EFFECT OF AIRCRAFT DE-ICING COMPOUNDS ON THE OPERATION AND PERFORMANCE OF THE SOUTH AUSTIN REGIONAL WASTEWATER TREATMENT PLANT

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ABSTRACT

The City of Austin (COA) through its Department of Aviation (DOA) owns and operates the Austin Bergstrom International Airport (ABIA). DOA collects and controls the discharge of storm water runoff from the gate and cargo apron areas at ABIA. During winter months, when the weather creates a potential for aircraft icing, ABIA uses aircraft deicing fluid (ADF) and aircraft anti-icing fluid (AAF), both of which contain high concentrations of glycol (typically propylene glycol) used to remove and prevent ice and frost on aircraft external surfaces. If discharged, high concentrations of glycol contaminated stormwater runoff can have an adverse effect on aquatic life in receiving water bodies. ABIA has implemented a standard operating procedure (SOP) to manage the discharge of glycol-contaminated runoff in a controlled manner. When the measured COD value of captured stormwater runoff is higher than 120 mg/L, the retained water is discharged to the City of Austin's South Austin Regional Wastewater Treatment Plant (SARWWTP) and treated in existing treatment Train B. After the expansion of SARWWTP to 75 million gallons per day (mgd) design treatment capacity in spring of 2006, a new influent flow split structure (IFS) was commissioned that has changed the plants way of handling influent sewage. The IFS now receives all flows and distributes the raw sewage to the three 25-mgd treatment trains. This modification may affect the way the biological process reacts to the addition of deicing compounds.

In recent years SARWWTP staff has observed periods of increased chlorine demand downstream of the aeration basins, which are suspected by SARWWTP staff to be related to stress in the plant's biological treatment process during discharges from ABIA. To assess the adequacy of current management practices for discharge of glycol-contaminated runoff to SARWWTP, and to investigate whether there is a relationship between the periods of increased chlorine demand observed in the SARWWTP effluent and the ABIA discharges, TCB conducted a study based on ABIA discharge flow and loading data, and corresponding SARWWTP performance data. The goals of this study were to assess the impacts of ABIA discharges on SARWWTP influent flows and loads, and on SARWWTP plant performance; evaluate the current COD: BOD_5 ratio of glycol-contaminated runoff; and consider the effects of the new IFS structure in relation to treatment of glycol-contaminated discharges.

KEYWORDS
Activated sludge, aircraft de-icing, anti-icing, glycol, nitrification.

BACKGROUND

Austin Bergstrom International Airport

Aircraft deicing and pavement deicing at ABIA are generally conducted between December and March. The majority of aircraft deicing applications involve dry weather defrosting of aircraft, with applications of 20-30 gallons of ADF being sprayed on each aircraft. The majority of the aircraft deicing activity at ABIA has historically taken place at the passenger terminal aprons, with less use of ADF/AAF taking place at the cargo apron, however, this pattern of aircraft deicing activity may be subject to change in the future.

Two main types of fluids are used for control of aircraft icing at ABIA. Both contain glycol, a water-soluble organic compound, which exerts a high Biochemical Oxygen Demand (BOD_5) of approximately 1 million milligrams per liter (mg/L). Type I (ADF) is the most commonly used source of glycol at ABIA and has a shorter residence time on the aircraft than Type IV (AAF), which includes a polymer additive. Both types of fluids, in addition to high concentrations of propylene glycol, generally contain small quantities of proprietary trade-secret additives to prevent corrosion and foaming, and to act as flame-retardants.

ABIA has a well defined system to capture and detain stormwater potentially contaminated with glycol. The system consists of trench drains and catch basins, storm sewers, and three stormwater quality retention ponds and associated pumping stations. According to ABIA, each pond is sized to capture the first half-inch of runoff during a storm event. The passenger terminal aprons and the cargo apron each have a separate apron drainage system to capture stormwater runoff. The storm drains from the terminal apron areas convey runoff to two 660,000-gallon retention ponds named Echo 1 and Echo 2. Each of these ponds has a layer of sand preceding the outlet to act as a filter to remove particulate matter. The collection system at the cargo apron is similar to that at the passenger terminal aprons. Trench drains collect and route runoff through storm sewers to an 829,000 gallon retention pond named the Cargo pond. Both the Echo ponds and Cargo ponds can either discharge to SARWWTP by pumping into nearby sanitary sewers, or can be released through gravity outfalls to surface discharge.

Discharges volumes are currently determined using the following formula developed as part of the 2002 Treatability Study[1]:

$$V = \frac{Q * L * r}{C}$$

where:

	V	=	Allowable discharge volume, gallons per day
	Q	=	SAR Train B flow, gallons per day
	L	=	Allowable glycol concentration (5 or 10 mg/L)
	r	=	Ratio of COD: BOD5 (1.7)
	C	=	COD in the ABIA pond, mg/L

This formula is used to arrive at a maximum allowable daily discharge volume. ABIA discharges this volume to SARWWTP during an 8-hour time period. Hence, the discharges from

ABIA to SARWWTP are intermittent, with periods of no discharge interspersed with days during which slugs of discharge occur. This inconsistency is detrimental to the acclimation of the biomass at SARWWTP to the discharges.

South Austin Regional Wastewater Treatment Plant

The South Austin Regional Wastewater Treatment Plant serves the central and south portions of the greater Austin area. SARWWTP currently consists of three treatment trains of similar size, type and layout with common support facilities (i.e. maintenance, disinfection, etc.). Construction of Train A was completed in 1986. Train A was originally designed for 18 mgd capacity, and then modified to 20 mgd. Train B was added in 1988, to increase the total design treatment capacity to 40 mgd. In 1995, Trains A and B were re-rated for a combined treatment capacity of 50 mgd. An expansion to add a third Train C with a treatment capacity of 25 mgd was completed in the spring of 2006, bringing the total capacity at SARWWTP to 75 mgd.

Raw sewage is fed to the facility from two influent lift stations located at the plant. Prior to the Train C addition, sewage from each of the influent lift stations was fed independently to Train A or Train B. With this configuration, Lift Station No.1 received glycol-contaminated runoff from ABIA as well as plant recycle flows such as sludge thickener supernatant, and the flow from Lift Station No. 1 was pumped entirely to Train B. With the addition of Train C, a new IFS was put in to service. The IFS receives all influent raw sewage and plant recycle streams pumped from both influent lift stations and distributes the mixed influent flow among SARWWTP Trains A, B and C. Figure 1 presents a schematic diagram of the flow at SARWWTP before and after construction of the IFS. Figure 2 presents a typical treatment train process.

Figure 1 - SARWWTP Influent Flow Diagram

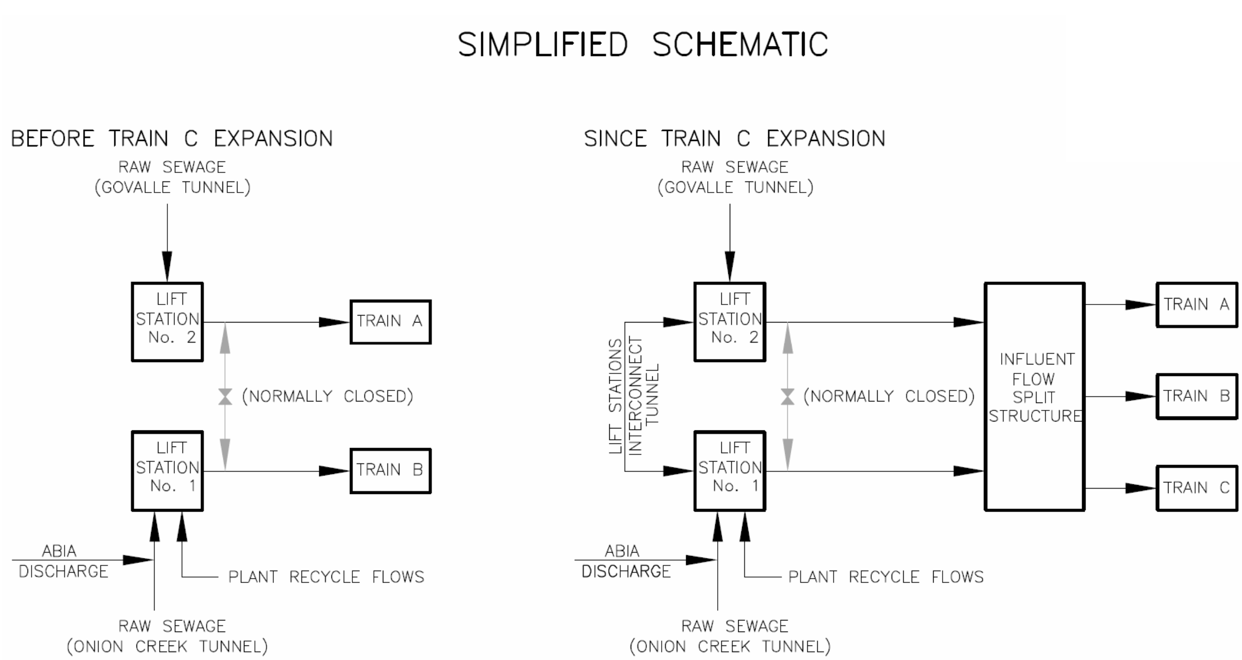
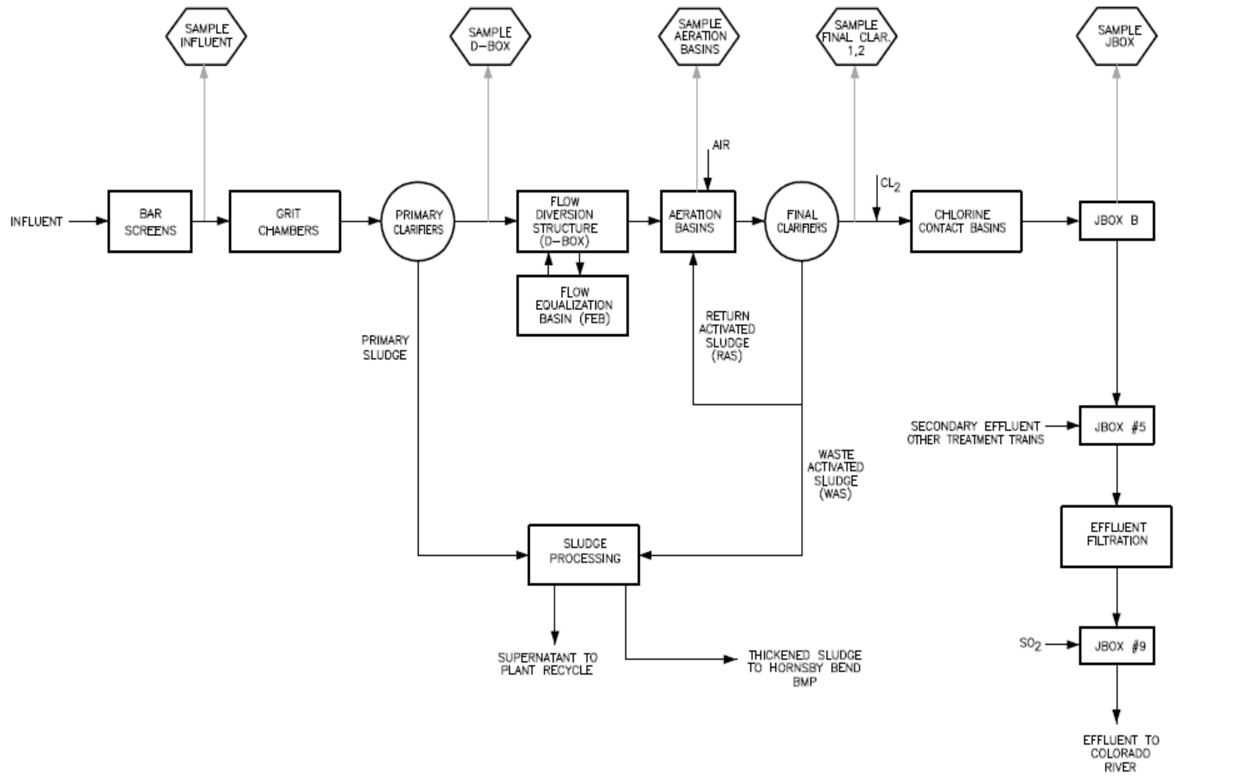


Figure 2 - SARWWTP Typical Treatment Process Flow Diagram



SARWWTP operational problems related to ABIA discharges occurred in February and March of 2001 when the plant experienced significant treatment process upsets. The first plant to experience upsets was Train B. Initial impacts reported by SARWWTP staff included foaming, die-off of biological microorganisms, and increased chlorine demand. In an attempt to combat the issue, flow was transferred between Trains A and B, leading to Train A experiencing similar difficulties. Although there was no direct correlation established between these upsets and ABIA discharges, it is believed that uncontrolled discharges from ABIA were a key contributor to the stress observed at SARWWTP. These issues were studied in depth in 2001 and early 2002.[1,2] Since early 2002, discharges from ABIA to SARWWTP have been controlled using the formula developed in the 2002 Treatability Study. In 2005-2006, plant staff reported suspected impacts to the nitrification reaction during periods of time close to ABIA discharges. Indicators reported include increased NH_3-N concentrations in secondary effluent and increased chlorine usage in the contact basins, as well as occasional increases in growth of filamentous bacteria. (Filamentous sludge bulking is not directly related to the nitrification reaction, but can indicate an actual or potential process upset condition).

Data Collection and Analysis

This study included evaluation of ABIA operational data related to glycol usage and management of glycol contaminated runoff from the winter of 1999-2000 through spring of 2006. For each of the periods during which glycol-contaminated runoff was discharged from ABIA to SARWWTP, ABIA operational data was reviewed starting one month before the first discharge from ABIA to SARWWTP and continuing for a month after the last ABIA discharge to SARWWTP. The ABIA operational data included the volume of runoff discharged daily from ABIA to SARWWTP, and ABIA discharge water quality data (BOD_5, COD and TSS).

ABIA discharged glycol-contaminated runoff to SARWWTP during the winter months of 2002-2003 and 2005-2006. For each of these two deicing seasons SARWWTP operational data was reviewed beginning a month prior to the first ABIA discharge and continuing through a month after the final ABIA discharge. SARWWTP also furnished comparable operational data for the winter months of 2003-2004, during which there were no discharges from ABIA to SARWWTP.

The data was analyzed to determine impacts of ABIA discharges on SARWWTP influent flows and loads, and impacts on SARWWTP performance. Since all of the ABIA discharges were conveyed to Lift Station No. 1 and pumped to Train B for treatment until the IFS was placed in service in spring of 2006, the review of SARWWTP operational data relates specifically to historical flow, loading and performance of Train B only.

ABIA Discharges

Table 1 summarizes historical flow and loading data for glycol contaminated discharges from ABIA to SARWWTP through the winter of 2005-2006. The maximum historical BOD_5 loading discharged from ABIA to SARWWTP was 5,360 lbs/day, discharged on January 16, 2001 when the entire contents of the Echo 1 pond was discharged in a single day at an estimated flow rate of 500 gpm, in the period immediately preceding the upset to the SARWWTP treatment process in early 2001. Since early 2001, the maximum single-day BOD_5 load discharged from ABIA to SARWWTP has been limited to no more than 1,950 lbs/day.

Table 1 - ABIA Historical ADF/AAF Discharge Daily Flows and Loads

Deicing Season		ABIA Discharge (gal/day)	Flow Rate (gpm)	COD (mg/L)	COD (Lbs/day)	BOD_5 (mg/L)[1]	BOD_5 (lbs/day)	TSS (mg/L)	TSS (lbs/day)
1999-2000		No Discharges from ABIA to SARWWTP							
2000 to 2001	Max	660,000	500	2,450	8,040	1,640	5,360	24	90
	Avg	425,100	500	1,140	4,200	760	2,800	11	40
	Min	152,400	500	474	870	320	579	3	15
2001 to 2002	Max	251,000	369	928	1,370	619	915	7	10
	Avg	82,600	140	680	390	460	260	7	4
	Min	6,400	13	292	20	195	11	7	0
2002 to 2003	Max	588,000	500	9,540	2,770	4,900	1,946	13	60
	Avg	41,100	89	4,750	1,150	2,970	700	8	3
	Min	2,000	5	425	60	318	52	4	0
2003-2004		No Discharges from ABIA to SARWWTP							

Deicing Season		ABIA Discharge (gal/day)	Flow Rate (gpm)	COD (mg/L)	COD (Lbs/day)	BOD_5 (mg/L)[1]	BOD_5 (lbs/day)	TSS (mg/L)	TSS (lbs/day)
2004-2005		No Discharges from ABIA to SARWWTP							
2005 to 2006	Max	250,000	604	12,700	1,370	10,200	1,110	19	30
	Avg	61,800	140	2,150	360	1,600	240	11	6
	Min	2,800	6	150	4	80	2	5	0

[1] BOD values for 2000-2002 calculated using a COD: BOD_5 ratio of 1.5. ABIA did not measure BOD during this time frame.

During that time, maximum COD and BOD_5 values measured in the ABIA retention ponds have exceeded those associated with discharges during 2000-2001, but the rate of discharge has been controlled using the formula recommended in the 2002 ABIA-SAR Glycol Treatability Study report. TSS concentrations and loads in the discharges from ABIA have been consistently very low relative to typical domestic sewage treated at SARWWTP.

ADF usage varied considerably from season to season, depending on the weather. In addition, there is a sizable difference between the ADF applied and the amount actually sent to SARWWTP for treatment.

SARWWTP Data Analysis

Data from winter months of 2002-2003, 2003-2004 and 2004-2005 was analyzed to determine the impact of ABIA discharges on SARWWTP influent flows and loads, and impacts on SARWWTP performance. Since all of the ABIA discharges were conveyed to Lift Station No. 1 and pumped to Train B for treatment until the IFS was placed in service in spring of 2006, the review of SARWWTP operational data relates specifically to historical flow, loading and performance of SARWWTP Train B.

Influent Flows

Table 2 summarizes maximum, minimum and average daily influent flows for SARWWTP Train B since the 2000-2001 deicing season, along with corresponding daily flow data for discharges of glycol-contaminated runoff from ABIA to SARWWTP.

Table 2 - SARWWTP Train B Influent Flows and ABIA Daily Discharges

Deicing Period	Train B Influent Flow (mgd)			ABIA Daily Discharge to SARWWTP (Mgal/day)			Ratio ABIA to Train B Flow (%)
	Max	Min	Avg	Max	Min	Avg	Avg
2000-2001	75	13	22	0.67	0.15	0.43	2%
2001-2002	20	15	17	0.25	0.006	0.08	0.5%
2002-2003	37	5	19	0.59	0.002	0.04	0.2%
2003-2004	21	7	14	No Discharges			
2004-2005	56	6	16	No Discharges			
2005-2006	22	8	15	0.25	0.003	0.062	0.4%

The daily influent flow rate to Train B varied from approximately 6 mgd to 75 mgd over the period between 2000-2001 and 2005-2006, with an average of 16 mgd. With the exception of the 2000-2001 deicing season, the average ABIA discharge flow was less than 1% of the Train B influent flow. Even considering the 8-hours per day pumping schedule for ABIA discharges, the flow rate of ABIA discharges to SARWWTP was less than 2% of the Train B flow rate.

Influent Loads

Influent concentrations of BOD_5, TSS, and NH_3-N for each treatment train at SARWWTP are measured by analyzing samples collected at the influent bar screens, and loads are calculated based on the influent concentration and flow rate of each treatment train. Prior to construction of Train C and the IFS, discharges from ABIA as well as supernatant from gravity sludge thickeners were conveyed to the treatment process in Train B only, causing higher loading on Train B than on Train A.

Table 3 lists maximum, minimum, and average loads for BOD_5, TSS, and NH_3-N for deicing seasons during the study period, together with BOD_5 and TSS loadings from ABIA discharges.

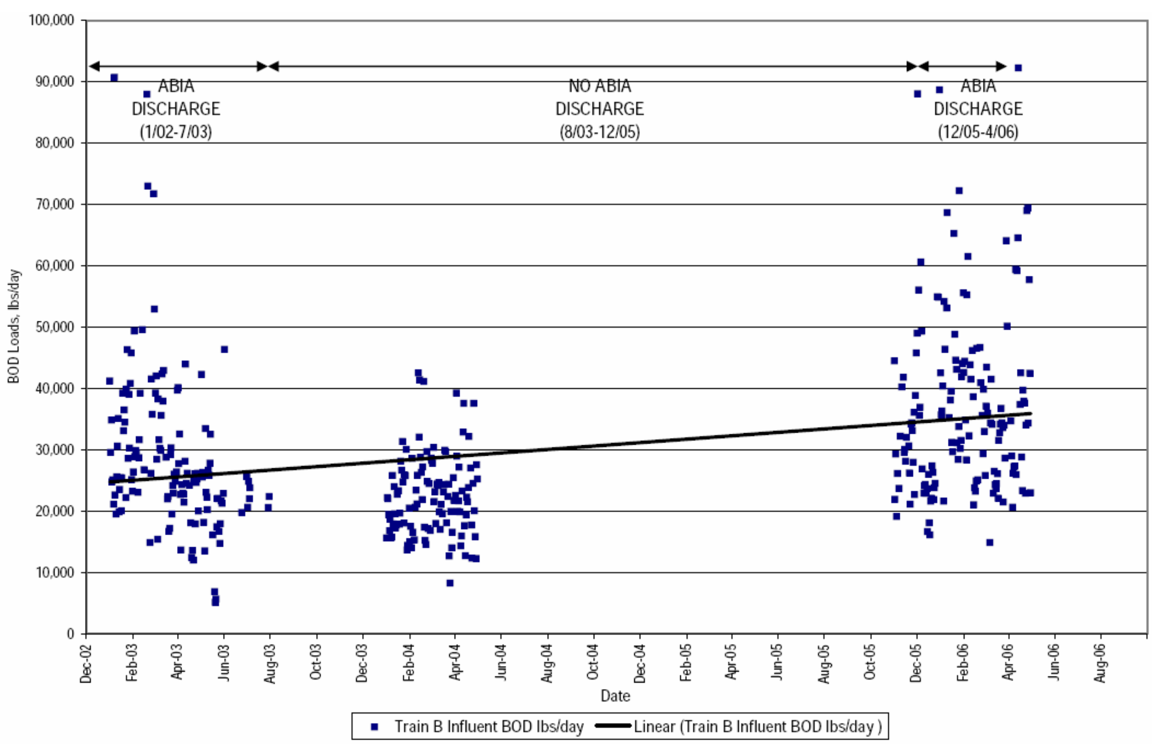
Table 3 - SARWWTP Train B Influent Loads and ABIA Discharges

Parameter	SARWWTP Train B Influent			ABIA Discharges		
	2002 to 2003	2003 to 2004	2005 to 2006	2002 to 2003	2003 to 2005	2005to 2006
BOD_5 (lbs/day)						
Maximum	90,700	42,500	92,200	1,946	—	1,107
Minimum	14,900	8,200	14,900	52	—	2
Average	34,000	22,500	36,600	700	—	235
TSS (lbs/day)						
Maximum	70,100	40,700	61,000	64	—	26
Minimum	19,900	5,800	6,400	0	—	0
Average	32,200	16,200	26,200	3	—	6

Parameter	SARWWTP Train B Influent			ABIA Discharges		
	2002 to 2003	2003 to 2004	2005 to 2006	2002 to 2003	2003 to 2005	2005to 2006
NH_3-N (lbs/day)						
Maximum	5,550	4,150	6,800	—	—	—
Minimum	1,640	1,540	1,700	—	—	—
Average	2,790	3,010	3,200	—	—	—

SARWWTP influent BOD_5 loads were highly variable, but generally increased over the study period. Figure 3 shows the historical influent BOD_5 loading to Train B, and includes a linear-regression trend line illustrating the increasing BOD_5 load. The average Train B influent BOD_5 (based on data furnished between January 2003 and May 2006) was 31,100 lbs/day. For the 2005-2006 deicing period, the Train B influent BOD_5 loading was 36,600 lbs/day. For the same season, the average ABIA discharge BOD_5 contribution was approximately 235 lbs/day, which is approximately 0.6 percent of overall Train B influent loading. From 2002-2006, discharges of glycol-contaminated stormwater runoff from ABIA to SARWWTP contributed approximately 2.5% of Train B's daily BOD_5 loading during discharges from ABIA.

Figure 3 - Train B Influent Biochemical Oxygen Demand (Loads), 2002-2006



The BOD_5 loading to the Train B secondary treatment process (following primary clarification) is presented in Figure 4. The anticipated secondary treatment BOD_5 loading criteria defined in the 1995 Capacity Assessment and Re-Rating Recommendations study was 26.7 lbs BOD_5 per day per 1,000 cubic feet of aeration basin volume.[4] This corresponds to an anticipated loading of 18,946 lbs BOD_5 per day per treatment train at the rated 25 mgd average daily flow through each treatment train, since Train A and Train B each have 709,600 ft^3 total aeration basin volume. Primary clarifier effluent BOD_5 loading to the SARWWTP Train B aeration basins averaged 18,600 lbs/day (based on data reviewed from January 2003 to May 2006). This loading is approximately 98 percent of the anticipated BOD_5 loading rate at the rated 25 mgd annual average daily flow capacity of Train B. However, this loading is approximately 75% of the maximum BOD_5 loading of 35 lbs/day/1,000 ft^3, allowed by TCEQ Design Criteria for single-stage nitrification, indicating that Train B was not organically overloaded relative to TCEQ requirements during the period for which data was reviewed.

Figure 4 - Train B Secondary BOD Loading

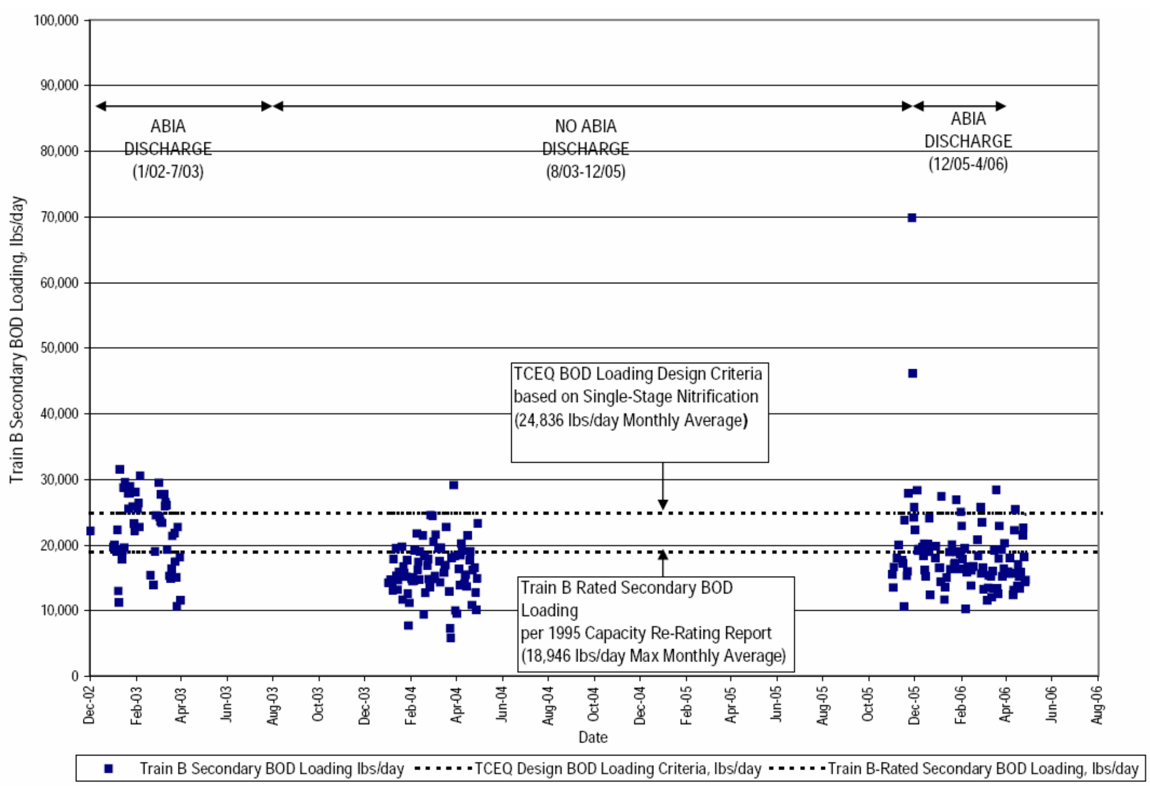


Table 4 lists maximum, minimum, and average BOD_5, TSS, and NH_3-N concentrations as well as BOD_5 and TSS concentrations from ABIA discharges.

Table 4 - SARWWTP Train B Influent Concentrations and ABIA Discharges

Parameter	SARWWTP Train B Influent			ABIA Discharges		
	2002 to 2003	2003 to 2004	2005 to 2006	2002 to 2003	2003 to 2005	2005 to 2006
BOD_5 (mg/L)						
Maximum	562	325	840	4,900	—	10,200
Minimum	79	86	130	318	—	80
Average	202	181	350	2,970	—	1600

Parameter	SARWWTP Train B Influent			ABIA Discharges		
	2002 to 2003	2003 to 2004	2005 to 2006	2002 to 2003	2003 to 2005	2005 to 2006
TSS (mg/L)						
Maximum	1700	660	8010	13	—	19
Minimum	80	62	64	4	—	5
Average	402	210	405	8	—	11
NH_3-N (mg/L)						
Maximum	25	32	47	—	—	—
Minimum	7	17	15	—	—	—
Average	18	24	26	—	—	—

Since discharges from ABIA after the winter of 2001-2002 were controlled based on the recommendations of the 2002 Treatability Study, which recommended a target glycol concentration of 5 mg/L BOD_5 from glycol in the SARWWTP influent, it can be inferred that the target concentration of 5 mg/L BOD_5 from glycol in the plant influent is equivalent to a maximum BOD_5 contribution from ABIA of 2.5% of the total influent BOD_5 to Train B. However, due to the 8-hour discharge procedure used at ABIA, the actual short-term percentage of BOD_5 loading contributed to the SARWWTP influent BOD_5 from ABIA could be much greater than 2.5% during discharge events, particularly if the discharge occurred during a low-flow period at SARWWTP. In the absence of a previously acclimated biomass, this short term loading could contribute to the potential for treatment process upsets.

SARWWTP Train B influent has been subject to high influent BOD_5 slug loadings, which exceeded 90,000 lbs/day in 2002-2003, and again in 2005-2006. These BOD_5 slug loadings were more than 55,000 lbs/day higher than the average influent BOD_5 loading. These events are a potential cause of process upset symptoms noted by SARWWTP staff.

The largest historical single-day discharge of BOD_5 from ABIA to SARWWTP was about 5,600 lbs/day, which took place in 2000-2001 as a result of an uncontrolled discharge. During BOD_5 slug loading events in 2002-2003 and 2005-2006 when the BOD_5 loading in the Train B influent exceeded 90,000 lb/day, the controlled discharges of glycol-contaminated runoff from ABIA to SARWWTP Train B were limited to a maximum BOD_5 loading of 1,946 lbs/day during the 2002-2003 deicing season, and 1,110 lbs/day in 2005-2006. These maximum loads discharged from ABIA in 2002-2003 and 2005-2006 account for only 3.5% of the 55,000 lb/day excess BOD_5 during slug loading events to Train B in 2002-2003, and 2% of the excess BOD_5 slug loading during 2005-2006. Based on this data, the glycol-contaminated discharges from ABIA were not responsible for the maximum BOD_5 slug loadings to the Train B influent.

The Train B influent TSS loading data during the study period did not show a clear increasing trend since TSS values tended to be lower in 2003-2004 than in 2002-2003 or 2005-2006. BOD_5 slug loads to the Train B influent appear to have been associated with very high influent TSS slug loads. Peak TSS loads and concentrations associated with the maximum BOD_5 slug loads to the Train B influent far exceed the TSS contribution from discharges from ABIA. This further supports the assessment that the highest BOD_5 slug loadings to SARWWTP Train B have been produced by a source other than ABIA discharges.

The 1995 Capacity Assessment and Re-Rating Recommendations study[4] included historical influent TSS data indicating that the average influent TSS concentration for Train B from 1990 through 1993 was 177 mg/L, and the historical maximum month influent TSS concentration during the same period was 359 mg/L, including the effects of plant recycle flows. During the winter of 2005-2006, the Train B influent average TSS concentration of 405 mg/L was 129% higher than the average TSS concentration for 1990 through 1993. During the same period, the Train B influent average TSS concentration was also 13% greater than the historic maximum month TSS concentration during 1990 through 1993.

Similar to BOD_5, Train B influent NH_3-N loads increased during the study period. The winter seasonal average NH_3-N loading increased from 2,790 lbs/day in 2002-2003 to 3,200 lbs/day in 2005-2006, representing a 15% increase over the study period.

High slug loadings of NH_3-N to the SARWWTP Train B influent exceeded 5,500 lbs/day during 2002-2003 and 6,700 lbs/day in 2005-2006, apparently in conjunction with the high slug loadings of BOD_5 and TSS. This provides further confirmation that the maximum loadings events placing the greatest stress on the Train B treatment process were not primarily associated with the controlled discharges of glycol-contaminated stormwater runoff from ABIA, although the presence of these slug loads may have compromised the ability of the Train B biological treatment process to provide robust treatment for the ABIA discharges.

ABIA does not test glycol- contaminated runoff for NH_3-N, since the ADF/AAF products used at ABIA typically are not known to contain ammonia or organic nitrogen compounds, and since pavement deicing events (during which ABIA uses urea, a source of ammonia nitrogen) have reportedly been limited to less than 100 gallons applied during the entire study period.

Overall, the historical Train B influent loading and concentration data reviewed by TCB indicated that ABIA's NH_3-N and TSS contributions to the SARWWTP influent loads have been minimal, and that potential impacts of discharges from ABIA to the SARWWTP influent BOD_5 loading has been managed effectively by controlling discharges from ABIA using the equation developed in the 2002 ABIA-SAR Glycol Treatability Study. The BOD_5:NH_3-N ratio in the SARWWTP influent during the study period was typically around 10, and the BOD_5:TSS ratio was around 1.0, both of which are within the range of typical ratios for municipal raw sewage.

However, the loading and concentration data reviewed by TCB indicated that BOD_5, TSS, and NH_3-N loading to Train B during winter months increased between December 2002 and August 2006. The data also indicated that the influent BOD_5, TSS, and NH_3-N concentrations all exceeded the assumptions of the 1995 Capacity Assessment and Re-Rating Report. Since the data set reviewed for this study was not comprehensive, a full review of influent flows and concentrations would be needed to confirm this trend.

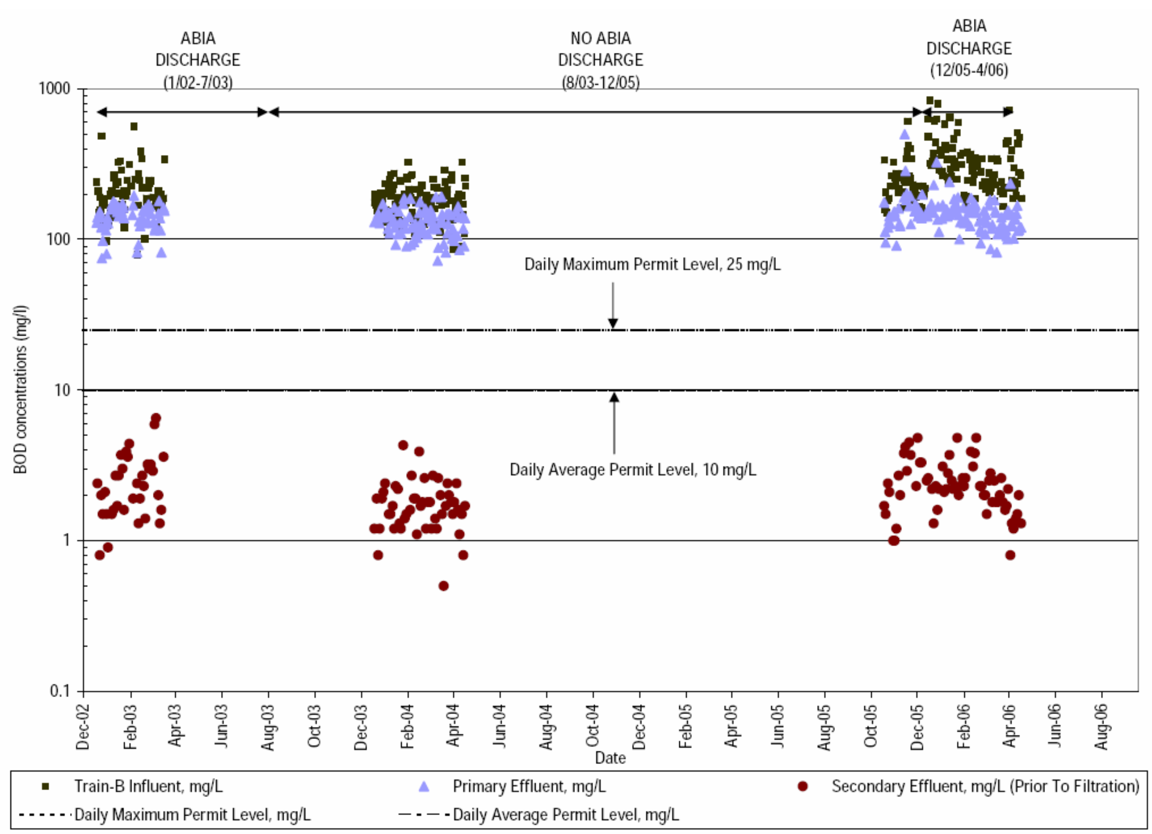
Lastly, the data indicated that SARWWTP Train B was subject to slug loadings of extremely high influent BOD_5, TSS, and NH_3-N which in some cases coincided with discharges from ABIA, but which were not consistent with the levels of these water quality parameters in the glycol-contaminated runoff discharged from ABIA during the same period.

SARWWTP Plant Performance

SARWWTP plant performance was evaluated based on the plant's overall ability to treat the influent raw sewage and discharge treated effluent meeting permit requirements. To assess the performance of treatment process units within the WWTP, concentration profiles were created for BOD_5, TSS, and NH_3-N through the liquid treatment train. The profiles were based on data collected at the following locations along the treatment train: raw influent, primary clarifier effluent (D-BOX), and final clarifier (secondary) effluent (FINALCLAR1,2). The locations of each of these sampling points are shown in Figure 2. The primary clarifiers, aeration basins, and secondary clarifiers represent the key facilities responsible for removal of BOD_5, TSS, and NH_3-N. It is critical that each of these facilities perform to their design levels to allow the plant to meet the permitted effluent limits.

Figure 5 presents a BOD_5 profile showing concentrations of influent, primary effluent, and secondary effluent during the study period. Figure 6 shows similar data for TSS, and Figure 7 for NH_3-N. These concentration profiles show that the unit processes within SARWWTP have performed well in removing BOD_5, TSS and NH_3-N during discharges of glycol-contaminated stormwater from ABIA, despite periodic slug loadings of BOD_5, TSS and NH_3-N from sources other than the ABIA discharges.

Figure 5 - Train B BOD Concentration Profile



This treatment process performance is confirmed by SARWWTP having reliably met permitted effluent requirements during the study period. Secondary effluent daily BOD_5 concentrations typically varied between 1 mg/L and 5 mg/L, meeting permitted effluent quality limits prior to filtration. As shown in Figure 6, secondary effluent daily TSS concentrations were often greater than 5 mg/L prior to filtration, and occasionally ranged up to 16 mg/L. This data indicates that while secondary effluent TSS readily meets daily average and daily maximum permitted effluent limits (15 mg/L and 40 mg/L), the effluent filters play an important role in further reducing the secondary effluent TSS to meet the permitted annual average TSS limit of 5 mg/L.

Figure 6 - Train B TSS Concentration Profile

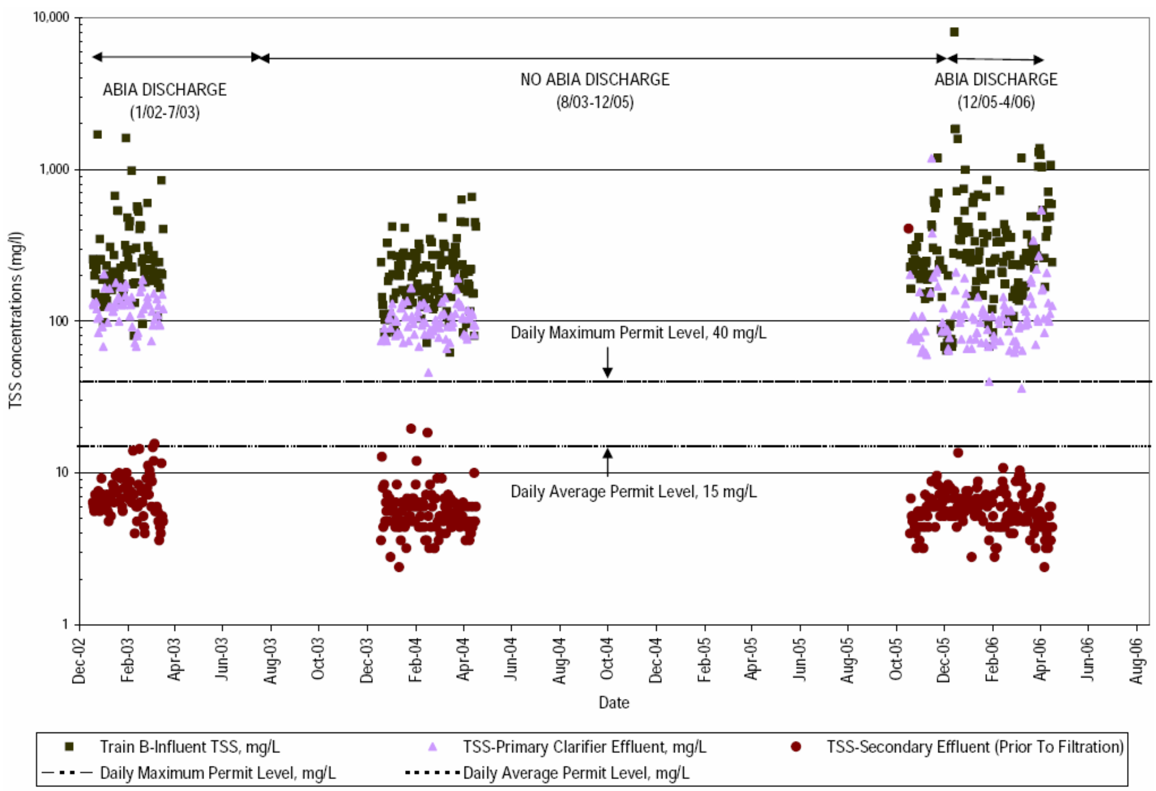
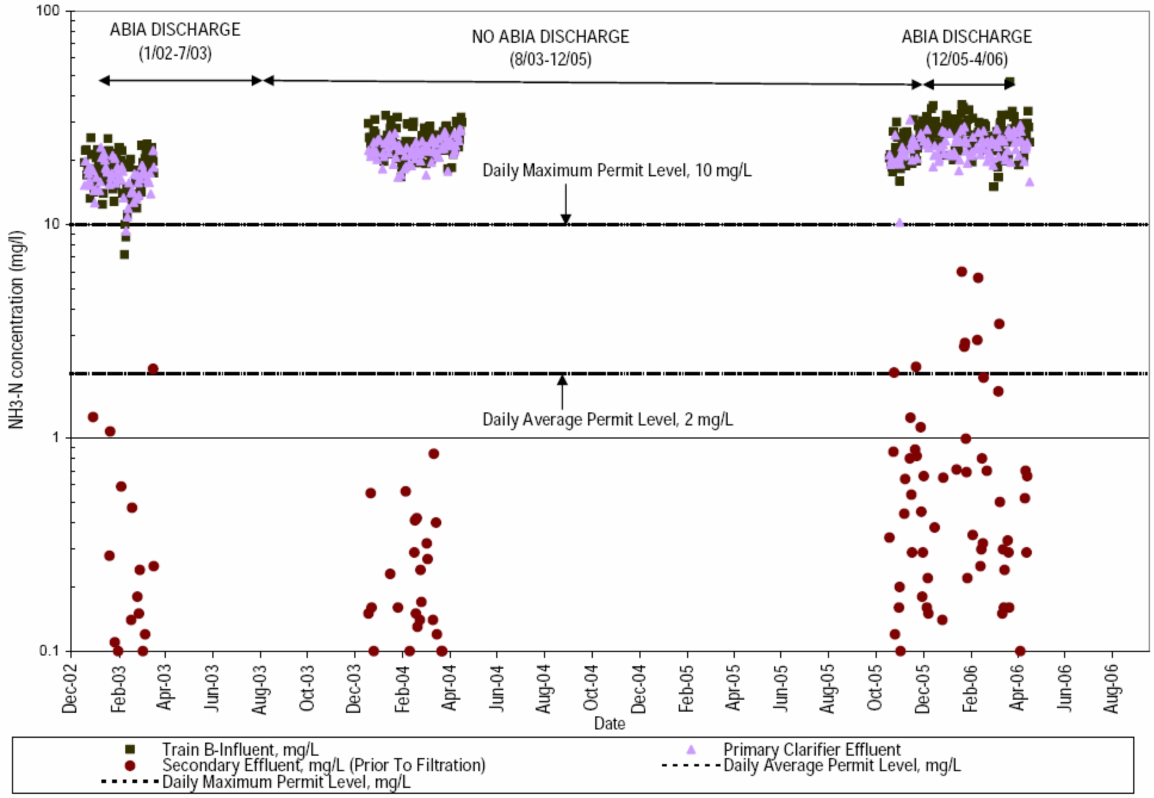


Figure 7 indicates that the secondary effluent daily NH_3-N concentration was highly variable. NH_3-N was lower during the winter of 2003-2004 than during 2002-2003 or 2005-2006, with the highest values occurring in 2005-2006, ranging at times up to 6 mg/L. The data tend to confirm SARWWTP staff's concern that the nitrification process in Train B has been increasingly stressed, although SARWWTP still met the permitted annual average and daily average 2 mg/L effluent quality limit and daily maximum limit of 10 mg/L for NH_3-N. While this apparent stress on the nitrification process occurred during a period of controlled discharges from ABIA, 2005-2006 also was a period of pronounced cold weather (as evidenced by the increased deicing activity and discharges from ABIA), and had the highest BOD_5, TSS, and NH_3-N daily loads during the study period, with very high slug loads in all three categories. Figure 7 tends to confirm that the nitrification process performance was somewhat less robust during 2005-2006 than in previous years, but does not clearly establish the cause of the decline in performance.

Figure 7 - Train B NH3-N Concentration Profile



Nitrification

SARWWTP uses a single-stage activated sludge biological process to remove NH_3-N. Key parameters that affect nitrification rates include alkalinity, pH, DO, temperature, BOD_5:TKN ratio, hydraulic retention time; Solids Retention Time (SRT) and inhibitory compounds in the influent wastewater. In Central Texas, alkalinity is typically high in natural waters and in raw wastewater, providing a relatively stable pH. SARWWTP currently does not monitor or calibrate biological reactor performance based on alkalinity or pH. SARWWTP maintains DO concentrations in the aeration basins consistently between the 4-8 mg/L range, which indicates that DO was not a controlling factor for nitrification performance. Other factors such as SRT, MLSS, and F: M ratio that are monitored and controlled by SARWWTP are discussed below.

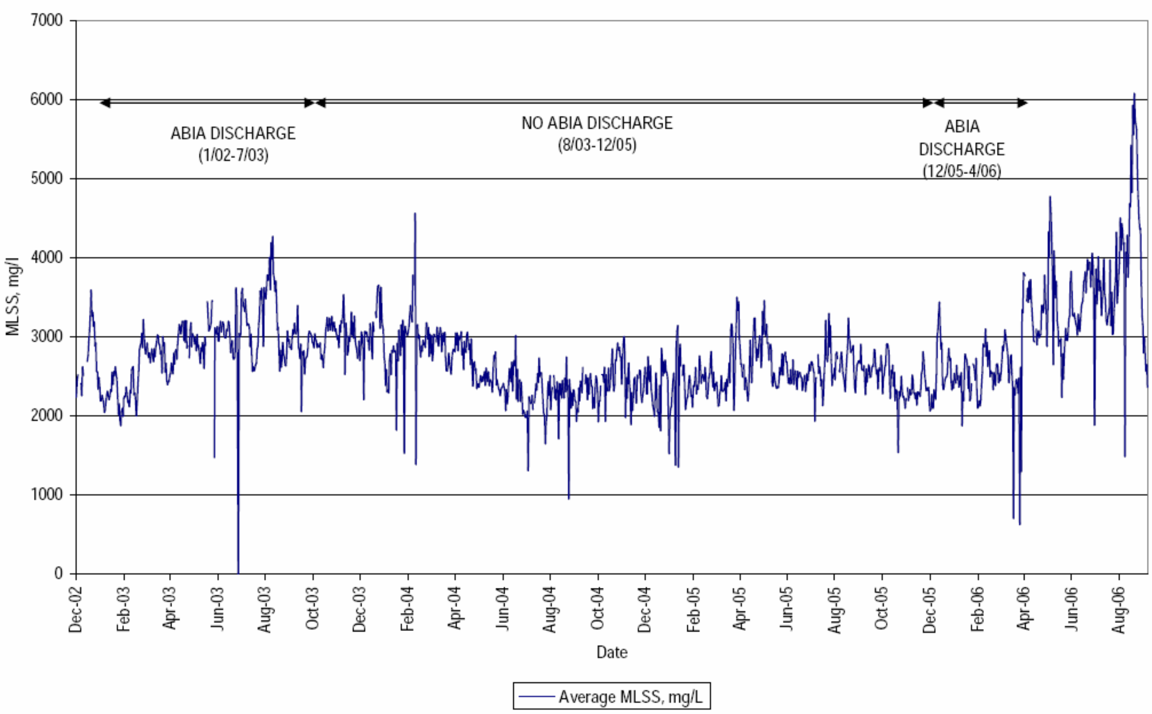
Solids Retention Time

SARWWTP typically maintains the SRT between 6-14 days during the winter. The sludge age is normally increased in response to an ABIA request to discharge to the plant. However, this is not for any purpose related to nitrification (since the discharges from ABIA to SARWWTP contain little if any ammonia nitrogen) but rather to assist in the acclimation process and to increase the amount of biomass that is available to remove the BOD_5 loading associated with the glycol-contaminated stormwater discharges from ABIA.

The SRT maintained in Train B was generally somewhat higher than in Train A, with occasional exceptions. The highest average SRT recorded in Train B was approximately 24 days in April 2003, during which month ABIA discharged approximately 16,500 lbs of BOD_5 to SARWWTP. While such data tend to confirm a correlation between increased SRT and loading from ABIA, the data do not indicate any adverse impacts to the nitrification process due to SRT being deliberately increased during ABIA discharge events. On the contrary, increased SRT would be expected to favor nitrification.

Figure 8 shows Mixed Liquor Suspended Solids (MLSS) concentrations in the Train B aeration basins. Based on a review of the data, SARWWTP staff has typically operated Train B at an MLSS concentration between 2,000 and 3,000 mg/L during warm months, and increased the MLSS concentrations to between 3,000 mg/L and 4,000 mg/L during winter conditions. Similar to SRT, MLSS concentrations were generally higher during ABIA discharge events, but peaks were also observed in the absence of any discharges from ABIA. Increasing the SRT and MLSS in anticipation of discharges from ABIA and during these discharges is an appropriate step in acclimating the biomass to the glycol-contaminated runoff.

Figure 8 - Train B MLSS Concentrations



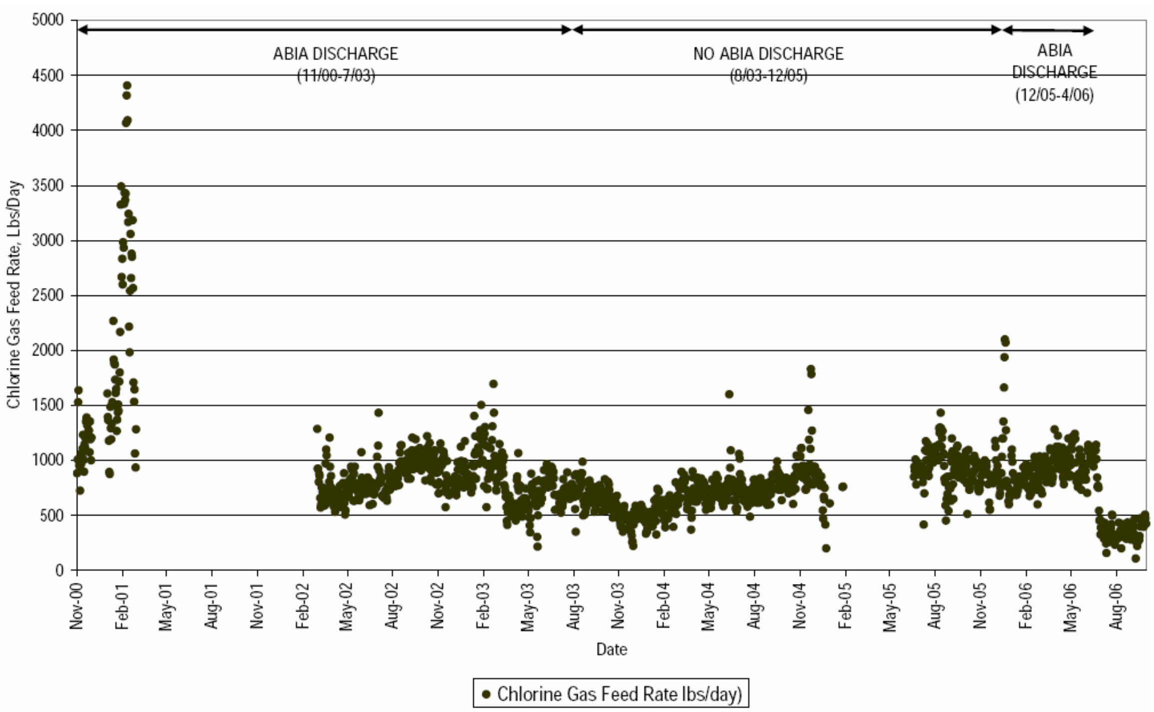
Closely related parameters to SRT and MLSS are solids inventory and Food to Microorganism ratio (F:M). Occasional peaks in the solids inventory were observed concurrent with discharges from ABIA, but in general the inventory stayed in the 40,000 to 80,000 pounds range. The highest sludge inventory of approximately 82,000 pounds was observed in February 2006. During this month the total BOD_5 contribution from ABIA was approximately 2,200 pounds, which was relatively small compared to Train B's influent BOD_5 loading.

F:M ratio is the estimated ratio of the mass of "food" introduced into a biological reactor each day to the mass of microorganisms present in the biological treatment process. F:M depends equally on both the mass of organisms present in the activated sludge, and the mass loading characteristics of the influent. The data indicate that F:M was maintained between 0.1 and 0.25, within the normal range for activated sludge treatment processes (0.05 to 1.0). The F:M ratio in Train B was generally lower than in Train A, which is consistent with Train B operating at a longer SRT and higher MLSS. The data do not identify a discernable impact of discharges from ABIA on the F:M ratio in Train B.

Chlorine Demand

Figure 9 shows chlorine demand in the SARWWTP Train B chlorine contact basins effluent (at the J-BOX B sample location as shown on Figure 2). Very high chlorine demands (4,500 lbs/day) occurred during the process upset condition in early 2001, associated with uncontrolled discharge of glycol-contaminated runoff from ABIA to SARWWTP.

Figure 9 - Train B Chlorine Demand



Since the SOP was adopted to control the daily quantities of glycol contaminated runoff from ABIA to SARWWTP, no comparable spikes in chlorine demand have been observed during 2002-2006. Smaller peaks (up to 1,500 lbs/day) were observed to occur both during periods of discharges from ABIA to SARWWTP, and during periods without any discharges of glycol-contaminated runoff from ABIA to SARWWTP.

RESULTS AND FINDINGS

Using current management practices, the average flow contribution during discharge events from ABIA's glycol-contaminated stormwater has been less than 1 percent of Train B's overall daily average flow, and the average daily BOD_5 loading contribution during discharge events from ABIA's glycol-contaminated stormwater has been approximately 2.5 percent of Train B's overall daily average BOD_5 loading. However, since ABIA's discharges have occurred over a period of about 8 hours per day (8 a.m. to 5 p.m.), the short-term contribution from ABIA discharges to total Train B influent BOD_5 may be higher than 2.5 percent during these 8-hour daily discharge events.

Using current management practices, SARWWTP Train B has performed well during the study period and has successfully met its permitted effluent quality requirements while receiving glycol contaminated discharges from ABIA. The data review appeared to substantiate that the biological nitrification process in Train B was intermittently stressed in 2005-2006 as noted by the SARWWTP staff, based on effluent ammonia nitrogen (NH_3-N) and chlorine demands. However, spikes in chlorine demand also occurred in the absence of discharges from ABIA, and no direct correlation was observed between glycol-contaminated discharges from ABIA and nitrification in Train B.

The average primary clarifier effluent BOD_5 loading to the SARWWTP Train B aeration basins (based on data furnished between January 2003 and May 2006) was 18,600 lbs/day. This loading correlates to approximately 98 percent of the BOD_5 loading rate of 26.7 lbs/day/1,000 ft^3 (18,946 lbs/day) anticipated at the rated 25 mgd capacity of Train B, per the 1995 Capacity Assessment and Re-rating Recommendations report, but is only approximately 75% of the maximum BOD_5 loading of 35 lbs/day/1,000 ft^3, allowed by TCEQ Design Criteria for single-stage nitrification, which indicates that Train B was not organically overloaded on average relative to TCEQ design requirements. Influent concentrations of BOD_5, TSS, and NH_3-N to Train B are highly variable but have been increasing, and have become significantly greater than anticipated when Trains A and B were re-rated to a total treatment capacity of 50 mgd.

The Train B influent has been subject to intermittent high slug loadings of particulate BOD_5, TSS, and NH_3-N which are not attributable to discharges of glycol-contaminated runoff from ABIA, but which may have adversely impacted the performance of the treatment process. Based on the characteristics of the slug loads, it is suspected that the source may be plant recycle streams such as supernatant from gravity sludge thickeners.

The ratio of COD to BOD_5 in glycol-contaminated runoff at ABIA varied between 1.2 and 2.1, with an average value of 1.57. The COD:BOD_5 ratio can be conservatively estimated using 1.5 as a typical value for the purpose of controlling discharges of glycol-contaminated runoff from ABIA to SARWWTP.

Additional treatment capacity constructed in 2006 in the Train C expansion, and distribution of influent and recycle streams to all three treatment trains through the IFS will further improve the treatment of glycol-contaminated runoff from ABIA at SARWWTP.

RECOMMENDATIONS

Based on the data review and the study findings, TCB recommends that both ABIA and SARWWTP maintain the current close working relationship, including providing advance notice of anticipated discharge requests, and follow the current SOP prior to and during ABIA discharge events, with the following changes:

i. ABIA discharge glycol-contaminated runoff to be on a 24-hour-a-day basis, and control discharges to SARWWTP on the basis of flow rate (in gallons per minute) rather than daily maximum volume.

ii. Use a COD to BOD_5 ratio of 1.5 for the purpose of determining the discharge flow rate of glycol-contaminated runoff from ABIA.

iii. SARWWTP use the new IFS structure to proportionally distribute the influent flow to each of the three treatment trains, with the allowable total discharge of glycol-contaminated runoff from ABIA calculated based on the total SARWWTP influent flow rate.

iv. Control the flow rate of glycol-contaminated runoff from ABIA to SARWWTP to limit the concentration of BOD_5 from glycol in the SARWWTP influent to 5 mg/L or less for the first two weeks of the discharge event, and to 10 mg/L or less starting on the 15th day of the discharge event.

v. Use the following modified formula to determine the allowable discharge flow rate from ABIA:

$$Q_{ABIA}(gpm) = \frac{Q_{SAR}(MGD) * 1{,}000{,}000(gal/Mgal) * L(mg/L) * r}{1440(\text{min}/day) * C(mg/L)}$$

where:

Q_{ABIA} = Maximum Allowable ABIA discharge flow rate, gallons per minute
Q_{SAR} = SARWWTP Total Plant Influent Flow Rate, mgd (75 maximum)
L = Allowable BOD_5 concentration from glycol at SARWWTP
(5 mg/L for 1st 14 days of discharge event; 10 mg/L after 14 days)
r = Ratio of COD: BOD_5 (1.5)
C = COD in the ABIA pond water

vi. ABIA improve pumping facilities and dedicate resources in order to monitor and control discharge rates from the retention ponds during all times when discharge is occurring. The recommended facilities improvements include:

- Provide automatic flow control and monitoring.
- Provide automatic level measurement with data-logging capability on the retention ponds.

- Provide jockey pumps to allow better control of low flow discharges of very high-strength glycol-contaminated runoff.

In summary, Train B influent has been subject to slug loadings other than discharges from ABIA. TCB recommends that a study be conducted to evaluate potential in-plant sources such as recycling of sludge thickener supernatant, and to develop recommendations to minimize stress to the treatment process. If this investigation indicates that the source of slug loading is from the off-site collection system, additional study may be required to identify the source and arrange for pre-treatment. TCB also recommends that the design basis for the storage capacity of the retention ponds at ABIA (which are sized to capture the first half-inch of runoff from a storm event) be evaluated relative to practices at other airports, and that the potential for any upcoming regulatory changes that could impact the ABIA retention pond sizing be investigated.

REFERENCES

1. ABIA-SAR Glycol Treatability Study, Alan Plummer Associates, Inc. (2002).

2. ABIA Glycol Management Preliminary Assessment, Alan Plummer Associates, Inc. (2001).

3. South Austin Regional Wastewater Treatment Plant Expansion and Improvements Preliminary Engineering Report Technical Memorandum 6, Train C – Process, Turner Collie & Braden Inc. (now TCB INC.) in association with CH2M Hill (1997).

4. Capacity Assessment and Re-rating Recommendations for South Austin Regional Wastewater Treatment Plant, CH2M Hill (1995).