KERR-McGEE CHEMICAL LLC

Susan Crowley
Staff Environmental Specialist

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April 6, 2005

Mr. Nadir Sous
Nevada Division of Environmental Protection
1771 East Flamingo Dr.
Las Vegas, NV

Subject: Use of Ferrous Sulfate for Reduction of Hexa-Valent Chromium

Dear Mr. Sous,

By this letter, Kerr-McGee Chemical LLC (Kerr-McGee) presents data from the successful test of augmenting the chromium remedial process (GWTP) with additions of ferrous sulfate solution. The ferrous sulfate addition has resulted in a GWTP capacity increase of about one third. GWTP treatment of about 20 gpm of water from the GW-11 pond along with normal interceptor well flows, has allowed the Fluidized Bed Reactors (FBRs) to operate near their design capacity in processing water to remove perchlorate.

Treatment of GW-11 water, while making GWTP operation slightly more difficult, is essential to reduce the pond level and provide storage capacity for any effluent from the biological treatment plant, which is not discharged directly to the wash. The high concentrations of chlorate and perchlorate in the GW-11 water have required somewhat higher levels of iron to destroy hexavalent chromium. Also, as the GW-11 water was introduced to the GWTP, chromium levels increased slightly from this process, but remain well below the 1986 Consent Order requirements for both total chromium and hexa-valent chromium. The GWTP effluent is not directly discharged, but goes to the FBRs for perchlorate reduction and no problems have been observed in meeting perchlorate process NPDES discharge permit limits for chromium or hexa-valent chromium.

In optimizing the GWTP operation, ferrous sulfate use has been found to have several advantages over operation of the original electrolytic cells. As noted in the attached report by Veolia Water North America, ferrous sulfate additions have improved GWTP operation by:

- Reducing the proportion of excess iron that would otherwise be required to account for declining electrolytic cell performance between daily acid cleanings,
- Simplifying process control,
- Reducing and potentially eliminating generation of hazardous wastes associated with daily sulfuric acid cleaning of the electrolytic cells.

Kerr-McGee requests that NDEP allow permanent use of ferrous sulfate additions at the GWTP to destroy hexavalent chromium. The electrolytic cells will be maintained in standby condition for use in the event of a problem with the ferrous sulfate system.

Thank you for your consideration. If you have questions or comments, please contact me at (702) 651-2234.

Sincerely,

Susan Crowley
Environmental Specialist

Express Mail Service

cc: KKBailey
PSCorbett
TLCubbage
D Shandy
FRStater
TWReed
Jeff Lambeth – Veolia WNA
Mary Cheung – Veolia WNA
Brad Dougherty – AIG
Tracy Hemmerling – Malcolm Pirnie
Tim Wolf - Malcolm Pirnie
Todd Croft – NDEP
Brian Rakvica – NDEP

Attachment

Smc/ ferrous sulfate permenate use to sous.doc

VEOLIA Water

VWNA Operating Services
Kerr McGee – Henderson, Nevada

6 April 2005

To: Susan Crowley, Environmental Specialist Henderson Facility
Keith Bailey, Corporate Environmental Group
Kerr-McGee Chemical LLC
Henderson, NV

FROM: Jeff Lambeth

cc: Norm Davis, Gerald Smart, Mark Minter, Mary Cheung

SUBJECT: Groundwater Treatment Plant – Test of Augmenting Electrolytic Chromium Reduction Process with Ferrous Sulfate Solution

Summary

This report covers the successful test augmenting capacity of the Kerr-McGee Chemical LLC (Kerr-McGee) Groundwater Treatment Plant (GWTP) with additions of ferrous sulfate solution. The GWTP was designed to use electrolytic dissolution of iron as the source of ferrous ions to precipitate hexavalent chromium. Limitations of electrolytic cell capacity, however, restricted flow through the system. Ferrous sulfate additions have allowed the plant to meet performance requirements and offer the potential to significantly improve long term GWTP performance.

In order to complete the contractually required Performance Demonstration on the new Fluidized Bed Reactor (FBR) perchlorate biological treatment system, Veolia Water North America (Veolia) was required to operate the FBRs near their design capacity. Additional water containing high concentrations of perchlorate, chlorate and nitrate, beyond the existing groundwater well and Seep surface flows, was needed to achieve the desired FBR loading. At the same time, Kerr-McGee sought to maximize treatment of water from the GW-11 pond to free up emergency effluent storage capacity. In addition to perchlorate and chlorate, the GW-11 pond water contained small quantities of hexavalent chromium and required treatment by the GWTP before it could be introduced to the FBR feed system.

Limitations on the existing GWTP electrolytic cells, which generate ferrous iron solution from iron plates, restricted flow through the GWTP. Approval was sought and received from the Nevada Division of Environmental Protection (NDEP) to test supplementing GWTP electrolytic cell operation with direct additions of ferrous sulfate solution (see NDEP letter to Susan Crowley dated April 1, 2004). The test of ferrous sulfate additions has been successful and has allowed

the GWTP to treat over 80 gpm of combined interceptor well and GW-11 water. GWTP effluent concentrations of hexavalent chromium have been near the 0.01 mg/L GWTP limit for direct discharge, though the water is not discharged until it has left the FBRs.

Veolia supports continued use of the ferrous sulfate addition system to augment GWTP capacity. Complete replacement of the electrolytic cells with ferrous sulfate additions would also offer several benefits including improved process control and reduced generation hazardous waste (associated with required electrolytic cell cleaning). Operation of the GWTP with ferrous sulfate, while maintaining the electrolytic cells as a backup system if the ferrous sulfate feed pumps have a problem, appears to be the most effective option for the plant.

Details

The GWTP converts soluble hexavalent chromium to insoluble trivalent chromium by reaction with ferrous iron. The trivalent chromium solids are separated from the water stream in an inclined plate clarifier and are filtered before being shipped to a landfill. As originally designed, the GWTP system generated ferrous iron by electrolytically dissolving iron plates. Limitations on the electrolytic cell capacity prompted testing of liquid ferrous sulfate additions.

Prior to the full scale GWTP tests, Veolia conducted a series of laboratory tests to determine the effectiveness of ferrous sulfate augmentation and the appropriate dosage rates based on the hexavalent chromium concentrations in the GWTP feed stream. These tests indicated that ferrous iron additions about twice the stoichiometric requirement were needed to effectively destroy the hexavalent chromium:

$$Cr_2O_7^{-} + 6\,Fe^{++} + 14\,H^{+} \Leftrightarrow 2\,Cr^{+++} + 6\,Fe^{+++} + 7\,H_2O \text{ and}$$

$$1\text{mg}Cr^{6+} \times \frac{\text{mol } Cr^{6+}}{52\text{ mg } Cr^{6+}} \times \frac{3\text{ mol } Fe^{2+}}{\text{mol } Cr^{6+}} \times \frac{55.8\text{mg } Fe^{2+}}{\text{mol } Fe^{2+}} = 3.2\text{ mg } Fe^{2+}$$

Lab tests on a blend of on-site well water and water from the GW-11 pond showed that the higher concentrations of chlorate and perchlorate in the pond water made it somewhat more difficult to precipitate the hexavalent chromium. The tests demonstrated, however, that the GWTP could achieve the 0.01 mg/L NPDES discharge level. Since sulfate levels in the site groundwater are in the 2,000 mg/L range, the small quantity of sulfate contained in the ferrous sulfate solution does not appreciably alter the GWTP effluent sulfate concentration.

Following the lab tests and receipt of NDEP approval to augment the electrolytic process, an LMI metering pump was installed to control the addition of ferrous sulfate solution to the GWTP from commercially supplied 300 gallon totes. The ferrous sulfate metering pump was equipped with a flow switch connected to the GWTP control system to warn the operator in the event of loss of flow. Additional indicators and controls were installed at the GWTP in November 2003 to improve the overall operability of the system, these controls and the ferrous sulfate feed pump system are displayed in the process flow diagram (Attachment A).

Prior to starting the ferrous sulfate augmentation test run, the GWTP was run according to the normal operating plan. Combined flows from the east and west on-site interceptor wells were fed at approximately 60 gpm. Veolia began ferrous sulfate augmentation on 4/20/04 while maintaining GWTP feed flow at approximately 60 gpm. The GWTP ferrous iron generation system (electrolytic/ferrous sulfate) was balanced and optimized during the period 4/20 and 5/27. The electrolytic cell current was reduced as operators found that process control was improved with ferrous sulfate solutions. Daily degradation of cell performance prior to chemical cleaning was minimized by reducing the portion of iron generated by the cells and increasing the ferrous sulfate additions. Veolia introduced GW-11 pond water to the GWTP on 6/3 at approximately 2.0 gpm and continued to raise the rate through 9/23 to approximately 20 gpm to achieve required loading on the FBR system. Operating data for the GWTP prior to ferrous sulfate augmentation (1/1 to 4/20), ferrous iron optimization (4/20 to 5/27) and test data with ferrous sulfate augmentation for the period (6/2 to 9/23) are displayed in the data table (Attachment B):

As expected from the lab test data, the full scale GWTP operating data show that the mass loading and concentration of hexavalent chromium in the effluent increased slightly following the introduction of GW-11 pond water. The concentration of hexavalent chromium in the GWTP discharge was near the NPDES direct discharge limit of 0.01 ppm.

Through the process of balancing ferrous iron generated by the electrolytic process and ferrous iron generated from ferrous sulfate solution Veolia operators attempted to optimize the GWTP operation. We learned that the system can be operated with little or no contribution from the electrolytic process and that by doing so, the process was more easily controlled. Daily variations associated with electrolytic cell operation previously required that the cells be operated to generate excess iron in order to guarantee that sufficient iron was available when the cell performance degraded. Daily chemical cleaning required that a cell be shut down and generated approximately 10 gallons per day of spent sulfuric acid cleaning solution requiring disposal as hazardous waste. During the initial test period (approximately 5/3 to 9/23) when the electrolytic cells were adjusted to minimum current flow and total ferrous sulfate addition, the GWTP effluent hexavalent chromium concentration remained near the NPDES discharge limit of 0.01 mg/L. It should be noted that: the GWTP effluent is currently being sent to the FBRs where further chromium reduction is possible.

Since September of 2004 the feed rate to the GWTP has been steadily increased due to the desire to lower GW-11 levels and with seasonal variations which resulted in an increase in flow from the interceptor wells. With peak flows in January and February the hydraulic limits of the GWTP system were challenged, but with the ferrous sulfate addition the effluent hexavalent chromium concentration was maintained near the NPDES permit limit of 0.01 mg/l. Refer to Attachments C and D.

Operation of the GWTP solids separation and filtration equipment remained the same throughout the test. A slight increase in the volume iron hydroxide filter cake was observed due to the increased loading to the GWTP.

Recommendations

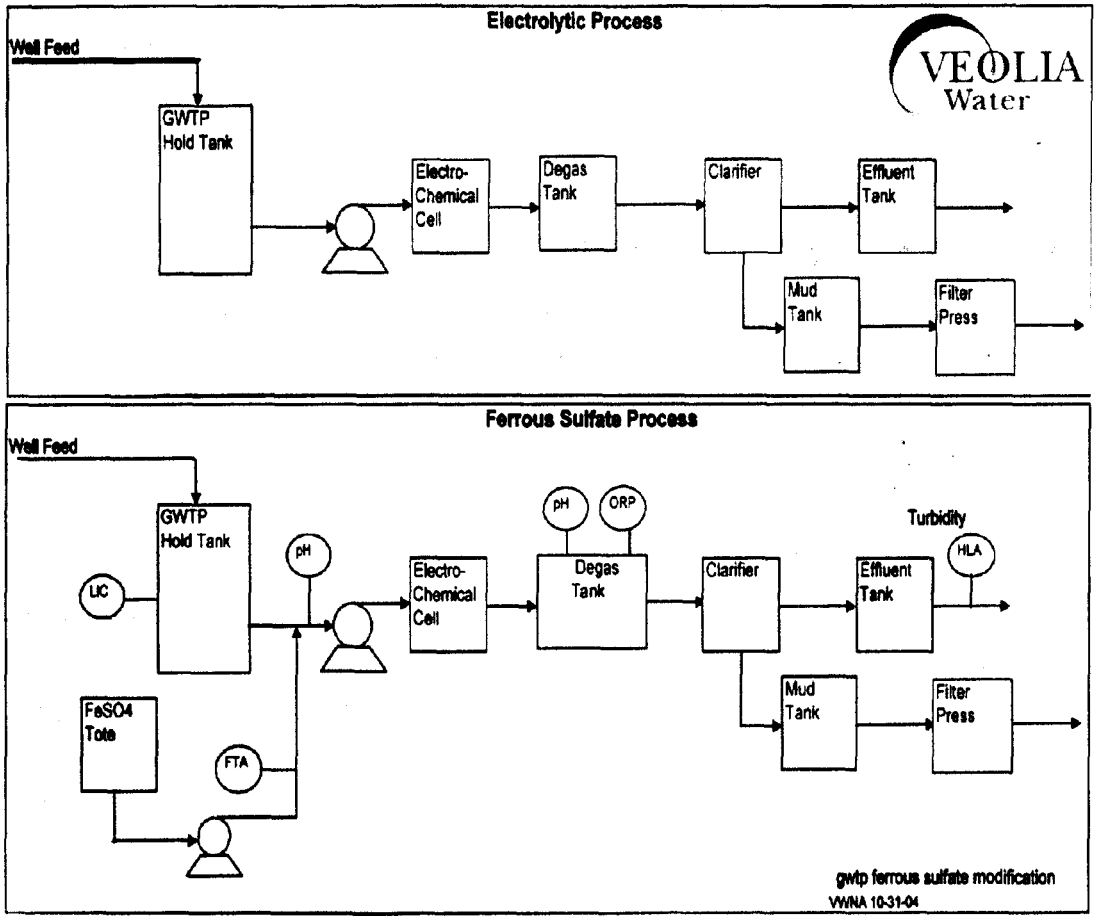
Augmentation of the GWTP electrolytic process with additions of ferrous sulfate solution met test expectations for increased water treatment. Reliable effluent quality was achieved while improving GWTP operability and reducing generation of hazardous wastes. Veolia recommends that Kerr-McGee approach NDEP regarding a permanent change to ferrous sulfate additions. The electrolytic ferrous iron generation equipment should remain in place as a backup if needed.

Sincerely,

Jeff Lambeth
Project Manager
Veolia Water North America

Attachment A

GWTP Process Flow Diagram



Attachment B

Veolia Water - GWTP Ferrous Sulfate Supplemental Treatment Operating Data

Date	GW-11 Pond Water Feed (gpm)	GWTP East Feed (gpm)	GWTP West Feed (gpm)	GWTP East/West Feed (gpm)	GWTP Total Discharge (gpm)	FeSO4 Feed Rate (ml/min)	Cell Current (amps)	GW-11 Pond Water Feed Cr6+ (ppm)	GWTP East Feed Cr6+ (ppm)	GWTP East Feed Total Cr (ppm)	GWTP West Feed Cr6+ (ppm)	GWTP West Feed Total Cr (ppm)	GWTP Eff pH (su)	GWTP Influent Cr6+ (ppm)	GWTP Eff Cr6+ (ppm)	GWTP Eff Total Cr (ppm)	GWTP Eff Perchlorate (ppb)	GWTP Cr6+ removal: mass of Cr6+ influent (lbs/day)	GWTP Cr6+ removal: mass of Cr6+ effluent (lbs/day)
1/2/2004	0.00	42.29	14.10	56.39	56.39			2.0	19.40	19.00	3.00	3.50	7.62	15.30	0.003	0.370	1,400,000	10.36	0.00
1/8/2004	0.00	43.44	14.48	57.92	57.92			2.0	18.90	19.00	3.40	3.40	7.28	15.03	0.049	0.290	1,300,000	10.45	0.03
1/15/2004	0.00	43.49	14.50	57.99	57.99			2.0	17.60	16.00	3.70	3.70	7.40	14.13	0.003	0.240	1,300,000	9.84	0.00
1/22/2004	0.00	44.79	14.93	59.72	59.72			2.0	17.60	18.00	3.30	3.30	7.71	14.03	0.009	0.120	1,400,000	10.06	0.01
1/29/2004	0.00	44.90	14.97	59.86	59.86			2.0	18.80	18.00	3.70	3.60	7.82	15.03	0.003	0.120	1,300,000	10.80	0.00
2/5/2004	0.00	43.85	14.62	58.47	58.47		51	2.0	17.90	17.00	3.90	3.80	7.45	14.40	0.007	0.280	1,300,000	10.11	0.00
2/12/2004	0.00	42.86	14.29	57.15	57.15		51	2.0	17.50	18.00	3.80	3.90	7.66	14.08	0.003	0.130	1,300,000	9.66	0.00
2/17/2004	0.00	42.24	14.08	56.32	56.32		52	2.0	19.00	19.00	3.20	3.30	7.47	15.05	0.003	0.120	1,300,000	10.18	0.00
2/27/2004	0.00	43.23	14.41	57.64	57.64		51	2.0	19.30	19.80	3.10	3.10	7.77	15.25	0.003	0.120	1,300,000	10.56	0.00
3/4/2004	0.00	43.91	14.64	58.54	58.54		51	2.0	19.20	19.00	3.60	3.30	7.51	15.30	0.003	0.160	1,300,000	10.76	0.00
3/11/2004	0.00	44.74	14.91	59.65	59.65		52	2.0	17.80	17.00	3.80	3.50	7.90	14.30	0.003	0.110	1,400,000	10.24	0.00
3/18/2004	0.00	45.47	15.16	60.63	60.63		53	2.0	18.20	18.00	3.50	3.50	7.63	14.53	0.003	0.110	1,300,000	10.58	0.00
3/25/2004	0.00	40.16	13.39	53.54	53.54		52	2.0	18.40	18.00	3.60	3.50	7.58	14.70	0.003	0.078	1,300,000	9.45	0.00
4/1/2004	0.00	13.44	4.48	17.92	17.92		52	2.0	18.20	18.00	4.10	3.50	7.62	14.68	0.003	0.110	2,400,000	3.16	0.00
4/9/2004	0.00	42.24	14.08	56.32	56.32		52	2.0	18.10	18.00	3.80	3.50	7.58	14.48	0.003	0.130	1,400,000	9.79	0.00
4/15/2004	0.00	41.87	13.96	55.83	55.83		52	2.0	18.80	19.00	3.30	2.30	7.56	14.93	0.003	0.094	1,300,000	10.01	0.00
								Ferrous Sulfate Injection Start Up											
4/20/2004	0.00	0.00	0.00	0.00			52	2.0					7.40					0.00	0.00
4/21/2004	0.00	0.00	0.00	0.00			35	2.0					6.86					0.00	0.00
4/22/2004	0.00	42.76	14.25	57.01	57.01		25	2.0	18.10	18.00	3.40	3.40	7.43	14.43	0.003	0.200	1,400,000	9.88	0.00
4/29/2004	0.00	44.33	14.78	59.10	59.10	192	5	2.0	19.10	18.00	3.40	3.20	6.32	15.18	0.003	0.170	1,200,000	10.77	0.00
5/6/2004	0.00	42.50	14.17	56.67	56.67		3	2.0	19.40	19.00	3.10	3.10	6.84	15.33	0.003	0.160	1,300,000	10.43	0.00
5/13/2004	0.00	41.04	13.68	54.72	54.72	170	2	2.0	18.90	19.00	3.30	3.20	6.36	15.00	0.003	0.087	1,300,000	9.86	0.00
5/20/2004	0.00	43.91	14.64	58.54	58.54	170	2	2.0	19.40	19.00	3.20	3.10	6.49	15.35	0.003	0.089	1,200,000	10.79	0.00
5/27/2004	0.00	44.54	14.85	59.38	59.38	170	2	2.0	18.90	18.00	3.20	3.20	6.38	14.98	0.003	0.180	1,300,000	10.68	0.00
								Introduction of GW-11 Pond Water											
6/3/2004	2.98	42.87	14.29	57.16	60.14	170	2	2.0	21.70	20.00	3.80	3.40	6.52	16.42	0.010	0.140	1,400,000	11.86	0.01
6/10/2004	3.13	41.56	13.85	55.41	58.54	145	2	2.0	20.80	19.00	3.60	3.40	6.54	15.72	0.020	0.150	1,400,000	11.06	0.01
6/17/2004	2.92	40.10	13.37	53.47	56.39	160	2	2.0	19.50	19.00	2.90	3.00	6.40	14.63	0.013	0.019	1,400,000	9.91	0.01
6/24/2004	8.03	43.14	14.38	57.53	65.56	170	2	2.0	18.30	19.00	2.90	3.50	6.49	12.92	0.015	0.140	1,400,000	10.18	0.01
7/1/2004	11.72	43.09	14.36	57.45	69.17	165	2	2.0	17.60	19.00	2.90	3.20	6.52	11.90	0.090	0.250	1,400,000	9.89	0.07
7/8/2004	12.08	42.09	14.03	56.11	68.19	160	2	2.0	21.10	20.00	3.20	3.30	6.40	14.03	0.100	0.170	1,400,000	11.49	0.08
7/15/2004	11.72	48.29	16.10	64.39	76.11	173	2	2.0	18.40	19.00	2.90	3.00	6.48	12.60	0.025	0.240	1,300,000	11.51	0.02
7/22/2004	12.02	42.60	14.20	56.80	68.82	165	2	2.0	19.10	22.00	3.10	3.20	6.57	12.81	0.060	0.170	1,400,000	10.59	0.05
7/29/2004	12.01	40.78	13.59	54.36	66.39	160	2	2.0	18.00	18.00	3.90	3.60	6.43	12.22	0.050	0.260	1,400,000	9.74	0.04
8/5/2004	12.04	33.16	11.05	44.21	56.25	170	2	2.0	18.90	18.00	4.10	3.70	6.45	12.37	0.013	0.180	1,400,000	8.36	0.01
8/12/2004	0.00	41.82	13.94	55.76	55.76	160	2	2.0	16.60	19.00	2.80	3.20	6.30	14.65	0.025	0.150	1,400,000	9.81	0.02
8/19/2004	0.00	41.20	13.73	54.93	54.93	140	2	2.0	19.20	19.00	3.60	3.20	6.29	15.30	0.014	0.130	1,300,000	10.09	0.01
8/26/2004	0.00	42.45	14.15	56.60	56.60	120	2	2.0	18.60	20.00	2.60	3.30	6.29	14.60	0.040	0.160	1,300,000	9.92	0.03
9/2/2004	0.00	38.87	12.96	51.83	51.83	125	2	2.0	18.60	18.00	3.70	3.20	6.28	14.88	0.011	0.300	1,200,000	9.26	0.01
9/9/2004	21.53	36.93	12.31	49.23	70.76	140	2	2.0	17.90	17.00	3.30	3.20	6.39	10.52	0.050	0.210	1,400,000	8.94	0.04
9/16/2004	20.55	42.14	14.05	56.19	76.74	140	2	2.0	20.00		2.80	2.80	6.50	12.03	0.003	1.900	1,500,000	11.09	0.00
9/23/2004	19.60	39.31	13.10	52.41	72.01	150	2	2.0	17.00	18.00	3.00	3.20	6.28	10.37	0.011	0.480	1,500,000	8.97	0.01

Attachment C
GWTP Operating Data Sept 04 – Mar 05

GWTP (On-Site Chromium Remediation)

Date	Treated Water Flow (gpm)	Feed Cr+6 Conc. (ppm)	GWTP Fe Feed ml/min	Total Cr Wkly Comp (ppm)	Cr +6 Wkly Comp (ppm)	Monthly Average Cr6+ (ppm)
9/2/04	67.3	15.6	140.0	0.300	0.011	
9/9/04	67.3	15.0	145.0	0.210		
9/16/04	67.3	16.4	145.0	1.900	0.000	
9/23/04	67.3		145.0	0.480	0.011	
9/30/04	67.3	13.9	140.0	0.370	0.000	0.006
10/7/04	75.8	15.7	150.0	0.480	0.000	
10/14/04	75.8	16.5	145.0	0.530	0.012	
10/21/04	75.8	13.8	145.0	0.720	0.000	
10/28/04	75.8	17.5	155.0	0.780	0.000	0.003
11/4/04	80.1	15.9	150.0	0.960	0.000	
11/9/04	80.1	15.9	145.0	0.660	0.000	
11/11/04	80.1	15.9	150.0			
11/18/04	80.1	14.6	145.0	0.700	0.000	
11/26/04	80.1	13.7	155.0	0.890	0.000	0.000
12/2/04	81.6	15.3	170.0	1.200	0.000	
12/10/04	81.6	14.5	165.0	1.400	0.000	
12/16/04	81.6	14.4	150.0	1.600	0.000	
12/23/04	81.6	15.4	155.0	2.200	0.000	
12/30/04	81.6	12.1	160.0	1.000	0.012	0.002
1/6/05	97.2	15.4	160.0	0.700	0.011	
1/13/05	97.2	14.0	160.0	1.100	0.016	
1/20/05	97.2	14.2	155.0	1.400	0.000	
1/27/05	97.2	14.0	170.0	1.500	0.011	0.010
2/3/05	97.9	14.9	170.0	1.500	0.016	
2/10/05	97.9	15.5	165.0	1.200	0.016	
2/17/05	97.9	13.1	170.0	1.000	0.020	
2/24/05	97.9	15.5	170.0	0.930	0.020	0.018
3/3/05	90.8	15.4	165.0	0.720	0.010	
3/10/05	90.8	15.9	165.0	0.780	0.012	
3/17/05	90.8	15.1	165.0	0.780	0.000	0.007

Attachment D

GWTP Feed Rate and Effluent Quality