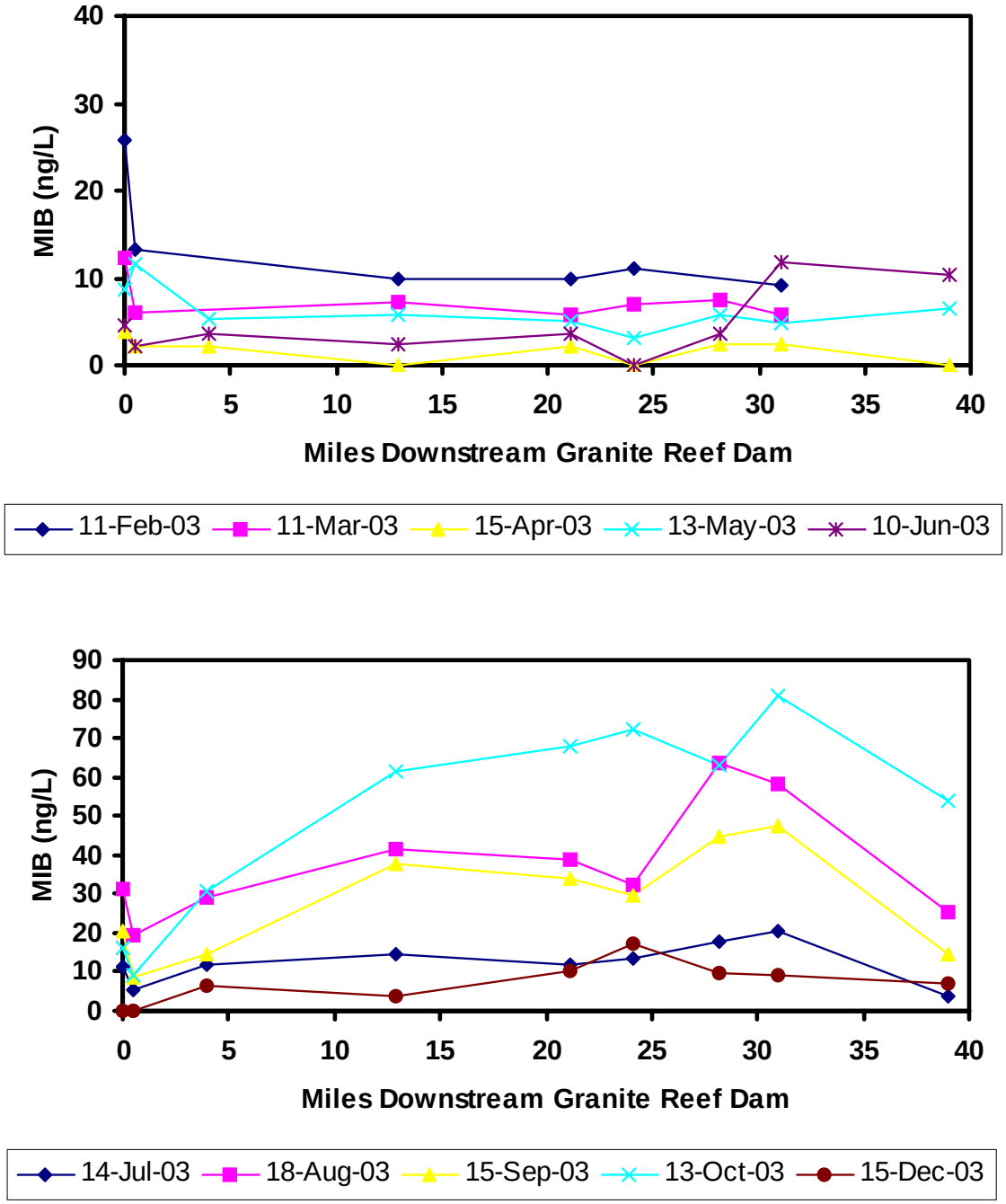


Figure 2.2 MIB concentrations along the length of the Arizona canal during cooler water months (upper) and warmer water months (lower).

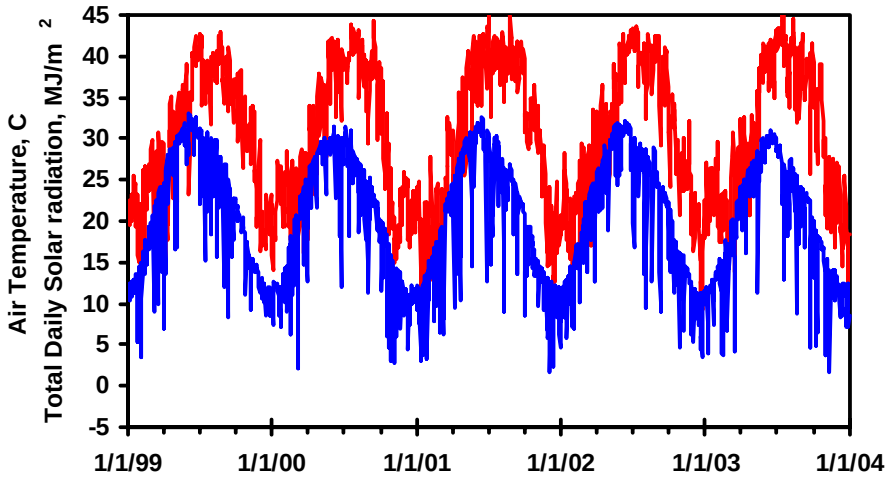


Figure 2.3 Seasonal air temperatures and solar radiation

Water Treatment Plants

Data for the influent and effluent T&O levels at the different WTPs is presented in the appendix. Figure 2.4 graphically summarizes the percentage MIB removal each WTP. A negative removal indicates production within the WTPs (e.g., South Tempe WTP and Union Hills). The percentage removal is a function of influent MIB concentration, so the percentage removals are only intended to provide a relative assessment of each plants ability to remove (or produce) MIB.

Tables 2.3 and 2.4 summarize the WTP raw and finished (Fin.) water MIB concentrations based upon different MIB concentration ranges. The number of samples is based on approximately monthly sampling January through June and weekly sampling July through December; finished water samples were not collected when facilities were off-line. Union Hills WTP and South Tempe WTP had very little MIB in raw (or finished water). Greenway WTP had significant levels of MIB in raw water, but the ozone-GAC biofiltration process removed the MIB very well. Phoenix's 24th Street, Deer Valley, and Val Vista WTPs did not have to control MIB when the raw water was < 5 ng/L (i.e., no "wasted" PAC addition required). PAC addition at these WTPs kept MIB concentrations below 30 ng/L, but PAC doses were not high enough to consistently keep finished water levels below 10 ng/L. The N. Tempe WTP performed similar to Phoenix WTPs, but tended to add a little more PAC and had more days with lower MIB concentrations.

Table 2.3– Percentage samples in different MIB concentration ranges (Phoenix WTPs)

MIB Range (ng/L)	24th Street		Deer Valley		Val Vista		Union Hills	
	Raw	Fin.	Raw	Fin.	Raw	Fin.	Raw	Fin.
<50	89%	100%	81%	100%	100%	100%	100%	100%
<30	63%	96%	44%	92%	93%	100%	100%	100%
<20	48%	76%	33%	67%	70%	91%	100%	100%
<15	33%	52%	33%	50%	44%	83%	100%	100%
<10	22%	32%	26%	29%	33%	61%	100%	100%
<5	11%	20%	7%	8%	7%	13%	93%	96%
<2	7%	12%	0%	4%	0%	9%	86%	54%
# 2003 Samples	27	25	27	24	27	23	28	28

Table 2.4 –Percentage samples in different MIB concentration ranges (Tempe&Peoria WTPs)

MIB Range (ng/L)	N. Tempe		S. Tempe		Greenway	
	Raw	Fin.	Raw	Fin.	Raw	Fin.
<50	83%	100%	100%	100%	92%	100%
<30	58%	92%	100%	100%	80%	100%
<20	42%	79%	100%	100%	52%	100%
<15	25%	67%	100%	100%	48%	100%
<10	25%	33%	88%	88%	36%	96%
<5	4%	8%	40%	40%	20%	96%
<2	4%	4%	8%	8%	12%	84%
# 2003 Samples	24	24	25	25	25	25

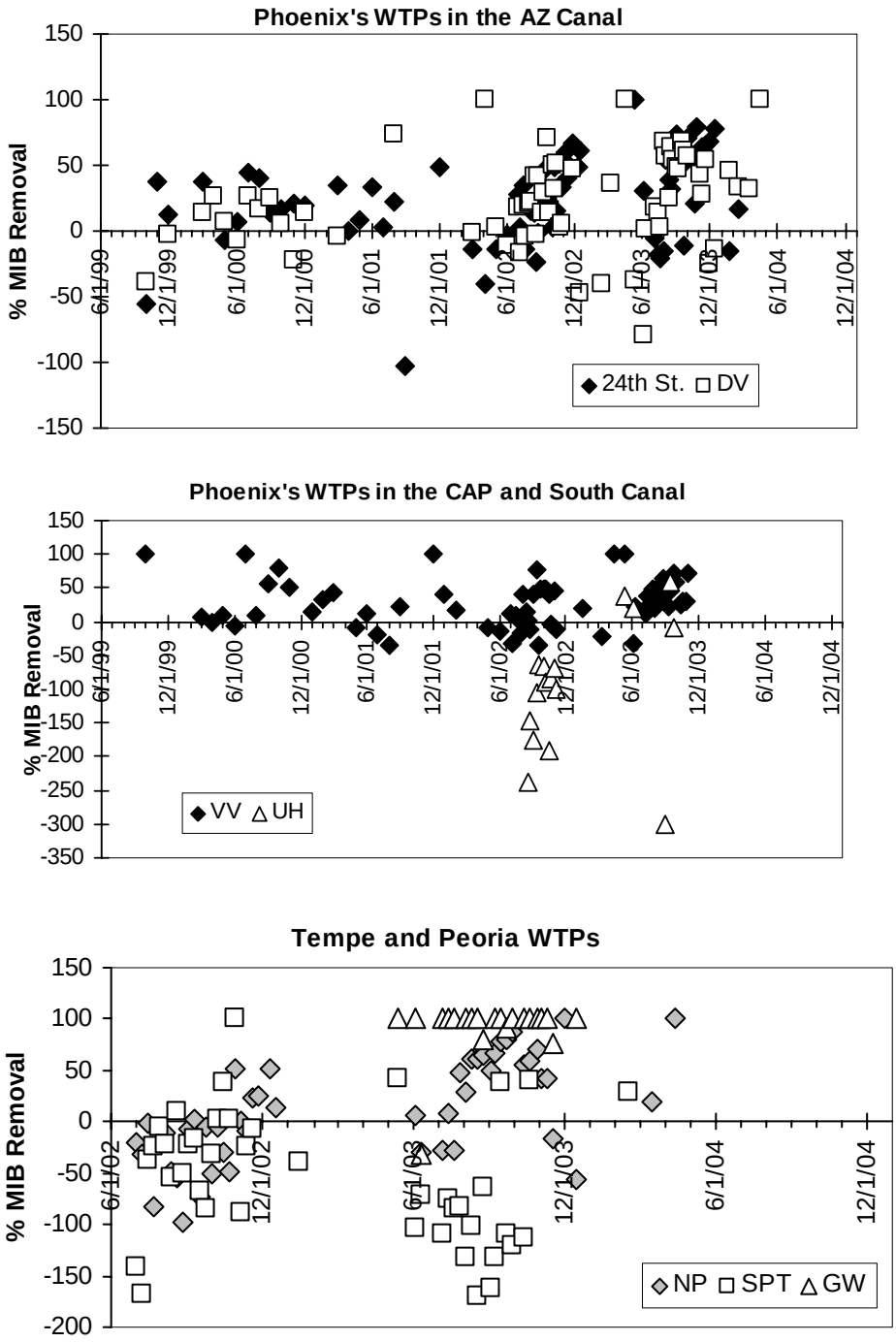


Figure 2.4 Percentage MIB removal at different WTPs

Organic Carbon

Dissolved organic carbon (DOC) patterns for the reservoirs influence raw water concentrations at the WTPs. Figure 2.4 summarizes long-term DOC patterns in the reservoirs. Since 1998 the state has been in a drought and not until the spring of 2003 did any significant runoff really enter the reservoirs due to snowmelt. This is clearly demonstrated for Bartlett Lake on the Verde River, where DOC concentrations increased following spring (March 2003) rains and snowmelt. The pulse of DOC increased DOC in the reservoir. Horseshoe Lake is upstream of Bartlett, but it remains essentially empty and provided no attenuation of the runoff or DOC. A similar result occurred for Saguaro Lake on the Salt River system. However, there are 4 upstream reservoirs on the Salt River which attenuated the DOC pulse in Saguaro Lake. Similar patterns were observed for nitrogen, and to a lesser extent for phosphorous (Figure 2.4).

Lake Pleasant DOC concentrations have been constant since 1998. Lake Pleasant has the lowest DOC (Table 2.5). A seasonal pattern of DOC is apparent in Lake Pleasant as water from the Colorado River is pumped into the reservoir between October and April of each year.

UV absorbing material occurs from aromatic moieties of DOC. These are important since they react with chlorine to form regulated DBPs (THM, HAA). Specific UV absorbance is calculated for filtered samples (GF/F) as UV absorbance at 254 nm divided by DOC, and has units of L/mg-cm. Figure 2.5 summarizes SUVA data from the reservoirs. Bartlett Lake has the highest variations due to the low attenuation of runoff events through upstream reservoirs. Lake Pleasant has the lowest SUVA (Table 2.5).

Table 2.5 – Average DOC and SUVA for 2003 measurements

Reservoir	DOC (mg/L)	SUVA (L/mg-cm)
Lake Pleasant	4.0	0.012
Saguaro Lake	4.4	0.015
Bartlett Lake	4.7	0.023

Figure 2.6 summarizes DOC removal across each WTP. On average 20% to 40% of the DOC is removed. The North Tempe and Greenway WTPs have a high potential to remove DOC. The South Tempe WTP treats primarily groundwater pumped into the Tempe canal, so raw water DOC levels average only 1.4 mg/L which are considerable lower than raw waters for other WTPs.

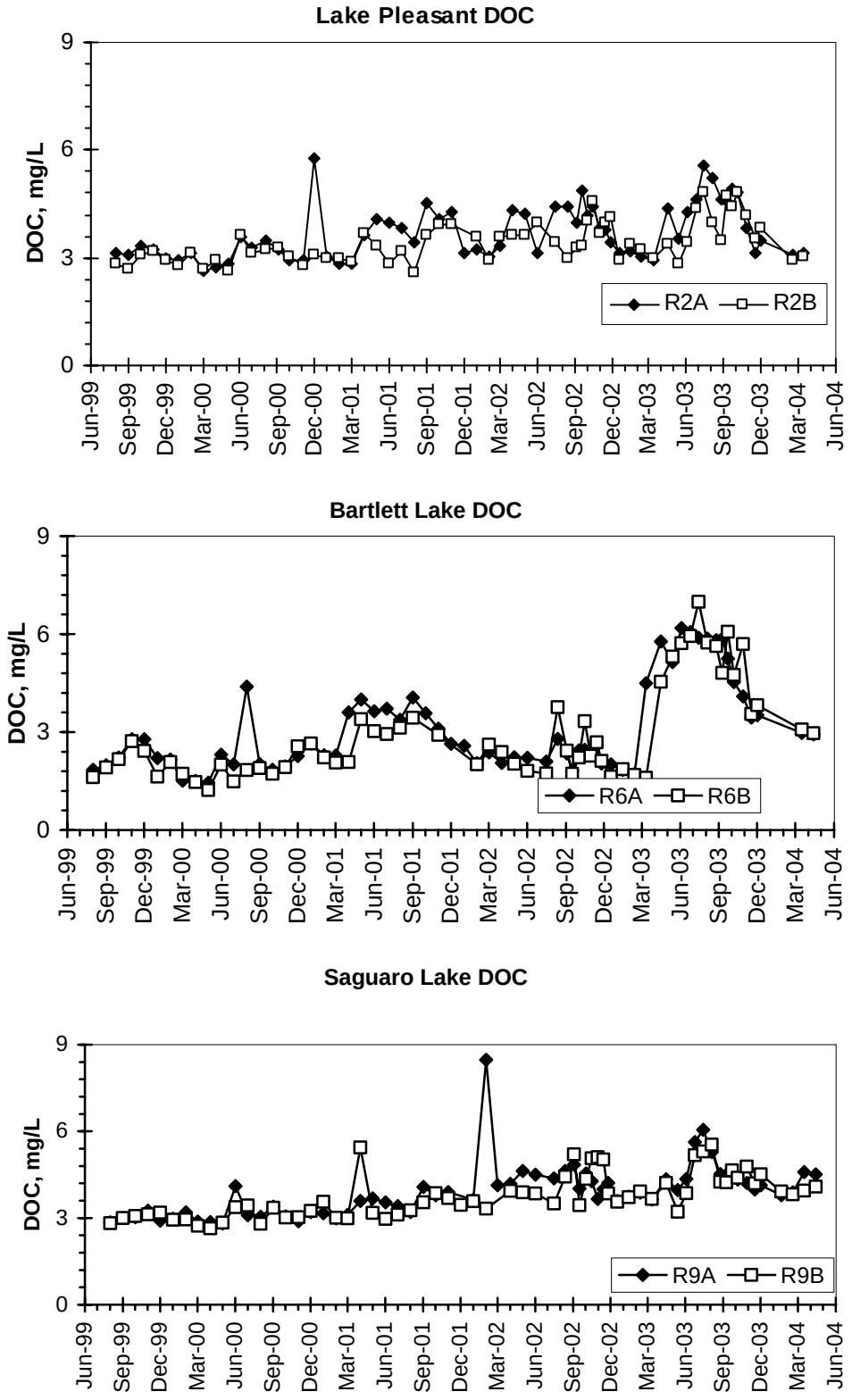


Figure 2.4a Trends in DOC concentration in epilimnion (R2A, R6A, R9A) and hypolimnion (R2B, R6B, R9B) of terminal reservoirs for the metro Phoenix region

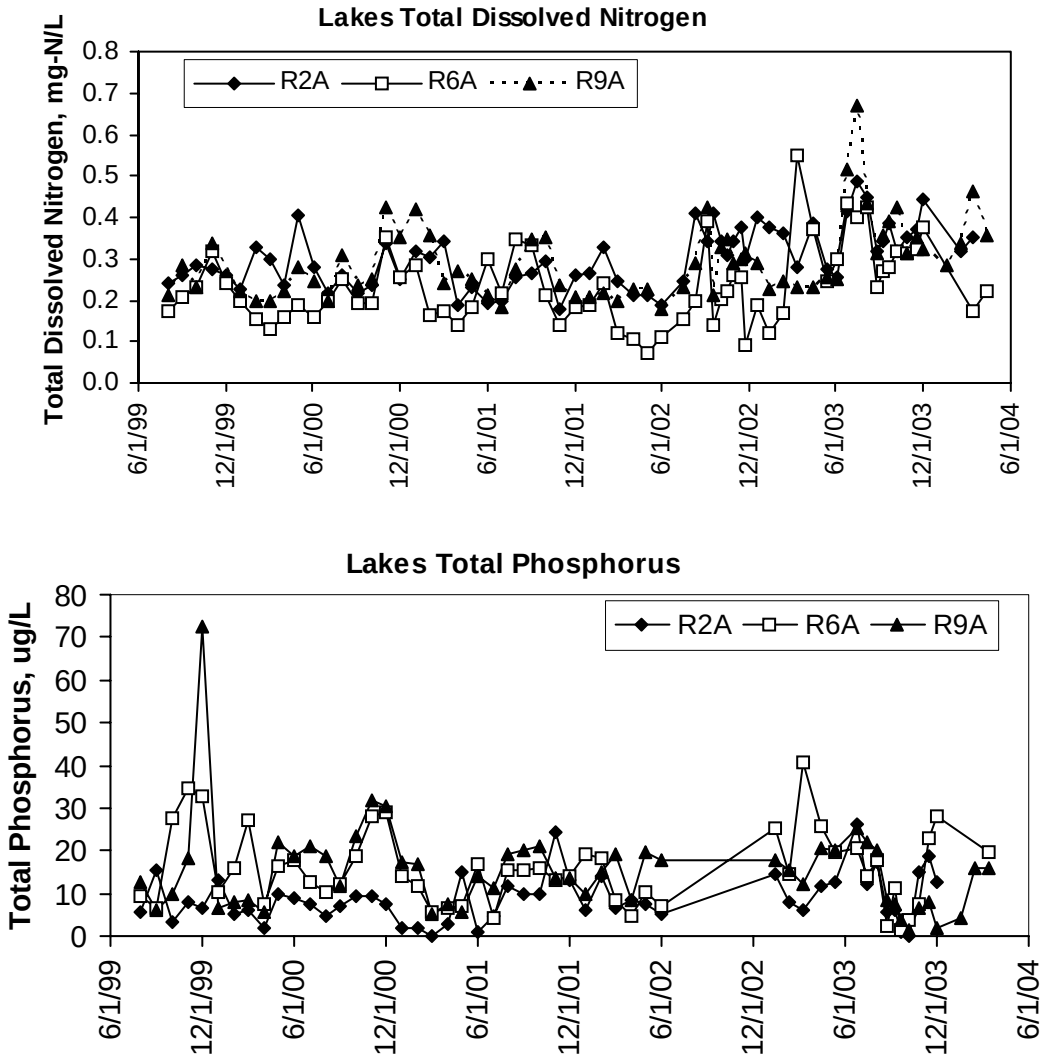


Figure 2.4b Trends in Nitrogen and Phosphorous concentration in epilimnion (R2A, R6A, R9A) of terminal reservoirs for the metro Phoenix region

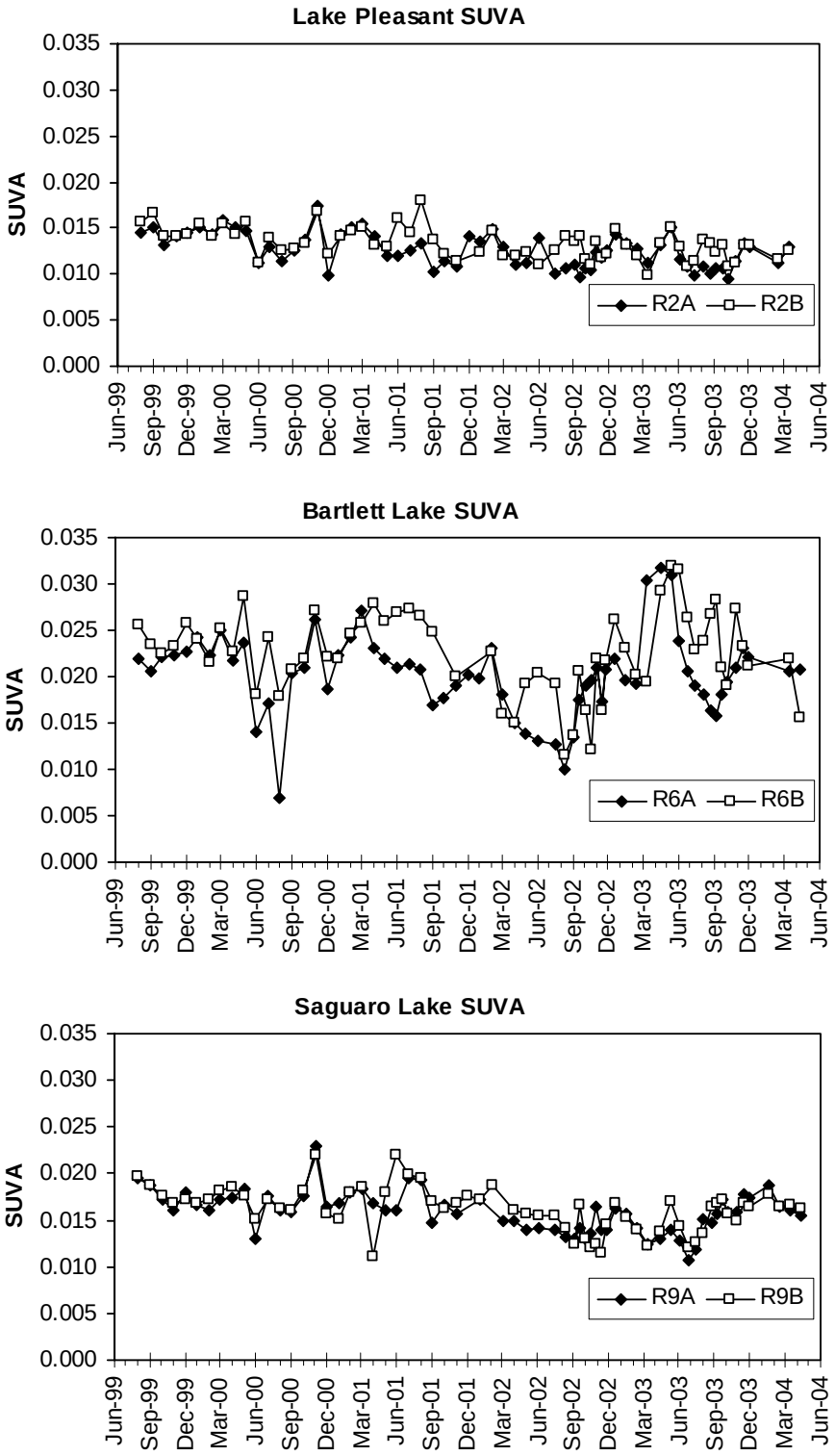


Figure 2.5 Trends in SUVA in epilimnion (R2A, R6A, R9A) and hypolimnion (R2B, R6B, R9B) of terminal reservoirs for the metro Phoenix region

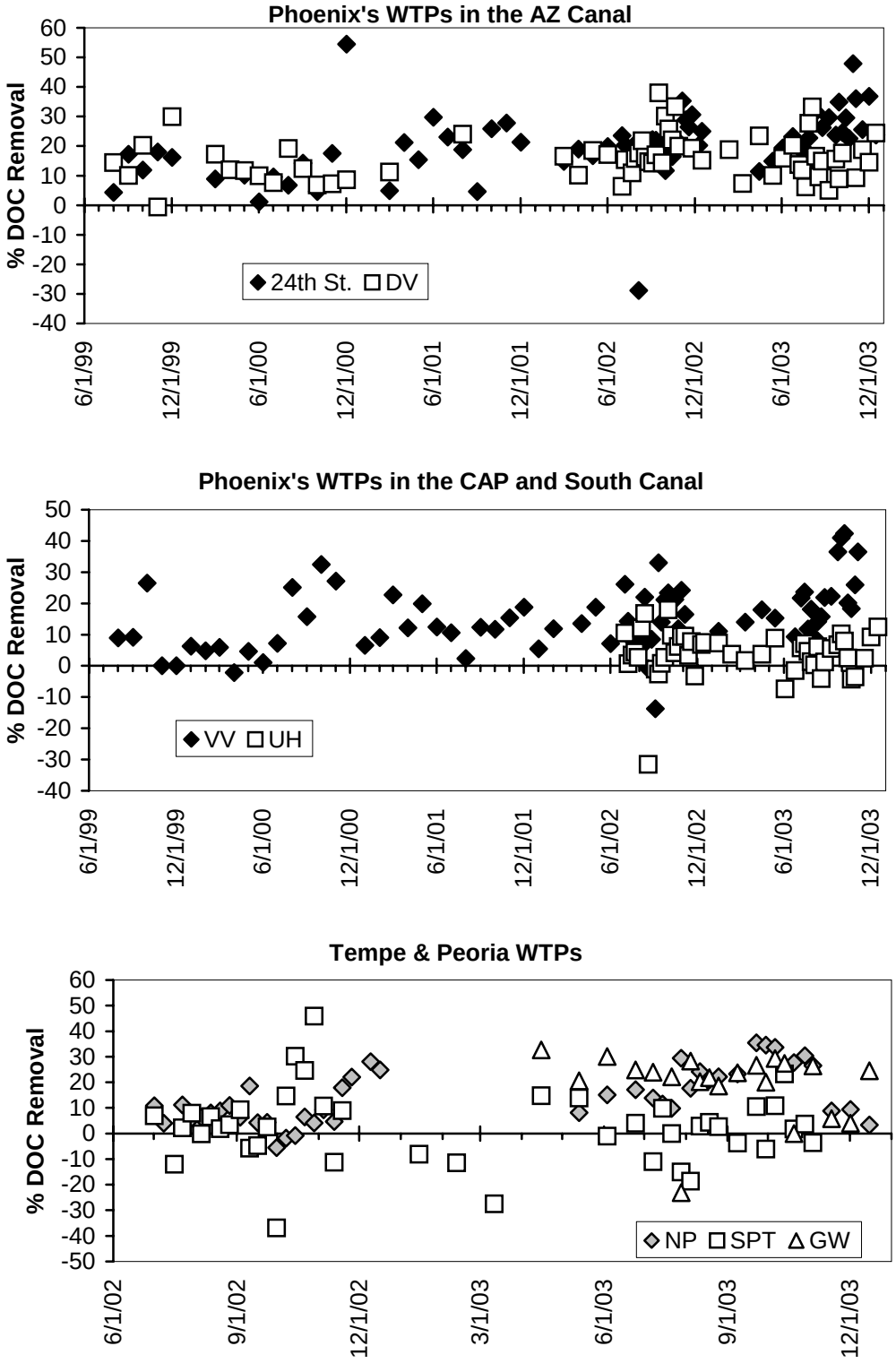


Figure 2.6 – Percentage DOC change across each WTP

Assessment of Forest Fires

A background review on forest fires is attached as an appendix. It is a AWWA Annual Conference (2004) proceeding.

A simple **hydraulic model** of the Salt River system was developed and two end-member scenarios considered. At the time of the fire (July 2002) the total volume in the Salt River reservoirs was 824,000 acre-ft. The first model assumed a plug-flow reactor (PFR) without dispersion. In this case a pulse of new water entering Roosevelt would move as a "slug" through the reservoir system. At a discharge rate of continuous 300 cfs from Saguaro Lake, it would take 3.8 years for the slug of fire-water runoff to exit Saguaro Lake; 1.1 years at a continuous discharge of 1000 cfs. This would represent the "longest" time to impact by the fires, and a noticeable "slug" of low quality water would be present in the reservoir system. Synoptic sampling of DOC did not reveal a slug of high DOC water in the reservoirs (August 2003): Roosevelt DOC = 4.9; Apache DOC = 4.5; Canyon DOC = 4.8; Saguaro DOC = 5.6 mg/L.

Reservoirs do not behave as PFRs, especially on the Salt River where SRP employs pump-back (runs turbines backwards) at night (low energy cost time) to maximize energy production along the Salt River. So the second scenario assumed the entire Salt River reservoir system behaved as a series of CSTRs linked together. Roosevelt was considered as a single CSTR and then the downstream reservoirs modeled as CSTRs in series. Figure 2.7 represents an exit-age distribution curve from this analysis. The maximum effect of the fire would be noticed at approximately 150 days (0.4 years) after a runoff event impacted Roosevelt Lake. This approach actually seems reasonable considering the DOC patterns in Saguaro Lake (Figure 2.4a) which increased approximately 4 to 5 months (0.4 year) after a large March 2003 runoff event.

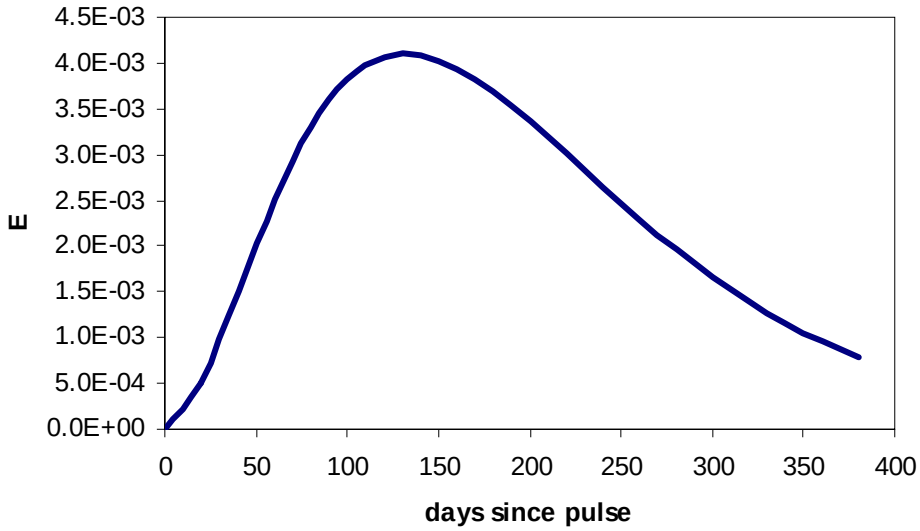


Figure 2.7 Exit age distribution plot for CSTRs in series to model hydraulics in Salt River reservoir system

Overall the Salt River reservoirs appear to be adequately represented by a CSTR in series model. This suggests the reservoirs will attenuate one-time large pulse inputs of contaminated fire water runoff. However, long term cumulative impacts from repeated runoff events could still transport low-quality water downstream. Furthermore, it suggests that a slug of dangerous water quality is not mysteriously moving its way through the Salt River reservoir system.

The water quality of a first-flush sample collected during the first major runoff event after the fires was collected in August 2002 by Carollo Engineers. Some water quality data from that sample is summarized in Table 2.6. Most of the "pollutants" were associated with particulate materials. This was true for organic carbon, nitrogen and phosphorous (Figure 2.8).

Table 2.8 – Water quality of first-flush sample (Salt River above Roosevelt, August 2002)

Constituent	Total	Dissolved	MCL, ug/L
As	127	17	10
Ba	5550	270	2000
Be	34	0	4
B	127	649	NA
Cd	24	0	5
Cr	168	0	100
Cu	375	6	1300
CN	0.12	0.1	200
Hg	0.7	0	2
Pb	688	0	15
Nitrate	NA	2.8	10
Se	3	2	50
Zn	1210	20	NA

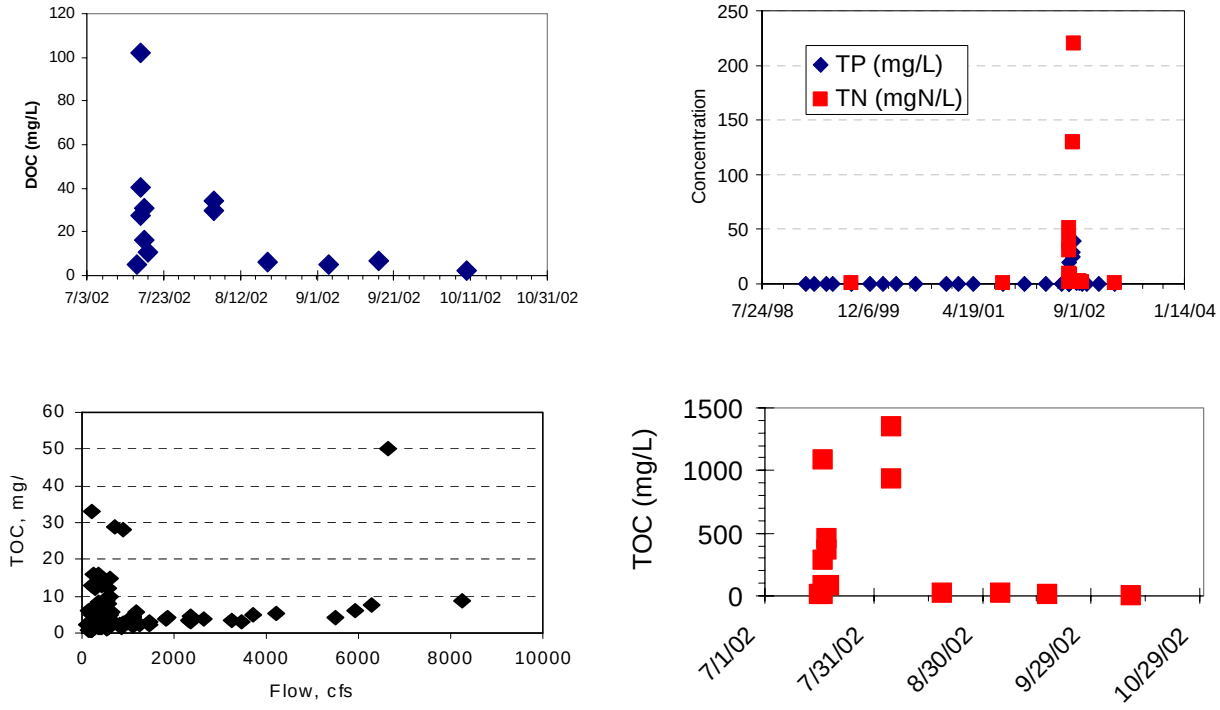


Figure 2.8 DOC, TOC, TN and TP after the fire and long-term analysis of TOC as a function of flowrate (Salt River above Roosevelt).

Analysis of water quality after the fire (July 2002) indicates that organic materials were transported into the reservoir system at a very high rate. Figure 2.9 summarizes loads of some constituents before and after the fires. While the volume of water flowing as runoff was lower in 2002-03 than historical averages the loading of TOC, DOC, total phosphorous and total nitrogen was higher than the long-term average. Further analysis indicated that most of the nitrogen and phosphorous was associated with the particulate fraction – which will settle out in the reservoirs and slowly release nutrients, which will impact the trophic status of the reservoir. The DOC load will be attenuated in the reservoir system (e.g., Figure 2.7).

Given the importance of DOC to drinking water facilities and the high DOC loading following the fire a detailed investigation of DOC in the sample of runoff water collected in Fall 2002 during the first major runoff event after the fire was conducted. DOC was isolated by macroporous resins. The DOC contained elevated levels of neutral compound classes, which are indicative of PAHs, Dioxins, and pyrolyzed sediments. ^{13}C-NMR, FTIR, and elemental analysis was conducted on the samples. The NMR and elemental data is summarized in Table 2.10. The hydrophobic neutral fraction had residual acetonitrile from the extraction process, causing the high nitrogen content. The materials did not have any features extremely out of normal for DOC from other sources, indicating that there was not a single class of compounds that might pose a health risk.

Table 2.9- Summary of DOC fractionation for August 2002 sample (Salt River above Roosevelt)

NOM Fraction	Percentage Total DOC
XAD8 acid fraction	29%
XAD4 acid fraction	21%
XAD4 + XAD8 Neutral Fraction	27%
Polar non-isolated fraction	23%

Table 2.10 Analysis of NOM Isolates

	Aliphatic		Anomeric	Aromatic		Carboxyl	Ketone	C	H	N
	0-62 ppm	62-90 ppm	90-110 ppm	110-140 ppm	140-160 ppm	160-190 ppm	190-230 ppm			
Hydrophobic Acid	37	10	4	21	8	16	4	38	1.7	2.0
Hydrophobic Neutral	47	10	4	13	5	17	4	44	3.8	7.4
Hydrophilic Acid	37	19	6	10	5	20	4	45	2.1	3.4
Hydrophilic Neutral	46	27	5	5	2	13	2	38	2.9	4.0

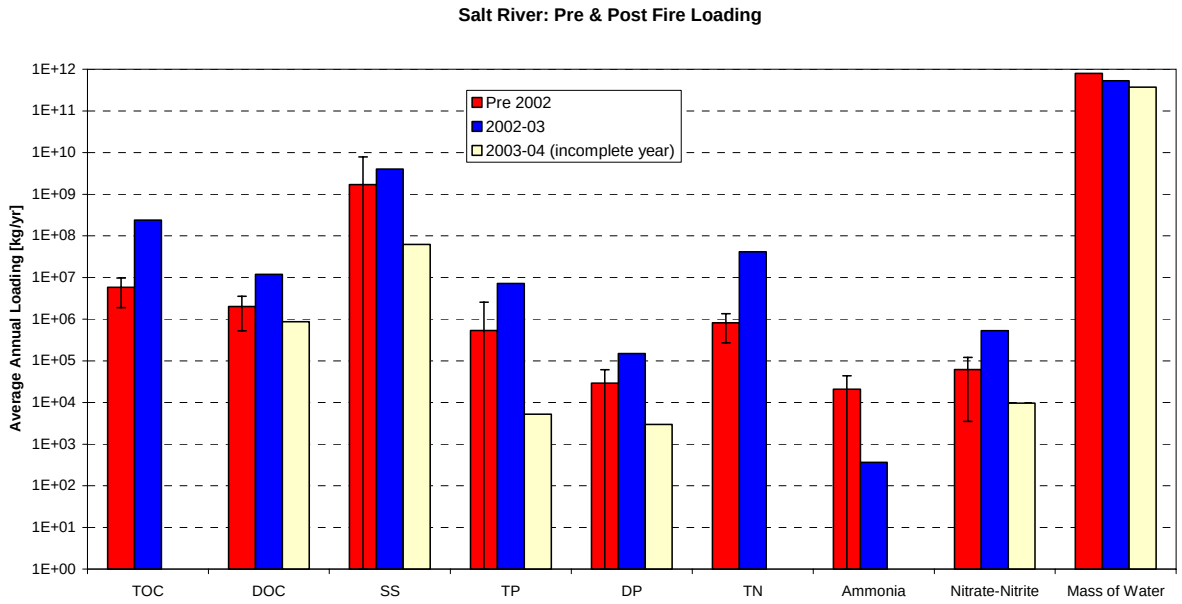


Figure 2.9 Loading analysis for the Salt River above Roosevelt Reservoir. Annual loading analysis taken as July 1 through June 30th to correspond with timing of forest fire.

Task 2 – Implementation Activities

ASU produced T&O Newsletters to disseminate MIB data, summarize plant performance, provide occasional special issues on regional water quality, and provide recommendations for in-plant changes, canal treatments, or blending scenarios. An example T&O Newsletter is provided as an appendix. Implementation activities also included:

- ASU meet with CAWCD and SRP to modify water supply (surface and ground water) to reduce T&O levels in water entering the canal systems. For example, the feasibility of changing the timing of CAWCD water by-pass pumping around Lake Pleasant could offset release of MIB and Geosmin from Lake Pleasant.
- ASU recommended implementing canal management (mechanical brushing and/or copper addition) or water supply management activities (e.g., shifting WTP production).
- ASU provided **T&O Forecasts** for two and four weeks into the future, providing guidance for purchasing of canal treatment equipment by SRP and PAC supplies by WTPs.

ASU coordinated **two workshops** (March and September 2003) to continue dissemination of T&O information, gather input and lead an integrated approach for improving regional water quality related to algae T&O and biotoxin issues.

ASU recommended and evaluated the effectiveness of Mechanical brushing and chemical treatments. Figure 2.10 illustrates the gain in MIB across different reaches of the Arizona canal. Arrows on these graphs indicate timing of specific canal treatments. Overall, the following conclusions can be made:

- Brushing was effective when thick/dense biomass present
- Copper was effective when less dense/thinner biomass present
- Both very effective in minimizing in-canal MIB production
- Reduced MIB production lasted for 2-4 weeks
- Treatments effectively controlled MIB, geosmin and cyclocitral
- Constant pro-active treatments throughout summer season can avoid MIB spikes due to in-canal MIB production

MIB production in the South Canal and Tempe canal was negligible in 2003 for four primary reasons. First, considerable quantities of CAP water was supplied into the South Canal. No major agriculture returns, that can convey nutrients, feed back into the South Canal. Third, the South canal is shorter and deeper than the Arizona Canal. Fourth, the Tempe Canal is comprised mostly of pumped groundwater and contains macrophytes that require periodic removal.

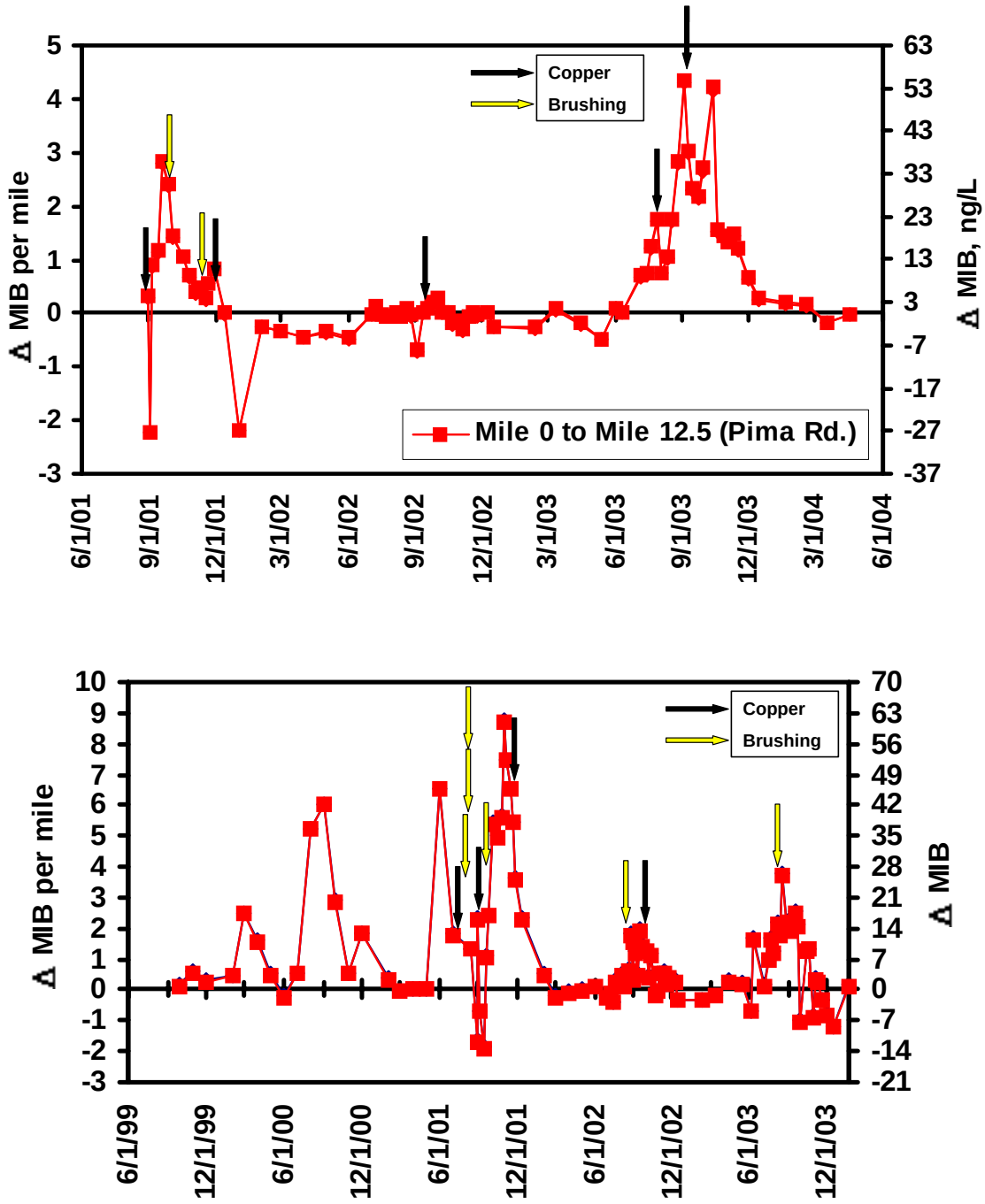


Figure 2.10 Change in MIB concentration per mile (ΔMIB) along the length of the Arizona Canal from the head to Pima Road of the Arizona canal (upper plot) and from 24th Street to 29th Avenue of the Arizona Canal (lower plot). Arrows indicate timing of chemical copper addition or SRP mechanical brushing.

Task 3 – Applied Research Products

Several applied research products were developed to maintain the progress in T&O control:

- To develop correlations between FPA and GC/MS analysis for T&O compounds
- To calibrate a commercially available model to determine what PAC doses are needed at WTPs
- To field-test emerging techniques for T&O monitoring and control
- To better understand mechanisms responsible for T&O production
- To facilitate collaboration between municipalities in obtaining external research funds to better understand and to respond to T&O problems

Flavor Profile Analysis (FPA)
ASU integrated COP's Flavor Profile Analysis (FPA) into the T&O Newsletter and statistically evaluated the correlation between FPA and direct MIB and Geosmin analysis by Gas Chromatography-Mass Spectroscopy (GC-MS).

Methodology. ASU collected influent and effluent samples from four of COP's WTPs (24th Street (24th), Deer Valley (DV), Union Hills (UH) and Val Vista (VV) WTPs) on the same day and at the same locations for both FPA and GC-MS analyses. A total of 140 samples were collected from May of 2003 to March of 2004 for FPA and GC/MS analysis. Approximately 36 %, 23 %, 22 % and 19 % of the 140 samples were from UH, DV, 24th, and VV WTPs, respectively. FPA samples were collected in 1-L odor-free amber bottles provided by COP's WTPs. Samples were delivered to two FPA panels at DV and UH WTPs within the same day of collection and analyzed within 24 hours. ASU provided COP with the sampling schedule at least three months in advance, so that FPA panels can be coordinated accordingly. GC-MS samples were collected in precleaned 125-ml MIB amber bottles (acid washed in 10 M HCl for 12 hours and ashed at 550 ^{o}C for 2 hours).

For analytical purposes, all GC/MS results with values below the detection limit (< 2.0 ng/L for MIB and Geosmin and < 5.0 for Cyclocitral) were given a value of 1 ng/L. Semi-log Weber-Fechner plots for MIB, Geosmin and cyclocitral were done to determine the possible correlation between these T&O compounds and E/M FPA intensity. It has been determined that changes in human perception to odor intensity is logarithmic because as odor intensity increases it requires a greater change in odor to sense the change (Weber, 1982).

Multiple-variable non-linear regressions (MVNLR) between the 140 paired FPA/GC-MS datapoints were also performed to determine an alternative correlations to the Weber-Fechner plots. The following 4 equations were used to perform MVNLRs:

$E/M\ FPA = a*MIB + b*Geosmin + c*Cyclocitral + d$ Equation 1

$E/M\ FPA = a*MIB+b*Geosmin+c*Cyclocitral$ Equation 1.1

$E/M\ FPA = a*MIB^{b} + c*Geosmin^{d} + e*Cyclocitral^{f}$ Equation 2

$E/M\ FPA = a*\ MIB^{b} * Geosmin^{c} * Cyclocitral^{d}$ Equation 3

During the first round of MVNLRs, the 140 paired datapoints were used to identify outliers that may bias the regressions. Two cases were tested considering only two (MIB and Geosmin) and

all three T&O compounds. Several outliers were identified during the first round of regressions and eliminated for the second round. During the second round of regressions, 43 datapoints < 1.0 and 7 outlier datapoints between 1.5 and 5.0 were eliminated. The second round of MVNLRs gave better results than the first round (R^2 > 0.55). For brevity, only the best fits during the second round of regression are presented herein

Results. Earthy/Musty odors were not detected by the panelist in approximately 31 % of the 140 samples (No E/M FPA intensity entered in table) (Figure 2.11). Only 11 % of the samples had objectable E/M FPA intensities (> 3). The number of samples with a certain E/M FPA Intensity decreased as the E/M Intensity increased (Figure 2.11). This inverse correlation made difficult the statistical analysis because the high variability of E/M FPA intensity < 1.

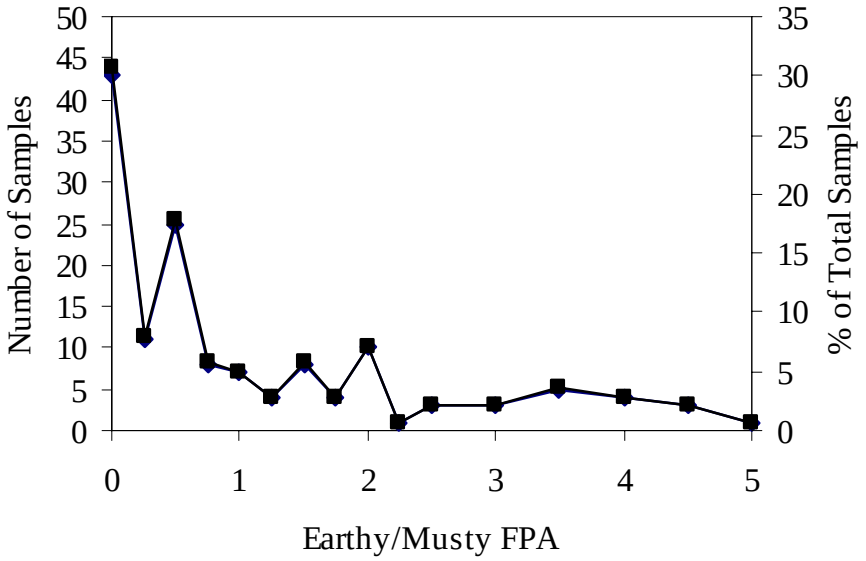


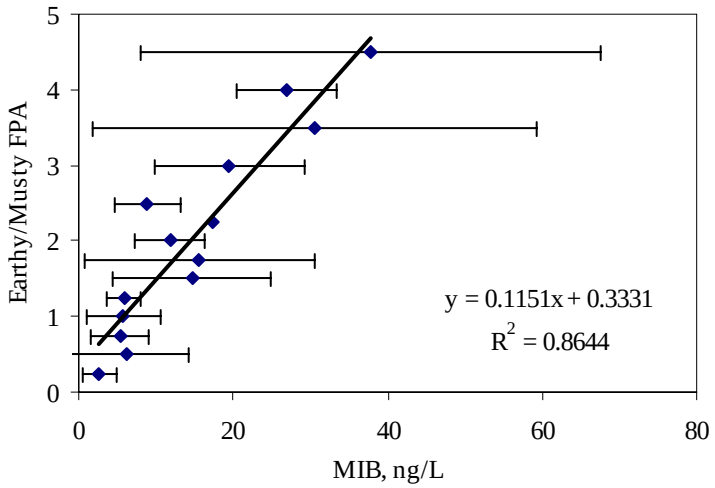
Figure 2.11 Number of samples vs. Earthy/Musty FPA.

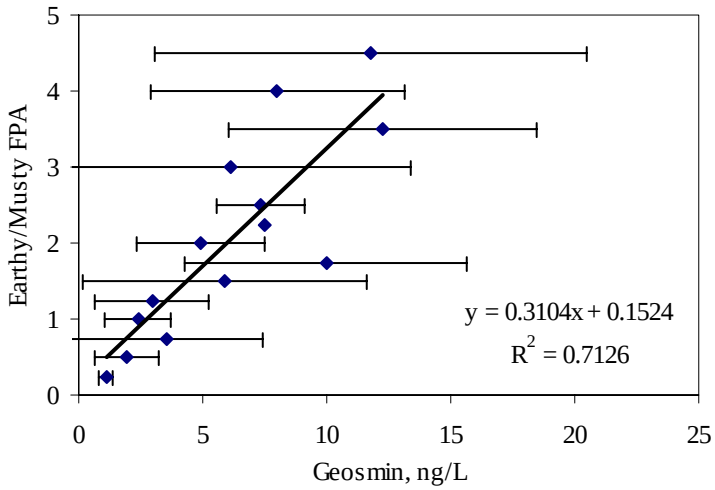
Figure 2.12 shows the Weber-Fechner plots for MIB, Geosmin and Cyclocitral. E/M FPA intensity showed a significant direct correlation with MIB and Geosmin (R^2 = 0.86 and R^2 = 0.71, respectively), but a weak correlation with Cyclocitral (R^2 = 0.08). The only problem with these plots it is that the GC/MS measurements had high variability for any given E/M FPA (Figure 2.12). A logarithmic correlation was expected using the Webe-Fechner plots (Weber, 1982), however, the equation that best fitted the datapoints was a linear equation.

Figure 2.13 shows the best MVNLRs determined during the second round of regressions. E/M FPA values between 1.25 and 4 were successfully predicted with all four equations. The best equations based on R^2 were Equations 1 and 3 (R^2 ~ 0.75). It is important to notice that Geosmin had a negative effect on the predicted E/M FPA in equations 1, 1.1, and 3 (the higher Geosmin, the lower the predicted E/M FPA). The causes of this trend have not been determined.

Conclusions. E/M FPA intensity was successfully predicted with the MIB and Geosmin Weber-Fechner plots and a three component (MIB, Geosmin, Ciclocytral) MVNLRs. However, plots

and regressions may lack of significance as variability was high and a lot of outliers were eliminated during the analysis. High variability may be attributed to the fact that approximately one third of the samples originated from UH WTP, which is located in the CAP Canal, a canal that does not present T&O problems during summer and has low T&O levels through the year. A better reproducibility of FPA results may be obtained if more samples with higher T&O are used during FPA.





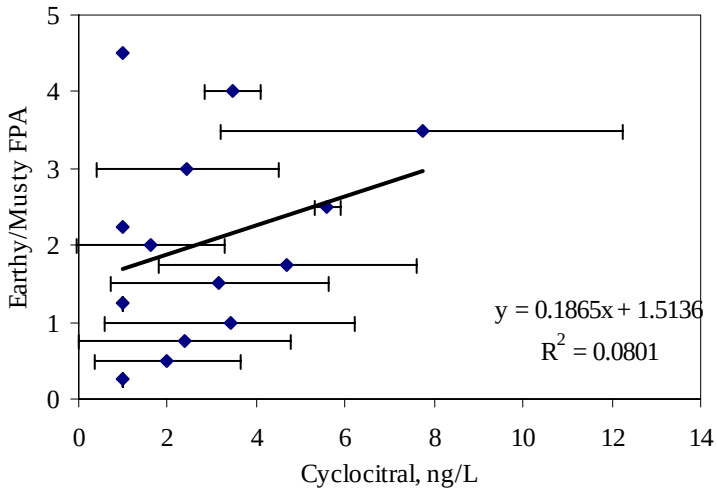
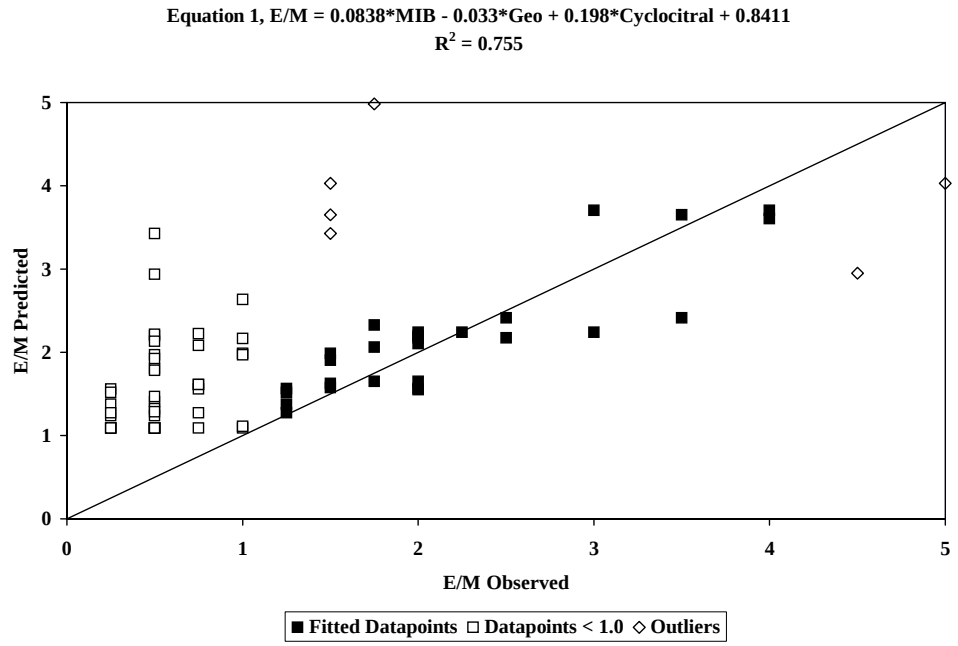


Figure 2.12 Multiple-Variable Non-Linear Regressions between Earthy/Musty FPA and three T&O Compounds



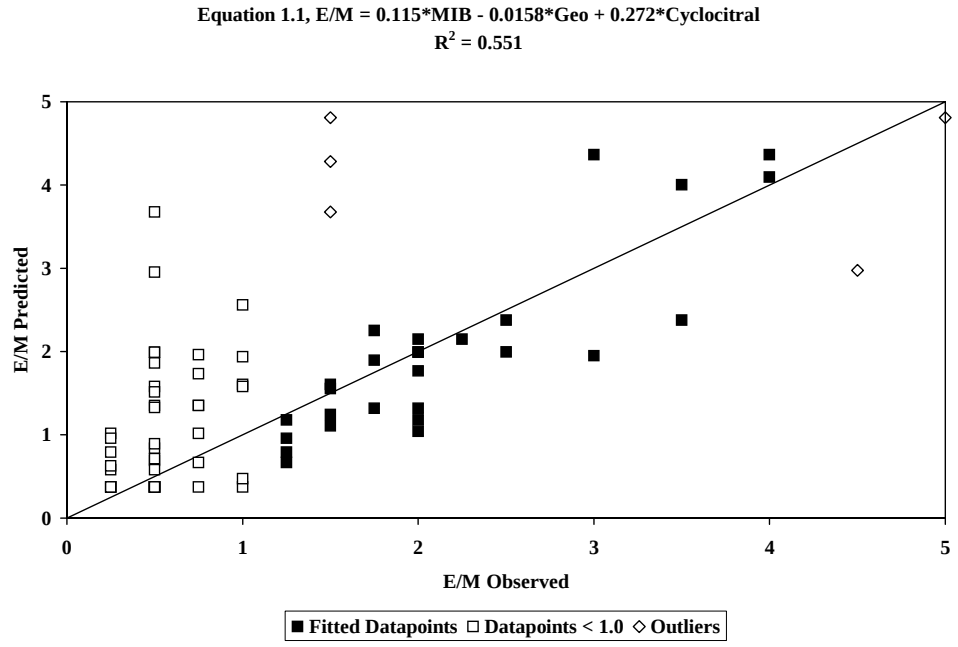
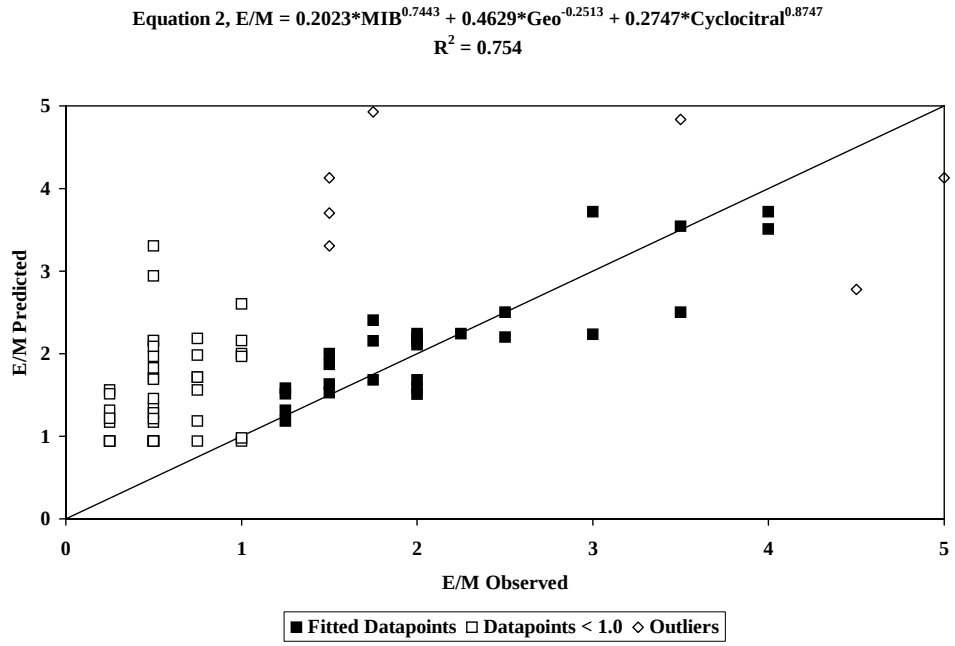


Figure 2.13 Earthy/Musty FPA predicted with multiple variable regression equations



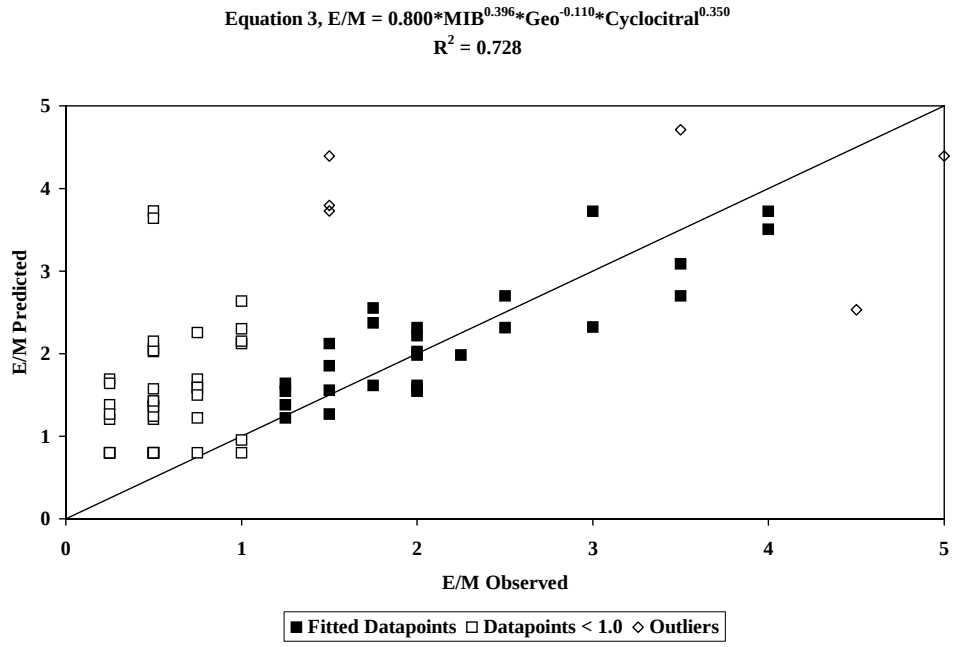


Figure 2.13 (Continued). Earthy/Musty FPA predicted with multiple variable regression equations

Powder Activated Carbon Kinetic Model

The purpose of developing an updated PAC dose-response model was to account for variable PAC contact times at different WTPs. In the past, PAC dose recommendations were based upon achieving a 4 hour contact time. Contact times influent MIB removal by PAC. Seasonally many of the WTPs have contact times significantly different than 4 hours. We attempted to purchase PACMANAGER from United Water (Contact: john.nixon@uwi.com.au) but the software was not commercially available in the USA and United Water wanted to conduct the MIB adsorption tests at a significant cost. Therefore ASU developed a simple EXCEL based interface model to predict PAC dosages to achieve specific MIB effluent concentrations, which includes variable PAC contact times.

Methodology. ASU received two commercial PAC products (Norit 20B and Westvaco AquaNuchar) and a third activated carbon product via Keith Greenberg from Norit (SuperPAC2). At the time, ASU was under the impression that SuperPAC2 would be developed as a PAC, however, it appears it will only be commercially available as a GAC. However, it still serves as an indicator for a high performing PAC material.

ASU collected four local source waters for testing (CAP, groundwater, Salt River and Verde River). Batch adsorption isotherms were developed in each water and one blend of the waters by spiking the source water with ^{14}C-radiolabeled MIB. Over 200 experiments were conducted. Freundlich constants (K and 1/n) for each PAC brand were determined from isotherm tests. Kinetic constants (surface diffusion (D_s) coefficient) were determined for each PAC brand using empirical equations describing solutions to the homogeneous surface diffusion model (HSDM). A Excel-based model developed by Prof. John Crittenden/ASU was used. The empirical equations of the HSDM and kinetic and isotherm constants were used to estimate effluent MIB concentrations for different PAC doses and several hydraulic contact times in an Excel spreadsheet. The spreadsheet was designed as user-friendly, so WTP operators would only need to enter raw water type, PAC brand, initial MIB concentration, total flowrate, and basin volume. The output of the model is a table and a figure with PAC doses for different effluent MIB concentrations.

Results. An example kinetic experiment for ^{14}C-radiolabeled MIB removal by AquaNuchar PAC in CAP water is presented in Figure 2.14. MIB removal occurred rapidly over the first two hours of the tests. PAC removal between 4 and 8 hours was minimal. Pseudo-equilibrium was assumed to be reached at 8 hours of contact time. This type of data was used to calibrate Freundlich isotherm model parameters (K, 1/n). It was observed that 1/n was nearly constant among the experiments, and an average 1/n value of 0.3 was selected for all subsequent modeling. Freundlich K values varied in each water and were linearly dependent upon the DOC of the water:

Norit 20B: $K\ ([mg/g][L/\mu g]^{1/n}) = -0.0038[\text{DOC in mg/L}] + 0.0340$

AquaNuchar: $K\ ([mg/g][L/\mu g]^{1/n}) = -0.0002[\text{DOC in mg/L}] + 0.0188$

SuperPAC2 $K\ ([mg/g][L/\mu g]^{1/n}) = -0.0051[\text{DOC in mg/L}] + 0.0436$

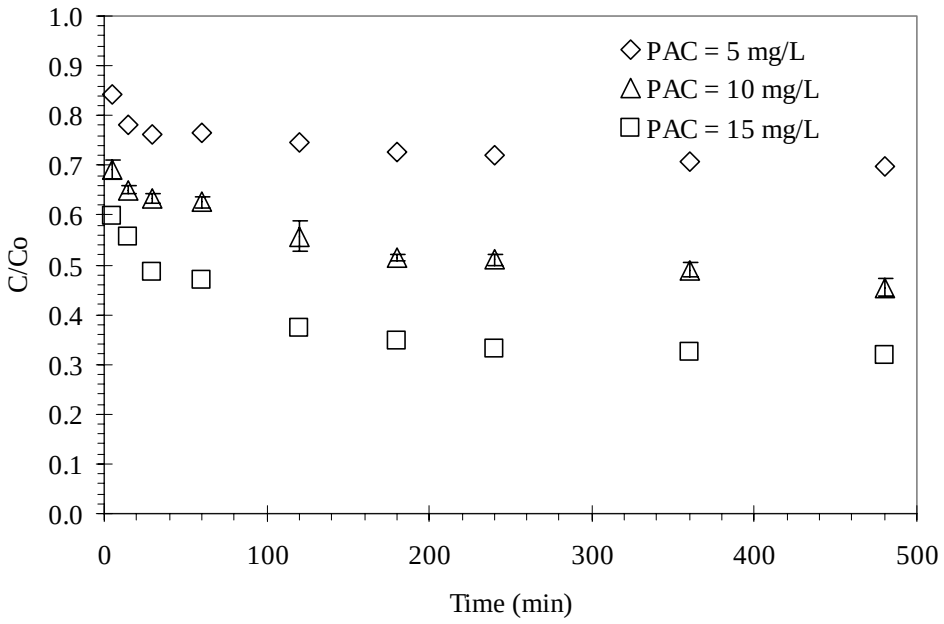


Figure 2.14 Effect of contact time on MIB (Co = 100 ng/L) removal from CAP water on Westvaco AquaNuchar

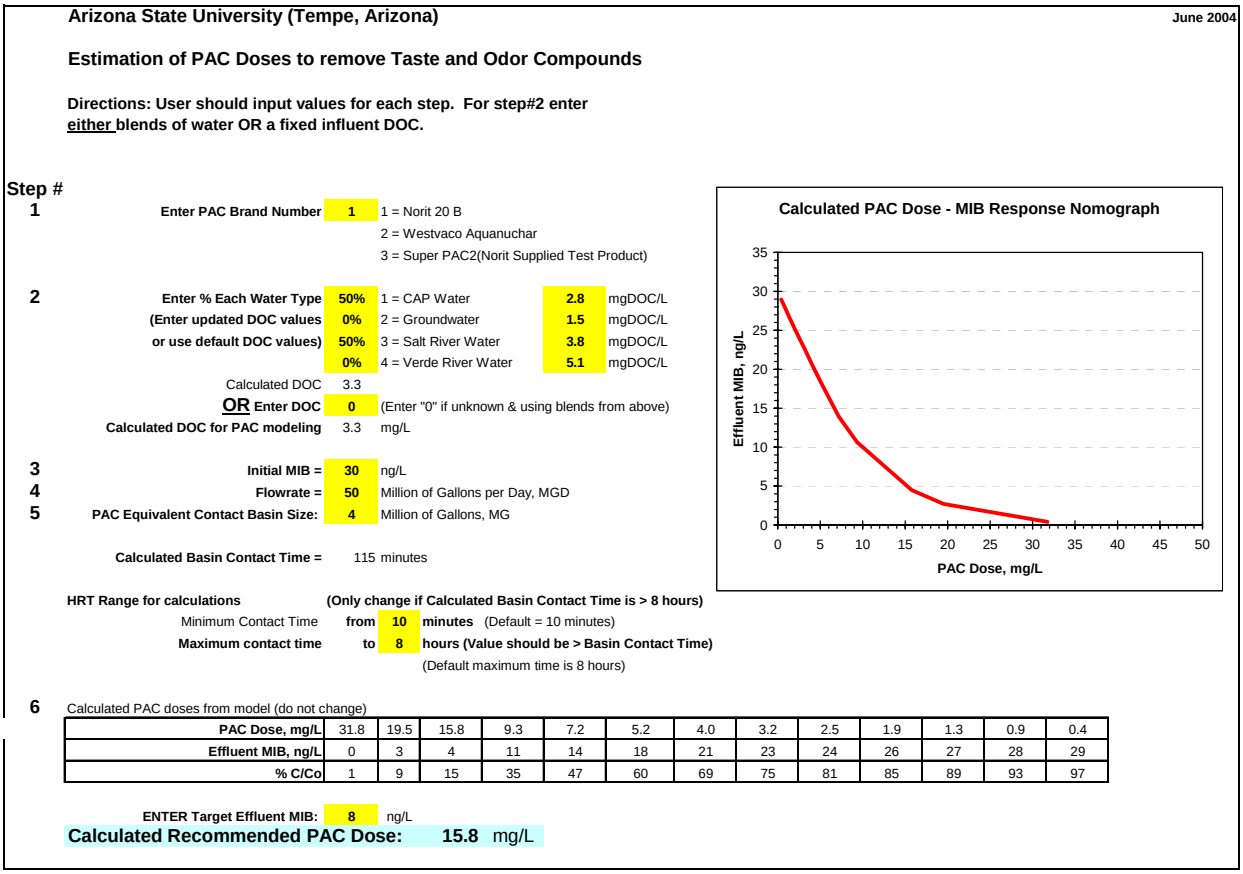
The kinetic data and 8 hour pseudo-equilibrium Freundlich parameters were used along with a constant PAC radius (0.0965 mm) to estimate the surface diffusion coefficient (D_s) using the homogeneous surface diffusion model (HSDM). An average D_s value of 10^{-10} cm^2/min was obtained and used in all subsequent model formulation.

The PAC model was developed for MIB because MIB occurs at higher concentrations than Geosmin for most central Arizona WTPs and because MIB is more difficult to remove than Geosmin by PAC. In general, if MIB concentrations are greater than Geosmin concentrations, than Geosmin will be also be removed as well (i.e., similar or greater percentage removal) based upon the recommended PAC dose from the model.

The PAC model was submitted to the sponsor agencies and will be posted on the ASU Regional Water Quality website (http://ceaspub.eas.asu.edu/pwest/tasteandodor.htm). Figure 2.15 presents a "snapshot" of the spreadsheet interface and output. The model has a 6-step data requirement which are entered by the user (highlighted boxes). The following is a description of the data inputs:

- Step #1 : Enter numeric code for which type of PAC is used. MIB removal varies with different PAC brands, and is accounted for through using different Freundlich K values.
- Step #2: Enter the blend of water sources and recent DOC data, OR just enter the DOC of the raw water for a specific WTP. DOC is used in the model to estimate Freundlich K values.

- Step #3: Enter influent MIB concentration in raw water
- Step #4: Enter plant flowrate, or process train flowrate
- Step #5: Enter volume of contact basins where PAC is added (include flocculation and presedimentation). A Contact Time is calculated based upon flowrate and basin volume.
- Step #6: Internal calculations develop a MIB dose-response curve for a fixed contact time. Results are shown graphically and in tabular format. User enters the target effluent MIB concentration and a corresponding PAC dose to achieve that effluent MIB calculated is extrapolated from the tabular data.



Arizona State University (Tempe, Arizona) June 2004

Estimation of PAC Doses to remove Taste and Odor Compounds

Directions: User should input values for each step. For step#2 enter either blends of water OR a fixed influent DOC.

Step #

1 **Enter PAC Brand Number** 1 = Norit 20 B; 2 = Westvaco Aquanuchar; 3 = Super PAC2(Norit Supplied Test Product)

2

Enter % Each Water Type	**50%**	1 = CAP Water	**2.8**	mgDOC/L
(Enter updated DOC values	**0%**	2 = Groundwater	**1.5**	mgDOC/L
or use default DOC values)	**50%**	3 = Salt River Water	**3.8**	mgDOC/L
	0%	4 = Verde River Water	**5.1**	mgDOC/L

Calculated DOC 3.3

OR Enter DOC 0 (Enter "0" if unknown & using blends from above)

Calculated DOC for PAC modeling 3.3 mg/L

3 **Initial MIB =** 30 ng/L

4 **Flowrate =** 50 Million of Gallons per Day, MGD

5 **PAC Equivalent Contact Basin Size:** 4 Million of Gallons, MG

Calculated Basin Contact Time = 115 minutes

Calculated PAC Dose - MIB Response Nomograph

HRT Range for calculations **(Only change if Calculated Basin Contact Time is > 8 hours)**

Minimum Contact Time **from** 10 **minutes** (Default = 10 minutes)

Maximum contact time **to** 8 **hours (Value should be > Basin Contact Time)**

(Default maximum time is 8 hours)

6 Calculated PAC doses from model (do not change)

PAC Dose, mg/L	31.8	19.5	15.8	9.3	7.2	5.2	4.0	3.2	2.5	1.9	1.3	0.9	0.4
Effluent MIB, ng/L	0	3	4	11	14	18	21	23	24	26	27	28	29
% C/Co	1	9	15	35	47	60	69	75	81	85	89	93	97

ENTER Target Effluent MIB: 8 ng/L

Calculated Recommended PAC Dose: 15.8 mg/L

Figure 2.15 "Snapshot" of Excel-based PAC model software for predicting PAC dosages for MIB removal

Biocide Coatings

Research conducted during 2002 indicates that biocide (algaecide) coatings applied to the canal may be effective at reducing algae growth and T&O production. A titanium-oxide paint product as a biocide was be tested in an existing device built by ASU and SRP. Larger scale applications have been hindered by (1) concern over leaching products from algaecide, (2) lack of NSF approval for EP2000, (3) difficulty in providing data for longevity of treatment, and (4) inability to apply EP2000 on large test-scale since Arizona Canal did not dry-up in winter 2003. A description of this work was written as a Awwa Annual Conference (Orlando, Fl 2004) proceeding (see appendix). The main findings of this research are:

- EP2000 had better periphytic algae inhibitor than Sun Wave.
- EP2000 and Sun Wave reduced periphytic algae growth by 99 % and 35 % for up to 3 months when compared to control substrates.
- The antifouling Coatings EP 2000 and Sun Wave leached H_2O_2 and zinc as result of the photocatalytic action of sunlight.
- Algal growth was inhibited in cement samples as their zinc oxide concentration increased.

Part of the work presented is based upon funding from Salt River Project and the ASU National Science Foundation Water Quality Center, again demonstrating our motivation to leverage research funding. More field-scale experiments are under way to test the inhibition effectiveness of EP2000 and Sun Wave on other source water, the Colorado River water. Coated tiles are being also tested for longer time periods in both source waters. More detailed leaching tests are also being performed. A more comprehensive experimental matrix involving 40 mixture designs is currently in progress. Additional admixtures will include copper slag, copper sulfate, ammonium chloride, sodium bromide, and cetyl-methyl-ammonium bromide. Overall, the cement-based additives approach does not seem as promising as algaecide coatings.

Culprit Algae – Role of Conductance on MIB Release

ASU's research suggests that the production of T&O compounds by culprit algae may be influenced by the dissolved salts or ion content of the water. Coincidentally with increasing specific conductance (a measure of total ion in solution), both reservoir and canal MIB and geosmin concentrations frequently also increase, suggesting that the culprit organisms may be responding either by exhibiting accelerated growth or through a metabolic shift that results in greater production and release of these compounds. A comparison of an upstream (R12) and downstream (R16) canal site exemplifies the relationship between conductance and the concentration of these compounds in the system (Figure 2.16). If this can be further demonstrated, ASU's ability to predict T&O events in the storage and distribution system will be greatly enhanced. From a fundamental research perspective, this will add to the knowledge of the cellular metabolic events that lead to production of the T&O compounds.

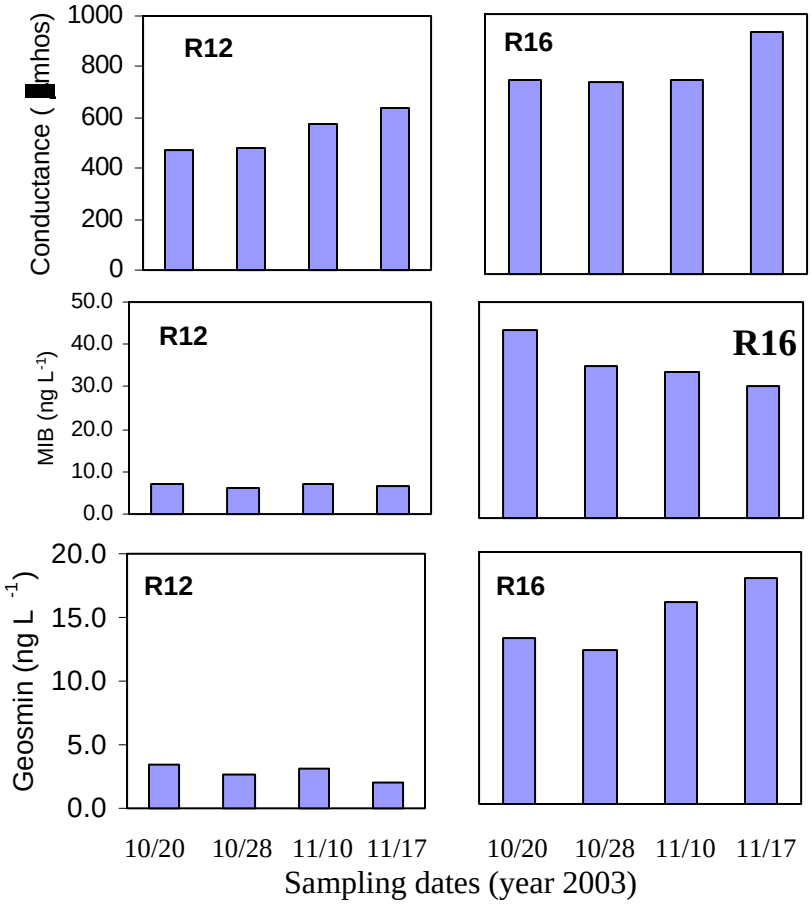


Figure 2.16 Relationship between conductance and MIB and geosmin in the Arizona Canal. R12 = upstream, above CAP cross-connect; R16 = downstream, above inlet to Deer Valley WTP of the Canal

Culprit Algae Early Warning Detection

ASU continued on-going attempts to genetically fingerprint the culprit T&O producers in the water system so that they can be more readily pinpointed for removal or mitigation efforts. A molecular fingerprinting technique was applied to probe for the presence of cyanobacteria that have the genetic potential to produce MIB and geosmin. This method involved denaturing gradient gel electrophoresis (DGGE) analysis of PCR-amplified 16S rDNA fragments. When analyzed by this method, the phylogenetic composition of periphyton cyanobacterial communities in the Arizona Canal differed substantially, with generally higher richness and diversity of cyanobacterial species at upstream sites compared to downstream sites in the Canal. Direct relationships were observed between specific DNA fingerprints, and episodes and intensity of MIB/geosmin production in specific sections of the Arizona Canal. This suggests that the method, along with GC/MS analysis, could serve as a reliable method for detection and possibly forecasting taste/odor episodes so that mitigation measures may be applied in advance of significant production. ASU plans to continue research along this line with the ultimate goal of implementing this molecular gene probe technology to improve T&O prevention or mitigation practices. This work is funded by Salt River Project, and a final report can be made available separately upon request.

Ozone-Enhanced Biofiltration for MIB and Geosmin Removal

ASU has been successful in obtaining funds for algae-related research, and that effort would be expected to continue. ASU finished its project: AWWARF – Solicited RFP#2775: PIs: P. Westerhoff, Z. Chowdhury, S. Summers. "Ozone-enhanced Biofiltration for MIB and Geosmin Removal" February 2002-2004 ($350,000). A draft final report has been submitted. This work included pilot plant analysis at Chandler and Phoenix. A draft executive summary is attached as an appendix.

Other Research Collaborations

ASU continues to collaborate through conducting pipeloop experiments on AWWARF – Tailored Collaboration Project: Cities of Phoenix, Scottsdale, and Tempe plus Arizona State University. "Developing a Customer-Driven Response Strategy for Dealing with Public Perception (taste and odors at the tap) and Potential Health Concerns (algal biotoxins)" April 2002-2004 (PIs: R. Gottler, P. Westerhoff) (>$150,000). Milt Sommerfeld has continued T&O monitoring, recommendations and research with the City of Chandler.

APPENDIX – EXAMPLE T&O NEWSLETTER FROM 2003

Taste and Odor NEWSLETTER
August 11, 2003
From the Phoenix-ASU "Taste and Odor" Project
PROJECT WEB PAGE: http://www.public.asu.edu/~westerho/tasteandodor.htm

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DISTRIBUTION: **Phoenix:** Walid Alsmadi, Edna Bienz, Frank Blanco, Nicoleta Buliga, Natasha Bernard, Alice.Brawley-Chesworth, Paul Burchfield, Jennifer Calles, Aimee Conroy, Tom Doyle, Ron Jennings, Francisco Gonzales, Randy Gottler, Keith Greenburg, Mike Gritzuk, Yu Chu Hsu, Maureen Hymel, Ron Jennings,Tom Martin, Shan Miller, Richard E. Musil, Paul Mally, Matt Palencia, Chris Rounseville, Mel Schlink, Raymond Schultz, Bonnie Smith, Jeff Van Hoy, Mike Welch, Kevin Williams, Vic Vanderslice; **SRP**: Gregg Elliott, Brian Moorehead, Rick Prigg: **CAWCD**: Doug Crosby, Patrick Dent, Brian Henning,Tim Kacerek; **Tempe**: Tom Hartman; Michael Bershad, Grant Osburn, German McCutheon.; **Scottsdale**: Michelle DeHaan,, B. Vernon; Suzanne Grendahl; **Gilbert:** Antonio Trejo; **Glendale**: Lee Hecht, Stephen Rot, Kim Remmel; **Mesa**: Alan Martindale; Charolette Jones; **Peoria**: A.J. Oswood, Dave Van Fleet, Linda Wahlstrom; **Chandler**: Lori Mccallum, Robert Goff, Pat Sampson, Victoria Sharp, Jackie Strong, Chris Kincaid; **Tuscon**: Michael Dew. **Consultants**: G. Masseeh, S. Kommineni (Malcom Pirnie); Warren Swanson (Schmueser Gordon Meyer, Inc., Colorado); Joe Eilers (JC Headwaters); Troy Day (CZN); Vance Lee, Carollo Engineering; Paul Westcott, Applied Biochemists, Shugen Pan, Greeley and Hanson. **ASU Team**: Michelle Cummings, Dawson, Tom Dempster, Mario Esparza, Kirsten Hintze, Marisa Masles, My-Linh Nguyen, Hu Qiang, Mari Rodriguez, D. Samantha, Milt Sommerfeld, Paul Westerhoff; **EPA**: Marvin Young; **DEQ**, Jeff Stuck and Casey Roberts

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SUMMARY: EVALUATION AND RECOMMENDATIONS

MIB in the Salt River is still very high – > 30 ng/L, and the MIB in the Verde River is now ~ 18 ng/L. Some dilution by CAP water and pumping is reducing MIB levels, but there is still MIB production within the Arizona Canal below the Squaw Peak WTP. We have recommended brushing to remove culprit algae. As before, both MIB and geosmin are elevated.

All three treatment plants along the Arizona Canal are using PAC to reduce MIB levels, reducing MIB levels to < 10 ng/L (Squaw Peak and Greenway WTPs) and 14 ng/L (Deer Valley). These plants should continue PAC treatment.

Val Vista and Tempe North are receiving water with ~ 20 ng/L MIB and are not successfully reducing MIB levels in product water. These plants should start or increase PAC treatment.

MIB levels in the canals that supply the Union Hills, Tempe South and Chandler WTPs are < 10 ng/L. No PAC treatment is needed in these plants.

CURRENT OPERATION AND COMMENTS FOR WTPS

WTP	PAC	Pre-chlor. Dose; duration	Cu	Temp, ^{o}C	T&O problem?	Comments/ Recommendations
Deer Valley	Dose 8/4 11.3 8/5 17.3 8/6 13.4 8/7 10.6 8/8 21.3 8/9 22.4 8/10 15 8/11 0	-	-	27-28	Musty odor when PAC ran out. Will resume PAC by Tues. or Wednesday.	Maintain PAC dose of 15 mg/L. High MIB (33 ng/L) and high geosmin (21 ng/L).
24th Street	Dose 8/01 10.4 8/02 10.9 8/03 7.8 8/04 11.0 8/05 10.2 8/06 8.4 8/07 10.3 8/08 10.2 8/09 9.9 8/10 10.1	No	No	23-25	Situation is improving	Current dose of ~ 10 mg/L is keeping MIB < 10 ng/L.
Union Hills						None – no T&O problem.
Val Vista	5-10 mg/L	No	No	26	--	MIB in product water is 18.5 ng/L – increase PAC dose to at least 12 ng/L.
Tempe North						Use 8 mg/L PAC to reduce MIB < 10 ng/L.
Tempe South	No	Yes, 2 ppm	No	29	No T&O complaints	None- no T&O problem.
Greenway						Presumably PAC is being used. Continue at 15 ng/L 20B.
Chandler	8 mg/L	No	No	31	--	Inlet MIB is 9 ng/L, so PAC may not be needed (but good insurance)

MONITORING RESULTS (Concentrations of MIB, geosmin, and cyclocitral are in ng/L)

WATER TREATMENT PLANTS. Sampling date: August 4-5, 2003.

Sample Description	MIB (ng/L)	Geosmin (ng/L)	Cyclocitral (ng/L)
Inlet to Squaw Peak WTP	**18.5**	**13.6**	8.9
Squaw Peak WTP treated water	8.4	<2.0	<2.0
Inlet to Deer Valley WTP	**33.8**	**20.7**	9.3
Deer Valley WTP treated water	**14.6**	2.0	2.4
Inlet to Val Vista WTP	**23.1**	4.3	5.5
Val Vista WTP treated water	**18.5**	3.4	4.0
Inlet to Union Hills WTP	<2.0	<2.0	<2.0
Union Hills Treated Water	2.9	<2.0	<2.0
Inlet to Tempe's North Plant	**19.2**	11.9	6.4
Tempe's North Plant treated water	**13.8**	3.2	3.1
Inlet to Tempe's South Plant	2.2	<2.0	<2.0
Tempe's South Plant treated water	5.1	2.2	<2.0
Inlet to Chandler's WTP	8.7	3.0	13.1
Chandler WTP treated water	5.2	<2.0	4.3
Inlet to Greenway WTP	**15.4**	4.8	<2.0
Greenway Inlet #2	**24.7**	**15.1**	8.4
Greenway WTP treated water	<2.0	<2.0	<2.0

Canal Sampling (August 4-5, 2003)

	Sample Description	MIB (ng/L)	Geosmin (ng/L)	Cyclocitral (ng/L)
CAP	Waddell Canal	<2.0	<2.0	<2.0
	Union Hills Inlet	<2.0	<2.0	<2.0
	CAP Canal at Cross-connect	<2.0	<2.0	4.2
AZ Canal	AZ Canal above CAP Cross-connect	28.7	3.4	2.5
	AZ Canal below CAP Cross-connect	5.6	2.7	4.4
	AZ Canal at Highway 87	7.9	3.1	7.0
	AZ Canal at Pima Rd.	15.1	9.7	7.8
	AZ Canal - 56th St. (Alma School Road)	17.8	10.1	7.3
	AZ Canal – Inlet to Squaw Peak WTP	18.5	13.6	8.9
	AZ Canal – Central Ave (N. of Northern)	33.6	20.0	9.0
	AZ Canal – Inlet to Deer Valley WTP	33.8	20.7	9.3
	Greenway WTP – Inlet	15.4	4.8	<2.0
	Greenway Inlet #2	24.7	15.1	8.4
South	South Canal below CAP Cross-connect	30.8	3.4	3.0
	South Canal at Val Vista WTP	23.1	4.3	5.5
	Cross-Cut Canal - Inlet to Tempe's North Plant	19.2	11.9	6.4
	Head of the Tempe Canal	19.1	3.9	4.9
	Tempe Canal - Inlet to Tempe's South Plant	2.2	<2.0	<2.0
	Chandler WTP - Inlet	8.7	3.0	13.1

RIVERS AND RESERVOIRS

	MIB (ng/L)	Geosmin (ng/L)	Cyclocitral (ng/L)
Lake Pleasant integrated sample	2.0	<2.0	13.6
Lake Pleasant integrated sample	<2.0	7.4	<2.0
Bartlett Reservoir near outlet	2.0	<2.0	<2.0
Bartlett Reservoir near outlet	<2.0	<2.0	<2.0
Verde River at Tangle			
Verde River at Beeline Highway	17.2	6.4	8.1
Saguaro Lake near inlet	15.2	<2.0	5.2
Saguaro Lake near inlet	17.0	<2.0	<2.0
Saguaro Lake near inlet	53.2	<2.0	<2.0
Salt River below Saguaro (Blue Point Bridge)	33.4	2.9	3.2

SRP/CAP OPERATIONS

Values in cfs, for August 8, 2003

	SRP Diversions	CAP
Arizona Canal	746	421
South Canal	549	117
Pumping	1346	-
Total	2641	538

Salt, % of SRP surface water: 54
Verde, % of SRP surface water: 46

OPERATIONAL NOTES

Specific conductance in the Salt River has been moving upward, to 2150 uS/cm in the most recent sample. This is one of the highest specific conductance values that has been recorded at this site since 1951. Specific conductance is directly proportional to TDS (for the Salt River, TDS ~ 0.51*specific conductance)., so a specific conductance of 2150 corresponds to a TDS of 1096 mg/L. There is an inverse relationship between specific conductance and flow in the Salt River, so conductivity (and TDS) increases as flow decreases.

Specific conductance is somewhat lower in the AZ Canal due to blending of Salt River water with water from the Verde River, the CAP Canal, and pumping. The most recent specific conductance value at the Squaw Peak WTP was 1135 uS/cm.

Some individuals can perceive elevated TDS, which may impart a salty or bitter taste. So far, no operators have noted complaints of this nature to us.

FEEDBACKS

If you have comments or questions, or have topics you would like to see discussed in the T&O Newsletter, please let us know. Send comments to bakerenv@earthlink.net.

APPENDIX - COATINGS AND CEMENT-BASED BIOCIDES TO CONTROL ALGAE GROWTH AND TASTE & ODOR RELEASE IN WATER DISTRIBUTION CANALS (AWWA ACE 2004 CONFERENCE PROCEEDING)

Coatings and Cement-based Biocides to Control Algae Growth and Taste & Odor Release in Water Distribution Canals

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Abstract

Characteristic earthy, musty, moldy, and fishy taste and odors (T&O) in drinking water supplies have been attributed to algal sources. Periphytic algal growth on the surface of drinking water conveyance structures (e.g., open channel canals) may induce seasonal T&O episodes. Over the past four years growth of periphytic algae on the walls of a concrete-lined canal conveying surface water has preceded the release of T&O compounds (MIB and Geosmin at rates of 2 to 15 ng/L/mile) into the flowing water during the summer months. Copper applications and/or mechanical brushing techniques have been successful in reducing periphytic biomass and preventing T&O production in the aforementioned canal. However, the use of fixed-surface

biocides to **prevent** periphytic algal growth **before** algae start producing T&O compounds may be more desirable. The main objective of this study was to determine the effectiveness of three antifouling coatings and nine concrete mix formulations to inhibit the periphytic algal growth on concrete structures. The antifouling coating EP2000 was a better inhibitor of periphytic algae than the protective barrier coating Sun Wave. EP2000 and Sun Wave reduced periphytic algal growth by 99 % and 35 % for up to 3 months when compared to control substrates. Algal growth inhibition was found to be directly proportional to the concrete samples zinc concentration. On-going research will be focused on the performance of EP2000 and Sun Wave for longer periods of time in two source waters. A more comprehensive experimental matrix involving 40 mixture designs is currently in progress.

Introduction

Periphytic algae and cyanobacteria, microorganisms growing on the surface of structures, are the most abundant population of microorganisms growing on water conveyance structures if the conditions are optimal for their growth. For optimal growth, periphytic organisms need micronutrients (nitrate and phosphate and other trace metals), sunlight and template temperatures. These conditions make Arizona one of the best-suited regions of the US for periphytic algae growth on water conveyance structures.

Different species of periphytic algae and cyanobacteria can produce volatile metabolites that impart taste and odor (T&O) to the water [1,2]. T&O problems in drinking water sources are a nuisance because the human threshold detection for some T&O compounds is very low for most individuals (Geosmin ~ 10 ng/L) [3]. Different methods have been implemented to control T&O-producing microorganisms growing on structures conveying source water: canal wall brushing, copper sulfate application, and water blending [4]. However these methods may be time consuming, expensive and their effectiveness short, requiring frequent reapplications.

The main objective of this paper was to determine the effectiveness of three antifouling coatings and various concrete mix formulations to inhibit the periphytic algal growth on concrete substrates. Coated tiles were submerged in the Arizona (AZ) Canal for different time periods to quantify periphyton biomass. Concrete samples made out of nine different formulations were submerged several months in an algal growth chamber containing nutrient-rich tap water with a mixture of colonizing plant Diasporas. Chlorophyll, a surrogate of algal biomass, was measured on the tiles and concrete samples to quantify the amount of algae grown on their surface.

Experimental Methods

Ceramic Tiles. Tile substrates were used in laboratory and field tests. Tiles were ordinary ceramic, industrial strength, unglazed quarry tiles 15 cm by 15 cm (Home Depot, Atlanta, GA). This type of tiles was selected because the smooth side of the tile simulated the surface of canal walls and antifouling coatings attached well.

Antifouling Coatings: Three coatings were tested on the tiles. 1) A water-based antifouling coating (EP 2000, E Paint Co., Falmouth, MA), which is recommended for use on all type of watercraft hulls; 2) A water-based protective barrier coating (Sunwave, E Paint Co., Falmouth, MA), a two-part coating recommended as a protective barrier coating for immersion service; 3) A white commercial paint (WCP). Tiles were coated following the manufacturer's instructions:

Briefly, three coats were applied with a theoretical film thickness per coat of 6-8 wet mils (1mil = 1/1000 inch) to obtain 3-4 dry mils. A dry-to-recoat period of 8 hours was followed.

Laboratory Tests with Antifouling Coatings. Recycle reactors were run in the laboratory to determine the inhibitory effect of the EP 2000 antifouling coating under lab conditions. The recycle reactor was a rectangular tank made out of ply propylene plastic (56 cm x 39 cm x 8.5 cm). Holed weirs were put on both ends of the reactor to smooth the flow of liquid medium into the center of the reactor. The reactor hydraulic residence time was set to 3.5 hours using a peristaltic pump with a flowrate of 2.8 ml/sec. Control and coated tiles were put alternatively in the middle of the reactor. Non-coated control tiles were used to compare the effects of antifouling coatings on untreated surfaces. To maximize the alga growth in the reactor, BG-11 medium was used [6]. The reactor was seeded with a mixed algae culture scrapped from the Arizona Canal. The algal culture was comprised of a mixture of Cyanobacteria, Chlorophyta and Chromophyta algal populations. An average light intensity of 50 umol m^{-2} s^{-1} (0.023 Watts m^{-2} s^{-1}) was provided with two 40-watts fluorescent tubes. Duplicates of control and coated tiles were taken from the reactor after one, two and three weeks. To collect the periphyton biomass, the tiles were put in Zip-lock bags to scrape biomass with a toothbrush and periodic rinsing with distilled water (100-200 ml). Scrapping was completed until all biomass was completely detached from the tile surface. Distilled water containing the scrapped biomass was then filtered with glass fiber filter (GF/C, Whatman, Maidstone, UK, ashed at 550 ^{o}C for two hours). Filters were rolled and put in a 50-ml plastic centrifuge tube for chlorophyll extraction as described in Standard Method 10200 H [5].

Leaching Tests. Leaching tests were conducted to determine the amount of H_2O_2 and zinc released by tiles when subjected to different sources of radiant energy (sunlight and fluorescent light). Coated and blank tiles were cut into 5 x 5 cm sections and put in 1-liter beakers with unfiltered AZ Canal water. Water samples were taken from the beakers at different contact times for H_2O_2 and zinc analysis.

Field Tests. Control and coated tiles were put in the AZ Canal in a custom-made tile holder. The capacity of the tile holder is 12 tiles. For details of the AZ Canal, see [4]. Coated and control tiles were left in the water for different periods of time ranging from one to three months. Tiles were taken from the tile holder, put in a Zip-lock bag, and stored in a cooler at 4 C during transportation to the laboratory. Biomass removal from the tiles was performed as previously discussed in the Laboratory Test Section. Biomass was also collected from the canal wall from an area close to the tile holder. Biomass was also collected from other sites along the AZ Canal to compare biomass density between sites. Canal wall biomass was collected to compare the amount of biomass growing on canal walls with that growing on the tiles. Biomass collection from canal walls was done using a custom-made periphyton sampler. For details of sampler and sampling procedure, see [4].

Concrete Samples Preparation. The effects of three cement additives were studied (fly ash (FA), Silica fume (SF), zinc oxide (ZN)). Concrete samples were prepared using different admixtures in ratios described in Table 1. Silica sand was used as the inert component of the mixture. A ratio of sand/cementitious solids of 0.8, water/cementitious solids of 0.5 and various levels of FA, SF, and ZN were used. Concrete constituents were mixed using a DR4000 tabletop

mixer. The materials were weighed on a balance with an accuracy of 0.001 and mixed using the standard mixing method. Briefly, the coarse aggregate (sand) was mixed first with 50% of water for 30 seconds. Then, all the materials were mixed together for 30 seconds. The final step involved the addition of water and mixing for 3 minutes to form a homogeneous mix. Concrete mixes were poured in a steel mold (0.0254 m x 0.0254 m x 0.30 m) and left for hardening. The molds were removed after 2 days of hardening. The samples were cured by completely immersing them in curing solution (10 % $Ca(OH)_2$) for 14 days. The cured concrete casts were cut into 0.0254 m x 0.0254 m x 0.0127 m size coupons with a diamond cone concrete saw. The coupons were classified based on their surface areas, size accuracy and roughness. Control samples were prepared without any chemical additive. Control samples were casted, cured and cut following the procedure described earlier. The control and admixed concrete samples were incubated in the algae growth chamber described in the next paragraph.

Table 1. Experimental matrix of concrete mixtures. W/C = Water/Concrete; S/C = Sand/Concrete

Sample ID	W/C Ratio	S/C Ratio	Admixture1	Amount, %	Admixture2	Amount, %
SF4ZN1	0.5	0.8	SF	5	ZnO	5
SF4ZN2	0.5	0.8	SF	10	ZnO	15
SF1	0.5	0.8	SF	10	N/A	N/A
SF2	0.5	0.8	SF	20	N/A	N/A
C1	0.55	0.8	N/A	N/A	N/A	N/A
C2	0.5	0.8	N/A	N/A	N/A	N/A
FA1	0.5	0.8	FA	20	N/A	N/A
FA2	0.5	0.8	FA	30	N/A	N/A
Plain	0.4	0.8	N/A	N/A	N/A	N/A

Algae Growth Chamber. The algae growth chamber was made in a steel frame with three layers (2.4 m x 2.1 m x 0.9 m). Each layer was 0.60 m high. Within each layer, three open channels were placed at a slope of 3%. The open channels were constructed of PVC pipes that were cut in half lengthwise. Each pipe was connected to plastic containers (0.6 m x 0.6 m). The plastic containers were used to stabilize the flow and transfer the liquid from each layer to the one below. A 75-L plastic container was used as reservoir at the bottom of the chamber. A 19-L plastic container was used overflow chamber at the top of the chamber. A magnetic pump was used to pump water from the main to the reservoir container via a 0.75" PVC pipe. Thereafter water flowed by gravity. Above the open channels on each layer of the frame, four sets of fluorescent lamps were continuously on to provide the illumination for the growth of algae. The study was conducted at ambient room temperature of 24 $\pm$ 3 °C.

Analytical Methods

Chlorophyll Analysis. Chlorophyll *a*, a major photosynthetic pigment present in cyanobacteria and other photosynthetic organisms is routinely used as a surrogate parameter to determine changes in algal biomass [4]. Chlorophyll content of algal biomass was done spectophotometrically following the Standard Method 10200 H [5]. Algal biomass was

concentrated by filtering sample with a glass-fiber filter (GF/C, Whatman, Maidstone, UK, ashed at 550 ^{o}C for two hours). Filter papers with the algal biomass were re-suspended in 30 ml of extraction solution (9:1 acetone:magnesium carbonate solution) to extract chlorophyll pigments. Filters were grounded inside the tube to improve the pigment extraction process. Centrifuge tubes were kept in opaque containers in the dark at 4 C for 24 hours. Samples were centrifuged at 3000 rpm for 5 minutes to separate the solids from suspension. After centrifugation, the samples were ready for spectrometric analysis (MultiSpec 1501, Shimadzu, Corporation, Kyoto, Japan).

MIB and Geosmin Analysis. Analysis of MIB and Geosmin was performed on a Varian Star 3400 CX gas chromatograph and mass spectrometer (GC/MS) using a solid phase microextraction method (SMPE) [4].

Hydrogen Peroxide Analysis. H_2O_2 concentration in solution was measured using the drop count titration method (HYP-1 Method, HACH, Loveland, CO).

Zinc Analysis. Zinc in solution was measured in water samples with a Zincon Method Kit (Method 8009, HACH, Loveland, CO), which is a modification of the Standard Method 3500-Zn B [5].

Radiation Energy. Radiation energy for the recycle reactor and leaching tests was measured with a radiometer/photometer (Model IL 1700, International Light, Newburyport, MA), equipped with a detector (Model SED005#776, Int. Light, MA) and a filter (DVD425#24739, Int. Light, MA). Light filter had a response in the 400-800 nm wavelength range. Radiation energy during the field tests was obtained from the Encanto weather station of the Arizona Meteorological Network of automated weather stations. The Encanto weather station was approximately 9 miles from the tile holder in the AZ Canal.

Results

Algae and Taste and Odor Problems in the AZ Canal

Production of T&O of periphytic algae origin in the AZ Canal have historically occurred [2, 7]. Excessive periphytic algae growth usually proceed T&O problems in summer and autumn months [2]. Figure 1 summarizes weekly MIB concentration measured along the AZ Canal in 2003. MIB is usually around 10 ng/L, the threshold odor detection limit, during winter and spring. However, MIB increases up to 100 ng/L in late summer and autumn. MIB concentration increased as result of higher temperatures and sunlight energy, two of the main energy sources for algae. Total daily solar radiation increases every year in a Gaussian pattern from approximately 12 Million of Joules per m^2 (MJ/m^2) in winter to approximately 30 MJ/m^2 in mid summer (Theoretical equation $MJ/m^2 = 20.7 * \exp[-(X - 170.21)^2/ 12{,}095.8] + 8$, X = day of the year]. Maximum daily temperature also follows the same Gaussian pattern (Maximum daily ^{o}C $= 22.31 * \exp[-(X - 204.68)^2/ 9{,}544.7] + 19.8$, X = day of the year].

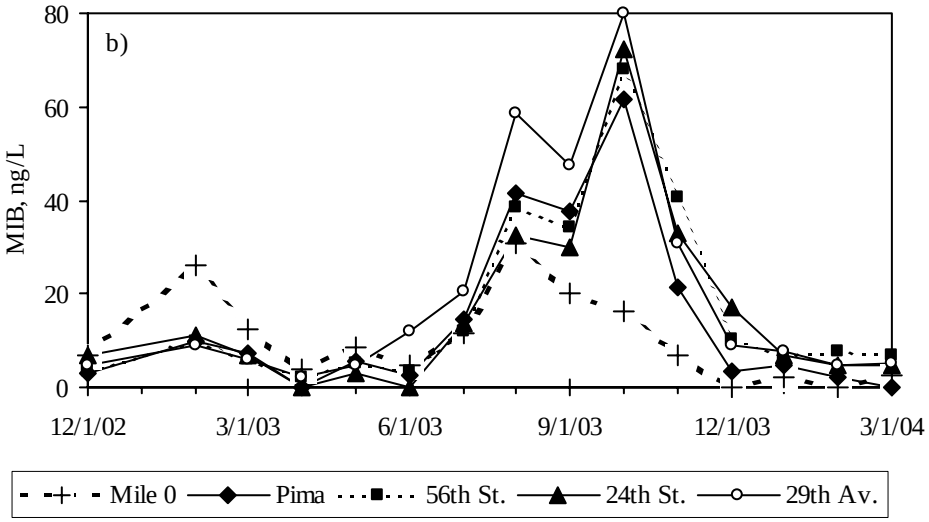

Figure 1. MIB concentration along the Arizona Canal during 2003.

Control of periphytic algae growth, with the subsequent reduction of T&O, has been accomplished in the AZ Canal by chemical [2] and mechanical [4] methods. The chemical method consisted in the application of different copper sulfate-based proprietary chemicals at concentrations less that 1 mg-Cu^{2+}/L to avoid damaging canal fish population [2]. The mechanical method consisted in brushing the canal wall with a tractor-mounted rotating metal brush [4]. However, both methods eliminated the periphytic algae and T&O problems for periods of two to three weeks. Re-application of chemicals and re-brushing of canal walls every three weeks was recommended to keep MIB concentrations close to the threshold detection concentration. Chemical and mechanical treatments of the AZ Canal were effective in reducing T&O problems in the AZ Canal. However, an alternative economic, less labor-intensive method with longer effectiveness periods was sought. Alternatives sought were the use of concrete and antifouling coating linings on canal walls to eliminate periphytic algal growth from canal walls before algae started growing and producing T&O.

Lab Scale Reactors

Lab recycle reactors were run to determine the effectiveness of an antifouling coating in inhibiting algal growth on a representative substrate under optimal growth conditions. Figure 2 shows the periphytic algae concentration that grew on coated and control tiles after one, two and three weeks. Chlorophyll-a was the dominant type of chlorophyll growing on coated and control tiles, indicating that coated tiles were growing the same type of algae as control tiles. Coated tiles had less periphytic algae than control tiles. After one week, coated tiles reduced periphytic algal growth 70 % when compared to control tiles. The percent of periphytic algae in coated tiles, relative to control tiles, decreased to 34 % after three weeks.

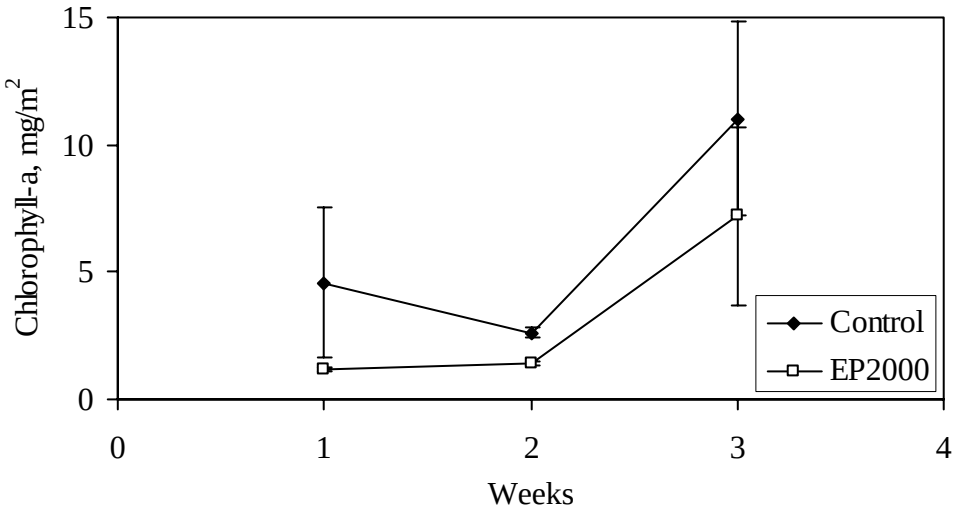

Figure 2. Periphytic algae chlorophyll-a of control and coated tiles (EP 2000) after three weeks in a recycle reactor. Flowrate = 2.8 ml/sec. Growth media = BG-11; Light intensity = 0.023 Watts*m^{-2}*s^{-1} from two 40-Watts fluorescent lights.

Photocatalytic By-products from Antifouling Coatings in Batch Reactors

Coated tiles and control tiles were submerged in beakers with AZ Canal water to quantify photocatalytic by-products released into solution when the coatings are exposed to light under water. Table 2 shows the photocatalytic by-products generated by two antifouling coatings under batch conditions in AZ Canal water. The concentrations measured in the batch reactors were corrected for the presence of each compound in the AZ Canal water. EP2000 generated less H_2O_2 and DOC than Sun Wave. On the other hand, EP2000 generated more Zinc and TDN than Sun Wave. The EP2000 control without light did not generated H_2O_2, indicating that light was photo catalytically generating this by-product. The EP2000 control tile without light generated less zinc, DOC and TDN than the EP2000 tile under the light. Zinc, DOC and TDN may be continuously leaching out of the EP2000 coating, but light and the concurrent photocatalytic process may induce the leaching of more zinc, DOC and TDN. Release of small amounts of H_2O_2 into solution may not be harmful to humans if present in drinking water, as this compound has been extensively used as oxidant to disinfect and purify water [8] and as preservative agent in the food industry [9]. The leaching of zinc from the antifouling coatings may also rise another health issue. However, zinc is regulated by the US EPA as secondary drinking water standard with a MCL of 5 mg/L [5].

Table 2. Photo catalytic by-products from two antifouling coatings under batch conditions (Water = Arizona Canal; Temperature = 25 ^{o}C; Total Radiation Energy = 28,400 J/m^2 from four 40-W fluorescent lights).

Sample	H_2O_2, mg/l	Zinc, mg/l	DOC, mg/l	TDN, mg/l
AZ Canal Water	0.4	0.01	3.41	0.31
EP 2000 I	0.2	0.66	4.73	0.80
EP 2000 II	0.2	0.68	5.18	0.89
EP 2000 w/o light	0.0	0.53	0.80	0.20
Sun Wave I	0.6	0.24	6.39	0.61
Sun Wave II	0.4	0.20	6.25	0.61

Antifouling Coating Performance in the AZ Canal

Table 3 shows the chlorophyll-a measured on canal walls, control and coated tiles after submersion in the AZ Canal for different time periods. The total solar energy for the same time periods is also included in Table 2. Figure 3 shows a detailed chlorophyll analysis of the samples after 12 weeks in the AZ Canal.

Table 3. Chlorophyll-a of control and coated tiles in the Arizona Canal after 3, 4, 6, 9 and 12 weeks submerged in the Arizona Canal. Standard deviations calculated for n = 2. The canal wall samples were collected from a spot approximately 6 feet upstream of the tile holder.

		Chlorophyll -a, mg/m^2				
Sample Name	**Weeks**	**3**	**4**	**6**	**9**	**12**
Canal Wall	**Average**	4.69	4.13	5.69	5.69	50.23
	Std. Dev.					
Control Tiles	**Average**	25.47	35.39	22.07	16.45	134.81
	Std. Dev.	5.16	0.33	21.27	8.28	16.45
EP2000	**Average**	0.09	0.28	0.13	0.06	1.47
	Std. Dev.	0.05	0.10	0.01	0.03	1.12
Sun Wave	**Average**	0.35	0.87		1.55	87.69
	Std. Dev.	0.05	0.42		0.86	16.45
White Commercial Paint	**Average**			22.54		
	Std. Dev.			0.93		
Total Solar Radiation, MJ/m^2		530	810	970	1475	1238

Control tiles had 3 to 8 times more algae than the canal wall adjacent to the tile holder, demonstrating that the selected tiles were good substrates. The amount of algae growing on the canal wall and the control tiles did not significantly varied between 3 and 9 weeks, 4-5 mg-chlor-a/m^2 and 16-35 mg-chlor-a/m^2, respectively (Table 3). However, the amount of algae on the canal wall and the control tiles increased approximately 10 times during the 12-weeks period. Similar growth trends were observed in other sections of the canal during the same time period

(Data not shown). The 10X increase in periphytic algae in control tiles during the 12-week period may be attributed to changes in water quality as canal operators change the source water blend at the head of the canal during late fall and early winter of each the year.

EP 2000 effectively reduced algal growth by 99 % when compared with control tiles for up to 12 weeks. However, Sun Wave was less effective than EP2000 in inhibiting algal growth. During the 3- and 12-weeks period, SW reduced algal growth between 98 and 35 % when compared to control tiles. During the 12-weeks period, the performance of Sun Wave significantly diminished as periphytic algae concentration increased from 1.55 mg-chlor-a/m^2 to 87.7 mg-chlor-a/m^2 (Table 3). The WCP was not a good antifouling option as many algae grew on the WCP tile as the control tile during a 6-week period (~ 22 mg-chlor-a/m^2) (Table 3). Approximately 30 % of the WCP detached from the tile during this 6-week period. No more experiments were performed with the WCP because of its poor performance.

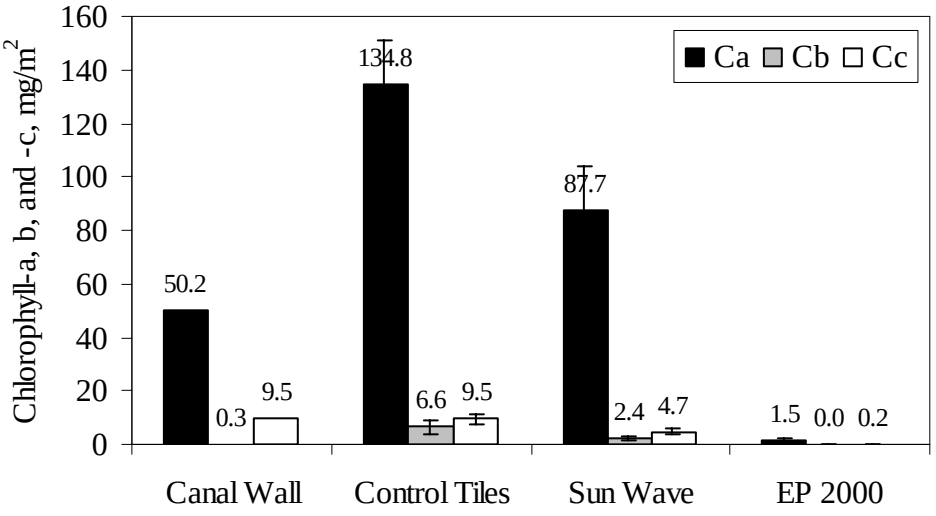

Figure 3. Chlorophyll of canal wall, control and coated tiles after being submerged 12 weeks in the Arizona Canal. Error bars represent one standard deviation for two sample replicates.

Concrete Samples Experiments in the Algae Growth Chamber

The chlorophyll content per unit of surface area (mg/m^2) of nine concrete samples after 4 and 10 months is presented in Figure 4. The data shows a clear difference in the chlorophyll content between the samples with zinc oxide and the samples without zinc oxide. The impact of additives can be seen even after ten months of algal growth (Figure 4b). This trend is seen for chlorophyll B and C concentrations, suggesting that zinc oxide is effective at suppressing the growth of algae belonging to Chromophyta and Chlorophyta species. Moreover, an increased suppression in the growth of groups of algae was observed with the increasing concentration of zinc oxide.

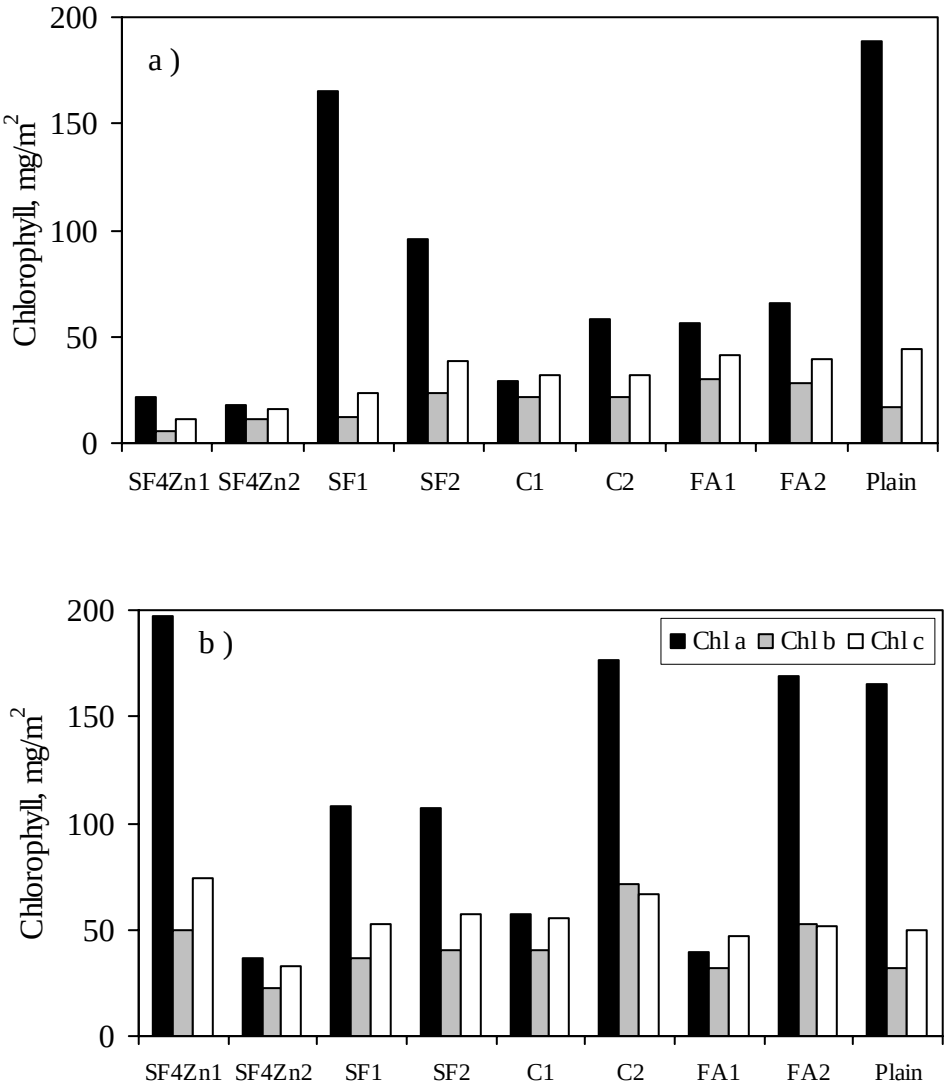

Figure 4. Chlorophyll of different concrete samples after a) four months and b) ten months in the algae growth chamber.

Conclusions

The main findings of this research are:

- EP2000 had better periphytic algae inhibitor than Sun Wave.
- EP2000 and Sun Wave reduced periphytic algae growth by 99 % and 35 % for up to 3 months when compared to control substrates.
- The antifouling Coatings EP 2000 and Sun Wave leached H_2O_2 and zinc as result of the photocatalytic action of sunlight.

- Algal growth was inhibited in cement samples as their zinc oxide concentration increased.

More field-scale experiments are under way to test the inhibition effectiveness of EP2000 and Sun Wave on other source water, the Colorado River water. Coated tiles are being also tested for longer time periods in both source waters. More detailed leaching tests are also being performed. A more comprehensive experimental matrix involving 40 mixture designs is currently in progress. Additional admixtures will include copper slag, copper sulfate, ammonium chloride, sodium bromide, and cetyl-methyl-ammonium bromide.

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APPENDIX - CHARACTERIZATION OF ORGANIC CARBON FROM WATERSHEDS AFTER FOREST FIRES (AWWA ACE 2004 CONFERENCE PROCEEDING)

Characterization of Organic Carbon from watersheds after Forest Fires

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Abstract

Many drinking water supply watersheds are forested, and forest management over the past century has focused on suppression of forest fires. The watersheds of 3,400 community water systems (CWSs) serving 60 million people in 900 cities are located within National Forest lands [1]. Many of the water supply systems are small, serving a few hundred to a few thousand people, and lack the technical and financial resources to deal with fire impacts on their water supplies on their own. Since 70% of the forest area in the USA is outside of National Forest lands, the number of people relying on forest land for water supplies is much greater. Growing populations at the wildland-urban interface, limited source water supplies, expanding areas of drought, and ever-tightening federal drinking water regulations increase the potential for wildland fires to seriously impact municipal water supplies. Wildland fires like the Hayman and Missionary Ridge fires in Colorado and the Rodeo-Chediski fire in Arizona can have a deleterious impact on water quality in drinking water watersheds. Introductory material in the presentation will cover the range of pollutants commonly associated with runoff after forest fires, in relationship to MCLs. Most of this pollutant load (>95%) is generally associated with particulate materials. The fate of these particulates in rivers, reservoirs, and water treatment plants is of a significant concern, and affects the longer-term duration impacts of the forest fires on water quality. The focus on organic carbon is of particular importance to the drinking water industry (i.e., DBP precursors, source of non biologically stable water).

Background

Forest fires produce immediate effects on nutrients in ecosystems, which in turn impact effected water bodies in the watershed. These effects include the volatilization of nitrogen as gas from

plant materials, mineralization of calcium, potassium, and magnesium as oxides followed by conversion to soluble carbonate salts [2-5]. Water quality parameters examined in the literature following wildfires included nutrients, organics, and ions.

Tiedemann et al studied water quality changes in receiving streams following a fire in central Washington in 1970 [2]. They found that the maximum nitrate-nitrogen concentrations increased primarily due to increased nitrification following the fire. This nitrification was likely due to reduced demand for nitrate nitrogen by vegetation, as well as increased soil pH and electrolyte concentration as a result of the fire [3]. Total phosphorous concentrations also increased 1.5 to 3 times concentrations in unburned watersheds. Concentrations of calcium, magnesium, potassium and sodium decreased below concentrations measured previous to the forest fire. The study concluded that changes in nitrate nitrogen, phosphorous, and ion concentrations produced negligible effects on water quality for municipal use [2].

Carignan et al noted that few studies have focused on the effects of fire on lake chemistry and hydrology [6]. Four major wildfires occurred in Quebec during the summer of 1995. Carignan et al conducted research to study the effects of these fires on impacted lakes. Burnt lake water quality was compared with reference lakes to determine fire impacts. Burnt lakes had higher concentration of total phosphorus (2 to 3 fold), total organic nitrogen (2 fold), and K^+, Cl^-, and Ca^{2+} (up to 6 fold). The ions K^+, Cl^-, SO_4^{2-}, NO_3, and some dissolved organic carbon (DOC) were rapidly flushed through the watersheds, showing a 50% decrease over three years. Other parameters, total phosphorous, total organic nitrogen, Ca^{2+}, and Mg^{2+} were still increasing or stayed the same three years following the fire. Possible explanations for low DOC concentrations in burnt lakes included the loss of organic carbons sources (leaves, shrubs, vegetation), the combustion of the organic topsoil due to fire, and loss of some DOC through sorption to ash and charcoal left behind by the fire [6].

Water quality studies of the Pecos and Gallinas rivers in New Mexico were studied following the 29,000 acre Viveash wildfire in May 2000. They saw a large increase in turbidity, total suspended solids (TSS), total dissolved solids (TDS), total phosphrous (TP), sulfate and chemical oxygen demand (COD) in the Pecos River in succeeding months [7]. Several metals were also measured in the Pecos river. Mercury and aluminum concentrations exceeded chronic standards at least ones in the months immediately following the fire. Cyanide was also measured in the rivers and will be discussed under the Heavy Metals section of this review. Hopkins' research did not include effects of the fire on receiving reservoirs at the time his report was printed.

Garcia and Carignan documented water quality effects following forest fires in Canadian lakes in Boreal forests [8]. Concentrations of sulfate, nitrate-nitrogen, TP, and chlorophyll-a were significantly higher in burned lakes than in reference lakes ($P > 0.01$). Dissolved oxygen concentrations, pH, alkalinity, and temperature were similar between burned and reference lakes.

Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are a group of different chemicals that are formed during the incomplete burning of oil and gas, coal, garbage or other organic substances like

wood [9]. The Center of Disease Control (CDC) provides a summary of the environmental occurrence of PAHs and health effects associated with these compounds. PAHs may enter the air when released due to forest fires. PAHs do not dissolve easily in water and stick to solid particles that settle to the bottom of lakes or may move through soil to contaminate groundwater. PAHs may break down by reacting with sunlight or other chemicals, or some microorganisms can break down PAHS in soil or water over weeks or months. PAHs may be transferred through drinking water and have been shown to cause birth defects in mice and some PAHs may reasonably be expected to be carcinogens [9].

Research was conducted in Malaysia to determine the source of atmospheric PAHs, using isotopic composition, following a 1997 fire in Indonesia [10]. Polycyclic aromatic hydrocarbon source identification was examined because of differing toxicity and genotoxicity of PAHs [11]. The research indicated that the fires did not significantly impact PAHs levels in Malaysia. However, Okuda et al, were able to identify compound specific carbon-isotope analysis of PAHs for source identification; a technique that may be useful in future PAH research [10].

Dioxins

Dioxins are persistent organic pollutants that are by-products of natural processes such as forest fires, and industrial processes [12]. The World Health Organization fact sheet on dioxins explains that dioxins consist of a family of structurally and chemically related polychlorinated dibenzo-para-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and polychlorinated biphenyls (PCBs). Dioxins dissolve in fats and have a half-life in the body of several years. Environmentally, dioxins bio-accumulate in the food chain. Short-term human exposure to dioxins may result in skin lesions and altered liver function. Long-term exposure may lead to impairment of the immune system, nervous system, endocrine systems and reproductive functions [12].

Following extensive forest fires in Alberta Canada (1998), polynuclear aromatic hydrocarbons, PCDD/Fs and PCBs in sediment were studied [13]. Gabos et al found a predominance of alkylated polynuclear aromatic hydrocarbon derivatives over parent polynuclear aromatic hydrocarbons. The presence of the polynuclear aromatic hydrocarbons was attributed to wood combustion. Very low concentrations of PCDD/Fs and PCBs were measured; the presence of these compounds was attributed to atmospheric contributing sources.

Heavy Metals

Forest fire ash may contain heavy metals. Living plants can extract and concentrate metals from their environments. In addition to trace metals utilized by plants for growth, these heavy metals may include cadmium, chromium, lead, cobalt, silver, selenium, and mercury [14]. The transport of mercury, cyanide and cadmium following forest fires has been documented. Cadmium transport is further discussed as it relates to algae growth.

Mercury. Mercury is deposited into catchments via atmospheric deposition [15]. Typically watersheds retain deposited mercury until it is mobilized following watershed disturbances such as forest fire [8, 16]. Increased runoff due to fire, leads to an increase of mercury and organic carbon in water reservoirs. Organic and inorganic matter provide a carbon source for methylation processes in lake sedimentation. Monomethylmercury may be produced following

fire runoff events through methylation processes. Monomethylmercury is the most toxic mercury compound [17]. Caldwell et al studied the effects of forest fire on the distribution of mercury and monomethylmercury in an arid land reservoir in south-central New Mexico [18]. They found that fire had a twofold effect on mercury concentrations. One, mercury trapped in a catchment was mobilized and found in sediments downstream from the burned area. Two, allochthonous organic carbon may promote the production of monomethylmercury through methylation. Hopkins also identified elevated levels of mercury in the Pecos River (400 ng/L) following the Viveash fire in New Mexico, but the mercury source was undetermined [7].

Garcia and Carignan explain that forest fires may influence the transport of mercury to aquatic ecosystems [8]. After a medium-intensity fire, the top layer of organic soil is exposed to erosion and transfers particulate and dissolved organic carbon to aquatic systems[19]. The DOC in soil is a vector of some metals including mercury and thus the concentration of mercury is expected to increase in effected waters [20]. High-intensity fires are more likely to cause the organic matter in the soil to mineralize and elements associated with the DOC may volatilize [21]. Garcia and Carignan's research focused on the effects of fire on the methyl mercury contamination of the zooplankton community. Methyl mercury was chosen because it accumulates and is bioamplified along the food web. The DOC loading in the burned lakes observed did not increase even when soil exposure increased following fire. Consequently, little change in methyl mercury concentrations was observed. The methyl mercury concentration may not have increased due to loss through volatilization, or dilution of mercury levels associated with biota due to the nutrient and productivity pulse following fire. For this study DOC was the most important predictor of methyl mercury concentrations, but Garcia and Carignan concluded that this relationship is still not well understood [8].

Cyanide. Increased levels of cyanide may be found in water following forest fires. Some cyanide may be produced naturally during forest fires [22], however a more common cyanide source is fire retardant slurries. Little and Calfee [23] explain that sodium ferrocyanide is often used as an anticorrosion agent in fire retardant. They further explain that sodium ferrocyanide has been shown to release Cn^- ions when exposed to high temperatures or UV radiation. Fire retardant containing sodium ferrocyanide was used in combating the Viveash fire in New Mexico. Hopkins reported levels of cyanide in both water and sediment at the Pecos River at levels up to 120 ug/L.

Algal Response

Forest fires impact algal communities in effected watersheds. Fires lead to increased flow, silt loads, and chemical concentrations in watersheds [24]. Water quality is impacted and productivity may be modified due to increased nutrient concentrations and decreased light penetration [6, 25]. Increased nutrients and changes in light penetration effect algae as well as increased heavy metal loads in the watershed following fires [14].

Planas et al [26] examined overall algal response in nine lake watersheds burned (50-100% of watershed area) in 1995. The impacted lakes were sampled for three years following wildfires. In the burnt lakes, benthic chlorophyll-a concentrations were as high as 100 mg/m^2 two years following the fire, with the highest corresponding reference lakes chlorophyll-a concentration of 30 mg/m^2. On average the chlorophyll-a concentrations increased 1.4- to 3- fold in impacted

lakes when compared with sixteen reference lakes. Phytoplankton was sampled three times per year, during the spring, summer and fall. Photoautotrophic diatoms increased in burnt lakes. During the three-year study, the most significant algal response was measured during the second year following the fires. Biomass increased and major taxa shifts were seen in burnt lakes. Algal biomass was proportional to the perturbed fraction of the catchment's area divided by the catchment's lake surface area.

Pace and Cole [27] assessed respiration following whole lake manipulations. Nutrients were added in the form of inorganic nitrogen and phosphorous. In general, planktonic respiration increased with nutrient addition, and was independent of DOC. Dissolved organic carbon was correlated with respiration in untreated lakes, but not with respiration responses in nutrient treated lakes. There were differences noted in respiration measurements of lakes treated with similar nutrient loads. These differences were attributed to zooplankton grazing determined by food web structure in the lakes.

Shin et al [14] examined the impact of cadmium (Cd) transferred by forest fire ash on micro- and macroalgae. Burned wood samples of the impacted watershed showed high concentrations of Cd and were considered to be the main source of Cd observed in receiving waters. Large quantities of Cd have been reported in several forest tree species, particularly in conifers [28, 29]. Cadmium is toxic to laboratory microalgae cultures [30]. The purpose of Shin et al's study was to determine the effects of forest fire ash containing Cd on the growth of the micoralga, *N. oculata* and the macrophyte *Ulva pertusa*. Their research documented a 20% reduction in the growth rate of *N. oculata* at low dosages of Cd (0.224-0.448 mg/L). At higher concentrations of Cd (1.792 mg/L), pigments were completely leached from both the micro- and macroalgal cultures. Bioaccumulations factors for the cultures indicated excessive bioconcentration of Cd [30].

Summary

In conclusion, the effects of wildfire on water quality include increases in nitrogen, phosphorous, and ion concentrations. Polycyclic aromatic hydrocarbon and dioxin concentrations are anticipated following forest fires. However, limited literature was available on PAH and dioxin concentrations following fires. Malaysian research provided a means of distinguishing PAHs released by combustion of wood from PAHs produced by fossil fuel combustion. Some dioxins have been monitored following fires, but no significant changes were observed. Based on the potential health hazards associated with PAHs and dioxins additional research in these areas may be appropriate in subsequent years following the Rodeo-Chediski fire. Forest fires also lead to increases heavy metal concentrations. Specific heavy metals discussed in the literature included mercury, chromium and cyanide. Finally, forest fires have been shown to effect algal growth through changes in nutrient loading, light penetration, increase in trace metals required for growth, and the addition of some heavy metals that are toxic to algae.

Preliminary results: long-term assessment

The summer of 2002 marked the occurrence of the largest and most severe forest fire in Arizona history, the Rodeo-Chediski fire. The Rodeo-Chediski fire began as two individual fires that merged to form one wildfire in eastern Arizona along the Mogollon Rim. The Rodeo fire began on June 18, 2002 on the Fort Apache Reservation northeast of Cibeque, Arizona. By June 20,

the fire had burned nearly 30,000 acres [31]. Also on June 20, another wildfire began northwest of Cibeque near Chediski Peak, the Chediski fire. The Rodeo and Chediski fires began approximately 15 miles apart. Within a day of the Chediski fire being reported, over 10,000 acres had already been consumed by fire. Due to the inclement weather conditions of drought and crosswinds, the fires burned out of control and merged to form the Rodeo-Chediski fire on June 23. The fires already burned more than 235,000 acres, an area equivalent to that of Tempe, Scottsdale, Mesa, and Chandler (Arizona). The fire continued to burn for the next two weeks, during which time thousands of people were evacuated from their homes until the blaze was contained and controlled. On July 7, the most destructive fire in Arizona was declared contained (Figure 1).

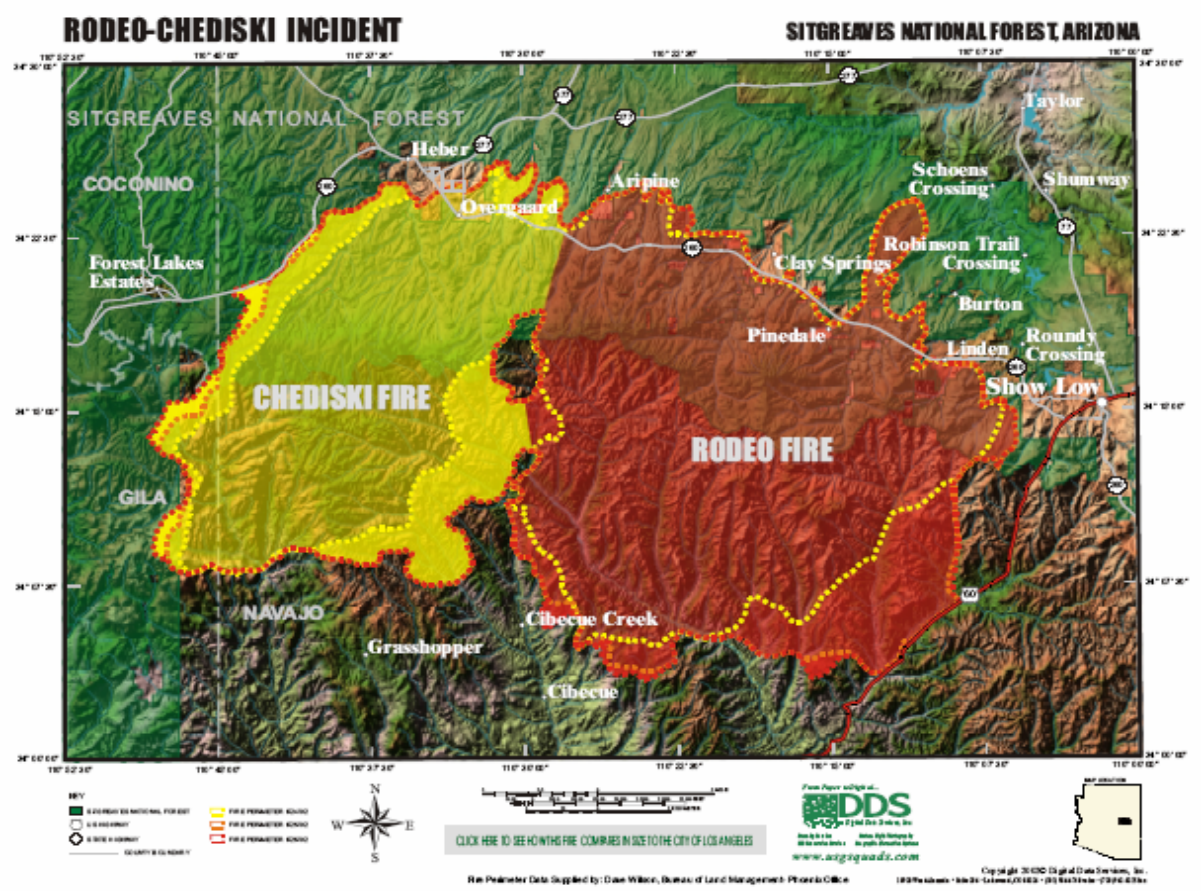

Figure 1. Area burned by the Rodeo-Chediski Fire (from http://www.usgsquads.com/downloads/maps/rodeo.pdf)

The fire devastated land within the Fort Apache Reservation, Apache-Sitgreaves National Forest, and Tonto National Forest, in addition to privately-owned land. The fire burned approximately 462,600 acres of land. 305,114 acres which was within the Salt River watershed. This represents ~11% of the Salt River watershed (Figure 2).

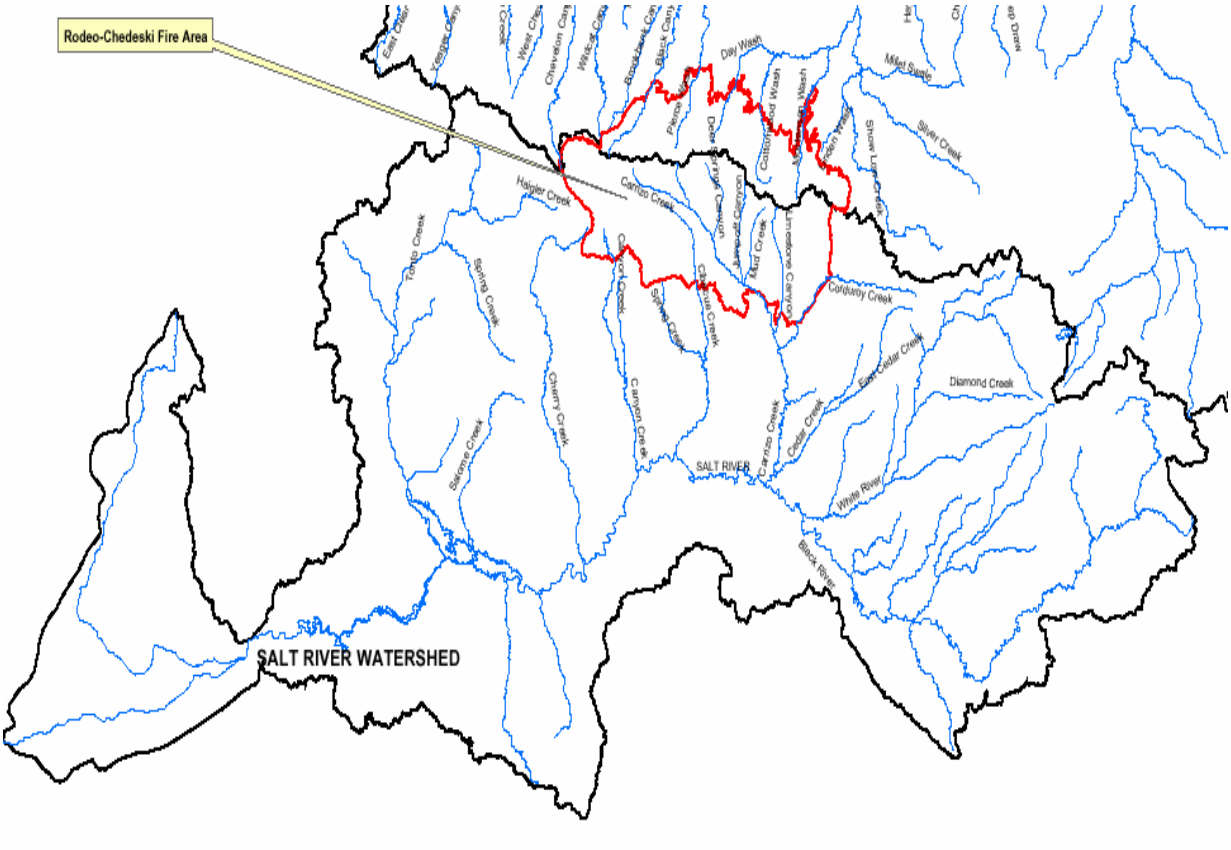

Figure 2. Burned area of Rodeo-Chediski fire and the Salt River watershed

The Rodeo-Chediski fire had evident short-term effects on water quality, such as ash and soot being transported into the Salt River. However, the extent of the long-term effects needs to be investigated. The lack of vegetation, such as chaparral, ponderosa pine, juniper, and brush caused increased run-off during storm events; therefore, causing nutrients, such as nitrogen, organic carbon, and phosphorous to be washed away. The nutrients were then deposited into the Salt River, which is a source of drinking water for the Phoenix Metropolitan area. The influxes of nutrients are of concern since nutrients cause eutrophication. The elevated levels of bacteria and algae may adversely impact drinking water because both produce chemicals that have been linked to taste and odor problems in the drinking water.

To determine if the Rodeo-Chediski fire adversely affected the quality of the drinking water, historical water quality data for the Salt River was analyzed, including nitrogen, phosphorous, organic carbon, and suspended sediment concentration data. Continuous flow data from 1913 – 2003 was utilized as well. A hydrograph for the Salt River since 1913 was generated to display the change in flow rates over time (Figure 3). Another hydrograph beginning in 2000 was created to display the flows prior to and immediately following the Rodeo-Chediski fire (Figure 3 inset). The increase in flow in the latter part of 2002 represents the major runoff event (i.e., first flush). The data was obtained from the United States Geological Survey (USGS) National Water Quality Assessment Program (NAWQA) and the USGS National Water Information System (NWIS) Data.

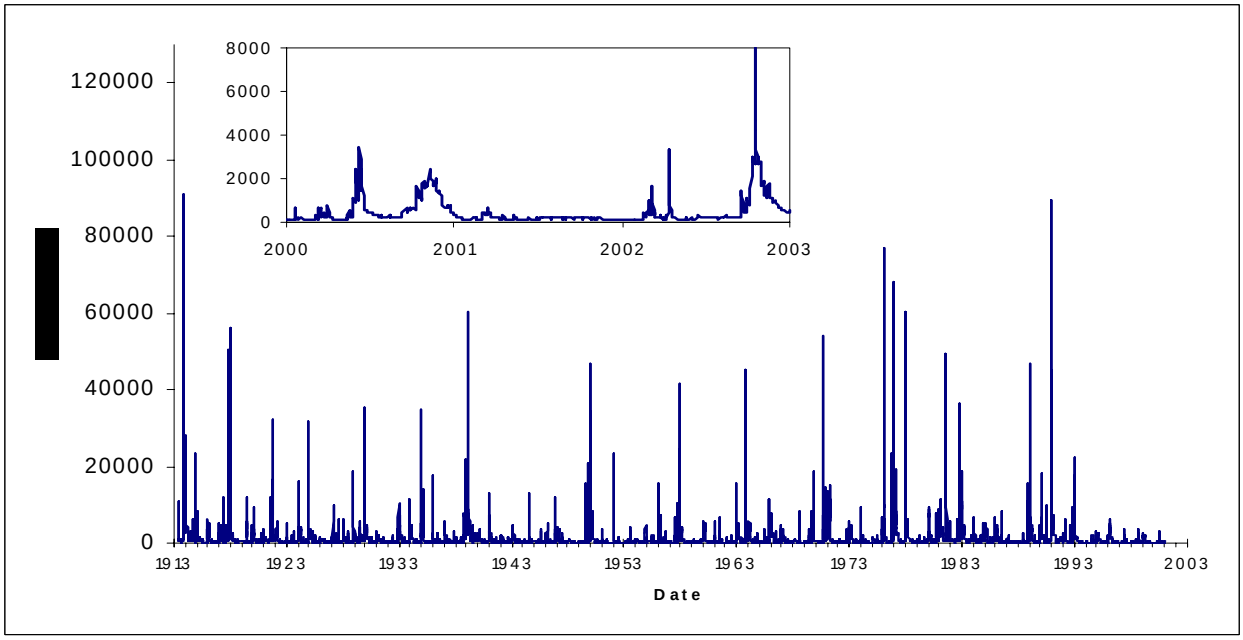

Figure 3. Salt River hydrograph 1913-2003

Two different methods were used to calculate the loadings for each of the constituents: the Simple Method (Equation 1) and Beale's ratio (Equation 2). Both methods take advantage of continuous flow data. However, Beale's ratio is preferred when the loading needs to be estimated with limited concentration data availability because it maintains a constant ratio between concentration and flow rate.

$$L_i = Q_i * C_i \qquad \text{Equation 1}$$

$$L_i = \frac{2.45 * \sum_{j=1}^{n} A_j * C_{ij} * Q_j}{\sum_{j=1}^{n} A_j} \qquad \text{Equation 2}$$

Where,

L_i = mean load estimate (kg) for the time interval
Q_i = daily flow rate (cfs)
C_i = concentration at the midpoint of the interval (mg/L)
n = time interval (days) and is one-half the duration between concentration measurements
A_j = 1 if the concentration data is available or 0 if it is not available
C_{ij} = concentration measured within the time interval
2.45 is a conversion factor for converting mg/L and cfs to kg/day

To determine wheterh or not the concentrations of the selected constituents have increased since the fire, concentration and flow rate data were used. An increase in total organic carbon (TOC)

(Figure 4) and dissolved organic carbon (DOC) (Figure 5) concentration was observed. There is also a noticeable increase in total phosphorous (TP) (Figure 6) and dissolved phosphorous (DP) (Figure 7) concentration. Although there was a rise in total nitrogen (TN) (Figure 8) concentrations, nitrate-nitrite (Figure 9) and ammonia (Figure 10) concentrations had minimal impact in the total nitrogen increase. Suspended sediment concentration rose slightly. However, this could be anticipated due to erosion.

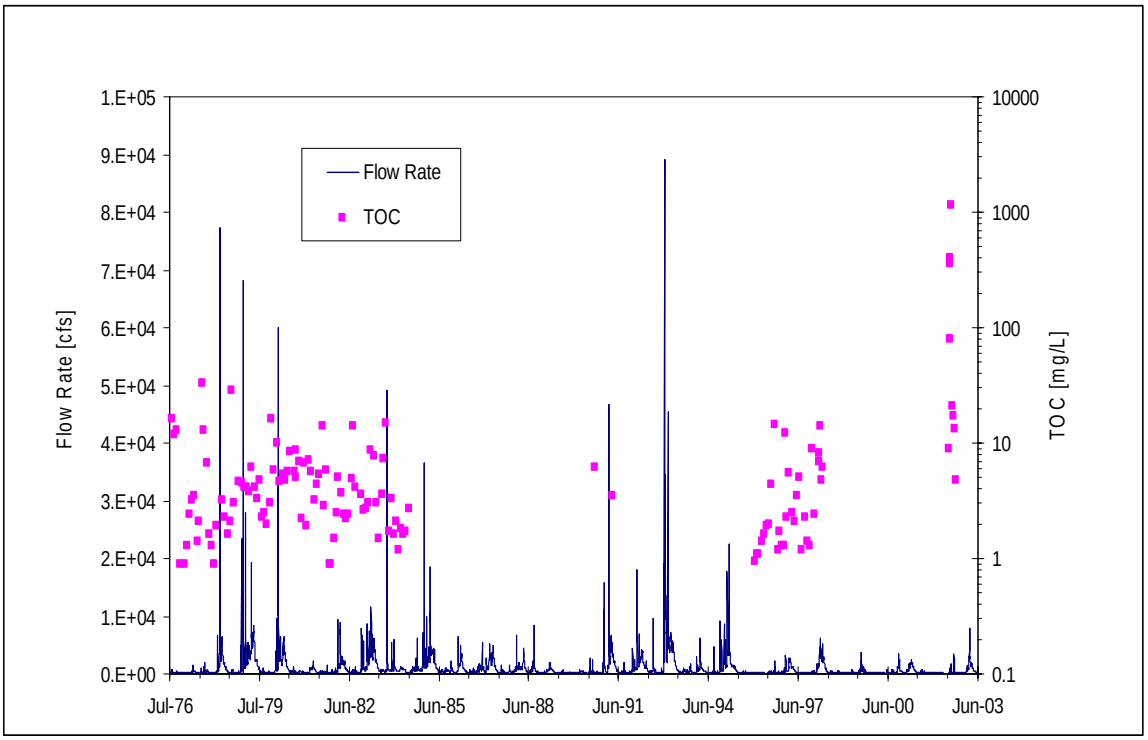

Figure 4. Annual variation of TOC concentration and flow rate in the Salt River

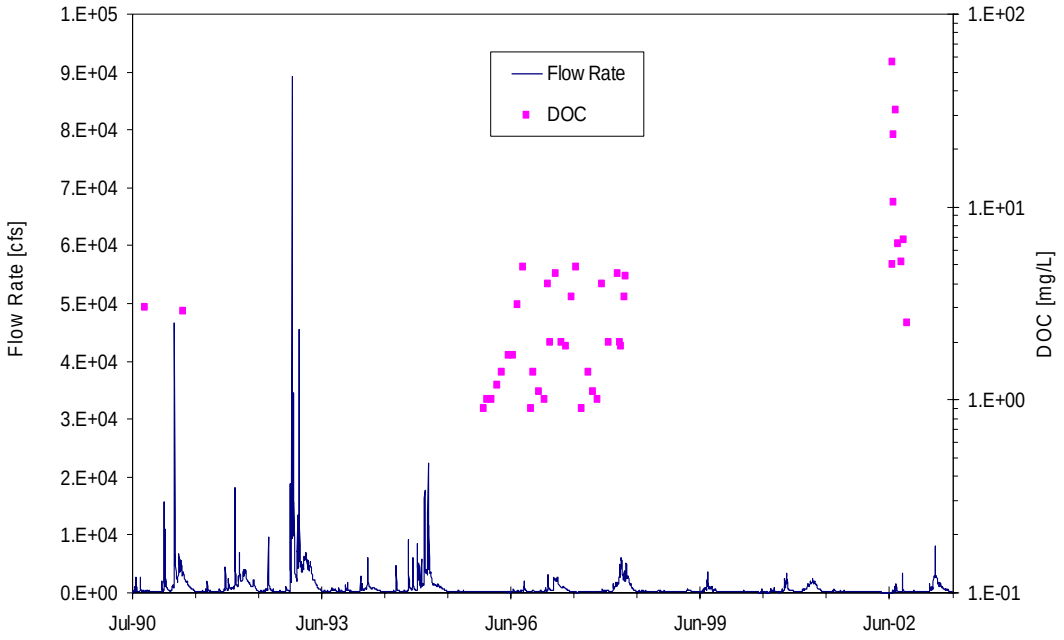

Figure 5. Annual variation of TP concentration and flow rate in the Salt River

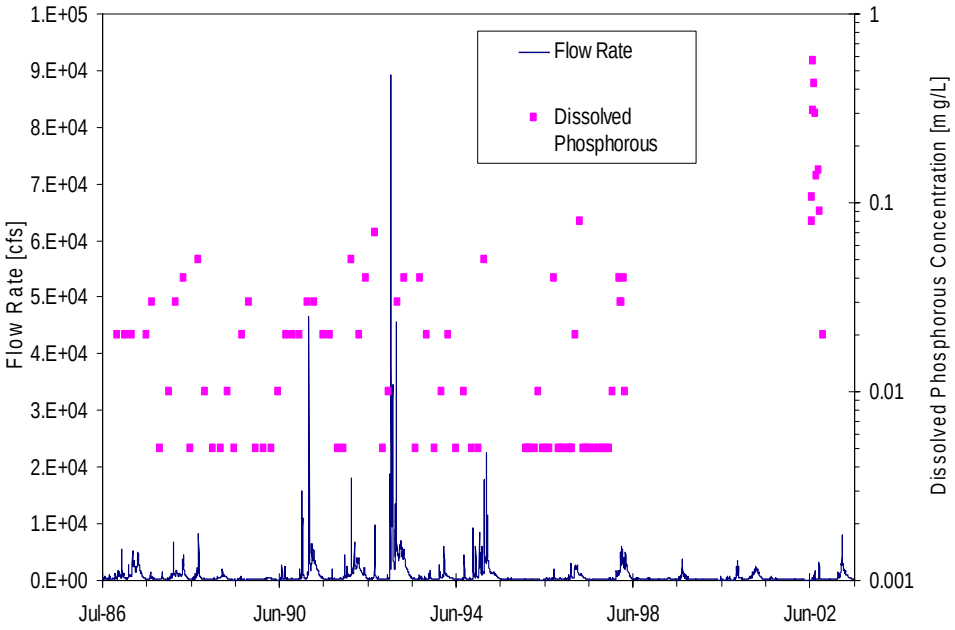

Figure 6. Annual variation of DP concentration and flow rate in the Salt River

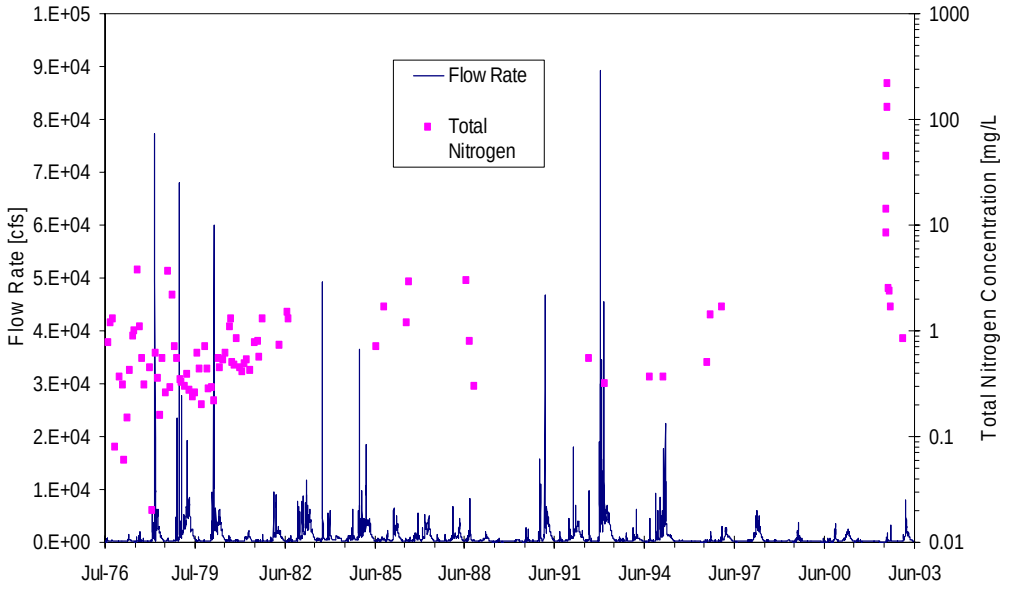

Figure 7. Annual variation of TN concentration and flow rate in the Salt River

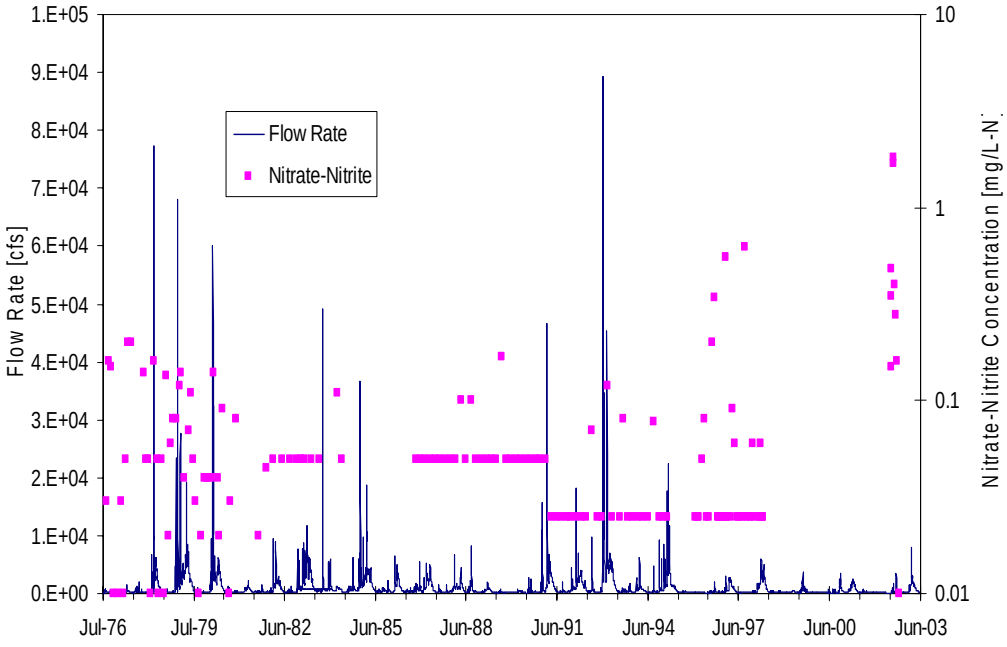

Figure 8. Annual variation of nitrate-nitrite concentration and flow rate in the Salt River

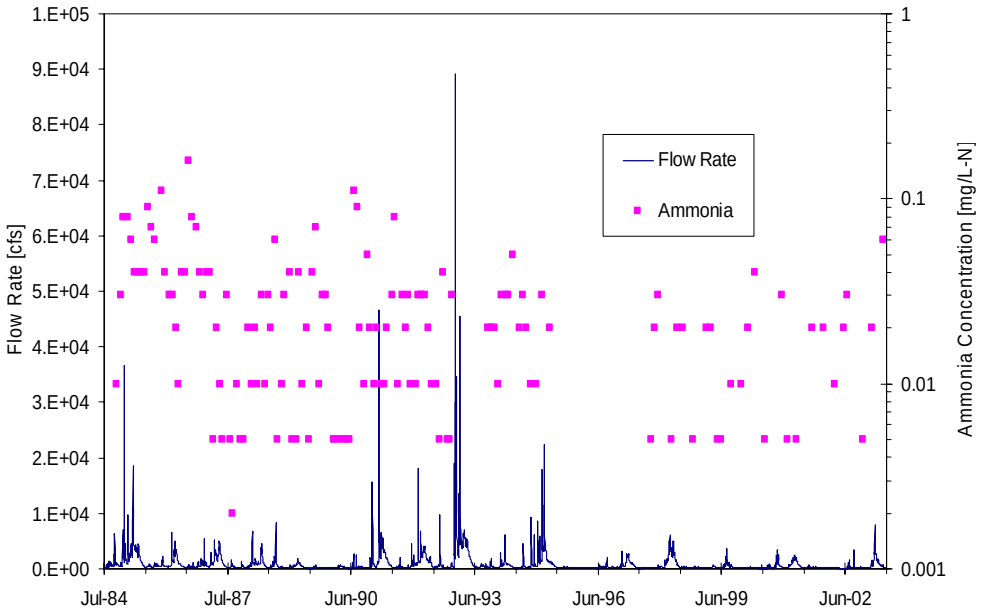

Figure 9. Annual variation of ammonia concentration and flow rate in the Salt River

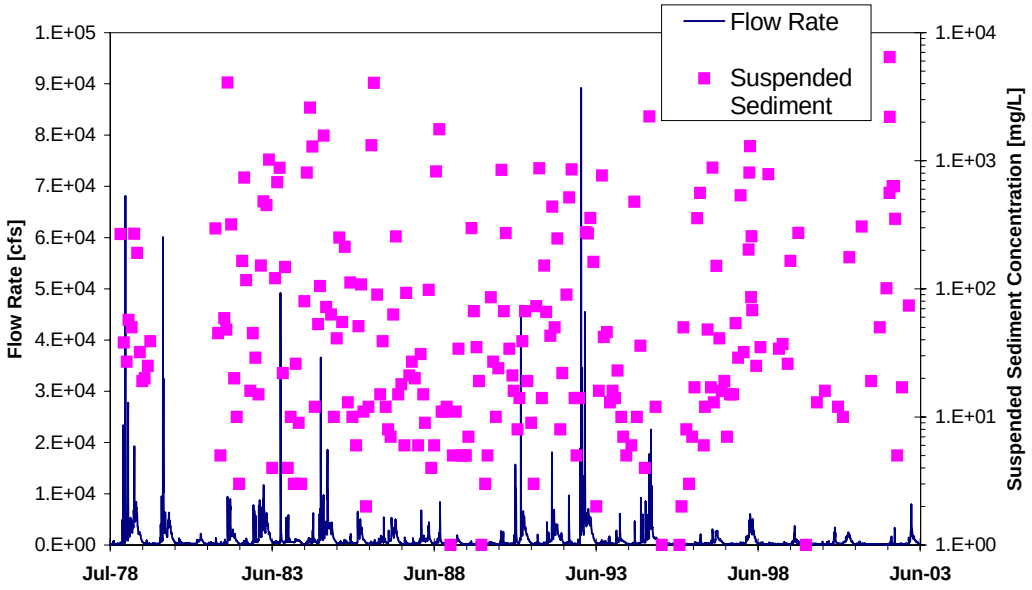

Figure 10. Annual variation of suspended sediment concentration and flow rate in the Salt River

The loading for each constituent (Table 1) was estimated using Beale's ratio.

Table 1 Loading for each constituent analyzed using Beale's ratio

Constituent	Loading (10^5 kg)	Concentration Data Range[1]
TOC	3794	1976-2003
DOC	472	1990-2003
TP	356	1986-2003
DP	5	1976-2003
TN	945	1976-2003
Nitrate-Nitrite	20	1976-2003
Ammonia	4	1984-2003
Suspended Sediment	829,647	1978-2003

[1]A year for concentration data is from July 1-June 30

The fraction of particulate concentration in the Salt River makes up a large portion of the concentration of organic carbon, phosphorous, and nitrogen. The particulate fraction is the difference between the total concentration and dissolved concentration for a particular nutrient. This is evident since 12% of the TOC is DOC, 1.4% of TP is DP, and 2.5% of TN is TDN. The nutrients in the dissolved phase will remain in the Salt River system for a shorter time period than the nutrients contained within the particulate fraction. The particulate portion is very likely to settle in the bottom of Roosevelt Lake, which is the reservoir that the Salt River flows directly into. The nutrients will then be slowly released into the water. This is a slow process due to the limited biological activity that occurs at the bottom of a lake. As the nutrients are released, a food source for algae and bacteria is created. Therefore, the higher the concentration of nutrients within the particulate fraction, the more likely algae and bacteria growth will be stimulated over time. The enhanced growth could hold potential for long-term taste and odor problems within the drinking water supply.

Preliminary results: NOM Fractionation and Characterization

A large volume sample was collected from the Salt River above Roosevelt during one of the first runoff-events (8/5/2002) following the forest fire. Visual observation indicated the presence of floating charcoal, similar to powder activated carbon. The sample had a TSS of 9060 mg/L, with a VSS of 1430 mg/L. The TOC was > 100 mg/L and the DOC at the time of NOM isolation was 32 mg/L, with a SUVA of 4.7 $(\text{m-mg/L})^{-1}$. 17% of the DOC was biodegraded in a 5-day BDOC aerobic reactor. Filtered water was subjected to XAD resin chromatography (Table 2), following methodologies developed by Aiken et al. Solid-state ^{13}C-NMR, FTIR and elemental analysis of each sample was conducted. The XAD8 acid fraction contained a high percentage of aromatic material. The neutral fraction contained aliphatic carbon indicative of carbon singly bonded to oxygen or nitrogen. Further description of the results will be provided at the time of presentation.

Table 2 – NOM Fractionation of Salt River Sample (8/5/2002)

NOM Fraction	Percentage Total DOC
XAD8 acid fraction	29%
XAD4 acid fraction	21%
XAD4 + XAD8 Neutral Fraction	27%
Polar non-isolated fraction	23%

Conclusions

Upon analysis of the USGS and NAWQA data, the forest fire has had obvious impacts on the Salt River. This is evident due to the increase in TOC, DOC, TP, DP, and TN concentrations after the fire. The rise in nutrient concentrations can have negative effects on drinking water quality since the potential for taste and odor problems within the drinking water supply is increased. The potential for long-term effects of the nutrients is present due to a large portion of organic carbon, phosphorous, and nitrogen being concentrated within the particulate fraction.

Acknowledgements

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APPENDIX – EXECUTIVE SUMMARY FROM DRAFT FINAL REPORT AWWARF #2775: OZONE-ENHANCED BIOFILTRATION FOR MIB AND GEOMSIN REMOVAL

EXECUTIVE SUMMARY

Tastes and odor (T&O) in water is a common source of customer complaints for water utilities. A survey conducted in more than 800 utilities in United States and Canada had found that 16% of the utilities experience serious T&O problems, and that Utilities spend an average of about 4.5% of their total budget on T&O control. In particular, control of earthy/musty odors is a worldwide concern. Often these earthy/musty odors are caused by the odorants 2-methyisoborneol (MIB) and/or trans-1,10-dimethyl-trans-9-decalol (geosmin). Microorganisms present in surface waters (blue green algae, actinomycetes) produce MIB and geosmin, resulting in part-per-trillion concentrations in water supplies. Ozone-enhanced biofiltration is widely used to achieve multiple water quality benefits (disinfection, trace organic removal, natural organic matter removal) and effectively removes odorants such as MIB and geosmin. However, there is little guidance available for the selection of appropriate ozone dosages or the role of biofiltration for direct oxidation or biodegradation of the odorants.

Although ozonation is very effective in removing MIB and geosmin, the lack of information on oxidation mechanisms (O_3 vs $OH^{\bullet}$ radicals) prevents optimization of ozone for T&O control, DBP control and microbial control. Much of the information on MIB and geosmin oxidation by ozone are dose-response relationships, which are inherently difficult to extrapolate from one pilot study or water to another location. Ozonation byproducts include identifiable low molecular weight oxygenated organic compounds and oxidized NOM, much of which serves as BDOC material for sustaining biological communities in biofilters. While ozonation itself may produce T&O, while oxidizing MIB and geosmin, many of those biodegrade during biofiltration. Most full-scale ozonation facilities apply less than 1 mgO_3/mg TOC to control MIB and geosmin, but there is little information available to determine if this is an optimal dose when ozonation is proceeded by biofiltration. MIB and geosmin remaining after ozonation should be biodegraded, yet few studies are available that directly quantify the extent of removal in well acclimated and controlled biofilters. In the available studies, biofiltration removes from <10% to >90% of the influent MIB or geosmin. This project aims to better understand ozone-enhanced biofiltration for MIB and geosmin removal by providing information on the above mentioned research gaps.

RESEARCH OBJECTIVES

The project emphasized the optimization of ozone-enhanced biofiltration for MIB and geosmin removal from a practical perspective. Specific objectives of this project were:

- Determine the mechanisms and rate constants for O_3 and $HO^{\bullet}$ oxidation of MIB and geosmin.
- Examine the effects of water source, pH, temperature, initial odorant concentration, hydrogen peroxide dosage and ozone dosage on the kinetics of MIB and geosmin oxidation.
- Conduct long-duration pilot tests with continuous MIB and geosmin feed to evaluate the time required for biofiltration systems to reach pseudo-equilibrium
- Conduct long-duration pilot tests with continuous MIB and geosmin feed to evaluate effects of biofilter media type (sand, anthracite, activated carbon), biofilter backwashing, empty bed contact time, ozone dose, temperature, pH, and influent odorant concentrations.

- Evaluate the status of ozone-enhanced biofiltration for MIB and geosmin control in full-scale treatment systems by measuring odorant concentrations at different locations along the process treatment trains of several systems at participating utilities facilities.
- Develop general relationships for design and operating criteria and costs for ozone-enhanced biofiltration for MIB and geosmin removal.

APPROACH

Considerable research has already been conducted on ozone-enhanced biofiltration processes for NOM and synthetic organic removal, operational optimization, and effects of water quality characteristics on biofilms. Likewise, oxidation mechanisms, by-products and beneficial effects of ozonation has been well documented. Therefore this report presents overviews of biofiltration and ozonation that support interpretation later in the report (Chapter 2). The experimental approach for laboratory and pilot testing is described in Chapter 3, along with descriptions of analytical methods. Laboratory ozonation experimental results provide a fundamental understanding for the mechanisms of odorant oxidation and include a modeling approach for predicting the beneficial and deleterious effects of ozonation (Chapter 4). Results from combined ozone-biofiltration systems at pilot-scale are presented with the aim at identifying critical control factors for odorant removal (Chapter 5). Building upon research at one pilot site (Boulder,CO), additional mechanistic studies were conducted with media from the pilot study for MIB and geosmin removal during biofiltration provide insight into controlling factors for odorant removal (Chapter 6). A survey of several full-scale utilities employing ozone-biofiltration systems support lab and pilot studies, confirming the ability of such systems to effectively remove odorants (Chapter 7). Appendices contain data obtained during the project that support material presented in Chapters 3 through 7. Chapter 8 summarizes key design, operating, and cost factors for ozone-enhanced biofiltration capable of removing MIB and geosmin. The report concludes (Chapter 9) with summary comments and recommendations for utilities currently employing or considering ozone-enhanced biofiltration for MIB and geosmin control.

CONCLUSIONS

Ozone Destruction of MIB and Geosmin (Chapter 4)

Laboratory experiments with ultrapure water and various source waters were conducted to investigate the mechanisms and rate constants for MIB and geosmin oxidation during ozonation. It was concluded that hydroxyl radicals ($HO^{\bullet}$) reactions with MIB and geosmin accounted for a larger fraction of odorant oxidation than molecular ozone (O_3). Rate constants between the odorants (MIB or geosmin) and the two important oxidants (O_3 and $HO^{\bullet}$) were fitted from experimental data:

$MIB + O_3 \rightarrow$ Products	$K_{O3,MIB} = 1\ M^{-1}s^{-1}$	(E.1)
$MIB + HO^{\bullet} \rightarrow$ Products	$K_{HO,MIB} = 8.2x10^{9}\ M^{-1}s^{-1}$	(E.2)
$Geosmin + O_3 \rightarrow$ Products	$K_{O3,Geosmin} = 7.5\ M^{-1}s^{-1}$	(E.3)
$Geosmin + HO^{\bullet} \rightarrow$ Products	$K_{HO,Geosmin} = 9.5x10^{9}\ M^{-1}s^{-1}$	(E.4)

Using the fitted rate constants from Nanopure water experiments, the values were used to simulate MIB and geosmin concentrations from natural water ozonation experiments. For most natural water experiments, simulations using Nanopure water rate constants (Equations 4.6

through 4.9) slightly overestimated MIB and geosmin oxidation. Re-fitted rate constants resulted in slightly higher $K_{O3,MIB}$(4 to 9 $M^{-1}s^{-1}$) and $K_{O3,Geosmin}$(5 to 11 $M^{-1}s^{-1}$) values than Nanopure water experiments, and slightly lower $K_{HO,MIB}$ ($1x10^9$ to $6x10^9$ $M^{-1}s^{-1}$) and $K_{HO,Geosmin}$ ($1x10^9$ to $4x10^9$ $M^{-1}s^{-1}$) values. These slight variations in rate constants may be attributed to the role of secondary oxidants (organic peroxides, carbonate radicals, etc) that were not explicitly accounted for in the model simulations.

$HO^{\bullet}$ contribute significantly to MIB and geosmin oxidation. The ratio (R_{CT}) of the $HO^{\bullet}$ and O_3 concentrations is calculated from via disappearance of an ozone-resistant probe compound (e.g., para-chlorobenzoic acid, PCBA) in the presence of an ozone residual *[1-4]*:

$$R_{CT} = \frac{\int HO^{\bullet} dt}{\int O_3 dt} \approx \frac{[HO^{\bullet}]}{[O_3]} \qquad \text{(E.5)}$$

The integrated value of ozone residual as a function of time ($\int O_3 dt$), has been termed "ozone exposure". The units on R_{CT} are mole hydroxyl radical per mole molecular ozone. During batch kinetic ozone experiments R_{CT} values ranged from high values of $5x10^{-7}$ during H_2O_2 addition experiments to < $1x10^{-10}$ mol $HO^{\bullet}$ / mol O_3 during T-butanol experiments. R_{CT} variations, as functions of water quality, directly affect MIB and geosmin oxidation kinetics. R_{CT} increased with higher pH, DOC and temperature and R_{CT} decreased with higher alkalinity. R_{CT} decreased with higher ozone dose, but the $HO^{\bullet}$ concentrations were higher (i.e., more MIB and geosmin oxidation) due to higher O_3 concentrations (Equation E.5). The bench-scale batch ozonation experimentation lead to the following conclusions:

- During ozonation the percentage geosmin removal exceeds is greater than the percentage MIB removal
- Hydroxyl radical ($HO^{\bullet}$) reactions accounted for a greater percentage of MIB or Geosmin oxidation than molecular ozone reactions.
- MIB and Geosmin oxidation increases with increase in ozone dose, pH, temperature and H_2O_2.
- The percentage of MIB or geosmin oxidized is independent of the initial odorant concentration.
- Knowledge of R_{CT}, or other approach to quantify $HO^{\bullet}$ concentrations, is critical in predicting odorant removal.
- Combining empirical and mechanistic models can allow investigation for effects of variable water quality or treatment conditions on microbial inactivation, bromate formation, and odorant oxidation as a function of contact time and other parameters.

Pilot-Scale Evaluations (Chapter 5)

Three pilot-scale studies were conducted. The primary objectives of the Chandler, Arizona pilot testing were to identify effective filter designs for T&O removal. The Phoenix, Arizona pilot testing was comprehensive and aimed primarily at TOC control, but a the effects of ozone dose, TOC levels, filter media, and backwashing was also studied in terms of T&O control. The goal of the two-phased (Phase I – Acclimation and Phase II – Post-Acclimation) Boulder, Colorado pilot test was to identify how media type, temperature, EBCT, and odorant concentration impact acclimation of biofilters specifically for odorant removal.

A comparison of MIB and geosmin percentage removals for equivalent medias and biofilter EBCTs for the three pilot plant testing programs is presented in Table (E.1). Comparable results were achieved. Acclimated GAC or GAC/sand biofilters achieved higher odorant removals than sand or anthracite sand biofilters. This may be attributed to both residual odorant adsorption capacity of the GAC (see Chapter 6) and higher biomass densities on GAC. The half-lives for the odorants on GAC biofilters or 2 to 4 minute EBCT are significantly shorter compared against the 15 to 17 minute EBCTs for anthracite/sand biofilters. GAC biofilters also achieved higher TOC removals. Other observed trends include:

- Ozonation removed higher percentages of geosmin than MIB
- Percentage MIB and geosmin removals during ozonation were independent of initial odorant concentrations
- Comparable MIB and geosmin percentage removals occurred during biofiltration, and were nearly independent of influent odorant concentrations
- Longer EBCTs lead to higher percentage odorant removal during biofiltration
- Lower temperatures reduced odorant removal during biofiltration
- Odorant removal during biofiltration was positively correlated with biomass density at the Arizona pilot tests
- Biofilters require significant time to become acclimated and capable of degrading odorants, this is an especially important consideration during pilot testing
- GAC acclimated to BDOC and odorants in water from one region of the country may require additional acclimation time when treating water with a different water chemistry.
- Sudden changes in water chemistry may decrease odorant removal during biofiltration.
- Backwashing practices affected biofilter performance for odorant removal; higher odorant removals and higher biomass densities occurred using non-chlorinated backwash water
- Combined ozonation-GAC biofiltration systems are more likely to remove odorants to below odor thresholds than biofiltration alone or ozonation with anthracite or sand biofilters, achieved acceptable turbidity control, and removed TOC and DBP precursors

Table E.1

Summary of percentage MIB and geosmin removals achieved with different biofiltration media during the three pilot tests conducted for this study and EBCTs of 2 to 4 minutes (same as Table 5.7)

Pilot Plant Location	Sand or Anthracite/Sand Biofilter		GAC or GAC/sand Biofilter	
	MIB Removal	Geosmin Removal	MIB Removal	Geosmin Removal
Chandler, AZ	19%	-	59%	-
Phoenix, AZ	6%	15%	40%	25%
Boulder, CO	13%	12%	80%	86%

Summary of MIB and Geosmin Biodegradation Mechanisms (Chapter 6)

In the pilot plant phase of this project the biofilters were run for 6 months and at the end the MIB and geosmin utilization rates were higher, i.e., more MIB and geosmin were being removed per

filter length or EBCT, in the bottom sections of the filter. After an additional three months of operation the biofilters no longer demonstrated this behavior. The removal was similar in both sections of the biofilter. This behavior was confirmed in experiments in which the segments of the biofilter were spilt and received a common influent. The MIB and geosmin removal was the same independent of the biomass and the section of the biofilter in which the media was taken. Biofilters in which the temperature was control to 6 °C yielded suppressed MIB and geosmin removal compared to those run at ambient temperature (21°C). Biofilters experiments with media that had been acclimated offsite for several years to water with MIB, were very effective (> 80% removal) in removing MIB and geosmin. The attached biomass of this CWW media was 5 to 8 times higher than the media acclimated at CU. The biomass and removal with the CWW media was similar to that of the BAC media in Phase II.

For one of two sets of experiments, low ozone doses yielded lower MIB and geosmin removal. The supports the primary (BDOC) / secondary (MIB and geosmin) substrate approach. In the second experimental set, increasing the ozone dose did not result in an increase in MIB and geosmin removal. Starting with this experiment, and continuing through the velocity, biomass and most of the influent concentration experiments, no significant MIB and geosmin removal by the biofilters was detected. However, in the last of the influent concentration experiments the biofilters re-acclimated and the anticipated MIB and geosmin removal was measured. We have no strong explanation for this behavior.

Data gathered from Phase I, II and III experiments were used to evaluate an overall pseudo first-order rate constant, $k'X$, of 0.039 and 0.079 min^{-1} for MIB and geosmin, respectively. If only Phase III data in which the biofilters did not yield a depth gradient for the utilization rate, were used overall pseudo first-order rate constants were found to be 0.054 and 0.114 min^{-1} for MIB and geosmin, respectively. In both case the rate constant for geosmin was twice that for MIB.

After 9 months of exposure to MIB and geosmin and prior to that 1 year exposure to TOC in a natural water, the BAC media was examined for residual adsorption. Residual adsorption capacity was found under both ambient and high MIB and geosmin concentrations. This indicates that some of the removal found in Phase II was in part adsorption. At the higher concentration geosmin yielded a higher adsorption capacity compared to that of MIB, and both MIB and geosmin were desorbed after three weeks.

Utility Survey (Chapter 7)

Raw water MIB and geosmin concentrations were in the range of < 2 to 20 ng/L during the sampling campaigns of full scale utilities. Ozone-enhanced biofiltration achieves 60-90% removals of MIB, 60-100% of geosmin, and 15-35% of TOC in general. Other observations included:

- Ozonation alone removed 30% to 40% of MIB and 50% to 60% of geosmin, but ranged from <10% to 90%.
- Biofiltration alone removed 50% to 70% of the MIB and 60% to >90% of the geosmin applied to the biofilters.
- GAC/sand biofilters had higher biomass densities and on average removed MIB, geosmin, and TOC better than anthracite coal biofilters

- One utility backwashed filters with non-chlorinated water, and this facility achieved the highest odorant removals.
- TOC removals attributed to ozone-enhanced biofiltration were comparable with TOC removed during coagulation-sedimentation for many utilities.
- The selected utilities clearly demonstrated that ozone-enhanced biofiltration effectively controls odorants.
- Most of the utilities had MIB and geosmin concentrations under 2 ng/L in treated water.

Unit Cost Curves (Chapter 8)

The O&M costs for the four proven technologies were developed for the following four MIB/geosmin occurrence scenarios:

- *Scenario 1* – Seasonal (2 episodes/year) low level (10-200 ng/L) MIB/geosmin occurrence. This was assumed to be 2 episodes/year, 4 weeks/episode, with MIB and geosmin concentrations of 20 ng/L each.
- *Scenario 2* – Seasonal (2 episodes/year) moderate level (20-200 ng/L) MIB/geosmin occurrence. This was assumed to be 2 episodes/year, 4 weeks/episode, with MIB and geosmin concentrations of 70 ng/L each.
- *Scenario 3* – Scenario 1 or 2 with short-term (<2 week) pulses of high MIB/geosmin levels. This was assumed to be 6 episodes/year, 1 week/episode, with MIB/geosmin concentrations of 70 ng/L each.
- *Scenario 4* – Greater than 150 days per year with MIB/geosmin occurrence of greater than 10 ng/L. This was assumed to be 6 months of MIB and geosmin (each) occurring at 20 ng/L concentration.

For seasonal occurrence of low levels of T&O compounds, one of the most economical (in terms of O&M cost) alternatives is adding PAC. The O&M costs for replaceable GAC filter cap are higher than the PAC addition O&M costs. For a treatment plant with annual average flow of 50 mgd, the annual O&M costs for T&O control for Scenario 1 are between $170,000-$500,000.

For seasonal, moderate levels of T&O compounds, the replaceable GAC filter cap is the least O&M cost alternative, followed by PAC addition, ozone biofiltration and GAC post-filter adsorption. For a treatment plant with annual average flow of 50 mgd, the annual O&M costs for T&O control for Scenario 2 are between $310,000-$500,000.

For short-term pulses of high MIB/geosmin scenario, the low cost treatment alternatives were PAC addition and GAC-sorption filter cap. For a treatment plant with annual average flow of 50 mgd, the annual O&M costs for T&O control for Scenario 3 are between $280,000-$500,000.

For prolonged (more than half of the year) MIB/geosmin occurrence, the GAC-sorption filter cap is the least O&M cost alternative. The costs for Scenario 4 for alternatives other than GAC filter cap are similar. For a treatment plant with annual average flow of 50 mgd, the annual O&M costs for T&O control for Scenario 4 are between $310,000-$500,000.

RECOMMENDATIONS FOR UTILITIES

Several tools provided within this report allow utilities to select and operate ozone-enhanced biofiltration systems for MIB and geosmin control. These include the following:

- Models developed for balancing MIB or geosmin removal against CT inactivation credit and bromate formation.
- Data synthesized to recommend GAC and GAC/sand filters are superior to anthracite/sand filters for MIB and geosmin removal or DOC control, and provide at least equivalent turbidity control.
- Models developed to understand the relationship between biomass density measurements and ability of biofilters to degrade MIB and geosmin.
- Data synthesized to recommend design criteria for ozone-enhanced biofiltration systems.
- Models developed for estimating O&M costs associated with four common methods of odorant control.

In part through the above tools, this research leads to the following specific recommendations regarding ozonation and biofiltration systems:

- Ozonation
    - Hydroxyl radicals ($HO^{\bullet}$) are important for most of the MIB and geosmin oxidation that occurs during ozonation. Techniques to increase $HO^{\bullet}$ concentrations include increasing pH during ozonation or adding hydrogen peroxide. The most common approach would add hydrogen peroxide into the final contactor, allowing it to react with residual molecular ozone and for $HO^{\bullet}$. Management of $HO^{\bullet}$ will enhance a utilities ability to oxidize odorants.
    - Molecular ozone (O_3) becomes a more important oxidant than $HO^{\bullet}$ in waters that exhibit low R_{CT} values, such as high alkalinity and low DOC lake waters.
    - Recognize that temperature affects the rate of ozone decay, thereby affecting the rate of $HO^{\bullet}$ production and $HO^{\bullet}$ concentrations. For equivalent ozone doses, $HO^{\bullet}$ decrease for lower temperatures.
    - Higher ozone doses increases $HO^{\bullet}$ concentrations and would increase odorant oxidation. In all cases, increasing ozone dosages increases odorant destruction.
    - Higher $HO^{\bullet}$ concentrations form during ozonation of water with higher DOC concentrations, so pre-ozonation may have an enhanced benefit for odorant destruction over intermediate ozonation (i.e., ozonation post sedimentation and before filtration).
    - Volatilization is not a major loss process for odorants during diffused ozone application.
- Biofiltration
    - Pilot-scale testing must spike MIB and geosmin continuously for weeks to months to pre-acclimate biofilters, before steady-state conditions can be established.
    - Pilot-testing relying upon MIB and geosmin spiking must use materials that are resistant to gas-permeation for odorant feed tanks, such as Teflon gas sampling bags.
    - Developing an understanding of biomass density variability seasonally, during filter runs, and amongst filters is important. Biomass density may be related to the ability for biofilters to degrade MIB and geosmin. This research used a phospholipids analysis, but other activity-based measurements may be superior.
    - Backwashing practices affect biomass density and performance of biofilters to remove MIB and geosmin. Backwashing with non-chlorinated water provided the best MIB and geosmin control.

- Biologically acclimated activated carbon was superior to anthracite/sand dual media filters for MIB and geosmin control, and always had higher biomass densities than anthracite/sand filters.
- Some MIB and geosmin adsorption capacity remains on biologically acclimated activated carbon after years of operation.
- Changes in influent water quality appears to disrupt or decrease the ability of biofilters to remove MIB or geosmin as efficiently as biofilters without such changes in water quality. Minimizing changes in water quality (rapid changes in feed water or pH) applied to biofilters is recommended.
- Biofiltration efficiency for MIB and geosmin removal tends to decrease at low temperatures.

- Combined Ozone-Biofiltration Systems
  - Provides multiple water quality benefits (high level of disinfection capability, improved biostability of water entering the water distribution system, reduced final disinfectant demand (e.g., chlorine demand), reduced DBP formation, removal of trace-level organics such as pesticides and synthetic organic compounds).
  - Ozonation does not *remove* TOC, but transforms a fraction of TOC into readily biodegradable DOC.
  - Biofiltration is a required post-treatment step to ozone to assure biologically stable water in distribution system. Biofiltration removes 5% to 25% of the TOC, more than conventional coagulation achieves in some waters.
  - Ozone and biofiltration systems operate synergistically, providing better water quality than either system if individually applied.
  - Ozone-enhanced biofiltration systems can handle periodic high raw water MIB or geosmin concentrations by increasing ozone dose, increasing pH during ozonation, adding hydrogen peroxide in the final ozone contactor, or scheduling replacement of GAC filter caps to correspond with the onset of an expected season T&O episode.

RECOMMENDATIONS FOR FUTURE RESEARCH

This project was successful in addressing many issues associated with MIB and geosmin oxidation, but identified other related research needs including the following:

- Develop approaches to measure, monitor, and predict $HO^{\bullet}$ concentrations and/or R_{CT} in full-scale and operational ozone contactors on a real-time basis.
- Improve the understanding of biological communities and enzyme pathways in biofilters for degradation of trace-level contaminants. How long does biological acclimation require? How frequent does a contaminant need to be present in the water column for acclimation to occur?
- Develop rapid and accurate biosensors to quantify active biomass density in-situ for biofilters.
- Attempt to separate sorption (onto substrate, into biomass) from biodegradation for odorants and other trace-level contaminants.
- Verify applicability of secondary substrate biofiltration models for emerging trace-level organics.

APPENDIX – DATA COLLECTED FOR PROJECT

Table 1.1 MIB (ng/l) from August 1999 to January 2004 - ASU analyses (0 <MDL of 2 ng/l, blank).

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21
08/01/99	0.0						19.5					17.7						0.0			17.5					
09/01/99	0.0						12.2					27.6						8.3			27.1					
10/01/99	0.0	0.0	0.0	0.0	0.0		0.0	0.0	6.0	6.0	0.0	11.0		6.0	8.0	0.0	8.0	9.0	27.0	42.0	28.0	39.0	24.0	0.0	0.0	
11/01/99	0.0	15.0	7.7	0.0	0.0		0.0	0.0	0.0	0.0	7.2	12.8		6.9	9.3	0.0	8.6	5.9	13.7	8.6	17.9					
11/17/99																										
12/01/99	0.0	9.3	9.9	0.0	0.0		0.0	0.0	0.0	0.0	5.8	0.0			5.8	0.0	0.0	0.0	7.0	6.1	9.2	9.5				
01/01/00	0.0	0.0	2.9	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	2.4	0.0	2.5						0.0	0.0	0.0	
02/01/00	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	2.1	0.0	2.2		5.6		0.0	0.0		
03/01/00	0.0	4.4	4.8	3.7	2.1	2.7	2.5	2.1	0.0	2.4	5.7	6.1		4.2	6.6	0.0	21.5	15.1	11.4	7.2	28.9	25.0	6.8	6.4	1.6	
04/01/00	4.0	4.6	4.5	3.4	3.1	2.2	5.2	2.2	2.4	4.6	8.3	10.1	6.9	5.4	4.2	0.0	6.5	4.2	4.9		16.2	12.0	6.5	6.5	4.4	
05/01/00	0.0	6.2	4.4	0.0	0.0	0.0	11.8	6.4	0.0	0.0	20.4	21.1	24.2	14.4	10.2	0.0	12.9	7.5	8.8	9.4	12.6	11.7	9.7	8.8	0.0	9.5
06/01/00	0.0	3.7	0.0	0.0	0.0	0.0	24.1	17.4	0.0	4.8	18.6	25.3	20.9	15.7	12.3	0.0	14.3	10.8	12.5	11.6	11.2	11.9	8.5	9.0	7.5	14.1
07/01/00	6.3	6.4	7.3	3.5	2.5	3.3	37.8	40.1	2.9	5.9	15.3	38.5	26.6	20.1	18.7	2.2	20.0	16.2	15.0	8.3	19.0	14.0	17.6	0.0	87.7	16.7
08/01/00	8.9		16.5	2.6	2.6	0.0	16.8	54.2	32.2	7.1	34.6	43.6	37.2	16.0	14.2	2.6	15.7	10.1	14.8	8.9	51.5	42.6	10.5	9.4	11.5	17.9
09/01/00	10.4	13.2	14.2	10.0	9.7	9.2	4.4	24.5	16.7	13.3	25.6	36.0	32.7	21.0	20.0	7.2	65.0	9.1	21.6	18.5	64.0	48.3	27.4	12.0	9.0	32.0
10/01/00	10.4	6.6	6.8	8.7	4.9	4.7	3.1	5.7	13.1	14.1	23.4	18.4	19.6	18.4	24.4	6.9	38.4	20.4	26.0	21.6	46.5	44.1	16.9	3.3	5.7	23.0
11/01/00	3.6	3.3	3.1	2.8	4.9	4.4	7.6	0.0	0.0	3.2	10.8	3.7	4.0	4.4	11.0	4.7	21.8	11.9	17.6	13.9	21.5	26.4	15.3	7.3	5.5	17.0
12/01/00	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	2.0	2.4	4.4	2.5	2.2	2.0	17.9	3.1	9.6	9.3	11.2	9.0	24.3	20.8			0.0	12.4
01/01/01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0	3.5	8.6	0.0	15.9						12.4	10.5	0.0	
02/01/01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.0	2.0		20.3		7.7	5.8	8.6		11.3		5.7	3.8	0.0	12.3
03/01/01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	3.7	4.1	2.4	51.6	0.0	24.6	15.0	15.0	9.7	14.9	15.5	4.6	2.6	0.0	12.4
04/01/01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	4.2	4.4	0.0	12.0	0.0	5.2	5.1	5.7	5.7	6.0		0.0	0.0	0.0	5.2
05/01/01		0.0	0.0	0.0	0.0	0.0	4.1	5.8	0.0	0.0	16.5	11.7	10.7	4.3	5.7	0.0	5.9	5.5	5.7	5.2	6.0		4.8	5.2	2.0	7.9
06/01/01	5.2	0.0	0.0	2.0	0.0	0.0	16.5	5.0	0.0	0.0	5.1	9.9	10.0	7.7	5.4	0.0	7.0	5.0	7.6	5.1	53.4		3.6	3.2	2.2	47.5
07/01/01	2.9	0.0	0.0	0.0	0.0	0.0	26.0	4.8	0.0	0.0	8.1	7.3	7.6	6.5	4.9	0.0	6.3	4.8	17.4	16.8	30.1		4.3	5.1	9.0	27.8
08/01/01	7.0	3.2	0.0	0.0	2.2	2.2	4.4	12.9	0.0	0.0	9.8	24.8	23.8	10.0	8.3	0.0	13.5	10.1	20.6	15.9	30.0	8.0	10.1	13.5	3.3	19.0
09/01/01	14.4	14.0	0.0	0.0	3.5	3.6	11.7	8.1	0.0	2.8	20.1	105.1	101.2	13.8	13.8	15.8	3.4	27.5	29.6	59.9	45.9		20.5	15.7		64.7
12/01/01	0.0	4.3		0.0	0.0	0.0	2.9	0.0		0.0	0.0	0.0		0.0	4.8	2.9	7.2	0.0	13.9	7.2	30.2		6.6	0.0	2.1	
01/01/02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.5	27.0	2.9		290.0		8.8	5.3		
02/01/02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	3.0	22.9		26.4		5.8	4.8		18.8
03/01/02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	2.3	0.0		0.0	0.0	15.0	4.1	12.5	14.3	11.2	11.3	5.7		2.9	9.8
04/01/02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	8.2	9.0		0.0	0.0	3.8	5.5	3.2	4.5	2.9	0.0	2.3		0.0	2.8
05/01/02	0.0	2.8	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0		10.0	9.8	7.6	6.1	0.0	3.4	4.3	3.5	4.0	3.5	3.4	2.1	2.3	0.0	3.1
06/01/02	0.0	0.0	0.0	0.0	0.0	0.0	11.8	2.9	0.0	0.0		11.3	10.0	9.3	6.7	0.0	6.8	5.7	4.4	4.5	5.3	5.9	5.3	6.1	6.6	6.3
07/01/02																0.0	5.1	5.3	5.3	3.8	3.9	3.2	4.9	4.3		4.5
07/08/02																0.0	6.1	3.8	4.3	4.2	3.6	4.2	2.8	3.7		5.5
07/16/02		5.1	0.0					49.9	0.0			15.5	16.6	7.9		0.0	5.4	4.2	6.3	4.1	3.6	2.9	3.3	3.0		5.7
07/22/02																2.1	5.5	2.8	3.5	4.0	5.7	5.9	3.9	3.7		5.5
07/29/02																0.0	5.9	3.9	4.3	3.5	5.6	4.4	4.5	5.3		4.2
07/30/02																										
08/05/02																3.8	6.4	5.1	6.8	5.8	10.4	8.1	5.9	3.5		6.8
08/12/02		28.2	0.0					82.9	6.7			43.4	51.6	15.7		5.8	10.4	8.3	9.7	8.3	10.6	6.2	5.7	4.9		10.6
08/19/02																7.3	12.5	9.4	12.1	15.0	16.8	17.3	10.9	10.7		15.7
08/26/02																7.7	11.4	9.6	15.5	15.7	28.2	16.3	9.6	10.8		18.5

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21
08/30/02																			15.3		17.8					25.4
08/31/02																			19.0		30.4					49.8
09/03/02		43.1	0.0					46.6	25.7			22.6	27.3	22.8		7.4	18.2	21.1	14.9	12.3	23.6	20.2	11.4	6.8		25.3
09/10/02																	15.1	12.2	12.5	6.8	16.2	11.5	15.3	3.7		22.2
09/16/02		37.2	3.0					30.5	14.5			29.9	31.9	28.8			12.3	7.3	14.7	11.1	28.6	8.4	8.1	11.0		25.2
09/23/02																	17.2	6.2	11.4	8.9	21.4	18.4	10.1	5.1		21.6
09/30/02																	24.2	7.0	11.0	10.7	20.2	10.2	8.3	4.2	3.9	24.0
10/02/02		46.1	0.0					18.6	11.9			50.4	45.6	37.5												
10/07/02																	19.5	6.0	10.8	5.5	13.8	9.4	13.4	7.0		14.4
10/14/02																5.0	25.4	6.1	10.8	9.1	18.8	9.1	14.0	8.4		12.9
10/16/02		38.8	7.1					10.8	12.7			44.6	37.1	39.2												
10/21/02																12.8	24.1	13.3	14.7	9.5	13.7	13.3	21.2	21.9		15.1
10/28/02																17.7	11.8	13.9	18.9	12.7	18.7	17.6	12.6	6.7		17.7
10/30/02		39.3	23.8					7.2	7.9			27.7	24.8	27.2											2.5	
11/04/02																16.8	12.7	16.4	24.2	9.9	28.1		15.6	17.5		20.9
11/12/02																2.1	10.2	7.1	13.0	7.7	17.0		6.7			14.6
11/13/02		9.1	13.9					2.2	0.0			11.3	13.0	11.6												
11/18/02																2.0	6.4	4.5	8.1	4.2	9.4		4.3			9.4
11/25/02		4.9	5.6					0.0	2.1			3.5	3.8	3.5		2.5	10.1	5.6	9.7	3.3	13.0	6.9				11.4
11/30/02																										
12/09/02																2.0	9.2	4.8	8.6	4.4	10.9					9.2
12/16/02																0.0	7.0	6.1	6.8	2.6	4.6	6.8				5.4
12/17/02		5.8	5.6					0.0	0.0			0.0	0.0	0.0												
12/30/02																									0.0	
01/14/03		5.1	4.4					0.0	0.0			0.0	0.0	0.0	5.3	0.0							9.6	7.8		
02/11/03		0.0	2.6					0.0	0.0			0.0	0.0	0.0	7.8		25.9	13.3	11.2		9.1	12.8	8.1			
03/11/03		0.0	0.0					0.0	0.0			0.0	0.0	0.0	5.7		12.4	6.1	6.9		5.8	3.7	6.7	8.2		7.4
04/15/03		0.0	0.0	0.0				0.0	0.0			5.9	6.0	0.0	4.6	0.0	3.8	2.2	0.0	0.0	2.3	0.0	2.1	0.0	0.0	2.3
05/13/03		11.1	2.6	4.1				3.6	4.2			13.5	12.7	12.3	4.5	3.3	8.7	11.6	3.1	0.0	4.8	6.6	5.2	0.0	2.7	5.8
06/03/03		8.3	3.7	5.0				18.3	3.9			12.5	13.3	9.8	10.2	3.1	9.4	7.5	9.8	6.8	5.2	9.3	7.5	9.9		10.5
06/10/03																0.0	4.5	2.1	0.0	0.0	11.8	11.6	17.3	13.6	2.7	3.5
06/24/03																										
07/07/03				0.0											18.7	0.0	10.8	3.8	9.5	10.0	10.7	8.7	7.0	6.1		9.8
07/14/03		2.1	0.0					0.0	0.0			15.1	15.9	23.6		0.0	11.4	5.3	13.5	15.9	20.5	17.7	8.3	5.2		17.9
07/21/03				0.0											24.7	0.0	11.6	6.8	19.1	23.2	31.0	30.0	11.1	8.0		27.2
07/28/03				0.0											39.0	0.0	22.8	16.1	17.8	20.5	26.5	8.5	18.0	9.3		28.0
08/04/03		2.0	0.0	0.0				2.0	0.0			15.2	17.0	53.2	33.4	0.0	28.7	5.6	18.5	8.4	33.8	14.6	23.1	18.5		33.6
08/11/03				0.0											47.1	0.0	26.7	12.5	25.5	15.5	38.0	28.7	24.4	11.7		38.7
08/18/03				0.0											55.6	2.0	31.0	19.5	32.3	22.1	58.4	20.9	22.4	15.6		63.5
08/25/03		3.7	2.2	0.0				0.0	0.0			22.8	21.9	67.2	39.6	3.5	28.4	12.1	40.1	16.5	54.8	25.2	26.3	9.6		62.2
09/02/03																	19.8	12.3	59.9	15.6	75.8	38.9	40.1	21.2		77.2
09/08/03		3.4	3.4	0.0				0.0	0.0			30.1	30.7	29.9	21.5	2.8	21.7	10.7	36.9	16.5	50.4	26.5	34.6	26.5		39.7
09/15/03															16.8	2.0	20.3	8.6	29.8	14.7	47.3	15.4	23.8	13.1		44.7
09/22/03		4.2	4.2					3.0	4.7			6.4	6.1	21.7	12.8	3.2	27.8	7.4	25.7	28.4	40.5	15.5	25.8	7.3	0.0	39.2
09/29/03															5.1	2.8	41.4	9.8	55.3	16.3	48.4	20.9	19.8	8.2		57.5

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21
10/06/03																										
10/13/03				5.5											5.5	4.6	16.1	9.3	72.1	30.0	81.0		17.3	13.1	0.0	63.1
10/20/03				4.2											4.7	4.1	7.0	5.8	34.0	27.1	43.4		17.0	12.0		35.9
10/28/03		5.4	2.9	0.0				7.4	0.0			3.0	3.2	3.7		0.0	6.0	5.3	41.2	8.5	35.4		13.7	9.5	0.0	38.3
11/03/03															4.0	0.0	7.1	6.7	24.9	12.3	27.7	15.9	16.5	4.7		42.2
11/10/03				0.0											4.3	0.0	6.9	5.4	32.0	11.7	33.8	24.5	15.0			31.8
11/17/03		3.2	3.7	3.0				7.6	8.5			5.4	5.6	5.6	4.8	0.0	6.8	6.4	32.8	11.6	30.6	14.2	14.6			25.5
12/01/03		0.0	0.0	0.0				0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0	2.7	12.0	3.8	6.7	8.4			0.0	13.3
12/15/03															0.0	0.0	0.0	0.0	17.3	3.8	9.0	10.3	3.2		0.0	9.8
01/20/04												0.0	0.0	0.0	0.0	0.0	2.1	2.1	6.8	7.8	7.9	4.3	2.6			5.8
02/16/04		0.0	0.0	0.0								0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	3.9	4.8	3.2	0.0			3.1
03/17/04								0.0	0.0			0.0	0.0	0.0	0.0	0.0	2.5	2.2	4.9		5.3	3.6	0.0	0.0		3.3

Table 1.2. (Continued) MIB (ng/l) from August 1999 to January 2004 - ASU analyses (0 <MDL of 2 ng/l, blank).

Date	R22	R25	R26	16th St.	19th Av.	32nd St.	44th St.	7th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	North.	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/01/99																										
09/01/99																										
10/01/99																										
11/01/99																										
11/17/99																										
12/01/99																										
01/01/00																										
02/01/00																										
03/01/00																										
04/01/00																										
05/01/00	10.5																									
06/01/00	11.7																									
07/01/00	13.0																									
08/01/00	10.7																									
09/01/00	13.2																									
10/01/00	20.2																									
11/01/00	16.5																									
12/01/00	9.7																									
01/01/01																										
02/01/01	9.1	3.0																								
03/01/01	19.9	2.0	16.6																							
04/01/01	4.3	0.0	4.8																							
05/01/01	5.5	18.6	7.0																							
06/01/01	4.1	8.0	8.6																							
07/01/01	6.9	10.3	9.7																							
08/01/01	17.2	9.7	17.2																							
09/01/01	49.5	15.3	47.9																							
12/01/01		0.0	9.6																							
01/01/02	6.7	52.8	0.0																							
02/01/02	13.4	0.0	14.9																							
03/01/02	7.5	0.0	13.0																							
04/01/02	4.8	3.0	5.1																							
05/01/02	3.1	5.4	4.9																							
06/01/02	4.9	5.8	5.2																							
07/01/02	5.2			3.7	5.1								3.3	5.9	5.0		3.5	4.2	5.2		4.5		3.1	7.5	0.0	0.0
07/08/02	4.4			4.2	6.3								3.2	5.8	5.0		3.5	4.6	5.2		4.4		3.8	10.2	0.0	0.0
07/16/02	3.9			4.9	4.7								3.3	3.5	3.8		4.4	4.5	3.7		3.7		5.5	7.5	0.0	0.0
07/22/02	3.5			5.2	5.1								3.6	3.6	3.4		3.0	5.5	2.2		3.4		5.6	6.9	0.0	0.0
07/29/02	3.6			5.0	5.3								4.7	5.3	3.4		4.2	4.5	3.2		2.7		6.7	7.0	0.0	2.1
07/30/02																										
08/05/02	5.1			7.3	10.6								2.9	5.4	5.9		5.5	6.1	5.2		5.4		8.1	9.9	0.0	3.4
08/12/02	7.2			9.4	12.2								5.0	7.2	9.1		5.4	8.0	7.6		6.6		8.7	13.4	0.0	4.0
08/19/02	8.8			14.9	16.4	13.5	10.4						7.8	10.9	11.1	17.3	8.4	12.9	10.6		10.4		17.5	15.8	2.1	7.1

Date	R22	R25	R26	16th St.	19th Av.	32nd St.	44th St.	7th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	North.	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/26/02	9.7			16.2	20.9	14.0	10.4						9.5	9.8	10.0	16.2	7.1	14.0	9.1		9.9		10.9	16.4	3.4	8.4
08/30/02	12.3			19.7	19.0	17.3	14.2	22.8								24.4										
08/31/02				25.3	55.6	17.9	11.9	51.1								49.6										
09/03/02	11.5			16.5	24.8	16.0	12.2	21.9					9.5	13.0	16.0	22.3	11.0	11.7	12.5		10.6		9.8	11.9	2.9	8.0
09/10/02	6.2			19.4	22.5	10.3	9.3	19.1					5.9	14.3	13.1	23.9	6.6	6.4	12.6		8.3		4.2	4.9	2.1	4.3
09/16/02	8.3			13.7	28.8								8.4	7.1	9.5		8.0	13.8	8.3		8.9		6.3	10.6	2.5	4.1
09/23/02	7.3			12.3	24.5								9.7	6.9	8.0		8.6	9.1	8.8		7.1		6.2	11.4	0.0	4.1
09/30/02	7.2			11.4	23.6								9.9	6.1	8.0		5.9	8.9	10.3		7.4		10.1	13.2	2.3	3.8
10/02/02																										
10/07/02	5.6			10.0	14.8								14.0	5.6	6.4		5.9	6.2	6.4		8.3		6.0	5.9	5.2	9.9
10/14/02	7.5			11.6	16.5								13.7	6.1	7.6		7.1	9.2	6.5		7.7		9.8	6.0	2.1	6.1
10/16/02																										
10/21/02	11.7			15.7	17.1								17.7	12.8	13.9		10.3	15.4	11.0		10.2		11.4	11.1	8.2	15.1
10/28/02	13.9			15.7	17.3								12.1	11.6	14.2		24.3	11.9	12.1		10.8		7.1	0.0	11.5	19.3
10/30/02																										
11/04/02	17.0			22.2	26.2								14.6	15.4	16.8		25.0	25.1	12.7		17.7		5.2	9.8	9.8	19.5
11/12/02	8.4			14.3	15.4								12.5	7.3	7.7		24.3	26.6	6.4		7.4		5.3	6.6	0.0	2.9
11/13/02																										
11/18/02	4.6			8.0	8.0								9.0	4.9	4.4		16.2	12.3	4.7		4.1		3.2	3.4	0.0	0.0
11/25/02	6.1			14.8	10.2									5.1	6.1		18.8	14.0	5.2		5.5				0.0	2.6
11/30/02																										
12/09/02	6.5			8.2	8.5									6.7	6.4		13.6	6.6	5.1		6.9				0.0	0.0
12/16/02	3.5			5.6	5.4									6.8	3.3		7.7	6.6	3.1		5.1				0.0	0.0
12/17/02																										
12/30/02																										
01/14/03		0.0											4.6									0.0	2.0	2.8	0.0	0.0
02/11/03	10.0	4.1											3.8						9.9			0.0	0.0	2.2	0.0	0.0
03/11/03	5.9	0.0											0.0						7.3			0.0	0.0	0.0	0.0	0.0
04/15/03	2.1	0.0							0.0	0.0	0.0	0.0	0.0	2.1					0.0			4.6	0.0	2.3	0.0	0.0
05/13/03	5.1	6.8							6.6	0.0	2.1	2.1	12.2	5.3			0.0	4.8	5.7	8.7		6.0	7.5	4.4	6.1	3.8
06/03/03	9.9	18.6							7.5	0.0			4.9	8.6			5.9	5.5	8.8			8.5	2.8	5.7	3.6	2.9
06/10/03	3.6								10.4	13.6	7.8		3.1	3.6			6.4	8.3	2.5	8.7		3.0	4.9	8.4	0.0	0.0
06/24/03																										
07/07/03	8.9	5.2							2.9	0.0			8.1	10.9			8.3	10.6	12.4			10.5	2.2	4.6	0.0	0.0
07/14/03	12.1	7.2							3.7	0.0			10.7	11.7			17.8	16.3	14.7			12.5	3.1	5.4	0.0	0.0
07/21/03	20.2	8.4							7.4	0.0			10.6	16.6			19.7	25.0	22.2			15.2	4.0	7.4	0.0	0.0
07/28/03	19.0	14.1							0.0	0.0			16.7	36.7			21.8	11.4	37.8			28.1	4.1	7.5	0.0	0.0
08/04/03	17.8	17.2							24.7	0.0			19.1	7.9			19.2	13.8	15.1			30.8	2.2	5.1	0.0	2.9
08/11/03	24.0	11.9							23.5	0.0			16.3	18.1			25.7	9.8	25.4			28.7	3.9	7.9	0.0	0.0
08/18/03	38.7	13.0							25.2	0.0			29.5	29.0			54.0	21.2	41.4			29.0	4.3	11.6	0.0	0.0
08/25/03	42.8	17.0							14.1	2.8			22.1	26.8			55.3	19.2	47.3			48.5	3.8	6.2	0.0	3.1
09/02/03									51.5					28.8			74.1	37.6	66.2				4.0	10.5	0.9	3.6
09/08/03	37.0	11.1							33.2	0.0			24.8	25.2			41.0	13.9	48.4			22.2	4.9	11.4	0.0	3.4
09/15/03	34.2	6.1							14.4	0.0			4.4	14.7			47.0	10.1	37.5			8.1	10.4	6.5	5.5	2.2
09/22/03	29.7	7.3							32.9	3.1			16.5	14.1			49.4	10.2	34.3			25.2	4.4	9.2	2.5	2.7

Date	R22	R25	R26	16th St.	19th Av.	32nd St.	44th St.	7th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	North.	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
09/29/03	42.5	8.3							21.2	0.0			16.1	18.8			59.1	7.0	43.3			22.9	2.8	6.2	0.0	3.3
10/06/03																										
10/13/03	68.0								53.9	0.0			19.2	30.7			49.6	21.9	61.5			15.6	3.9	8.3	0.0	4.0
10/20/03	48.6	5.5							23.1	0.0			7.3	8.6			34.0	14.0	25.2			7.6	4.2	2.5	0.0	6.0
10/28/03	34.0	2.8							31.0	0.0			8.9	8.4			29.9	8.8	23.3			6.6	0.0	0.0	0.0	0.0
11/03/03	26.3								25.0	0.0			8.8	10.0			19.5	11.4	23.4			7.8	0.0	2.7	0.0	2.0
11/10/03	25.8	5.3							22.4	0.0			13.5	10.9			32.1	18.4	23.8			8.1	0.0	2.2	0.0	0.0
11/17/03	40.6	4.1							16.5	3.8				13.4			27.1	31.4	21.4						0.0	2.8
12/01/03	16.2	0.0							0.0	0.0				5.2			9.5	0.0	10.8						0.0	0.0
12/15/03	10.1	0.0							6.9	0.0	0.0	0.0		6.3			5.6	8.7	3.6						0.0	0.0
01/20/04	6.9	0.0									0.0	0.0	0.0	3.3			5.3		4.6				0.0	0.0	0.0	0.0
02/17/04	7.6	0.0												0.0					2.1			2.0	3.2	2.3	0.0	2.1
03/16/04	6.8	0.0							3.0								5.9	4.8	0.0			0.0			0.0	0.0

Table 2.1. Geosmin (ng/l) from August 1999 to January 2004 - ASU analyses (0 <MDL of 2 ng/l).

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21
08/01/99	0.0						0.0					0.0						0.0			9.1					
09/01/99	0.0						0.0					0.0						5.2			8.0					
10/01/99	0.0	0.0	0.0	43.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	7.0	8.0	0.0	0.0	11.0	18.0	18.0	21.0	8.0	20.0	6.0	
11/01/99	5.1	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	7.9	0.0	0.0	0.0	0.0	0.0	6.4					
11/17/99																										
12/01/99	8.4	0.0	0.0	8.1	6.7		0.0	0.0	0.0	0.0	0.0	0.0			9.9	0.0	0.0	0.0	6.1	0.0	8.7	9.0				
01/01/00	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	3.6	0.0	0.0						0.0	0.0	0.0	
02/01/00	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	2.1	0.0	0.0	0.0	0.0		2.8		0.0	0.0		
03/01/00	5.1	0.0	0.0	6.6	3.4	4.1	2.3	0.0	0.0	0.0	2.2	2.1		0.0	0.0	0.0	3.8	0.0	4.0	0.0	6.2	5.9	0.0	2.4	2.1	
04/01/00	4.1	0.0	0.0	7.1	7.1	6.1	2.0	0.0	2.3	4.9	6.2	0.0	2.4	0.0	0.0	3.1	0.0	2.3	5.4		8.5	9.3	9.7	7.0	3.7	
05/01/00	0.0	5.3	2.9	4.8	6.3	7.2	3.1	7.1	0.0	5.9	2.6	0.0	2.7	2.1	2.4	6.4	3.3	2.4	5.7	5.5	7.5	9.1	5.2	5.6	4.3	4.3
06/01/00	2.2	0.0	0.0	0.0	2.2	0.0	4.9	4.5	3.0	5.1	0.0	3.9	3.7	2.3	3.5	2.7	2.6	2.8	4.6	3.7	4.5	5.3	3.0	2.5	39.2	4.1
07/01/00	0.0	0.0	0.0	0.0	0.0	0.0	109.0	0.0	0.0	5.5	0.0	2.7	0.0	0.0	2.4	0.0	2.1	0.0	3.3	2.2	5.7	3.2	2.5	2.8	6.6	13.6
08/01/00	7.0	4.3	2.4	3.4	3.1	2.7	0.0	2.4	3.0	7.1	5.2	4.5	3.3	2.7	3.5	4.2	4.1	4.1	5.4	3.6	7.1	6.7	6.7	6.9	5.1	8.2
09/01/00	3.8	0.0	0.0	0.0	0.0	2.2	5.1	0.0	0.0	5.0	3.6	3.1	2.8	2.2	2.9	0.0	7.0	0.0	5.4	5.3	14.5	9.7	5.1	2.2	9.5	12.1
10/01/00	2.5	0.0	0.0	0.0	2.5	2.2	2.3	0.0	2.7	4.4	3.4	2.4	2.7	3.3	2.8	2.7	2.8	2.9	6.6	5.1	12.9	15.5	4.2	0.0	0.0	8.8
11/01/00	0.0	0.0	0.0	0.0	3.4	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	0.0	0.0	3.5	2.2	4.4	6.8	0.0	0.0	3.3	5.2
12/01/00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	4.1	2.5	11.6	9.2			0.0	6.5
01/01/01	0.0	0.0	0.0	0.0	0.0	0.0	3.1	2.7	0.0	0.0	0.0	0.0	0.0	2.1	0.0	4.7	0.0						0.0	0.0	2.0	
02/01/01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0		2.1		0.0	0.0	0.0	2.5
03/01/01	0.0	0.0	0.0	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	4.2	0.0	4.1	2.7	2.7	0.0	3.0	2.2	6.9	8.0	2.6	0.0	0.0	2.5
04/01/01	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	3.0	2.7	2.7	3.2		0.0	0.0	0.0	2.9
05/01/01		0.0	0.0	0.0	0.0	0.0	0.0	43.7	8.9	3.1	4.0	9.4	8.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6		2.5	2.0	2.2	4.1
06/01/01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0	3.5	5.1	6.0	2.9	3.0	0.0	2.6	2.1	3.0	2.9	19.1		0.0	0.0	8.5	16.5
07/01/01	2.6	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	2.1	4.0	3.8	0.0	2.8	0.0	2.7	2.6	6.7	6.8	10.7		3.3	2.7	9.8	10.4
08/01/01	3.1	0.0	0.0	0.0	2.6	2.6	0.0	0.0	0.0	0.0	0.0	2.7	2.8	0.0	2.8	0.0	2.4	2.7	6.3	2.4	6.6	0.0	3.7	5.9	4.8	4.6
09/01/01	3.2	0.0	0.0	3.4	2.8	3.2	0.0	0.0	0.0	2.8	3.2	4.0	3.8	2.6	2.6	3.0	4.1	4.0	3.6	7.3	5.9		3.1	2.6		6.5
10/01/01	0.0	0.0	0.0	3.2	3.7	3.9	0.0	0.0			2.7	2.5	0.0	0.0	3.3	4.8	3.4	2.9	4.7	0.0	4.7		3.9	0.0	3.4	
11/01/01	10.4	0.0	0.0	13.2	12.5	11.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	4.3	0.0	3.2		2.0	0.0	2.9	3.4
12/01/01	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0		0.0	18.9	21.7	0.0	0.0	3.6	1.5	2.6		3.6	0.0	2.8	
01/01/02	5.0	2.1	3.0	4.8	6.7	7.1	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	9.0	10.4	8.5	8.2		2.1		4.2	2.6		
02/01/02	2.7	0.0	0.0	2.5	3.3	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	2.2	6.5		3.6		3.7	5.0		4.8
03/01/02	3.7	0.0	0.0	3.4	3.2	3.6	0.0	0.0	0.0	0.0	2.6	2.5	2.6		3.0	3.0	2.0	3.0	3.2	3.0	2.5	2.7	2.5		2.4	3.0
04/01/02	6.0	0.0	0.0	4.5	4.2	4.3	0.0	0.0	0.0	0.0	0.0	3.1	2.8		0.0	4.9	0.0	3.3	2.2	2.0	2.2	0.0	2.6		0.0	2.5
05/01/02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0
06/01/02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		3.3	2.5	0.0	0.0	0.0	0.0	0.0	2.2	2.0	2.1	2.6	2.1	2.0	8.7	2.7
07/01/02																0.0	0.0	0.0	2.1	0.0	2.3	0.0	0.0	0.0		0.0
07/08/02																0.0	0.0	0.0	0.0	0.0	2.2	2.2	0.0	0.0		2.1
07/16/02		0.0	0.0					2.0	0.0			0.0	0.0	0.0		0.0	0.0	0.0	3.1	2.5	2.9	2.4	0.0	0.0		2.9
07/22/02																0.0	2.0	0.0	3.7	3.3	4.2	4.0	2.5	2.8		3.9
07/29/02																0.0	2.6	0.0	3.9	4.3	3.9	4.8	3.0	4.0		4.2
07/30/02																										
08/05/02																0.0	2.0	0.0	3.3	3.5	4.1	4.2	0.0	0.0		4.1
08/12/02		0.0	0.0					0.0	0.0			0.0	2.3	0.0		0.0	2.7	0.0	5.2	4.3	5.3	1.7	2.8	2.5		5.4

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21
08/19/02																0.0	2.1	0.0	3.0	5.9	6.7	4.1	3.7	3.4		6.3
08/26/02																0.0	2.4	0.0	5.4	6.4	6.5	4.8	3.1	3.6		5.9
08/30/02																			5.7		6.9					8.4
08/31/02																			6.2		8.9					14.3
09/03/02		0.0	0.0					0.0	0.0			0.0	0.0	0.0		0.0	3.0	18.4	5.2	3.1	18.4	5.2	4.3	0.0		7.0
09/10/02																	3.0	3.1	6.5	2.2	5.6	2.8	8.0	0.0		7.5
09/16/02		0.0	0.0					0.0	0.0			2.8	2.7	0.0			2.2	2.2	6.1	3.1	5.7	0.0	3.3	3.4		7.6
09/23/02																	2.1	0.0	5.2	3.0	6.9	5.7	3.6	0.0		6.8
09/30/02																	2.6	2.7	4.9	3.5	5.8	0.0	5.4	0.0	0.0	7.3
10/02/02		0.0	0.0					0.0	0.0			0.0	0.0	0.0												
10/07/02																	2.7	2.1	4.5	2.9	4.4	0.0	7.2	0.0		5.4
10/14/02																4.3	2.7	4.3	7.9	4.0	7.2	2.1	6.9	0.0		6.9
10/16/02		0.0	0.0					0.0	0.0			2.2	2.2	0.0												
10/21/02																3.8	3.1	3.5	6.6	3.1	5.8	5.2	7.5	6.1		6.7
10/28/02																4.6	0.0	3.2	8.6	3.7	6.6	5.2	6.4	0.0		6.3
10/30/02		0.0	0.0					0.0	0.0			2.5	0.0	0.0											2.1	
11/04/02																5.6	2.1	3.8	10.3	0.0	12.2		9.2	8.6		8.1
11/12/02																6.3	2.8	4.9	18.2	14.2	15.1		8.4			15.3
11/13/02		0.0	0.0					0.0	0.0			0.0	0.0	0.0												
11/18/02																3.4	0.0	2.9	8.5	2.2	10.6		11.2			10.7
11/25/02		0.0	0.0					0.0	0.0			0.0	0.0	0.0		6.1	0.0	4.3	9.4	0.0	10.8	4.3				9.9
11/30/02																										
12/09/02																6.2	0.0	4.2	5.9	0.0	6.7					6.0
12/16/02																2.0	2.3	2.4	4.0	0.0	3.6	3.8				3.2
12/17/02		0.0	0.0					0.0	0.0			0.0	0.0	0.0												
12/30/02																									0.0	
01/14/03		0.0	0.0					0.0	0.0			0.0	0.0	0.0	5.7	4.0							6.3	5.8		
02/11/03		0.0	0.0					0.0	0.0			0.0	0.0	0.0	5.0		3.5	3.6	6.0		5.4	6.5	2.7			
03/11/03		0.0	0.0					0.0	0.0			0.0	0.0	0.0	2.3		2.3	2.6	2.9		2.8	2.2	3.1	2.4		2.8
04/15/03		0.0	0.0	0.0				0.0	0.0			2.9	3.1	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
05/13/03		0.0	0.0	0.0				0.0	0.0			2.0	0.0	0.0	0.0	0.0	2.1	0.0	2.0	0.0	2.0	0.0	2.1	0.0	0.0	0.0
06/03/03		0.0	0.0	0.0				17.9	2.0			0.0	0.0	0.0	0.0	0.0	2.0	0.0	3.0	2.5	3.4	3.0	0.0	0.0		4.2
06/10/03																0.0	0.0	0.0	0.0	0.0	2.8	2.4	0.0	0.0	0.0	3.0
06/24/03																										
07/07/03				0.0											0.0	0.0	2.0	0.0	7.9	6.8	9.8	6.2	2.3	0.0		9.6
07/14/03		0.0	0.0					2.5	0.0			0.0	0.0	0.0		0.0	2.3	0.0	9.1	9.1	16.3	12.9	2.7	0.0		14.5
07/21/03				0.0											0.0	0.0	2.9	2.1	12.9	13.8	19.9	19.3	3.7	0.0		19.1
07/28/03				0.0											3.1	10.4	3.6	3.2	10.7	12.1	15.4	2.5	3.6	0.0		16.6
08/04/03		0.0	7.4	0.0				0.0	0.0			0.0	0.0	0.0	2.9	0.0	3.4	2.7	13.6	0.0	20.7	2.0	4.3	3.4		20.0
08/11/03				0.0											2.9	0.0	3.4	2.3	14.5	4.2	18.5	14.2	4.1	0.0		17.4
08/18/03				3.4											4.2	0.0	4.3	3.3	18.5	5.0	25.5	5.4	4.3	0.0		29.9
08/25/03		0.0	5.5	0.0				0.0	0.0			2.3	2.5	3.6	7.0	3.7	5.0	4.2	19.6	3.0	22.6	7.4	3.9	0.0		28.7
09/02/03																	2.6	3.1	19.5	1.4	23.1	9.0	3.1	1.0		24.4
09/08/03		0.0	14.1	3.1				0.0	0.0			0.0	0.0	2.5	3.8	2.2	3.3	2.8	12.0	0.0	14.6	5.4	3.5	2.8		13.4
09/15/03															3.3	3.4	2.7	3.1	9.9	0.0	12.9	3.5	2.6	0.0		12.4

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21
09/22/03		0.0	0.0					0.0	0.0			2.0	2.0	2.7	3.7	6.7	2.7	5.9	9.3	6.2	12.2	3.5	4.0	0.0	0.0	13.3
09/29/03															2.8	5.2	2.1	4.8	14.4	0.0	11.6	3.9	4.1	0.0		17.9
10/06/03																										
10/13/03				6.3											0.0	4.7	3.2	4.3	19.9	4.1	16.2		3.6	3.1	2.8	16.0
10/20/03				2.1											0.0	2.4	3.4	2.8	12.1	8.4	10.6		3.0	2.9		12.0
10/28/03		0.0	0.0	0.0				0.0	5.7			0.0	0.0	0.0		0.0	2.7	0.0	13.4	0.0	9.8		2.4	0.0	2.8	13.4
11/03/03															0.0	0.0	3.7	2.7	10.3	5.2	10.1	5.1	3.2	0.0		18.7
11/10/03				0.0											0.0	0.0	3.1	2.3	13.8	0.0	12.8	7.7	3.0			13.5
11/17/03		0.0	0.0	0.0				0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.2	3.3	14.4	2.9	2.4			7.4
12/01/03		0.0	0.0	0.0				0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4	0.0	7.1	5.6			0.0	9.5
12/15/03															0.0	0.0	0.0	0.0	7.5	2.6	6.9	4.6	0.0		10.1	6.4
01/20/04												0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1	7.5	7.3	3.5	0.0			6.1
02/17/04		0.0	0.0	0.0								0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	2.9	3.9	0.0	0.0			3.4
03/16/04				2.1				0.0	0.0			0.0	0.0	0.0	0.0	2.2	2.0	2.1	4.9		5.6	2.2	0.0	0.0		4.6

Table 2.2. (Continued) Geosmin (ng/l) from August 1999 to January 2004 - ASU analyses (0 <MDL of 2 ng/l).

Date	R22	R25	R26	16th St.	19th Av.	32nd St.	44th St.	7th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	Northn.	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/01/99																										
09/01/99																										
10/01/99																										
11/01/99																										
11/17/99																										
12/01/99																										
01/01/00																										
02/01/00																										
03/01/00																										
04/01/00																										
05/01/00	7.2																									
06/01/00	3.6																									
07/01/00	2.8																									
08/01/00	4.4																									
09/01/00	3.5																									
10/01/00	3.9																									
11/01/00	3.2																									
12/01/00	0.0																									
01/01/01																										
02/01/01	0.0	0.0																								
03/01/01	6.0	2.9	4.3																							
04/01/01	0.0	0.0	2.2																							
05/01/01	2.0	3.0	2.3																							
06/01/01	2.5	3.4	3.8																							
07/01/01	4.1	2.4	5.4																							
08/01/01	4.4	3.3	5.9																							
09/01/01	4.9	4.0	6.2																							
10/01/01	3.1	2.4	4.8																							
11/01/01	2.9	0.0	3.1																							
12/01/01		0.0	3.4																							
01/01/02	2.1	12.1	0.0																							
02/01/02	4.7	0.0	5.2																							
03/01/02	2.8	3.0	2.7																							
04/01/02	0.0	3.0	2.1																							
05/01/02	0.0	2.3	0.0																							
06/01/02	2.3	6.2	2.8																							
07/01/02	0.0			0.0	0.0								0.0	0.0	0.0		0.0	0.0	0.0		0.0		0.0	2.3	0.0	0.0
07/08/02	0.0			0.0	0.0								0.0	0.0	0.0		0.0	2.4	0.0		0.0		0.0	2.8	0.0	0.0
07/16/02	0.0			3.1	3.4								2.1	0.0	0.0		0.0	4.1	0.0		0.0		2.1	2.4	0.0	0.0
07/22/02	0.0			3.1	3.3								2.2	0.0	0.0		0.0	3.2	2.0		0.0		2.4	2.7	0.0	0.0
07/29/02	2.1			3.9	3.8								2.4	0.0	2.1		3.0	3.2	0.0		0.0		2.3	2.9	0.0	0.0
07/30/02																										
08/05/02	0.0			3.8	3.7								0.0	0.0	2.0		2.0	3.2	0.0		2.1		2.3	2.7	0.0	0.0

Date	R22	R25	R26	16th St.	19th Av.	32nd St.	44th St.	7th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	Northn.	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/12/02	2.6			5.1	5.5								2.7	2.1	3.0		2.2	5.0	2.7		2.5		2.8	3.0	0.0	0.0
08/19/02	2.7			6.7	5.3	3.9	3.2						2.9	2.3	2.9	6.6	2.1	8.3	2.7		2.9		6.2	5.5	0.0	0.0
08/26/02	2.4			5.6	6.7	3.4	2.6						2.8	2.0	2.7	5.6	2.2	12.2	2.2		2.4		2.3	3.8	0.0	0.0
08/30/02	3.6			7.6	6.5	4.8	3.8	8.5								7.9										
08/31/02				8.0	21.8	3.9	3.3	16.9								10.3										
09/03/02	3.3			5.9	6.2	4.2	3.2	5.8					6.2	2.6	4.0	6.2	2.5	5.8	3.7		3.0		2.0	0.0	0.0	0.0
09/10/02	2.8			6.8	6.6	4.7	3.4	6.8					4.7	3.6	4.4	7.9	2.8	0.0	3.8		2.1		0.0	0.0	0.0	0.0
09/16/02	3.5			6.0	5.9								3.4	2.4	3.2		2.8	4.1	2.7		3.2		4.9	6.3	0.0	0.0
09/23/02	3.3			5.5	7.0								3.4	2.0	2.7		2.7	3.7	2.9		2.6		3.9	7.3	0.0	0.0
09/30/02	3.8			5.8	6.9								5.5	2.8	3.7		2.8	7.3	3.4		3.2		5.5	9.5	0.0	0.0
10/02/02																										
10/07/02	2.7			4.8	4.8								4.1	2.9	3.5		2.6	8.1	3.3		0.0		3.0	0.0	0.0	0.0
10/14/02	4.8			7.2	7.4								6.1	4.4	5.5		2.9	10.4	4.5		5.2		7.3	0.0	0.0	3.2
10/16/02																										
10/21/02	4.4			7.5	6.7								5.1	3.7	4.7		2.6	9.2	4.1		3.9		3.2	0.0	0.0	2.7
10/28/02	3.6			6.8	5.7								6.9	2.8	2.9		4.2	0.0	3.0		2.8		3.5	0.0	0.0	0.0
10/30/02																										
11/04/02	5.2			11.1	12.4								8.1	4.9	4.4		4.1	5.0	3.2		4.8		2.9	4.0	0.0	0.0
11/12/02	5.5			22.7	20.3								7.8	5.4	5.5		8.0	7.5	5.2		4.6		0.0	2.7	0.0	3.2
11/13/02																										
11/18/02	3.3			9.5	8.7								6.6	3.0	2.8		3.7	2.3	3.1		3.1		0.0	0.0	0.0	2.2
11/25/02	4.8			11.0	9.7									4.6	4.3		4.1	0.0	4.5		4.5				0.0	2.1
11/30/02																										
12/09/02	3.7			6.0	6.2									3.7	3.6		3.0	0.0	3.8		3.6				2.2	3.9
12/16/02	2.2			3.9	3.5									2.1	2.0		0.0	0.0	2.0		2.8				0.0	2.1
12/17/02																										
12/30/02																										
01/14/03		2.0											5.2									4.5	0.0	0.0	0.0	0.0
02/11/03	5.8	2.3											0.0						2.9			2.5	0.0	0.0	0.0	0.0
03/11/03	2.4	2.4											0.0						2.2			3.4	0.0	0.0	0.0	0.0
04/15/03	0.0	0.0							0.0	0.0	0.0	0.0	0.0	0.0					0.0			0.0	0.0	0.0	0.0	0.0
05/13/03	0.0	3.1							0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	2.0	3.5		2.4	0.0	0.0	0.0	0.0
06/03/03	0.0	4.1							0.0	0.0			0.0	0.0			0.0	2.1	0.0			0.0	0.0	0.0	0.0	0.0
06/10/03	0.0								0.0	0.0	0.0		0.0	0.0			0.0	0.0	0.0	3.5		0.0	0.0	0.0	0.0	0.0
06/24/03																										
07/07/03	4.1	2.8							0.0	0.0			0.0	2.3			4.5	4.3	4.8			0.0	0.0	2.8	0.0	0.0
07/14/03	2.8	4.1							0.0	0.0			3.2	3.0			7.8	8.1	4.6			2.6	12.7	2.9	0.0	0.0
07/21/03	9.6	4.9							2.0	0.0			3.3	4.4			10.3	11.7	10.4			3.4	0.0	2.0	0.0	0.0
07/28/03	9.6	5.3							0.0	0.0			3.7	14.1			10.8	0.0	14.7			4.5	0.0	3.1	0.0	0.0
08/04/03	10.1	6.4							15.1	0.0			3.9	3.1			11.9	3.2	9.7			3.4	0.0	2.2	0.0	0.0
08/11/03	12.1	4.6							11.9	0.0			3.5	3.9			12.2	0.0	11.3			3.3	0.0	3.6	0.0	0.0
08/18/03	17.8	5.3							5.8	0.0			4.8	6.2			26.0	2.9	17.3			4.0	0.0	3.1	0.0	0.0
08/25/03	21.2	7.3							2.3	0.0			5.5	7.3			25.0	2.6	19.2			5.1	0.0	0.0	0.0	2.9
09/02/03									15.8					4.1			21.1	2.8	17.6				0.6	2.1	1.4	2.1
09/08/03	10.6	3.6							12.0	0.0			3.9	4.9			10.2	0.0	11.7			2.9	0.0	2.3	0.0	2.4

Date	R22	R25	R26	16th St.	19th Av.	32nd St.	44th St.	7th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	Northn.	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
09/15/03	10.0	2.7							5.0	0.0			0.0	4.0			12.7	0.0	9.4			0.0	6.9	0.0	0.0	3.4
09/22/03	10.7	3.0							9.4	0.0			3.6	7.0			14.2	0.0	10.9			2.9	0.0	0.0	0.0	4.9
09/29/03	11.6	3.1							6.7	0.0			3.6	6.3			13.1	0.0	10.3			4.7	0.0	2.1	0.0	5.1
10/06/03																										
10/13/03	17.3								10.3	0.0			4.5	6.4			12.7	0.0	12.4			3.6	0.0	0.0	0.0	3.5
10/20/03	14.1	4.8							4.2	0.0			2.7	3.3			9.7	0.0	8.5			3.0	2.2	0.0	2.1	0.0
10/28/03	9.4	3.6							8.0	0.0			2.4	2.8			10.0	0.0	7.2			2.4	0.0	0.0	0.0	0.0
11/03/03	9.3								8.7	0.0			3.1	3.9			7.3	0.0	9.8			2.7	0.0	0.0	0.0	0.0
11/10/03	8.6	2.8							9.9	0.0			3.2	3.5			12.3	3.0	9.5			0.0	2.6	0.0	0.0	0.0
11/17/03	12.8	0.0							5.1	0.0				2.3			11.9	9.8	8.2						0.0	0.0
12/01/03	9.1	0.0							0.0	0.0				2.1			7.8	0.0	7.9						0.0	0.0
12/15/03	9.7	5.5							3.5	0.0	0.0	0.0		2.4			7.1	10.1	5.4						0.0	0.0
01/20/04	5.9	0.0									3.4	2.4	3.3	2.1			14.3		3.4				0.0	0.0	0.0	0.0
02/17/04	3.7	0.0											3.5	0.0					2.3			3.5	0.0	0.0	0.0	0.0
03/16/04	6.5	2.2							3.5					0.0			12.7	3.8	2.2			0.0			0.0	0.0

Table 3. MIB (ng/l) from August 1999 to January 2004 - COP analyses (0 <MDL of 2 ng/l).

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21
08/01/99	0	12	0	0	0		38	9	0	0	12	34		4	6	0	10	5	0	12	19	22	14	9		
09/01/99	4	45	0	0	0		14	10	10	8	13	22		19	13	0	12	9	29	33	46	33	31	23		
10/01/99	5	30	20	6	3		6	12	11	12	16	20		19	15	4	18	19	42	43	39	44	37	21	0	
11/01/99	0	27	15	2	0		2	0	0	2	13	16		14	12	0	10	7	23	22	19					
11/17/99																										
12/01/99	0	14	14	0			0	0	0	0	7	5			8	0	6	9	15	16	22	13				
01/01/00		10	6											5									10	11		
02/01/00																			15		31					
03/01/00												15		0		0	24	21								
04/01/00																			7		18	9	4			
05/01/00																			7	5	5	5	6			
06/01/00																			8	7	8	10	7			
07/01/00																			10	7	12	15	10			
08/01/00																			15	10	51	35	9			
09/01/00																			17	15	52	37	30			
10/01/00																			29	25	37	34	20			
11/01/00																										
12/01/00																										
01/01/01					0											0	17						13	13		
02/01/01																0	11						7	5		
03/01/01																				8	8	11	4	4		
04/01/01																			3	3	5		3	4		
05/01/01																			4	3	4		4			
06/01/01																			8	7			4			
07/01/01																			15	11	22		0			
08/01/01																			44	35	54	20	23			
09/01/01																			50		50		17			
10/01/01																			45	26	92		22			
11/01/01																			46	13			23			
12/01/01																										
01/01/02																					333		7			
02/01/02																										
03/01/02																										
04/01/02																										
05/01/02																										
06/01/02																										
07/01/02																										
07/08/02																										
07/16/02																										
07/22/02																										
07/29/02																										
07/30/02																										

Table 4. Geosmin (ng/l) from August 1999 to January 2004 - COP analyses (0 <MDL of 2 ng/l).

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21
08/01/99	2	0	0	0	0		0	0	0	7	0	0		0	0	0	2	3	0	7	6	9	4	3		
09/01/99	2	0	0	3	9		0	0	0	8	0	0		0	4	8	3	3	10	10	14	11	4	3		
10/01/99	0	0	0	50	6		0	0	0	2	3	2		2	5	13	4	5	9	7	9	10	8	2	2	
11/01/99	2	0	0	2	0		0	0	0	0	3	2		2	8	2	0	0	5	5	5					
11/17/99																										
12/01/99	4	0	0	4			0	0	0	0	0	2			8	3	2	0	4	5	7	5				
01/01/00		0	0											3									3	3		
02/01/00																			2		6					
03/01/00												8		0		5	3	6								
04/01/00																			4		5	4	3			
05/01/00																			3	2	2	3	2			
06/01/00																			2	2	3	3	2			
07/01/00																			3	2	4	5	2			
08/01/00																			5	4	7	6	6			
09/01/00																			5	4	15	9	5			
10/01/00																			9	6	15	18	3			
11/01/00																										
12/01/00																										
01/01/01					0											4	0						0	0		
02/01/01																2	2						2	2		
03/01/01																				3	3	3	2	0		
04/01/01																			5	5	4		3	3		
05/01/01																			2	2	3		2			
06/01/01																			2	0			0			
07/01/01																			4	3	8		0			
08/01/01																			17	6	24	0	9			
09/01/01																			5		4		2			
10/01/01																			3	0	2		0			
11/01/01																			7	0			0			
12/01/01																										
01/01/02																					0		6			
02/01/02																										
03/01/02																										
04/01/02																										
05/01/02																										
06/01/02																										
07/01/02																										
07/08/02																										
07/16/02																										
07/22/02																										
07/29/02																										
07/30/02																										

Table 5.1. Total nitrogen (mg-N/l) from August 1999 to January 2004 (0 <MDL).

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18
08/01/99	0.30	0.23	0.32	0.39	0.34		0.55	0.20	0.27	0.28	0.24	0.27		0.35	0.21	0.35	0.20	0.25	0.25		0.27		0.29
09/01/99	0.26	0.32	0.32	0.37	0.34		0.51	0.23	0.37	0.40	0.33	0.31		0.45	0.21	0.34	0.30	0.27	0.29		0.33		0.29
10/01/99	0.32	0.33	0.34	0.32	0.28		0.44	0.32	0.29	0.41	0.27	0.28		0.36	0.28	0.28	0.31	0.33	0.37		0.39		0.27
11/01/99	0.45	0.29	0.35	0.43	0.42		0.36	0.35	0.37	0.37	0.34	0.35		0.32	0.35	0.44	0.29	0.37	0.32		0.47		
12/01/99		0.28	0.28		0.39		0.23	0.31		0.35									0.42		0.31		
01/01/00	0.40	0.27	0.31	0.40	0.37		0.11	0.23	0.21	0.21	0.53	0.24		0.23	0.11	0.37	0.16						0.21
02/01/00	0.41	0.34	0.29	0.41	0.41		0.37	0.18	0.21	0.24	0.24	0.25		0.26	0.17	0.42	0.16	0.34	0.32		0.18		0.41
03/01/00	0.41	0.33	0.31	0.45	0.43	0.39	0.36	0.19	0.30	0.27	0.21	0.25		0.48	0.21	0.46	0.26	0.33	0.50		0.44		0.37
04/01/00	0.44	0.30	0.31	0.37	0.42	0.41	0.33	0.19	0.21	0.23	0.26	0.26	0.25	0.33	0.23	0.41	0.26	0.30	0.49		0.75		0.37
05/01/00	0.50	0.30	0.40	0.41	0.44	0.46	0.69	0.22	0.23	0.27	0.27	0.30	0.31	0.34	0.25	0.43	0.25	0.32	0.41		0.71		0.38
06/01/00	0.47	0.26	0.26	0.34	0.32	0.38	0.31	0.24	0.43	0.20	0.27	0.33	0.29	0.33	0.24	0.36	0.24	0.26	0.27		0.44		0.27
07/01/00	0.37	0.35	0.35	0.36	0.41	0.40	0.36	0.24	0.22	0.30	0.37	0.35	0.28	0.70	0.31	0.36	0.28	0.26	0.24		0.23		0.25
08/01/00	0.32	0.35	0.33	0.28	0.33	0.29	0.31	0.31	0.34	0.24	0.31	0.44	0.33	0.22	0.28	0.29	0.27	0.27	0.29		0.29		0.27
09/01/00	0.30	0.28	0.27	0.27	0.27	0.29	0.48	0.31	0.24	0.37	0.39	0.42	0.32	0.32	0.36	0.34	0.23	0.48	0.33		0.60		0.28
10/01/00	0.23	0.26	0.31	0.32	0.23	0.26	0.26	0.38	0.63	0.51	0.38	0.34	0.31	0.33	0.26	0.25	0.33	0.36	0.37		0.72		0.30
11/01/00	0.38	0.38	0.41	0.39	0.33	0.33	0.47	0.35	0.33	0.37	0.58	0.44	0.41	0.52	0.33	0.38	0.25	0.26	0.31		0.30		0.34
12/01/00	0.26	0.29	0.30	0.27	0.27	0.27	0.23	0.29	0.39	0.30	0.46	0.38	0.39	0.37	0.13	0.27	0.16	0.19	0.47		0.50		
01/01/01	0.36	0.36	0.35	0.40	0.36	0.39	0.19	0.33	0.35	0.26	0.52	0.44	0.43	0.48	0.20	0.34	0.22						0.22
02/01/01	0.43	0.33	0.39	0.42	0.40	0.40	0.17	0.21	0.23	0.23	0.45	0.39	0.40	0.44	0.17	0.39	0.21	0.19	0.28		0.22		0.27
03/01/01	0.50	0.35	0.37	0.44	0.43	0.43	0.37	0.17	0.20	0.20	0.37	0.27	0.25	0.35	0.22	0.43	0.16	0.27	0.50		0.79		0.42
04/01/01	0.38	0.20	0.34	0.40	0.56	0.59	0.13	0.15	0.19	0.16	0.24	0.30	0.24	0.27	0.23	0.38	0.10	0.12	0.19		0.54		0.29
05/01/01		0.26	0.40	0.30	0.32	0.31	0.15	0.23	0.17	0.18	0.26	0.30	0.30	0.31	0.22	0.34	0.23	0.25	0.29		0.66		0.27
06/01/01	0.26	0.27	0.33	0.53	0.45	0.25	0.03	0.35	0.35	0.16	0.22	0.29	0.30	0.29	0.21	0.31	0.30	0.37	0.30		0.50		0.27
07/01/01	0.26	0.29	0.42	0.36	0.37	0.31	0.30	0.19	0.34	0.16	0.24	0.26	0.25	0.23	0.19	0.29	0.35	0.36	0.25		0.67		0.26
08/01/01	0.39	0.26	0.32	0.38	0.29	0.42	0.32	0.36	0.39	0.22	0.31	0.32	0.21	0.29	0.24	0.27	0.20		0.26		0.30		0.24
09/01/01	0.29	0.29	0.29	0.25	0.29	0.24	0.19	0.31	0.26	0.26	1.43	0.72	0.43	0.76	0.63	0.40	0.61	0.37	0.45		0.59		0.35
10/01/01	0.29	0.33	0.35	0.36	0.30	0.29	0.35	0.26		0.32	0.70	0.41	0.41	0.45	0.37	0.37	0.25	0.25	0.36	0.35	0.74		0.34
11/01/01	0.25	0.28	0.22	0.22	0.20	0.19	0.10	0.23	0.21	0.21	0.33	0.26	0.28	0.29	0.22		0.18	0.14	0.58		0.67		0.22
12/01/01	0.34	0.29		0.33	0.32	0.31	0.06	0.22		0.20	0.40	0.28	0.26	0.26	0.13	0.32	0.16	0.12	0.12		1.27		0.13
01/01/02		0.28		0.34	0.32	0.31	0.03	0.21		0.19	0.30	0.28	0.25	0.26	0.20	0.33	0.12	0.15	0.62		0.32		0.19
02/01/02	0.38	0.35	0.29	0.39	0.44	0.43	0.05	0.25	0.22	0.17	0.27	0.26	0.26	0.27	0.19	0.37	0.21	0.24	0.29		0.25		0.24
03/01/02	0.44	0.29	0.36	0.44	0.46	0.46	0.08	0.15	0.34	0.18	0.83	0.34	0.36		0.21	0.49	0.25	0.38	0.49		0.67		0.39
04/01/02	0.42	0.23	0.37	0.41	0.44	0.42	0.18	0.14	0.26	0.21	0.26	0.30	0.32	0.24	0.42	0.47	0.26	0.26	0.39		0.62		0.38
05/01/02	0.34	0.22	0.34	0.33	0.34	0.32	0.08	0.10	0.13	0.15		0.30	0.35	0.23	0.20	0.34	0.19	0.24	0.27		0.28		0.27
06/01/02	0.31	0.21	0.31	0.32	0.32	0.28	0.11	0.15	0.10	0.12		0.31	0.38	0.25	0.20	0.30	0.24	0.22	0.28		0.38		0.24
07/01/02																							
07/08/02																							
07/16/02																							
07/22/02																							
07/29/02																							
07/30/02																							
08/05/02																							
08/12/02																							
08/19/02																							

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18
08/26/02																							
08/30/02																							
09/03/02																							
09/10/02																							
09/16/02																							
09/23/02																							
09/30/02																							
10/02/02																							
10/07/02																							
10/14/02																							
10/16/02																							
10/21/02																							
10/28/02																							
10/30/02																							
11/04/02																							
11/12/02																							
11/13/02																							
11/18/02																							
11/25/02																							
11/30/02																							
12/09/02																							
12/16/02																							
12/17/02																							
12/30/02																							
01/14/03																							
02/11/03																							
03/11/03		0.32	0.35					0.55	0.18			0.25	0.25	0.43									
04/15/03		0.37	0.53					0.40	0.98			0.29	0.51	0.29									
05/13/03		0.30	0.39					0.24	0.43			0.27	0.47	0.24									
06/03/03		0.29	0.41					0.39	0.51			0.31	0.30	0.25									
06/10/03																							
06/24/03																							
07/07/03																							
07/14/03		0.46	0.66					0.48	0.71			0.81	0.61	0.78									
07/21/03																							
07/28/03																							
08/04/03		0.49	0.49					0.71	0.54			0.52	0.50	0.76									
08/11/03																							
08/18/03																							
08/25/03		0.38	0.32					0.34	0.41			0.40	0.43	0.40									
09/02/03																							
09/08/03		0.37	0.52					0.32	0.35			0.42	0.37	0.40									
09/15/03																							
09/22/03		0.40	0.41					0.33	0.56			0.40	0.41	0.45									
09/29/03																							

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18
10/06/03		0.40	0.46					0.31	0.36			0.42	0.47	0.52									
10/13/03																							
10/20/03																							
10/28/03		0.33	0.55					0.29	0.70			0.36	0.40	0.52									
11/03/03																							
11/10/03																							
11/17/03		0.39	0.49					0.33	0.33			0.36	0.32	0.40									
12/01/03		0.46	0.52					0.48	0.42			0.35	0.36	0.53									
12/15/03																							
01/20/04												0.37	0.33	0.43									
02/17/04		0.31	0.33									0.33	0.33	0.36									
03/16/04								0.15	0.29			0.49	0.41	0.33									

Table 5.2. (Continued) Total nitrogen (mg-N/l) from August 1999 to January 2004 (0 <MDL).

Date	R19	R20	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/01/99		0.17																					
09/01/99		0.63																					
10/01/99		0.20																					
11/01/99		0.08																					
12/01/99																							
01/01/00		0.11																					
02/01/00	0.28																						
03/01/00		0.17																					
04/01/00		0.16																					
05/01/00		0.22																					
06/01/00		0.21																					
07/01/00		0.24																					
08/01/00		0.68																					
09/01/00		0.14																					
10/01/00		0.28																					
11/01/00		0.02																					
12/01/00		0.10																					
01/01/01		0.04																					
02/01/01		0.12	0.20																				
03/01/01		0.07	0.13	0.47																			
04/01/01		0.09	0.08	0.28																			
05/01/01			0.11	0.39																			
06/01/01		0.12	0.11	0.37																			
07/01/01			0.18	0.60																			
08/01/01			0.14	0.37																			
09/01/01		0.77	0.29	0.73																			
10/01/01	0.30	0.22	0.30	0.39																			
11/01/01		0.04	0.23																				
12/01/01		0.00	0.12	0.26																			
01/01/02			0.04																				
02/01/02		0.16	0.12	0.28																			
03/01/02			0.16	0.57																			
04/01/02		0.16	0.20	0.45																			
05/01/02			0.12	0.32																			
06/01/02			0.49	0.31																			
07/01/02																							
07/08/02																							
07/16/02																							
07/22/02																							
07/29/02																							
07/30/02																							
08/05/02																							
08/12/02																							

Date	R19	R20	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/19/02																							
08/26/02																							
08/30/02																							
09/03/02																							
09/10/02																							
09/16/02																							
09/23/02																							
09/30/02																							
10/02/02																							
10/07/02																							
10/14/02																							
10/16/02																							
10/21/02																							
10/28/02																							
10/30/02																							
11/04/02																							
11/12/02																							
11/13/02																							
11/18/02																							
11/25/02																							
11/30/02																							
12/09/02																							
12/16/02																							
12/17/02																							
12/30/02																							
01/14/03																							
02/11/03																							
03/11/03		0.24																					
04/15/03		0.10																					
05/13/03		0.33							0.55	0.49													
06/03/03									0.42	0.42													
06/10/03																							
06/24/03																							
07/07/03																							
07/14/03		0.15																					
07/21/03																							
07/28/03																							
08/04/03																							
08/11/03																							
08/18/03																							
08/25/03		0.29							0.32	0.27													
09/02/03																							
09/08/03																							
09/15/03																							
09/22/03																							

Date	R19	R20	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
09/29/03																							
10/06/03																							
10/13/03																							
10/20/03																							
10/28/03		0.14																					
11/03/03																							
11/10/03																							
11/17/03																							
12/01/03		0.08																					
12/15/03		0.07																					
01/20/04																							
02/17/04		0.05							0.45	0.43													
03/16/04		0.61							0.49	0.49													

Table 6.1 Total dissolved nitrogen (mg/l) from August 1999 to January 2004 (0 <MDL).

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/01/99	0.266	0.243	0.336	0.379	0.348		0.448	0.173	0.326	0.286	0.237	0.213		0.266	0.203	0.352	0.212	0.225	0.225		0.241		0.234	
09/01/99	0.233	0.262	0.315	0.335	0.322		0.372	0.207	0.343	0.363	0.281	0.283		0.311	0.211	0.334	0.201	0.215	0.250		0.226		0.238	
10/01/99	0.279	0.284	0.255	0.275	0.251		0.318	0.230	0.226	0.331	0.226	0.233		0.284	0.256	0.273	0.253	0.235	0.268		0.343		0.228	
11/01/99	0.364	0.273	0.292	0.372	0.365		0.292	0.318	0.276	0.338	0.362	0.336		0.270	0.287	0.408	0.292	0.280	0.285		0.335			
12/01/99		0.260	0.280		0.380		0.120	0.240		0.260									0.400		0.430			
01/01/00	0.380	0.225	0.288	0.362	0.362		0.053	0.197	0.136	0.149	0.230	0.220		0.222	0.106	0.354	0.109						0.156	
02/01/00	0.352	0.326	0.298	0.392	0.372		0.200	0.152	0.140	0.202	0.206	0.196		0.202	0.142	0.378	0.130	0.270	0.224		0.196		0.292	0.268
03/01/00	0.378	0.300	0.286	0.410	0.398	0.380	0.146	0.132	0.248	0.146	0.196	0.198		0.220	0.184	0.370	0.152	0.258	0.414		0.404		0.368	
04/01/00	0.412	0.238	0.266	0.320	0.380	0.376	0.188	0.158	0.142	0.188	0.226	0.220	0.236	0.254	0.232	0.382	0.224	0.288	0.330		0.560		0.334	
05/01/00	0.446	0.404	0.422	0.466	0.404	0.410	0.528	0.188	0.182	0.234	0.252	0.280	0.304	0.264	0.240	0.420	0.224	0.338	0.378		0.632		0.306	
06/01/00	0.434	0.278	0.228	0.332	0.312	0.358	0.150	0.160	0.168	0.162	0.216	0.244	0.270	0.266	0.188	0.322	0.200	0.246	0.256		0.382		0.228	
07/01/00	0.262	0.216	0.258	0.322	0.316	0.314	0.158	0.196	0.146	0.164	0.288	0.196	0.220	0.322	0.204	0.388	0.232	0.230	0.322		0.296		0.238	
08/01/00	0.296	0.258	0.258	0.252	0.282	0.242	0.178	0.250	0.295	0.248	0.270	0.310	0.248	0.238	0.220	0.258	0.246	0.290	0.262		0.282		0.314	
09/01/00	0.268	0.216	0.244	0.240	0.232	0.252	0.226	0.194	0.180	0.310	0.278	0.238	0.234	0.220	0.246	0.256	0.188	0.230	0.240		0.478		0.228	
10/01/00	0.238	0.234	0.254	0.238	0.216	0.248	0.152	0.194	0.524	0.458	0.350	0.252	0.248	0.288	0.238	0.208	0.270	0.238	0.322		0.680		0.230	
11/01/00	0.362	0.338	0.342	0.348	0.330	0.318	0.452	0.350	0.314	0.344	0.504	0.426	0.394	0.440	0.310	0.292	0.248	0.256	0.266		0.280		0.312	
12/01/00	0.242	0.252	0.266	0.260	0.254	0.256	0.232	0.256	0.282	0.250	0.450	0.352	0.372	0.356	0.090	0.220	0.126	0.146	0.396		0.486			
01/01/01	0.330	0.318	0.338	0.378	0.340	0.358	0.100	0.282	0.272	0.246	0.504	0.418	0.426	0.386	0.178	0.328	0.194						0.224	
02/01/01	0.386	0.306	0.338	0.384	0.386	0.376	0.104	0.162	0.204	0.224	0.456	0.356	0.356	0.424	0.168	0.348	0.190	0.142	0.242		0.212		0.232	
03/01/01	0.490	0.340	0.360	0.424	0.408	0.420	0.278	0.172	0.180	0.166	0.338	0.242	0.246	0.342	0.204	0.406	0.138	0.270	0.486		0.776		0.402	
04/01/01	0.380	0.190	0.316	0.372	0.536	0.536	0.082	0.138	0.140	0.154	0.230	0.270	0.222	0.250	0.190	0.350	0.112	0.114	0.180		0.520		0.258	
05/01/01		0.232	0.400	0.296	0.282	0.292	0.134	0.182	0.158	0.174	0.242	0.250	0.278	0.300	0.204	0.346	0.210	0.202	0.262		0.656		0.224	
06/01/01	0.235	0.193	0.322	0.397	0.281	0.244	0.037	0.297	0.388	0.138	0.227	0.210	0.230	0.283	0.253	0.301	0.312	0.273	0.203		0.469		0.201	
07/01/01	0.235	0.200	0.371	0.324	0.280	0.297	0.112	0.215	0.261	0.140	0.183	0.183	0.199	0.183	0.179	0.282	0.141	0.168	0.201		0.560		0.156	
08/01/01	0.298	0.257	0.281	0.336	0.290	0.281	0.281	0.347	0.346	0.197	0.213	0.276	0.237	0.284	0.216	0.265	0.186		0.261		0.311		0.230	
09/01/01	0.243	0.264	0.253	0.225	0.250	0.233	0.213	0.333	0.275	0.262	0.448	0.349	0.305	0.715	0.278	0.276	0.270	0.349	0.539		0.544		0.248	
10/01/01	0.289	0.295	0.315	0.332	0.271	0.265	0.210	0.213		0.269	0.297	0.351	0.338	0.356		0.265	0.205	0.147	0.346	0.410	0.733		0.310	0.293
11/01/01	0.301	0.179	0.131	0.194	0.179	0.188	0.077	0.141	0.186	0.165	0.234	0.237	0.224	0.226	0.149		0.138	0.142	0.532	0.135	0.681		0.187	0.141
12/01/01	0.340	0.262		0.301	0.327	0.328	0.042	0.184		0.188	0.371	0.206	0.197	0.224	0.127	0.330	0.097	0.123	0.081	0.048	1.199		0.176	0.602
01/01/02		0.265		0.304	0.329	0.290	0.028	0.187		0.146	0.268	0.208	0.233	0.202	0.155	0.251	0.111	0.134	0.525		0.327		0.144	0.132
02/01/02	0.411	0.327	0.280	0.362	0.375	0.408	0.045	0.239	0.203	0.143	0.226	0.216	0.214	0.256	0.173	0.327	0.140	0.214	0.259		0.192		0.238	0.183
03/01/02	0.387	0.248	0.304	0.377	0.387	0.393	0.076	0.120	0.223	0.167	0.230	0.196	0.205		0.192	0.381	0.147	0.299	0.343	0.357	0.522	0.650	0.331	
04/01/02	0.394	0.214	0.296	0.371	0.394	0.391	0.116	0.108	0.141	0.180	0.158	0.227	0.225	0.221	0.208	0.368	0.207	0.215	0.261	0.234	0.569	0.563	0.296	0.295
05/01/02	0.308	0.210	0.286	0.282	0.297	0.269	0.046	0.071	0.156	0.138		0.225	0.218	0.186	0.155	0.301	0.186	0.200	0.173	0.079	0.141	0.112	0.176	0.108
06/01/02	0.270	0.187	0.282	0.325	0.257	0.253	0.062	0.112	0.068	0.096		0.179	0.221	0.164	0.169	0.266	0.135	0.182	0.169	0.103	0.235	0.163	0.143	0.108
07/01/02																0.237	0.169	0.179	0.157	0.129	0.269	0.338	0.155	0.115
07/08/02																0.353	0.198	0.275	0.244	0.241	0.213	0.242	0.314	0.265
07/16/02		0.246	0.280					0.153	0.113			0.231	0.248	0.236		0.339	0.197	0.203	0.177	0.153	0.377	0.498	0.167	0.138
07/22/02																0.266	0.233	0.248	0.214	0.186	0.395	0.256	0.202	0.464
07/29/02																0.270	0.186	0.230	0.254	0.190	0.476	0.592	0.230	0.210
07/30/02																								
08/05/02																0.302	0.222	0.236	0.262	0.204	0.252	0.260	0.258	0.234
08/12/02		0.410	0.412					0.199	0.563			0.290	0.312	0.415		0.326	0.290	0.244	0.232	0.186	0.216	0.216	0.300	0.242
08/19/02																0.232	0.184	0.210	0.210	0.170	0.180	0.182	0.250	0.234

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/26/02																0.296	0.210	0.290	0.202	0.158	0.374	0.416	0.212	0.204
08/30/02																								
09/03/02		0.340	0.440					0.392	0.402			0.422	0.442	0.732		0.238	0.200	0.284	0.202	0.144	0.382	0.460	0.280	0.258
09/10/02																	0.270	0.246	0.208	0.176	0.230	0.204	0.278	0.174
09/16/02		0.410	0.384					0.142	0.130			0.214	0.218	0.316			0.214	0.214	0.280	0.232	0.402	0.318	0.160	0.132
09/23/02																	0.170	0.166	0.452	0.190	0.408	0.352	0.222	0.182
09/30/02																	0.190	0.196	0.222	0.162	0.192	0.136	0.184	0.162
10/02/02		0.342	0.380					0.204	0.326			0.330	0.358	0.360										
10/07/02																	0.182	0.190	0.186	0.134	0.556	0.504	0.236	0.178
10/14/02																0.210	0.214	0.202	0.252	0.200	0.484	0.464	0.228	0.164
10/16/02		0.308	0.536					0.222	0.594			0.346	0.366	0.756										
10/21/02																0.204	0.162	0.204	0.246	0.186	0.488	0.214	0.174	0.134
10/28/02																0.230	0.162	0.182	0.244	0.188	0.212	0.414	0.210	0.142
10/30/02		0.342	0.526					0.260	0.262			0.290	0.412	0.590										
11/04/02																0.228	0.174	0.240	0.268	0.220	0.228		0.234	0.192
11/12/02																0.316	0.170	0.238	0.274	0.216	1.032		0.224	
11/13/02		0.374	0.534					0.254	0.224			0.300	0.356	0.394										
11/18/02																0.238	0.064	0.180	0.196	0.198	0.710		0.306	
11/25/02		0.298	0.406					0.090	0.128			0.312	0.256	0.218		0.294	0.106	0.192	0.168	0.154	0.218	0.302	0.458	
11/30/02																								
12/09/02																0.342	0.132	0.250	0.272	0.244	0.264			
12/16/02																0.358	0.108	0.174	0.312	0.328	0.312	0.274		
12/17/02		0.398	0.388					0.188	0.192			0.288	0.298	0.350										
12/30/02																								
01/14/03		0.378	0.357					0.121	0.165			0.229	0.225	0.204	0.193	0.343							0.281	0.258
02/11/03		0.361	0.390					0.171	0.174			0.246	0.351	0.259	0.248		0.163	0.300	0.197		0.345	0.384	0.345	
03/11/03		0.280	0.319					0.550	0.166			0.231	0.274	0.352	0.242		0.146	0.328	0.450		0.492	0.452	0.303	0.261
04/15/03		0.384	0.368	0.404				0.373	0.562			0.230	0.237	0.258	0.242	0.403	0.129	0.313	0.431	1.183	0.808	0.790	0.335	0.271
05/13/03		0.277	0.380	0.519				0.247	0.441			0.254	0.317	0.243	0.279	0.413	0.203	0.343	0.367	0.381	0.398	0.387	0.288	0.283
06/03/03		0.254	0.404	0.342				0.297	0.511			0.252	0.253	0.232	0.225	0.354	0.218	0.326	0.361	0.347	0.625	0.450	0.265	0.288
06/10/03																0.361	0.195	0.288	0.323	0.341	0.563	0.508	0.287	0.278
06/24/03		0.414	0.661	0.411				0.434	0.532			0.515	0.379	0.576	0.236	0.356	0.196	0.300	0.327	0.318	0.562	0.320	0.270	0.267
07/07/03				0.458											0.290	0.382	0.223	0.319	0.344	0.311	0.517	0.316	0.308	0.272
07/14/03		0.485	0.680					0.399	0.657			0.672	0.489	0.797		0.343	0.240	0.342	0.354	0.353	0.415	0.298	0.270	0.257
07/21/03				0.448											0.249	0.362	0.262	0.314	0.338	0.280	0.288	0.250	0.300	0.276
07/28/03				0.405											0.294	0.367	0.270	0.305	0.362	0.320	0.598	0.379	0.314	0.266
08/04/03		0.449	0.464	0.418				0.425	0.509			0.432	0.402	0.652	0.283	0.348	0.277	0.330	0.292	0.277	0.349	0.253	0.272	0.273
08/11/03				0.391											0.328	0.259	0.263	0.239	0.370	0.261	0.364	0.333	0.268	0.296
08/18/03				0.246											0.268	0.230	0.246	0.234	0.232	0.264	0.588	0.418	0.232	0.216
08/25/03		0.318	0.291	0.240				0.231	0.417			0.313	0.367	0.377	0.271	0.227	0.264	0.235	0.272	0.192	0.638	0.563	0.312	0.243
09/02/03																								
09/08/03		0.341	0.465	0.284				0.268	0.317			0.358	0.342	0.380	0.283	0.270	0.253	0.259	0.314	0.281	0.647	0.364	0.304	0.266
09/15/03																								
09/22/03		0.387	0.392	0.296				0.281	0.540			0.388	0.359	0.466	0.341	0.310	0.277	0.282	0.280	0.315	0.640	0.530	0.280	0.210
09/29/03															0.547	0.356	0.265	0.322	0.340	0.291	0.444	0.389	0.367	0.261

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
10/06/03		0.320	0.495	0.333				0.316	0.378			0.425	0.399	0.456	0.647	0.279	0.259	0.290	0.343	0.311	0.420	0.348	0.301	0.189
10/13/03				0.325											0.477	0.327	0.233	0.289	0.334	0.319	0.493		0.255	0.258
10/20/03				0.387											0.265	0.321	0.231	0.292	0.297	0.340	0.465		0.281	0.252
10/28/03		0.353	0.562	0.349				0.313	0.764			0.312	0.379	0.478		0.359	0.246	0.318	0.268	0.213	0.381		0.309	0.267
11/03/03															0.253	0.421	0.331	0.374	0.392	0.315	0.832	0.713	0.459	0.339
11/10/03																								
11/17/03		0.369	0.503	0.365				0.321	0.335			0.352	0.339	0.399	0.224	0.383	0.205	0.301	0.377	0.315	0.932	1.076		
12/01/03		0.443	0.523	0.382				0.374	0.468			0.321	0.345	0.419	0.192	0.373	0.187	0.224	0.257	0.480	0.581	0.575		
12/15/03															0.187	0.340	0.151	0.259	0.248	0.246	0.373	0.364		
01/20/04												0.282	0.272	0.411	0.199	0.366	0.233	0.336	0.509	0.456	1.297	1.150		
02/17/04		0.364	0.327	0.415								0.342	0.325	0.320	0.181	0.364	0.170	0.248	0.322	0.295	0.675	0.705	0.271	
03/16/04								0.173	0.263			0.462	0.375	0.333		0.464	0.231	0.36	0.390		0.625	0.656	0.398	0.378

Table 6.2. (Continued) Total dissolved nitrogen (mg/l) from August 1999 to January 2004 (0 <MDL).

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/01/99	0.110																							
09/01/99	0.380																							
10/01/99	0.188																							
11/01/99	0.080																							
12/01/99																								
01/01/00	0.042																							
02/01/00																								
03/01/00	0.146																							
04/01/00	0.104																							
05/01/00	0.260																							
06/01/00	0.128																							
07/01/00	0.188																							
08/01/00	0.402																							
09/01/00	0.076																							
10/01/00	0.280																							
11/01/00	0.014																							
12/01/00	0.062																							
01/01/01	0.020																							
02/01/01	0.108			0.160																				
03/01/01	0.070			0.126	0.498																			
04/01/01	0.066			0.080	0.280																			
05/01/01				0.116	0.370																			
06/01/01	0.164			0.122	0.345																			
07/01/01	1.246			0.081	0.330																			
08/01/01				0.118	0.373																			
09/01/01	0.301			0.235	0.396																			
10/01/01	0.158			0.246	0.376																			
11/01/01	0.044			0.083																				
12/01/01	0.000			0.108	0.237																			
01/01/02				0.027																				
02/01/02	0.101			0.079	0.238																			
03/01/02				0.138	0.444																			
04/01/02	0.090			0.150	0.369																			
05/01/02				0.115	0.263																			
06/01/02	0.083			0.225	0.233																			
07/01/02		0.183	0.140				0.275					0.217	0.184	0.161	0.131	0.171	0.152		0.169		1.062	1.042	0.309	0.223
07/08/02		0.252	0.245			0.306	0.212					0.643	0.257	0.263	0.271	0.197	0.258		0.272		1.273	1.259	0.439	0.352
07/16/02		0.157	0.191			0.206	0.159					0.525	0.161	0.158	0.174	0.135	0.175		0.181		1.426	1.092	0.450	0.303
07/22/02		0.218	0.226			0.238	0.236					0.493	0.196	0.203	0.187	0.114	0.223		0.225		1.432	1.489	0.394	0.240
07/29/02		0.242	0.224			0.240	0.226					0.602	0.204	0.202	0.226	0.182	0.212		0.246		1.680	1.096	0.308	0.224
07/30/02																								
08/05/02		0.254	0.228			0.236	0.224					0.550	0.256	0.222	0.222	0.164	0.208		0.212		1.680	1.430	0.362	0.248
08/12/02		0.224	0.246			0.229	0.216					0.313	0.260	0.240	0.226	0.178	0.250		0.228		1.709	1.666	0.380	0.248

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/19/02		0.230	0.180			0.236	0.220					0.480	0.260	0.210	0.226	0.154	0.200		0.204		1.930	1.796	0.260	0.188
08/26/02		0.188	0.196			0.182	0.188					0.554	0.188	0.190	0.268	0.126	0.180		0.206		1.556	1.578	0.254	0.276
08/30/02																								
09/03/02		0.200	0.222			0.254	0.196					0.528	0.184	0.204	0.244	0.192	0.190		0.258		1.914	1.794	0.218	0.190
09/10/02		0.238	0.244			0.246	0.298					0.996	0.228	0.204	0.206	0.242	0.194		0.226		2.536	2.422	0.264	0.172
09/16/02		0.202	0.270			0.188	0.220					0.538	0.216	0.220	0.234	0.174	0.200		0.274		2.242	2.262	0.210	0.172
09/23/02		0.248	0.216			0.236	0.238					0.734	0.170	0.172	0.298	0.208	0.180		0.242		2.422	2.368	0.206	0.166
09/30/02	0.158	0.238	0.260			0.228	0.200					0.512	0.202	0.222	0.250	0.176	0.234		0.294		1.796	1.682	0.192	0.140
10/02/02																								
10/07/02		0.206	0.176			3.790	0.620					0.810	0.148	0.168	0.200	0.160	0.168		0.200		2.216	2.210	0.222	0.142
10/14/02		0.262	0.218			0.250	0.238					0.676	0.202	0.208	0.306	0.236	0.170		0.216		1.318	1.362	0.218	0.146
10/16/02																								
10/21/02		0.220	0.226			0.338	0.218					0.168	0.200	0.198	0.240	0.214	0.242		0.212		1.250	1.330	0.276	0.160
10/28/02		0.560	0.262			0.246	0.210					0.716	0.184	0.180	0.226	0.302	0.194		0.232		2.540	2.506	0.322	0.154
10/30/02	0.184																							
11/04/02		0.250	0.312			0.270	0.234					1.064	0.208	0.190	0.286	0.244	0.244		0.256		1.872	1.748	0.278	0.182
11/12/02		0.242	0.236			0.248	0.442					0.546	0.230	0.172	0.304	0.266	0.174		0.222		2.034	2.120	0.368	0.286
11/13/02																								
11/18/02		0.162	0.166			0.518	0.236					0.160	0.110	0.102	0.186	0.164	0.138		0.162		1.918	2.208	0.298	0.178
11/25/02		0.248	0.170			0.194	0.174						0.136	0.142	0.238	0.214	0.176		0.174				0.348	0.246
11/30/02																								
12/09/02		0.298	0.272			0.252	0.278						0.150	0.166	0.358	0.314	0.162		0.262				0.390	0.290
12/16/02		0.330	0.330			0.304	0.314						0.148	0.256	0.418	0.306	0.258		0.338				0.428	0.292
12/17/02																								
12/30/02	0.038																							
01/14/03	0.116			0.146								1.513								0.327	2.643	2.382	0.375	0.294
02/11/03	0.372		0.215	0.201								1.018					0.304			0.410	2.735	2.704	0.405	0.359
03/11/03	0.194		0.442	0.143								1.436					0.196			0.391	2.826	2.656	0.436	0.368
04/15/03	0.125	0.941	0.339	0.126				2.005	2.160			0.601	0.268				0.425			0.189	1.860	1.697	0.410	0.338
05/13/03	0.130	0.421	0.388	0.225				1.407	0.688	0.532	0.511	0.669	0.362		0.392	0.359	0.339			0.240	2.011	1.878	0.496	0.372
06/03/03		0.339	0.354	0.199				0.386	0.462	0.414	0.437	0.584	0.295		0.377	0.307	0.337	2.480		0.212	1.331	1.320	0.410	0.347
06/10/03		0.369	0.335					1.298	1.414			0.549	0.260		0.357	0.241	0.255			0.225	2.041	1.919	0.358	0.325
06/24/03	0.113	0.341	0.317	0.188				0.444	0.472	0.417	0.368	0.483	0.263		0.347	0.272	0.438			0.230	1.789	1.631	0.359	0.324
07/07/03		0.339	0.318	0.236				1.120	0.944			0.552	0.316		0.325	0.282	0.282			0.227	1.807	1.451	0.371	0.320
07/14/03	0.115	0.325	0.298	0.232								0.428	0.305		0.296	0.274	0.288			0.227	1.591	1.609	0.357	0.310
07/21/03		0.354	0.351	0.241				1.471	0.562			0.361	0.324		0.291	0.224	0.299			0.640	1.157	1.118	0.412	0.326
07/28/03		0.346	0.364	0.253				0.614	1.375			0.739	0.307		0.418	0.355	0.283			0.253	2.103	1.928	0.396	0.333
08/04/03		0.320	0.340	0.244				0.332	0.322			0.795	0.308		0.341	0.295	0.311	2.195		0.299	2.487	2.313	0.391	0.321
08/11/03		0.268	0.279	0.225				0.649	0.559			0.939	0.280		0.306	0.243	0.281			0.300	2.060	2.045	0.318	0.283
08/18/03				0.208				0.400	0.491			0.298			0.264	0.228				0.235	1.466	1.469	0.257	0.196
08/25/03	0.309			0.186				2.040	0.688	0.273	0.259	0.926			0.268	0.221				0.252	2.214	2.117	0.241	0.184
09/02/03																								
09/08/03				0.181				0.872	0.527			0.599			0.357	0.290				0.294	1.831	1.554	0.247	0.227
09/15/03																								
09/22/03	0.186			0.152				1.158	0.548			0.602			0.692	0.200				0.302	2.064	2.056	0.297	0.242

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
09/29/03				0.219				1.872	1.988			0.772			0.436	0.368				0.294	2.078	1.795	0.332	0.271
10/06/03				0.207				0.342	0.306			0.338			0.466	0.355				0.267	1.896	2.470	0.342	0.215
10/13/03								0.871	0.808	0.298	0.333	0.713			0.435	0.314				0.227	1.262	1.680	0.373	0.271
10/20/03				0.376				2.421	1.431			0.970			0.457	0.386				0.228	2.698	2.795	0.401	0.300
10/28/03	0.123			0.293				1.331	3.577			0.917			0.273	0.264				0.248	1.788	2.007	0.356	0.330
11/03/03								1.287	1.561			1.136			0.363	0.309				0.389	3.350	3.245	0.369	
11/10/03																								
11/17/03				0.191				0.715	0.419						0.489	0.443							0.355	0.308
12/01/03	0.072			0.178				2.846	3.201						0.402	0.494							0.387	0.335
12/15/03	0.087			0.175				2.589	3.032	0.370	0.353				0.378	0.323							0.340	0.312
01/20/04				0.259						0.361	0.396	1.074									2.401	2.163	0.381	0.317
02/17/04				0.192						0.395	0.385	0.656								0.146	2.676	2.515	0.378	0.336
03/16/04								2.825		0.460	0.469				0.484	0.439				0.374			0.446	0.415

Table 7.1. Total phosphorous (ug/l) from August 1999 to January 2004 (0 <MDL).

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/01/99	4.1	5.5	2.1	9.5	5.6		39.2	9.5	31.6	34.3	28.5	12.8		42.4	24.3	1.5	28.0	19.5	9.5		22.7		16.6	
09/01/99	0.0	15.4	39.7	9.6	0.0		43.0	6.4	30.3	40.2	17.9	6.0		13.9	25.6	0.0	28.0	15.8	32.3		29.5		14.4	
10/01/99	0.0	3.2	9.4	6.5	0.0		53.7	27.5	15.4	40.1	23.1	9.7		17.6	20.1	0.0	44.0	28.9	48.6		28.8		16.8	
11/01/99	15.1	8.1	12.8	6.4	7.1		34.5	34.6	62.6	32.1	25.9	18.4		19.8	13.5	40.3	31.8	44.2	33.1		50.6			
12/01/99	5.3	6.6	8.8	5.2	5.5		31.3	32.6	160.6	36.0	24.2	72.6		0.0	6.6	20.0	31.1	27.8	21.0		14.0			
01/01/00	12.2	13.0	10.0	12.6	3.3		14.2	10.1	22.9	12.4	15.3	6.5		5.8	0.0	0.0	12.3						8.4	
02/01/00	7.4	5.2	1.2	3.0	7.2		91.4	15.8	20.0	26.6	23.4	8.0		17.8	6.4	3.2	15.8	13.0	29.2		7.2		22.0	0.2
03/01/00	1.4	6.0	2.8	1.8	4.0	3.2	101.0	27.0	43.8	34.8	19.6	8.2		85.6	10.2	7.2	40.0	27.0	30.8		11.8		4.2	
04/01/00	2.8	2.0	0.6	2.8	1.0	0.6	54.2	7.4	8.6	18.2	13.0	5.6	5.0	12.8	8.0	0.0	11.0	10.0	45.4		38.0		6.2	
05/01/00	11.0	9.6	11.2	11.0	10.4	10.6	113.8	16.4	29.0	26.6	23.2	22.0	21.4	46.0	22.6	11.4	17.4	15.6	19.2		38.2		21.8	
06/01/00	9.6	9.0	8.2	8.8	8.8	10.0	85.2	17.6	266.8	28.2	22.2	18.8	18.6	29.4	19.2	11.0	21.6	14.6	14.8		18.2		17.0	
07/01/00	10.2	7.6	15.2	10.6	10.2	8.8	52.2	12.6	25.8	27.2	29.2	21.2	18.0	139.8	28.2	9.8	30.8	25.4	15.0		12.8		15.6	
08/01/00	4.6	4.8	7.4	4.6	6.2	7.2	35.6	10.2	35.4	26.8	22.0	18.8	10.0	15.8	17.0	8.4	17.4	11.4	12.0		11.6		11.4	
09/01/00	4.4	7.2	11.2	11.0	11.2	11.4	43.0	12.0	18.6	42.0	28.0	11.8	7.2	7.6	20.0	11.4	19.8	11.8	12.0		7.6		9.8	
10/01/00	5.6	9.4	10.4	13.6	7.0	7.2	67.6	18.6	93.2	84.4	38.4	23.6	22.2	27.6	18.2	9.4	44.4	30.8	20.2		14.8		17.4	
11/01/00	7.8	9.2	16.0	8.2	7.2	8.0	25.4	28.0	34.8	36.6	43.6	32.0	32.2	32.8	18.0	5.0	28.0	21.0	31.4		26.2		17.0	
12/01/00	7.4	7.6	13.2	9.2	9.4	9.4	34.4	28.8	47.6	39.6	39.8	30.2	31.4	30.0	12.8	9.6	33.2	31.8	28.2		20.0			
01/01/01	2.0	2.0	3.0	0.0	0.0	0.0	27.4	14.2	24.8	12.2	24.8	17.4	13.4	15.6	0.0	0.0	12.8						6.8	
02/01/01	10.6	2.0	8.0	3.4	8.2	2.2	16.0	11.6	13.8	14.0	26.8	17.0	17.0	19.0	7.8	3.8	29.4	24.8	30.0		14.6		14.2	
03/01/01	6.2	0.0	5.0	1.8	2.0	1.6	59.6	5.6	10.8	6.6	17.4	5.0	7.0	15.0	9.8	1.6	9.8	3.6	8.2		7.0		4.8	
04/01/01	2.6	2.8	3.4	3.6	2.8	3.0	12.6	6.4	25.8	15.4	14.6	7.6	7.8	13.8	12.0	3.0	12.4	13.8	22.4		8.4		10.8	
05/01/01		14.8	0.0	4.2	0.0	0.0	26.6	6.8	2.4	12.0	12.4	5.8	5.8	21.4	8.4	0.0	6.0	3.4	1.8		1.8		2.6	
06/01/01	3.4	0.8	0.9	3.7	7.8	4.6	24.0	16.9	2.1	26.4	19.1	14.2	15.6	15.4	16.4	2.8	18.6	17.0	30.9		19.4		14.5	
07/01/01	0.0	4.7	8.7	4.9	5.6	2.0	30.9	4.4	6.5	20.5	16.2	11.2	3.8	9.9	12.6	0.4	9.2	10.4	16.7		5.7		5.0	
08/01/01	13.1	11.6	14.1	15.0	14.3	13.7	84.6	15.4	19.4	35.9	25.4	19.0	20.2	31.9	30.5	13.2	33.0		26.5		19.8		22.7	
09/01/01	3.4	9.6	11.4	13.4	14.2	10.2	73.4	15.6	15.0	40.8	36.2	20.0	17.8	29.0	31.0	14.6	37.8	36.4	35.2		23.4		11.4	
10/01/01	6.1	9.7	12.4	31.0	16.7	16.0	65.9	15.9		87.0	19.7	21.2	23.4	23.7	14.2	28.9	25.0	24.7	8.0	15.2	28.9		7.4	37.8
11/01/01	6.4	24.2	7.3	5.2	7.5	4.4	27.4	13.0	18.8	15.9	29.0	13.7	18.2	16.3	11.3		18.5	21.0	16.9		15.9		22.4	
12/01/01	8.0	13.3		46.1	7.3	6.4	15.6	14.0		24.3	37.3	13.7	12.4	12.6	6.8	9.8	14.2	14.6	11.5		9.5		12.5	
01/01/02		6.1		7.3	8.3	7.0	16.1	19.1		23.7	25.6	9.7	12.4	12.1	11.3	4.9	9.4	12.1			9.1		13.9	
02/01/02	5.1	14.0	9.7	8.5	12.9	6.0	13.4	18.4	17.9	15.6	20.3	14.8	11.1	12.8	9.4	24.0	15.1	9.7	11.1		13.2		11.8	
03/01/02	5.5	6.4	6.6	8.9	7.6	7.4	15.2	8.6	20.2	14.9		19.3	21.1		11.0	51.9	19.9	9.5	34.6		30.6		17.7	
04/01/02	7.6	8.6	5.7	6.2	4.4	4.1	37.5	4.9	7.6	13.3	15.7	8.4	9.8	3.5	21.2	8.9	20.3	14.2	21.0		31.4		20.9	
05/01/02	7.6	7.3	7.3	7.4	7.0	7.5	32.9	10.1	15.6	14.1		19.7	22.3	18.9	29.3	8.9	18.9	15.7	21.0		23.4		12.2	
06/01/02	5.4	5.3	5.4	5.9	6.4	6.3	32.3	6.9	12.6	20.2		17.6	17.5	10.9	18.9	3.5	20.9	19.4	19.4		18.9		18.2	
07/01/02																								
07/08/02																								
07/16/02																								
07/22/02																								
07/29/02																								
07/30/02																								
08/05/02																								
08/12/02																								
08/19/02																								

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/26/02																								
08/30/02																								
09/03/02																								
09/10/02																								
09/16/02																								
09/23/02																								
09/30/02																								
10/02/02																								
10/07/02																								
10/14/02																								
10/16/02																								
10/21/02																								
10/28/02																								
10/30/02																								
11/04/02																								
11/12/02																								
11/13/02																								
11/18/02																								
11/25/02																								
11/30/02																								
12/09/02																								
12/16/02																								
12/17/02																								
12/30/02																								
01/14/03		14.4	13.8					25.1	24.2			17.8	15.9	18.8	11.8	8.3							11.9	
02/11/03		7.9	5.4					14.7	54.0			15.6	18.5	18.9	18.0		28.8	20.3			33.4		22.4	
03/11/03		6.3	8.5					40.6	19.0			12.2	21.7	15.0	14.1		29.4	21.3			16.0		9.4	
04/15/03		11.8	9.8	6.0				25.8	29.9			20.7	22.9	20.4	20.5	6.6	38.1	16.1			46.1		11.5	
05/13/03		12.8	12.4	6.0				19.8	20.2			20.2	20.6	10.8	17.2	5.6	16.8	6.4			32.8		30.0	
06/03/03																								
06/10/03																								
06/24/03		26.3	13.6	12.2				20.4	20.6			25.2	22.8	25.7	37.0	13.2	28.6	17.8			21.6		30.2	
07/07/03																								
07/14/03		12.1	7.8					14.1	11.3			22.1	20.1	36.9		5.3	14.6	8.7			10.3		11.6	
07/21/03																								
07/28/03																								
08/04/03		17.5	17.2					17.7	23.8			20.1	19.0	23.1										
08/11/03				22.2											28.2	20.4	35.4	26.2			24.6		31.8	
08/18/03																								
08/25/03		5.6	5.8					2.3	8.8			8.2	8.0	6.2										
09/02/03																								
09/08/03		6.2	7.6					11.2	13.2			7.6	9.0	14.0										
09/15/03															24.8	11.2	32.9	19.2			16.2			28.8
09/22/03		1.1	2.3					1.6	2.8			3.9	1.6	3.1										
09/29/03																								

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
10/06/03		0.0	2.6					3.8	3.5			1.3	0.0	1.2										
10/13/03				6.0											32.8	7.0	10.6	6.4			4.1			
10/20/03																								
10/28/03		14.8	25.1					7.7	30.2			6.5	5.7	5.2										
11/03/03																								
11/10/03																								
11/17/03		18.8	14.7	7.7				22.7	32.5			7.9	6.0	9.8	11.9	9.9	23.2	10.6			14.6			
12/01/03		12.8	10.8					28.3	25.8			1.8	6.3	2.3										
12/15/03															10.0	7.4	20.5	10.6			11.8			
01/20/04																								
02/17/04																								
03/16/04																								

Table 7.2. (Continued) Total phosphorous (ug/l) from August 1999 to January 2004 (0 <MDL).

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/01/99	15.6																							
09/01/99	154.0																							
10/01/99	29.3																							
11/01/99	5.8																							
12/01/99																								
01/01/00	3.2																							
02/01/00																								
03/01/00	27.2																							
04/01/00	11.6																							
05/01/00	35.0																							
06/01/00	50.2																							
07/01/00	46.4																							
08/01/00	80.2																							
09/01/00	20.4																							
10/01/00	15.4																							
11/01/00	10.6																							
12/01/00	0.0																							
01/01/01	7.6																							
02/01/01	5.4			15.8																				
03/01/01	8.6			5.4																				
04/01/01	11.0			10.2	13.6																			
05/01/01				9.6	4.6																			
06/01/01	163.5			6.8	34.4																			
07/01/01				0.4	15.0																			
08/01/01				14.8	23.8																			
09/01/01	149.8			14.6	27.2																			
10/01/01	32.6			20.1																				
11/01/01	7.3			24.0																				
12/01/01	5.9			11.8	13.9																			
01/01/02				10.1																				
02/01/02	9.9			9.9	11.6																			
03/01/02				8.4	32.3																			
04/01/02				13.2	18.4																			
05/01/02				12.8	18.3																			
06/01/02				78.5	20.5																			
07/01/02																								
07/08/02																								
07/16/02																								
07/22/02																								
07/29/02																								
07/30/02																								
08/05/02																								
08/12/02																								

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/19/02																								
08/26/02																								
08/30/02																								
09/03/02																								
09/10/02																								
09/16/02																								
09/23/02																								
09/30/02																								
10/02/02																								
10/07/02																								
10/14/02																								
10/16/02																								
10/21/02																								
10/28/02																								
10/30/02																								
11/04/02																								
11/12/02																								
11/13/02																								
11/18/02																								
11/25/02																								
11/30/02																								
12/09/02																								
12/16/02																								
12/17/02																								
12/30/02																								
01/14/03				25.0								22.2								10.8	7.5		10.6	
02/11/03	138.4			28.4								18.3					31.5			12.4	13.3		10.4	
03/11/03	68.5			25.1								12.1					23.5				2.2		7.2	
04/15/03												16.3								38.5	8.0		7.0	
05/13/03	10.0			29.5								19.6								39.3	8.8		19.6	
06/03/03																								
06/10/03																								
06/24/03	34.6			32.6				19.1				23.2			19.4					33.4	16.0		13.2	
07/07/03																								
07/14/03				11.2								13.4			9.2					14.3	6.6		4.3	
07/21/03																								
07/28/03																								
08/04/03																								
08/11/03				56.5								27.6			32.6		18.8				18.8		19.8	
08/18/03																								
08/25/03	43.8																							
09/02/03																								
09/08/03																								
09/15/03				20.4								29.8			32.8								11.2	
09/22/03	24.1																							

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
09/29/03																								
10/06/03																								
10/13/03												7.4			5.5		3.7				1.2			
10/20/03																								
10/28/03																								
11/03/03																								
11/10/03																								
11/17/03				22.1				21.8							7.7		6.1						4.8	
12/01/03																								
12/15/03				20.6				12.3							18.3		8.9						6.6	
01/20/04																								
02/17/04																								
03/16/04																								

Table 8.1. Total dissolved phosphorous (ug/l) from August 1999 to January 2004 (0 <MDL).

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/01/99	7.0	1.8	0.0	3.1	0.0		15.9	2.6	22.9	22.2	15.8	0.0		25.6	17.3	0.0	33.6	18.9	11.5		7.8		33.3	
09/01/99	10.0	10.6	0.0	9.0	3.5		26.9	1.9	42.1	30.2	16.8	0.0		2.4	12.9	0.0	9.9	19.4	15.2		4.8		5.6	
10/01/99	0.0	0.0	0.0	0.0	0.0		20.6	4.7	2.5	23.0	13.5	6.2		10.3	13.7	0.0	22.2	9.0	10.2		5.7		5.2	
11/01/99	3.4	5.1	8.2	3.0	2.7		10.5	19.7	16.0	12.8	19.6	9.9		9.6	10.8	32.4	14.9	14.5	15.8		18.0			
12/01/99	3.6	5.7	5.8	4.1	3.3		7.1	19.2	17.0	15.0	22.6	13.4		10.7		12.4	13.3	11.8	10.2		9.0			
01/01/00	0.0	0.0	0.0	0.0	0.0		0.0	5.5	4.1	3.9	14.8	3.8		3.1	0.0	0.0	1.4						0.0	
02/01/00	2.4	2.8	0.0	0.0	0.0		16.6	4.0	5.6	10.6	16.1	4.2		6.4	4.0	0.0	9.4	0.0	5.2		5.2		0.8	0.2
03/01/00	1.0	3.8	1.4	0.6	0.4	0.0	9.8	5.2	16.2	8.4	16.0	4.0		14.6	5.6	0.0	7.4	3.2	4.2		4.6		0.2	
04/01/00	0.0	0.0	0.0	0.0	0.0	0.0	7.4	0.0	0.0	5.8	2.4	0.0	0.0	6.8	3.6	0.0	1.4	0.0	1.2		2.0		0.2	
05/01/00	9.6	8.8	7.8	8.0	8.0	8.2	30.4	14.4	12.2	19.4	18.4	14.4	15.6	25.0	16.6	9.4	15.2	10.2	13.8		14.8		11.6	
06/01/00	7.8	7.2	6.4	7.2	7.2	7.4	18.6	10.6	13.4	18.8	15.6	10.2	14.0	16.0	13.4	8.8		4.2	12.2		12.8		10.0	
07/01/00	7.2	6.4	6.6	8.0	9.0	7.4	18.0	10.2	25.0	24.0	16.6	10.0	9.8	55.6	24.2	7.8	19.4	19.2	9.4		11.2		14.8	
08/01/00	2.2		4.8	4.6	2.4	1.8	11.6	5.6	27.6	22.2	11.8	7.6	5.8	14.0	13.2	4.4	12.0	9.4	7.8		6.0		6.6	
09/01/00	18.0	15.4	15.2	19.4	17.4	16.8	29.2	16.2	19.4	49.4	28.0	14.8	18.6	14.0	30.0	17.4	21.2	16.4	20.8		15.6		6.4	
10/01/00	5.6	5.2	6.2	5.6	8.4	4.4	18.6	10.8	62.8	57.4	27.8	14.4	19.8	21.8	15.0	17.6	34.4	21.0	23.6		21.6		21.4	
11/01/00	4.8	5.6	6.0	5.4	5.2	7.4	12.6	19.6	19.0	19.4	35.8	26.2	23.0	25.2	12.4	3.6	10.2	9.4	8.8		19.8		10.6	
12/01/00	4.4	4.2	6.8	7.0	6.2	7.2	25.6	21.4	25.6	24.4	35.2	25.6	26.2	26.4	9.4	5.8	12.8	14.6	14.4		13.8			
01/01/01	1.6	0.0	0.0	0.0	0.0	0.0	2.0	6.0	12.0	5.2	21.6	15.6	9.6	9.0	0.0	0.0	1.0						0.0	
02/01/01	5.2	2.0	1.8	1.4	0.0	1.0	5.2	4.6	9.2	7.2	22.8	11.4	11.0	16.8	5.4	2.0	7.2	8.0	13.2		8.4		4.8	
03/01/01	3.2	0.0	1.0	0.0	0.0	0.0	21.4	4.6	7.0	5.6	14.6	4.2	3.8	9.4	3.8	1.6	8.0	2.6	6.0		3.4		1.2	
04/01/01	1.4	2.0	2.4	1.6	2.8	1.6	10.8	6.2	16.2	14.4	13.8	6.4	5.4	13.2	10.4	2.2	8.6	8.0	8.8		5.8		4.4	
05/01/01		8.4	0.0	2.4	0.0	0.0	13.6	3.2	0.0	12.0	10.4	5.4	4.6	20.0	7.4	0.0	5.4	2.2	1.0		1.0		0.0	
06/01/01	0.0	0.0	0.0	0.0	0.0	0.0	5.7	0.0	0.0	6.4	5.5	0.0	0.0	6.5	10.4	0.0	5.4	3.6	0.0		0.0		0.0	
07/01/01	5.4	3.8	6.5	6.5	4.7	2.2	23.8	18.1	5.7	15.6	2.2	0.0	4.6	10.1	12.0	0.0	7.7	7.7	3.6		49.7		2.4	
08/01/01	11.1	12.9	12.1	13.5	12.6	36.1	40.9	12.8	19.5	36.1	22.7	19.2	15.7	30.4	28.4	11.0	28.1		17.9		13.8		19.1	
09/01/01	3.0	7.8	9.0	8.0	9.4	7.4	20.4	3.8	14.2	27.6	17.0	18.6	8.0	22.0	18.0	7.4	16.8	18.4	13.6		17.2		19.8	
10/01/01	5.0	6.5	5.0	20.6	14.5	11.4	23.5	6.2		8.7	12.3	12.0	14.7	21.6	9.7	13.1	16.5	14.2	7.6	8.1	12.7		7.3	9.9
11/01/01	5.0	4.2	3.2	1.5	5.3	3.5	11.1	5.9	11.1	8.5	15.8	6.3	8.6	9.6	6.5		11.7	11.8	11.4	8.7	9.1		13.1	20.9
12/01/01	4.8	9.1		2.4	6.7	5.7	9.8	11.3		13.3	25.1	8.3	7.1	8.3	6.1	6.0	10.8	14.5	7.1	3.2	5.2		10.2	3.7
01/01/02		5.1		2.3	5.0	5.8	8.9	9.3		11.8	22.3	7.7	7.0	8.5	5.6	2.6	9.1	7.4			5.1		5.3	4.0
02/01/02	4.5	3.3	6.1	7.4	2.2	3.6	7.2	12.1	11.4	8.7	16.4	6.3	6.7	11.3	8.3	7.9	8.0	5.6	6.3		6.5		8.3	4.1
03/01/02	3.3	5.2	5.4	3.8	4.7	4.8	9.9	5.9	11.4	8.9	9.0	7.4	7.6		7.1	9.4	6.7	5.1	6.8	6.9	8.3	5.8	9.2	
04/01/02	5.7	5.8	4.8	2.9	1.8	1.4	10.9	2.6	4.0	5.5	3.1	1.4	1.9	1.4	9.9	5.6	11.5	7.2	7.2		7.5		8.1	
05/01/02	5.3	4.8	6.2	4.5	5.5	7.2	12.4	9.1	10.2	9.7		9.1	10.9	13.3	24.0	5.8	14.6	9.6	14.0		9.2		4.2	
06/01/02	3.9	1.7	5.6	6.0	2.6	8.0	7.1	2.8	5.1	5.1		4.5	5.1	3.6	10.2	2.8	6.6	7.2	6.2		6.6		6.7	
07/01/02																								
07/08/02																								
07/16/02																								
07/22/02																								
07/29/02																								
07/30/02																								
08/05/02																								
08/12/02																								
08/19/02																								

Table 8.2. (Continued)Total dissolved phosphorous (ug/l) from August 1999 to January 2004 (0 <MDL).

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/01/99	6.3																							
09/01/99	28.2																							
10/01/99	4.7																							
11/01/99	4.4																							
12/01/99																								
01/01/00	3.0																							
02/01/00																								
03/01/00	3.6																							
04/01/00	0.0																							
05/01/00	10.0																							
06/01/00	10.2																							
07/01/00	4.0																							
08/01/00	7.4																							
09/01/00	18.8																							
10/01/00	9.6																							
11/01/00	8.8																							
12/01/00	0.0																							
01/01/01	2.0																							
02/01/01	4.6			6.6																				
03/01/01	7.2			3.8																				
04/01/01	4.0			7.4	7.4																			
05/01/01				4.8	1.6																			
06/01/01	5.6			5.9	7.3																			
07/01/01				2.6	19.5																			
08/01/01				14.5	20.5																			
09/01/01	16.0			12.4	19.4																			
10/01/01	20.6			23.2																				
11/01/01	5.4			12.4																				
12/01/01	4.2			9.7	8.7																			
01/01/02				7.6																				
02/01/02	6.6			8.4	8.0																			
03/01/02				9.9	23.2																			
04/01/02				8.2	8.1																			
05/01/02				9.9	9.5																			
06/01/02				10.7	6.6																			
07/01/02																								
07/08/02																								
07/16/02																								
07/22/02																								
07/29/02																								
07/30/02																								
08/05/02																								
08/12/02																								

Table 9.1. Chlorophylla (ug/l) from August 1999 to January 2004 (0 < MDL).

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/01/99	0.3	0.3	0.6	0.8	1.1		7.6	3.8	2.1	3.6	1.7	9.0		5.1	4.2	1.7	5.4	5.1	0.6		3.1		2.8	
09/01/99	1.9	2.6	0.0	0.3	0.0		7.5	3.7	2.8	2.4	2.0	7.7		5.1	7.1	0.0	5.1	4.0	3.1		2.8		2.6	
10/01/99	1.2	2.3	2.2	1.7	1.1		6.0	5.7	5.9	5.1	7.4	4.8		4.2	4.0	2.8	4.8	4.8	5.9		2.2		2.8	
11/01/99	2.6	4.3	2.1	1.4	0.8		8.6	2.0	1.7	1.8	1.7	10.0		4.5	1.5	1.2	4.6	4.9	4.8		1.1			
12/01/99	0.3	0.0	0.4	0.0	2.0		15.2	2.1	4.9	0.2	1.1	7.2			1.1	1.4	4.0	5.5	6.0		2.8			
01/01/00	2.8	4.8	3.4	1.9	1.7		7.7	2.8	3.4	4.3	1.4	2.8		2.8	4.8	1.6	4.2						6.8	
02/01/00	0.9	0.1	0.1	0.9	2.6		5.5	2.3	3.4	2.0	1.8	3.5		2.9	2.1	11.2	2.7	5.8	3.8		1.5		10.4	
03/01/00	0.8	0.5	0.0	0.3	1.1	0.6	9.0	2.0	1.4	2.2	0.5	2.5		5.5	2.2	3.7	6.2	4.2	9.2		1.4		2.0	
04/01/00	0.9	2.9	2.6	0.9	0.9	1.2	8.6	4.3	2.3	1.4	2.6	1.2	0.9	1.1	4.3	0.6	1.7	1.7	5.4		5.2		2.0	
05/01/00	0.6	0.9	0.3	0.0	0.3	0.3	12.9	3.1	3.1	1.1	1.4	4.3	4.0	2.5	2.0	1.2	2.0	1.7	3.8		4.9		1.4	
06/01/00	2.0	0.3	0.0	0.1	0.6		9.5	4.3	7.0	1.2	0.6	4.6	4.3	2.9	2.0	1.5	2.0	2.3	6.6		3.4		5.2	
07/01/00	2.1	2.0	0.9	0.9	0.6	0.6	9.7	2.6	1.4	2.8	4.9	9.9	10.2	15.6	4.3	0.9	3.8	3.8	4.3		0.8		4.8	
08/01/00	0.9	3.2	2.0	1.2	2.3	2.0	6.7	2.3	2.2	3.2	2.5	14.5	5.2	1.1	3.1	5.4	3.1	4.2	6.3		1.7		2.5	
09/01/00	0.3	3.4	3.1	2.8	1.7	1.1	21.0	4.3	3.7	3.8	7.7	7.7	7.4	8.0	2.8	2.5	2.8	1.7	3.1		1.4		2.0	
10/01/00	2.6	4.0	2.9	4.9	4.3	4.0	2.4	6.0	2.5	4.8	2.3	9.0	7.6	2.8	4.3	4.8	4.2	4.2	2.8		1.1		3.5	
11/01/00	3.4	3.7	3.5	3.4	0.9	1.2	3.8	3.7	4.8	5.4	2.0	4.0	4.9	4.3	3.5	4.0	3.5	3.5	1.5		1.5		1.7	
12/01/00	4.5	4.5	4.0	4.2	2.9	3.4	6.9	2.9	3.1	3.4	0.3	1.7	1.7	2.0	2.8	6.0	2.6	3.7	4.3		12.6			
01/01/01	2.6	3.7	4.5	4.8	2.8	3.7	4.9	4.3	4.3	3.2	0.6	7.4	6.6	5.7	0.6	5.7	2.4						2.3	
02/01/01	4.8	6.4	7.1	6.5	4.5	3.6	2.2	2.8	2.5	5.1	2.0	4.0	4.0	1.1	0.8	4.5	2.8	2.3	4.3		1.7		6.3	
03/01/01	1.8	2.5	2.0	1.2	1.8	1.7	2.0	3.1	0.9	1.1	1.4	3.4	4.1	0.9	0.9	5.5	2.3	2.6	3.7		0.6		2.3	
04/01/01	0.6	3.1	0.0	0.9	0.6	0.6	3.5	0.9	10.0	1.1	2.3	3.7	3.2	0.6	2.3	0.9	4.1	3.8	12.5		2.9		2.6	
05/01/01		2.6	0.3	2.9	1.1	1.1	4.9	13.8	2.8	2.0	1.8	3.7	4.6	0.9	14.6	1.2	3.5	3.5	5.1		0.9		2.9	
06/01/01	1.7	1.4	1.4	0.5	0.9	0.9	5.9	9.2	0.6	2.0	2.3	9.7	10.3	4.5	6.6	1.4	3.4	3.4	5.4		2.3		5.4	
07/01/01	1.2	4.7	0.0	0.8	1.7	1.7	5.2	10.8	0.3	1.5	5.2	12.5	10.5	0.6	1.5	1.2	1.8	1.8	2.0		1.4		2.0	
08/01/01	0.3	1.4	0.3	0.9	2.0	1.7	4.3	0.9	0.0	1.2	1.7	1.9	3.9	0.3	4.5	1.1	4.6	3.4	2.0		1.5		3.1	
09/01/01	0.6	1.2	0.0	1.7	1.2	0.9	4.6	0.3	0.0	0.6	0.9	1.1	0.9	0.9	8.9	0.4	2.9	2.6	2.4		2.0		1.2	
10/01/01	0.9	1.7	0.8	1.5	1.7	1.6	1.8			1.1	66.9	4.9	4.6	2.6	1.1	8.2	2.8	2.5	1.1		1.1		2.3	
11/01/01																								
12/01/01																								
01/01/02																								
02/01/02	1.5	2.3	2.3	1.7	1.2	1.4	0.0	2.0	1.4	2.3	6.0	9.1	10.2	2.3	2.3	1.4	5.6	1.1	1.4		2.6		2.8	
03/01/02																								
04/01/02																								
05/01/02																								
06/01/02																								
07/01/02																								
07/08/02																								
07/16/02		0.3	0.0					7.1	0.0			10.7	10.7	2.2										
07/22/02																								
07/29/02																								
08/05/02																								

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/12/02		0.5	0.3					0.7	2.3			1.3	2.6	1.4										
08/19/02																								
08/26/02																								
09/03/02		0.7	0.2					1.5	2.1			2.5	2.7	3.0										
09/10/02																								
09/16/02		0.9	0.2					1.5	3.4			3.5	3.1	1.5										
09/23/02																								
09/30/02																								
10/02/02		0.8	0.2					1.7	1.8			2.1	2.0	2.6										
10/07/02																								
10/14/02																								
10/16/02		1.5	0.4					4.8	3.4			3.1	1.2	2.9										
10/21/02																								
10/28/02																								
10/30/02		1.5	0.7					5.0	3.6			3.6	4.1	3.2										
11/04/02																								
11/12/02																								
11/13/02		2.6	0.7					5.3	4.4			4.8	4.9	5.3										
11/18/02																								
11/25/02																								
12/09/02																								
12/16/02																								
12/17/02		0.4	0.5					2.0	0.7			4.8	3.9	5.3										
01/14/03		1.6	4.7					3.1	1.9			3.6	4.0	3.9										
02/11/03		2.0	2.1					0.5	2.5			2.4	2.9	3.6										
03/11/03		9.7	4.5					11.2	5.6			7.6	8.3	4.5										
04/15/03		6.7	1.5					7.2	3.4			8.5	8.3	5.1										
05/13/03		4.8	1.5					7.4	4.2			11.2	10.9	5.5										
06/03/03		5.7	2.8					10.7	5.4			11.7	11.0	5.4										
06/10/03																								
06/24/03																								
07/07/03																								
07/14/03																								
07/21/03																								
07/28/03																								
08/04/03																								
08/11/03																								
08/18/03																								
08/25/03																								
09/02/03																								
09/08/03																								
09/15/03																								
09/22/03																								
09/29/03																								
10/06/03																								

Table 9.2. (Continued) Chlorophylla (ug/l) from August 1999 to January 2004 (0 < MDL).

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/01/99																								
09/01/99																								
10/01/99																								
11/01/99																								
12/01/99																								
01/01/00																								
02/01/00																								
03/01/00	0.8																							
04/01/00	0.3																							
05/01/00																								
06/01/00	1.7																							
07/01/00	1.4																							
08/01/00	6.7																							
09/01/00	2.4																							
10/01/00	2.3																							
11/01/00																								
12/01/00	0.0																							
01/01/01																								
02/01/01	0.0			7.1																				
03/01/01	0.9			1.7	6.1																			
04/01/01	0.9			5.2																				
05/01/01				1.1	7.1																			
06/01/01				1.1	4.5																			
07/01/01				0.3	1.4																			
08/01/01				0.6	2.6																			
09/01/01	0.0			0.0	1.7																			
10/01/01				3.4	0.2																			
11/01/01																								
12/01/01																								
01/01/02																								
02/01/02	0.0			0.3	1.4																			
03/01/02																								
04/01/02																								
05/01/02																								
06/01/02																								
07/01/02																								
07/08/02																								
07/16/02																								
07/22/02																								
07/29/02																								
08/05/02																								
08/12/02																								
08/19/02																								

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/26/02																								
09/03/02																								
09/10/02																								
09/16/02																								
09/23/02																								
09/30/02																								
10/02/02																								
10/07/02																								
10/14/02																								
10/16/02																								
10/21/02																								
10/28/02																								
10/30/02																								
11/04/02																								
11/12/02																								
11/13/02																								
11/18/02																								
11/25/02																								
12/09/02																								
12/16/02																								
12/17/02																								
01/14/03																								
02/11/03	0.2																							
03/11/03																								
04/15/03																								
05/13/03																								
06/03/03																								
06/10/03																								
06/24/03																								
07/07/03																								
07/14/03																								
07/21/03																								
07/28/03																								
08/04/03																								
08/11/03																								
08/18/03																								
08/25/03																								
09/02/03																								
09/08/03																								
09/15/03																								
09/22/03																								
09/29/03																								
10/06/03																								
10/13/03																								
10/20/03																								

Table 10.1. Specific conductance (uS/cm) from August 1999 to January 2004.

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/01/99	800	890	850	870	830		500	490	490	500	1200	1220		1210	1200	850	1120	1120	1130		1060		1030	
09/01/99	750	800	785	790	780		480	480	460	450	1060	1080		1085	1055	770	1025	1015	1020		1010		1020	
10/01/99	760	850	810	770	760		425	495	490	480	1120	1150		1180	1180	780	1010	1000	995		995		995	
11/01/99	705	745	775	690	705		439	432	439	435	1185	1120		1125	1190	730	495	495	500		495			
12/01/99	715	755	745	703	655		504	417	420	427	1230	1225			1233	795	503	520	415		420			
01/01/00	762	790	775	728	742		520	486	499	494	1141	1104		1102	1145	719	496						593	
02/01/00	704	715	732	700	690		488	483	466	473	1077	1081		1079	1094	698	495	612	619		490		627	
03/01/00	740	760	770	715	703	702	443	497	501	495	1120	1103		1104	1127	712	511	652	660		655		709	
04/01/00	810	857	835	790	818	811	495	503	500	506	1203	1212	1205	1211	1199	785	1047	931	984		972		930	
05/01/00	737	790	795	728	748	749	592	475	500	502	1298	1253	1252	1253	1262	798	1190	1000	923		951		1000	
06/01/00	799	900	897	841	897	899	605	485	502	515	1255	1190	1170	1154	1162	760	1145	1009	1252		1290		1182	
07/01/00	830	898	912	846	875	860	670	503	500	502	1453	1399	1400	1400	1435	890	1405	1348	1143		1189		1247	
08/01/00	758	805	810	792	712	711	587	480	480	490	1510	1500	1500	1500	1455	804	1370	1221	990		995		875	
09/01/00	837	945	920	918	916	914	640	535	530	517	1485	1435	1436	1420	1451	892	1195	890	939		980		998	
10/01/00	745	837	840	866	810	800	590	530	495	491	1422	1365	1367	1372	1394	802	1210	980	995		1000		912	
11/01/00	740	762	760	750	770	765	548	600	503	510	1397	1369	1370	1390	1380	723	985	908	900		999		885	
12/01/00	721	712	710	699	700	700	479	498	453	491	1345	1315	1310	1301	1300	700	499	503	545		570			
01/01/01	702	705	702	695	721	717	448	448	650	427	1285	1306	1305	1330	1290	702	501						585	
02/01/01	645	623	622	627	725	720	319	399	396	385	1383	1376	1370	1360	1402	757	501	500	495		481		567	
03/01/01	830	805	800	790	780	780	220	455	510	503	1315	1399	1400	1403	1415	807	590	685	695		730		745	
04/01/01	775	722	720	691	700	700	298	345	445	435	1207	1233	1233	1227	1298	700	475	495	500		510		600	
05/01/01		615	600	575	725	720	422	237	265	345	1470	1407	1400	1402	1375	738	1299	1170	1045		1050		1070	
06/01/01	670	633	648	687	660	658	501	258	292	412	1435	1380	1347	1385	1398	719	1322	1324	1208		1160		1089	
07/01/01	662	670	660	682	595	590	528	265	298	330	1376	1278	1290	1330	1342	695	1280	1125	998		1000		1036	
08/01/01	640	625	605	615	607	605	412	292	285	325	1305	1320	1318	1335	1345	695	1350	1195	1155		1180		1125	
09/01/01	605	600	598	587	600	599	433	275	245	269	1201	1198	1201	1196	1210	615	1187	1169	1183		1198		1070	
10/01/01	601	611	608	600	622	620	425			266	1201	1298	1296	1293	1236	602	362	394	500		624		500	
11/01/01																								
12/01/01																								
01/01/02																								
02/01/02	717	703	701	692	706	702	429	397	399	421	1334	1327	1324	1342	1400	698	1149	970	999		1022		1020	
03/01/02	710	730	728	711	710	711	495	448	458	440	1387	1400	1375		1381	701	895	777	792		805		880	
04/01/02	750	727	718	699	728	703	500	415	430	435	1444	1390	1387	1399	1430	778	1298	1170	1118		1140		1142	
05/01/02	612	599	599	583	580	580	430	352	348	345		1177	1180	1173	1155	580	1103	1000	936		945		889	
06/01/02	638	642	633	640	648	650	498	399	397	410		1435	1480	1478	1499	751	1403	1345	1031		1028		1026	
07/01/02																970	1763	1736	1518	1529		1571	1580	1580
07/08/02																975	1748	1420	1520	1544	1546	1543	1431	1434
07/16/02		1008	982					631	644			1850	1860	1867		962		1431	1434	1436	1443	1439		1291
07/22/02																965	1736	1234	1154	1173	1161	1232	1407	1378
07/29/02																965	1642	1160	1129	1151	1139	1178	1293	1286
08/05/02																971	1738	1385	1387	1424	1419	1425	1194	1195
08/12/02		1015	949					640	649			1894	1922	1875		953	1730	1367	1362	1387	1361	1379	1151	1091
08/19/02																972	1768	1472	1540	1538	1466	1498	1264	1247
08/26/02																984	1184	1152	1138	1176	1152	1191	1223	1235

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
09/03/02		1032	988					665	654			1943	1940	1936		962	1767	1301	1246	1274	1270	1219	1157	
09/10/02																	1781	1507	1038	991		1123	1459	1172
09/16/02		1046	986					665	660			1974	1937	1947			1619	1143	1096	1100	1119	1119	1314	1290
09/23/02																	1540	1050	1028	1038	1029	1026		1196
09/30/02																	1498	1026	1013	1002	983	999	1090	1081
10/02/02		1023	986					672	647			1977	1976	1988										
10/07/02																	1521	1010	999	1008	1020	1062	1351	1375
10/14/02																950	1589	991	988	1000	1014	1020	1243	1265
10/16/02		1031	983					680	660			1970	1972	1959										
10/21/02																981	1223	992	984	1000	1009	1015	1171	1185
10/28/02																809	904	927	923	987	1024		890	913
10/30/02		1028	998					687	690			1974	1985	1983										
11/04/02																1020	1050	1045	1067	1112	1130		1035	1070
11/12/02																958	733	852	829	856	885		847	
11/13/02		1055	988					691	689			1975	1979	1985										
11/18/02																959	738	829	730	862	890		874	
11/25/02																								
12/09/02																								
12/16/02																963	748	810	855	908	871	866		
12/17/02		1015	990					693	701			1986	2004	1986										
01/14/03		992	1002					724	696			2004	1998	1997	1974	968							897	
02/11/03		990	1008					677	689			2018	2001	2042	1982		773	870	839		809		916	
03/11/03		983	1009					494	653			2013	2023	2006	2006		735	869	889		834		860	
04/15/03		973	966	960				347	474			1978	1986	1990	2035	966	659	822	852		868		823	
05/13/03		957	1005	990				342	345			2047	2015	1950	2056	992	527	873	865		862		734	
06/03/03		958	995	981				346	330			2014	2019	1996	1995	988	1719	1293	1250		1266		1507	
06/10/03																970	1495	1263	1176		1167		1346	
06/24/03		1010	1006	999				400	357			2155	2124	2090	2070	995	1345	1110	1104		1114		1272	
07/07/03				1011											2125	980	1310	1122	1223		1143		1235	
07/14/03		979	995	1005				396	366			2159	2167	2109	2153	995	1362	1154	1087		1142			
07/21/03																								
07/28/03				993											2185	980	1725	1413	1135		1113		1518	
08/25/03																								
09/02/03																								
09/08/03																								
09/15/03																								
09/22/03																								
09/29/03																								
10/06/03		1008	993	993				490	489			2253	2254	2240	2286	1000	702	950	942		948		904	
10/13/03																								
10/20/03				983											2277	993	471	731	721		748		791	
10/28/03		1004	1002	993				497	409			2255	2253	2247		995	480	734	728		735		751	
11/03/03																								
11/10/03				1000											2285	993	574	784	740		744		924	
11/17/03				993											2264	996	637	889	875		933			

Table 10.2. (Continued) Specific conductance (uS/cm) from August 1999 to January 2004.

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOC A	SPT In	SPT Out	UH In	UH Out
08/01/99																								
09/01/99																								
10/01/99																								
11/01/99																								
12/01/99																								
01/01/00																								
02/01/00																								
03/01/00	402																							
04/01/00	499																							
05/01/00																								
06/01/00	749																							
07/01/00	587																							
08/01/00	470																							
09/01/00	552																							
10/01/00	412																							
11/01/00																								
12/01/00	500																							
01/01/01																								
02/01/01	485			403																				
03/01/01	420			508	702																			
04/01/01	380			480																				
05/01/01				480	1065																			
06/01/01				423	1200																			
07/01/01				355	1009																			
08/01/01				325	1175																			
09/01/01	400			288	1185																			
10/01/01				297	531																			
11/01/01																								
12/01/01																								
01/01/02																								
02/01/02				423	1022																			
03/01/02	499			426	782																			
04/01/02	440			455	1178																			
05/01/02	460			348	970																			
06/01/02				519	1045																			
07/01/02		1511	1606			1512	1514					1470	1627	1650	1616	1627	1633		1599		1460	1453	974	980
07/08/02		1537	1538			1534	1532					1360	1481	1491	1530	1540	1540		1543		1315	1352	981	980
07/16/02		1434	1444			1434	1417					1269	1447			1436	1467		1444		1288	1309		
07/22/02		1148	1185			1165	1154					1309	1239	1235	1160	1174	1226		1161		1304	1331	967	977

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
07/29/02		1131	1125			1126	1130					1242	1170	1175	1123	1151	1159		1145		1284	1301	965	975
08/05/02		1407	1400			1381	1425					1159	1437	1398	1406	1443	1437		1430		1210	1222	970	986
08/12/02		1362	1360			1335	1362					1126	1353	1372	1359	1379	1366		1346		1198	1196		
08/19/02		1514	1508			1517	1463					1249	1526	1521	1483	1500	1522		1492		1281	1256	970	985
08/26/02		1145	1134			1137	1147					1232	1158	1139	1146	1215	1143		1145		1275	1281	969	980
09/03/02		1253	1254			1241	1248					1168	1300	1273	1262	1240	1264		1224		1216	1257	973	974
09/10/02			982			984	1026					1093	1575	1415	1006		1309		1162		1262	1263	955	956
09/16/02		1098	1120			1092	1085					1166	1121	1115	1089	1085	1107		1096		1195	1246	987	953
09/23/02		890	1016			1020	1011					1187	1043	1026	1008	990	1008		1020		1233	1236	956	968
09/30/02		982	999			993	998					1096	988	977	995	1005	1012		999		1193	1215	954	962
10/02/02																								
10/07/02		997	998			1003	1056					1228	1006	1011	1021	1004	996		999		1284	1288	971	971
10/14/02		978	981			985	977					1203	996	985	991	995	997		986		1175	1174	954	964
10/16/02																								
10/21/02		982	984			984	982					1192	991	963	992	1005	979		991		1260	1240	978	992
10/28/02		1010	897			940	1030					1003	873	865	1024	1026	865		874		1049		1011	1002
10/30/02																								
11/04/02		1107	1061			1104	1127					1142	1038	1050		1123	1054		1063		1103	1122	1023	1038
11/12/02		853	837			835	875					952	833	834		862	836		832		1086	1119	956	964
11/13/02																								
11/18/02		853	844			808	853					859	830	835	836	848	855		830		1113	1189	962	971
11/25/02																								
12/09/02																								
12/16/02		878	873				873							879	879	890	881		882				961	978
12/17/02																								
01/14/03	661			681								1087								946	1221		967	
02/11/03	451		832	677								927			1233		872			973			977	
03/11/03	302		838	652								1080					812			853	1270		963	
04/15/03	691		840	610								965					825			719	1095		973	
05/13/03	717		897	476								852			831		864	1668		564	1130		961	
06/03/03			1262	480				1171				1407			1243		1272			1670	1361		975	
06/10/03			1190	476								1294			1170		1239			1465	1255		983	
06/24/03			1132	395				1120				1233			1124		1134			1363	1281		990	
07/07/03			1118	386				1079				1215			1115		1130			1313	1235		985	
07/14/03	779		1078	395				1180				1095			1140		1105			1385	1190		994	
07/21/03																								
07/28/03			1141	403				1063				1328			1138		1385			1622	1317		991	
09/29/03																								
10/06/03			940	435				1014				890			936		949			890	1150		978	
10/13/03																								
10/20/03			744	407				699				940			741		724			603	1227		992	
10/28/03			758	438				708				905			734		756			566	1064		992	
11/03/03																								
11/10/03			757	508				825				915			754		756			850			996	
11/17/03			883	540				695							880								992	

Table 11. Temperature (°C) for Lake Pleasant from August 1999 to January 2004.

Date	0	5	10	15	20	25	30	35	40	45	50	4.6	9.1	13.7	18.3	22.9	27.4	32	36.6	41.1	45.7	50.3
08/01/99	28.6	27.9	27.8	20.2	17.5	15.9	15.3	14.6	14.4	14.6	14.6											
09/01/99	26.6	26.5	26.5	26.5	19.4	17.4	16.6	15.4	15.4	15.4												
10/01/99	23.8	23.6	23.5	23.5	23.4	18.3	17.9	18.2	18.3	18.2												
11/01/99	19.9	18.7	18.5	18.5	18.5	18.4	18.0	17.8	16.9	15.7												
12/01/99	14.0	14.0	14.0	14.0	13.9	13.9	13.9	13.9	13.9	13.9												
01/01/00	12.3	11.7	11.6	11.6	11.6	11.6	11.6	10.9	10.7	10.7												
02/01/00	12.1	12.1	12.1	12.1	12.1	12.0	11.8	11.6	11.6	11.5												
03/01/00	14.8	13.8	13.7	13.5	13.3	12.5	12.3	12.2	12.2	12.1												
04/01/00	19.0	18.3	17.1	15.4	15.0	14.7	14.5	12.5	12.5	12.4												
05/01/00	21.3	21.1	19.0	15.2	13.8	13.1	12.8	12.6	12.6	12.8												
06/01/00	26.5	25.8	24.1	19.6	15.5	14.8	14.5	12.9	12.8	12.7												
07/01/00	29.6	28.4	28.0	21.3	16.9	15.0	14.6	14.1	14.0	14.0												
08/01/00	29.8	29.3	29.1	26.7	22.7	22.2	22.2	22.4	22.2	22.1												
09/01/00	28.5	27.7	27.4	27.1	27.1																	
10/01/00	24.1	23.6	23.6	23.6																		
11/01/00	16.4	16.0	15.9	15.6	15.6	15.6	15.5	15.5	15.5													
12/01/00	13.5	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3												
01/01/01	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2												
02/01/01	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8													
03/01/01	13.0	12.5	12.4	12.2	12.2	11.5	11.2	11.1	11.0	10.9	10.9											
04/01/01	19.9	17.0	16.8	13.1	12.8	12.1	11.6	11.5	11.4	11.3	11.3											
05/01/01	24.4	22.4	17.0	14.1	12.9	12.2	11.8	11.7	11.7	11.6	11.6											
06/01/01	25.9	25.3	19.1	14.1	12.8	12.2	11.9	12.0	12.0	12.0	12.0											
07/01/01	28.0	27.5	24.6	15.3	13.6	12.9	12.5	12.3	12.1	12.0	12.0											
08/01/01																						
09/01/01	27.5	27.1	27.0	26.8	19.5	16.8	15.1	14.0														
10/01/01	22.6	22.9	22.7	22.6	22.5	22.4	19.3	15.4	15.0	15.1												
11/01/01	20.4	20.9	20.9	20.1																		
12/01/01	14.6	14.6	14.4	14.2	13.8	13.8	13.8															
01/01/02	11.8	11.7	11.6	11.6	11.6	11.6	11.5	11.3	11.3													
02/01/02	11.7	10.7	10.6	8.0	8.1	7.9	7.8															
03/01/02	13.0	12.3	12.2	12.1	12.1	11.8	11.4	18.8	19.9	20.2												
04/01/02	18.7	16.8	14.2	12.9	12.1	11.7	11.4	11.4	11.6	11.6												
05/01/02	21.8	20.5	19.8	12.9	12.1	11.7	11.5	11.4	11.4	11.4												
06/01/02	26.2	25.0	20.8	13.9	12.4	11.8	11.6	11.6	11.5													
07/16/02	28.4											28.4	26.5	17.7	13.7	12.8	12.4		12.0	11.7	11.6	11.6
08/12/02	28.0											27.9	27.8	20.6	16.4	14.4	13.5	13.0	12.4	12.0	12.0	11.9
09/03/02	27.5											27.5	27.4	25.3	18.1	15.8	14.8	13.6	12.7	12.4	12.4	12.3
09/16/02	26.4											26.3	26.3	24.6	19.5	16.5	14.4	13.6	12.8	12.6	12.5	
10/02/02	24.1											24.1	24.2	24.1	22.8	18.4	16.6	14.7	13.4	13.2	13.2	
10/16/02	22.4											22.5	22.5	22.5	22.4	22.2	19.6	15.6	13.9	13.6	13.4	
10/30/02	20.4											20.5	20.5	20.5	20.5	20.5	20.5	17.1	14.1	13.9	13.7	
11/13/02	18.2											18.2	18.3	18.2	18.2	18.2	17.7	17.4	16.7	14.3	13.7	
11/25/02	16.0											16.2	16.2	16.1	16.1	16.2	16.1	16.1	16.1	16.1	16.1	

Date	0	5	10	15	20	25	30	35	40	45	50	4.6	9.1	13.7	18.3	22.9	27.4	32	36.6	41.1	45.7	50.3
12/17/02	13.1											13.2	13.2	13.2	13.1	13.0	12.9	12.9	12.9	12.9	12.9	12.9
02/11/03	13.5											13.3	12.7	12.6	12.4	12.3	12.2	12.2	12.2	12.1	12.1	12.1
03/11/03	15.8											14.6	14.0	13.7	13.2	12.9	12.6	12.6	12.5	12.5	12.4	12.3
04/15/03	17.9											16.7	16.3	15.1	14.4	14.0	13.2	13.1	12.9	12.9	12.8	12.7
05/13/03	19.7											19.6	19.3	15.5	14.9	14.5	13.9	13.5	13.3	13.2	13.1	13.0
06/03/03	25.0											24.8	19.1	16.6	15.4	14.7	14.0	13.6	13.5	13.4	13.3	13.2
06/10/03																						
06/24/03	24.7											24.7	20.6	16.9	15.3	14.7	14.2	13.8	13.7	13.6	13.4	13.3
07/07/03																						
07/14/03	29.1											28.7	23.2	17.9	16.2	15.5	14.9	14.5	14.3	13.8	13.6	13.5
07/21/03																						
07/28/03																						
08/04/03	29.0											29.0	28.4	19.2	16.8	16.1	15.7	15.3	14.8	14.2	14.0	13.9
08/11/03																						
08/18/03																						
08/25/03	29.3											29.3	29.0	22.8	18.6	17.1	16.3	15.9	15.1	14.7	14.6	14.5
09/02/03																						
09/08/03	28.4											28.4	28.2	25.3	20.0	18.3	17.3	16.1	15.7	15.1	15.0	14.9
09/15/03																						
09/22/03	26.0											25.9	25.9	25.7	21.9	19.6	18.2	16.9	16.1	15.3		
09/29/03																						
10/06/03	24.5											24.6	24.6	24.6	23.2	20.1	18.7	17.4	16.5	15.8		
10/13/03																						
10/20/03																						
10/28/03	21.9											22.0	22.0	22.0	22.0	21.7	21.6	21.4	20.6	17.1	15.8	
11/03/03																						
11/10/03																						
11/17/03	18.2											18.2	18.2	18.2	18.2	18.1	18.0	17.9	17.8	17.7	17.8	
12/01/03																						
12/15/03																						
01/20/04																						
02/17/04																						
03/16/04																						

Table 12. Dissolved Oxygen (mg/l) for Lake Pleasant from August 1999 to January 2004.

Date	R2-5	R2-10	R2-15	R2-20	R2-25	R2-30	R2-35	R2-40	R2-45	R2-4.6	R2-9.1	R2-13.7	R2-18.3	R2-22.9	R2-27.4	R2-32.0	R2-36.6	R2-41.1	R2-45.7	R2-50.0	R2-50.3
08/01/99																					
09/01/99	10.5	9.4	9.2	5.6	5.5	5.2	3.5	2.8	2.6												
10/01/99	9.7	8.3	7.4	7.1	5.2	3.6	2.8	2.3	2.1												
11/01/99	10.7	9.4	8.9	8.7	8.5	8.2	7.1	3.9	1.3												
12/01/99	8.6	7.8	7.5	7.2	6.9	6.5	6.4	6.5	5.2												
01/01/00	9.3	9.1	8.9	9.0	9.3	8.8	8.8	8.8	8.5												
02/01/00	10.0	8.5	8.5	8.1	7.9	7.4	6.7	6.4													
03/01/00	10.2	10.1	9.2	8.8	8.5	8.1	7.9	7.7	7.4												
04/01/00	10.7	9.8	9.0	7.6	7.1	7.0	6.7	6.6	6.4												
05/01/00	9.5	9.9	9.3	8.5	7.7	7.1	7.0	3.5	3.4												
06/01/00	7.2	8.0	8.4	7.8	6.5	5.2	4.7	4.7	1.7												
07/01/00	6.9	6.2	7.0	6.4	5.4	4.9	2.4	2.5	2.5												
08/01/00	6.9	6.1	3.4	3.8	2.5	2.6	2.5	2.4	2.5												
09/01/00	6.2	5.9	3.0	3.0																	
10/01/00	6.0	5.8	5.6	5.8																	
11/01/00	7.2	7.0	7.4	7.5	7.4	7.3	7.1	7.1													
12/01/00	7.8	7.6	7.5	7.1	4.9	4.9	4.6	4.3	4.2												
01/01/01	9.4	9.3	9.3	9.1	9.0	8.9	8.5	7.7	8.6												
02/01/01	9.5	9.3	8.9	9.3	8.6	8.6	8.3	8.4													
03/01/01	10.1	9.6	9.6	9.7	9.3	8.9	8.8	8.4	8.4											8.3	
04/01/01	10.2	9.7	8.7	8.5	8.3	7.8	7.8	7.5	7.3											7.4	
05/01/01	10.2	9.8	8.7	8.6	8.6	8.4	8.1	7.8	7.5											7.3	
06/01/01	8.5	7.4	5.8	6.0	5.9	5.8	2.7	2.7	2.7											2.9	
07/01/01	6.1	5.4	3.0	3.7	3.8	3.5	3.3	3.3	3.3											3.3	
08/01/01																					
09/01/01	6.2	6.1	5.8	0.3	0.3	0.3	0.3														
10/01/01	6.3	6.6	6.3	6.5	6.4	1.3	1.4	1.2	1.3												
11/01/01	8.2	7.9	7.8																		
12/01/01	7.4	7.4	7.4	7.4	7.7	7.7															
01/01/02	4.8	4.6	4.5	4.4	4.3	4.2	4.2	4.2													
02/01/02	10.5	10.5																			
03/01/02	9.8	9.7	9.6	9.4	9.3	9.1	4.8	4.8	4.7												
04/01/02	10.3	10.6	10.1	9.5	9.2	9.0	8.6	8.5	8.0												
05/01/02	7.5	7.4	7.5	7.2	6.8	6.7	6.8	6.7	6.7												
06/01/02	7.0	7.1	6.7	5.8	5.4	5.2	5.0	4.9													
07/16/02										8.3	8.2	9.3	7.3	6.4	5.8		5.4	5.2	5.1		5.1
08/12/02										7.3	7.3	5.8	5.2	4.5	3.8	3.1	2.7	2.6	2.5		2.5
09/03/02										7.8	8.0	4.6	4.1	4.2	3.7	2.1	1.1	1.2	1.2		1.1
09/16/02										7.8	7.9	1.5	2.6	3.0	1.5	0.8	0.5	0.3	0.2		
10/02/02										6.4	6.2	5.9	1.3	1.4	0.9	0.2	0.1	0.1	0.1		
10/16/02										7.4	7.4	7.3	7.4	6.3	0.3	0.2	0.1	0.1	0.1		
10/30/02										6.9	7.0	6.9	6.9	6.9	6.8	0.3	0.2	0.2	0.1		
11/13/02										7.8	7.7	7.7	7.7	7.8	8.1	8.0	5.6	0.4	0.2		
11/25/02										9.0	9.1	9.1	9.0	9.0	9.0	9.0	9.0	9.0	9.0		

Date	R2-5	R2-10	R2-15	R2-20	R2-25	R2-30	R2-35	R2-40	R2-45	R2-4.6	R2-9.1	R2-13.7	R2-18.3	R2-22.9	R2-27.4	R2-32.0	R2-36.6	R2-41.1	R2-45.7	R2-50.0	R2-50.3
12/17/02										9.2	9.2	9.1	9.2	9.3	9.2	9.3	9.4	9.1	8.9		8.8
02/11/03										10.9	10.8	10.5	10.3	10.2	10.3	10.3	10.3	9.9	9.7		9.5
03/11/03										11.2	11.4	11.2	11.0	10.5	10.1	10.0	10.0	9.9	9.7		9.4
04/15/03										9.5	9.8	9.0	8.5	8.4	7.9	8.0	8.0	7.8	7.6		7.4
05/13/03										9.9	10.0	7.4	6.8	6.9	6.5	6.5	6.3	6.4	6.1		6.0
06/03/03										9.4	9.2	5.6	4.8	4.6	4.9	4.8	4.8	4.9	4.9		4.9
06/10/03																					
06/24/03										9.2	6.6	2.2	2.1	2.4	3.0	3.2	3.4	3.5	3.4		3.3
07/07/03																					
07/14/03										7.5	4.8	0.4	0.7	0.9	1.4	1.6	1.7	1.8	1.9		1.9
07/21/03																					
07/28/03																					
08/04/03										7.5	7.2	0.5	0.3	0.3	0.2	0.2	0.2	0.2	0.2		0.2
08/11/03																					
08/18/03																					
08/25/03										7.3	6.5	0.5	0.2	0.2	0.1	0.1	0.1	0.1	0.1		0.1
09/02/03																					
09/08/03										6.8	6.0	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1		0.1
09/15/03																					
09/22/03										6.7	6.2	5.2	0.3	0.2	0.1	0.1	0.1	0.1			
09/29/03																					
10/06/03										5.3	5.2	5.2	1.1	0.6	0.4	0.3	0.3	0.3			
10/13/03																					
10/20/03																					
10/28/03										6.8	6.7	6.7	6.4	6.4	6.3	5.9	4.4	0.9	0.4		
11/03/03																					
11/10/03																					
11/17/03										7.8	7.8	7.6	7.4	7.4	7.3	7.4	7.3	7.6	7.4		
12/01/03																					
12/15/03																					
01/20/04																					
02/17/04																					
03/16/04																					

Table 13. pH for Lake Pleasant from August 1999 to January 2004.

Date	R2-5	R2-10	R2-15	R2-20	R2-25	R2-30	R2-35	R2-40	R2-45	R2-4.6	R2-9.1	R2-13.7	R2-18.3	R2-22.9	R2-27.4	R2-32.0	R2-36.6	R2-41.1	R2-45.7	R2-50	R2-50.3
08/01/99																					
09/01/99																					
10/01/99																					
11/01/99	8.4	8.4	8.4	8.4	8.3	8.2															
12/01/99	8.3	8.3	8.3	8.3	8.2	8.2															
01/01/00	8.3	8.3	8.3	8.3	8.3	8.3															
02/01/00	8.1	8.1	8.1	8.0	8.0	8.0															
03/01/00	8.2	8.1	8.0	7.9	7.8	7.7															
04/01/00	8.1	7.7	7.6	7.0	4.4	3.7															
05/01/00	8.4	8.3	8.0	7.0	6.4	5.9															
06/01/00	8.0	7.9	7.6	7.0	6.7	3.9															
07/01/00	7.9	7.6	7.1	6.2	6.2	5.7															
08/01/00	8.7	7.8	6.9	6.4	5.8	2.4															
09/01/00	8.2	8.1	7.7	7.5																	
10/01/00	7.9	7.8	7.7																		
11/01/00	8.1	8.0	7.9	7.9	7.7	7.6															
12/01/00	8.0	7.9	7.7	7.6	7.4	6.7															
01/01/01																					
02/01/01	8.5	8.5	8.4	8.3	8.2	8.1															
03/01/01	8.7	8.6	8.3	8.0	7.7	7.4															
04/01/01	8.4	8.2	7.8	7.6	7.3	7.0															
05/01/01	8.4	8.0	7.3	6.9	6.6	6.3															
06/01/01	8.4	8.3	7.9	7.8	7.7	7.6															
07/01/01	8.3	8.2	7.8	7.2	7.0	6.8															
08/01/01																					
09/01/01	6.5	4.1	1.9	6.9	4.7	2.7															
10/01/01	8.0	7.8	7.3	6.3	5.4																
11/01/01	8.2	8.1	8.0																		
12/01/01	7.7	7.8	7.9	7.9	7.9	7.8															
01/01/02	8.6	8.6	8.5	8.4	8.3	8.2															
02/01/02	8.2	8.7	8.1	8.1	8.1	8.0															
03/01/02	8.3	8.6	8.5	8.4	8.3																
04/01/02	8.6	8.6	8.4	8.2	8.0	7.9															
05/01/02	8.2	8.3	7.9	7.6	7.4	7.2															
06/01/02	8.6	8.6	8.2	8.0	7.8	7.6															
07/16/02																					
08/12/02																					
09/03/02																					
09/16/02																					
10/02/02																					
10/16/02																					
10/30/02																					
11/13/02																					
11/25/02																					

Date	R2-5	R2-10	R2-15	R2-20	R2-25	R2-30	R2-35	R2-40	R2-45	R2-4.6	R2-9.1	R2-13.7	R2-18.3	R2-22.9	R2-27.4	R2-32.0	R2-36.6	R2-41.1	R2-45.7	R2-50	R2-50.3
12/17/02																					
02/11/03																					
03/11/03																					
04/15/03																					
05/13/03																					
06/03/03																					
06/10/03																					
06/24/03																					
07/07/03																					
07/14/03																					
07/21/03																					
07/28/03																					
08/04/03																					
08/11/03																					
08/18/03																					
08/25/03																					
09/02/03																					
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10/13/03																					
10/20/03																					
10/28/03																					
11/03/03																					
11/10/03																					
11/17/03																					
12/01/03																					
12/15/03																					
01/20/04																					
02/17/04																					
03/16/04																					

Table 14. Temperature (^{o}C) for Bartlett Lake from August 1999 to January 2004.

Date	R6A	R6-5	R6-10	R6-15	R6-20	R6-25	R6-30	R6-35	R6-40	R6-45	R6-4.6	R6-9.1	R6-13.7	R6-18.3	R6-22.9	R6-27.4	R6-32.0	R6-36.6	R6-41.1	R6-45.7	R6-50.3
08/01/99	28.7	28.1	27.6	21.5	18.5	16.8	15.9	15.8	15.9	16.0											
09/01/99	27.5	27.1	26.8	26.5	22.0	19.5	17.9	17.0	17.4	17.5											
10/01/99	23.0	23.1	23.1	23.0	23.0	22.9	22.8	21.3	21.4	21.4											
11/01/99	18.0	18.0	18.0	18.0	17.9	17.9	17.9	17.9	17.9	17.9											
12/01/99	12.7	12.8	12.8	12.8	12.8	12.7	12.6	12.5	12.5	12.5											
01/01/00	9.9	9.9	9.9	9.9	9.6	9.2	9.0	8.8	8.8	8.8											
02/01/00	12.4	12.3	11.2	10.9	10.6	10.3	10.0	10.1	10.1	10.1											
03/01/00	14.8	14.8	13.5	12.7	12.5	11.9	11.8	11.1	11.1	11.1											
04/01/00	19.9	19.6	16.9	14.9	13.5	13.3	13.3	13.3	13.3	13.3											
05/01/00	22.3	22.0	18.2	16.1	15.4	15.3	15.4	15.3	15.2	15.2											
06/01/00	26.3	25.5	21.1	18.0	15.7	14.6	14.6	14.6	14.6	14.6											
07/01/00	28.2	28.1	23.5	18.5	16.2	15.0	14.5	14.4	14.4	14.4											
08/01/00	29.0	29.2	27.3	21.1	19.0	18.2	15.3	15.5	15.6	15.7											
09/01/00	26.7	26.7	26.5	26.0	22.8	19.0	17.9	17.7													
10/01/00	22.3	22.3	22.3	22.3	22.3	22.2	19.7	17.9	18.1												
11/01/00	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1												
12/01/00	13.2	13.3	13.3	13.3	12.9	12.6	12.5	12.5													
01/01/01	10.3	10.2	10.2		10.2	10.2	10.2	10.2													
02/01/01	10.0	10.0	10.0	10.0	10.0	9.9	9.9														
03/01/01	13.3	13.2	12.6	11.9	11.0	10.6	10.4	10.4													
04/01/01	18.7	18.6	16.8	14.8	13.1	12.2	11.8	11.2	11.2	11.2											
05/01/01	23.6	23.4	18.7	16.5	15.2	13.7	13.7														
06/01/01	26.6	25.3	20.0	16.8	15.2	14.2	13.6	13.0	12.3												
07/01/01	27.7	27.6	21.5	17.7	15.8	14.9	14.2	13.3	12.9	12.7											
08/01/01																					
09/01/01	27.2	27.1	27.0	21.6	17.5	16.4	15.6	14.8	14.3	13.8											
10/01/01	22.6																				
11/01/01	20.0	19.9	19.9	19.9	19.8	19.8	19.7	19.6	19.6												
12/01/01	14.3	14.3	14.3	14.3	14.2	14.1	13.7														
01/01/02	10.7	10.6	10.6	10.5	10.3	10.0	10.0														
02/01/02	9.6	9.5	9.5	4.9	4.7	4.6	4.4														
03/01/02	12.5	12.4	12.4	11.0	10.5	10.2	10.1	10.1	12.8												
04/01/02	19.4	18.6	14.0	12.0	11.0	10.8	10.6	10.6													
05/01/02	22.4	21.4	19.0	12.9	11.9	11.3	11.0	11.1	11.0	11.0											
06/01/02	26.2	25.5	20.8	15.2	13.1	12.1	11.4	11.3	16.2												
07/16/02	28.1										27.9		20.3		13.5		12.6				
08/12/02	28.8										28.3	27.5	22.5	17.9	15.9	14.7	13.6				
09/03/02	28.1										27.6	27.0	24.0	19.9	17.3	15.8	14.8				
09/16/02	25.9										25.8	25.6	25.3	22.9	19.1	17.5	15.8				
10/02/02	24.0										24.0	24.0	24.0	23.9	20.6	18.1	16.8				
10/16/02	22.9										22.0	22.0	22.0	22.0	21.8	19.7	18.0				
10/30/02	20.4										20.3	20.3	20.2	20.2	20.2	19.9	19.7				
11/13/02	15.0										14.9	14.8	14.7	14.5	14.3	14.1	17.5				
11/25/02	15.8										15.8	15.9	15.9	15.8	15.4	15.2					

Date	R6A	R6-5	R6-10	R6-15	R6-20	R6-25	R6-30	R6-35	R6-40	R6-45	R6-4.6	R6-9.1	R6-13.7	R6-18.3	R6-22.9	R6-27.4	R6-32.0	R6-36.6	R6-41.1	R6-45.7	R6-50.3
12/17/02	13.5										13.4	13.3	13.3	13.1	12.8	12.6					
02/11/03	13.2										12.8	11.6	11.4	11.2	11.2	11.0	10.7				
03/11/03	14.7										14.3	12.7	12.3	11.7	11.3	11.2	11.2	11.2			
04/15/03	16.5										16.1	16.0	14.4	12.8	12.7	12.5	12.3	12.0	11.8	11.7	
05/13/03	21.1										20.8	17.0	15.0	13.7	12.9	12.4	12.3	12.1	12.0		
06/03/03	26.6										24.8	18.7	16.4	14.7	13.8	13.0	12.8	12.5	12.3		
06/10/03																					
06/24/03	25.5										25.2	23.2	18.3	16.2	14.9	14.2	13.4	13.0	12.6		
07/07/03																					
07/14/03	29.3										28.6	24.9	20.3	17.5	16.0	15.3	14.5	13.8	13.2		
07/21/03																					
07/28/03																					
08/04/03	29.1										29.0	26.6	22.1	18.7	17.2	15.9	15.1	14.5	14.0		
08/11/03																					
08/18/03																					
08/25/03	29.9										29.2	27.9	23.7	20.5	18.5	17.4	16.5	15.5	14.9		
09/02/03																					
09/08/03	28.0										28.0	27.6	24.5	21.3	19.0	17.8	16.6	15.8	15.4		
09/15/03																					
09/22/03	27.2										27.0	26.8	26.5	26.3	26.1	25.9					
09/29/03																					
10/06/03	25.8										25.8	25.8	25.8	25.8	25.7	25.4					
10/13/03																					
10/20/03																					
10/28/03	22.2										22.2	22.3	22.3	22.3	22.3	21.9	19.5	18.1			
11/03/03																					
11/10/03																					
11/17/03	18.6										18.6	18.6	18.6	18.6	18.6	18.6	18.3	18.2			
12/01/03																					
12/15/03																					
01/20/04																					
02/17/04																					
03/16/04																					

Table 15. Dissolved oxygen (mg/l) for Bartlett Lake from August 1999 to January 2004.

Date	R6-5	R6-10	R6-15	R6-20	R6-25	R6-30	R6-35	R6-40	R6-45	R6-4.6	R6-9.1	R6-13.7	R6-18.3	R6-22.9	R6-27.4	R6-32	R6-36.6	R6-41.1	R6-45.7	R6-50.3
08/01/99	8.8	6.2	0.3			0.3			0.1											
09/01/99	5.6	5.2	3.3	0.0	0.1	0.1	0.1	0.1	0.1											
10/01/99	6.0	5.6	5.5	5.5	4.5	3.4	0.7	0.6	0.6											
11/01/99	7.5	7.5	7.4	7.2	7.1	7.0	0.6	0.4	0.3											
12/01/99	8.3	8.0	7.1	6.8	6.4	1.2	1.0	1.0	0.9											
01/01/00	9.1	8.5	8.2	8.0	7.7	7.6	7.4	4.4	4.0											
02/01/00	10.4	8.6	8.0	7.5	6.7	4.9	4.9	4.6	4.5											
03/01/00	10.0	9.4	7.9	7.0	5.0	4.2	0.4	0.4	0.4											
04/01/00	9.6	9.1	6.4	5.4	0.8	0.5	0.4	0.4	0.4											
05/01/00	8.3	4.3	4.0	3.2	2.3	2.2	2.5	2.6	2.4											
06/01/00	12.9	4.3	3.0	4.3	1.8	1.8	1.7	1.6	1.6											
07/01/00	6.6	0.9	0.8	0.7	0.5	0.4	0.3	0.2	0.2											
08/01/00	5.9	1.2	0.9	0.9	0.8	0.6	0.4	0.3	0.3											
09/01/00	7.0	5.0	1.7	0.6	0.6	0.5	0.4													
10/01/00	5.5	5.5	5.6	4.9	1.3	1.3	1.2													
11/01/00	6.5	5.9	5.7	5.8	5.5	5.1	5.2	4.5												
12/01/00	6.6	6.8	7.0	6.7	6.1	5.0	5.3													
01/01/01	8.5	8.6	8.3	8.3	8.2	8.2	7.0													
02/01/01	9.2	8.6	9.0	8.7	6.8	6.4														
03/01/01	12.0	11.9	11.3	10.3	9.9	9.9	9.8													
04/01/01	9.4	8.3	7.3	8.7	9.0	8.7	8.0	6.1	6.3											
05/01/01	9.1	6.1	6.7	8.3	8.8															
06/01/01	7.0	3.2	3.2	5.1	5.5	5.5	6.6	5.5												
07/01/01	5.7	2.4	2.8	2.9	3.3	3.4	3.6	3.2	2.1											
08/01/01																				
09/01/01	6.7	6.5	1.5	1.6	1.4	1.3	1.2	1.2	1.2											
10/01/01																				
11/01/01	8.2	8.9	8.7	8.4	8.3	8.4	8.2													
12/01/01	8.8	8.6	8.5	8.4	8.4	8.2														
01/01/02	11.6	12.0	12.1	12.4	11.9	12.0														
02/01/02	9.8	9.8																		
03/01/02	9.8	10.0	9.3	9.0	8.4	8.6	11.3	2.4												
04/01/02	8.5	8.3	7.2	7.6	7.3	7.1	6.3													
05/01/02	14.8	13.1	14.8	14.4	14.3	14.0	10.8	8.8	8.5											
06/01/02	3.2	2.5	2.2	2.3	2.4	2.8	2.2													
07/16/02										9.2		1.0		0.6		0.3				
08/12/02										8.0	4.4	0.2	0.2	0.1	0.2	0.1				
09/03/02										7.5	5.2	0.6	0.3	0.3	0.3	0.3				
09/16/02										6.6	5.5	2.9	0.4	0.3	0.3	0.3				
10/02/02										5.7	5.7	5.7	5.2	0.2	0.1	0.1				
10/16/02										7.1	7.1	7.1	7.0	4.1	0.3	0.2				
10/30/02										6.7	6.6	6.6	6.6	6.7	6.4	6.2				
11/13/02										9.0	9.1	9.0	8.4	7.9	7.3	5.7				
11/25/02										8.3	8.1	8.0	7.8	7.3	6.6					

Date	R6-5	R6-10	R6-15	R6-20	R6-25	R6-30	R6-35	R6-40	R6-45	R6-4.6	R6-9.1	R6-13.7	R6-18.3	R6-22.9	R6-27.4	R6-32	R6-36.6	R6-41.1	R6-45.7	R6-50.3
12/17/02										8.8	8.9	8.8	8.6	8.4	8.4					
02/11/03										11.4	9.7	9.9	10.0	9.4	8.6	8.0				
03/11/03										12.6	11.0	10.5	9.6	9.1	9.0	8.8	7.9			
04/15/03										8.7	8.6	7.3	7.0	6.9	7.2	7.5	7.0	5.7	4.4	
05/13/03										8.7	4.8	5.1	5.4	5.7	5.8	5.7	5.8	4.7		
06/03/03										7.5	3.1	3.7	5.1	5.2	5.4	5.3	5.1	4.2		
06/10/03																				
06/24/03										6.4	0.3	0.2	1.9	3.0	3.5	3.6	3.7	2.9		
07/07/03																				
07/14/03										6.7	0.4	0.3	0.2	0.7	1.3	1.6	1.3	0.7		
07/21/03																				
07/28/03																				
08/04/03										7.8	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2		
08/11/03																				
08/18/03																				
08/25/03										8.6	1.0	0.2	0.1	0.1	0.1	0.1	0.1	0.1		
09/02/03																				
09/08/03										6.2	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
09/15/03																				
09/22/03										5.6	3.8	0.5	0.3	0.2	0.2					
09/29/03																				
10/06/03										4.3	4.2	4.0	4.0	1.5	0.4					
10/13/03																				
10/20/03																				
10/28/03										5.3	5.3	5.0	4.8	4.7	2.0	0.3	0.3			
11/03/03																				
11/10/03																				
11/17/03										5.8	5.6	5.2	4.7	4.5	4.0	3.7	3.2			
12/01/03																				
12/15/03																				
01/20/04																				
02/17/04																				
03/16/04																				

Table 16. pH for Bartlett Lake from August 1999 to January 2004.

Date	R6-5	R6-10	R6-15	R6-20	R6-25	R6-30	R6-35	R6-40	R6-45	R6-4.6	R6-9.1	R6-13.7	R6-18.3	R6-22.9	R6-27.4	R6-32	R6-36.6	R6-41.1	R6-45.7	R6-50.3
08/01/99																				
09/01/99																				
10/01/99	8.5	8.5	8.5		8.5	8.5	8.5													
11/01/99	8.5	8.5	8.5	8.4	8.4	8.4														
12/01/99	8.4	8.4	8.4	8.4	8.4	7.6														
01/01/00	8.4	8.4	8.4	8.3	8.3	8.3														
02/01/00	8.6	8.5	8.4	8.4	8.2	7.7														
03/01/00	8.6	8.4	8.2	8.0	7.7	7.5														
04/01/00	8.2	7.9	7.5	7.2	6.5															
05/01/00	8.4	8.2	8.1	8.0	8.0	7.9														
06/01/00	8.3	7.7	7.3	7.0	7.0	6.8														
07/01/00	8.2	7.2	6.7	6.3	6.0	5.6														
08/01/00	8.3	7.4	6.7	6.3	5.8															
09/01/00	8.2	7.7	7.0	7.3	7.2	7.1														
10/01/00	8.0	8.0	7.9	7.9	7.8	7.7														
11/01/00	8.3	8.0	8.1	8.1	7.9	7.8														
12/01/00	8.0	7.8	7.5	7.2	6.9	4.6														
01/01/01																				
02/01/01	8.7	8.6	8.5	8.4	8.2	8.2														
03/01/01	8.7	8.4	8.1	7.6	7.2	6.4														
04/01/01	8.1	7.8	7.6	7.5	7.1	6.8														
05/01/01	8.6	8.2	7.7	7.5	7.3	7.2														
06/01/01	8.9	8.1	7.9	7.8	7.8	7.7														
07/01/01	8.8	8.3	8.0	7.9	7.7	7.6														
08/01/01																				
09/01/01	8.4	8.2	7.0	5.8	4.0	1.9														
10/01/01																				
11/01/01	8.0	7.9	7.5	6.8	5.4	6.2														
12/01/01	7.5	7.7	7.2	6.7	6.0	5.2														
01/01/02	7.8	6.9	5.0	3.7	2.3	1.0														
02/01/02	8.4	8.5	8.4	8.3	8.3	8.2														
03/01/02	8.6	8.6	8.4	8.3	8.1	7.9														
04/01/02	8.3	8.3	8.1	7.5	6.5	5.1														
05/01/02	8.5	8.4	8.2	8.0	7.8	7.6														
06/01/02	8.7	8.6	8.2	7.9	7.8	7.6		7.1												
07/16/02																				
08/12/02																				
09/03/02																				
09/16/02																				
10/02/02																				
10/16/02																				
10/30/02																				
11/13/02																				
11/25/02																				

Date	R6-5	R6-10	R6-15	R6-20	R6-25	R6-30	R6-35	R6-40	R6-45	R6-4.6	R6-9.1	R6-13.7	R6-18.3	R6-22.9	R6-27.4	R6-32	R6-36.6	R6-41.1	R6-45.7	R6-50.3
12/17/02																				
02/11/03																				
03/11/03																				
04/15/03																				
05/13/03																				
06/03/03																				
06/10/03																				
06/24/03																				
07/07/03																				
07/14/03																				
07/21/03																				
07/28/03																				
08/04/03																				
08/11/03																				
08/18/03																				
08/25/03																				
09/02/03																				
09/08/03																				
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10/20/03																				
10/28/03																				
11/03/03																				
11/10/03																				
11/17/03																				
12/01/03																				
12/15/03																				
01/20/04																				
02/17/04																				
03/16/04																				

Table 17. Temperature (°C) for Saguaro Lake from August 1999 to January 2004.

Date	R9A	R9-5	R9-10	R9-15	R9-20	R9-25	R9-30	R9-35	R9-40	R9-45	R9-4.6	R9-9.1	R9-13.7	R9-18.3	R9-22.9	R9-27.4	R9-32.0	R9-36.6	R9-41.1	R9-45.7	R9-50.3
08/01/99	30.0	27.4	24.5	23.9	23.7	23.6	23.6	23.6	23.6	23.6											
09/01/99	27.5	26.9	25.2	24.6	24.2		23.7		23.5												
10/01/99	25.4	24.0	23.9	23.6	23.2	23.1	22.9	22.9	22.9	22.9											
11/01/99	20.4	20.1	20.0	20.0	19.9	19.9	19.9	19.9	19.9	19.9											
12/01/99	15.5	15.5	15.5	15.5	15.5	15.5	15.5														
01/01/00	12.8	12.5	12.4	12.4	12.4	12.4	12.3	12.2	12.2	12.2											
02/01/00	14.5	13.6	13.1	12.9	12.8	12.8	12.8	12.5	12.5	12.5											
03/01/00	16.7	16.1	13.9	13.4	13.1	13.0	12.9	12.9	13.0	12.9											
04/01/00	20.6	20.1	15.4	13.7	13.4	13.3	13.2	13.2	13.2	13.2											
05/01/00	23.8	22.8	18.9	18.2	17.7	17.0	16.1	15.6	15.8	15.8											
06/01/00	26.9	25.3	20.9	20.6	20.0	20.0	19.3	18.9	18.9	18.9											
07/01/00	29.1	25.5	23.8	23.0	22.6	22.2	21.7	21.6	21.7	21.7											
08/01/00	30.0	27.1	24.9	24.4	24.2	24.0	23.5	23.4	23.4	23.4											
09/01/00	28.1	27.3	25.9	25.1	24.7	24.5	23.9	23.8													
10/01/00	23.9	24.0	24.1	24.3	24.4	24.6	24.8														
11/01/00	18.6	18.7	18.7	18.7	18.7	18.7	18.6	18.6													
12/01/00	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4													
01/01/01	13.4	12.8	12.7	12.7	12.6	12.6	12.6														
02/01/01	13.0	12.5	12.3	12.2	12.1	12.1	12.1														
03/01/01	14.8	14.1	13.5	12.6	12.5	12.6	12.5														
04/01/01	20.8	18.6	15.3	13.7	13.1	12.9	12.8														
05/01/01	25.0	22.4	19.7	18.8	18.3	17.2	15.6														
06/01/01	25.8	23.3	21.7	20.7	20.5	20.2	19.7	19.7	19.8												
07/01/01	27.5	27.1	22.7	22.0	21.7	21.5	21.3														
08/01/01	29.6	26.4	23.7	23.2	23.0	22.8	22.5	22.3													
09/01/01	27.9	27.5	25.5	24.7	24.2	24.2	24.1														
10/01/01	23.0	22.4	22.4	22.3	22.3	22.1	22.0	22.0													
11/01/01	20.7	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6											
12/01/01	15.5	15.9	16.0	16.0	16.0	16.0	16.0														
01/01/02	12.8	12.8	12.8	12.8	12.8	12.8	12.8														
02/01/02	12.2	12.0	12.0	9.3	9.3	9.5	9.6														
03/01/02	14.9	14.1	12.7	12.4	12.3	12.3	12.3														
04/01/02	20.8	19.5	15.2	13.5	13.3	12.9	12.8	13.0													
05/01/02	22.6	17.9	17.2																		
06/01/02	21.5	19.2	18.7	18.4	18.2	17.9	17.7	17.8	17.9												
07/16/02	27.8										22.0	19.7	19.2	18.6	18.0	17.9	17.7				
08/12/02	28.6										24.6	21.9	20.7	20.2	19.9	19.5					
09/03/02	30.8										25.3	23.0	22.0	21.6	21.3	21.0	20.4				
09/16/02	26.3										25.4	23.7	22.5	22.1	21.8	21.5					
10/02/02	24.1										23.9	23.9	23.0	22.4	22.0	21.7					
10/16/02	24.4										22.8	22.6	22.5	22.5	22.5	22.2	21.9				
10/30/02	21.9										21.5	21.4	21.4	21.4	21.4	21.3	21.3				
11/13/02	17.6										17.0	16.8	16.7	16.6	16.6	16.5	19.6				
11/25/02	18.2										18.2	18.2	18.1	18.1	18.1	18.0					

Date	R9A	R9-5	R9-10	R9-15	R9-20	R9-25	R9-30	R9-35	R9-40	R9-45	R9-4.6	R9-9.1	R9-13.7	R9-18.3	R9-22.9	R9-27.4	R9-32.0	R9-36.6	R9-41.1	R9-45.7	R9-50.3
12/17/02	15.9										15.7	15.6	15.6	15.5	15.5	15.5					
02/11/03	14.6										14.1	13.6	13.4	13.3	13.3	13.3	13.2				
03/11/03	15.5										15.2	14.2	13.8	13.6	13.5	13.5					
04/15/03	17.8										17.7	16.3	14.9	14.3	14.1	13.9					
05/13/03	23.7										21.0	18.4	16.0	15.5	14.6	14.3					
06/03/03	27.0										23.4	21.6	19.9	17.9	16.8	16.1					
06/10/03																					
06/24/03	26.2										25.4	23.1	22.4	21.6	20.9	19.8					
07/07/03																					
07/14/03	30.1										26.2	24.9	24.0	23.1	22.6	22.2					
07/21/03																					
07/28/03																					
08/04/03	30.9										28.4	26.1	25.2	24.6	24.2	23.6	22.6				
08/11/03																					
08/18/03																					
08/25/03	30.1										28.9	26.9	25.9	25.6	25.4	25.0					
09/02/03																					
09/08/03	28.4										28.3	28.1	26.4	26.2	26.0	25.8					
09/15/03																					
09/22/03	25.9										25.9	25.9	25.9	25.7	20.7	18.4	16.6	15.9	15.6	15.6	
09/29/03																					
10/06/03	25.0										25.0	25.1	25.1	25.1	25.0	20.6	17.4	16.5	16.2		
10/13/03																					
10/20/03																					
10/28/03	24.6										24.2	2.2	24.1	24.1	24.1	24.0					
11/03/03																					
11/10/03																					
11/17/03	21.0										20.6	20.5	20.5	20.4	20.4	20.4					
12/01/03																					
12/15/03																					
01/20/04	13.2										13.1	13.1	13.1	13.1	13.1	13.1					
02/17/04																					
03/16/04																					

Table 18. Dissolved oxygen (mg/l) for Saguaro Lake from August 1999 to January 2004.

Date	R9-5	R9-10	R9-15	R9-20	R9-25	R9-30	R9-35	R9-40	R9-45	R9-4.6	R9-9.1	R9-13.7	R9-18.3	R9-22.9	R9-27.4	R9-32.0	R9-36.6	R9-41.1	R9-45.7	R9-50.3
08/01/99	4.4	0.6	0.7	1.2	1.5	1.7	1.6	1.7	1.4											
09/01/99	7.2	0.3	0.3	1.9		2.4		0.4												
10/01/99	6.6	4.9	2.7	4.2	4.5	3.9	3.4	3.2	3.2											
11/01/99	7.4	7.3	6.9	6.6	6.4	5.7	0.7	0.5	0.5											
12/01/99	5.9	5.1	5.4	5.3	5.2	5.2	4.0	4.0	4.2											
01/01/00	9.9	9.5	9.3	8.9	8.4	8.3	7.6	7.4	7.2											
02/01/00	8.9	7.4	7.1	7.0	5.9	5.6	4.0	3.7	3.7											
03/01/00	9.6	7.3	5.9	5.2	4.7	4.5	3.8	3.6	3.5											
04/01/00	8.0	6.8	4.8	4.3	3.7	3.0	3.2	2.6	2.6											
05/01/00	8.5	5.9	5.0	4.9	4.1	3.1	0.7	0.5	0.4											
06/01/00	7.9	4.3	4.0	3.5	4.6	3.3	0.4	0.4	0.3											
07/01/00	4.2	0.9	0.9	0.8	0.7	0.3	0.3	0.3	0.4											
08/01/00	3.6	0.7	0.6	1.1	1.4	0.4	0.5	0.4	0.4											
09/01/00	6.0	0.4	0.4	0.3	0.3	0.3	0.3													
10/01/00	5.3	4.7	4.5	4.0	3.5	3.5	2.3													
11/01/00	5.1	4.7	5.0	4.9	5.0	4.7	1.4													
12/01/00	6.2	5.7	5.7	5.7	5.7	5.6	4.9													
01/01/01	7.2	6.9	6.7	7.0	6.8	6.7														
02/01/01	9.2	8.5	7.6	7.1	7.0	7.1														
03/01/01	10.2	8.6	6.7	6.7	6.7	6.1														
04/01/01	9.8	6.0	6.2	6.4	6.1	5.7														
05/01/01	9.3	6.0	5.7	5.8	5.2	3.6														
06/01/01	7.2	2.9	4.1	4.7	4.8	3.0	2.3	2.1												
07/01/01		1.3	1.4	2.1	1.9	1.2														
08/01/01	3.7	2.2	2.0	2.0	2.4	1.9	1.7													
09/01/01																				
10/01/01	4.4	4.1	4.0	2.8	2.5	1.7	0.5													
11/01/01	7.3	7.3	7.3	7.3	7.4	7.4	6.7	6.6	6.6											
12/01/01	9.5	9.6	9.8	9.8	9.8	9.7														
01/01/02	0.3	0.3	0.3	0.3	0.3	0.3														
02/01/02	9.4	9.2																		
03/01/02	10.3	6.5	5.7	5.7	5.5	3.5														
04/01/02	9.9	3.7	2.2	2.9	2.4	1.4	1.3													
05/01/02																				
06/01/02																				
07/16/02										1.2	1.0	1.0	1.0	1.7	1.0	0.8				
08/12/02										1.5	0.3	0.2	0.2	0.2	0.2					
09/03/02										3.0	0.5	0.3	0.3	0.2	0.2	0.2				
09/16/02										1.7	0.4	0.3	0.3	0.3	0.3					
10/02/02										3.6	3.9	0.2	0.2	0.2	0.1					
10/16/02										5.4	5.0	4.8	4.5	3.9	0.3	0.2				
10/30/02										5.4	5.0	4.8	4.5	3.9	0.3	0.2				
11/13/02										8.5	8.2	8.1	8.0	7.7	7.3	5.9				
11/25/02										6.4	6.4	6.4	6.5	6.4	6.2					

Date	R9-5	R9-10	R9-15	R9-20	R9-25	R9-30	R9-35	R9-40	R9-45	R9-4.6	R9-9.1	R9-13.7	R9-18.3	R9-22.9	R9-27.4	R9-32.0	R9-36.6	R9-41.1	R9-45.7	R9-50.3
12/17/02										7.8	7.3	7.4	7.7	7.4	7.3					
02/11/03										10.3	8.7	8.6	8.4	8.3	8.0	7.5				
03/11/03										10.7	10.0	8.3	6.3	5.9	5.5					
04/15/03										9.8	7.2	4.3	3.6	3.3	3.2					
05/13/03										9.9	6.5	1.3	0.8	0.8	0.5					
06/03/03										9.8	5.8	3.2	0.5	0.2	0.2					
06/10/03																				
06/24/03										9.0	2.0	0.9	0.2	0.2	0.2					
07/07/03																				
07/14/03										6.1	1.5	0.2	0.1	0.1	0.1					
07/21/03																				
07/28/03																				
08/04/03										7.2	0.4	0.2	0.2	0.2	0.1	0.1				
08/11/03																				
08/18/03																				
08/25/03										5.0	0.2	0.1	0.1	0.1	0.1					
09/02/03																				
09/08/03										4.2	0.4	0.2	0.1	0.2	0.1					
09/15/03																				
09/22/03										7.6	7.4	7.3	6.7	0.5	0.2	0.2	0.1	0.1	0.1	
09/29/03																				
10/06/03										7.1	7.1	7.2	7.0	6.9	0.3	0.2	0.2	0.2		
10/13/03																				
10/20/03																				
10/28/03										6.0	5.6	5.3	5.3	5.2	5.0					
11/03/03																				
11/10/03																				
11/17/03										6.0	5.7	5.8	5.6	5.4	5.4					
12/01/03																				
12/15/03																				
01/20/04																				
02/17/04																				
03/16/04																				

Table 19. pH for Saguaro Lake from August 1999 to January 2004.

Date	R9-5	R9-10	R9-15	R9-20	R9-25	R9-30	R9-35	R9-40	R9-45	R9-4.6	R9-9.1	R9-13_7	R9-18.3	R9-22.9	R9-27.4	R9-32.0	R9-36.6	R9-41.1	R9-45.7	R9-50.3
08/01/99																				
09/01/99																				
10/01/99	7.8	7.8	7.8			7.7	7.7	7.7												
11/01/99	7.8	7.9	7.8	7.8	7.8	7.7														
12/01/99	8.0	7.9	7.9	7.9	7.9	7.8														
01/01/00	7.9	8.0	8.3	8.8	8.0	8.0														
02/01/00	8.3	8.2	8.1	8.0	7.9	7.8														
03/01/00	8.3	8.1	7.8	7.6	7.5	7.3			6.7											
04/01/00	8.0	7.9	7.5	7.3	7.1	5.2														
05/01/00	8.3	7.9	7.7	7.6	7.6	7.5														
06/01/00	8.4	8.0	7.6	7.3	7.0	6.7														
07/01/00	7.9	7.6	7.4	7.2	7.1	6.9														
08/01/00	7.3	6.9	6.6	6.4	3.7															
09/01/00	8.2	7.3	7.1	6.9	6.7	6.5														
10/01/00	7.6	7.4	7.3	7.1	6.9	6.8														
11/01/00	7.8	7.6	7.5	7.4	7.3	7.1														
12/01/00	7.6	7.5	7.4	7.3	7.2	7.0														
01/01/01																				
02/01/01	8.3	8.0	7.7	7.5	7.2	7.0														
03/01/01	8.9	8.5	8.0	7.7	7.4	7.1														
04/01/01	8.9	7.7	7.0	6.7	6.5	6.4														
05/01/01	8.3	7.7	7.4	7.2	6.9	6.5														
06/01/01	8.2	7.8	7.6	7.6	7.6	7.5														
07/01/01	7.7	7.3	7.0	6.8	6.6	6.0														
08/01/01	8.3	8.0	7.6	7.2	6.8	5.2														
09/01/01	7.3	6.6	5.9	5.4	5.6	5.9														
10/01/01	7.8	7.8	7.7	7.5	7.3	7.3	7.1													
11/01/01	7.6	7.6	7.7	7.6	7.6	7.5														
12/01/01	8.2	8.2	8.2	8.1	8.0	8.0														
01/01/02																				
02/01/02	8.1	8.1	7.9	7.8	7.7	7.6														
03/01/02	9.2	8.3	8.8	8.8	8.8	8.5														
04/01/02	9.1	8.3	8.0	7.6	7.2	6.9														
05/01/02	8.2	7.8	7.5	7.4	7.2															
06/01/02																				
07/16/02																				
08/12/02																				
09/03/02																				
09/16/02																				
10/02/02																				
10/16/02																				
10/30/02																				
11/13/02																				
11/25/02																				

Date	R9-5	R9-10	R9-15	R9-20	R9-25	R9-30	R9-35	R9-40	R9-45	R9-4.6	R9-9.1	R9-13_7	R9-18.3	R9-22.9	R9-27.4	R9-32.0	R9-36.6	R9-41.1	R9-45.7	R9-50.3
12/17/02																				
02/11/03																				
03/11/03																				
04/15/03																				
05/13/03																				
06/03/03																				
06/10/03																				
06/24/03																				
07/07/03																				
07/14/03																				
07/21/03																				
07/28/03																				
08/04/03																				
08/11/03																				
08/18/03																				
08/25/03																				
09/02/03																				
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10/28/03																				
11/03/03																				
11/10/03																				
11/17/03																				
12/01/03																				
12/15/03																				
01/20/04																				
02/17/04																				
03/16/04																				

Table 20.1. Temperature (°C) for streams and canals from August 1999 to January 2004.

Date	R1	R2A	R3	R4	R4-Dup	R5	R6A	R7	R8	R9A	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21
08/01/99	31.1	28.6	15.9	18.1			28.7			30.0							30.0					
09/01/99		26.6	18.0	17.0			27.5	27.1	24.7	27.5		26.6			27.0	28.0		28.0				
10/01/99	24.1	23.8	23.5	23.6		21.5	23.0			25.4		22.5	21.0	21.2	25.0		24.3		21.8			
11/01/99		19.9		18.6			18.0		20.3	20.4	18.3	19.0	17.3	17.2	18.7		19.0					
12/01/99	12.5	14.0	12.8	10.1		8.5	12.7	13.0	14.6	15.5	9.1	1.7	10.2	10.3	4.2		9.6					
01/01/00	11.0	12.3	11.0	12.0		8.0	9.9	11.0	12.5	12.8	9.3	9.5	9.3						10.2	12.4		
02/01/00	12.2	12.1	15.1	14.3		14.0	12.4	12.5	14.6	14.5	14.5	13.7	13.1	13.7	14.4		15.2		13.9			
03/01/00	17.5	14.8	17.5	17.3		16.4	14.8	12.6	13.3	16.7	18.0	16.8	17.9	17.5	19.1		20.3		17.1			
04/01/00	21.8	19.0	30.1	21.2		20.7	19.9	14.9	18.7	20.6	16.0	21.1	17.9	19.4	18.3		21.8		18.6			
05/01/00	23.0	21.3	23.8	22.0		21.5	22.3	15.6	17.8	23.8	18.0	22.2	18.5	20.7	20.0	21.5	21.8	21.6	18.9	20.0		
06/01/00	27.3	26.5	14.0	17.8		25.6	26.3	18.1	19.2	26.9	21.6	17.0	20.0	19.3	24.0		24.9		19.4			
07/01/00	29.3	29.6	14.6	15.4		28.6	28.2	18.0	25.9	29.1	23.6	15.8	22.5	22.8	22.9		23.6		21.3			
08/01/00	31.2	29.8	17.9	19.7		30.0	29.0	19.2	28.7	30.0	24.8	20.0	25.2	23.0	25.6		26.6		22.3			
09/01/00	28.2	28.5	25.8	25.3		26.4	26.7	18.0	27.9	28.1	23.8	25.3	26.8	25.4	24.9		27.7		25.2			
10/01/00	21.5	24.1	23.9	21.7		18.7	22.3	18.4	23.1	23.9	21.9	21.8	20.7	21.3	22.0		21.9		22.0			22.3
11/01/00	15.0	16.4	15.3	15.0		11.3	17.1	16.6	18.2	18.6	16.2	13.6	14.4	14.4	10.7	14.2	14.1		15.6			
12/01/00	13.1	13.5	13.0	12.2		11.0	13.2	13.0	14.7	15.4	10.8	12.3	11.2	11.4	11.5	11.4	11.1	11.9				11.3
01/01/01	11.0	11.2	11.0	10.1		9.9	10.3	10.2	12.4	13.4	12.8	13.1	16.3	10.0								
02/01/01	8.4	10.8	11.0	11.4		10.6	10.0	10.4	11.9	13.0	12.7	11.3	10.6		11.0		12.2		11.9	10.9		12.0
03/01/01	14.9	13.0	14.9	15.6		11.9	13.3	12.1	15.3	14.8	16.1	14.2	16.1	15.3	16.8		17.9	17.8	15.3	15.5		
04/01/01	20.0	19.9	22.2	19.7		17.0	18.7	13.5	18.3	20.8	22.4	19.9	16.6	16.7	19.7	24.4	20.9		19.0	22.0		20.0
05/01/01		24.4	23.6	23.5		24.2	23.6	14.7	23.1	25.0	18.5	23.0	17.6	17.0	21.6		23.9		18.9			22.7
06/01/01	26.2	25.9	13.4	21.1		24.8	26.6	15.8	20.8	25.8	21.8	20.8	20.4	20.6	22.4	25.5	22.7		20.1	23.0		22.2
07/01/01	29.3	28.0	13.2	17.3		26.8	27.7	16.7		27.5	23.3	18.7	22.8	21.3	25.3		27.2		22.1			26.0
08/01/01	30.8		14.4	18.6		28.0		16.9	22.5	29.6	24.4	18.5	23.7	22.4	26.4	25.8	27.8	21.0	23.6	25.1	26.8	27.1
09/01/01	28.0	27.5	15.2	17.8		24.8	27.2	16.3	22.4	27.9	24.6	19.2	23.7	24.1	27.7	28.3	26.7		22.6	26.0		26.4
10/01/01	18.2	22.6	21.0	18.8		18.9	22.6	16.2	24.0	23.0	20.4	18.8	17.3	17.5	22.0		20.0		18.2			20.9
11/01/01		20.4					20.0			20.7												
12/01/01	12.6	14.6	12.6	12.8		8.4	14.3	13.9		15.5	9.4	8.6	11.5	11.9	11.3		13.3		10.9			11.1
01/01/02	11.1	11.8	11.2	10.9		9.1	10.7	9.4	12.2	12.8	12.3	11.1	10.0	10.4					12.8			
02/01/02	11.2	11.7	11.4	11.1		9.5	9.6	9.8		12.2	10.9	10.6	11.9	11.6	12.8		13.1		12.5	15.0		13.9
03/01/02	14.5	13.0	13.8	14.1		13.8	12.5	10.6	16.7	14.9	13.9	13.7	15.0	14.2	15.5		16.5	17.5	21.0			16.4
04/01/02	20.5	18.7	19.7	20.1		19.6	19.4	13.0	16.8	20.8	14.0	20.1	16.4	17.3	19.4	23.3	22.1		18.5	22.0		20.6
05/01/02		21.8	22.0	23.1		23.5	22.4	14.0	23.4	22.6	16.9	22.5	17.4	18.7	22.0	24.0	22.2	24.2	20.3	23.0		21.6
06/01/02		26.2	17.5	22.0		26.7	26.2	27.8		21.5	19.6	22.5	18.7	19.0	23.6		24.3		19.8			24.0
07/01/02												19.0	20.0		24.2		24.6					24.8
07/08/02												16.4	20.7		24.9		25.5					25.0
07/16/02		28.4					28.1			27.8		19.5	22.0		25.5		26.8					26.1
07/22/02												18.9	22.7		22.8		25.1					23.6
07/29/02												19.7	23.8		23.7		26.8					25.0
08/05/02												17.6	22.1		22.8		23.8					23.0
08/12/02		28.0					28.8			28.6		19.6	24.1		25.0		26.0					25.4
08/19/02												21.7	22.5		25.2		25.6					25.8
08/26/02												20.7	23.8		23.0		25.0					23.4

Date	R1	R2A	R3	R4	R4-Dup	R5	R6A	R7	R8	R9A	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21
09/03/02		27.5					28.1			30.8		22.7	24.7		26.2		27.4					26.8
09/10/02													22.6		23.3		26.0					23.5
09/16/02		26.4					25.9			26.3			24.3		26.1		28.0					27.5
09/23/02													24.1		23.1		25.6					24.2
09/30/02													23.8		21.7		23.0					22.5
10/02/02		24.1					24.0			24.1												
10/07/02													21.7		20.2		22.3					21.3
10/14/02												20.3	21.0		21.1		23.0					22.2
10/16/02		22.4					22.9			24.4												
10/21/02												19.1	20.9		20.3		21.9					21.0
10/28/02												18.7	17.7		19.8		19.6					19.7
10/30/02		20.4					20.4			21.9												
11/04/02												18.9	18.0		19.2		19.3					18.8
11/12/02												17.1	16.4		18.2		19.0					17.5
11/13/02		18.2					15.0			17.6												
11/18/02												15.8	14.9		16.0		15.9					16.3
11/25/02		16.0					15.8			18.2		14.0	13.5		14.8		15.4					14.2
12/09/02												14.0	13.5		14.8		15.4					14.2
12/16/02												13.0	13.1		13.8		13.4					13.5
12/17/02		13.1					13.5			15.9												
01/14/03											13.8	13.6										
02/11/03		13.5					13.2			14.6	16.4		16.5		17.8		15.6					
03/11/03		15.8					14.7			15.5	18.1		18.1		21.0		21.5					
04/15/03		17.9					16.5			17.8	21.6		16.4	17.8	19.0		20.0					19.6
05/13/03		19.7	23.4				21.1			23.7	23.7	21.6	19.7		22.8		24.6					
06/03/03		25.0	28.0				26.6			27.0	17.8	26.0	21.3		26.9		27.2					27.0
06/10/03												24.3	20.2		25.0		25.3					25.0
06/24/03		24.7	15.0				25.5			26.2	24.1	23.2	23.2		23.1		24.6					23.6
07/07/03			14.8								23.4	18.8	24.2		25.2		25.9					25.4
07/14/03		29.1					29.3			30.1		19.1	25.5		26.1		26.9					26.5
07/21/03			16.3								24.0	20.1	25.2		26.5		27.5					26.8
07/28/03			15.0								24.0	19.7	26.0		24.8		25.0					24.8
08/04/03		29.0	15.7				29.1			30.9	24.2	20.1	27.2		26.1		28.6					27.0
08/11/03			15.9								25.3	16.7	26.1		24.8		26.5					25.5
08/18/03			16.3								25.2	16.6	25.9		25.6		28.3					27.9
08/25/03		29.3	18.6				29.9			30.1	26.4	23.1	28.5		27.6		29.2					28.7
09/02/03																						
09/08/03		28.4	17.4				28.0			28.4	26.2	24.4	27.3		27.0		27.9					27.0
09/15/03												20.5	25.3		24.2		26.2					25.2
09/22/03		26.0	18.6				27.2			25.9	25.1	19.1	24.6		22.1		24.4					23.3
09/29/03											25.3	20.7	26.5		25.1		25.4					25.5
10/06/03		24.5					25.8			25.0		22.8	22.5		24.2							25.0
10/13/03			23.7								25.0	24.3	24.2		27.0		27.5					26.2
10/20/03			24.8								22.0	24.2	20.4		23.9		24.8					24.0
10/28/03		21.9	21.6				22.2			24.6		20.8	17.6		20.1		20.2					20.6

Date	R1	R2A	R3	R4	R4-Dup	R5	R6A	R7	R8	R9A	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21
11/03/03											17.9	19.8	18.9		18.6		19.3					19.6
11/10/03			18.3								15.1	18.0	17.1		17.2		18.1					18.2
11/17/03		18.2	17.8				18.6			21.0	15.4	17.5	16.1		18.0		18.2					17.8
12/01/03			14.3										12.0		14.0							14.2
12/15/03											10.5		12.4		13.4		12.6					
01/20/04										13.2		12.2	13.3		14.2		15.3					
02/17/04																						
03/16/04																						

Table 20.2. (Continued) Temperature (^{o}C) for streams and canals from August 1999 to January 2004.

Date	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/01/99																						
09/01/99																						
10/01/99																						
11/01/99																						
12/01/99																						
01/01/00																						
02/01/00																						
03/01/00																						
04/01/00																						
05/01/00																						
06/01/00																						
07/01/00																						
08/01/00																						
09/01/00																						
10/01/00	21.8																					
11/01/00																						
12/01/00																						
01/01/01																						
02/01/01	12.2	12.4																				
03/01/01	17.9	19.3	24.7																			
04/01/01	19.8		21.3																			
05/01/01		29.6																				
06/01/01	22.0	30.4	23.3																			
07/01/01	24.8	34.0	26.4																			
08/01/01		34.2	28.3																			
09/01/01	26.1	30.3	26.8																			
10/01/01	19.7	20.4																				
11/01/01																						
12/01/01	11.7	13.8																				
01/01/02		13.8																				
02/01/02	12.5	15.8	13.8																			
03/01/02	14.5	22.5	16.7																			
04/01/02	19.1	25.8																				
05/01/02	21.6	26.1	24.2																			
06/01/02	22.6	28.0	24.3																			
07/01/02	23.5			24.4	24.9						20.2				21.6		23.2					
07/08/02	23.7			25.0	25.3					22.7	19.9				22.7		23.3					
07/16/02	24.7			26.2	26.2					22.8	22.2				24.1		24.5					
07/22/02	22.3			23.0	24.8					22.6	21.5				22.4		2.3					
07/29/02	22.7			24.4	26.0					22.7	21.8				22.7		22.8					
08/05/02	22.1			22.8	23.7					20.5	20.9				21.7		22.1					
08/12/02	24.5			25.6	25.7					22.2	23.0				24.3		24.4					
08/19/02	24.8			25.5	25.3					23.4	22.8				24.0		24.5					

Date	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/26/02	22.1			23.3	24.2					21.4	22.3				22.4		22.0					
09/03/02	25.5			26.7	27.2					23.7	24.4				25.4		25.3					
09/10/02	22.7			23.4	24.1					22.0	23.1				24.0		22.9					
09/16/02	24.8			26.5	27.9					24.2	24.3				24.5		24.5					
09/23/02	21.8			23.5	25.0					22.5	21.4				21.6		22.5					
09/30/02	20.8			22.0	22.8						20.8				21.0		20.5					
10/02/02																						
10/07/02	19.3			20.5	21.7						20.0				20.4		19.4					
10/14/02	20.3			21.6	22.3						20.6				19.8		19.9					
10/16/02																						
10/21/02	19.5			20.7	21.4					19.8	19.9				19.7		19.1					
10/28/02	18.2			19.9	19.1						19.0				19.3		18.5					
10/30/02																						
11/04/02	18.7			19.3	19.2					18.3	18.6				17.9		17.7					
11/12/02	16.8			18.4	17.3					17.1	16.9				16.2		16.2					
11/13/02																						
11/18/02	15.0			16.5	15.7					14.2	15.4				15.3		14.6					
11/25/02	14.3			15.2	13.9						13.5				13.2		13.5					
12/09/02	14.3			15.2	13.9						13.5				13.2		13.5					
12/16/02	13.5			13.8	13.8						12.9				12.2		12.8					
12/17/02																						
01/14/03		14.6								16.9												
02/11/03	17.1	17.8								18.4	17.9											
03/11/03	20.6	17.7								20.6					19.1							
04/15/03	17.9	16.8								17.8	18.5				18.4			16.7				
05/13/03	21.8									21.2	21.5				22.6			20.2				
06/03/03	25.9	25.7								23.5	26.0				24.7							
06/10/03	24.5									23.5	23.2				24.3							
06/24/03	22.7									22.8	23.7				25.6			23.0				
07/07/03	24.1	24.3								24.4	22.3				23.9			24.1				
07/14/03	24.8	25.3								25.3	22.7				24.6			25.2				
07/21/03	25.7	25.4								25.5	23.3				24.7			25.0				
07/28/03	23.9	26.5								25.2	24.2				25.6			25.7				
08/04/03	24.6	26.0								25.1	22.2				23.7			26.8				
08/11/03	23.9	25.3				30.4				24.9	22.8				23.9			25.6				
08/18/03	24.4									25.0	23.4				25.0			25.6				
08/25/03	26.0	29.5				31.4				25.7	25.8				26.3			27.9				
09/02/03																						
09/08/03	26.2	26.9				29.8				24.9	26.1				26.5			26.3				
09/15/03	22.9					29.4				23.2	23.2				23.0			24.4				
09/22/03	20.8					26.7				21.3	22.8				20.8			23.4				
09/29/03	23.2	25.3				30.3												22.7				
10/06/03	23.1					26.1				22.9	22.9				22.7			22.5				
10/13/03	24.9					27.4				23.9	25.3				24.8			24.2				
10/20/03	22.5					29.2				21.4	22.9				23.1			21.2				

Date	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
10/28/03	18.6					22.3				19.4	19.4				19.0			17.9				
11/03/03	17.9					19.3				19.9	19.1				18.5			19.2				
11/10/03	16.4					19.2				17.7	17.6				17.1			17.7				
11/17/03	18.0					22.2									16.4							
12/01/03	12.7					22.1									12.8							
12/15/03	13.2					16.7									11.5							
01/20/04	13.3									16.5					13.2							
02/17/04																						
03/16/04																						

Table 21. Dissolved oxygen (mg/l) for streams and canals from August 1999 to January 2004.

Date	R1	R2A	R4	R4-Dup	R6A	R8	R9A	R10	R11	R12	R13	R14	R16	R18	R19	R21	R22	R25	R26
08/01/99		6.8			7.8		7.6												
09/01/99		9.8			6.5		7.9												
10/01/99	7.9	8.6	7.7		7.0		6.8			7.7	6.8	10.4	24.3	7.2					
11/01/99		9.0	10.0		7.6	9.2	8.5		11.5	9.8	9.9	10.4	10.6						
12/01/99		9.2	10.2		8.6	7.5	6.5	9.3	10.8	9.3	9.0	10.4	11.6						
01/01/00		9.0			10.4	10.7	10.3	11.9	10.6	10.2				10.9	11.5				
02/01/00	10.0	11.5	11.2		11.3	9.4	10.2	8.1	10.5	9.0	9.2	8.9	10.2	8.8					
03/01/00		10.6	11.0		11.5	7.8	10.4	8.1	10.1	7.9	9.3	9.5	9.4	9.4					
04/01/00		11.1			9.9	9.3	9.4	8.2	7.6	8.1	8.4	11.3	9.6	9.7					
05/01/00		9.9			9.7	7.2	9.0	8.8	9.4	9.0	9.1	11.6	10.5	10.0					
06/01/00		7.2			15.3	6.4	7.8	7.3	10.4	8.2	9.4	9.3	8.2	9.0					
07/01/00		7.0	7.1		7.5	7.0	8.4	6.1	10.4	6.6	6.6	10.4	8.4	9.1					
08/01/00		7.6			7.7	8.2	9.2	7.2	11.7	7.2	9.7	8.1	7.9	7.7					
09/01/00		7.5	7.7		8.0	5.7	6.8	7.5	8.4	7.5	9.3	8.0	7.4	7.2					
10/01/00		6.7	8.1		5.7	5.5	5.9	6.9	8.8	7.3	8.3	7.2	7.7	8.0		7.6	8.8		
11/01/00		8.0	10.1		7.7	6.2	5.8	8.5	8.6	8.5	9.0	13.6	10.0	9.1			12.8		
12/01/00		9.1	9.8		8.1	7.7	6.8	8.0	9.7	9.0	8.8	10.1	10.3						
01/01/01		9.7	10.0		9.3	8.1	8.0	9.6	7.9	9.4	8.6								
02/01/01		10.4	10.1		10.3	10.6	10.0	10.1	13.5	12.4		10.6	10.3	9.5				10.8	
03/01/01		10.5	9.5		11.7	8.8	10.6	8.1	10.6	8.6	9.5	8.9	8.2	8.8	7.9		8.1	8.4	5.7
04/01/01		9.9	9.5		9.3		9.0	6.3	10.2	9.4	9.8	8.6	8.1	7.9		6.5	9.0		
05/01/01		10.1			9.8	9.7	8.6	9.8	8.9	8.8	8.7	8.6	8.9	9.0				9.0	
06/01/01		8.3	6.6		9.0	6.9	8.5		9.5	8.1	8.0	7.1	7.2	6.6		7.3	6.9	8.4	7.5
07/01/01		6.3	8.0		6.1		5.0	4.5	5.2	4.3	5.2	8.9	7.9	8.8		8.3	8.7		8.7
08/01/01			5.8			5.4	7.2	9.1	9.7	7.0	8.4	7.6	7.5	7.6		7.5		10.5	
09/01/01		6.2	4.5		6.8				10.9			6.4	6.5	6.3					
10/01/01			6.3			8.2	4.3	6.1	8.6	7.2	7.4	8.8	9.5	8.2		7.7	8.5	8.5	
11/01/01		8.3			8.2		7.4												
12/01/01		7.5			9.0		9.2	9.7	10.2	9.8	9.9			1.4					
01/01/02		5.2	11.7		11.4	0.4	0.3	0.3	0.3	0.3	0.3			10.4				0.2	
02/01/02		10.5	11.1		9.9		9.9	9.8	10.9	9.6	10.5	10.3	10.2	9.7		9.9	10.9	11.1	10.3
03/01/02		9.7	9.6		10.2	12.0	11.1	8.8	10.5	9.6	11.7	9.0	7.9	7.3		8.1	9.4	9.8	8.4
04/01/02		10.6	9.9		8.4	9.7	11.2	7.8	9.3	7.2	8.7	10.2	8.6	9.8		9.6	9.0	10.6	
05/01/02		7.7	8.6		14.9			6.9	9.2	7.8	9.0	8.5	8.5	8.6		8.9	8.7	10.0	
06/01/02		7.8	8.3		7.6			8.2		8.4	9.6	10.8	10.0	10.0		10.0	10.8		7.3
07/01/02																			
07/08/02																			
07/16/02		7.5			8.9		7.8												
07/22/02																			
07/29/02																			
08/05/02																			
08/12/02		7.2			8.2		8.1												
08/19/02																			
08/26/02																			

Date	R1	R2A	R4	R4-Dup	R6A	R8	R9A	R10	R11	R12	R13	R14	R16	R18	R19	R21	R22	R25	R26
09/03/02		7.5			7.3		7.3												
09/10/02																			
09/16/02		7.7			6.2		6.3												
09/23/02																			
09/30/02																			
10/02/02		6.4			5.9		4.0												
10/07/02																			
10/14/02																			
10/16/02		7.5			6.8		5.7												
10/21/02																			
10/28/02																			
10/30/02		7.0			6.6		5.7												
11/04/02																			
11/12/02																			
11/13/02		8.0			9.0		8.5												
11/18/02																			
11/25/02		8.8			8.2		7.1												
12/09/02																			
12/16/02										9.1		9.2	9.1			9.2	9.2		
12/17/02		9.2			9.0		8.3												
01/14/03																			
02/11/03		10.5			11.2		10.2												
03/11/03		10.8			13.0		10.7												
04/15/03		9.3			8.4		9.7												
05/13/03		9.7			8.7		9.4												
06/03/03		9.3			9.0		10.2												
06/10/03																			
06/24/03		9.0			6.9		9.2												
07/07/03																			
07/14/03		7.3			7.6		9.6												
07/21/03																			
07/28/03																			
08/04/03		7.3			7.6		8.1												
08/11/03																			
08/18/03																			
08/25/03		7.1			8.8		7.6												
09/02/03																			
09/08/03		6.7			6.2		5.5												
09/15/03																			
09/22/03		6.2			5.7		7.2												
09/29/03																			
10/06/03		4.9			3.8		7.0												
10/13/03																			
10/20/03																			
10/28/03		6.7			5.3		6.5												

Date	R1	R2A	R4	R4-Dup	R6A	R8	R9A	R10	R11	R12	R13	R14	R16	R18	R19	R21	R22	R25	R26
11/03/03																			
11/10/03																			
11/17/03		7.7			5.6		6.5												
12/01/03																			
12/15/03																			
01/20/04																			
02/17/04																			
03/16/04																			

Table 22.1. pH for streams and canals from August 1999 to January 2004.

Date	R1	R2A	R3	R4	R4-Dup	R5	R6A	R7	R8	R9A	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R21	R22
08/01/99																						
09/01/99																						
10/01/99	8.3		8.4	8.4		8.0						9.0	8.1	8.1	8.6		8.4		8.3			
11/01/99		8.2		8.4			8.5		8.1	7.7	7.4	8.3	8.4	8.5	8.7		8.7					
12/01/99		8.2		8.3			8.3		7.7	7.9	8.0	8.6	8.6	8.6	8.7	7.8	8.7	7.8				
01/01/00		8.2		7.8			8.3		8.0	7.7	8.1	8.3	8.4						8.3			
02/01/00		8.0		8.2			8.5		7.8	8.2	8.0	8.2		8.4	8.1		8.2		8.0			
03/01/00	8.6	8.2	8.6	8.7		8.7	8.7	8.7	8.4	8.3	8.1	8.5	8.4	8.5	8.6		8.7		8.5			
04/01/00	8.3	8.3	8.3	8.4		8.2	8.5	8.3	7.9	7.6	7.7	8.4	8.0	8.2	8.3		8.2		8.3			
05/01/00	8.5	8.4	8.4			8.3	8.4	8.4	7.8	8.4	8.1	8.7	8.2	8.5	8.5	7.6	8.4	7.6	8.3	7.8		
06/01/00	8.3	8.1	7.8	8.1		8.1	8.4	7.8	7.4	8.7	7.9	8.2	7.7	8.0	8.4		8.4		8.1			
07/01/00	8.4	8.8	7.6	7.9		8.2	8.5	7.8	7.5	8.6	7.9	8.3	8.0	8.0	8.4		8.5		8.1			
08/01/00	8.3	8.2	7.5	7.9		8.5	8.6	8.0	7.7	8.4	7.7	8.1	7.7	7.9	8.4		8.3		8.1			
09/01/00	7.8	8.4	7.8	8.2		8.3	8.5	7.9	7.6	8.3	8.0	8.2	8.6	8.4	8.3		8.4		8.4			
10/01/00	8.6	7.9	8.5	8.5		8.6	8.4	8.2	7.4	7.7	8.1	8.6	8.4	8.5	8.5		8.3		8.4		8.6	8.3
11/01/00	8.6	8.1	8.6	8.6		8.3	8.6	8.6	7.8	7.9	8.2	8.6	8.6	8.7	8.6	7.4	8.7	7.6	8.4			8.5
12/01/00	8.6	8.2	8.6	8.6		8.3	8.3	8.6	7.6	7.7	8.3	8.6	8.5	8.6	8.9	6.7	8.7	8.2			8.3	
01/01/01			8.5	8.5		8.9		8.5						8.6								
02/01/01	11.1	8.5	8.4	8.5		8.4	8.7	8.5	8.2	8.4	8.3	8.3	8.4		8.5		8.7		8.5	8.0	8.6	8.6
03/01/01	8.4	8.8	8.4	8.4		8.2	8.8	8.4	8.3	9.0	8.1	8.4	8.6	8.5	9.4		8.4	7.8	8.2	8.2		8.5
04/01/01	8.5	8.4	8.5	8.5		9.4	8.4	8.3	7.9	8.5	8.0	8.6	8.6	8.6	8.0	7.2	8.5		8.5	7.8	8.5	8.5
05/01/01		8.4	8.3	8.5		8.2	8.8	8.4	7.4	8.3	8.1	8.3	7.9	8.1	8.4		8.5		8.2		8.2	
06/01/01	8.4	8.4	7.9	8.3		8.4	8.8	8.4	7.2	8.6	8.2	8.3	7.9	8.1	8.4	7.7	8.2		8.2	7.7	8.3	8.4
07/01/01	8.0	8.2	7.6			7.9	9.0	7.8		8.3	7.3	7.4	6.8	7.1								
08/01/01	8.2		7.4	7.7		8.2		8.1	7.9	8.8	8.0	8.0	7.8	7.9	8.2	7.0	8.1	7.6	7.9	7.7	8.0	
09/01/01	8.2	7.6	7.3	7.5		8.3	8.4	8.0	7.5	8.0	8.0	8.1	7.8	7.8	8.1	7.7	7.3		7.8	7.6	7.6	8.2
10/01/01		8.0		7.6		6.8	8.0		8.1	7.9	7.8	8.1	805.0	8.1	7.7		8.2		7.9	7.9	8.0	8.1
11/01/01		8.2					8.3			7.5												
12/01/01	8.5	7.3	8.5	8.1		8.4	7.6	8.3		8.1	7.9	8.6	8.4	8.4	8.8		8.4		8.5		8.5	8.7
01/01/02	8.5	8.6	8.5	8.1		8.5	8.5	8.4			7.9	8.4	8.3	8.3					8.1			
02/01/02	7.4	8.2	6.7	8.2		7.8	8.4	7.1		8.2	7.8	8.3	8.3	8.3	8.3		8.5		8.0	8.3	8.4	8.2
03/01/02	8.4	8.1	8.4	8.3		8.2	8.5	7.3	9.2	8.9	8.0	8.4	8.3	8.4	8.3		8.1	7.6	7.9		8.3	8.2
04/01/02	8.4	8.4	7.9	8.6		8.4	8.0	7.2	8.3	8.9	7.3	8.4	7.3	7.3	8.6	7.8	8.6		8.1	7.8	8.5	8.5
05/01/02		8.1	8.2	8.6		8.4	8.4	7.3	8.8	8.9	8.0	8.6	8.2	18.7	8.5	7.7	8.5	7.6	8.3		8.4	8.4
06/01/02		8.6	7.4	8.4		8.0	8.7				8.2	8.5	7.8	8.0	8.4		8.4		8.1		8.3	8.3
07/01/02												7.2	7.6		8.5		8.6				8.5	8.5
07/08/02												8.4	8.3		8.6						8.6	8.5
07/16/02												8.3	8.4		8.5		8.7				8.6	8.5
07/22/02												7.3	8.4		8.3		8.8				8.6	8.3
07/29/02													8.4		8.4		8.7				8.7	8.4
08/05/02												8.3	8.1		8.5		8.6				8.5	8.5
08/12/02												8.4	8.2		8.6		8.6				8.5	8.6
08/19/02												8.5	8.0		8.6		8.6				8.5	8.6

Date	R1	R2A	R3	R4	R4-Dup	R5	R6A	R7	R8	R9A	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R21	R22
08/26/02												8.5	8.5		8.6		8.6				8.6	8.6
09/03/02												8.6	8.2		8.6		8.6				8.6	8.6
09/10/02													8.0		8.8		8.5				8.7	8.5
09/16/02													8.5		8.6		8.6				8.7	8.5
09/23/02													8.7		8.6		8.7				8.7	8.4
09/30/02													8.6		8.5		8.7				8.8	8.4
10/02/02																						
10/07/02													8.7		8.6		8.6				8.8	8.5
10/14/02												8.5	8.5		8.6		8.8				8.8	8.5
10/16/02																						
10/21/02												8.4	8.7		8.8		8.6				9.0	8.6
10/28/02												8.4	8.5		8.9		8.7				8.7	8.6
10/30/02																						
11/04/02												8.6	8.7		9.1		9.0				8.8	8.7
11/12/02												8.6	8.6		9.1		8.9				8.8	8.8
11/13/02																						
11/18/02												6.6	6.6		6.5		6.5				6.5	6.4
11/25/02												9.1	9.1		9.2		9.1				9.1	9.2
12/09/02												9.1	9.1		9.2		9.1				9.1	9.2
12/16/02												9.1										
12/17/02																						
01/14/03											8.8	9.3										
02/11/03											8.6		9.5		9.2		9.2					9.2
03/11/03											8.7		9.3		9.1		9.1					9.2
04/15/03											8.6		9.2	9.2	9.3		9.2				9.3	9.2
05/13/03			9.1								8.6	9.1	9.3		9.1		9.1					9.1
06/03/03			9.1								8.8	9.0	8.8		8.9		8.9				9.0	9.0
06/10/03												9.0										
06/24/03			7.9								8.3	8.0	8.4		8.5		8.5				8.5	8.4
07/07/03			7.5								7.7	8.1	7.9		8.4		8.4				8.4	8.4
07/14/03												8.0	8.0		8.4	8.3					8.4	8.4
07/21/03			7.9								7.5	8.1	8.0		8.5		8.5				8.4	8.5
07/28/03			7.7								7.5	8.0	7.9		8.3		8.3				8.3	8.3
08/04/03			7.7								7.6	8.1	8.3		8.4		8.4				8.3	8.3
08/11/03			7.8								7.7	8.0	8.0		8.4		7.8				8.4	8.4
08/18/03			8.0								7.9	8.2	8.0		8.3		8.3				8.4	8.2
08/25/03			8.0								7.9	8.2	8.2		8.3		8.4				8.4	8.2
09/02/03																						
09/08/03			7.7								7.8	8.0	8.0		8.2		8.3				8.2	8.2
09/15/03												8.0	8.1		8.3		8.3				8.3	8.1
09/22/03			7.9								7.2	8.0	8.3		8.3		8.4				8.4	8.1
09/29/03											7.7	8.0	8.4		8.5		8.2				8.5	8.2
10/06/03												8.1	8.3		8.4						8.4	8.1
10/13/03			8.7								7.9	8.3	8.4		8.6		8.5				8.3	8.4
10/20/03			8.2								7.5	8.1	8.4		8.5		8.5				8.5	8.3

Date	R1	R2A	R3	R4	R4-Dup	R5	R6A	R7	R8	R9A	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R21	R22
10/28/03			8.5									8.2	8.4		8.6		8.5				8.7	8.4
11/03/03											7.7	8.3	8.7		8.5		8.6				8.6	8.4
11/10/03			8.6								8.4	8.6	8.8		8.7		8.9				8.8	8.6
11/17/03			8.6								8.9	8.7	8.8		8.9		8.8				8.7	8.7
12/01/03			8.5										8.3		8.9						8.8	8.6
12/15/03											7.4		8.5		8.9		8.7					8.8
01/20/04												8.5	8.3		8.4		8.3					8.4
02/17/04																						
03/16/04																						

Table 22.2. (Continued) pH for streams and canals from August 1999 to January 2004.

Date	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/01/99																					
09/01/99																					
10/01/99																					
11/01/99																					
12/01/99																					
01/01/00																					
02/01/00																					
03/01/00																					
04/01/00																					
05/01/00																					
06/01/00																					
07/01/00																					
08/01/00																					
09/01/00																					
10/01/00																					
11/01/00																					
12/01/00																					
01/01/01																					
02/01/01	8.5																				
03/01/01	8.5	8.4																			
04/01/01		8.6																			
05/01/01	8.5																				
06/01/01		8.4																			
07/01/01	8.5																				
08/01/01	8.6	8.4																			
09/01/01	8.6	8.0																			
10/01/01	8.5																				
11/01/01																					
12/01/01	8.6																				
01/01/02	7.3																				
02/01/02	8.4	8.3																			
03/01/02	8.4	8.3																			
04/01/02	9.4																				
05/01/02	9.4	8.6																			
06/01/02	8.1	8.3																			
07/01/02			8.5	8.6						8.5				5.6		8.5					
07/08/02			8.6	8.7					8.3	8.6				8.6		8.5					
07/16/02			8.5	8.6					8.2	8.6				8.6		8.5					
07/22/02			8.5	8.8					7.8	8.6				8.5		8.4					
07/29/02			8.5	8.8					8.2	8.7				8.5		8.4					
08/05/02			8.5	8.5					8.1	8.4				8.6		8.5					
08/12/02			8.6	8.6					8.2	8.5				8.6		8.5					
08/19/02			8.6	8.5					8.2	8.3				8.4		8.5					
08/26/02			8.6	8.6					8.3	8.8				8.7		8.5					

Date	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
09/03/02			8.6	8.6					8.2	8.6				8.6		8.6					
09/10/02			8.8	8.6					8.2	8.4				8.3		8.4					
09/16/02			8.6	8.7					8.2	8.6				8.6		8.4					
09/23/02			8.7	8.7					8.4	8.5				8.5		8.6					
09/30/02			8.6	8.8						8.6				8.4		8.3					
10/02/02																					
10/07/02			8.7	8.6						8.6				8.4		8.4					
10/14/02			8.6	8.9						8.6				8.4		8.6					
10/16/02																					
10/21/02			8.9	8.7					8.4	8.8				8.5		8.5					
10/28/02			8.9	8.7						8.4				8.7		8.6					
10/30/02																					
11/04/02			9.0	8.8					8.4	8.5				8.7		8.6					
11/12/02			8.1	8.7					8.5	8.9				8.8		8.6					
11/13/02																					
11/18/02			6.5	6.5					9.1	6.6				6.5		6.5					
11/25/02			9.1	9.1						9.2				9.1		9.1					
12/09/02			9.1	9.1						9.2				9.1		9.1					
12/16/02																					
12/17/02																					
01/14/03	9.4								9.0												
02/11/03	9.5								8.9	9.0											
03/11/03	9.1								8.8					9.2							
04/15/03	9.1								9.2	9.2				9.2			9.2				
05/13/03									9.0	9.1				9.2			9.2				
06/03/03	9.2								8.8	9.0				9.0							
06/10/03																					
06/24/03									8.4	8.6				8.6			8.4				
07/07/03	8.4								8.2	8.1				8.5			8.0				
07/14/03	8.0								8.0	8.3				8.4			8.0				
07/21/03	7.1								8.4	8.0				8.4			8.0				
07/28/03	6.7								8.0	8.0				8.3			7.9				
08/04/03	8.0								8.0	8.3				8.3			8.1				
08/11/03	8.3				8.4				8.1	8.2				8.4			8.0				
08/18/03									8.2	8.3				8.3			8.0				
08/25/03	8.2				8.3				8.1	8.4				8.4			7.9				
09/02/03																					
09/08/03	8.3				8.2				7.8	8.2				8.3			8.0				
09/15/03					8.3				8.0	7.8							8.1				
09/22/03					8.4				7.9	8.2				8.3			8.2				
09/29/03	7.9				8.3												8.3				
10/06/03					8.4				8.1	7.5				8.4			8.2				
10/13/03					8.4				8.0	8.3				8.5			8.4				
10/20/03					8.3				7.9	7.8				9.6			8.2				
10/28/03					8.6				8.0	8.3				8.5			8.2				

Date	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
11/03/03					8.7				8.1	8.6				8.7			8.5				
11/10/03					8.8				8.5	8.7				8.8			8.7				
11/17/03					8.7									8.7							
12/01/03					8.4									8.9							
12/15/03					8.7									8.6							
01/20/04									7.7					8.4							
02/17/04																					
03/16/04																					

Table 23.1. Total organic carbon (mg/l) from August 1999 to January 2004.

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/01/99	2.87	3.09	2.88	2.72	2.76		2.75	1.93	1.74	1.78	2.75	2.94		2.91	2.94	2.73	3.02	2.60	2.49	2.36	2.73	2.45	2.58	2.38
09/01/99	2.78	3.19	2.83	2.59	2.62		2.47	2.06	1.93	1.69	2.75	3.45		3.10	2.83	2.76	2.60	2.57	2.91	2.37	2.92	2.49	2.65	2.45
10/01/99	3.80	3.42	3.10	3.19	2.78		3.23	2.28	2.19	2.30	2.77	2.95		2.96	2.79	2.81	2.60	2.70	2.67	2.22	2.55	2.41	2.49	2.03
11/01/99	2.90	3.33	3.18	2.94	2.98		3.09	2.81	2.86	3.01	3.30	3.32		3.45	2.43	3.07	2.24	2.29	2.72	2.18	2.56	2.43	2.87	
12/01/99	2.63	6.65	2.90	2.61	2.75		1.34	2.48	2.45	2.58	3.40	3.21		3.10	2.17	2.68	2.06	2.11	2.07	1.79	2.09	1.88		
01/01/00	2.73	2.88	2.88	2.69	2.62		1.00	2.31	1.74	1.85	2.77	2.97		2.91	2.05	2.70	1.68						2.04	1.67
02/01/00	2.83	3.04	3.12	2.76	2.65		1.14	2.16	2.12	2.13	2.59	3.08		3.00	2.15	2.70	1.84	2.43	2.64		1.89		2.37	2.23
03/01/00	2.50	2.68	2.78	2.48	2.50	2.51	1.75	1.48	1.74	1.70	2.66	3.30		3.27	2.06	2.55	1.29	1.92	2.06	1.67	1.99	1.87	2.06	1.96
04/01/00	2.54	2.96	3.35	2.82	2.61	2.61	2.63	1.62	1.69	1.59	2.88	3.32	3.00	2.99	2.40	2.40	2.04	2.27	2.32		2.17	1.92	2.23	2.14
05/01/00	2.50	2.87	2.56	2.57	2.53	2.53	1.04	1.49	1.33	1.34	2.61	2.62	2.73	2.75	2.75	2.61	2.60	2.49	2.50	2.30	2.73	2.52	3.01	2.42
06/01/00	3.34	3.55	3.62	3.19	3.22	3.19	1.81	2.31	2.03	1.83	3.42	4.02	3.49	3.49	3.15	3.20	3.06	3.24	3.10	2.99	3.47	3.01	2.99	3.06
07/01/00	3.43	3.46	3.37	2.92	2.93	3.03	1.47	1.97	1.67	1.56	3.29	3.25	3.10	3.66	2.91	3.02	2.96	3.07	3.09	2.75	3.04	2.75	2.68	2.58
08/01/00	3.10	3.56	3.28	2.91	2.90	2.97	1.32	4.50	1.95	1.53	3.12	3.21	3.36	2.93	2.93	3.11	2.78	2.78	3.37	2.79	2.97	2.75	2.74	2.74
09/01/00	3.24	3.25	3.30	3.12	3.22	3.44	2.53	2.30	2.08	1.66	3.66	3.62	3.50	3.54	2.96	3.10	2.29	2.91	2.97	2.78	3.05	2.80	2.90	2.39
10/01/00	2.91	3.06	3.04	3.07	2.84	2.90	1.16	3.66	1.74	1.66	2.92	3.00	3.05	3.10	3.00	2.97	2.82	2.87	3.08	2.70	2.82	2.65	2.77	1.86
11/01/00	2.67	2.81	2.83	2.66	2.64	2.62	1.28	2.04	1.98	1.93	2.75	3.02	2.95	3.00	2.91	2.88	2.25	2.34	2.35	2.09	2.42	2.35	1.45	1.13
12/01/00	2.81	2.97	4.06	3.61	2.97	2.95	3.32	2.20	3.15	2.52	3.08	5.97	3.18	3.03	2.78	2.95	2.07	8.23	2.84	1.83	2.41	2.22		
01/01/01	2.88	3.11	3.08	2.89	2.74	2.77	1.74	2.67	2.65	2.51	2.99	3.11	3.15	3.25	2.42	3.02	1.79						1.71	1.58
02/01/01	2.72	3.07	3.15	2.70	2.64	2.79	2.30	2.25	2.26	2.27	2.86	3.00	2.97	3.00	2.19	2.86	2.19	2.01	2.01		2.03		2.13	1.91
03/01/01	2.78	2.92	2.97	2.66	2.68	2.62	5.16	2.54	2.05	2.11	3.05	3.17	3.23	3.08	2.11	2.64	1.54	1.98	1.96	1.90	2.13	1.81	2.07	1.59
04/01/01	2.83	3.45	2.86	3.08	3.09	3.58	3.04	3.05	2.11	2.03	3.10	3.48	3.21	3.07	2.22	2.68	1.87	2.25	2.18	2.08	2.15		2.30	2.11
05/01/01		4.32	4.00	3.75	3.10	2.98	1.57	3.82	3.26	2.42	3.25	3.84	3.76	3.33	3.38		3.26	3.12	3.18	3.12	3.51		3.75	2.93
06/01/01	2.58	3.53	2.73	2.70	2.93	2.85	0.81	4.35	2.92	2.03	2.91	3.21	3.16	2.93	2.86	2.71	2.61	2.62	3.03	2.20	3.15		2.60	2.43
07/01/01	3.07	3.90	3.31	3.15	3.09	3.05	1.77	3.82	3.24	2.62	3.31	3.46	4.87	3.44	3.13	3.11	3.12	3.04	2.99	2.54	3.14		2.90	3.24
08/01/01	2.52	3.54	2.63	2.64	2.64	2.60	2.17	3.71	3.54	2.31	3.07	3.50	3.14	3.49	2.81	2.74	2.73	2.63	2.69	2.15	2.79	1.95	2.59	2.35
09/01/01	3.75	4.79	3.59	3.34	3.27	3.32	1.53	3.79	3.49	3.28	3.66	3.73	3.92	3.67	3.72	3.30	3.42	3.61	3.84	2.93	5.26		3.39	2.96
10/01/01	3.18	4.19	3.97	3.34	3.37	3.53	1.95	3.70		3.46	4.53	3.77	3.66	3.88	3.47	3.43	3.11	3.48	3.11	2.43	3.25		3.30	2.69
11/01/01	3.31	3.90	3.84	3.21	3.40	3.49	1.12	2.99	2.96	3.28	3.67	3.64	3.64	3.87	0.50		2.61	2.62	2.88	2.06	2.67		2.78	2.28
12/01/01	2.95	3.55		3.21	3.13	2.99	1.11	20.59			4.49		4.23	4.09	2.36	5.29	2.26	2.29	2.16	1.52	2.27		2.25	12.31
01/01/02	2.85	3.82	10.29	2.96	15.64	9.95	1.28	24.78		2.33		3.91	3.93	3.65	18.09	3.08	26.17	11.81	5.46		3.00		8.43	2.79
02/01/02	2.72	4.73	3.00	4.71	2.72	2.66	42.99	2.81	2.28	8.54	3.53	21.82	3.76	3.53	1.40	2.77		2.88	2.83		2.78		2.66	2.43
03/01/02	3.24	3.29	3.58	2.84	2.88	3.10	1.13	2.12	2.17	2.17	10.99	4.31	4.31		3.34	3.01	2.26	2.67	2.81	2.33	2.72	2.41	2.39	
04/01/02	3.21	3.79	3.55	4.11	3.48	3.16	2.20	2.16	1.93	2.23	3.72	4.62	4.66	6.33	5.31	3.19	4.12	3.36	3.45	2.90	3.34	2.98	3.32	2.99
05/01/02	3.07	4.12	3.38	3.30	3.12	3.36	1.20	1.95	1.97	2.02		4.84	4.98	4.03	3.79	3.26	3.76	3.49	3.51	2.97	4.66	3.52	3.45	3.53
06/01/02	3.67	3.57	4.84	3.68	3.52	3.53	1.50	2.64	2.14	2.40		5.91	5.37	4.63	4.59	3.44	4.04	4.04	4.91	3.24	3.85	3.38	3.59	3.63
07/01/02																								
07/08/02																								
07/16/02																								
07/22/02																								
07/29/02																								
07/30/02																								
08/05/02																								
08/12/02		4.53	3.31					2.13	3.71			5.09	5.06	4.64										
08/19/02																								

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/26/02																								
08/30/02																								
09/03/02		4.34	3.39					2.63	2.57			5.20	5.00	5.98										
09/10/02																								
09/16/02		5.36	3.28					1.85	1.81			4.08	3.72	4.35										
09/23/02																								
09/30/02																								
10/02/02		4.21	3.58					2.63	2.19			4.52	4.75	4.24										
10/07/02																								
10/14/02																								
10/16/02		4.27	4.56					2.73	3.35			3.96	5.53	5.57										
10/21/02																								
10/28/02																								
10/30/02		4.02	3.88					2.44	2.59			3.74	4.24	5.90										
11/04/02																								
11/12/02																								
11/13/02		3.63	3.45					2.53	2.40			3.79	4.02	4.43										
11/18/02																								
11/25/02		3.38	3.82					2.20	2.12			3.89	3.87	3.77										
11/30/02																								
12/09/02																								
12/16/02																								
12/17/02		3.25	3.02					2.18	1.86			3.61	3.64	3.72										
12/30/02																								
01/14/03		3.37	3.38					1.98	2.35			4.29	4.27	4.01										
02/11/03		2.45	3.24					1.56	1.51			3.82	3.96	3.99										
03/11/03		3.00	3.06					4.27	1.67			3.98	3.80	4.34										
04/15/03		4.59	3.67					5.99	4.72			4.69	5.11	4.19										
05/13/03		4.15	3.27					5.98	4.73			4.78	3.88	1.42										
06/03/03		4.57	3.45					7.00	6.10			4.83	4.73	4.05										
06/10/03																								
06/24/03																								
07/07/03																								
07/14/03		5.96	5.00					6.78	7.66			7.29	6.52	5.68										
07/21/03																								
07/28/03																								
08/04/03																								
08/11/03																								
08/18/03																								
08/25/03		5.13	3.68					6.70	5.32			5.02	5.06	4.04										
09/02/03																								
09/08/03		4.96	5.13					6.44	5.22			5.09	4.98	4.45										
09/15/03																								
09/22/03		5.17	4.26					5.48	5.80			4.50	4.56	4.08										
09/29/03																								

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
10/06/03		4.86	4.55					4.52	4.68			4.18	4.31	4.27										
10/13/03																								
10/20/03																								
10/28/03		3.77	3.62					4.07	5.62			4.34	4.50	5.08										
11/03/03																								
11/10/03																								
11/17/03		3.16	3.28					3.51	3.54			4.01	3.95	4.06										
12/01/03		3.60	3.99					3.69	3.79			4.26	4.40	4.77										
12/15/03																								
01/20/04												3.72	3.75	3.64										
02/17/04																								
03/16/04																								

Table 23.2. (Continued) Total organic carbon (mg/l) from August 1999 to January 2004.

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/01/99	1.01																							
09/01/99	3.53																							
10/01/99	0.89																							
11/01/99	1.37																							
12/01/99																								
01/01/00	1.02																							
02/01/00																								
03/01/00	2.26																							
04/01/00	0.86																							
05/01/00	1.92																							
06/01/00	1.49																							
07/01/00	1.39																							
08/01/00	2.06																							
09/01/00	0.96																							
10/01/00	2.77																							
11/01/00	1.03																							
12/01/00	0.79																							
01/01/01	0.79																							
02/01/01	2.82			1.93																				
03/01/01	1.51			1.56	1.99																			
04/01/01	1.54			2.15																				
05/01/01				1.59																				
06/01/01	0.72			1.35																				
07/01/01	21.00			2.11																				
08/01/01				1.80																				
09/01/01	1.20			2.32																				
10/01/01	1.66			4.09																				
11/01/01				2.77																				
12/01/01				1.36																				
01/01/02	1.50			1.35																				
02/01/02				3.32																				
03/01/02	1.29			1.49																				
04/01/02				1.77																				
05/01/02	1.14			1.78																				
06/01/02				5.89																				
07/01/02																								
07/08/02																								
07/16/02																								
07/22/02																								
07/29/02																								
07/30/02																								
08/05/02																								
08/12/02																								

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/19/02																								
08/26/02																								
08/30/02																								
09/03/02																								
09/10/02																								
09/16/02																								
09/23/02																								
09/30/02	1.99																							
10/02/02																								
10/07/02																								
10/14/02																								
10/16/02																								
10/21/02																								
10/28/02																								
10/30/02	2.14																							
11/04/02																								
11/12/02																								
11/13/02																								
11/18/02																								
11/25/02																								
11/30/02																								
12/09/02																								
12/16/02																								
12/17/02																								
12/30/02	0.71																							
01/14/03	0.48																							
02/11/03	6.64																							
03/11/03	5.31																							
04/15/03	1.42																							
05/13/03	1.35									3.63	3.85													
06/03/03										2.81	2.86													
06/10/03																								
06/24/03																								
07/07/03																								
07/14/03	1.31																							
07/21/03																								
07/28/03																								
08/04/03																								
08/11/03																								
08/18/03																								
08/25/03	2.34									2.85	2.88													
09/02/03																								
09/08/03																								
09/15/03																								
09/22/03																								

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
09/29/03																								
10/06/03																								
10/13/03																								
10/20/03																								
10/28/03	1.39																							
11/03/03																								
11/10/03																								
11/17/03																								
12/01/03	0.93																							
12/15/03	0.51																							
01/20/04																								
02/17/04																								
03/16/04																								

Table 24.1. Dissolved organic carbon from August 1999 to January 2004.

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/01/99	2.94	3.11	2.84	2.71	2.71		2.78	1.85	1.61	1.63	2.67	2.85		2.82	2.71	2.61	2.63	2.53	2.41	2.31	2.67	2.28	2.53	2.31
09/01/99	2.72	3.07	2.70	2.64	2.71		2.43	1.99	1.92	1.69	2.69	3.00		3.00	2.60	2.62	2.54	2.55	2.67	2.21	2.57	2.31	2.51	2.28
10/01/99	2.80	3.33	3.10	3.20	2.82		3.28	2.23	2.17	2.20	2.71	3.03		3.07	2.84	3.09	2.40	2.40	2.58	2.28	2.82	2.25	2.81	2.07
11/01/99	2.78	3.24	3.17	2.96	2.94		3.07	2.78	2.72	3.08	3.23	3.25		3.13	2.45	3.02	2.17	2.18	2.57	2.11	2.35	2.36	2.48	
12/01/99	2.61	2.99	2.95	2.59	2.74		1.56	2.78	2.42	2.46	2.71	2.90		3.19	1.86	2.81	2.87	2.38	2.13	1.78	2.74	1.92		
01/01/00	2.63	2.92	2.77	2.69	2.61		1.03	2.20	1.64	1.82	2.71	2.98		2.94	2.01	2.63	1.73						1.84	1.72
02/01/00	2.80	3.12	3.11	2.74	2.72		1.28	2.16	2.08	2.14	2.69	3.20		2.95	2.35	2.78	1.77	2.52	2.52		1.97		2.33	2.22
03/01/00	2.48	2.64	2.67	2.44	2.51	2.43	1.83	1.51	1.73	1.71	2.64	2.88		2.73	1.97	2.55	1.18	1.91	2.04	1.86	2.02	1.67	2.09	1.97
04/01/00	2.69	2.74	2.92	2.55	2.45	2.38	2.46	1.51	1.47	1.47	2.67	2.86	2.70	2.64	2.42	2.33	2.08	2.44	2.24		2.11	1.86	2.16	2.21
05/01/00	2.65	2.83	2.62	2.70	2.57	2.82	1.12	1.45	1.22	1.29	2.66	2.81	2.89	2.84	2.67	2.57	2.44	2.54	2.75	2.48	2.56	2.26	2.38	2.27
06/01/00	3.29	3.59	3.61	3.22	3.15	3.31	1.73	2.31	2.01	1.85	3.07	4.10	3.39	3.37	3.11	3.20	3.30	3.08	3.01	2.97	3.16	2.85	3.08	3.04
07/01/00	3.21	3.29	3.13	2.94	4.08	3.37	1.41	2.02	1.48	1.59	3.00	3.09	3.06	3.43	2.81	2.96	2.75	2.80	2.81	2.54	2.84	2.62	2.74	2.54
08/01/00	3.01	3.48	3.25	2.89	2.88	2.88	1.28	4.39	1.84	1.58	3.12	3.05	3.07	2.80	2.77	3.01	2.64	2.72	2.77	2.59	3.52	2.85	3.42	2.56
09/01/00	3.11	3.22	3.29	3.15	3.13	3.09	2.39	2.02	1.90	1.56	3.21	3.40	4.00	3.35	3.03	3.38	2.32	2.97	3.25	2.79	3.18	2.79	2.84	2.39
10/01/00	2.92	2.91	3.02	2.97	2.81	2.82	0.77	1.84	1.72	1.58	2.87	3.05	2.92	3.02	2.93	3.05	2.58	2.77	2.82	2.69	2.70	2.52	2.76	1.86
11/01/00	2.50	2.92	2.81	2.66	2.69	2.97	1.27	1.95	1.92	1.97	2.91	2.88	2.90	3.03	2.85	2.67	2.14	2.23	2.49	2.05	2.49	2.31	1.43	1.04
12/01/00	4.17	5.77	3.08	2.81	3.79	2.81	4.17	2.26	2.56	2.47	4.25	3.21	3.15	3.24	2.13	3.48	2.07	2.12	3.90	1.78	2.31	2.12		
01/01/01	2.75	3.05	3.01	2.91	2.85	2.84	1.69	2.65	2.65	2.62	2.94	3.17	3.13	3.56	2.19	2.91	2.03						1.88	1.76
02/01/01	2.63	2.82	2.99	2.66	2.61	2.68	1.99	2.29	2.22	2.19	2.89	2.99	3.01	3.01	2.09	2.68	2.02	1.93	1.98		2.02		2.14	1.94
03/01/01	2.58	2.82	2.89	2.49	2.62	2.61	4.71	2.28	2.07	2.02	3.00	3.10	3.02	2.99	2.01	2.57	1.38	1.89	1.89	1.80	2.04	1.81	2.08	1.61
04/01/01	2.85	3.63	3.70	3.30	2.93	3.88	3.40	3.60	2.08	2.06	3.22	3.59	3.15	5.44	2.34	2.74	1.84	1.95	2.17	1.71	2.10		2.27	2.00
05/01/01		4.06	3.33	3.31	3.15	3.21	1.91	4.00	3.39	3.19	3.44	3.68	3.71	3.18	3.51	2.99	3.03	3.14	3.12	2.64	3.43		3.85	3.09
06/01/01	2.78	3.99	2.85	2.70	2.78	2.77	0.88	3.64	3.03	1.88	2.88	3.54	3.22	2.97	2.74	2.64	2.71	2.54	3.06	2.15	3.07		2.58	2.26
07/01/01	3.10	3.83	3.18	3.00	3.06	3.04	1.55	3.72	2.94	2.60	3.36	3.41	3.25	3.11	3.18	3.18	3.01	3.00	3.19	2.46	3.09		2.92	2.61
08/01/01	3.46	3.44	2.59	2.41	2.61	2.49	1.97	3.37	3.13	2.26	3.00	3.21	2.88	3.27	2.76	2.67	2.65	2.76	2.63	2.13	2.65	2.01	2.39	2.33
09/01/01	3.62	4.52	3.64	3.53	3.35	3.63	1.52	4.06	3.43	3.16	3.52	4.08	3.80	3.55	3.41	3.31	3.79	3.66	3.50	3.34	5.13		3.24	2.84
10/01/01	3.28	4.07	3.94	3.36	3.31	3.70	1.65	3.58		3.85	4.08	3.79	3.71	3.86	3.49	3.34	3.33	3.65	3.12	2.31	3.06		3.34	2.95
11/01/01	3.42	4.27	3.94	3.20	3.36	3.57	1.09	3.10	2.91	2.91	4.35	3.90	3.61	3.69	2.62		2.82	2.71	2.87	2.07	2.64		2.62	2.22
12/01/01	2.77	3.15		2.85	2.84	2.94	1.26	2.64			3.45		3.77	3.46	5.08	4.99	2.17	2.29	2.26	1.78	2.03		1.93	1.56
01/01/02	2.79	3.22	3.56	2.82	2.78	2.69	0.96	2.58		1.85	3.91	3.63	3.60	3.58	3.49	2.82	3.11	3.05	4.99		2.75		2.72	2.57
02/01/02	2.71	3.02	2.96	2.68	2.89	2.58	0.89	2.05	2.01	1.97	3.16	8.47	3.46	3.32	1.40	2.87	3.06	2.85	2.79		2.82		2.61	2.30
03/01/02	3.25	3.33	3.57	2.91	2.92	2.86	1.35	2.38	2.61	1.99	4.09	4.13	4.14		3.36	2.85	2.24	2.82	2.72	2.31	2.77	2.31	1.61	
04/01/02	3.36	4.33	3.61	4.35	3.23	3.31	1.98	2.05	2.39	2.19	3.83	4.19	4.45	3.94	3.90	3.02	3.90	3.79	3.47	2.81	3.29	2.96	3.39	2.93
05/01/02	3.43	4.23	3.62	3.48	3.48	3.36	1.47	2.23	2.03	2.13		4.63	4.97	3.89	4.32	3.31	3.62	3.78	3.67	3.06	3.89	3.18	3.74	3.04
06/01/02	2.94	3.11	3.98	3.10	3.24	3.02	1.11	2.22	1.81	1.85		4.50	4.74	3.85	3.66	3.16	3.58	3.52	3.71	2.97	3.58	2.97	3.33	3.09
07/01/02																3.02	3.40	3.21	3.61	2.76	3.20	2.99	3.90	2.88
07/08/02																3.44	3.39	3.31	3.41	2.72	3.37	2.85	3.78	3.24
07/16/02		4.44	3.41					2.10	1.73			4.37	4.03	3.50		3.18	3.52	3.29	3.27		3.11		3.21	2.95
07/22/02																3.11	3.32	3.23	3.06	2.66	3.30	2.94	3.26	
07/29/02																2.99	3.40	3.13	3.03	2.40	3.05	2.57	2.79	2.52
07/30/02																								
08/05/02																3.00	3.01		3.26	4.19	3.12	2.57	2.85	2.68
08/12/02		4.42	3.01					2.79	3.76			4.63	4.76	4.43		3.09	3.13	3.16	3.13	2.57	3.07	2.40	3.42	2.67
08/19/02																3.06	3.16	3.19	3.27	2.70	3.28	2.74	2.96	2.99

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/26/02																3.06	2.93	2.92	2.99	2.55	2.90	2.48	2.83	2.59
08/30/02																								
09/03/02		3.97	3.29					2.35	2.44			4.85	4.70	5.20		2.94	3.80	2.94	3.01	2.34	2.92	2.50	2.82	3.21
09/10/02																	3.23	2.95	2.90	2.26	2.92	2.42	2.67	1.79
09/16/02		4.89	3.33					1.82	1.73			4.02	4.33	3.44			2.90	2.99	2.99	2.43	3.00	1.86	2.73	2.35
09/23/02																	2.67	2.98	3.04	2.46	2.94	2.52	2.66	2.10
09/30/02																	2.55	3.21	3.08	2.72	3.07	2.15	2.84	2.18
10/02/02		4.17	4.03					2.44	2.22			4.54	4.64	4.35										
10/07/02																	2.62	3.14	3.29	2.63	3.13	2.33	2.55	2.04
10/14/02																3.32	2.62	3.04	3.01	2.51	2.90	2.26	2.58	2.03
10/16/02		4.44	4.57					2.46	3.33			4.27	4.40	5.06										
10/21/02																3.15	2.32	3.07	3.04	2.48	3.54	2.36	2.45	2.16
10/28/02																3.30	1.88	2.35	2.44	1.92	2.42	1.94	2.25	1.71
10/30/02		3.83	3.70					2.32	2.27			3.66	4.18	5.10										
11/04/02																3.40	1.87	2.72	2.74	1.77	2.51		3.03	2.53
11/12/02																2.82	1.67	2.23	2.57	1.83	2.31		2.11	
11/13/02		3.77	3.96					2.60	2.68			4.00	4.26	5.03										
11/18/02																2.85	1.60	2.26	2.21	1.63	2.11		2.42	
11/25/02		3.44	4.11					2.04	2.12			4.22	4.11	3.84		2.80	1.57	2.20	2.25	1.56	2.18	1.76	1.94	
11/30/02																								
12/09/02																2.89	1.38	2.17	1.88	1.50	1.88			
12/16/02																2.59	1.19	1.56	2.06	1.55	2.06	1.75		
12/17/02		3.12	2.93					2.01	1.64			3.59	3.53	3.56										
12/30/02																								
01/14/03		3.20	3.40					1.84	1.87			3.74	3.81	3.72	2.59	2.79							1.82	1.62
02/11/03		3.03	3.25					1.71	1.69			3.88	3.94	3.92	2.92		1.63	2.37	2.14		2.13	1.73	1.92	
03/11/03		2.94	2.97					4.50	1.60			3.64	3.74	3.66	2.74		1.40	2.07	2.01		1.86	1.73	1.48	1.27
04/15/03		4.39	3.39	3.08				5.77	4.54			4.34	4.28	4.21	3.11	3.04	2.40	2.75	2.99	2.65	2.90	2.22	2.73	2.24
05/13/03		3.51	2.84	2.99				5.14	5.31			3.97	4.14	3.21	2.78	2.79	3.24	2.74	2.62	2.23	2.58	2.32	2.88	2.44
06/03/03		4.30	3.42	3.05				6.18	5.72			4.35	4.37	3.86	3.85	2.96	3.70	3.28	3.25	2.62	3.09	2.60	3.21	
06/10/03																								
06/24/03		4.63	4.40					6.06	5.94			5.63	5.22	5.17			4.58	4.03	3.65	2.80	3.61	2.88	3.55	3.22
07/07/03				3.11											3.74	3.12	4.02	3.43	3.44	2.77	3.34	2.88	3.59	2.81
07/14/03		5.55	4.80					5.89	6.99			6.05	5.43	5.30		3.18	4.28	3.68	3.71	2.98	3.69	3.25	3.93	3.00
07/21/03				3.25											3.78	3.15	4.14	3.62	3.90	3.25	3.74	3.51	3.90	3.44
07/28/03				3.10											3.81	3.23	3.78	3.63	3.38	2.61	3.29	2.38	3.48	2.85
08/04/03		5.22	3.97	3.18				5.86	5.74			5.28	5.18	5.54	3.89	3.45	3.93	3.27	3.57	2.40	3.79	2.53	3.67	3.34
08/11/03				3.39											4.40	3.29	4.18	3.75	3.99	2.73	3.75	3.13	3.87	3.32
08/18/03				3.27											4.23	3.85	4.60	4.17	4.39	3.81	4.19	3.79	4.32	3.64
08/25/03		4.62	3.49	4.18				5.82	5.63			4.52	4.71	4.25	4.53	4.15	4.51	4.02	4.16	3.07	4.36	3.71	4.02	3.14
09/02/03																								
09/08/03		4.57	4.71	4.02				5.86	4.81			4.49	4.45	4.23	4.61	3.98	4.41	3.99	3.95	2.78	3.96	3.76	4.18	3.25
09/15/03																								
09/22/03		4.92	4.41	3.30				5.25	6.07			4.43	4.48	4.65	3.88	3.34	3.63	3.44	3.45	2.63	3.40	2.87	3.29	2.09
09/29/03															4.02	3.63	3.16	3.56	3.44	2.24	3.37	3.07	3.51	2.07

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
10/06/03		4.84	4.80	3.79				4.53	4.75			4.33	4.48	4.39	3.88	3.34	3.56	3.45	3.41	2.57	3.41	2.81	3.40	1.96
10/13/03				3.90											3.38	3.37	3.91	3.54	3.66	2.58	3.47		3.53	2.82
10/20/03				2.92											4.22	3.02	3.99	3.56	3.54	2.74	3.61		3.22	2.63
10/28/03		3.81	4.17	2.77				4.09	5.69			4.21	4.53	4.78		2.80	3.90	3.45	3.93	2.05	3.33		3.12	2.31
11/03/03															2.93	2.85	3.72	3.27	3.44	2.20	3.24	2.94	2.99	1.90
11/10/03																								
11/17/03		3.12	3.54	2.54				3.45	3.55			3.99	3.79	4.19	3.03	2.55	2.51	2.61	2.50	1.86	2.50	2.03		
12/01/03		3.49	3.85	2.66				3.52	3.82			4.13	4.12	4.51	2.70	2.72	2.72	2.67	2.58	1.63	2.48	2.12		
12/15/03															2.61	2.61	2.54	2.46	2.36	1.80	2.66	2.01		
01/20/04												3.79	3.63	3.92	2.44	2.66	1.70	2.02	2.49	2.01	2.32	2.11		
02/17/04		3.09	2.94									3.89	3.82	3.86	2.80	2.68	2.47	2.49	2.50	2.17	2.66	2.08	2.34	
03/16/04								2.97	3.075			4.59	4.22	3.95	3.67	2.65	2.45	2.62	2.63		2.55	2.06	2.50	1.945

Table 24.2. (Continued) Dissolved organic carbon from August 1999 to January 2004.

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/01/99	0.95																							
09/01/99	3.74																							
10/01/99	0.88																							
11/01/99	1.15																							
12/01/99																								
01/01/00	1.15																							
02/01/00																								
03/01/00	1.56																							
04/01/00	0.56																							
05/01/00	1.70																							
06/01/00	1.48																							
07/01/00	1.13																							
08/01/00	1.98																							
09/01/00	0.95																							
10/01/00	2.61																							
11/01/00	1.88																							
12/01/00	0.88																							
01/01/01	0.77																							
02/01/01	2.57			1.83																				
03/01/01	1.72			1.59	1.99																			
04/01/01	1.56			1.88																				
05/01/01				2.01																				
06/01/01	0.77			1.20																				
07/01/01	19.61			1.72																				
08/01/01				2.14																				
09/01/01	1.06			1.94																				
10/01/01	1.25			3.24																				
11/01/01	0.87			2.85																				
12/01/01				2.38																				
01/01/02	1.01			2.15																				
02/01/02				4.16																				
03/01/02	1.28			1.51																				
04/01/02				1.70																				
05/01/02	1.02			1.63																				
06/01/02	1.45			3.86																				
07/01/02		3.28	3.61			3.59	3.70					3.78	3.77	3.37	3.38	3.01	4.27		3.42		2.23	2.08	3.00	2.69
07/08/02		3.40	3.52			3.43	3.30					3.47	3.20	3.35	3.21	3.08	3.30		3.30		2.92	19.99	3.03	3.01
07/16/02		3.23	4.21			3.43	3.50					2.51	3.24	3.23	3.38		3.13		3.13		1.98	2.21	3.00	2.90
07/22/02		3.32	3.41			3.07	3.21					2.69	3.18	3.51	3.22	2.86	3.27		3.13		1.67	1.63	2.96	2.83
07/29/02		2.94	3.15			3.26	3.21					2.13	3.12	3.03	2.94	2.77	2.91		3.34		2.04	1.87	2.81	2.73
07/30/02																								
08/05/02		3.05	3.15			3.03	3.01					2.40	3.51	3.25	2.98	2.79	3.32				1.42	1.43	3.00	2.63
08/12/02		3.07	3.12			3.23	3.08					2.33	3.25	3.23	3.14	2.88	3.29		3.06		1.48	1.39	3.38	2.81

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/19/02		3.25	3.31			3.29	3.24					2.64	3.40	3.19	3.27	2.98	3.33		4.21		1.42	1.39	2.90	3.81
08/26/02		2.91	2.98			2.99	3.04					2.67	3.01	2.94	2.87	2.56	2.97		2.94		1.34	1.30	3.05	
08/30/02																								
09/03/02		2.89	2.86			2.99	2.97					2.31	2.84	2.94	2.80	2.62	2.97		2.84		1.06	0.96	2.79	2.82
09/10/02		2.94	2.94			3.00	3.03					2.01	2.92	2.57	2.95	2.40	2.47		2.90		0.77	0.81	2.68	2.75
09/16/02		3.03	2.92			3.02	3.06					2.11	3.04	2.94	2.87	2.75	3.02		2.86		0.63	0.66	2.82	2.80
09/23/02		2.99	2.95			3.06	3.01					1.83	3.06	3.02	2.94	2.81	3.00		2.96		0.66	0.64	2.87	2.79
09/30/02	1.51	3.10	3.08			3.06	3.09					2.22	3.08	3.17	2.87	3.03	3.13		2.98		0.69	0.95	3.39	2.78
10/02/02																								
10/07/02		3.27	3.36			3.36	3.13					1.81	3.07	3.18	3.15	3.20	3.17		3.20		0.74	0.64	3.00	2.71
10/14/02		3.06	3.04			3.05	2.95					1.84	3.07	3.11	2.88	2.90	3.14		3.01		1.16	0.81	3.06	2.93
10/16/02																								
10/21/02		3.38	3.15			3.11	3.06					2.51	3.64	3.10	3.08	2.88	3.11		3.08		1.63	1.23	3.09	2.90
10/28/02		2.84	2.24			2.45	2.50					2.00	2.23	2.22	2.42	2.32	2.27		2.17		0.85	0.46	3.40	3.08
10/30/02	1.54																							
11/04/02		2.42	2.80			2.47	2.47					1.57	2.74	2.72	2.38	2.16	2.89		2.71		0.73	0.65	3.35	3.03
11/12/02		2.32	2.11			2.25	2.47					1.56	2.19	2.21	2.36	2.25	2.17		2.22		0.67	0.75	2.69	2.60
11/13/02																								
11/18/02		2.24	2.10			2.22	2.29					2.43	2.24	2.11	2.27	1.86	2.18		2.15		0.77	0.70	2.77	2.56
11/25/02		2.17	2.18			2.17	2.32						2.18	2.12	2.25	1.75	2.22		2.15				2.73	2.82
11/30/02																								
12/09/02		1.88	1.92			1.88	1.93						1.95	1.99	1.89	1.36	1.96		1.89				2.83	2.63
12/16/02		2.05	2.01			2.00	2.10						1.57	2.10	1.97	1.48	2.13		2.02				2.63	2.43
12/17/02																								
12/30/02	0.71																							
01/14/03	0.86			1.13								0.99								2.58	0.67	0.72	2.78	2.58
02/11/03	6.50		2.38	1.57								0.83					2.06			2.69	0.61	0.68	2.67	2.57
03/11/03	5.28		1.94	1.30								0.76					2.29			2.52	0.43	0.55	2.55	2.51
04/15/03	1.07	3.74	2.85	2.66				2.08	1.40			2.92	2.78				3.17			2.46	1.29	1.10	2.98	2.87
05/13/03	1.11	2.63	2.57	3.49				2.14	1.70	3.02	3.40	2.24	2.76		2.58	2.37	2.73			3.10	1.08	0.93	2.72	2.48
06/03/03		3.19	3.25	3.56				2.86	2.00	2.78	2.81	2.60	3.31		3.24	2.75	3.50	16.68		3.57	1.89	1.91	2.71	2.91
06/10/03																								
06/24/03	0.97							3.83	2.88	2.91	2.87	3.96			4.57	3.79				4.62	2.49	2.39	3.22	3.27
07/07/03		3.50	3.40	4.54				2.88	2.19			3.11	3.56		3.39	2.92	3.52			3.96	1.55	1.72	2.95	2.78
07/14/03	1.25	3.73	3.70	4.69								3.28	3.73		3.74	3.31	3.75			4.23	2.04	1.84	3.09	2.87
07/21/03		3.82	3.88	4.33				3.26	2.54			3.68	3.68		3.88	3.50	3.75			4.41	2.33	2.33	3.01	2.87
07/28/03		3.47	3.39	4.35				2.42	2.98			2.69	3.64		3.50	2.47	3.67			3.82	1.53	1.76	3.04	3.00
08/04/03		3.54	3.68	3.80				3.29	2.36			2.64	3.28		3.45	2.84	3.39			3.92	0.91	1.08	3.14	3.13
08/11/03		3.68	3.76	4.53				3.32	2.65			2.68	4.40		3.79	2.88	3.89			4.30	1.37	1.33	3.25	3.05
08/18/03				4.76				4.17	3.26			4.17			4.26	3.37				4.79	1.87	1.79	3.18	3.31
08/25/03	2.26			4.05				3.34	2.72	2.69	2.76	3.00			4.48	3.49				4.86	1.87	1.82	3.92	3.87
09/02/03																								
09/08/03				3.92				3.92	2.99			3.37			4.13	3.17				4.45	2.38	2.47	3.81	3.60
09/15/03																								
09/22/03	1.42			2.83				3.08	2.26			2.63			3.69	2.38				3.65	1.53	1.37	3.13	2.92

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
09/29/03				2.99				2.30	1.84			2.42			3.44	2.25				3.40	1.14	1.21	3.32	2.98
10/06/03				3.59				3.51	2.48			3.56			3.45	2.29				3.41	1.20	1.07	3.14	2.89
10/13/03								3.36	2.44	2.91	2.88	3.02			3.59	2.70				3.78	2.15	1.65	3.12	3.04
10/20/03				3.27				2.38	2.38			2.23			3.79	2.74				3.65	1.11	1.09	2.60	2.71
10/28/03	1.12			3.90				3.25	20.52			2.22			3.74	2.60				3.59	1.09	1.05	2.55	2.64
11/03/03								3.29	2.42			1.89			3.51	2.58				3.31	0.84	0.87	2.72	
11/10/03																								
11/17/03				2.39				2.08	1.96						2.51	2.29							2.46	2.40
12/01/03	0.95			2.84				1.50	1.44						2.46	2.23							2.60	2.36
12/15/03	0.61			2.60				1.96	1.48	2.30	2.39				2.41	2.33							2.82	2.47
01/20/04				2.13						2.41	2.37	1.06									0.56	0.53	2.52	2.31
02/17/04				2.61						2.62	2.59	2.05								2.43	0.78	0.79	2.58	2.45
03/16/04								2.06		2.61	2.65				2.58	2.09				2.57			2.58	2.12

Table 25.1. SUVA ($cm^{-1}*(mg/l)^{-1}$) from August 1999 to January 2004.

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18
08/01/99	0.015	0.014	0.016	0.016	0.016		0.029	0.022	0.026	0.023	0.019	0.019		0.020	0.020	0.017	0.021	0.020	0.020	0.019	0.019	0.019	0.020
09/01/99	0.016	0.015	0.017	0.017	0.016		0.031	0.021	0.023	0.025	0.021	0.019		0.019	0.020	0.016	0.020	0.020	0.022	0.018	0.020	0.017	0.020
10/01/99	0.015	0.013	0.014	0.013	0.014		0.029	0.022	0.023	0.024	0.019	0.017		0.018	0.019	0.014	0.020	0.020	0.020	0.015	0.017	0.016	0.017
11/01/99	0.015	0.014	0.014	0.014	0.014		0.024	0.022	0.023	0.020	0.016	0.016		0.017	0.015	0.014	0.021	0.022	0.021	0.012	0.021	0.016	0.020
12/01/99	0.016	0.015	0.014	0.016	0.015		0.021	0.023	0.026	0.025	0.018	0.018		0.017	0.017	0.015	0.018	0.022	0.025	0.014	0.017	0.018	
01/01/00	0.016	0.015	0.015	0.016	0.016		0.020	0.024	0.024	0.023	0.017	0.017		0.017	0.015	0.016	0.023						0.021
02/01/00	0.016	0.014	0.014	0.016	0.016		0.020	0.022	0.022	0.021	0.016	0.016		0.017	0.016	0.016	0.023	0.017	0.018		0.022		0.019
03/01/00	0.017	0.016	0.016	0.017	0.017	0.017	0.024	0.025	0.025	0.025	0.018	0.017		0.018	0.018	0.016	0.023	0.018	0.019	0.010	0.019	0.015	0.017
04/01/00	0.015	0.015	0.014	0.016	0.017	0.017	0.019	0.022	0.023	0.024	0.019	0.017	0.019	0.019	0.019	0.017	0.019	0.017	0.019		0.019	0.017	0.018
05/01/00	0.016	0.015	0.016	0.016	0.017	0.016	0.031	0.024	0.029	0.029	0.018	0.018	0.018	0.018	0.018	0.017	0.019	0.018	0.017	0.010	0.020	0.015	0.018
06/01/00	0.013	0.011	0.011	0.013	0.013	0.013	0.017	0.014	0.018	0.019	0.015	0.013	0.015	0.015	0.016	0.014	0.015	0.015	0.016	0.009	0.015	0.014	0.015
07/01/00	0.014	0.013	0.014	0.014	0.011	0.013	0.023	0.017	0.024	0.022	0.018	0.018	0.018	0.017	0.019	0.015	0.019	0.018	0.017	0.011	0.017	0.016	0.017
08/01/00	0.013	0.012	0.013	0.014	0.015	0.014	0.017	0.007	0.018	0.020	0.017	0.016	0.015	0.016	0.016	0.013	0.018	0.017	0.017	0.010	0.014	0.015	0.013
09/01/00	0.014	0.013	0.013	0.014	0.014	0.014	0.026	0.020	0.021	0.022	0.018	0.016	0.014	0.016	0.017	0.013	0.018	0.014	0.013	0.010	0.014	0.013	0.016
10/01/00	0.014	0.014	0.013	0.014	0.015	0.014	0.027	0.021	0.022	0.022	0.019	0.018	0.018	0.018	0.018	0.013	0.019	0.017	0.017	0.010	0.017	0.015	0.016
11/01/00	0.018	0.017	0.017	0.016	0.016	0.015	0.025	0.026	0.027	0.028	0.023	0.023	0.023	0.022	0.022	0.018	0.025	0.025	0.022	0.016	0.024	0.020	0.027
12/01/00	0.011	0.010	0.012	0.013	0.011	0.013	0.022	0.019	0.022	0.021	0.013	0.016	0.016	0.016	0.014	0.011	0.020	0.019	0.012	0.014	0.018	0.015	
01/01/01	0.015	0.014	0.014	0.014	0.014	0.014	0.023	0.022	0.022	0.023	0.017	0.017	0.017	0.015	0.015	0.013	0.018						0.017
02/01/01	0.016	0.015	0.015	0.015	0.016	0.015	0.025	0.024	0.025	0.025	0.018	0.018	0.018	0.018	0.016	0.015	0.023	0.025	0.025		0.026		0.019
03/01/01	0.016	0.016	0.015	0.016	0.016	0.016	0.037	0.027	0.026	0.026	0.021	0.018	0.019	0.019	0.019	0.016	0.026	0.020	0.024	0.010	0.021	0.010	0.018
04/01/01	0.015	0.014	0.013	0.013	0.015	0.012	0.026	0.023	0.028	0.026	0.019	0.017	0.019	0.011	0.020	0.016	0.027	0.026	0.025	0.014	0.026		0.021
05/01/01		0.012	0.013	0.013	0.014	0.013	0.021	0.022	0.026	0.018	0.016	0.016	0.016	0.018	0.016	0.014	0.018	0.017	0.018	0.008	0.016		0.014
06/01/01	0.015	0.012	0.016	0.016	0.016	0.016	0.034	0.021	0.027	0.030	0.018	0.016	0.017	0.022	0.019	0.016	0.020	0.019	0.022	0.008	0.019		0.018
07/01/01	0.014	0.013	0.015	0.015	0.015	0.015	0.028	0.021	0.027	0.026	0.018	0.020	0.020	0.020	0.019	0.016	0.019	0.018	0.017	0.012	0.018		0.018
08/01/01	0.013	0.013	0.018	0.019	0.018	0.018	0.039	0.021	0.027	0.031	0.020	0.019	0.022	0.020	0.025	0.017	0.022	0.020	0.021	0.013	0.021		0.021
09/01/01	0.012	0.010	0.014	0.014	0.014	0.013	0.025	0.017	0.025	0.024	0.017	0.015	0.016	0.017	0.018	0.014	0.015	0.016	0.018	0.010	0.013		0.016
10/01/01	0.013	0.012	0.012	0.015	0.014	0.013	0.032	0.018		0.023	0.017	0.017	0.017	0.016	0.017	0.014	0.025	0.021	0.023	0.016	0.021		0.020
11/01/01	0.012	0.011	0.012	0.013	0.013	0.013	0.024	0.019	0.020	0.020	0.015	0.016	0.017	0.017	0.017		0.019	0.020	0.020	0.013	0.020		0.020
12/01/01	0.015	0.014		0.015	0.014	0.014	0.021	0.020			0.018		0.016	0.018	0.008	0.012	0.019	0.018	0.018	0.012	0.019		0.021
01/01/02	0.015	0.014	0.012	0.016	0.015	0.017	0.028	0.020		0.023	0.015	0.017	0.018	0.017	0.018	0.015	0.017	0.018	0.018		0.016		0.018
02/01/02	0.016	0.015	0.015	0.016	0.015	0.016	0.022	0.023	0.023	0.022	0.018		0.018	0.019	0.019	0.015	0.016	0.016	0.018		0.017		0.018
03/01/02	0.013	0.013	0.012	0.015	0.015	0.015	0.021	0.018	0.016	0.024	0.016	0.015	0.015		0.017	0.015	0.018	0.016	0.016	0.012	0.016	0.012	0.015
04/01/02	0.013	0.011	0.012	0.010	0.014	0.013	0.022	0.015	0.015	0.019	0.015	0.015	0.014	0.016	0.016	0.014	0.014	0.014	0.015	0.012	0.015	0.012	0.149
05/01/02	0.013	0.011	0.012	0.012	0.013	0.013	0.022	0.014	0.019	0.018		0.014	0.013	0.016	0.015	0.013	0.016	0.016	0.015	0.012	0.014	0.014	0.014
06/01/02	0.015	0.014	0.011	0.014	0.013	0.015	0.029	0.013	0.020	0.021		0.014	0.013	0.016	0.016	0.014	0.016	0.016	0.018	0.014	0.017	0.014	0.016
07/01/02																0.013	0.015	0.016	0.014	0.013	0.015	0.013	0.012
07/08/02																0.013	0.016	0.015	0.015	0.014	0.016	0.014	0.013
07/16/02		0.010	0.013					0.013	0.019			0.014	0.015	0.015		0.014	0.016	0.015	0.015		0.016		0.014
07/22/02																0.014	0.016	0.014	0.015	0.013		0.011	0.014
07/29/02																0.014	0.015	0.014	0.016	0.013	0.015	0.013	0.016
07/30/02																							
08/05/02																0.014	0.017		0.015	0.008	0.015	0.014	0.015
08/12/02		0.011	0.014					0.010	0.012			0.013	0.013	0.014		0.015	0.019	0.016	0.016	0.015	0.016	0.014	0.013
08/19/02																0.013	0.017	0.015	0.015	0.014	0.015	0.014	0.015

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18
08/26/02																0.013	0.016	0.014	0.014	0.013	0.014	0.013	0.014
08/30/02																							
09/03/02		0.011	0.014					0.013	0.014			0.013	0.013	0.012		0.014	0.013	0.015	0.015	0.014	0.015	0.014	0.015
09/10/02																	0.019	0.018	0.017	0.013	0.017	0.014	0.018
09/16/02		0.010	0.014					0.018	0.021			0.014	0.014	0.017			0.016	0.014	0.014	0.012	0.013	0.011	0.015
09/23/02																	0.017	0.014	0.013	0.011	0.014	0.013	0.015
09/30/02																	0.018	0.015	0.014	0.012	0.015	0.011	0.014
10/02/02		0.011	0.012					0.019	0.016			0.013	0.013	0.013									
10/07/02																	0.017	0.013	0.013	0.012	0.013	0.011	0.015
10/14/02																0.013	0.018	0.014	0.015	0.013	0.015	0.012	0.016
10/16/02		0.010	0.011					0.020	0.012			0.014	0.014	0.012									
10/21/02																0.014	0.020	0.015	0.015	0.013	0.012	0.012	0.019
10/28/02																0.014	0.025	0.020	0.021	0.017	0.020	0.016	0.020
10/30/02		0.012	0.014					0.021	0.022			0.016	0.015	0.012									
11/04/02																0.013	0.022	0.016	0.016	0.013	0.017		0.014
11/12/02																0.014	0.022	0.017	0.016	0.013	0.016		0.018
11/13/02		0.012	0.012					0.017	0.016			0.014	0.013	0.011									
11/18/02																0.014	0.021	0.016	0.015	0.012	0.016		0.014
11/25/02		0.013	0.012					0.021	0.022			0.014	0.014	0.015		0.014	0.024	0.017	0.018	0.013	0.018	0.014	0.017
11/30/02																							
12/09/02																0.014	0.022	0.018	0.018	0.013	0.018		
12/16/02																0.015	0.025	0.022	0.017	0.012	0.017	0.015	
12/17/02		0.014	0.015					0.022	0.026			0.016	0.017	0.017									
12/30/02																							
01/14/03		0.013	0.013					0.020	0.023			0.016	0.016	0.015	0.016	0.014							0.015
02/11/03		0.013	0.012					0.019	0.020			0.014	0.021	0.014	0.014		0.018	0.015	0.019		0.020	0.015	0.015
03/11/03		0.011	0.010					0.030	0.020			0.013	0.012	0.012	0.016		0.024	0.017	0.019		0.019	0.009	0.018
04/15/03		0.013	0.013	0.013				0.032	0.029			0.013	0.013	0.014	0.015	0.013	0.023	0.017	0.018	0.013	0.018	0.013	0.017
05/13/03		0.015	0.015	0.013				0.031	0.032			0.014	0.013	0.017	0.016	0.014	0.032	0.020	0.021	0.016	0.020	0.016	0.025
06/03/03		0.012	0.013	0.013				0.024	0.032			0.013	0.013	0.014	0.014	0.013	0.017	0.015	0.015	0.014	0.015	0.014	0.016
06/10/03																							
06/24/03		0.011	0.011					0.021	0.026			0.011	0.012	0.012			0.018	0.013	0.014	0.013	0.014	0.014	0.019
07/07/03				0.014											0.015	0.013	0.022	0.017	0.017	0.014	0.016	0.014	0.019
07/14/03		0.010	0.012					0.019	0.023			0.012	0.013	0.013		0.013	0.021	0.017	0.017	0.015	0.017	0.015	0.020
07/21/03				0.014											0.016	0.013	0.022	0.018	0.020	0.017	0.020	0.019	0.023
07/28/03				0.015											0.017	0.014	0.020	0.018	0.016	0.013	0.016	0.013	0.018
08/04/03		0.011	0.014	0.014				0.018	0.024			0.015	0.013	0.014	0.016	0.011	0.020	0.014	0.015	0.011	0.014	0.012	0.018
08/11/03				0.016											0.015	0.014	0.022	0.018	0.017	0.014	0.018	0.015	0.019
08/18/03				0.014											0.015	0.011	0.019	0.016	0.015	0.009	0.015	0.013	0.018
08/25/03		0.010	0.013	0.011				0.016	0.027			0.015	0.014	0.016	0.013	0.010	0.015	0.012	0.012	0.008	0.011	0.005	0.013
09/02/03																							
09/08/03		0.011	0.012	0.011				0.016	0.028			0.016	0.015	0.017	0.014	0.010	0.016	0.013	0.013	0.008	0.012	0.005	0.013
09/15/03																							
09/22/03		0.011	0.013	0.017				0.018	0.021			0.017	0.016	0.017	0.019	0.016	0.020	0.016	0.016	0.013	0.016	0.008	0.018
09/29/03															0.017	0.013	0.020	0.014	0.014	0.009	0.014	0.006	0.014

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18
10/06/03		0.009	0.011	0.014				0.019	0.019			0.016	0.015	0.016	0.018	0.013	0.025	0.014	0.015	0.011	0.015	0.006	0.016
10/13/03				0.012											0.017	0.012	0.025	0.014	0.015	0.011	0.015		0.019
10/20/03				0.012											0.025	0.011	0.025	0.019	0.019	0.014	0.019		0.018
10/28/03		0.011	0.011	0.013				0.021	0.027			0.016	0.015	0.015		0.013	0.025	0.019	0.016	0.012	0.020		0.021
11/03/03															0.019	0.015	0.026	0.021	0.020	0.014	0.020	0.010	0.017
11/10/03																							
11/17/03		0.013	0.013	0.015				0.023	0.023			0.018	0.019	0.017	0.019	0.015	0.024	0.017	0.018	0.014	0.017	0.008	
12/01/03		0.013	0.013	0.013				0.022	0.021			0.017	0.018	0.016	0.018	0.014	0.022	0.021	0.020	0.015	0.020	0.010	
12/15/03															0.018	0.014	0.020	0.017	0.025	0.013	0.017	0.008	
01/20/04												0.019	0.019	0.018	0.022	0.015	0.027	0.022	0.016	0.014	0.016	0.008	
02/17/04		0.011	0.011									0.016	0.016	0.016	0.015	0.012	0.019	0.016	0.016	0.007	0.015	0.005	0.016
03/16/04								0.022	0.022			0.016	0.016	0.016	0.017	0.013	0.019	0.014	0.016		0.015	0.005	0.014

Table 25.2. (Continued) SUVA ($cm^{-1}*(mg/l)^{-1}$) from August 1999 to January 2004.

Date	R19	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/01/99	0.016	0.034																							
09/01/99	0.019	0.032																							
10/01/99	0.014	0.023																							
11/01/99		0.014																							
12/01/99																									
01/01/00	0.010	0.014																							
02/01/00	0.015																								
03/01/00	0.015	0.028																							
04/01/00	0.018	0.037																							
05/01/00	0.017	0.014																							
06/01/00	0.013	0.022																							
07/01/00	0.016	0.028																							
08/01/00	0.015	0.033																							
09/01/00	0.012	0.021																							
10/01/00	0.011	0.033																							
11/01/00	0.009	0.015																							
12/01/00		0.019																							
01/01/01	0.013	0.024																							
02/01/01	0.011	0.026			0.024																				
03/01/01	0.009	0.023			0.024	0.023																			
04/01/01	0.019	0.022			0.026																				
05/01/01	0.013				0.017																				
06/01/01	0.017	0.029			0.028																				
07/01/01	0.016				0.023																				
08/01/01	0.020				0.018																				
09/01/01	0.015	0.028			0.021																				
10/01/01	0.016	0.019			0.026																				
11/01/01	0.016	0.019			0.020																				
12/01/01	0.013				0.018																				
01/01/02	0.016	0.023			0.012																				
02/01/02	0.016				0.014																				
03/01/02		0.016			0.018																				
04/01/02	0.012				0.016																				
05/01/02	0.013	0.027			0.018																				
06/01/02	0.015	0.017			0.026																				
07/01/02	0.014		0.014	0.014			0.012	0.014					0.011	0.013	0.015	0.015	0.009	0.011		0.014		0.014	0.008	0.011	0.007
07/08/02	0.012		0.016	0.015			0.015	0.016					0.012	0.016	0.015	0.016	0.009	0.016		0.016		0.011	0.003	0.014	0.007
07/16/02	0.012		0.016	0.012			0.015	0.015					0.015	0.015	0.016	0.015		0.017		0.017		0.014	0.008	0.016	0.007
07/22/02			0.014	0.014			0.015	0.015					0.014	0.015	0.014	0.014	0.009	0.014		0.015		0.015	0.010	0.013	0.009
07/29/02	0.014		0.016	0.014			0.014	0.014					0.016	0.014	0.015	0.016	0.009	0.016		0.013		0.011	0.009	0.015	0.008
07/30/02																									
08/05/02	0.013		0.015	0.015			0.016	0.016					0.015	0.014	0.015	0.016	0.008	0.015				0.014	0.008	0.013	0.008
08/12/02	0.014		0.017	0.017			0.016	0.016					0.016	0.016	0.016	0.016	0.010	0.017		0.017		0.015	0.012	0.013	0.010

Date	R19	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/19/02	0.012		0.016	0.015			0.015	0.015					0.015	0.015	0.016	0.015	0.009	0.015		0.012		0.014	0.012	0.013	0.007
08/26/02	0.013		0.014	0.014			0.014	0.014					0.013	0.014	0.014	0.014	0.009	0.015		0.015		0.013	0.008	0.013	
08/30/02																									
09/03/02	0.010		0.016	0.015			0.015	0.015					0.015	0.017	0.016	0.016	0.009	0.015		0.015		0.014	0.008	0.014	0.010
09/10/02	0.013		0.016	0.016			0.016	0.017					0.017	0.019	0.020	0.016	0.010	0.021		0.019		0.016	0.015	0.015	0.009
09/16/02	0.013		0.014	0.014			0.014	0.014					0.014	0.014	0.014	0.014	0.009	0.014		0.014		0.014	0.007	0.014	0.007
09/23/02	0.012		0.014	0.014			0.014	0.014					0.015	0.014	0.014	0.014	0.009	0.014		0.014		0.014	0.010	0.014	0.007
09/30/02	0.012	0.029	0.014	0.014			0.015	0.015					0.014	0.014	0.014	0.015	0.011	0.014		0.014		0.015	0.009	0.012	0.009
10/02/02																									
10/07/02	0.012		0.013	0.013			0.013	0.014					0.014	0.014	0.013	0.014	0.009	0.013		0.013		0.015	0.011	0.014	0.008
10/14/02	0.013		0.014	0.014			0.015	0.015					0.016	0.014	0.014	0.015	0.010	0.014		0.014		0.015	0.010	0.013	0.008
10/16/02																									
10/21/02	0.015		0.014	0.015			0.014	0.015					0.018	0.012	0.015	0.014	0.009	0.015		0.015		0.017	0.009	0.014	0.008
10/28/02	0.014		0.019	0.022			0.022	0.020					0.019	0.022	0.021	0.021	0.015	0.021		0.023		0.021	0.015	0.013	0.008
10/30/02		0.046																							
11/04/02	0.012		0.017	0.016			0.017	0.018					0.016	0.016	0.016	0.019	0.016	0.016		0.016		0.016	0.010	0.013	0.007
11/12/02			0.017	0.018			0.017	0.017					0.019	0.017	0.018	0.016	0.014	0.018		0.018		0.015	0.008	0.014	0.008
11/13/02																									
11/18/02			0.016	0.017			0.016	0.015					0.016	0.016	0.017	0.016	0.014	0.017		0.016		0.013	0.007	0.013	0.008
11/25/02			0.018	0.018			0.018	0.017						0.018	0.018	0.018	0.009	0.018		0.018				0.014	0.009
11/30/02																									
12/09/02			0.017	0.017			0.018	0.017						0.017	0.017	0.020	0.014	0.017		0.017				0.013	0.009
12/16/02			0.017	0.018			0.018	0.017						0.021	0.017	0.018	0.009	0.017		0.017				0.015	0.010
12/17/02																									
12/30/02		0.028																							
01/14/03	0.013	0.021			0.023								0.017								0.014	0.015	0.010	0.013	0.008
02/11/03		0.042		0.019	0.018								0.014					0.018			0.014	0.010	0.007	0.013	0.008
03/11/03	0.014	0.028		0.021	0.023								0.015					0.019			0.014	0.015	0.016	0.014	0.008
04/15/03	0.016	0.025	0.018	0.017	0.021				0.017	0.008			0.016	0.020				0.016			0.022	0.160	0.010	0.012	0.008
05/13/03	0.022	0.021	0.020	0.021	0.035				0.020	0.009	0.013	0.011	0.024	0.020		0.021	0.017	0.020			0.032	0.020	0.011	0.013	0.009
06/03/03			0.015	0.015	0.025				0.015	0.022	0.014	0.014	0.016	0.015		0.016	0.014	0.015	0.045		0.017	0.016	0.010	0.014	0.008
06/10/03																									
06/24/03	0.015	0.023							0.013	0.005	0.013	0.013	0.014			0.012	0.007				0.017	0.011	0.006	0.011	0.006
07/07/03	0.014		0.016	0.017	0.029				0.016	0.007			0.019	0.017		0.017	0.010	0.017			0.022	0.017	0.008	0.013	0.008
07/14/03	0.015	0.026	0.017	0.017	0.028								0.019	0.017		0.017	0.010	0.017			0.021	0.017	0.010	0.013	0.008
07/21/03	0.021		0.019	0.020	0.028				0.020	0.011			0.023	0.019		0.021	0.014	0.020			0.022	0.021	0.011	0.014	0.009
07/28/03	0.016		0.015	0.015	0.029				0.007	0.015			0.018	0.017		0.015	0.012	0.017			0.020	0.017	0.010	0.015	0.009
08/04/03	0.014		0.015	0.015	0.028				0.015	0.007			0.016	0.014		0.015	0.012	0.015			0.020	0.014	0.009	0.014	0.008
08/11/03	0.017		0.018	0.018	0.028				0.017	0.015			0.020	0.016		0.017	0.013	0.018			0.022	0.019	0.011	0.014	0.009
08/18/03	0.012				0.025				0.016	0.007			0.018			0.015	0.011				0.019	0.015	0.007	0.013	0.007
08/25/03	0.008	0.040			0.019				0.011	0.004	0.015	0.014	0.012			0.011	0.008				0.014	0.007	0.003	0.010	0.005
09/02/03																									
09/08/03	0.009				0.021				0.012	0.004			0.013			0.012	0.008				0.014	0.010	0.006	0.010	0.006
09/15/03																									
09/22/03	0.011	0.022			0.027				0.016	0.007			0.018			0.016	0.011				0.019	0.016	0.011	0.016	0.011

Date	R19	R20	R21	R22	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
09/29/03	0.010				0.025				0.013	0.005			0.015			0.013	0.010				0.016	0.012	0.007	0.013	0.008
10/06/03	0.010				0.026				0.015	0.006			0.017			0.015	0.010				0.017	0.012	0.005	0.013	0.007
10/13/03	0.014								0.016	0.007	0.012	0.012	0.018			0.015	0.012				0.022	0.017	0.008	0.013	0.007
10/20/03	0.015				0.017				0.016	0.008			0.017			0.019	0.014				0.023	0.007	0.013	0.012	0.006
10/28/03	0.014	0.023			0.026				0.020	0.006			0.018			0.018	0.014				0.025	0.014	0.011	0.013	0.007
11/03/03	0.010								0.019	0.009			0.016			0.020	0.015				0.020	0.014	0.008	0.013	
11/10/03																									
11/17/03					0.023				0.019	0.012						0.020	0.013							0.016	0.010
12/01/03		0.026			0.022				0.018	0.012						0.021	0.017							0.014	0.009
12/15/03		0.031			0.022				0.016	0.010	0.015	0.014				0.018	0.014							0.012	0.008
01/20/04					0.025						0.015	0.016	0.020									0.024	0.017	0.015	0.010
02/17/04					0.018						0.011	0.012	0.013								0.021	0.013	0.008	0.012	0.006
03/16/04	0.009				0.021				0.015		0.013	0.013				0.015	0.011				0.014			0.013	0.007

Table 26. Planktonic algae (total organisms/ml) from August 1999 to January 2004.

Date	R1	R2A	R2B	R3	R4	R5	R6A	R6B	R7	R8	R9A	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
08/01/99	147	76	18	18	61	302	522	127	204	44	849	420	208	337	464	258	86		366		171		
09/01/99	41	65	22	15	25	141	352	136	272	42	274	0	135	28	388	252	192		194		186		
10/01/99	75	136	201	150	121	100	128	142	266	72	135	137	122	187	531	359	156		127		366		
11/01/99	115	87	452	1022	612	476	244	425	581	112	1043	474	49	525	503	490	395		539				
12/01/99	350	152	158	332	51	525	95	266	171	73	322		94	157	358	302	712		524				
01/01/00	712	230	157	827	1252	310	316	424	273	143	76	136	495	229	265						272		
02/01/00	87	56	22	130	331	286	46	51	102	7	11	30	19	711	237	394	273		309		877		
03/01/00	382	51	81	236	236	221	26	19	287	8	0	251	115	271	461	194	273		193		216		157
04/01/00	55	56	26	22	40	87	44	29	62	4	4	23	381	38	164	243	394		531		73		26
05/01/00	92	22	35	75	87	59	7	22	171	18	34	91	238	150	288	227	460		330		237		
06/01/00	257	44	40	51	164	619	243	93	215	18	108	229	317	80	307	330	763		446		440		92
07/01/00	167	337	48	22	178	391	323	42	329	313	1518	5201	237	237	503	482	358		266		301		49
08/01/00	141	488	252	113	143	251	81	65	308	45	148	55	191	218	229	159	992		920		274		179
09/01/00	164	532	337	273	229	365	115	98	193	66	171	178	136	108	193	136	271		431		193		130
10/01/00	1267	288	202	295	274	468	432	806	734	346	706	1246	151	166	497	497	108		223		158		684
11/01/00	612	122	295	418	151	562	1303	799	648	670	403	583	323	252	432	814	648		346		310		0
12/01/00	418	1123	382	302	425	619	1678	245	302	475	878	1267	65	547	446	367	259		2938				
01/01/01	317	972	475	526	281	446	482	396	331	526	482	533	115	202	626						252		14
02/01/01	490	482	324	562	828	216	446	187	389	144	29	101	158	576	389	245	490		418		864		144
03/01/01	173	43	29	180	101	36	65	72	115	14	22	7	137	1080	108	418	180		72		367		144
04/01/01	288	58	22	144	202	317	36	655	130	58	58	36	202	425	295	317	598		130		425		166
05/01/01		86	43	605	137	268	283	137	165	129	770	57	454	331	274	274	324		36		404		201
06/01/01	129	14	7	29	144	187	734	14	173	57	1137	72	360	173	547	648	533		677		663		
07/01/01	201	21	35	35	100	375	474	86	144	331	1731	118	100	122	360	259	274		244		476		
08/01/01																							
09/01/01	116	50	86	72	57	245	35	22	230	43	166	14	259	50	533	749	417		792		360		
10/01/01	115	144	129	36	201	187			172	5919	100	57	159	446	533	403	259		302		360		
11/01/01	137	7	43	122	7	65	36	7	58	115	173	187	144		252	58	58		403		151		14
12/01/01	115	50		151	43	65	50		94	43	281	274	22	36	655	482	130		562		302		14
01/01/02	338	58	72	115	130	65	288		288	72	137	158	446	43	461	324	137		1080		1087		
02/01/02	346	310	130	295	310	101	43	58	130	806	115	58	209	425	742	158	94		518		223		
03/01/02																							
04/01/02																							
05/01/02																							
06/01/02																							
07/01/02																							
07/08/02																							
07/16/02																							
07/22/02																							
07/29/02																							
08/05/02																							
08/12/02																							
08/19/02																							
08/26/02																							

Table 27. Planktonic diatoms (organisms/ml) from August 1999 to January 2004.

Date	R1	R2A	R2B	R3	R4	R5	R6A	R6B	R7	R8	R9A	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
08/01/99	135	76	0	18	54	195	493	91	189	19	777	297	165	302	402	229	0		366		164		
09/01/99	22	61	15	7	7	63	317	115	222	28	137		128	28	352	245	178		158		172		
10/01/99	68	94	136	78	100	86	93	107	180	7	57	86	108	158	481	345	142		120		338		
11/01/99	79	57	309	1022	569	368	186	360	503	36	1000	438	41	504	489	483	395		474				
12/01/99	346	148	137	328	51	511	91	266	171	62	301		90	153	337	295	648		517				
01/01/00	705	223	143	820	1245	303	295	417	266	122	72	108	474	229	265						258		
02/01/00	87	48	22	130	331	257	34	37	102	0	4	22	19	711	230	387	273		309		870		
03/01/00	382	47	62	215	208	164	15	11	266	8	0	251	108	271	403	166	273		186		188		143
04/01/00	44	44	26	11	25	55	0	11	58	4	4	23	374	30	157	236	387		517		69		26
05/01/00	81	18	27	75	87	41	7	8	171	18	26	91	231	136	281	227	460		330		237		
06/01/00	78	18	0	44	129	166	201	57	201	14	101	201	259	62	300	330	735		432		440		78
07/01/00	22	273	44	18	152	355	129	28	301	247	1094	5030	230	237	503	482	337		259		301		49
08/01/00	51	424	223	63	129	179	40	39	128	33	65	19	187	199	229	138	985		906		245		136
09/01/00	100	475	302	216	222	344	58	72	193	55	71	93	136	65	193	129	192		388		100		94
10/01/00	1152	274	180	166	216	425	346	720	677	216	590	1238	137	108	338	418	94		173		115		648
11/01/00	324	115	274	223	50	562	1296	792	468	468	158	482	223	216	79	706	641		338		266		0
12/01/00	389	1116	317	288	425	619	1656	245	302	446	871	1267	65	533	446	353	238		2938				
01/01/01	144	432	389	281	101	439	324	259	317	526	475	526	108	101	626						216		14
02/01/01	310	101	86	497	511	202	439	187	374	65	0	29	130	274	374	238	490		418		482		130
03/01/01	151	21	22	151	101	29	36	72	108	7	7	0	115	1080	108	396	180		65		367		144
04/01/01	259	7	22	144	202	317	36	648	130	50	0	36	202	410	295	317	598		130		425		166
05/01/01		79	43	605	137	216	158	108	158	115	727	50	432	302	274	274	317		36		382		158
06/01/01	86	7	0	29	43	173	720	0	144	43	1123	72	360	130	518	634	490		619		634		
07/01/01	158	14	21	21	93	317	446	72	130	288	1397	101	72	108	331	259	245		230		418		
08/01/01																							
09/01/01	58	36	72	58	43	245	14	22	187	22	101	14	245	50	504	720	374		749		331		
10/01/01	58	86	115	29	187	187			158	101	72	43	130	432	504	389	245		288		302		
11/01/01	122	0	14	122	0	58	14	0	50	94	173	187	122		238	50	58		403		151		14
12/01/01	94	43		151	36	65	43		86	14	259	259	14	14	655	482	115		562		302		14
01/01/02	338	36	65	115	130	58	274		281	72	101	122	439	43	461	324	137		1080		1080		
02/01/02	331	310	130	295	302	101	29	58	130	792	36	22	180	425	742	108	72		511		223		
03/01/02																							
04/01/02																							
05/01/02																							
06/01/02																							
07/01/02																							
07/08/02																							
07/16/02																							
07/22/02																							
07/29/02																							
08/05/02																							
08/12/02																							
08/19/02																							
08/26/02																							

Table 28. Planktonic green algae (organisms/ml) from August 1999 to January 2004.

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R5dup	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
08/01/99	0	0	18	0	0		21		4	4	4	0	29		29	0	14	7	0	0		0		0		
09/01/99	0	0	0	0	7		14		14	0	14	0	65			0	0	0	0	0		7		0		
10/01/99	0	14	7	0	14		0		14	14	43	36	35		0	7	0	0	0	0		0		0		
11/01/99	0	4	14	0	29		36		0	14	28	0	7		14	4	0	7	7	0		0				
12/01/99	0	0	21	4	0		0		4	0	0	0	7			0	0	7	0	7		0				
01/01/00	0	7	7	0	7		7		14	7	0	14	4		21	14	0	0						0		
02/01/00	0	8	0	0	0		0		12	7	0	0	7		4	0	0	7	7	0		0		0		
03/01/00	0	0	11	0	0		7		0	8	7	0	0		0	0	0	0	7	0		0		14		0
04/01/00	0	8	0	0	4		0		40	7	0	0	0		0	7	0	0	7	0		0		0		0
05/01/00	11	4	8	0	0		0		0	0	0	0	0		0	0	0	0	0	0		0		0		
06/01/00	93	0	0	0	7		0		21	7	0	0	0		7	0	0	0	0	7		0		0		0
07/01/00	36	7	4	0	11		0		14	0	7	4	122		0	0	0	0	0	0		0		0		0
08/01/00	29	14	7	0	0		7		19	8	0	4	36		0	0	4	0	0	0		0		0		7
09/01/00	14	21	14	14	0		7		36	11	0	0	50		57	0	0	0	7	0		7		7		0
10/01/00	115	14	0	29	50		0		0	0	0	0	22		0	0	22	0	0	7		0		0		0
11/01/00	22	0	22	22	14		0		0	7	22	7	0		22	7	0	0	0	0		0		7		0
12/01/00	7	7	0	14	0		0		14	0	0	7	7		0	0	0	0	0	0		0				
01/01/01	7	7	7	0	0		7		43	36	14	0	7		7	7	94	0						0		0
02/01/01	0	7	7	29	0		0		7	0	14	22	29		72	7	7	14	0	0		0		0		0
03/01/01	14	7	0	0	0		0		14	0	0	0	14		7	7	0	0	0	0		0		0		0
04/01/01	7	29	0	0	0		0		0	0	0	0	50		0	0	0	0	0	0		0		0		0
05/01/01		0	0	0	0		0		79	7	7	7	14		0	22	0	0	0	0		0		0		0
06/01/01	0	7	7	0	0		0		14	7	0	0	14		0	0	0	0	0	0		0		0		
07/01/01	29	0	0	0	0		0		14	0	14	0	158		0	0	0	0	0	0		0		0		
08/01/01																										
09/01/01	29	7	0	0	0		0		7	0	0	7	22		0	0	0	0	0	0		0		0		
10/01/01	43	58	0	0	14		0				0	5818	14		0	22	14	0	0	0		0		0		
11/01/01	14	0	7	0	0		7		14	0	7	0	0		0	22		14	0	0		0		0		0
12/01/01	7	7		0	0		0		7		7	22	22		14	7	0	0	0	0		0		0		0
01/01/02	0	22	7	0	0		7		14		7	0	14		22	0	0	0	0	0		0		7		
02/01/02	7	0	0	0	7		0		14	0	0	0	79		36	22	0	0	43	22		7		0		
03/01/02																										
04/01/02																										
05/01/02																										
06/01/02																										
07/01/02																										
07/08/02																										
07/16/02																										
07/22/02																										
07/29/02																										
08/05/02																										
08/12/02																										
08/19/02																										
08/26/02																										

Table 29. Planktonic blue-green algae (organisms/ml) from August 1999 to January 2004.

Date	R1	R2A	R2B	R3	R4	R5	R6A	R6B	R7	R8	R9A	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
08/01/99	8	0	0	0	7	79	25	92	7	25	36	87	43	21	58	29	86		0		7		
09/01/99	19	4	7	8	11	64	14	21	36	14	72		7	0	36	7	14		29		14		
10/01/99	7	28	58	72	7	14	21	21	43	29	43	51	7	29	50	14	14		7		28		
11/01/99	36	26	129	0	14	72	58	51	50	76	36	22	4	21	7	0	0		65				
12/01/99	4	4	0	0	0	14	0	0	0	11	14		4	4	14	7	58		7				
01/01/00	0	0	7	7	0	0	7	0	7	7	0	7	7	0	0						14		
02/01/00	0	0	0	0	0	0	0	7	0	0	0	4	0	0	0	0	0		0		7		
03/01/00	0	4	8	21	28	43	11	0	14	0	0	0	7	0	58	21	0		7		14		14
04/01/00	11	4	0	11	11	32	4	11	4	0	0	0	0	8	7	0	7		14		4		0
05/01/00	0	0	0	0	0	18	0	14	0	0	4	0	0	14	7	0	0		0		0		
06/01/00	86	18	36	7	14	439	14	29	14	4	7	21	58	18	7	0	21		14		0		14
07/01/00	26	50	0	4	15	29	144	14	21	8	252	157	7	0	0	0	14		7		0		0
08/01/00	50	50	22	50	14	65	22	18	180	8	47	36	4	15	0	21	7		14		29		36
09/01/00	36	36	21	43	7	14	21	15	0	11	50	28	0	43	0	0	79		36		79		36
10/01/00	0	0	14	101	7	43	86	86	58	130	50	7	14	36	22	79	7		50		43		36
11/01/00	58	7	0	36	0	0	7	0	158	194	245	79	94	29	353	108	7		7		36		0
12/01/00	22	0	65	0	0	0	0	0	0	7	0	0	0	14	0	14	22		0				
01/01/01	0	14	79	14	0	0	65	86	0	0	0	0	0	7	0	0	0		0		36		0
02/01/01	7	0	0	0	0	0	0	0	0	0	0	0	22	7	7	7	0		0		0		14
03/01/01	7	7	7	22	0	7	14	0	7	7	0	0	14	0	0	22	0		7		0		0
04/01/01	22	22	0	0	0	0	0	7	0	7	7	0	0	14	0	0	0		0		0		0
05/01/01		0	0	7	0	22	36	22	0	7	29	7	0	29	0	0	7		0		22		43
06/01/01	43	0	0	14	101	14	14	7	29	14	0	0	0	43	29	14	43		58		29		
07/01/01	14	7	14	14	7	58	14	0	0	43	158	7	14	14	29	0	29		14		58		
08/01/01																							
09/01/01	29	0	14	14	14	0	14	0	29	14	43	0	14	0	29	29	43		43		29		
10/01/01	14	0	0	7	0	0			14	0	14	14	7	0	29	14	14		14		58		
11/01/01	0	0	0	0	0	0	0	0	7	0	0	0	22		14	7	0		0		14		0
12/01/01	14	0		0	7	0	0		0	7	0	0	0	22	0	0	14		0		0		
01/01/02	0	0	0	0	0	0	0		0	0	14	14	7	0	0	0	0		0		0		
02/01/02	7	0	0	0	0	0	0	0	0	14	0	0	7	0	0	7	0		0		0		
03/01/02																							
04/01/02																							
05/01/02																							
06/01/02																							
07/01/02																							
07/08/02																							
07/16/02																							
07/22/02																							
07/29/02																							
08/05/02																							
08/12/02																							

Table 30.1. Dissolved organic nitrogen (mg-N/l) from August 1999 to January 2004.

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/01/99																								
09/01/99																								
10/01/99																								
11/01/99																								
12/01/99																								
01/01/00																								
02/01/00																								
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07/01/01																								
08/01/01																								
09/01/01																								
10/01/01																								
11/01/01																								
12/01/01																								
01/01/02																								
02/01/02																								
03/01/02	0.08	0.14	0.2	0.11	0.09	0.091	0.08	0.1	0.12	0.11	0.22	0.2	0.155		0.18	0.12	0.15	0.05	0.13	0.16	0.1	0.15	0.06	
04/01/02	0.08		0.12	0.12	0.1	0.101	0.09	0.08	0.04	0.08	0.14	0.21	0.205	0.19	0.11	0.1	0.18	0.14	0.15	0.11	0.16	0.15	0.18	0.1
05/01/02	0.04	0.18	0.13	0.09	0.06	0.029	0.02	0.06	0.07	0.06		0.22	0.162	0.15	0.13	0.07	0.16	0.12	0.13	0.02	0.09	0.05	0.07	0
06/01/02	0.12	0.06	0.27	0.18	0.11	0.125	0.03	0.06	0.04	0.06		0.17	0.201	0.14	0.16	0.13	0.12	0.15	0.17	0.09	0.14	0.04	0.14	0.09
07/01/02																0.15	0.16	0.15	0.12	0.12	0.08	0.15	0.14	0.11
07/08/02																0.18	0.17	0.2	0.22	0.2	0.19	0.19	0.23	0.19
07/16/02		0.22	0.1					0.15	0.11			0.23	0.248	0.2		0.13	0.14	0.13	0.17	0.1	0.13	0.06	0.11	0.07
07/22/02																0.17	0.21	0.2	0.19	0.17	0.27	0.14	0.16	0.16
07/29/02																0.2	0.17	0.18	0.22	0.17	0.21	0.17	0.19	0.17
07/30/02																								
08/05/02																0.15	0.16	0.15	0.18	0.14	0.19	0.12	0.15	0.13
08/12/02		0.35	0.38					0.17	0.5			0.24	0.286	0.36		0.14	0.19	0.14	0.16	0.12	0.15	0.09	0.17	0.13
08/19/02																0.18	0.18	0.21	0.21	0.17	0.18	0.15	0.22	0.22

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/26/02																0.12	0.1	0.22	0.16	0.11	0.12	0.04	0.15	0.08
08/30/02																								
09/03/02		0.28	0.28					0.32	0.31			0.34	0.361	0.55		0.13	0.14	0.24	0.17	0.11	0.15	0.14	0.21	0.16
09/10/02																	0.23	0.22	0.2	0.13	0.2	0.16	0.15	0.11
09/16/02		0.34	0.21					0.09	0.12			0.2	0.212	0.26			0.13	0.17	0.2	0.13	0.08	0	0.08	0.05
09/23/02																	0.14	0.14	0.38	0.11	0.2	0.1	0.16	0.13
09/30/02																	0.11	0.11	0.13	0.08	0.13	0.08	0.11	0.1
10/02/02		0.21	0.23					0.15	0.14			0.28	0.303	0.26										
10/07/02																	0.11	0.12	0.13	0.06	0.21	0.18	0.13	0.09
10/14/02																0.12	0.11	0.13	0.14	0.09	0.16	0.11	0.09	0.04
10/16/02		0.27	0.38					0.2	0.35			0.31	0.326	0.49										
10/21/02																0.17	0.15	0.17	0.2	0.15	0.17	0.13	0.15	0.12
10/28/02																0.18	0.13	0.16	0.17	0.13	0.18	0.11	0.15	0.08
10/30/02		0.29	0.34					0.24	0.23			0.26	0.375	0.53										
11/04/02																0.21	0.13	0.22	0.17	0.11	0.17		0.19	0.14
11/12/02																0.17	0.13	0.15	0.18	0.1	0.15		0.16	
11/13/02		0.26	0.31					0.24	0.19			0.24	0.302	0.33										
11/18/02																0.1	0.05	0.08	0.08	0.04	0.02		0.09	
11/25/02		0.21	0.27					0.08	0.1			0.25	0.206	0.15		0.15	0.08	0.1	0.11	0.05	0.11	0.04	0.12	
11/30/02																								
12/09/02																0.16	0.09	0.14	0.12	0.08	0.12			
12/16/02																0.16	0.09	0.11	0.14	0.08	0.14	0.1		
12/17/02		0.23	0.21					0.17	0.14			0.24	0.25	0.29										
12/30/02																								
01/14/03		0.19	0.2					0.12	0.15			0.22	0.216	0.18	0.17	0.16							0.11	0.09
02/11/03		0.16	0.15					0.09	0.02			0.19	0.19	0.2	0.13		0.03	0.1	0.06		0.1	0.06	0.07	
03/11/03		0.17	0.18					0.2	0.11			0.22	0.265	0.27	0.21		0.11	0.16	0.14		0.16	0.09	0.08	0.08
04/15/03		0.29	0.18	0.13				0.2	0.12			0.21	0.229	0.21	0.21	0.13	0.12	0.14	0.21	0.56	0.15	0.09	0.16	0.14
05/13/03		0.26	0.18	0.27				0.24	0.24			0.25	0.308	0.24	0.25	0.18	0.19	0.17	0.17	0.14	0.18	0.17	0.18	0.17
06/03/03		0.25	0.2	0.18				0.28	0.2			0.25	0.253	0.23	0.23	0.16	0.22	0.22	0.2	0.19	0.19	0.16	0.19	0.22
06/10/03																0.16	0.16	0.17	0.17	0.2	0.21	0.17	0.2	0.19
06/24/03		0.37	0.43	0.14				0.4	0.3			0.48	0.35	0.5	0.23	0.2	0.19	0.19	0.18	0.18	0.18	0.19	0.19	0.18
07/07/03				0.19											0.24	0.2	0.21	0.21	0.22	0.19	0.2	0.18	0.24	0.2
07/14/03		0.45	0.49					0.37	0.59			0.66	0.477	0.62		0.18	0.2	0.2	0.27	0.23	0.23	0.23	0.23	0.17
07/21/03				0.2											0.24	0.21	0.21	0.16	0.21	0.19	0.23	0.17	0.23	0.17
07/28/03				0.12											0.2	0.19	0.22	0.19	0.17	0.12	0.13	0.11	0.17	0.12
08/04/03		0.42	0.44	0.25				0.35	0.46			0.42	0.371	0.59	0.23	0.19	0.24	0.22	0.21	0.15	0.27	0.17	0.26	0.22
08/11/03				0.26											0.31	0.16	0.22	0.22	0.32	0.19	0.21	0.21	0.23	0.22
08/18/03				0.13											0.26	0.21	0.22	0.22	0.2	0.17	0.15	0.18	0.19	0.18
08/25/03		0.3	0.27	0.2				0.23	0.33			0.31	0.35	0.37	0.26	0.2	0.2	0.21	0.24	0.16	0.16	0.11	0.23	0.19
09/02/03																								
09/08/03		0.33	0.44	0.2				0.26	0.25			0.35	0.313	0.34	0.26	0.22	0.21	0.22	0.21	0.18	0.15	0.19	0.23	0.19
09/15/03																								
09/22/03		0.34	0.37	0.28				0.26	0.48			0.38	0.325	0.38	0.28	0.23	0.23	0.22	0.21	0.23	0.2	0.13	0.2	0.14
09/29/03															0.29	0.21	0.19	0.12	0.19	0.18	0.14	0.11	0.32	0.16

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
10/06/03		0.3	0.4	0.23				0.27	0.31			0.38	0.363	0.37	0.26	0.21	0.18	0.23	0.21	0.18	0.22	0.16	0.22	0.14
10/13/03				0.21											0.23	0.27	0.2	0.22	0.27	0.22	0.26		0.22	0.14
10/20/03				0.25											0.25	0.25	0.21	0.23	0.24	0.22	0.25		0.22	0.2
10/28/03		0.28		0.09				0.28				0.31	0.349	0.46		0.2	0.21	0.17	0.22	0.15	0.19		0.2	0.1
11/03/03															0.11	0.16	0.2	0.22	0.23	0.13	0.21	0.13	0.12	0.13
11/10/03																								
11/17/03		0.22	0.36	0.11				0.22	0.23			0.28	0.272	0.33	0.19	0.19	0.15	0.17	0.21	0.14	0.12	0.09		
12/01/03				0.18											0.15	0.19	0.17	0.17	0.15	0.12	0.16	0.1		
12/15/03															0.15	0.14	0.14	0.14	0.12	0.1	0.14	0.13		
01/20/04												0.21	0.192	0.29	0.15	0.13	0.13	0.03	0.13	0.08	0.04	0.04		
02/17/04																								
03/16/04																								

Table 30.2. (Continued) Dissolved organic nitrogen (mg-N/l) from August 1999 to January 2004.

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Hwy 87	Mesa	Pima	Scotts	NP In	NP Out	Green In	Green Out	Hav. 1	Hav. 2	HTC	Roosvelt	SOCA	SPT In	SPT Out	UH In	UH Out
08/01/99																								
09/01/99																								
10/01/99																								
11/01/99																								
12/01/99																								
01/01/00																								
02/01/00																								
03/01/00																								
04/01/00																								
05/01/00																								
06/01/00																								
07/01/00																								
08/01/00																								
09/01/00																								
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11/01/00																								
12/01/00																								
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08/01/01																								
09/01/01																								
10/01/01																								
11/01/01																								
12/01/01																								
01/01/02																								
02/01/02	0.092																							
03/01/02				0.11																				
04/01/02	0.047			0.1	0.37																			
05/01/02				0.06																				
06/01/02	0.037			0.21																				
07/01/02		0.14	0.11				0.213	0.166	0.15	0.145	0.124	0.123	0.16					0.14			0.088	0.062	0.209	0.124
07/08/02		0.22	0.23			0.253	0.19	0.231	0.241	0.243	0.238	0.218	0.134					0.23			0.236	0.288	0.237	0.196
07/16/02		0.14	0.17			0.176	0.119	0.146	0.143	0.158	0.144	0.138	0.117					0.05			0.038	0.007	0.133	0.081
07/22/02		0.18	0.2			0.21	0.217	0.176	0.189	0.21	0.195	0.158	0.094					0.02			-0.141	-0.05	0.212	0.139
07/29/02		0.22	0.2			0.212	0.208	0.187	0.186	0.197	0.192	0.197	0.155					0.13			0.063	0.054	0.18	0.14
07/30/02																								
08/05/02		0.17	0.17			0.161	0.171	0.18	0.153	0.157	0.165	0.153	0.109					0.1			-0.062	-0.106	0.163	0.1
08/12/02		0.16	0.16			0.163	0.133	0.175	0.18	0.185	0.146	0.15	0.098					-0.26			-0.18	-0.147	0.109	0.094

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Hwy 87	Mesa	Pima	Scotts	NP In	NP Out	Green In	Green Out	Hav. 1	Hav. 2	HTC	Roosvelt	SOCA	SPT In	SPT Out	UH In	UH Out
08/19/02		0.23	0.17			0.236	0.22	0.26	0.21	0.2	0.204	0.218	0.154					0.18			0.059	-0.012	0.141	0.151
08/26/02		0.15	0.15			0.134	0.145	0.145	0.142	0.158	0.133	0.184	0.085					0.11			-0.187	-0.189	0.088	0.054
08/30/02																								
09/03/02		0.16	0.15			0.221	0.139	0.153	0.171	0.166	0.143	0.191	0.144					0.11			0.022	-0.046	0.103	0.093
09/10/02		0.21	0.22			0.246	0.271	0.212	0.192	0.178	0.2	0.172	0.193					0.26			0.674	0.444	0.216	0.103
09/16/02		0.08	0.18			0.073	0.12	0.178	0.178	0.163	0.191	0.132	0.112					0.17			0.152	0.146	0.097	0.083
09/23/02		0.16	0.14			0.157	0.142	0.157	0.169	0.155	0.137	0.211	0.161					0.08			0.352	0.335	0.158	0.119
09/30/02	0.101	0.15	0.15			0.147	0.146	0.126	0.182	0.187	0.2	0.128	0.097					0.12			-0.287	-0.194	0.104	0.061
10/02/02																								
10/07/02		0.08	0.12			3.715	0.21	0.085	0.118	0.117	0.123	0.121	0.101					0.07			0.046	0.07	0.119	0.066
10/14/02		0.14	0.09			0.134	0.116	0.151	0.118	0.105	0.086	0.151	0.104					0.1			-0.058	-0.107	0.097	0.044
10/16/02																								
10/21/02		0.19	0.2			0.204	0.185	0.187	0.181	0.206	0.196	0.173	0.137					0.13			0.035	0.002	0.189	0.131
10/28/02		0.19	0.17			0.195	0.174	0.16	0.157	0.167	0.166	0.169	0.203					0.09			-0.063	-0.114	0.202	0.13
10/30/02	0.121																							
11/04/02		0.18	0.18			0.172	0.172	0.175	0.172	0.185	0.186	0.153	0.131					0.07			0.012	-0.045	0.209	0.137
11/12/02		0.15	0.15			0.168	0.178	0.139	0.145	0.154	0.153	0.177	0.155					0.14			-0.005	0.044	0.169	0.13
11/13/02																								
11/18/02		0.11	0.07			0.072	0.084	0.093	0.079	0.082	0.073	0.111	0.059					0.12					0.102	0.049
11/25/02		0.12	0.11			0.083	0.13	0.103	0.12	0.115	0.113	0.124	0.021										0.098	0.082
11/30/02																								
12/09/02		0.13	0.13			0.093	0.134	0.116	0.122	0.126	0.123	0.115	0.072										0.181	0.106
12/16/02		0.14	0.14			0.135	0.144	0.117	0.133	0.145	0.149	0.13	0.039										0.172	0.097
12/17/02																								
12/30/02	0.034																							
01/14/03	0.026			0.09																0.176			0.149	0.098
02/11/03	0.154		0.12	0.03						0.029								0.07		0.14	0.069	0.142	0.086	0.073
03/11/03	0.131		0.13	0.1						0.173								0.07		0.131	0.075	0.076	0.141	0.103
04/15/03	0.116	0.48	0.12	0.11				0.143		0.229								0.14		0.117	0.025		0.118	0.058
05/13/03	0.124	0.19	0.19	0.18				0.178		0.197		0.174	0.14		0.06	0.198	0.199	0.04		0.204			0.241	0.126
06/03/03		0.18	0.2	0.2				0.195		0.237		0.189	0.156	0.182	0.105	0.141	0.17	0.14	0.922	0.197	0.103	0.059	0.168	0.141
06/10/03		0.23	0.18					0.177		0.17		0.213	0.175	0.128	0.146			0.17		0.198	0.178	0.151	0.121	0.116
06/24/03	0.076	0.19	0.17	0.18				0.162		0.331		0.216	0.168	0.176	0.131	0.18	0.151	0.15		0.204	0.141	0.11	0.135	0.149
07/07/03		0.22	0.2	0.22				0.215		0.215		0.191	0.16	0.162	0.112			0.18		0.196	0.122	0.075	0.183	0.14
07/14/03	0.095	0.21	0.18	0.17				0.203		0.206		0.206	0.205					0.18		0.209	0.087	0.069	0.174	0.131
07/21/03		0.18	0.22	0.2				0.231		0.208		0.172	0.155	0.122	0.106			0.18		0.33	0.095	0.102	0.229	0.125
07/28/03		0.16	0.17	0.17				0.192		0.182		0.183	0.122	0.105	0.183			0.1		0.166	0.1	0.172	0.145	0.146
08/04/03		0.23	0.28	0.19				0.228		0.225		0.21	0.183	0.253	0.149			0.15	0.94	0.176	-0.061	0.067	0.224	0.162
08/11/03		0.25	0.21	0.2				0.244		0.26		0.218	0.207	0.222	0.144			0.12		0.265	0.09	0.105	0.235	0.184
08/18/03				0.2								0.217	0.191	0.183	0.084			0.23		0.212	0.076	-0.013	0.215	0.177
08/25/03	0.124			0.16								0.24	0.192	0.061	0.072	0.179	0.182	0.01		0.204	0.047	0.019	0.203	0.169
09/02/03																								
09/08/03				0.16								0.188	0.137	0.145	0.085			0.11		0.262	0.026	0.006	0.193	0.171
09/15/03																								
09/22/03	0.186			0.11								0.544	0.182	0.064	0.093			0.07		0.199	0.019		0.193	0.197

Date	R20	R21	R22	R25	R26	16th St.	19th Av.	Hwy 87	Mesa	Pima	Scotts	NP In	NP Out	Green In	Green Out	Hav. 1	Hav. 2	HTC	Roosvelt	SOCA	SPT In	SPT Out	UH In	UH Out
09/29/03				0.16								0.146	0.128	0.053	0.152			0.13		0.195	0.134	0.054	0.141	0.201
10/06/03				0.17								0.236	0.089	0.179	0.112			0.25		0.217	0.122	0.099	0.239	0.177
10/13/03												0.235	0.076	0.233	0.172	0.23	0.253	0.22		0.192	0.24	0.153	0.272	0.242
10/20/03				0.27								0.252	0.177	0.182	0.158			0.16		0.201	0.353	0.503	0.222	0.222
10/28/03	0.102			0.16								0.215	0.165	0.115				0.07		0.19	0.05		0.153	0.194
11/03/03												0.158	0.185	0.164	0.044					0.24	0.136	0.353	0.171	
11/10/03																								
11/17/03				0.17								0.136	0.193	0.111	0.103								0.153	0.147
12/01/03				0.15								0.213	0.182	0.336	0.235								0.207	0.107
12/15/03	0.069			0.16								0.151	0.098	0.068	0.035	0.13	0.103						0.133	0.111
01/20/04				0.14												0.115	0.139	0.03					0.086	0.086
02/17/04																								
03/16/04																								

Table 31.1. Nitrate (mg-N/l) from August 1999 to January 2004.

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/01/99																								
09/01/99																								
10/01/99																								
11/01/99																								
12/01/99																								
01/01/00																								
02/01/00																								
03/01/00																								
04/01/00																								
05/01/00																								
06/01/00																								
07/01/00																								
08/01/00																								
09/01/00																								
10/01/00																								
11/01/00																								
12/01/00																								
01/01/01																								
02/01/01																								
03/01/01	0.255	0.145	0.109	0.292	0.280	0.284	0.054	0.000	0.013	0.011	0.110	0.017	0.011	0.095	0.000	0.286	0.000	0.109	0.343		0.699		0.262	
04/01/01	0.229	0.000	0.188	0.205	0.231	0.223	0.000	0.000	0.064	0.073	0.025	0.000	0.000	0.082	0.000	0.207	0.000	0.000	0.069		0.416		0.136	
05/01/01		0.000	0.235	0.133	0.118	0.121	0.034	0.000	0.000	0.053	0.011	0.000	0.000	0.082	0.000	0.130	0.000	0.031	0.052		0.367		0.044	
06/01/01																								
07/01/01																								
08/01/01																								
09/01/01																								
10/01/01																								
11/01/01																								
12/01/01																								
01/01/02																								
02/01/02	0.277	0.186	0.100	0.246	0.548	0.301	0.000	0.061	0.084	0.049	0.095	0.011	0.018	0.055	0.000	0.215	0.000	0.100	0.095		0.038		0.059	0.080
03/01/02	0.296	0.095	0.080	0.264	0.286	0.293	0.000	0.000	0.076	0.046	0.000	0.000	0.042		0.000	0.251	0.000	0.242	0.204	0.182	0.411	0.484	0.234	
04/01/02	0.263	0.193	0.108	0.200	0.260	0.256	0.000	0.000	0.077	0.079	0.000	0.000	0.000	0.000	0.000	0.244	0.000	0.050	0.079	0.086	0.359	0.379	0.096	0.141
05/01/02	0.233	0.013	0.146	0.176	0.224	0.222	0.015	0.000	0.082	0.066		0.000	0.024	0.036	0.022	0.227	0.024	0.068	0.040	0.055	0.042	0.053	0.097	0.097
06/01/02	0.122	0.117	0.006	0.130	0.125	0.119	0.028	0.036	0.018	0.029		0.008	0.014	0.011	0.006	0.124	0.013	0.020	0.001	0.010	0.082	0.108	0.000	0.000
07/01/02																0.069	0.000	0.015	0.002	0.000	0.159	0.168	0.000	0.000
07/08/02																0.154	0.024	0.074	0.022	0.034	0.022	0.041	0.079	0.069
07/16/02		0.017	0.155											0.000		0.168	0.043	0.064	0.010	0.024	0.241	0.430	0.054	0.056
07/22/02																0.072	0.001	0.037	0.003	0.001	0.114	0.095	0.025	0.268
07/29/02																0.062	0.000	0.036	0.000	0.001	0.249	0.408	0.023	0.027
07/30/02																								
08/05/02																0.099	0.000	0.036	0.023	0.006	0.012	0.083	0.057	0.055
08/12/02		0.000	0.000					0.000	0.000			0.000	0.000	0.000		0.090	0.002	0.034	0.005	0.002	0.013	0.075	0.054	0.054

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/19/02																0.038	0.000	0.000	0.000	0.000	0.000	0.032	0.011	0.000
08/26/02																0.138	0.047	0.061	0.029	0.031	0.237	0.337	0.061	0.108
08/30/02																								
09/03/02		0.042	0.140					0.049	0.056			0.068	0.063	0.064		0.080	0.036	0.037	0.033	0.033	0.227	0.307	0.060	0.073
09/10/02																	0.030	0.027	0.011	0.045	0.030	0.047	0.075	0.066
09/16/02		0.023	0.109					0.018	0.000			0.000	0.000	0.000			0.026	0.031	0.053	0.062	0.310	0.303	0.058	0.055
09/23/02																	0.000	0.012	0.054	0.052	0.198	0.214	0.048	0.039
09/30/02																	0.029	0.029	0.050	0.049	0.029	0.023	0.034	0.031
10/02/02		0.070	0.082					0.014	0.010			0.002	0.004	0.002										
10/07/02																	0.023	0.033	0.017	0.026	0.293	0.290	0.063	0.055
10/14/02																0.040	0.025	0.035	0.072	0.073	0.280	0.307	0.065	0.060
10/16/02		0.016	0.026					0.014	0.022			0.008	0.006	0.011										
10/21/02																0.010	0.005	0.004	0.016	0.018	0.301	0.068	0.000	0.000
10/28/02																0.011	0.008	0.003	0.053	0.035	0.015	0.273	0.039	0.037
10/30/02		0.018	0.009					0.003	0.000			0.002	0.003	0.005										
11/04/02																0.006	0.008	0.002	0.066	0.090	0.028		0.020	0.028
11/12/02																0.107	0.010	0.056	0.066	0.088	0.861		0.042	
11/13/02		0.085	0.039					0.015	0.007			0.015	0.011	0.007										
11/18/02																0.108	0.000	0.050	0.075	0.123	0.672		0.067	
11/25/02		0.050	0.091					0.000	0.001			0.003	0.001	0.008		0.119	0.000	0.057	0.028	0.073	0.082	0.213	0.164	
11/30/02																								
12/09/02																0.146	0.012	0.086	0.128	0.140	0.111			
12/16/02																0.168	0.001	0.044	0.152	0.228	0.146	0.159		
12/17/02		0.095	0.132					0.004	0.002			0.003	0.004	0.000										
12/30/02																								
01/14/03		0.159	0.126					0.000	0.000			0.000	0.000	0.000	0.000	0.170							0.149	0.157
02/11/03		0.153	0.133					0.017	0.021			0.010	0.085	0.000	0.019		0.026	0.127	0.024		0.163	0.229	0.188	
03/11/03		0.100	0.095					0.319	0.021			0.000	0.000	0.012	0.007		0.005	0.145	0.267		0.306	0.341	0.190	0.159
04/15/03		0.024	0.152	0.266				0.115	0.394			0.008	0.000	0.023	0.010	0.262	0.000	0.159	0.197	0.454	0.613	0.629	0.148	0.119
05/13/03		0.000	0.190	0.233				0.000	0.190			0.000	0.000	0.000	0.000	0.219	0.003	0.163	0.173	0.220	0.188	0.197	0.090	0.102
06/03/03		0.001	0.199	0.131				0.006	0.311			0.001	0.000	0.005	0.000	0.185	0.000	0.100	0.127	0.137	0.407	0.260	0.067	0.064
06/10/03																0.163	0.000	0.084	0.102	0.101	0.310	0.299	0.053	0.054
06/24/03		0.000	0.184	0.243				0.000	0.187			0.000	0.000	0.000	0.000	0.149	0.000	0.098	0.115	0.105	0.344	0.086	0.055	0.053
07/07/03				0.239											0.011	0.163	0.000	0.098	0.095	0.098	0.288	0.091	0.053	0.054
07/14/03		0.016	0.152					0.007	0.011			0.005	0.002	0.010		0.160	0.007	0.104	0.058	0.101	0.158	0.049	0.044	0.061
07/21/03				0.212											0.002	0.144	0.012	0.098	0.092	0.058	0.038	0.042	0.072	0.083
07/28/03				0.254											0.038	0.169	0.041	0.094	0.167	0.162	0.417	0.243	0.108	0.106
08/04/03		0.000	0.000	0.170				0.000	0.000			0.000	0.000	0.000	0.000	0.107	0.000	0.079	0.029	0.063	0.037	0.054	0.011	0.027
08/11/03				0.077											0.000	0.039	0.008	0.010	0.019	0.070	0.098	0.103	0.020	0.033
08/18/03				0.021											0.000	0.000	0.000	0.000	0.000	0.000	0.415	0.205	0.000	0.005
08/25/03		0.000	0.000	0.000				0.000	0.000			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.463	0.413	0.044	0.029
09/02/03																								
09/08/03		0.000	0.000	0.000				0.000	0.000			0.000	0.000	0.000	0.000	0.025	0.000	0.009	0.059	0.061	0.438	0.152	0.044	0.043
09/15/03																								
09/22/03		0.005	0.000	0.012				0.011	0.000			0.000	0.000	0.000	0.029	0.002	0.013	0.002	0.046	0.037	0.419	0.383	0.047	0.034

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
09/29/03															0.186	0.040	0.000	0.035	0.089	0.081	0.163	0.178	0.011	0.062
10/06/03		0.000	0.000	0.026				0.014	0.000			0.018	0.012	0.015	0.191	0.033	0.000	0.019	0.076	0.103	0.166	0.167	0.041	0.013
10/13/03				0.022											0.119	0.003	0.014	0.033	0.012	0.062	0.159		0.000	0.055
10/20/03				0.071											0.011	0.029	0.000	0.027	0.033	0.081	0.159		0.037	0.027
10/28/03		0.023	0.023	0.140				0.005	0.000			0.000	0.000	0.000		0.125	0.015	0.082	0.037	0.040	0.149		0.089	0.108
11/03/03															0.013	0.164	0.127	0.129	0.146	0.156	0.592	0.552	0.164	0.176
11/10/03																								
11/17/03		0.077	0.076	0.191				0.089	0.070			0.000	0.000	0.000	0.000	0.158	0.018	0.094	0.133	0.150	0.770	0.979		
12/01/03				0.191											0.000	0.153	0.000	0.013	0.079	0.234	0.402	0.453		
12/15/03															0.000	0.194	0.001	0.100	0.113	0.136	0.218	0.234		
01/20/04												0.056	0.062	0.052	0.045	0.225	0.046	0.262	0.342	0.338	1.221	1.105		
02/17/04																								
03/16/04																								

Table 31.2. (Continued) Nitrate (mg-N/l) from August 1999 to January 2004.

Date	R20	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/01/99																						
09/01/99																						
10/01/99																						
11/01/99																						
12/01/99																						
01/01/00																						
02/01/00																						
03/01/00																						
04/01/00																						
05/01/00																						
06/01/00																						
07/01/00																						
08/01/00																						
09/01/00																						
10/01/00																						
11/01/00																						
12/01/00																						
01/01/01																						
02/01/01	0.000																					
03/01/01	0.000	0.000																				
04/01/01	0.000	0.000	142.000																			
05/01/01		0.000	0.173																			
06/01/01																						
07/01/01																						
08/01/01																						
09/01/01																						
10/01/01																						
11/01/01																						
12/01/01																						
01/01/02																						
02/01/02	0.000	0.041																				
03/01/02		0.024																				
04/01/02	0.011	0.022																				
05/01/02		0.055																				
06/01/02	0.034	0.013																				
07/01/02					0.000					0.042	0.000	0.000	0.000	0.000	0.000		0.024		0.962	0.978	0.090	0.099
07/08/02				0.044	0.022					0.402	0.024	0.022	0.045	0.056	0.015		0.030		1.022	0.941	0.176	0.156
07/16/02				0.022	0.034					0.454	0.010	0.013	0.020	0.018	0.017		0.036		1.376	1.085	0.255	0.222
07/22/02				0.002	0.000					0.457	0.000	0.000	0.018	0.007	0.000		0.017		1.540	1.539	0.148	0.101
07/29/02				0.005	0.000					0.442	0.000	0.000	0.008	0.008	0.000		0.034		1.589	1.027	0.106	0.084
07/30/02																						
08/05/02				0.006	0.000					0.389	0.013	0.009	0.007	0.008	0.000		0.000		1.675	1.497	0.138	0.110
08/12/02				0.006	0.019					0.517	0.012	0.000	0.020	0.025	0.000		0.022		1.806	1.774	0.144	0.105

Date	R20	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/19/02				0.000	0.000					0.300	0.000	0.000	0.000	0.000	0.000		0.000		1.855	1.808	0.095	0.037
08/26/02				0.036	0.029					0.441	0.030	0.025	0.053	0.019	0.018		0.053		1.719	1.736	0.135	0.189
08/30/02																						
09/03/02				0.033	0.040					0.393	0.026	0.025	0.053	0.022	0.024		0.100		1.876	1.840	0.113	0.097
09/10/02				0.000	0.027					0.728	0.016	0.012	0.034	0.049	0.016		0.026		1.860	1.978	0.048	0.069
09/16/02				0.068	0.080					0.340	0.028	0.026	0.090	0.062	0.024		0.075		2.090	2.116	0.111	0.089
09/23/02				0.056	0.048					0.623	0.000	0.000	0.070	0.047	0.013		0.076		2.070	2.033	0.047	0.043
09/30/02	0.024			0.038	0.031					0.355	0.022	0.019	0.095	0.059	0.017		0.067		1.742	1.648	0.044	0.065
10/02/02																						
10/07/02				0.020	0.351					0.691	0.026	0.021	0.038	0.024	0.021		0.028		2.096	2.084	0.067	0.056
10/14/02				0.073	0.065					0.529	0.027	0.027	0.131	0.104	0.029		0.082		1.292	1.406	0.089	0.062
10/16/02																						
10/21/02				0.099	0.012					0.003	0.000	0.000	0.054	0.067	0.017		0.004		1.206	1.328	0.074	0.029
10/28/02				0.025	0.016					0.614	0.000	0.001	0.015	0.053	0.010		0.050		2.592	2.580	0.087	0.024
10/30/02	0.033																					
11/04/02				0.067	0.032					0.962	0.008	0.000	0.086	0.076	0.016		0.050		1.840	1.786	0.039	0.030
11/12/02				0.061	0.237					0.353	0.061	0.006	0.095	0.078	0.005		0.049		2.022	2.066	0.174	0.152
11/13/02																						
11/18/02				0.324	0.130					0.008	0.007	0.002	0.056	0.059	0.018		0.070		2.079	2.344	0.171	0.129
11/25/02				0.073	0.026						0.016	0.009	0.104	0.183	0.034		0.036				0.164	0.164
11/30/02																						
12/09/02				0.119	0.120						0.019	0.025	0.227	0.211	0.023		0.121				0.209	0.184
12/16/02				0.147	0.150						0.024	0.094	0.266	0.255	0.097		0.174				0.228	0.195
12/17/02																						
12/30/02	0.000																					
01/14/03	0.000	0.035								1.513								0.144	2.699	2.491	0.218	0.195
02/11/03	0.133	0.075								0.861					0.181			0.214	2.596	2.550	0.289	0.242
03/11/03	0.037	0.026								1.351					0.004			0.247	2.748	2.580	0.287	0.265
04/15/03	0.000	0.003				2.032	2.288			0.436	0.107				0.162			0.054	1.818	1.770	0.288	0.280
05/13/03	0.004	0.027				1.452	0.620	0.285	0.299	0.615	0.162		0.193	0.190	0.126			0.019	2.055	1.930	0.245	0.241
06/03/03		0.004				0.204	0.355	0.269	0.256	0.431	0.082		0.128	0.120	0.085	1.479		0.013	1.228	1.261	0.240	0.205
06/10/03						1.122	1.238			0.358	0.053		0.102	0.051	0.051			0.007	1.858	1.760	0.204	0.182
06/24/03	0.007	0.000				0.237	0.314	0.205	0.182	0.296	0.079		0.078	0.076	0.059			0.000	1.616	1.521	0.201	0.170
07/07/03		0.007				0.944	0.811			0.349	0.076		0.099	0.102	0.051			0.010	1.666	1.365	0.168	0.175
07/14/03	0.000	0.000								0.226	0.080		0.054	0.058	0.059			0.000	1.488	1.540	0.182	0.178
07/21/03		0.013				1.344	0.440			0.147	0.069		0.082	0.054	0.054			0.036	1.047	0.985	0.177	0.167
07/28/03		0.053				0.489	1.174			0.594	0.087		0.198	0.196	0.080			0.058	1.992	1.755	0.226	0.176
08/04/03		0.000				0.037	0.150			0.590	0.059		0.081	0.050	0.059	1.205		0.000	2.488	2.246	0.167	0.130
08/11/03		0.000				0.367	0.374			0.762	0.000		0.037	0.000	0.000			0.000	1.935	1.907	0.076	0.073
08/18/03		0.000				0.191	0.390			0.016			0.001	0.000				0.000	1.387	1.482	0.030	0.002
08/25/03	0.129	0.000				1.930	0.607	0.075	0.045	0.854			0.000	0.000				0.000	2.151	2.098	0.034	0.011
09/02/03																						
09/08/03		0.007				0.669	0.432			0.436			0.101	0.085				0.000	1.796	1.548	0.047	0.030
09/15/03																						
09/22/03	0.000	0.024				1.063	0.443			0.467			0.134	0.004				0.016	2.039	2.085	0.094	0.010

Date	R20	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
09/29/03		0.035				1.741	1.826			0.558			0.148	0.147				0.025	1.902	1.680	0.112	0.011
10/06/03		0.032				0.087	0.169			0.016			0.166	0.173				0.000	1.767	2.360	0.094	0.026
10/13/03						0.571	0.622	0.042	0.031	0.418			0.095	0.036				0.000	1.010	1.483	0.069	0.015
10/20/03		0.023				2.217	1.260			0.759			0.131	0.134				0.000	2.345	2.272	0.157	0.070
10/28/03	0.000	0.100				1.174	1.435			0.810			0.049	0.051				0.030	1.738	2.009	0.194	0.137
11/03/03						1.100	1.489			1.047			0.119	0.082				0.130	3.214	2.892	0.190	0.202
11/10/03																						
11/17/03		0.000				0.555	0.303						0.288	0.200							0.182	0.160
12/01/03		0.000				2.499	2.960						0.161	0.264							0.179	0.182
12/15/03	0.010	0.015				2.501	2.987	0.206	0.223				0.204	0.210							0.207	0.200
01/20/04		0.098						0.229	0.238	1.029									2.397	2.175	0.284	0.231
02/17/04																						
03/16/04																						

Table 32.1. Ammonia (mg-N/l) from August 1999 to January 2004.

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/01/99																								
09/01/99																								
10/01/99																								
11/01/99																								
12/01/99																								
01/01/00																								
02/01/00																								
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10/01/00																								
11/01/00																								
12/01/00																								
01/01/01																								
02/01/01																								
03/01/01																								
04/01/01	0.024	0.022	0.020	0.029	0.045	0.019	0.013	0.015	0.000	0.002	0.056	0.030	0.034	0.014	0.044	0.026	0.000	0.040	0.016		0.030		0.040	
05/01/01																								
06/01/01																								
07/01/01																								
08/01/01																								
09/01/01																								
10/01/01																								
11/01/01																								
12/01/01																								
01/01/02																								
02/01/02	0.023	0.041	0.022	0.027	0.022	0.024	0.011	0.040	0.041	0.015	0.036	0.019	0.021	0.043	0.015	0.027	0.021	0.026	0.031		0.030		0.021	0.028
03/01/02	0.015	0.016	0.029	0.007	0.009	0.009	0.000	0.016	0.023	0.011	0.007	0.000	0.009		0.010	0.012	0.000	0.012	0.011	0.016	0.010	0.017	0.037	
04/01/02	0.049	0.047	0.065	0.050	0.036	0.034	0.029	0.024	0.022	0.023	0.020	0.019	0.020	0.036	0.094	0.021	0.027	0.030	0.028	0.040	0.047	0.035	0.025	0.051
05/01/02	0.035	0.017	0.014	0.018	0.018	0.018	0.010	0.007	0.007	0.014		0.007	0.032	0.000	0.000	0.006	0.000	0.010	0.000	0.006	0.006	0.009	0.006	0.009
06/01/02	0.026	0.015	0.009	0.014	0.021	0.009	0.008	0.013	0.012	0.012		0.007	0.006	0.018	0.000	0.014	0.004	0.012	0.000	0.000	0.015	0.016	0.006	0.019
07/01/02																0.016	0.005	0.013	0.037	0.006	0.032	0.016	0.013	0.009
07/08/02																0.017	0.000	0.001	0.000	0.010	0.004	0.008	0.003	0.005
07/16/02		0.006	0.027					0.000	0.000			0.000	0.000	0.034		0.044	0.014	0.011	0.001	0.025	0.010	0.014	0.007	0.016
07/22/02																0.022	0.025	0.014	0.017	0.020	0.007	0.024	0.015	0.040
07/29/02																0.011	0.017	0.013	0.038	0.021	0.017	0.018	0.018	0.016
07/30/02																								
08/05/02																0.055	0.062	0.051	0.062	0.056	0.055	0.053	0.056	0.048
08/12/02		0.063	0.029					0.031	0.062			0.049	0.026	0.056		0.095	0.098	0.073	0.063	0.061	0.059	0.052	0.081	0.056

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
08/19/02																0.011	0.008	0.000	0.000	0.000	0.000	0.005	0.022	0.015
08/26/02																0.042	0.065	0.005	0.016	0.020	0.019	0.042	0.000	0.021
08/30/02																								
09/03/02		0.016	0.019					0.025	0.034			0.011	0.018	0.120		0.027	0.022	0.012	0.001	0.003	0.010	0.015	0.013	0.029
09/10/02																	0.011	0.000	0.000	0.000	0.000	0.000	0.050	0.003
09/16/02		0.044	0.070					0.031	0.006			0.011	0.006	0.054			0.055	0.013	0.025	0.043	0.013	0.012	0.026	0.024
09/23/02																	0.034	0.011	0.018	0.026	0.010	0.037	0.015	0.016
09/30/02																	0.048	0.053	0.041	0.035	0.037	0.033	0.044	0.028
10/02/02		0.066	0.065					0.042	0.181			0.045	0.051	0.100										
10/07/02																	0.052	0.039	0.040	0.044	0.054	0.030	0.042	0.038
10/14/02																0.048	0.077	0.041	0.036	0.035	0.046	0.050	0.074	0.064
10/16/02		0.023	0.129					0.012	0.227			0.027	0.034	0.260										
10/21/02																0.027	0.008	0.028	0.030	0.018	0.014	0.019	0.024	0.016
10/28/02																0.038	0.022	0.024	0.022	0.023	0.022	0.031	0.024	0.023
10/30/02		0.033	0.182					0.019	0.032			0.026	0.034	0.053										
11/04/02																0.017	0.035	0.020	0.036	0.024	0.028		0.022	0.028
11/12/02																0.040	0.035	0.035	0.031	0.027	0.020		0.028	
11/13/02		0.031	0.187					0.000	0.031			0.049	0.044	0.055										
11/18/02																0.028	0.019	0.046	0.038	0.038	0.019		0.148	
11/25/02		0.038	0.050					0.009	0.027			0.062	0.049	0.058		0.028	0.029	0.031	0.030	0.035	0.027	0.052	0.176	
11/30/02																								
12/09/02																0.039	0.033	0.027	0.021	0.021	0.030			
12/16/02																0.027	0.017	0.023	0.022	0.024	0.023	0.017		
12/17/02		0.071	0.051					0.016	0.048			0.042	0.044	0.060										
12/30/02																								
01/14/03		0.032	0.035					0.006	0.020			0.013	0.009	0.022	0.021	0.014							0.023	0.014
02/11/03		0.046	0.104					0.064	0.129			0.050	0.077	0.062	0.095		0.109	0.072	0.116		0.083	0.094	0.089	
03/11/03		0.014	0.042					0.029	0.034			0.007	0.009	0.068	0.023		0.032	0.024	0.042		0.030	0.022	0.029	0.021
04/15/03		0.076	0.035	0.010				0.054	0.053			0.008	0.008	0.027	0.027	0.012	0.012	0.019	0.027	0.171	0.049	0.073	0.028	0.017
05/13/03		0.013	0.013	0.018				0.004	0.014			0.003	0.009	0.008	0.032	0.013	0.009	0.011	0.021	0.021	0.034	0.024	0.018	0.013
06/03/03		0.000	0.007	0.035				0.011	0.000			0.000	0.000	0.000	0.000	0.010	0.000	0.007	0.034	0.021	0.030	0.028	0.012	0.001
06/10/03																0.043	0.032	0.034	0.049	0.045	0.042	0.043	0.036	0.036
06/24/03		0.047	0.045	0.026				0.035	0.041			0.039	0.029	0.080	0.008	0.012	0.009	0.016	0.037	0.035	0.037	0.043	0.030	0.034
07/07/03				0.029											0.036	0.017	0.015	0.011	0.027	0.026	0.027	0.046	0.018	0.023
07/14/03		0.020	0.039					0.025	0.060			0.011	0.011	0.169		0.008	0.030	0.039	0.023	0.024	0.030	0.019	0.000	0.023
07/21/03				0.033											0.012	0.011	0.040	0.056	0.041	0.036	0.021	0.040	0.000	0.028
07/28/03				0.027											0.058	0.012	0.010	0.024	0.026	0.040	0.048	0.024	0.033	0.043
08/04/03		0.031	0.023	0.000				0.075	0.049			0.018	0.031	0.062	0.055	0.050	0.036	0.032	0.050	0.063	0.040	0.031	0.004	0.030
08/11/03				0.055											0.018	0.056	0.033	0.015	0.034		0.051	0.025	0.021	0.048
08/18/03				0.092											0.012	0.025	0.025	0.014	0.033	0.092	0.024	0.035	0.042	0.031
08/25/03		0.017	0.017	0.041				0.006	0.087			0.005	0.018	0.005	0.013	0.027	0.062	0.023	0.032	0.037	0.019	0.044	0.041	0.024
09/02/03																								
09/08/03		0.013	0.022	0.089				0.006	0.069			0.014	0.029	0.043	0.025	0.030	0.041	0.030	0.046	0.040	0.055	0.020	0.034	0.032
09/15/03																								
09/22/03		0.041	0.024	0.009				0.012	0.063			0.005	0.034	0.087	0.030	0.083	0.038	0.059	0.020	0.049	0.023	0.014	0.031	0.033

Date	R1	R2A	R2B	R3	R4	R4-Dup	R5	R6A	R6B	R7	R8	R9A	R9A-Dup	R9B	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19
09/29/03															0.070	0.108	0.076	0.168	0.057	0.030	0.143	0.100	0.038	0.038
10/06/03		0.022	0.094	0.075				0.030	0.065			0.027	0.024	0.076	0.197	0.040	0.082	0.038	0.060	0.031	0.035	0.019	0.038	0.036
10/13/03				0.097											0.129	0.057	0.018	0.032	0.050	0.037	0.079		0.034	0.068
10/20/03				0.069											0.006	0.044	0.022	0.031	0.028	0.039	0.058		0.029	0.029
10/28/03		0.051		0.125				0.032				0.000	0.030	0.022		0.038	0.020	0.064	0.015	0.027	0.039		0.021	0.061
11/03/03															0.135	0.097	0.006	0.030	0.020	0.031	0.035	0.037	0.177	0.037
11/10/03																								
11/17/03		0.076	0.072	0.064				0.016	0.033			0.073	0.067	0.072	0.031	0.033	0.039	0.035	0.033	0.027	0.038	0.009		
12/01/03				0.008											0.038	0.034	0.023	0.040	0.032	0.128	0.021	0.023		
12/15/03															0.041	0.003	0.011	0.019	0.013	0.011	0.014	0.005		
01/20/04												0.017	0.018	0.072	0.007	0.010	0.054	0.045	0.038	0.034	0.036	0.004		
02/17/04																								
03/16/04																								

Table 32.2. (Continued) Ammonia (mg-N/l) from August 1999 to January 2004.

Date	R20	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/01/99																						
09/01/99																						
10/01/99																						
11/01/99																						
12/01/99																						
01/01/00																						
02/01/00																						
03/01/00																						
04/01/00																						
05/01/00																						
06/01/00																						
07/01/00																						
08/01/00																						
09/01/00																						
10/01/00																						
11/01/00																						
12/01/00																						
01/01/01																						
02/01/01																						
03/01/01	0.010																					
04/01/01		0.000	0.000																			
05/01/01																						
06/01/01																						
07/01/01																						
08/01/01																						
09/01/01																						
10/01/01																						
11/01/01																						
12/01/01																						
01/01/02																						
02/01/02	0.009	0.040																				
03/01/02		0.000																				
04/01/02	0.032	0.028																				
05/01/02		0.000																				
06/01/02	0.012	0.005																				
07/01/02				0.000	0.062					0.036	0.018	0.011	0.008	0.010	0.007		0.021		0.012	0.002	0.010	0.000
07/08/02				0.009	0.000					0.012	0.002	0.000	0.007	0.007	0.000		0.004		0.015	0.030	0.025	0.000
07/16/02				0.008	0.007					0.021	0.005	0.002	0.016	0.001	0.000		0.002		0.012	0.000	0.062	0.000
07/22/02				0.027	0.019					0.017	0.020	0.014	0.012	0.013	0.013		0.013		0.033	0.000	0.034	0.000
07/29/02				0.024	0.018					0.028	0.018	0.016	0.022	0.019	0.015		0.020		0.028	0.015	0.022	0.000
07/30/02																						
08/05/02				0.069	0.053					0.058	0.063	0.061	0.063	0.047	0.051		0.047		0.067	0.039	0.061	0.038
08/12/02				0.060	0.064					0.056	0.074	0.061	0.056	0.055	0.065		0.060		0.083	0.040	0.127	0.049

Date	R20	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
08/19/02				0.000	0.000					0.005	0.000	0.000	0.008	0.000	0.000		0.000		0.016	0.000	0.024	0.000
08/26/02				0.012	0.014					0.002	0.013	0.024	0.031	0.022	0.004		0.020		0.024	0.031	0.031	0.033
08/30/02																						
09/03/02				0.000	0.017					0.025	0.005	0.009	0.000	0.026	0.000		0.015		0.016	0.000	0.002	0.000
09/10/02				0.000	0.000					0.006	0.000	0.000	0.000	0.000	0.000		0.000		0.002	0.000	0.000	0.000
09/16/02				0.047	0.020					0.024	0.010	0.016	0.013	0.000	0.013		0.009		0.000	0.000	0.002	0.000
09/23/02				0.023	0.048					0.030	0.013	0.003	0.017	0.000	0.012		0.029		0.000	0.000	0.001	0.004
09/30/02	0.033			0.043	0.023					0.038	0.054	0.021	0.027	0.020	0.030		0.027		0.341	0.228	0.044	0.014
10/02/02																						
10/07/02				0.055	0.060					0.049	0.037	0.030	0.041	0.035	0.030		0.049		0.074	0.056	0.036	0.020
10/14/02				0.043	0.057					0.044	0.024	0.063	0.024	0.028	0.037		0.048		0.084	0.063	0.033	0.040
10/16/02																						
10/21/02				0.035	0.021					0.032	0.013	0.017	0.013	0.010	0.019		0.012		0.009	0.000	0.013	0.000
10/28/02				0.026	0.020					0.017	0.025	0.022	0.042	0.046	0.017		0.016		0.011	0.040	0.033	0.000
10/30/02	0.029																					
11/04/02				0.031	0.030					0.029	0.025	0.018	0.047	0.037	0.043		0.020		0.020	0.007	0.031	0.015
11/12/02				0.019	0.027					0.052	0.030	0.021	0.032	0.033	0.015		0.020		0.017	0.010	0.025	0.004
11/13/02																						
11/18/02				0.122	0.023					0.029	0.010	0.021	0.019	0.046	0.038		0.019		0.016	0.004	0.025	0.000
11/25/02				0.038	0.018						0.017	0.013	0.010	0.010	0.027		0.025				0.087	0.000
11/30/02																						
12/09/02				0.040	0.024						0.015	0.019	0.017	0.031	0.014		0.018				0.000	0.000
12/16/02				0.022	0.020						0.007	0.029	0.022	0.012	0.016		0.015				0.028	0.000
12/17/02																						
12/30/02	3.900																					
01/14/03	0.091	0.018								0.012								0.007	0.009	0.005	0.009	0.001
02/11/03	0.085	0.100								0.083					0.094			0.056	0.070	0.012	0.030	0.043
03/11/03	0.026	0.023								0.015					0.019			0.013	0.003	0.000	0.008	0.000
04/15/03	0.009	0.011				0.014	0.007			0.023	0.018				0.034			0.018	0.017	0.020	0.004	0.000
05/13/03	0.002	0.019				0.009	0.008	0.049	0.013	0.014	0.022		0.025	0.029	0.016			0.017	0.000	0.000	0.010	0.005
06/03/03		0.000				0.000	0.002	0.004	0.011	0.010	0.018		0.060	0.032	0.015	0.079		0.003	0.000	0.000	0.001	0.000
06/10/03						0.048	0.030			0.025	0.031		0.043	0.015	0.035			0.020	0.006	0.009	0.033	0.028
06/24/03	0.030	0.010				0.031	0.028	0.032	0.036	0.035	0.022		0.053	0.028	0.047			0.026	0.032	0.000	0.023	0.005
07/07/03		0.013				0.014	0.021			0.028	0.024		0.034	0.020	0.017			0.021	0.019	0.010	0.021	0.005
07/14/03	0.021	0.060								0.025	0.022		0.036	0.011	0.023			0.018	0.017	0.000	0.002	0.000
07/21/03		0.033				0.006	0.015			0.031	0.024		0.037	0.015	0.037			0.274	0.015	0.032	0.006	0.034
07/28/03		0.029				0.021	0.018			0.050	0.028		0.038	0.036	0.022			0.029	0.012	0.001	0.025	0.012
08/04/03		0.056				0.042	0.023			0.054	0.022		0.051	0.062	0.028	0.050		0.123	0.060	0.000	0.000	0.029
08/11/03		0.024				0.060	0.042			0.063	0.037		0.051	0.036	0.021			0.035	0.035	0.034	0.007	0.026
08/18/03		0.010				0.026	0.017			0.055			0.046	0.037				0.022	0.004	0.000	0.012	0.017
08/25/03	0.057	0.023				0.050	0.009	0.019	0.032	0.060			0.028	0.029				0.049	0.017	0.000	0.003	0.004
09/02/03																						
09/08/03		0.015				0.059	0.011			0.053			0.068	0.068				0.032	0.009	0.000	0.007	0.026
09/15/03																						
09/22/03	0.000	0.023				0.031	0.012			0.068			0.014	0.014				0.087	0.006	0.000	0.009	0.036

Date	R20	R25	R26	16th St.	19th Av.	Green In	Green Out	Hav. 1	Hav. 2	HTC	Hwy 87	Mesa	NP In	NP Out	Pima	Rosvlt.	Scot.	SOCA	SPT In	SPT Out	UH In	UH Out
09/29/03		0.025				0.078	0.010			0.089			0.142	0.093				0.074	0.042	0.061	0.079	0.059
10/06/03		0.009				0.076	0.025			0.074			0.064	0.094				0.050	0.007	0.011	0.009	0.012
10/13/03						0.067	0.015	0.026	0.049	0.080			0.105	0.203				0.035	0.013	0.045	0.032	0.014
10/20/03		0.086				0.022	0.014			0.053			0.074	0.075				0.027	0.000	0.020	0.023	0.009
10/28/03	0.022	0.032				0.042				0.035			0.008	0.048				0.028	0.000	0.024	0.009	0.000
11/03/03						0.023	0.028			0.101			0.086	0.042				0.020	0.000	0.000	0.008	0.028
11/10/03																						
11/17/03		0.018				0.049	0.014						0.066	0.050							0.020	0.002
12/01/03		0.028				0.011	0.006						0.028	0.047							0.001	0.046
12/15/03	0.008	0.006				0.020	0.010	0.034	0.028				0.023	0.016							0.000	0.001
01/20/04		0.023						0.018	0.019	0.019									0.017	0.000	0.011	0.000
02/17/04																						
03/16/04																						