Appendix A Arid West Quality Research Project

A number of AWWQRP research projects have been completed or are in progress. A brief description of each follows:

- Pre-Research Survey of Municipal NPDES Dischargers in the Arid and Semi-Arid West (Discharger Survey) - This research was implemented following a recommendation that the Project survey as many arid West dischargers as possible to obtain information necessary to properly characterize arid West discharges and associated water quality concerns. A key finding of the resulting report, completed in March 2000, was that there was a general lack of data that effectively described effluent-dependent water habitats.
- Habitat Characterization Study - Based on the findings of the Discharger Survey, the Habitat Characterization Study was commissioned for the purpose of characterizing the physical, chemical and biological characteristics of selected effluent-dependent waters across the arid West. It is believed that this effort represents the first attempt to focus data gathering efforts on this type of aquatic ecosystem. The final report was published in winter 2002.
- Extant Criteria Evaluation - The primary focus of this project was to evaluate existing methods for generating federal ambient water quality criteria (AWQC), methods for site-specific modifications to criteria and, if appropriate, develop an approach for regional AWQC modification that takes into account the unique characteristics of ephemeral and effluent-dependent watercourses in the arid West. Four "model" AWQC, which represent different types of pollutants, were used as the basis for this evaluation: copper, selenium, diazinon and ammonia. The final report was completed with a limited publication in September 2003 and is expected to be published by the Society of Environmental Toxicology and Chemistry (SETAC) in 2005/2006.
- Evaluation of Whole Effluent Toxicity Testing as an Indicator of Aquatic Health - This recently initiated project is a collaborative research effort between the AWWQRP and the Water Environment Research Foundation (WERF, Project No. 03-ECO-2). WERF is managing and directing the research project. The AWWQRP, as a collaborative partner, is contributing research funds and technical oversight. The objectives of this pilot study include identifying which biological assemblages should be sampled to assess effluent impacts, appropriate sampling methods for macroinvertebrates, and determining if proposed data and measurement quality objectives are achievable on a regular basis. The project will be completed in 2006.
- Evaluation of the Reliability of the Biotic Ligand Model (BLM) Predictions for Copper Toxicity in Waters Characteristic of the Arid West - The focus of this newly initiated research project is a series of studies designed to further evaluate the reliability

of the BLM to predict copper toxicity in arid West waters. Additionally, a series of tests to further evaluate the different roles of calcium vs. magnesium in controlling copper toxicity to invertebrates and fishes will also be conducted. This project will be completed in late 2005.

- Use of EPA Recalculation Procedure in Arid West Effluent-Dependent Waters – The contract for this work is in the final approval stage. The research will include pilot studies on selected arid West effluent-dependent waters and the development of a resident species list for each of those sites. An evaluation of the appropriateness of species in the EPA toxicity database and identification of arid West species which would improve the effectiveness of using the Recalculation Procedure in the pilot study sites will be conducted.
- Water-Effect Ratio (WER) for Ammonia to Take Into Account Local or Regional Water Quality Characteristics in Arid West Effluent-Dependent Waters – Project will soon be initiated to conduct WER tests with selected species to evaluate acute ammonia toxicity under varying water quality conditions (e.g., hardness, alkalinity, pH, anions, cations, and temperature) representative of arid West effluent-dependent waters.

Appendix B PCWWM Facility Plan Permit Information

AIR QUALITY

The Environmental Protection Agency has promulgated primary and secondary National Ambient Air Quality Standards (NAAQS) for six criteria pollutants (carbon monoxide, nitrogen dioxide, particulate matter, ozone, sulfur dioxide, and lead). Primary standards are adopted to protect public health. Secondary standards are adopted to protect public welfare. States are required to adopt ambient air quality standards, which are at least as stringent as the federal NAAQS, however, the state standards may be more stringent. Arizona has adopted the federal NAAQS as indicated in the following table:

State and Federal Ambient Air Quality Standards

Pollutant		Averaging Time	Primary Standard	Secondary Standard
Carbon Monoxide (CO) in parts per million (ppm)		1-hr 8-hr	35 9	--- ---
Nitrogen Dioxide (NO_2) in ppm		Annual	0.05	0.05
Particulate Matter (micrograms per cubic meter)	PM_{10} [a]	24-hr Annual	150 50	150 50
	$PM_{2.5}$ [b,c]	8-hr[c] Annual[c]	65 15	--- ---
Ozone in ppm		1-hr 8-hr[c]	0.12 0.08	0.12 ---
Sulfur Dioxide (SO_2) in ppm		3-hr 24-hr Annual	--- 365(0.14) 80(0.03)	1300(0.5) --- ---
Lead in micrograms per cubic meter		Calendar Quarter	1.5	1.5

[a] Particulate matter with a diameter of 10 microns or smaller
[b] Particulate matter with a diameter of 2.5 microns or smaller
[c] Federal standard implemented July 18, 1997

Title 17, Chapter 16, Article 160 of the Pima County Code covers air quality regulations for general fuel burning equipment that burns fuel for the primary purpose of producing power, steam, hot water, hot air or other liquids, gases or solids and in the course of doing so the products of combustion do not come into direct contact with process materials. When any products or by-products of a manufacturing process are burned for the same purpose or in conjunction with any fuel, the same maximum emission limitation shall apply.

The Ina Road WPCF is permitted and classified as a major source. A new permits for the existing major source is expected in early 2004. The Roger Road WWTP is currently permitted as a minor source. Additional emission monitoring may be necessary to confirm that Roger Road WWTP is still a minor source. The Pima County PCWWM also has two permits for portable engine generators.

CCTV EVALUATION, Aviation Corridor to Santa Cruz (ACSC) Interceptor Reaches, Condition Grade 4 Total
Pima County Wastewater Management Department, Systems Design Section

Project Name: INTERCEPTOR SEWER SYSTEM, CCTV ASSESMENT FINAL 180 MILES (NON-RCP)
Date : 3/30/2005

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
16	ACSC	141.9	9907-36	9907-35	4	1		207	24"	Pipe Failure, Hole from 11 to 12 o´clock	$37,000	CIPP
9	ACSC-T	131	8808-68	9885-49	4	1		188	20"	Pipe Failure, Hole from 10 to 11 o´clock	--	VCP
9	ACSC-T	147.8	8808-68	9885-49	4	1		188	20"	Pipe Failure, Broken, Soil Visible from 11 to 01 o´clock	--	VCP
9	ACSC-T	152	8808-68	9885-49	4	1		188	20"	Pipe Failure, Broken, Soil Visible from 11 to 01 o´clock	--	VCP
9	ACSC-T		8808-68	9885-49	4	1		188	20"	--, *	$158,000	VCP
										Note: *Repair Cost of $158,000 includes all 4 S#'s with 9		
CONDITION GRADE 4, PRIORITY 1 TOTAL								**960**	**feet**		**$195,000**	
ENGINEERING AND ADMINISTRATION (15%)											**$ 29,250**	
TOTAL											**$224,250**	
ACSC INTERCEPTOR, CONDITION GRADE 4, GRAND TOTAL								**960**	**feet**		**$224,250**	

CCTV EVALUATION, Aviation Coridor to South East (ACSE) Interceptor Reaches, Condition Grades 3 & 4 Total
Pima County Wastewater Management Department, Systems Design Section

Project Name: INTERCEPTOR SEWER SYSTEM, CCTV ASSESMENT FINAL 180 MILES (NON-RCP)
Date : 3/30/2005

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
40	ACSE-T		9838-18	9838-17	4	1		450	15"	Fracture, Multiple	$49,000	VCP
42	ACSE-T		9838-16	9838-15	4	1		400	15"	Fracture, Multiple	$45,000	VCP
43	ACSE-T		9838-15	9838-14	4	1		413	15"	Fracture, Multiple	$46,000	VCP
CONDITION GRADE 4, PRIORITY 1 TOTAL								**1,263**	**feet**		**$140,000**	

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
2	ACSE-TGOLF	276.9	5549-17	5549-16	4	3	313	313.4	15"	Pipe Corrosion	$59,000	DIP
5	ACSE-TGOLF	597.6	5549-14	5549-13	4	3	22	619.3	15"	Pipe Corrosion	$29,000	DIP
CONDITION GRADE 4, PRIORITY 3 TOTAL							**335**	**feet**			**$88,000**	
CONDITION GRADE 4, TOTAL							**1,598**	**feet**			**$228,000**	
ENGINEERING AND ADMINISTRATION (15%)											**$ 34,200**	
TOTAL											**$262,200**	

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
13	ACSE-TGOLF	204	8101-05	8101-04	3	1	56	389.5	15"	Bubbles	$30,000	DIP
20	ACSE-TGOLF	122.5	5549-11	5549-12	3	1	21	622	15"	Flakes/Corrosion	$30,000	DIP
CONDITION GRADE 3, PRIORITY 1 TOTAL							**77**	**feet**			**$60,000**	

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
8	ACSE-TGOLF	85.1	8101-10	8101-09	3	2	22	107.3	15"	Blisters	$26,000	DIP
9	ACSE-TGOLF	98	8101-09	8101-08	3	2	17	426.3	15"	Blisters	$27,000	DIP

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	CIP BUDGET NUMBER ($'s)	FAILURE DESCRIPTION
7	ACSE-TGOLF	8101-11	8101-10	DIP	74	15"	3	2	$206	$15,131	50%	$22,696	JOINT FAILURES
CONDITION GRADE 3, PRIORITY 2 TOTAL					**113**	**feet**						**$75,696**	
CONDITION GRADE 3, TOTAL					**190**	**feet**						**$135,696**	
ENGINEERING AND ADMINISTRATION (15%)												**$ 20,354**	
TOTAL												**$156,050**	
ACSE INTERCEPTOR, CONDITION GRADES 3 & 4, GRAND TOTAL							**1,788**	**feet**				**$418,250**	

CCTV EVALUATION, Cañada del Oro (CDO) Interceptor Reaches, Condition Grades 3 & 4 Total
Pima County Wastewater Management Department, Systems Design Section

Project Name: INTERCEPTOR SEWER SYSTEM, CCTV ASSESMENT FINAL 180 MILES
Date : 3/30/2005

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL	LINER
130	CDO-A		1732-04A	1732-03A	4	1		799.8	36"	HOLE	$27,000	DIP	ZZ
94	CDO-T1NORT		5310-02	5310-03	4	1		101.3	24"	LINING FAILURE @ MH	$24,000	DIP	ZZ
44	CDO-T2 THO	163.5	5245-01	5247-09	4	1		301	15"	Pipe Failure, Hole, Soil Visible from 11 to 01 o´clock	$36,000	VCP	
18	CDO-T6 INA	3	6094-01	9549-06	4	1		330	15"	Fracture, Multiple from 11 to 05 o´clock	$39,000	VCP	
5	CDO-T7 HAR	179.9	5333-13	5333-12	4	1		192	15"	Fracture, Multiple from 09 to 03 o´clock	$36,000	VCP	
CONDITION GRADE 4, PRIORITY 1 TOTAL								**1,725**	**feet**		**$162,000**		

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	CIP BUDGET NUMBER ($'s)	FAILURE DESCRIPTION
1	CDO-B	4660-1052	4660-1085	DIP	479	16"	4	3	$206	$98,607	50%	$147,910	BLISTER/FLAKES
2	CDO-B	4660-1085	4660-1076	DIP	476	16"	4	3	$206	$98,051	50%	$147,076	BLISTER/FLAKES
74	CDO-T4 CMO	5339-08	1728-06	DIP	8	24"	4	3	$223	$1,784	50%	$2,676	BLISTER/FLAKES
75	CDO-T4 CMO	1728-06	5339-08	DIP	290	24"	4	3	$223	$64,594	50%	$96,890	BLISTER/FLAKES
76	CDO-T4 CMO	1728-05	1728-06	DIP	493	24"	4	3	$223	$109,834	50%	$164,750	BLISTER/FLAKES
77	CDO-T4 CMO	1728-05	5222-01	DIP	167	24"	4	3	$223	$37,191	50%	$55,786	BLISTER/FLAKES
78	CDO-T4 CMO	5222-01	5222-03	DIP	275	24"	4	3	$223	$61,361	50%	$92,041	BLISTER/FLAKES
79	CDO-T4 CMO	5222-03	1728-04	DIP	141	24"	4	3	$223	$31,438	50%	$47,158	BLISTER/FLAKES
45	CDO-T6 INA	9553-02	9553-01	DIP	166	24"	4	3	$223	$36,923	50%	$55,385	BLISTER/FLAKES
CONDITION GRADE 4, PRIORITY 3 TOTAL					**2,494**	**feet**						**$809,672**	
CONDITION GRADE 4, TOTAL					**4,219**	**feet**						**$971,672**	
ENGINEERING AND ADMINISTRATION (15%)												**$145,751**	
												$1,117,423	

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	CIP BUDGET NUMBER ($'s)	FAILURE DESCRIPTION
64	CDO T4 OES	1728-13	1728-12	DIP	45	15"	3	1	$206	$9,181	50%	$13,772	FLAKEY
105	CDO-A	1732-28A	4064-01	DIP	272	30"	3	1	$223	$60,736	50%	$91,104	SURFACE DAMAGE
65	CDO-T1	5310-20	5310-19	DIP	415	18"	3	1	$206	$85,494	50%	$128,240	BLISTER
67	CDO-T1	5310-18	5310-17	DIP	169	18"	3	1	$206	$34,790	50%	$52,185	BLISTER
68	CDO-T1	5310-17	5310-16	DIP	318	18"	3	1	$206	$65,381	50%	$98,072	BLISTER

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
4	CDO-T6 INA	545	9521-03	9521-02	3	1	25	600	15"	Blisters/Flakes	$29,000	DIP
CONDITION GRADE 3, PRIORITY 1 TOTAL					**1,244**	**feet**						**$412,374**

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	CIP BUDGET NUMBER ($'s)	FAILURE DESCRIPTION
60	CDO-A	1732-72A	1732-73A	DIP	318	24"	3	2	$223	$70,970	50%	$106,456	JOINT FAILURES
61	CDO-A	1732-71A	1732-72A	DIP	231	24"	3	2	$223	$51,438	50%	$77,158	JOINT FAILURES
62	CDO-A	1732-70A	1732-71A	DIP	254	24"	3	2	$223	$56,656	50%	$84,984	JOINT FAILURES
63	CDO-A	1732-70A	1732-69A	DIP	442	24"	3	2	$223	$98,596	50%	$147,894	JOINT FAILURES
64	CDO-A	1732-69A	1732-68A	DIP	632	24"	3	2	$223	$140,960	50%	$211,440	JOINT FAILURES
65	CDO-A	1732-68A	1732-67A	DIP	509	24"	3	2	$223	$113,468	50%	$170,202	JOINT FAILURES
66	CDO-A	1732-67A	1732-66A	DIP	594	24"	3	2	$223	$132,465	50%	$198,697	JOINT FAILURES
67	CDO-A	1732-66A	1732-65A	DIP	417	24"	3	2	$223	$93,022	50%	$139,533	JOINT FAILURES
68	CDO-A	1732-65A	1732-64A	DIP	266	24"	3	2	$223	$59,332	50%	$88,997	JOINT FAILURES
69	CDO-A	1732-64A	1732-63A	DIP	592	24"	3	2	$223	$132,086	50%	$198,128	JOINT FAILURES
70	CDO-A	1732-63A	1732-62A	DIP	591	24"	3	2	$223	$131,684	50%	$197,526	JOINT FAILURES
71	CDO-A	1732-62A	1732-61A	DIP	596	24"	3	2	$223	$132,933	50%	$199,399	JOINT FAILURES
72	CDO-A	1732-61A	1732-60A	DIP	596	24"	3	2	$223	$132,911	50%	$199,366	JOINT FAILURES
73	CDO-A	1732-60A	1732-59A	DIP	596	24"	3	2	$223	$132,821	50%	$199,232	JOINT FAILURES
11	CDO-T1	6430-04	6430-03	DIP	30	15"	3	2	$206	$6,176	50%	$9,264	BLISTER

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
39	CDO T4 OES	300.2	4722-02	4722-01	3	2	44	457.1	15"	Slight blister/Joint peeling	$26,000	DIP
CONDITION GRADE 3, PRIORITY 2 TOTAL					**6,709**	**feet**						**$2,254,276**
CONDITION GRADE 3, TOTAL					**7,953**	**feet**						**$2,666,649**
ENGINEERING AND ADMINISTRATION (15%)												**$ 399,997**
TOTAL												**$3,066,646**
CDO INTERCEPTOR, CONDITION GRADES 3 & 4, GRAND TOTAL								**12,171**	**feet**			**$4,184,069**

CCTV EVALUATION, Green Valley (GV) Interceptor Reaches, Condition Grades 3 & 4 Total
Pima County Wastewater Management Department, Systems Design Section

Project Name: INTERCEPTOR SEWER SYSTEM, CCTV ASSESMENT FINAL 180 MILES (NON-RCP)
Date : 3/30/2005

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
17	GV.CENTRAL	190.8	6834-04	6834-05	4	1	161	352	21"	Bubbles/Peeling	$30,000	DIP
CONDITION GRADE 4, PRIORITY 1 TOTAL							**161**	**feet**			**$30,000**	

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
21	GV.CENTRAL	34	4042-41	6834-01	4	2	23	122.5	12"	Bubbles	$25,000	DIP

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	CIP BUDGET NUMBER ($'s)	FAILURE DESCRIPTION
34	GV.CENTRAL	1633-01	1606-15	DIP	69	16"	4	2	$206	$14,184	50%	$21,276	LINING FAIL/CORROSION
17	GV.SOUTH	9970-03	9970-02	DIP	423	30"	4	2	$223	$94,337	50%	$141,506	BUBBLES/FAIL
18	GV.SOUTH	9970-02	9970-01	DIP	170	30"	4	2	$223	$37,904	50%	$56,857	BUBBLES/FAIL
17	GV.WEST	7050-08A	7050-07A	DIP	357	15"	4	2	$206	$73,410	50%	$110,114	LINING FAIL/CORROSION
23	GV.WEST	7050-03A	8760-01	DIP	25	16"	4	2	$206	$5,044	50%	$7,565	LINING FAIL/CORROSION
24	GV.WEST	8760-01	7050-02A	DIP	65	16"	4	2	$206	$13,422	50%	$20,133	LINING FAIL/CORROSION
CONDITION GRADE 4, PRIORITY 2 TOTAL					**1,131**	**feet**						**$382,451**	
CONDITION GRADE 4, TOTAL					**1,292**	**feet**						**$412,451**	
ENGINEERING AND ADMINISTRATION (15%)												**$ 61,868**	
TOTAL												**$474,319**	

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	CIP BUDGET NUMBER ($'s)	FAILURE DESCRIPTION
49	GV.CENTRAL	1606-03	1606-04	DIP	85	18"	3	1	$206	$17,539	50%	$26,309	LINING FAIL/PEEL
51	GV.CENTRAL	6635-01	6635-02	DIP	117	18"	3	1	$206	$24,065	50%	$36,097	JOINT FAILURES
96	GV.CENTRAL	8865-I	8865-J	DIP	538	30"	3	1	$223	$119,845	50%	$179,767	LINING FAIL/PEEL
97	GV.CENTRAL	8865-I	8865-H	DIP	478	30"	3	1	$223	$106,511	50%	$159,767	LINING FAIL/PEEL
98	GV.CENTRAL	8865-H	8865-G	DIP	572	30"	3	1	$223	$127,604	50%	$191,406	LINING FAIL/PEEL
99	GV.CENTRAL	8865-F	8865-G	DIP	391	30"	3	1	$223	$87,180	50%	$130,770	LINING FAIL/PEEL
100	GV.CENTRAL	8865-E	8865-F	DIP	419	30"	3	1	$223	$93,468	50%	$140,202	LINING FAIL/PEEL
101	GV.CENTRAL	8865-E	8865-D	DIP	480	30"	3	1	$223	$107,046	50%	$160,570	LINING FAIL/PEEL
102	GV.CENTRAL	8865-D	8865-C	DIP	283	30"	3	1	$223	$63,033	50%	$94,549	LINING FAIL/PEEL
103	GV.CENTRAL	8865-C	8865-B	DIP	293	30"	3	1	$223	$65,285	50%	$97,927	LINING FAIL/PEEL
104	GV.CENTRAL	8865-B	8865-A	DIP	92	30"	3	1	$223	$20,468	50%	$30,703	LINING FAIL/PEEL
105	GV.CENTRAL	8865-A	8865-01	DIP	170	30"	3	1	$223	$37,949	50%	$56,923	LINING FAIL/PEEL
106	GV.CENTRAL	8865-01	8865-IN	DIP	19	30"	3	1	$223	$4,259	50%	$6,388	LINING FAIL/PEEL

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
2	GV-WEST	360.9	7050-14	6038-02	3	1	33	469.7	15"	Bubbles/Peeling	$29,000	DIP
CONDITION GRADE 3, PRIORITY 1 TOTAL					**3,970**	**feet**						**$1,340,378**
CONDITION GRADE 3, TOTAL					**3,970**	**feet**						**$1,340,378**
ENGINEERING AND ADMINISTRATION (15%)												**$ 201,057**
TOTAL												**$1,541,435**
GV INTERCEPTOR, CONDITION GRADES 3 & 4, GRAND TOTAL								**5,262**	**feet**			**$2,015,754**

CCTV EVALUATION, North Rillito Interceptor (NRI) Reaches, Condition Grade 3 Total
Pima County Wastewater Management Department, Systems Design Section

Project Name: INTERCEPTOR SEWER SYSTEM, CCTV ASSESMENT FINAL 180 MILES (NON-RCP)
Date : 3/30/2005

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	CIP BUDGET NUMBER ($'s)	FAILURE DESCRIPTION
33	NRI-T VENT	1781-09	6518-01	DIP	270	15"	3	1	$206	$55,479	50%	$83,219	BLISTER/FLAKES
34	NRI-T VENT	6518-01	1781-08	DIP	104	15"	3	1	$206	$21,389	50%	$32,083	BLISTER/FLAKES
73	NRI-T VENT	8240-02	8240-01	DIP	63	18"	3	1	$206	$12,866	50%	$19,299	BLISTER/FLAKES
CONDITION GRADE 3, PRIORITY 1 TOTAL					**436**	**feet**						**$134,601**	
CONDITION GRADE 3, TOTAL					**436**	**feet**						**$134,601**	
ENGINEERING AND ADMINISTRATION (15%)												**$ 20,190**	
TOTAL												**$154,791**	
NRI, CONDITION GRADE 3, GRAND TOTAL								**436**	**feet**			**$154,791**	

CCTV EVALUATION, Old Nogales Highway (ONH) Interceptor Reaches, Condition Grade 4 Total
Pima County Wastewater Management Department, Systems Design Section

Project Name: INTERCEPTOR SEWER SYSTEM, CCTV ASSESMENT FINAL 180 MILES
Date : 3/30/2005

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	CIP BUDGET NUMBER ($'s)	FAILURE DESCRIPTION
1	ONH	4707-38	4707-39	DIP	14	18"	4	1	$206	$2,964	50%	$4,447	LINING FAIL/PEEL
2	ONH	4707-38	4707-37	DIP	324	18'	4	1	$206	$66,699	50%	$100,048	LINING FAIL/PEEL
3	ONH	4707-36	4707-37	DIP	216	18"	4	1	$206	$44,507	50%	$66,760	LINING FAIL/PEEL
4	ONH	4707-35	4707-36	DIP	36	18"	4	1	$206	$7,432	50%	$11,147	LINING FAIL/PEEL
5	ONH	4707-35	4707-34	DIP	113	18"	4	1	$206	$23,242	50%	$34,862	LINING FAIL/PEEL
6	ONH	4707-34	4707-33	DIP	392	18"	4	1	$206	$80,635	50%	$120,953	LINING FAIL/PEEL
7	ONH	4707-32	4707-33	DIP	370	18"	4	1	$206	$76,209	50%	$114,314	LINING FAIL/PEEL
8	ONH	4707-32	4707-31	DIP	71	18'	4	1	$206	$14,616	50%	$21,924	LINING FAIL/PEEL
9	ONH	4707-30	4707-31	DIP	467	18"	4	1	$206	$96,095	50%	$144,143	LINING FAIL/PEEL
10	ONH	4707-30	4707-29	DIP	469	18"	4	1	$206	$96,548	50%	$144,822	LINING FAIL/PEEL
11	ONH	4707-29	4707-28	DIP	211	18"	4	1	$206	$43,436	50%	$65,155	LINING FAIL/PEEL
12	ONH	4707-28	4707-29 OVERL	DIP	404	18"	4	1	$206	$83,167	50%	$124,751	LINING FAIL/PEEL
13	ONH	4707-28	4707-27	DIP	628	18"	4	1	$206	$129,198	50%	$193,796	LINING FAIL/PEEL
14	ONH	4707-27	4707-26	DIP	627	18"	4	1	$206	$129,156	50%	$193,734	LINING FAIL/PEEL
15	ONH	4707-25	4707-26	DIP	627	18"	4	1	$206	$129,095	50%	$193,642	LINING FAIL/PEEL
16	ONH	4707-25	4707-24	DIP	608	18"	4	1	$206	$125,224	50%	$187,837	LINING FAIL/PEEL
17	ONH	4707-24	4707-23	DIP	638	18"	4	1	$206	$131,338	50%	$197,008	LINING FAIL/PEEL
18	ONH	4707-23	4707-22	DIP	508	18"	4	1	$206	$104,618	50%	$156,927	LINING FAIL/PEEL
19	ONH	4707-22	4707-21	DIP	516	18"	4	1	$206	$106,224	50%	$159,335	LINING FAIL/PEEL
20	ONH	4707-21	4707-20	DIP	516	18"	4	1	$206	$106,244	50%	$159,366	LINING FAIL/PEEL
21	ONH	4707-20	4707-19	DIP	634	18"	4	1	$206	$130,433	50%	$195,649	LINING FAIL/PEEL
22	ONH	4707-19	4707-18	DIP	619	18"	4	1	$206	$127,407	50%	$191,110	LINING FAIL/PEEL
23	ONH	4707-18	4707-17	DIP	623	18"	4	1	$206	$128,189	50%	$192,283	LINING FAIL/PEEL
24	ONH	4707-17	4707-16	DIP	630	18"	4	1	$206	$129,692	50%	$194,537	LINING FAIL/PEEL
25	ONH	4707-16	4707-15	DIP	617	18"	4	1	$206	$126,912	50%	$190,369	LINING FAIL/PEEL
26	ONH	4707-15	4707-14	DIP	365	18"	4	1	$206	$75,118	50%	$112,677	LINING FAIL/PEEL
27	ONH	4707-13	4707-14	DIP	489	18"	4	1	$206	$100,748	50%	$151,122	LINING FAIL/PEEL
28	ONH	4707-13	4707-12	DIP	375	18"	4	1	$206	$77,218	50%	$115,827	LINING FAIL/PEEL
29	ONH	4707-12	4707-11	DIP	372	18"	4	1	$206	$76,580	50%	$114,870	LINING FAIL/PEEL
30	ONH	4707-11	4707-10	DIP	614	18"	4	1	$206	$126,315	50%	$189,473	LINING FAIL/PEEL
31	ONH	4707-10	4707-09	DIP	614	18"	4	1	$206	$126,398	50%	$189,597	LINING FAIL/PEEL
32	ONH	4707-09	4707-08	DIP	153	18"	4	1	$206	$31,538	50%	$47,307	LINING FAIL/PEEL
33	ONH	4707-08	4707-07	DIP	262	18"	4	1	$206	$53,935	50%	$80,903	LINING FAIL/PEEL
34	ONH	4707-07	4707-06	DIP	613	18"	4	1	$206	$126,192	50%	$189,288	LINING FAIL/PEEL
35	ONH	4707-06	4707-05	DIP	615	18"	4	1	$206	$126,563	50%	$189,844	LINING FAIL/PEEL
36	ONH	4707-05	4707-04A	DIP	517	18"	4	1	$206	$106,388	50%	$159,582	LINING FAIL/PEEL
37	ONH	4707-04A	4707-04	DIP	410	18"	4	1	$206	$84,464	50%	$126,696	LINING FAIL/PEEL
38	ONH	4707-04	4707-03	DIP	247	18"	4	1	$206	$50,909	50%	$76,364	LINING FAIL/PEEL
39	ONH	4707-03	4707-02	DIP	516	18"	4	1	$206	$106,182	50%	$159,274	LINING FAIL/PEEL
40	ONH	4707-02	4707-01	DIP	63	18"	4	1	$206	$12,887	50%	$19,330	LINING FAIL/PEEL
49	ONH	8994-03	8994-04	DIP	307	18"	4	1	$206	$63,199	50%	$94,798	LINING FAIL/PEEL

CONDITION GRADE 4, PRIORITY 1 TOTAL	**17,410**	**feet**		**$5,375,870**
ENGINEERING AND ADMINISTRATION (15%)				**$ 806,381**
SUBTOTAL				**$6,182,251**
ONH INTERCEPTOR, CONDITION GRADE 4, TOTAL (NON-RCP)		**17,410**	**feet**	**$6,182,251**
ONH INTERCEPTOR, CONDITION GRADE 4, TOTAL (RCP)		**8,649**	**feet**	**$1,928,727**
ENGINEERING AND ADMINISTRATION (15%)				**$289,309**
				$2,218,036
ONH INTERCEPTOR, CONDITION GRADE 4, GRAND TOTAL				**$8,400,287**

CCTV EVALUATION, Pantano Interceptor (PTI) Reaches, Condition Grades 3 & 4 Total
Pima County Wastewater Management Department, Systems Design Section

Project Name: INTERCEPTOR SEWER SYSTEM, CCTV ASSESMENT FINAL 180 MILES (NON-RCP)
Date : 3/30/2005

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	NUMBER ($'s)	FAILURE DESCRIPTION
36	PTI	6592-02	6592-01	DIP	11	21"	4	2	$206	$2,285	50%	$3,428	BLISTER/DELAM
49	PTI	2741-03	2741-02	DIP	564	12"	4	2	$206	$116,125	50%	$174,188	LINING FAIL/PEEL
164	PTI	8964-22	8964-21	DIP	115	36"	4	2	$223	$25,730	50%	$38,596	BLISTER/DELAM
165	PTI	8964-21	8964-20	DIP	234	36"	4	2	$223	$52,085	50%	$78,128	BLISTER/DELAM
CONDITION GRADE 4, PRIORITY 2 TOTAL					**924**	**feet**						**$294,339**	

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	CIP BUDGET NUMBER	FAILURE DESCRIPTION
169	PTI	8964-17	8964-16	DIP	170	36"	4	3	$223	$37,949	50%	$56,923	BLISTER/DELAM

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
163	PTI	105	8964-22A	8964-22	4	3	172	277.4	36"	Blisters/Flakes	$40,000	DIP
CONDITION GRADE 4, PRIORITY 3 TOTAL							**342**	**feet**			**$96,923**	
CONDITION GRADE 4, TOTAL					**1,266**	**feet**					**$391,262**	
ENGINEERING AND ADMINISTRATION (15%)											**$ 58,689**	
TOTAL											**$449,951**	

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
35	PTI	514	6592-03	6592-02	3	1	79	592.7	21"	Blisters/Flakes	$31,000	DIP

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	CIP BUDGET NUMBER	FAILURE DESCRIPTION
52	PTI	2741-01	6036-37	DIP	55	18"	3	1	$206	$11,405	50%	$17,107	BLISTER
21	PTI-T1	8030-09	8030-08	DIP	63	16"	3	1	$206	$12,907	50%	$19,361	JOINT FAIL
CONDITION GRADE 3, PRIORITY 1 TOTAL					**197**	**feet**						**$67,468**	

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
29	PTI	263	6592-09	6592-08	3	2	119	382.3	21"	Blisters	$34,000	DIP

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	CIP BUDGET NUMBER	FAILURE DESCRIPTION
30	PTI	6592-08	6592-07	DIP	132	21"	3	2	$206	$27,153	50%	$40,729	BLISTER
31	PTI	6592-07	6592-06	DIP	377	21"	3	2	$206	$77,588	50%	$116,383	BLISTER
135	PTI	5364-03	5364-02	DIP	447	33"	3	2	$223	$99,555	50%	$149,332	JOINT FAIL
CONDITION GRADE 3, PRIORITY 2 TOTAL					**1,074**	**feet**						**$340,444**	
CONDITION GRADE 3, TOTAL					**1,271**	**feet**						**$407,912**	
ENGINEERING AND ADMINISTRATION (15%)												**$ 61,187**	
TOTAL												**$469,099**	
PTI, CONDITION GRADES 3 & 4, GRAND TOTAL								**2,538**	**feet**			**$919,050**	

CCTV EVALUATION, Santa Cruz Central (SCC) Reaches, Condition Grade 3 Total
Pima County Wastewater Management Department, Systems Design Section

Project Name: INTERCEPTOR SEWER SYSTEM, CCTV ASSESMENT FINAL 180 MILES
Date : 3/30/2005

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	CIP BUDGET NUMBER ($'s)	FAILURE DESCRIPTION
40	SCC	6677-04	6677-03	DIP	293	24"	3	2	$223	$65,329	50%	$97,994	BLISTER
41	SCC	6677-04	6677-03	DIP	293	24"	3	2	$223	$65,419	50%	$98,128	BLISTER
42	SCC	6677-04	6677-03	DIP	293	24"	3	2	$223	$65,262	50%	$97,894	BLISTER
CONDITION GRADE 3, PRIORITY 2 TOTAL					**879**	**feet**						**$294,015**	
CONDITION GRADE 3, TOTAL (NON-RCP)					**879**	**feet**						**$294,015**	
ENGINEERING AND ADMINISTRATION (15%)												**$44,102**	
NON-RCP SUBTOTAL												**$338,118**	
CONDITION GRADE 3, TOTAL (RCP)					**1,108**	**feet**						**$250,000**	
ENGINEERING AND ADMINISTRATION (15%)												**$37,500**	
RCP SUBTOTAL												**$287,500**	

CCTV EVALUATION, Santa Cruz Interceptor (SCI) Reaches, Condition Grade 4 Total
Pima County Wastewater Management Department, Systems Design Section

Project Name: INTERCEPTOR SEWER SYSTEM, CCTV ASSESMENT FINAL 180 MILES (NON-RCP)
Date : 3/30/2005

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
14	SCI-B	156.7	4366-60	4366-59B	4	2	21	203.5	21"	Bubbles	$28,000	DIP
16	SCI-B	93.2	4366-59	4366-59A	4	2	70	361.9	21"	Bubbles	$32,000	DIP
CONDITION GRADE 4, PRIORITY 2 TOTAL							**91**	**feet**			**$60,000**	

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
5	SCI-B	83.9	8893-61	9912-36	4	3	38	153.5	18"	Badly Corroded	$30,000	DIP

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	CIP BUDGET NUMBER ($'s)	FAILURE DESCRIPTION
49	SCI	4360-06	4360-05	DIP	368	20"	4	3	$206	$75,798	50%	$113,696	LINING FAIL/CORROSION
99	SCI	9918-12A	4366-70	DIP	10	30"	4	3	$223	$2,207	50%	$3,311	LINING FAIL/CORROSION
100	SCI	4366-70	4366-69	DIP	67	30"	4	3	$223	$14,872	50%	$22,308	LINING FAIL/CORROSION
101	SCI	4366-69	4366-68	DIP	202	30"	4	3	$223	$45,106	50%	$67,659	LINING FAIL/CORROSION
102	SCI	4366-68	4366-67	DIP	118	30"	4	3	$223	$26,310	50%	$39,465	LINING FAIL/CORROSION
103	SCI	4366-67	4366-66	DIP	63	30"	4	3	$223	$13,958	50%	$20,937	LINING FAIL/CORROSION
104	SCI	4366-66	4366-65	DIP	70	30"	4	3	$223	$15,585	50%	$23,378	LINING FAIL/CORROSION
121	SCI	4360-11	4360-10	DIP	305	20"	4	3	$206	$62,684	50%	$94,026	LINING FAIL/CORROSION
CONDITION GRADE 4, PRIORITY 3 TOTAL					**1,240**	**feet**						**$414,781**	
CONDITION GRADE 4, TOTAL					**1,331**	**feet**						**$474,781**	
ENGINEERING AND ADMINISTRATION (15%)												**$71,217**	
TOTAL												**$545,998**	
SCI CONDITION GRADE 4, GRAND TOTAL								**1,331**	**feet**			**$545,998**	

CCTV EVALUATION, Southeast Interceptor (SEI) Reaches, Condition Grades 3 & 4 Total
Pima County Wastewater Management Department, Systems Design Section

Project Name: INTERCEPTOR SEWER SYSTEM, CCTV ASSESMENT FINAL 180 MILES
Date : 3/30/2005

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
46	SEI-DWNTWN	95.5	5662-10	5662-09	4	1	110	110	15"	Bubbled/Blocked	$45,000	DIP
10	SEI-C	221.3	9917-28	9917-27	4	1		857	30"	Pipe Failure, Broken from 08 to 10 o´clock	$38,000	VCP
25	SEI-DWNTWN	572.3	5654-10	5654-09	4	1		608	15"	Fracture, Longitudinal at 11 o´clock	$27,000	VCP
17	SEI-DWNTWN	278.8	5654-18	5654-17	4	1		501	12"	Pipe Failure, Hole from 11 to 12 o´clock	$37,000	VCP
CONDITION GRADE 4, PRIORITY 1 TOTAL								**2,075**	**feet**		**$147,000**	

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	CIP BUDGET NUMBER ($'s)	FAILURE DESCRIPTION
34	SEI-B	8033-24	8033-23	DIP	120	30"	4	3	$223	$26,734	50%	$40,101	BLISTER/FLAKES
35	SEI-B	8033-23	8033-22	DIP	162	30"	4	3	$223	$36,188	50%	$54,281	BLISTER/FLAKES
80	SEI-B	8130-19	8130-18	DIP	850	36"	4	3	$223	$189,433	50%	$284,149	BLISTER/FLAKES
30	SEI-DWNTWN	8130-22B	8130-22A	DIP	94	16"	4	3	$206	$19,248	50%	$28,872	BLISTER/FLAKES
31	SEI-DWNTWN	8130-22A	8130-22	DIP	22	16"	4	3	$206	$4,447	50%	$6,670	BLISTER/FLAKES
65	SEI-RITA R	4190-11C	4190-10C	DIP	417	18"	4	3	$206	$85,802	50%	$128,703	BLISTER/FLAKES
75	SEI-RITA R	4190-01C	4190-22	DIP	204	18"	4	3	$206	$41,934	50%	$62,900	BLISTER/FLAKES
84	SEI-RITA R	4190-13	4190-14	DIP	132	24"	4	3	$223	$29,365	50%	$44,047	LINING FAILURE @ FL
CONDITION GRADE 4, PRIORITY 3 TOTAL					**1,999**	**feet**						**$649,724**	
CONDITION GRADE 4, TOTAL (NON-RCP)					**4,074**	**feet**						**$796,724**	
ENGINEERING AND ADMINISTRATION (15%)												**$119,509**	
NON-RCP SUBTOTAL												**$916,232**	
CONDITION GRADE 4, TOTAL (RCP)					**2,111**	**feet**						**$470,753**	
ENGINEERING AND ADMINISTRATION (15%)												**$70,613**	
RCP SUBTOTAL												**$541,366**	

S#	Interceptor	Feet from Start	Start MH	Stop MH	Condition Grade	Priority	Affected Length	Reach Length	Dia	COMMENTS	REPAIR COST	MATERIAL
61	SEI-DWNTWN	129.2	5667-11	5667-10A	3	2	22	231	15"	Slight Corrosion	$33,000	DIP

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	CIP BUDGET NUMBER ($'s)	FAILURE DESCRIPTION
1	SEI-RITA R	4636-34A	4636-35A	DIP	159	18"	3	2	$206	$32,649	50%	$48,974	JOINT FAILURES
2	SEI-RITA R	4636-34A	4636-33A	DIP	240	18"	3	2	$206	$49,489	50%	$74,233	JOINT FAILURES
3	SEI-RITA R	4636-33A	4636-32A	DIP	169	18"	3	2	$206	$34,729	50%	$52,093	JOINT FAILURES
4	SEI-RITA R	4636-32A	4636-31A	DIP	167	18"	3	2	$206	$34,358	50%	$51,537	JOINT FAILURES
5	SEI-RITA R	4636-31A	4636-30A	DIP	356	18"	3	2	$206	$73,245	50%	$109,867	JOINT FAILURES
6	SEI-RITA R	4636-30A	4636-29A	DIP	349	18"	3	2	$206	$71,907	50%	$107,860	JOINT FAILURES
7	SEI-RITA R	4636-28A	4636-29A	DIP	609	18"	3	2	$206	$125,410	50%	$188,115	JOINT FAILURES
8	SEI-RITA R	4636-27A	4636-28A	DIP	494	18"	3	2	$206	$101,695	50%	$152,542	JOINT FAILURES
9	SEI-RITA R	4636-27A	4636-26A	DIP	327	18"	3	2	$206	$67,234	50%	$100,851	JOINT FAILURES
10	SEI-RITA R	4636-26A	4636-25A	DIP	328	18"	3	2	$206	$67,584	50%	$101,376	JOINT FAILURES
11	SEI-RITA R	4636-25A	4636-23A	DIP	607	18"	3	2	$206	$124,916	50%	$187,373	JOINT FAILURES
12	SEI-RITA R	4636-22A	4636-23A	DIP	355	18"	3	2	$206	$73,121	50%	$109,682	JOINT FAILURES
13	SEI-RITA R	6761-01	4636-22A	DIP	531	18"	3	2	$206	$109,291	50%	$163,936	JOINT FAILURES
14	SEI-RITA R	4636-21A	6761-01	DIP	76	18"	3	2	$206	$15,542	50%	$23,314	JOINT FAILURES
15	SEI-RITA R	4636-21A	4636-24A	DIP	236	18"	3	2	$206	$48,521	50%	$72,782	JOINT FAILURES
16	SEI-RITA R	4636-24A	4636-20A	DIP	370	18"	3	2	$206	$76,086	50%	$114,129	JOINT FAILURES
17	SEI-RITA R	4636-20A	4636-19A	DIP	607	18"	3	2	$206	$124,854	50%	$187,281	JOINT FAILURES
18	SEI-RITA R	4636-18A	4636-19A	DIP	553	18"	3	2	$206	$113,779	50%	$170,668	JOINT FAILURES
19	SEI-RITA R	4636-17A	4636-18A	DIP	458	18"	3	2	$206	$94,181	50%	$141,271	JOINT FAILURES
20	SEI-RITA R	4636-17A	4636-16A	DIP	600	18"	3	2	$206	$123,413	50%	$185,119	JOINT FAILURES
21	SEI-RITA R	4636-16A	4636-15A	DIP	313	18"	3	2	$206	$64,516	50%	$96,775	JOINT FAILURES
22	SEI-RITA R	4636-15A	4636-14A	DIP	615	18"	3	2	$206	$126,521	50%	$189,782	JOINT FAILURES
23	SEI-RITA R	4636-14A	4636-13A	DIP	308	18"	3	2	$206	$63,302	50%	$94,953	JOINT FAILURES
24	SEI-RITA R	4636-13A	4636-12A	DIP	612	18"	3	2	$206	$125,924	50%	$188,887	JOINT FAILURES
25	SEI-RITA R	4636-11A	4636-12A	DIP	614	18"	3	2	$206	$126,377	50%	$189,566	JOINT FAILURES
26	SEI-RITA R	4636-11A	4636-10A	DIP	616	18"	3	2	$206	$126,748	50%	$190,122	JOINT FAILURES
27	SEI-RITA R	4636-10A	4636-09A	DIP	615	18"	3	2	$206	$126,542	50%	$189,813	JOINT FAILURES
28	SEI-RITA R	4636-09A	4636-08A	DIP	326	18"	3	2	$206	$67,110	50%	$100,665	JOINT FAILURES
29	SEI-RITA R	4636-08A	4636-07A	DIP	326	18"	3	2	$206	$67,131	50%	$100,696	JOINT FAILURES
30	SEI-RITA R	4636-07A	4190-06A	DIP	109	18"	3	2	$206	$22,500	50%	$33,751	JOINT FAILURES
31	SEI-RITA R	4190-06A	4190-05A	DIP	114	18"	3	2	$206	$23,447	50%	$35,171	JOINT FAILURES
32	SEI-RITA R	4636-17B	4636-16B	DIP	613	18"	3	2	$206	$126,192	50%	$189,288	JOINT FAILURES
33	SEI-RITA R	4636-15B	4636-16B	DIP	614	18"	3	2	$206	$126,315	50%	$189,473	JOINT FAILURES
34	SEI-RITA R	4979-01	4636-15B	DIP	72	18"	3	2	$206	$14,842	50%	$22,264	JOINT FAILURES
35	SEI-RITA R	4979-01	4636-14B	DIP	542	18"	3	2	$206	$111,617	50%	$167,426	JOINT FAILURES
36	SEI-RITA R	4636-14B	4636-13B	DIP	612	18"	3	2	$206	$125,966	50%	$188,948	JOINT FAILURES
37	SEI-RITA R	4636-12B	4636-13B	DIP	388	18"	3	2	$206	$79,935	50%	$119,903	JOINT FAILURES
38	SEI-RITA R	4190-11B	4636-12B	DIP	330	18"	3	2	$206	$68,016	50%	$102,024	JOINT FAILURES
39	SEI-RITA R	4190-10B	4190-11B	DIP	86	18"	3	2	$206	$17,704	50%	$26,556	JOINT FAILURES
40	SEI-RITA R	4190-10B	4190-09B	DIP	394	18"	3	2	$206	$81,150	50%	$121,725	JOINT FAILURES
41	SEI-RITA R	4190-09B	4190-08B	DIP	424	18"	3	2	$206	$87,346	50%	$131,019	JOINT FAILURES
42	SEI-RITA R	4190-08B	4190-07B	DIP	463	18"	3	2	$206	$95,251	50%	$142,877	JOINT FAILURES
43	SEI-RITA R	4190-07B	4190-06B	DIP	387	18"	3	2	$206	$79,668	50%	$119,502	JOINT FAILURES
44	SEI-RITA R	4190-05B	4190-06B	DIP	379	18"	3	2	$206	$78,000	50%	$117,000	JOINT FAILURES
45	SEI-RITA R	4190-04B	4190-05B	DIP	381	18"	3	2	$206	$78,350	50%	$117,525	JOINT FAILURES
46	SEI-RITA R	4190-03B	4190-04B	DIP	496	18"	3	2	$206	$102,024	50%	$153,036	JOINT FAILURES
47	SEI-RITA R	4190-03B	4190-02B	DIP	271	18"	3	2	$206	$55,850	50%	$83,775	JOINT FAILURES
48	SEI-RITA R	4190-02B	4190-01B	DIP	360	18"	3	2	$206	$74,048	50%	$111,072	JOINT FAILURES
49	SEI-RITA R	4190-01B	4190-05A	DIP	520	18"	3	2	$206	$107,026	50%	$160,540	JOINT FAILURES
50	SEI-RITA R	4190-05A	4190-04A	DIP	452	24"	3	2	$223	$100,670	50%	$151,004	JOINT FAILURES
51	SEI-RITA R	4190-04A	4190-03A	DIP	512	24"	3	2	$223	$114,137	50%	$171,205	JOINT FAILURES
52	SEI-RITA R	4190-02A	4190-03A	DIP	504	24"	3	2	$223	$112,398	50%	$168,597	JOINT FAILURES
53	SEI-RITA R	4190-02A	4190-01A	DIP	505	24"	3	2	$223	$112,688	50%	$169,031	JOINT FAILURES
54	SEI-RITA R	4190-01A	4190-13	DIP	502	24"	3	2	$223	$111,818	50%	$167,727	JOINT FAILURES
61	SEI-B	8130-39	8130-38	DIP	595	36"	3	2	$223	$132,732	50%	$199,098	JOINT FAILURES
CONDITION GRADE 3, PRIORITY 2 TOTAL					**22,578**	**feet**						**$7,076,796**	
CONDITION GRADE 3, TOTAL (NON-RCP)					**22,578**	**feet**						**$7,076,796**	
ENGINEERING AND ADMINISTRATION (15%)												**$1,061,519**	
TOTAL												**$8,138,315**	
SEI, CONDITION GRADES 3 & 4, GRAND TOTAL								**26,652**	**feet**			**$9,595,913**	

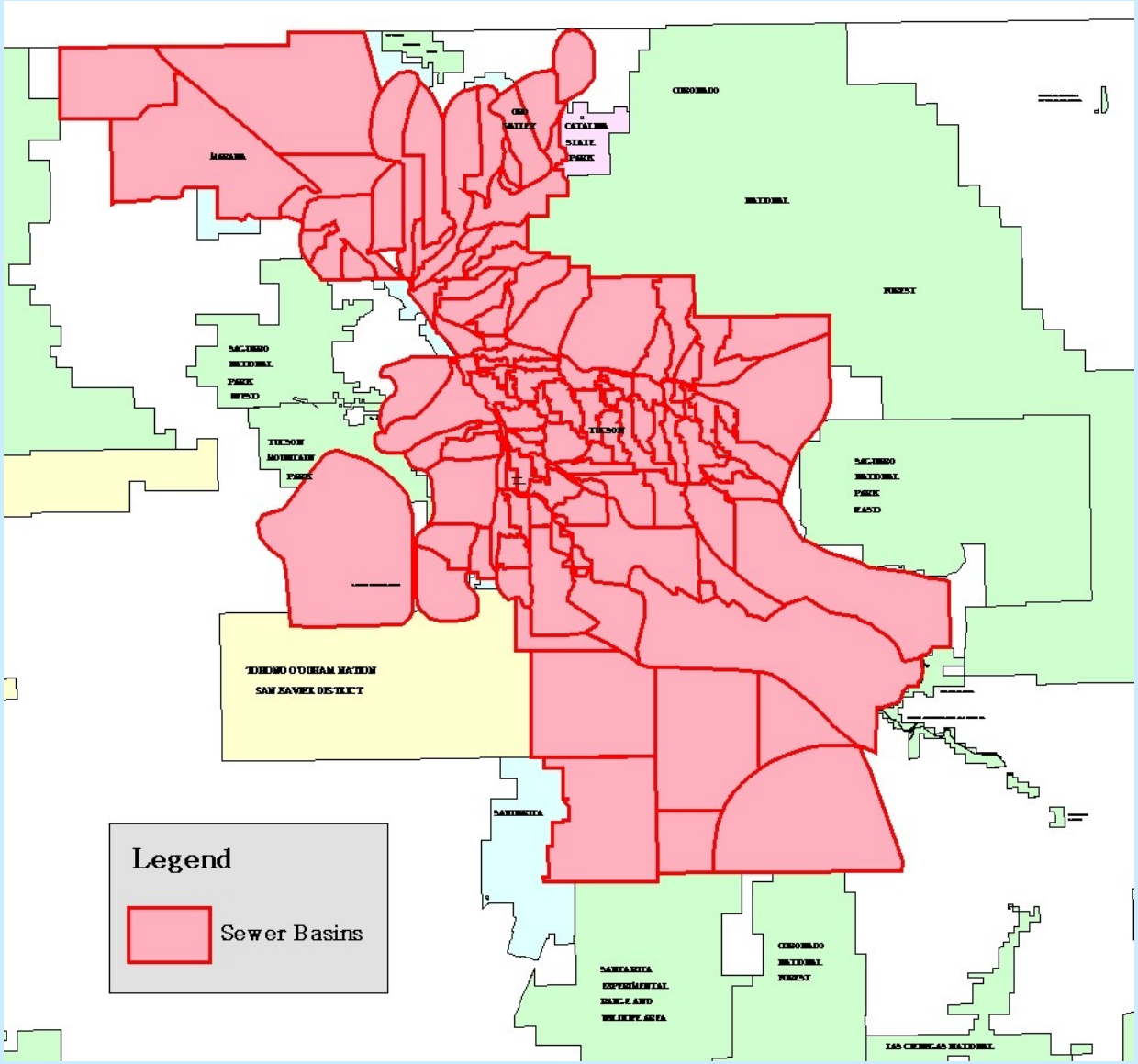
CCTV EVALUATION, South Rillito Roger Road (SRRR) Interceptor Reaches, Condition Grade 4 Total
Pima County Wastewater Management Department, Systems Design Section

Project Name: INTERCEPTOR SEWER SYSTEM, CCTV ASSESMENT FINAL 180 MILES
Date : 3/30/2005

S#	Interceptor	Start MH	Stop MH	MAT'L	Reach Length	Dia	Condition Rating	Priority	$'s / Ft	CIPP COST	CLEAN	CIP BUDGET NUMBER ($'s)	FAILURE DESCRIPTION
22	SRRR	6804-02	6804-02A	DIP	59	24"	4	3	$223	$13,066	50%	$19,599	BUBBLED
CONDITION GRADE 4, PRIORITY 3 TOTAL					**59**	**feet**						**$19,599**	
CONDITION GRADE 4, TOTAL					**59**	**feet**						**$19,599**	
ENGINEERING AND ADMINISTRATION (15%)												**$2,940**	
TOTAL												**$22,539**	
SRRR INTERCEPTOR, CONDITION GRADE 4, GRAND TOTAL									**59**	**feet**		**$22,539**	

Pima County Sewer Facility Plan Conveyance Model Pilot Project

- **Create sewer basins**
- Obtain projected population numbers
- Transfer population numbers to sewer basins using area proportion method
- Multiply population numbers by 85 gallons per day per person to obtain total sewer flow for each basin
- Identify specific manholes used in connecting basins
- Connect manholes based upon flow logic provided by Wastewater Management
- Transfer population and flow numbers from basin polygons to sewer arcs using the Arc command Identity
- QC data layer to ensure arcs flow in the proper direction and that population and flow numbers are not duplicated
- Calculate sewer capacities at manholes with data provided by Wastewater Management
- Run sewer model



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Projected population data was obtained from Pima Association of Governments, in the ArcInfo format as census tracts.

The following population totals are based upon that portion of Pima County which is contained within the sewer basins.

Total population for year 2005	804,110
Total population for year 2010	863,397
Total population for year 2015	938,384
Total population for year 2020	1,009,308
Total population for year 2025	1,080,716
Total population for year 2030	1,145,292

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Area proportion is a popular GIS tool which allows for recalculation of numbers after the original boundaries have been altered.

Pima County Sewer Facility Plan Conveyance Model Pilot Project

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85 gallons per person per day is the average volume of liquid waste produced per capita.

The following basin flow totals are based upon the previous population projections.

Total population for year 2005	804,110	x 85	68,349,350 gpd
Total population for year 2010	863,397	x 85	73,388,745 gpd
Total population for year 2015	938,384	x 85	79,762,640 gpd
Total population for year 2020	1,009,308	x 85	85,791,180 gpd
Total population for year 2025	1,080,716	x 85	91,860,860 gpd
Total population for year 2030	1,145,292	x 85	97,349,820 gpd

Pima County Sewer Facility Plan Conveyance Model Pilot Project

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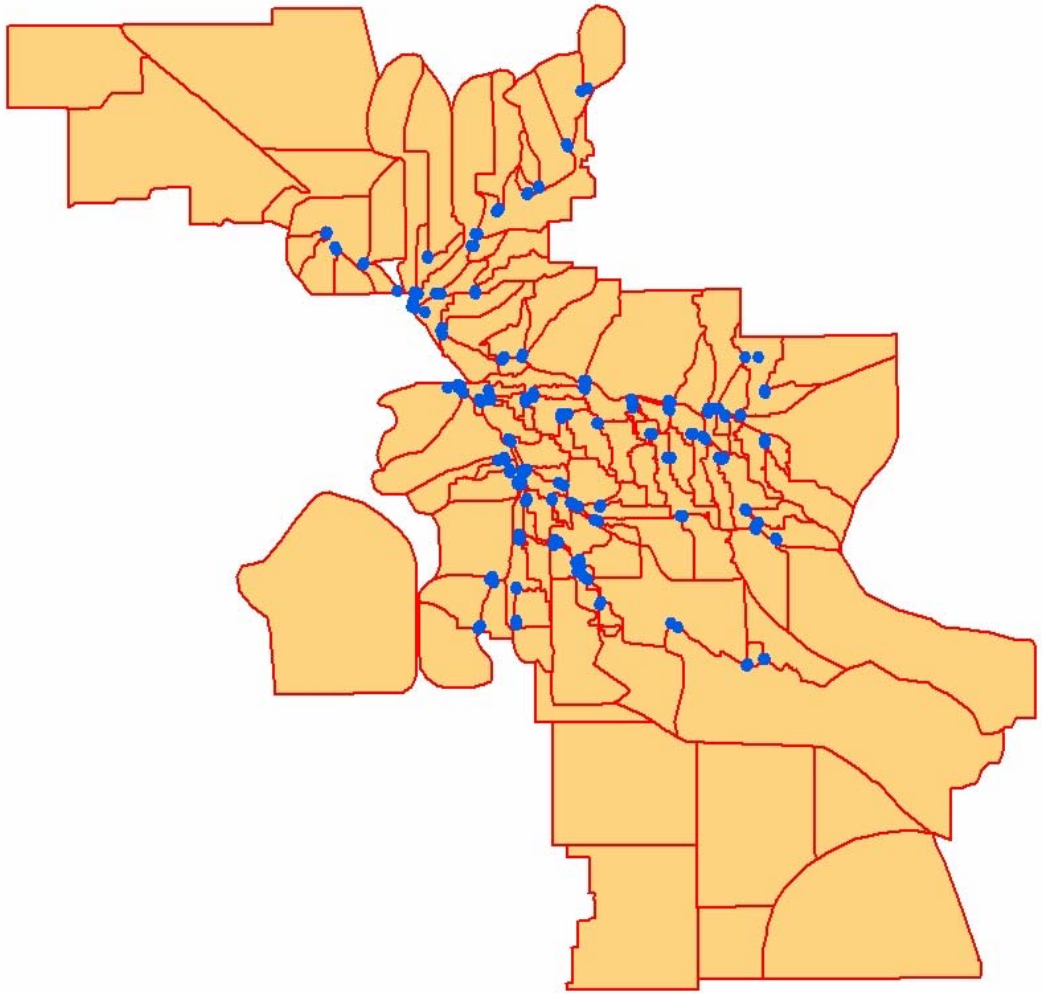

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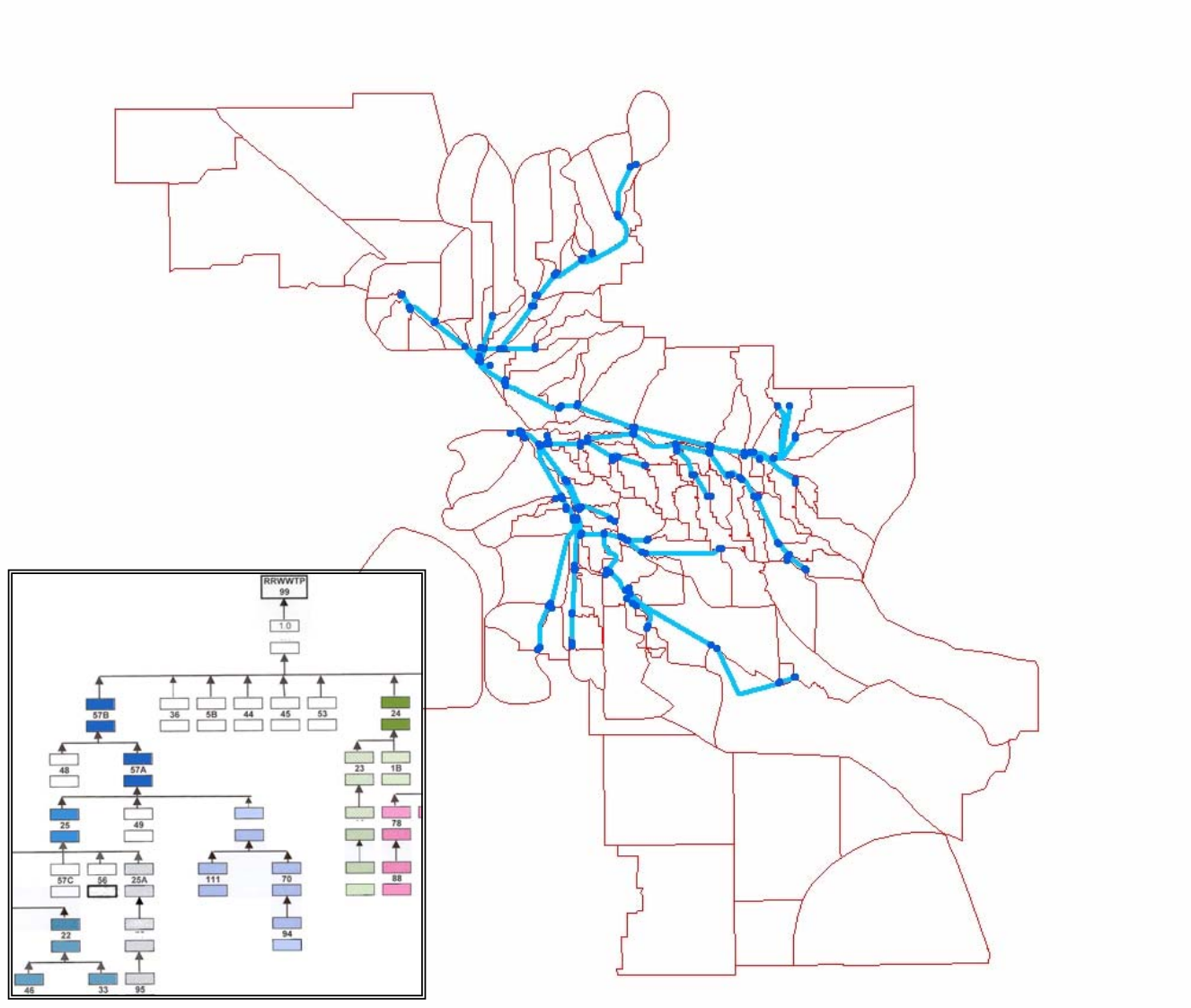

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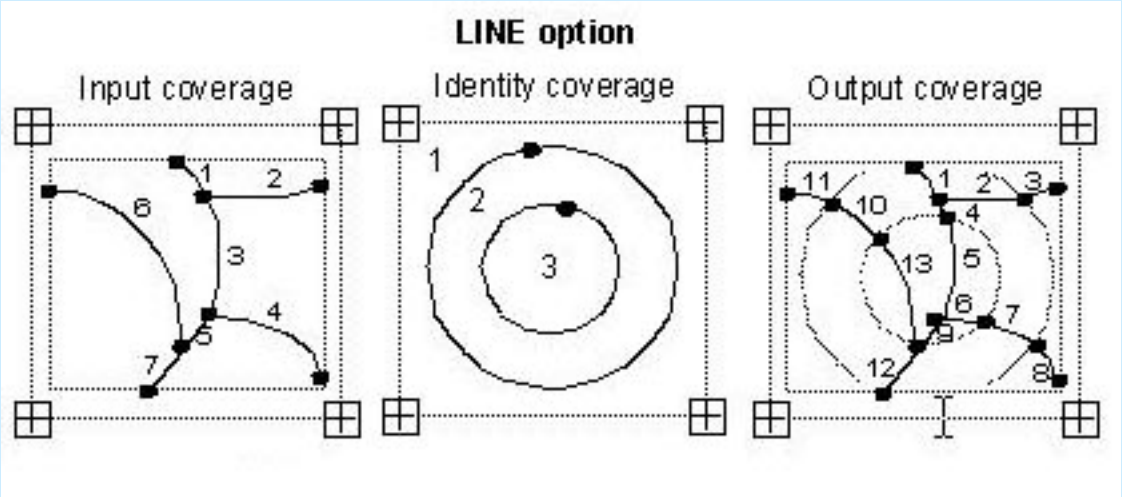
ArcInfo description of IDENTITY command:

Computes the geometric intersection of two data layers.
All features of the input data layer, as well as those features of the identity data layer that overlap the input data layer, are preserved in the output data layer.



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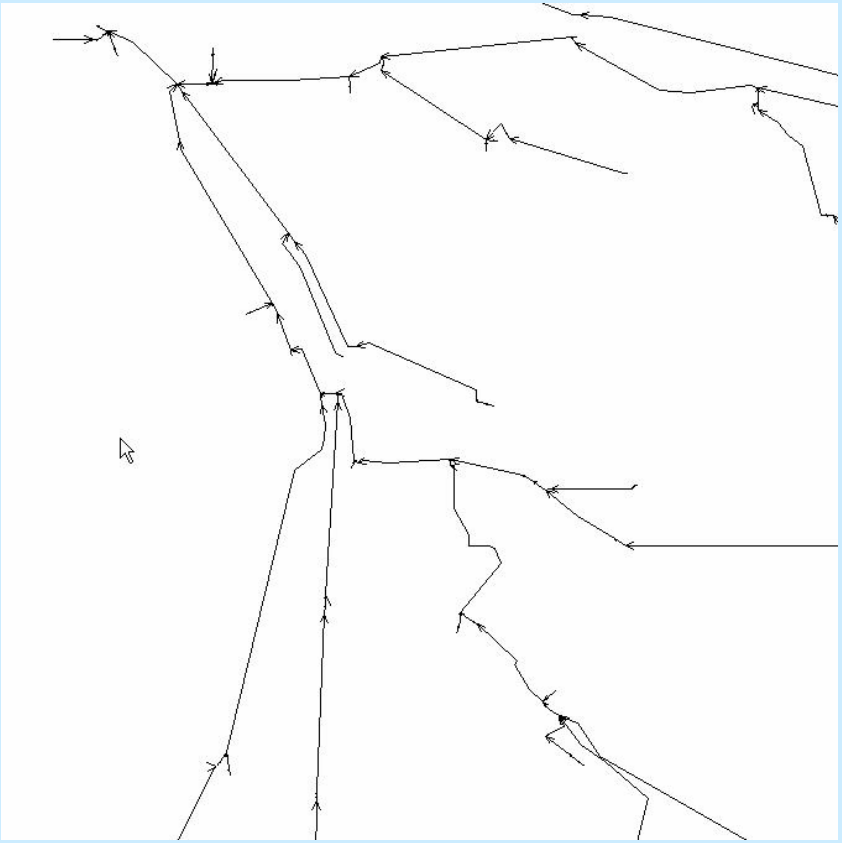
Quality Control issues that need to be analyzed are:

1. Proper direction for each arc representing sewer flow.
2. Duplicate population and flow values resulting from an arc being split by the basins during the identity process.



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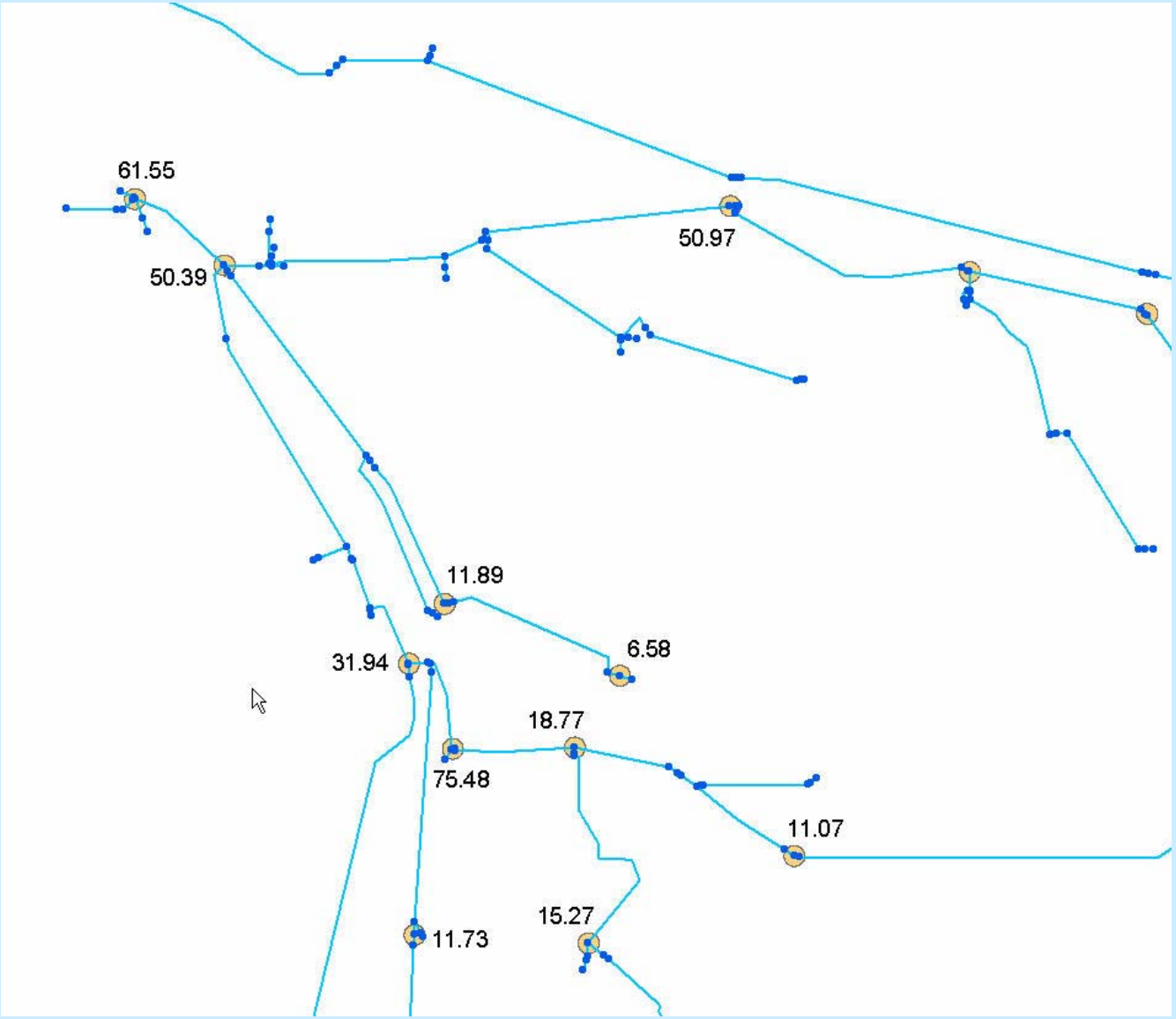

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- Calculate sewer capacities at manholes with data provided by Wastewater Management
- **Run sewer model**

The following slides will demonstrate the actual Sewer Model in use.

Sewer Model: zoom in to detail

```
Arc: &r trace

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ARCPLOT 8.2 (Thu Mar 14 16:26:27 PST 2002)

(thread0001, trace.aml)

  5:  shadeset cal999.shd
  6:  lineset plotter8.lin
  8:  mape wwm_model3
  9:  linesymbol 7
 10:  polygonshades targets 100
 11:  arcs wwm_model3
 12:  nodes wwm_model3
 13:  mape *
Define the box
 14:  clear
 15:  polygonshades targets 100
 16:  arcs wwm_model3
 17:  nodes wwm_model3
 18:  reselect wwm_model3 nodes box *
Define the box
WWM_MODEL3 nodes : 1 of 297 selected.
 19:  list wwm_model3 node capacity
Record        capacity
  81          61.55 MGD

 20:  asel wwm_model3 nodes
WWM_MODEL3 nodes : 297 of 297 selected.
 21:  &pause
Hit <return> to continue:
 22:  trace upstream wwm_model3 trace2 # *
Enter point
wwm_model3 nodes : 189 of 297 traced.
wwm_model3 arcs : 188 of 295 traced.
 23:  &type ENTER 9 TO QUIT
ENTER 9 TO QUIT
 24:  mape wwm_model3
 25:  clear
 26:  polygonshades targets 100
```

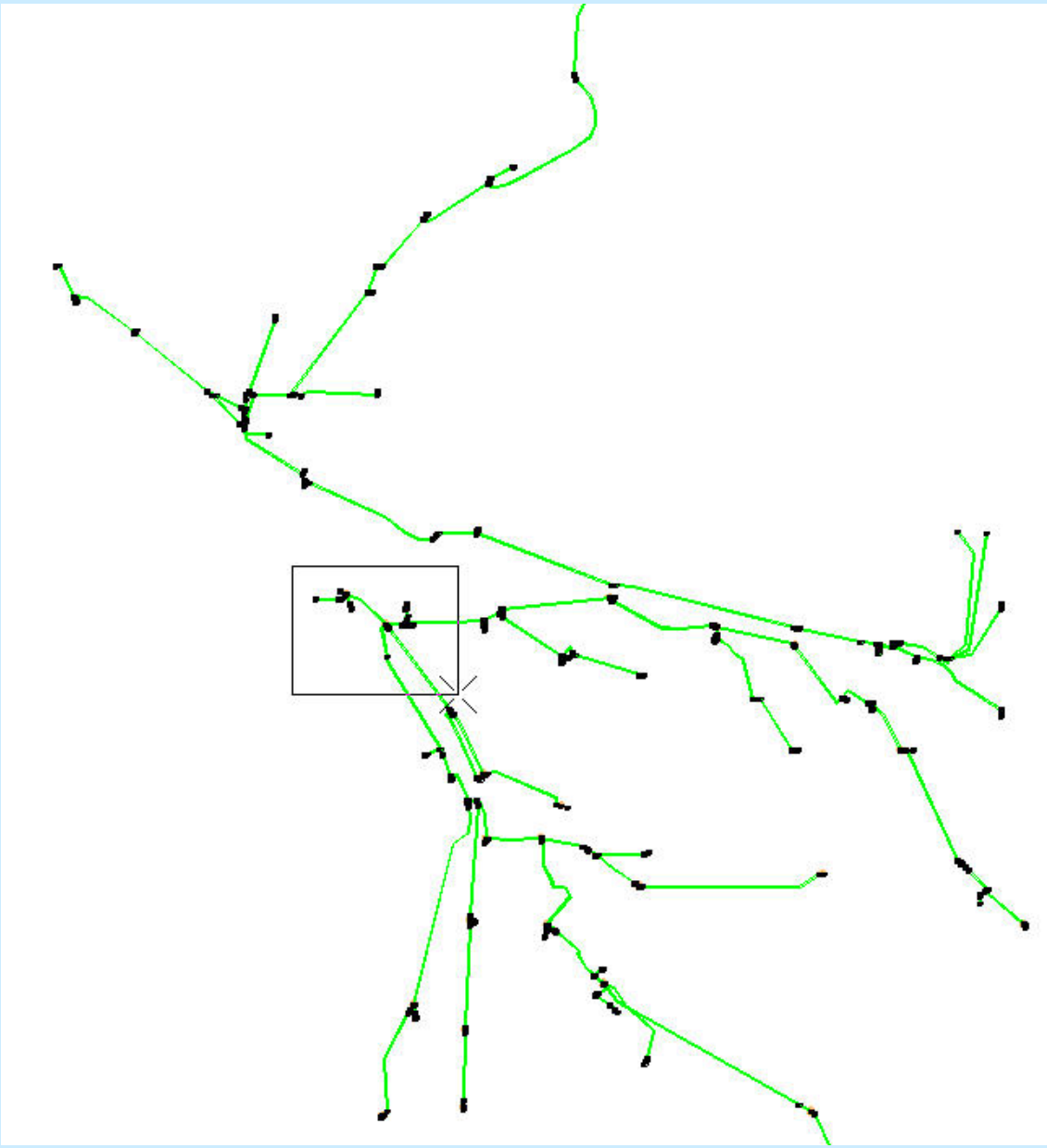

Sewer Model: select target manhole for baseline capacity

```
Arc: &r trace

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ARCPLOT 8.2 (Thu Mar 14 16:26:27 PST 2002)

(thread0001, trace.aml)

  5:  shadeset cal999.shd
  6:  lineset plotter8.lin
  8:  mape wwm_model3
  9:  linesymbol 7
 10:  polygonshades targets 100
 11:  arcs wwm_model3
 12:  nodes wwm_model3
 13:  mape *
Define the box
 14:  clear
 15:  polygonshades targets 100
 16:  arcs wwm_model3
 17:  nodes wwm_model3
 18:  reselect wwm_model3 nodes box *
Define the box
WWM_MODEL3 nodes : 1 of 297 selected.
 19:  list wwm_model3 node capacity
Record        capacity
  81          50.39 MGD

 20:  asel wwm_model3 nodes
WWM_MODEL3 nodes : 297 of 297 selected.
 21:  &pause
Hit <return> to continue:
 22:  trace upstream wwm_model3 trace2 # *
Enter point
wwm_model3 nodes : 189 of 297 traced.
wwm_model3 arcs : 188 of 295 traced.
 23:  &type ENTER 9 TO QUIT
ENTER 9 TO QUIT
 24:  mape wwm_model3
 25:  clear
 26:  polygonshades targets 100
```

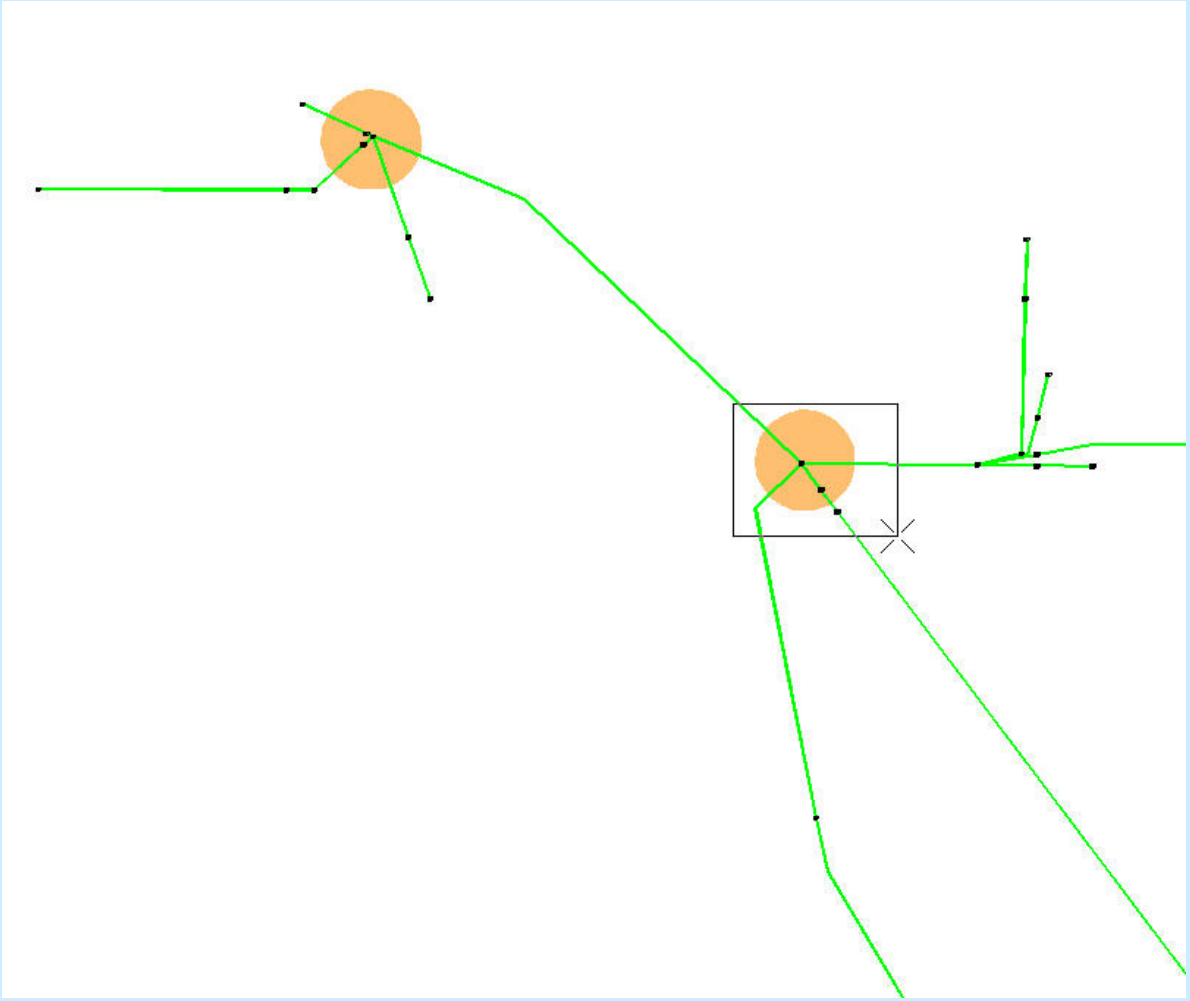

Sewer Model: initiate upstream network trace

```
Arc: &r trace

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ARCPLOT 8.2 (Thu Mar 14 16:26:27 PST 2002)

(thread0001, trace.aml)

  5:  shadeset cal999.shd
  6:  lineset plotter8.lin
  8:  mape wwm_model3
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 10:  polygonshades targets 100
 11:  arcs wwm_model3
 12:  nodes wwm_model3
 13:  mape *
Define the box
 14:  clear
 15:  polygonshades targets 100
 16:  arcs wwm_model3
 17:  nodes wwm_model3
 18:  reselect wwm_model3 nodes box *
Define the box
WWM_MODEL3 nodes : 1 of 297 selected.
 19:  list wwm_model3 node capacity
Record        capacity
  81          50.39 MGD

 20:  asel wwm_model3 nodes
WWM_MODEL3 nodes : 297 of 297 selected.
 21:  &pause
Hit <return> to continue:
 22:  trace upstream wwm_model3 trace2 # *
Enter point
wwm_model3 nodes : 189 of 297 traced.
wwm_model3 arcs : 188 of 295 traced.
 23:  &type ENTER 9 TO QUIT
ENTER 9 TO QUIT
 24:  mape wwm_model3
 25:  clear
 26:  polygonshades targets 100
```
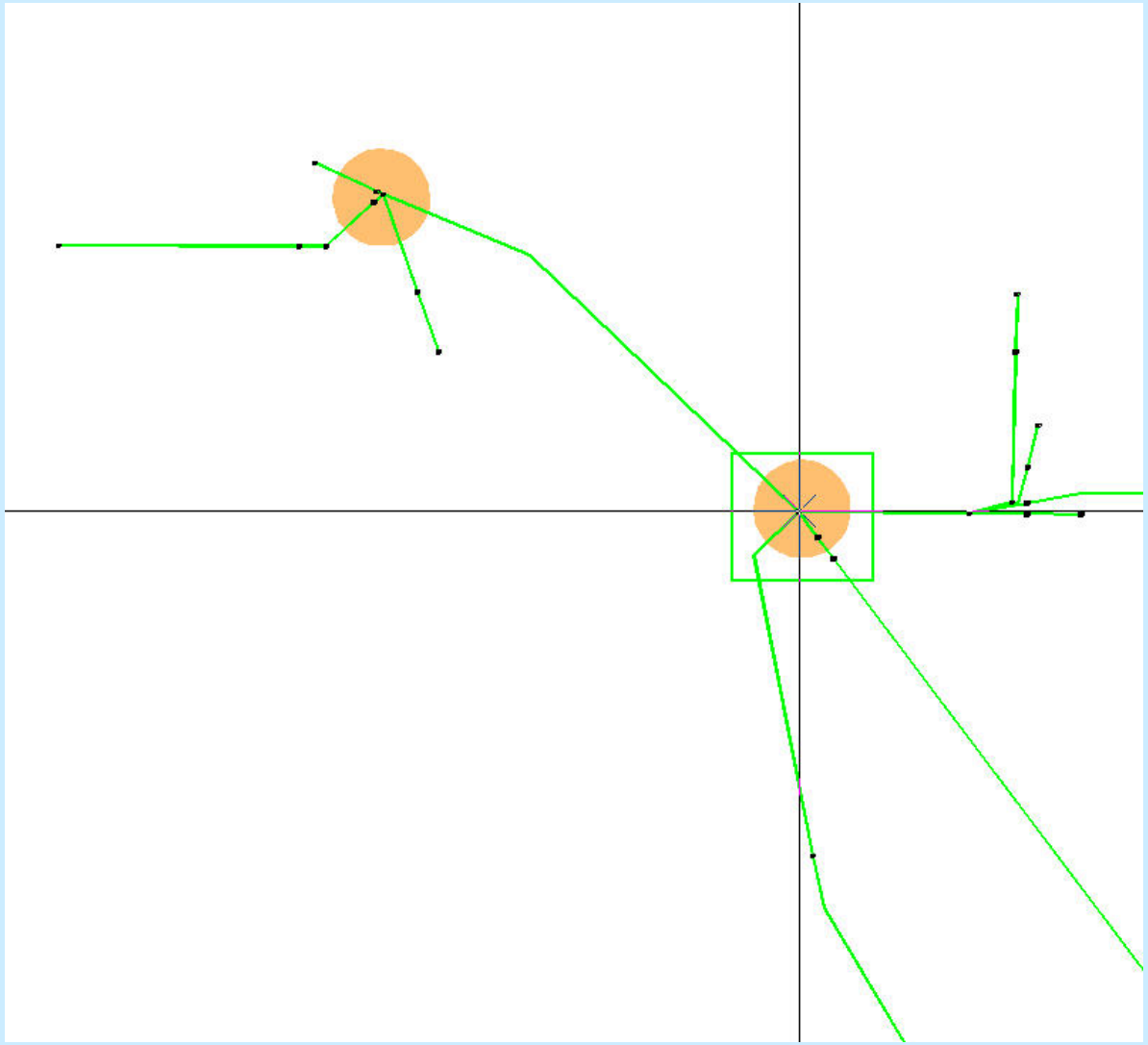
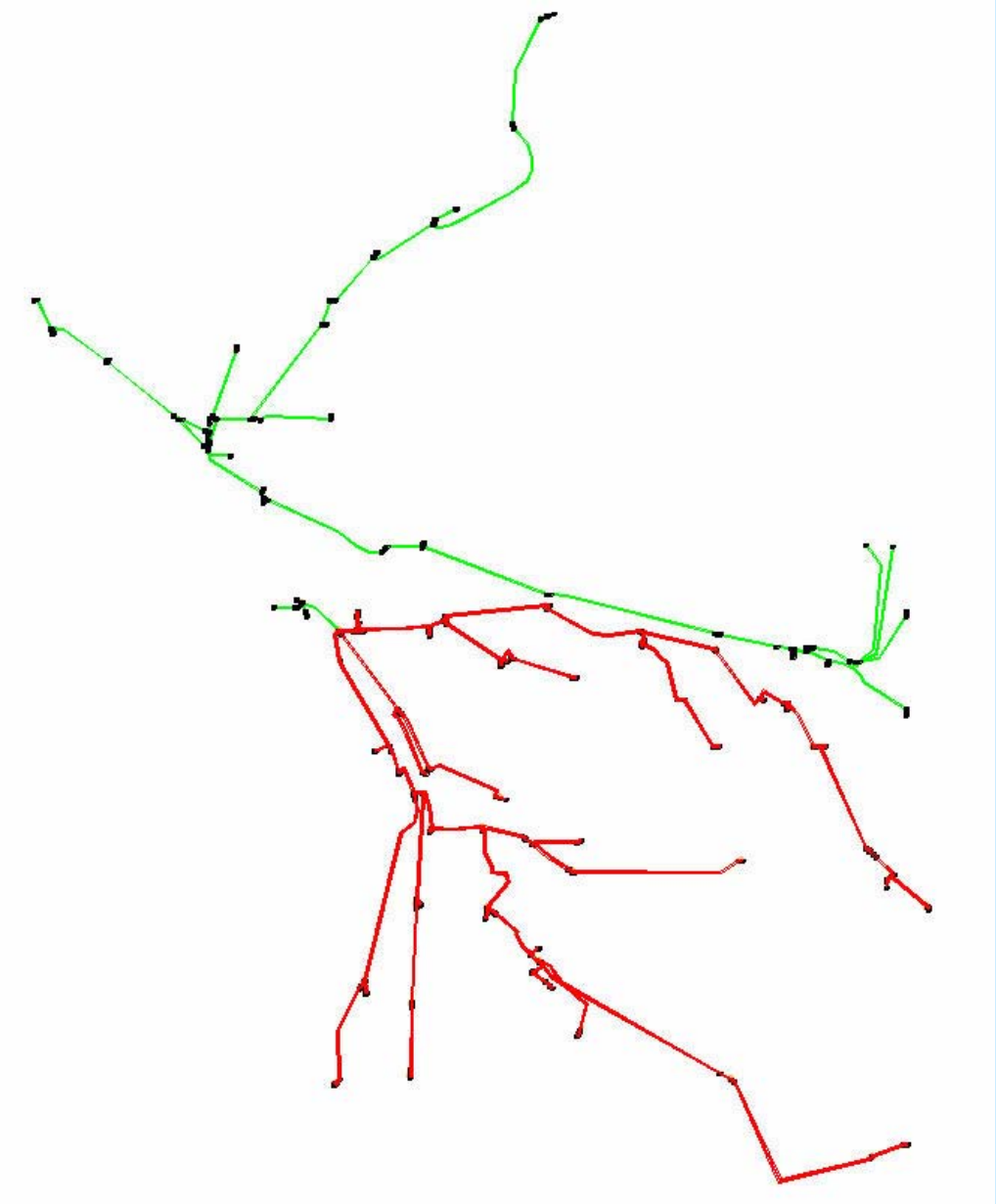



Sewer Model: display traced upstream sewer network

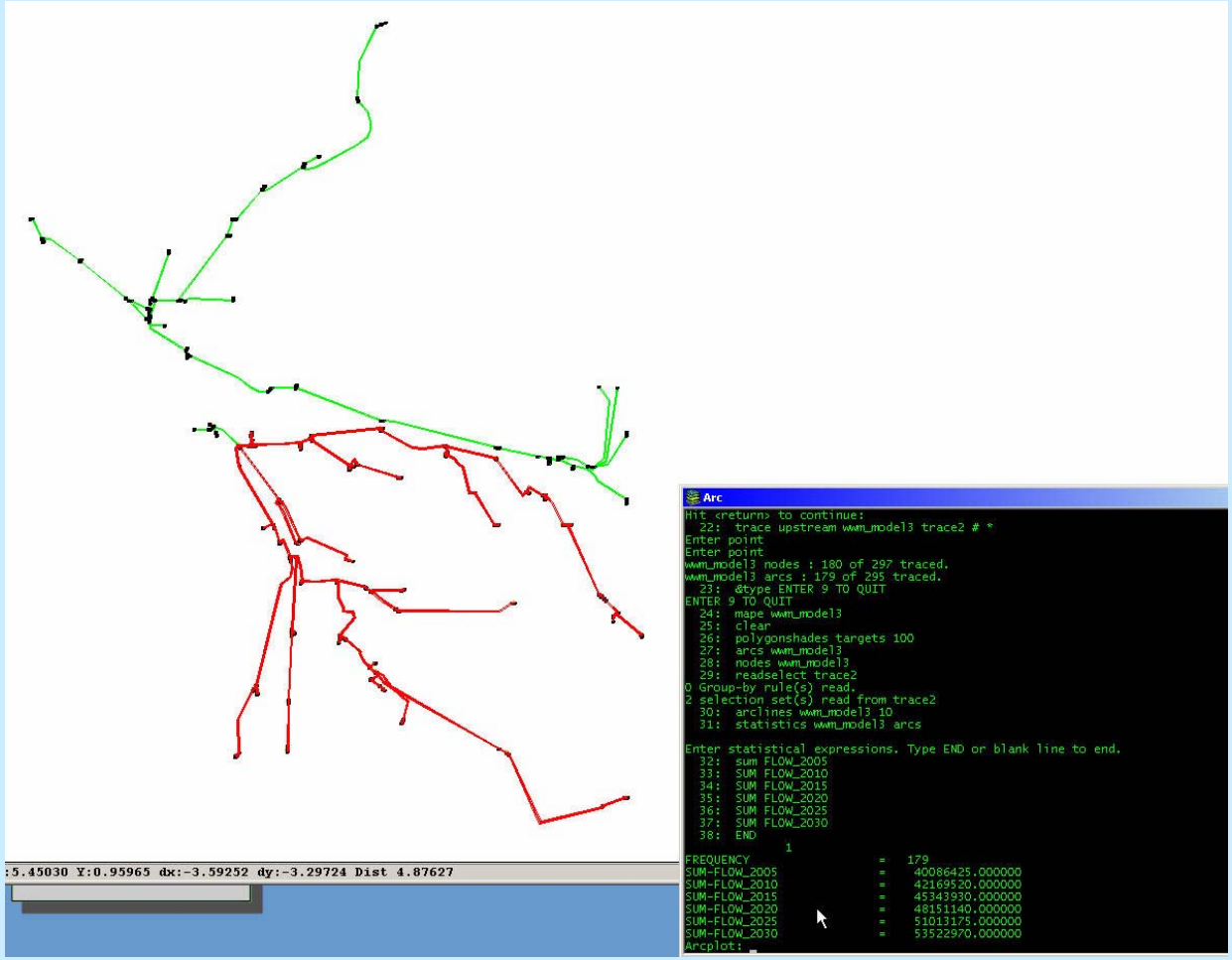
```
20: asel wwm_model3 nodes
WWM_MODEL3 nodes : 297 of 297 selected.
21: &pause
Hit <return> to continue:
22: trace upstream wwm_model3 trace2 # *
Enter point
wwm_model3 nodes : 189 of 297 traced.
wwm_model3 arcs : 188 of 295 traced.
23: &type ENTER 9 TO QUIT
ENTER 9 TO QUIT
24: mape wwm_model3
25: clear
26: polygonshades targets 100
27: arcs wwm_model3
28: nodes wwm_model3
29: readselect trace2
30: arclines wwm_model3 10
31: statistics wwm_model3 arcs

Enter statistical expressions. Type END or
blank line to end.
32: SUM FLOW_2005
33: SUM FLOW_2010
34: SUM FLOW_2015
35: SUM FLOW_2020
36: SUM FLOW_2025
37: SUM FLOW_2030
38: END
1
FREQUENCY          =  188
SUM-FLOW_2005      =  41,594,835
SUM-FLOW_2010      =  43,758,765
SUM-FLOW_2015      =  47,025,740
SUM-FLOW_2020      =  49,926,280
SUM-FLOW_2025      =  52,880,285
SUM-FLOW_2030      =  55,479,585
Arcplot:
```



Sewer Model: generate network flow statistics

- 20: asel wwm_model3 nodes
- WWM_MODEL3 nodes : 297 of 297 selected.
- 21: &pause
- Hit <return> to continue:
- 22: trace upstream wwm_model3 trace2 # *
- Enter point
- wwm_model3 nodes : 189 of 297 traced.
- wwm_model3 arcs : 188 of 295 traced.
- 23: &type ENTER 9 TO QUIT
- ENTER 9 TO QUIT
- 24: mape wwm_model3
- 25: clear
- 26: polygonshades targets 100
- 27: arcs wwm_model3
- 28: nodes wwm_model3
- 29: readselect trace2
- 30: arclines wwm_model3 10
- **31: statistics wwm_model3 arcs**

- **Enter statistical expressions. Type END or blank line to end.**
- **32: SUM FLOW_2005**
- **33: SUM FLOW_2010**
- **34: SUM FLOW_2015**
- **35: SUM FLOW_2020**
- **36: SUM FLOW_2025**
- **37: SUM FLOW_2030**
- **38: END**
- **1**
- **FREQUENCY = 188**
- **SUM-FLOW_2005 = 41,594,835**
- **SUM-FLOW_2010 = 43,758,765**
- **SUM-FLOW_2015 = 47,025,740**
- **SUM-FLOW_2020 = 49,926,280**
- **SUM-FLOW_2025 = 52,880,285**
- **SUM-FLOW_2030 = 55,479,585**
- Arcplot:



```
20: asel wwm_model3 nodes
WWM_MODEL3 nodes : 297 of 297 selected.
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32: SUM FLOW_2005
33: SUM FLOW_2010
34: SUM FLOW_2015
35: SUM FLOW_2020
36: SUM FLOW_2025
37: SUM FLOW_2030
38: END
1
FREQUENCY = 188
SUM-FLOW_2005 = 41,594,835
SUM-FLOW_2010 = 43,758,765
SUM-FLOW_2015 = 47,025,740
SUM-FLOW_2020 = 49,926,280
SUM-FLOW_2025 = 52,880,285
SUM-FLOW_2030 = 55,479,585

MANHOLE CAPACITY = 50.39 MGD
```

Sewer Model: summary

Conclusion:

The capacity of the selected manhole is reported as 50.39 MGD (million gallons per day) and based on this particular trace, the Sanitary Sewer should reach its capacity somewhere between the years 2020 and 2025.

Hydromantis, Inc.
Consulting Engineers

1685 Main Street West, Suite 302
Hamilton, Ontario, Canada
L8S 1G5
Tel: (905) 522-0012 x210
Fax: (905) 522-0031
E-mail: belia@hydromantis.com

Technical Memorandum

To:	Pima County
From:	Hydromantis, Inc.
Date:	9 February 2005
Subject:	Additional Modeling of Ina Road and Roger Road WWTP - Final
Project:	799-01

1. INTRODUCTION

Hydromantis Inc., was retained by Pima County to provide additional modeling services for the Ina and Roger Road WWTP. This technical memorandum summarizes the results of a simulation-based analysis of the two plants.

The results were based on the calibrated and preliminary models developed in a number of projects and described in the following reports:

1. Modeling of Ina Road WWTP – Final, 30 August 2003
2. Modeling of Ina Road WWTP HPO – Final, 30 June 2003
3. Modeling of Ina Road WWTP Biosolids Stream – Final, August 2003
4. Modeling of Roger Road WWTP – Final, 26 July 2004 (includes the biosolids stream and RSHF models)

The scope of work for the additional simulation scenarios resulted from conversations with PIMA County and it included (the e-mail containing the original scope of work has been included in Appendix A):

Ina Road WWTP

Task 1a: Run the un-calibrated BNRAS and calibrated HPO layouts with 25 MGD going to the HPO plant and 12.5 MGD going to the BNRAS plant (4 trains). All currently produced centrate (200,000 gpd) will be returned to the BNRAS. Evaluate the effluent from each plant and the blended effluent for BOD, TSS, nitrate, ammonia and TN.

Task 1b: Run the uncalibrated BNRAS and calibrated HPO layout with 25 MGD going to the HPO plant and the maximum flow providing complete nitrification going to the BNRAS plant (4 of 5 trains) and with all of the currently produced flow of centrate (200,000 gpd) returned to the BNRAS. The effluent from each plant and the blended effluent will be evaluated for BOD, TSS, nitrate, ammonia, and TN.

Task 2a: Convert the HPO to a nutrient removal plant by adding fixed film carriers and an anoxic zone. The HPO plant will receive 25MGD and the BNRAS will receive 25 MGD. The BNRAS plant will be the existing plant if it can fully nitrify 25 MGD and if not it will have an additional 4 trains of BNRAS plant. The centrate added to the BNRAS will correspond to Ina centrate plus centrate from a 20 MGD Roger (IFAS NdeN) operation.

Task 2b: Convert the HPO to nutrient removal plant by adding fixed film carriers and an anoxic zone. The HPO plant will receive 25MGD and the BNRAS will receive 12.5 MGD. The centrate added to the BNRAS train will correspond to Ina centrate plus centrate from a 50 MGD Roger (IFAS NdeN) operation.

Roger Road WWTP

Task 1a: Run the calibrated layout (20°C and winter influent concentrations) with the "old" operation, with RAS and biofilter effluent recycled upstream of the biofilters and 20 MGD of raw flow. The secondary effluent will be evaluated for BOD, TSS, nitrate, ammonia and TN.

Task 1b: Run the calibrated layout (20°C and winter influent concentrations) with the "old" operation, with RAS and biofilter effluent recycled upstream of the biofilters and 41 MGD of raw flow. The secondary effluent will be evaluated for BOD, TSS, nitrate, ammonia and TN.

Task 2a: Run the calibrated layout (20°C and winter influent concentrations) with the "new" operation, with no RAS recycle to the biofilters (activated sludge operation) and 20 MGD of raw flow. The secondary effluent will be evaluated for BOD, TSS, nitrate, ammonia and TN.

Task 2b: As per task 2a with a raw flow of 41 MGD.

Task 3a: Modify the calibrated layout to include in the aeration lanes fixed film carriers of 60% fill (20°C and winter influent concentrations). RAS will be re-circulating to the head of aeration and no flow will be re-circulating to the biofilters. Both aeration trains will be simulated as one unit with and internal recycle and 1/4 of their combined volume as anoxic. Optimize operations to minimize the effluent TKN and evaluated secondary clarifier effluent and for BOD, TSS, and TN. The raw flow will be 20 MGD.

Task 3b: As per task 3a with raw flow of 41 MGD.

Task 3c: As per task 3a with raw flow of 50 MGD.

The objective of this memorandum is to convey the results of the requested scenario simulations to Pima County and is not intended as a recommendation of any particular course of action at the Ina Road WWTP.

2. REVIEW OF INA ROAD WWTP PLANT MODEL DESCRIPTION

The following sections detail the HPO and the BNRAS model set-up.

2.1. Model Set-Up

The plant layout was constructed from the following process units:

a) **Influent**: For the HPO primary influent, a COD/TSS based influent model was implemented with the major data inputs being COD, TSS and TKN. For the BNRAS primary influent, a COD based influent model was implemented with the major data inputs being COD and TKN. A third influent object was included in the layout to simulate centrate addition to the BNRAS facility. A BOD based model was used for the centrate. A forth influent object was included to simulate methanol addition to the BNRAS facility for specific scenarios where carbon was limited.

b) **Primary Clarifiers:** For the HPO plant, the four (4) primary clarifiers were combined into one single unit with an equivalent surface area. For the BNRAS plant, the two (2) primary clarifiers were combined into one single unit with an equivalent surface area. The clarifiers were modeled with the one dimensional settler model that uses the double exponential settling equation.

c) **HPO**: The HPO tank was modeled as a single, plug flow unit consisting of three (3) completely mixed tanks-in-series. The mathematical model used to simulate the biological conversions in the activated sludge process was ASM2d. ASM2d was implemented to provide the option to evaluate phosphorous removal.

d) **BNRAS**: The BNRAS was modeled as a single, plug flow unit, consisting of eight (8) completely mixed tanks-in-series with an internal recycle flow connecting tank No.8 with tank No. 1. The mathematical model used to simulate the conversions in the activated sludge process was ASM2d, allowing for future phosphorous removal evaluation.

e) **Final Clarifiers:** For the HPO clarifiers, the four (4) secondary clarifiers were combined into one single unit with an equivalent surface area. For the BNRAS plant, the three (3) secondary clarifiers were combined into one single unit with an equivalent surface area. The clarifiers were modeled with the one dimensional settler model that uses the double exponential settling equation. This model is used to describe the vertical suspended solids profile from the sludge blanket to the weir under dynamic conditions.

Figure 2.1 shows the plant layout in GPS-X. The following sections detail the physical and operational parameters used in the plant model for each of the unit processes.

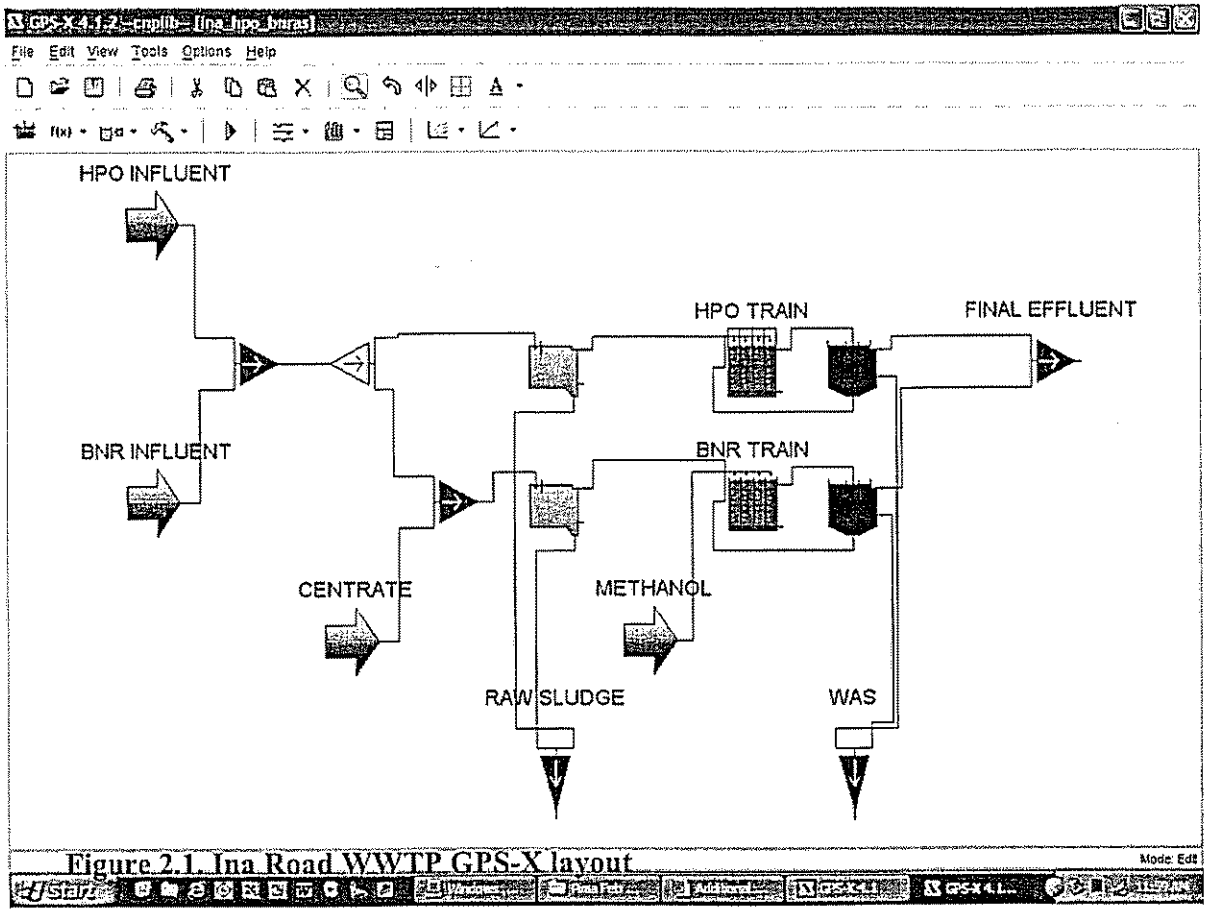


Figure 2.1. Ina Road WWTP GPS-X layout

2.2. Plant Raw Influent and Centrate Characteristics

The detailed profile used to model the Ina Road influent streams was based on the data obtained during an intensive sampling campaign in March 2003. Table 2.1 shows the average influent characteristics included in the model for both the HPO and BNRAS streams. The characteristics of the centrate have also been included.

Table 2.1 – Raw Influent and Centrate Characteristics – Averages for March 2003

Stream	Flow (MGD)	COD (mg/L)	$cBOD_5$ (mg/L)	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	NH_4-N (mg/L)
HPO Stream	25	590	300	270	220	57	37
BNRAS Stream	12.5	590	300	270	220	57	37
Centrate	0.2	3226	240	1335	1007	1285	1084

The stoichiometric ratios implemented in the raw influent models as well as the centrate are shown in Table 2.2.

Table 2.2 – Raw Influent and Centrate Stoichiometry

Stoichiomtetric ratio	HPO	BNRAS	Centrate
VSS/TSS	0.8	0.8	0.75
Soluble fraction of total COD	0.27	0.27	0.50
Inert fraction of soluble COD	0.33	0.33	0.85
COD content of VSS (XCOD/VSS)	1.9	1.9	0.30
BOD_5/BOD_{ult}	0.68	0.68	0.35

2.3. Ina Road WWTP Model Parameters

Table 2.3 summarizes the physical characteristics of the HPO model.

Table 2.3 – HPO Model Physical Parameters

Unit Object	Diameter (ft)	Total Surface Area (ft^2)	SWD (ft)	Total Volume (ft^3)	Gas Headspace Volume (ft^3)	SVI (mL/g)
Primary Clarifiers	-	34,560	8	-	-	-
Four trains	-	-	-	255,552	139,719	-
Final Clarifiers	115	41,548	14	-	-	150

Note: (-) in the table indicates that parameter is not required as model data entry.

Table 2.4 summarizes the physical characteristics of the BNRAS model.

Table 2.4 – BNRAS Model Primary Clarifiers

	Dimensions per Clarifier (ft)	Total Surface Area (ft^2)	SWD (ft)	Total Volume (gal)	Underflow Rate (gpm)	SVI (mL/g)
Primary Clarifiers	220 x 40	17,600	10	1,316,576	100	-
Anoxic: 4 trains with 4 stages	Each train: 112x28x21	-	-	263,424 (ft3)	-	-
Aerobic: 4 trains with 4 stages	Each train: 264x28x20	-	-	591,360(ft3)	-	-
Final Clarifiers	-	42,942	18	-	8,500 – 39,000	150

In addition to the information included in Tables 2.3 and 2.4 the following were also used in the model:

- BNRAS Train: Internal recycle pumps with an installed capacity of 4x13,000 gpm (1 standby). Operating range: 250-300% of AAF (AAF = 12.5 MGD, 31.25 – 37.5 MGD, average 275% = 34.4 MGD)
- BNRAS Train: The target MLSS concentration for the BNRAS train quoted in the CDM design tables was 3,000 mg/L.
- The maximum specific growth rate (μ_a) of the autotrophic group was 0.9 d^{-1} (@ 20°C) and the decay rate (b_a) was 0.17 d^{-1} (@ 20°C).
- BNRAS Aeration: The design tables provided by Pima County gave the diffuser distribution and blower capacity. The alpha and beta values used in the model were left at the defaults. The SOTE values were assumed to be the same as the target SOTE values shown in the US Filter Clean Water Oxygen Transfer Tests, August 2002. Table 2.5 shows the parameters used to model the aeration system of the BNRAS Train.

Table 2.5 – Ina Road BNRAS Train Aeration System Parameters

Parameter	Ina Road Model Values
α	0.6 - 0.8
β	0.95
θ	1.024
Total air flow installed (cfm)	28,000
Air flow distribution (% of total - stages 5 to 8)	48, 27, 17, 8
Specific oxygen transfer efficiency (% - stages 5 to 8)	31%, 31%, 29.5%, 29.5%

The HPO model set-up in this project did not consider the addition of liquid oxygen. The available oxygen feed was assumed to be provided by the PSA system only.

3. SIMULATION SCENARIOS AND RESULTS FOR THE INA ROAD WWTP PROCESS STREAM

3.1. Task 1a (Benchmark Scenario)

The basic performance of the Ina Road WWTP plant was established using a steady state simulation with the available design information. The un-calibrated BNRAS and calibrated HPO layouts were run with 25 MGD going to the HPO plant and 12.5 MGD going to the BNRAS plant (4 trains). All currently produced centrate (200,000 gpd) was returned to the BNRAS. The following operational parameters, detailed in Table 3.1 were used. This simulation was used as the benchmark case to investigate if the BNRAS train was carbon limited.

Table 3.1 – Task 1a Benchmark Scenario

Scenario Name	HPO Influent Flow (MGD)	BNRAS Influent Flow (MGD)	Centrate Flow (gpd)	Methanol Flow (gpd)	BNRAS Internal Recycle (MGD)	T (°C)
Task 1a	25	12.5	200,000	0	34.4	20

Table 3.2 shows the results for the benchmark scenario.

Table 3.2 – Task 1a Benchmark Scenario Results

	TSS (mg/L)	BOD_5 (mg/L)	TN (mg/L)	NH_4–N (mg/L)	Nitrate (mg/L)
HPO Final Effluent	22.3	16.6	38.0	35.7	0.1
BNRAS Final Effluent	7.0	2.6	35.9	1.1	33.9
Combined Final Effluent	16.9	11.7	37.3	23.6	11.9

The high total nitrogen (TN) concentration in the BNRAS effluent and the high nitrate concentration of the BNRAS effluent are indicative of incomplete denitrification due to a carbon limitation.

3.1.1. Sensitivity Analysis: Plant Performance vs. Methanol Addition

Following identification of a carbon limitation in the BNRAS tank, a sensitivity analysis was performed to evaluate the BNRAS plant performance with varying methanol addition rates. For this analysis, the plant internal recycle rate in the BNRAS tank was kept constant at 34.4 MGD

and the methanol addition was varied from 0 to 2,000 gallons per day (100% methanol solution). Figure 3.1 shows the effect of the variation of methanol addition on final effluent TN. The graphs included in this report are for 20°C. Detailed results and additional figures have been included in Appendix 1: Plant Performance vs. Methanol Addition.

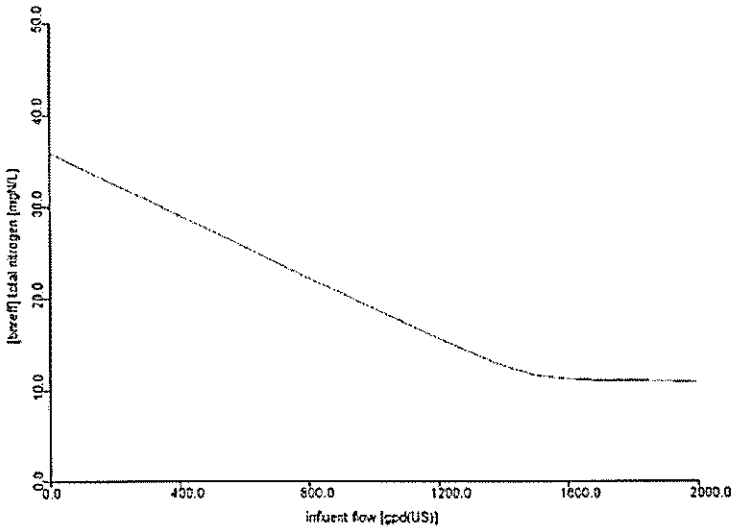


Figure 3.1. Effect of increasing methanol addition on final effluent TN of the BNRAS train

Figure 3.1 shows that no additional effluent TN benefit is achieved once the methanol addition exceeds 1,800 gpd. Furthermore, the results show that irrespective of the carbon addition, the desired effluent TN of 6-8 mgN/L could not be achieved using these model settings.

3.1.2. Sensitivity Analysis: Plant Performance vs. Methanol Addition – High Internal Recycle

A second sensitivity analysis was performed to evaluate the BNRAS plant performance with varying methanol addition rates using a higher internal recycle rate. For this analysis, the plant internal recycle rate in the BNRAS tank was 56.2 MGD (this value exceeds the installed pump capacity but was used to demonstrate the overall effect of internal recycle rates) and the methanol addition was varied from 0 to 2,000 gallons per day (100% methanol solution). Figure 3.2 shows the effect of the variation of methanol addition on final effluent TN with an increased internal recycle rate. The graphs included in this report are for 20°C. Detailed results and additional figures have been included in Appendix 2: Plant Performance vs. Methanol Addition – High IR.

Although these results show that a lower effluent TN may be achieved compared to the previous sensitivity analysis, the concentration it still higher than 8 mgN/L. Figure 3.2 shows that 1,800 gpd pure methanol is required to achieve desired TN. Increasing the internal recycle rate will not enhance denitrification.

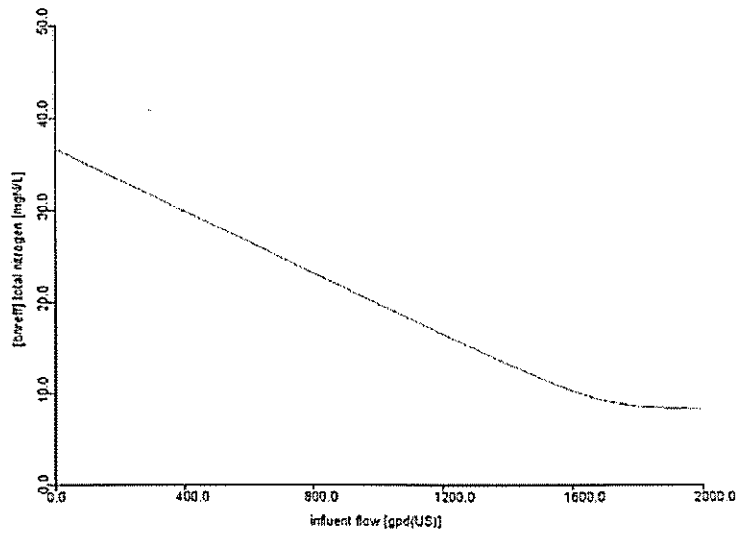


Figure 3.2. Effect of increasing methanol addition on final effluent TN of the BNRAS train.

3.2. Task 1b - BNRAS Nitrification Capacity: Impact of BNRAS Influent Flow on Effluent Ammonia

The preliminary model was used to investigate the capacity of the BNRAS train. A sensitivity analysis was performed varying the raw influent flow to the BNRAS plant from 5 to 25 MGD. The centrate flow was held constant at 200,000 gpd and no methanol was added to the plant. Figures 3.3 & 3.4 show the effect of the variation of the BNRAS influent flow on the influent and effluent ammonia concentrations of the BNRAS. The graphs included in this report are for 20°C. Detailed results and additional figures have been included in Appendix 3: Plant Performance vs. BNRAS Influent Flow.

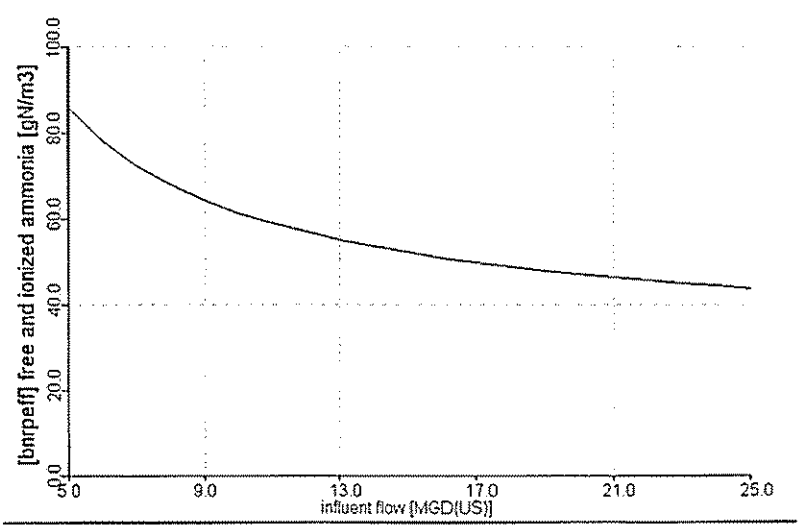


Figure 3.3. Effect of increasing the BNRAS influent flow on the influent ammonia concentration of the BNRAS.

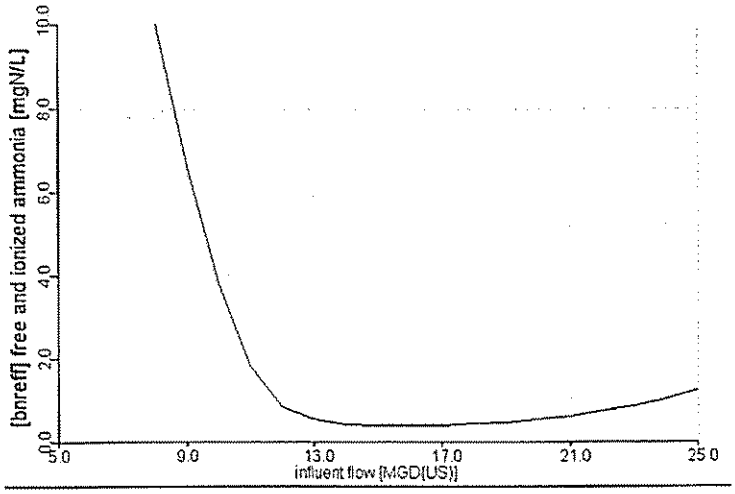


Figure 3.4. Effect of increasing the BNRAS influent flow on final effluent ammonia of the BNRAS (4 trains).

Figure 3.3 shows that the influent ammonia concentration of the BNRAS decreased with the increase of influent flow rate. Figure 3.4 shows that as the influent flow of the BNRAS train increased, the effluent ammonia concentration decreased as a result of dilution (up to 21MGD). At decreased flows, the centrate loading had a greater impact on the BNRAS influent concentration. It should be noted that nitrification occurred at all flows. This analysis was performed with an MLSS controller maintaining the target concentration of 3,500 mg/L. This target MLSS concentration was selected to allow for higher SRTs at the high ammonia loading rates used for the sensitivity analysis, even though it was 500 mg/L higher than the design concentration.

3.3. Task 2a – HPO NdeN Configuration with Centrate from 20 MGD IFAS NdeN Roger Road Operation

For this scenario, the HPO plant was converted to a nutrient removal plant by adding fixed film carriers and an anoxic zone. The HPO plant received a raw influent flow of 18 MGD (maximum flow at which the HPO train can nitrify as shown in the HPO Technical Memorandum) and the BNRAS plant received a raw influent flow of 25 MGD. The model results indicated that the existing BNRAS plant could not fully nitrify at 25 MGD of influent flow, so an additional four (4) trains were added to the BNRAS model (total additional volume - 854,784 ft^3). The centrate added to the BNRAS corresponded to Ina centrate plus centrate from Roger when simulated as an IFAS NdeN plant using an influent flow of 20 MGD. Table 3.3 shows the flow and quality of sludge generated at Roger Road.

Table 3.3 – Roger Road Operation - 20 MGD IFAS NdeN

Sludge Stream	Flow (MGD)	TSS (mg/L)	NH_4–N (mg/L)
Raw	0.84	8,983	22
WAS	1.00	3,607	0.46
Digested	0.173	21,137	2,480

The Ina and Roger sludge were fed into the Regional Solids Handling Facility (RSHF) model. Table 3.4 shows the centrate quality as predicted by the Regional Solids Handling Facility (RSHF) model after combining the Roger Road flow with the estimated Ina Road contribution.

Table 3.4 – New Centrate Quality

	Flow (gpd)	TSS (mg/L)	TKN (mg/L)	NH_4-N (mg/L)
RSHF – Centrate Quality	302,790	2,346	1,738	1,475

Figure 3.5 shows the effect of the variation of the BNRAS influent flow on the effluent ammonia concentration of the BNRAS with the new centrate (Table 3.4) for the 20°C run.

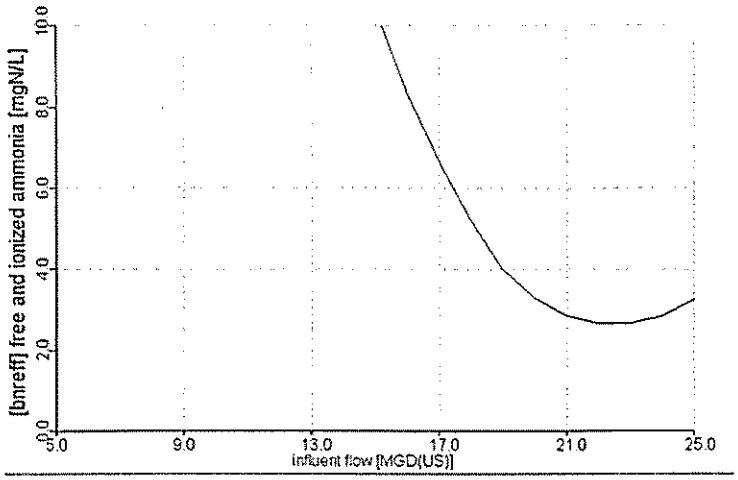


Figure 3.5. Effect of increasing the influent flow on final effluent ammonia of the existing BNRAS (4 trains) – with new centrate addition.

The centrate flow and quality shown in Table 3.4 was fed back into the Ina Road WWTP model and a steady state simulation was run to investigate its impact on the plant effluent quality. Table 3.5 summarizes the effluent quality results for this operational configuration.

Table 3.5 – Task 2a Results

Effluent Stream	TSS (mg/L)	BOD_5 (mg/L)	TN (mg/L)	NH_4-N (mg/L)	NOx-N (mg/L)
HPO Final Effluent	19	9	6	0.8	3.6
BNRAS Final Effluent (8 trains)	13	5	30	1.0	28
Combined Final Effluent	15	7	20	0.9	18

The low ammonia concentration in the BNRAS effluent indicates that the plant can nitrify under this scenario.

3.4. Task 2b – HPO NdeN Configuration with Centrate from 50 MGD IFAS NdeN Roger Road Operation

For this scenario both the HPO tank and the Roger Road facility were modeled as IFAS NdeN systems. The HPO plant was fed a raw influent flow of 18 MGD and the BNRAS plant was fed a raw influent flow of 12.5 MGD. The centrate added to the BNRAS corresponded to Ina centrate plus centrate from Roger when simulated as an IFAS NdeN plant using an influent flow of 50 MGD. Table 3.6 shows the flow and quality of sludge generated at Roger Road.

Table 3.6 – Roger Road Operation - 20 MGD IFAS NdeN

Sludge Stream	Flow (MGD)	TSS (mg/L)	NH_4–N (mg/L)
Raw	0.84	8,983	22
WAS	2.00	2,039	1.34
Digested	0.173	20,970	2,470

The Ina and Roger sludge were fed into the Regional Solids Handling Facility (RSHF) model. Table 3.7 shows the centrate quality as predicted by the Regional Solids Handling Facility (RSHF) model after combining the Roger Road flow with the estimated Ina Road contribution.

Table 3.7 – New Centrate Quality

	Flow (gpd)	TSS (mg/L)	TKN (mg/L)	NH_4 -N (mg/L)
RSHF – Centrate Quality	302,790	2,335	1,732	1,470

The centrate flow produced at the RSHF for the various future flow conditions could not be estimated accurately as it depends heavily on the following unknown operational parameters:

- Future operation of the thickening units at Roger Road
- Future retrofitting and feed pattern of the digesters at Roger Road
- Operation of the blending/dilution and pumping of digested sludge from Roger Road to Ina Road
- Blending and storing of the Ina and Roger sludge in the future, prior to feeding the centrifuge

In view of all these unknown parameters, it was assumed that several optimizations to the sludge processing streams would be undertaken to reduce the sludge produced and therefore the centrate flow was kept constant for the 50 MGD Roger Road operational scenarios and a sensitivity analysis on the impact of increased centrate flow was performed (Figure 3.6).

The centrate flow and quality shown in Table 3.7 was fed back into the Ina Road WWTP model and a steady state simulation was run to investigate its impact on the plant effluent quality. Table 3.8 summarizes the effluent quality results for this operational configuration.

Table 3.8 – Task 2b Results

	TSS (mg/L)	BOD_5 (mg/L)	TN (mg/L)	NH_4-N (mg/L)	NOx-N (mg/L)
HPO Final Effluent	19	9	6	0.8	3.6
BNRAS Final Effluent	7	3	56	18.5	36.5
Combined Final Effluent	14	6	26	8.1	17.1

To investigate the impact of a changing centrate load (due to changes in operation) on nitrification capacity, a sensitivity analysis was performed by varying the centrate flow and noting the resulting effluent ammonia concentrations. Figure 3.6 shows the results.

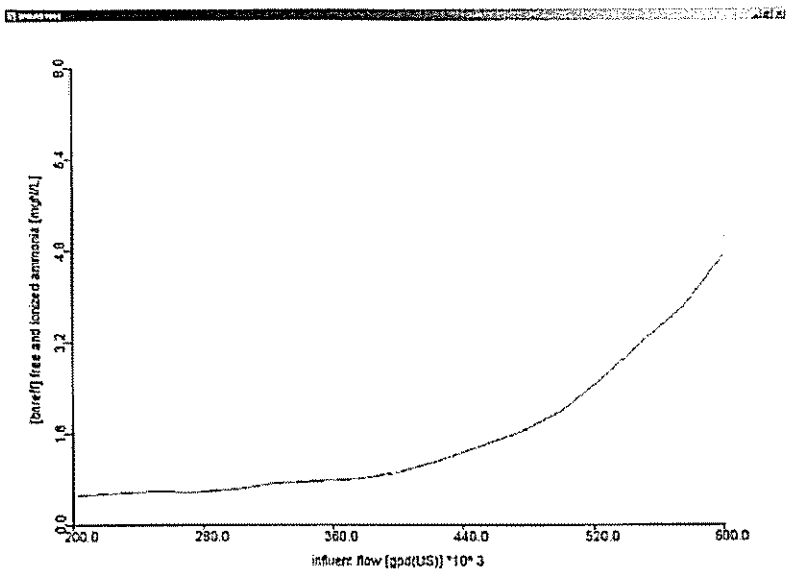


Figure 3.6. Effect of increasing centrate flow on final effluent ammonia concentrations of the BNRAS.

4. INA ROAD MODELLING RESULTS SUMMARY

The simulations results presented in Section 3 can be summarized as follows:

Task 1a: With the current plant configuration the model indicated that the HPO train could not nitrify at 25 MGD. The BNRAS train could produce an effluent ammonia concentration of 1 mg/L when treating 12.5 MGD and 200,000 gpd of centrate of the quality shown in Table 2.1.

Task 1b: The preliminary model indicated that the BNRAS train could treat up to 17 MGD of raw flow and 200,000 gpd of centrate of the quality shown in Table 2.1 and produce an effluent ammonia concentration of 1 mg/L.

Task 2a: The model results indicated that the hybrid HPO configuration combined with eight BNRAS trains could fully nitrify (<1 mg/L of ammonia) 50 MGD of raw flow (25 to the HPO 25

to the BNRAS) and 300,000 gpd of centrate of the quality shown in Table 3.4. The model indicated that the plant was limited in the amount of denitrification it could achieve.

Task 2b: The model results indicated that the hybrid HPO configuration could fully nitrify (<1 mg/L of ammonia) 25 MGD of raw flow. However the BNRAS with four trains could not fully nitrify 12.5 MGD of raw flow and 300,000 gpd of centrate of the quality shown in Table 3.7 (generated from Roger when treating 50 MGD). The model indicated that the plant was limited in the amount of denitrification it could achieve.

It must be noted that all simulation results were steady state runs. Additional evaluations need to be undertaken to verify the impact of plant influent dynamics on plant performance. Furthermore, the results presented here assume an ideal mix between the centrate and raw flows upstream of the primary tanks.

5. REVIEW OF ROGER ROAD WWTP PLANT MODEL DESCRIPTION

The following sections detail the Roger Road model set-up.

5.1. Model Set-Up

The plant layout was constructed from the following process units:

a) **Influent**: A BOD based influent model was implemented with the major data inputs being TSS, BOD and TKN. A second influent object with a BOD based model was included in the layout to simulate all return streams.

b) **Primary Clarifiers:** The six (6) primary clarifiers were simulated as three units, each with the equivalent surface area of two primary tanks. The clarifiers were modeled with the one dimensional settler model that uses the double exponential settling equation.

c) **Biofilters:** The two biofilters were simulated as one unit with the equivalent surface area. The biological model used was **Mantis**, modified to include diffusion in the biofilm.

d) **Aeration Tanks**: Each aeration train was modeled with a single, plug flow object, representing one (for AS 1-2) and four (for AS 3-6) completely mixed tanks-in-series. The bioreactor kinetics were modeled using the **Mantis** model, a modified version of ASM1. This kinetic model is capable of describing BOD-removal, nitrification and denitrification.

e) **Final Clarifiers:** The nine (9) secondary clarifiers were grouped into two units with an equivalent surface area. The clarifiers were modeled with the one dimensional settler model that uses the double exponential settling equation. This model is used to describe the suspended solids profile from the sludge blanket to the weir under dynamic conditions.

Figure 5.1 shows the plant layout in GPS-X. The following sections detail the physical and operational parameters used in the plant model for each of the unit processes.

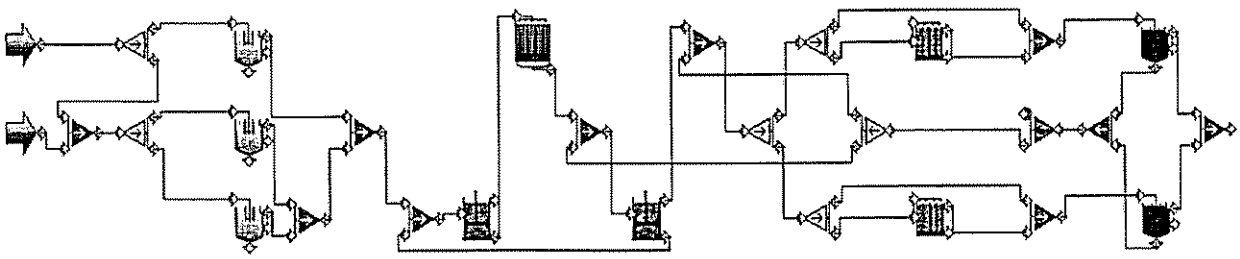


Figure 5.1. Roger Road WWTP GPS-X layout

5.2. Plant Raw Influent Characteristics

Table 5.1 shows the influent characteristics used in the model as determined by field measurements from January 2001 to March 2001. No recycle streams are included in these measurements.

Table 5.1 – Roger Road WWTP Model Influent Characteristics

COD (mg/L)	sCOD (mg/L)	BOD_5 (mg/L)	$sBOD_5$ (mg/L)	TSS (mg/L)	VSS (mg/L)	NH_4-N (mg/L)	TKN (mg/L)
585	261	231	115.5	228	180	25.7	39

From the data in Table 5.1, the following stoichiometric ratios were calculated (Table 5.2).

Table 5.2 – Raw Influent Stoichiometry

Parameter	Values in model - winter
VSS/TSS	0.79
Ammonia/TKN	0.66
Soluble substrate/BOD_{ult}	0.50
XCOD/VSS	1.80
BOD_5/BOD_{ult}	0.50

5.3. Roger Road WWTP Model Parameters

Table 5.3 summarizes the physical characteristics of the Roger Road model.

Table 5.3 – Roger Road WWTP Model Physical Parameters

Unit Process	Diameter /Unit (ft)	Total Surface Area (ft^2)	SWD (ft)	Total Volume (gal)
Primary Clarifiers 5-8	105	34,620	8	-
Primary Clarifiers 9-10	120	22,608	12	-
Biofilters	165	42,744	26	-
Aeration tanks 1, 2 (2 single stage basins)	-	264x41	15	151,000 x 2
Aeration tanks 3-6 (4 two-pass basins)	-	115x25	16.3	94,000 x 4
Final Clarifiers 1, 2	100	15,700	9	-
Final Clarifiers 3, 4	105	17,310	8	-
Final Clarifiers 5, 6	105	17,310	11	-
Final Clarifiers 7, 8, 9	105	25,965	12	-

In addition to the information included in Tables 5.2 and 5.3 the following were also used in the model:

- The raw flow split between the two sets of primary clarifiers was assumed to be 33.4% to PSTs 9-10 and 66.6% to PSTs 5-8.
- A 50% - 50% flow split between aeration trains 1-2 and 3-6 was assumed.
- The maximum specific growth rate (μ_a) of the autotrophic group was 0.9 d^{-1} (@ 20°C) and the decay rate (b_a) was 0.17 d^{-1} (@ 20°C).

- Aeration tanks 1 and 2 send flow to final clarifiers 1 to 4 and aeration tanks 3 to 6 send flow to final clarifiers 5 to 9.

Table 5.4 shows the values used in the model for the aeration system. No design information was available for the parameters included in **Error! Reference source not found.**5.4.

Table 5.4 – Aeration System Parameters

Parameter	Roger Road Model Values
α	0.6-0.8
β	0.95
θ	1.024
Total capacity installed (scfm)	Duty for AS 1-2: 7,000 scfm Duty for AS 3-6: 7,000 scfm Stand-by unit for both: 7,000 scfm
Air flow distribution across tanks (% of total)	Uniform (data not available)
Elevation (ft)	2,250
Specific oxygen transfer efficiency	0.04 (calibrated)

6. SIMULATION SCENARIOS AND RESULTS FOR THE ROGER ROAD WWTP

6.1. Tasks 1 and 2 - Impact of RAS Recirculation on Final Effluent

The calibrated model was used to establish plant secondary treatment performance using average influent flows of 20 MGD and 41 MGD in two modes of operation:

- "Old" operation – RAS and biofilter effluent are recycled upstream of the biofilters
- "New" operation – RAS and biofilter effluent are recycled downstream of the biofilters (i.e. the return stream does not contribute to the loading of the biofilter)

Tables 6.1, 6.2 and 6.3 summarize the operational parameters, biofilter performance and the overall plant performance for each scenario. The individual runs shown in the tables were:

- Task 1a: "old" operation and raw flow of 20 MGD.
- Task 1b: "old" operation and raw flow of 41 MGD.
- Task 2a: "new" operation and raw flow of 20 MGD.
- Task 2b: "new" operation and raw flow of 41 MGD.

The total recycle flow was kept constant at a rate of 12 MGD for all scenarios.

Table 6.1 – Operational Parameters

Scenario	Operation Mode	Raw Flow (MGD)	T (°C)	Last Cell DO AS 1-2 (mg/L)	Last Cell DO AS 3-6 (mg/L)	RAS Flow (MGD)	RAS TSS (mg/L)
Task 1a	Old	20	20	3.2	4.3	12	1204
Task 1b	Old	41	20	0.1	0.2	12	1338
Task 2a	New	20	20	4.4	5.1	12	843
Task 2b	New	41	20	0.2	0.2	12	1169

Table 6.2 – Biofilter Effluent

Scenario	COD (mg/L)	sCOD (mg/L)	BOD_5 (mg/L)	$sBOD_5$ (mg/L)	TSS (mg/L)	TN (mg/L)	NH_4-N (mg/L)	NOx-N (mg/L)
Task 1a	359	46	166	10	193	48	24.0	0.3
Task 1b	320	121	149	60	121	39	23.1	0.1
Task 2a	163	39	53	6	72	31	16.4	3.4
Task 2b	232	111	99	54	69	32	21.2	0.1

Table 6.3 – Final Effluent

Scenario	COD (mg/L)	sCOD (mg/L)	BOD_5 (mg/L)	$sBOD_5$ (mg/L)	TSS (mg/L)	TN (mg/L)	NOx-N (mg/L)
Task 1a	41	31	6	0.4	9	26	0.3
Task 1b	60	41	18	7	15	26	0.1
Task 2a	40	31	5	0.4	8	23	3.4
Task 2b	68	49	22	13	15	22	0.1

6.2. Task 3 - Impact of an Alternative Process Configuration on Final Effluent

The calibrated model was used as the basis for a preliminary model of an alternative process configuration that could be used to provide nitrogen removal. The aeration tanks were converted to hybrid systems containing fixed-film carriers, with 60% fill. An anoxic compartment was added to the head of the tank (¼ of total tank volume). An internal recycle flow was added to recycle nitrate to the head of the hybrid tank. The model was run with the "New" mode of operation, the RAS being re-circulated to the head of the hybrid tanks and no flow re-circulated to the biofilters. Operations were adjusted to minimize the final effluent TN. The performance of the hybrid system was evaluated for the following raw influent flows:

- Task 3a: 20 MGD
- Task 3b: 41 MGD
- Task 3c: 50 MGD

Tables 6.4, 6.5 and 6.6 summarize the operational parameters, biofilter performance and the plant performance for each scenario. The DO concentrations for the aerobic sections of the hybrid system were approximately 2 mg/L.

Table 6.4 – Hybrid System - Operational Parameters

Scenario	Operation Mode	Raw Flow (MGD)	T (°C)	Hybrid TSS (mg/L)	RAS Flow (MGD)	RAS TSS (mg/L)	RAS VSS (mg/L)
Task 3a	New	20	20	590	15	1590	1210
Task 3b	New	41	20	860	40	1870	1600
Task 3c	New	50	20	1010	50	2040	1730

Table 6.5 – Hybrid System – Biofilter Effluent

Scenario	COD (mg/L)	sCOD (mg/L)	BOD_5 (mg/L)	$sBOD_5$ (mg/L)	TSS (mg/L)	TN (mg/L)	NH_4-N (mg/L)	NOx-N (mg/L)
Task 3a	163	39	53	6	72	31	16.4	3.4
Task 3b	232	111	99	54	69	32	21.2	0.1
Task 3c	251	140	111	72	65	32	21.6	0

Table 6.6 – Hybrid System – Final Effluent

Scenario	COD (mg/L)	sCOD (mg/L)	BOD_5 (mg/L)	$sBOD_5$ (mg/L)	TSS (mg/L)	TN (mg/L)	NH_4-N (mg/L)	NOx-N (mg/L)
Task 3a	42	32	5	1	9	17	0.4	12.6
Task 3b	54	32	7	1	17	13	0.5	7.3
Task 3c	56	32	8	1	19	10	1.2	4.0

7. ROGER ROAD MODELLING RESULTS SUMMARY

The simulations results presented in Section 6 can be summarized as follows:

Tasks 1 and 2: The model indicated that, with the existing configuration, the Roger Road plant could not nitrify at either 20 or 41 MGD – with the "new" or the "old" operation. The main reasons for this were the low SRT the plant is currently operated at and the inefficient aeration system.

Task 3: The model results indicated that a hybrid configuration in combination with the existing biofilters could fully nitrify (~1 mg/L of ammonia) 20 to 50 MGD of raw flow. Increasing the DO concentration in the hybrid system for the 50 MGD scenario allows the ammonia to drop below 1 mg/L (results not shown). The model indicated that the plant was limited in the amount of denitrification it could achieve. However the addition of a post denitrification filter would allow complete denitrification.

It must be noted that all simulation results were steady state runs. Additional evaluations need to be undertaken to verify the impact of plant influent dynamics on plant performance.

APPENDIX A – ORIGINAL SCOPE OF WORK DOCUMENT

From: Dennis Froehlich

Sent: Tuesday, January 25, 2005 1:08 PM

To: 'Lina Belia'

Cc: Ed Curley; Steve Munsell

Subject: RE: New tasks

Following our phone conversation (Friday 21st and Monday 24th Jan 2005), the requested Scope of Work tasks are summarized as follows:

Presentation (1-day)

Friday February 11th - full-day meeting to present and discuss Facility Plan Scenario Simulation Results with Facility Plan Team (CDD, Treatment, and Engineering).

Roger Road (1 -day)

1. The calibrated layout (20C winter influent concentrations) will be run and secondary effluent evaluated for BOD, TSS, and nitrate, ammonia, and TN under the following scenarios:

1a. "Old" operation, with RAS and biofilter effluent recycled upstream of biofilters, raw flow 20 MGD.

1b. "Old" operation, with RAS and biofilter effluent recycled upstream of biofilters, raw flow 41 MGD.

2a. "New" operation, no recycle flow to biofilters, raw flow 20 MGD (activated sludge operation).

2b. "New" operation, no recycle flow to biofilters, raw flow 41 MGD (activated sludge operation).

2. The calibrated layout (winter influent concentrations) will be modified to include fixed film carriers of 60% fill, with RAS recirculating to head of aeration, no flow recirculating to biofilters, both aeration trains simulated as one unit with and internal recycle and 1/4 of their combined volume as anoxic, with tertiary denitrification filter. Operations will be optimized to minimize effluent TKN. Secondary Clarifier effluent and denite filter effluent will be evaluated for BOD, TSS, and TN.

2a. Raw flow of 20 MGD

2b. Raw flow of 41 MGD

2c. Raw flow of 50 MGD

Note: I would like to rerun these scenarios later using the new Biofilter media with 40 ft2/ft3 replacing the current 27 ft2/ft3 media that may be compromised.

Ina Road (1-day)

1a. The uncalibrated BNRAS and calibrated HPO layout will be run with 25 MGD going to the HPO plant and 12.5 MGD going to the BNRAS plant (4 trains) and with all of the currently produced flow of centrate returned to the BNRAS. The effluent from each plant and the blended effluent will be evaluated for BOD, TSS, nitrate, ammonia, and TN.

1b. The uncalibrated BNRAS and calibrated HPO layout will be run with 25 MGD going to the HPO plant and the maximum flow providing complete nitrification going to the BNRAS plant (4 of 5 trains) and with all of the currently produced flow of centrate returned to the BNRAS. The effluent from each plant and the blended effluent will be evaluated for BOD, TSS, nitrate, ammonia, and TN.

2a. HPO will be converted to nutrient removal plant by adding fixed film carriers and an anoxic zone (exiting 3 reactor cells /train with first anoxic and second two aerobic - for all four trains and internal recycle), the HPO will receive 25MGD and the BNRAS will receive 25 MGD (the "25 MGD" BNRAS plant will be the existing plant if it can fully nitrify 25 MGD and if it cannot fully nitrify 25 MGD, the 25 MGD BRAS will be an additional 4 trains of BNRAS plant) and the centrate will be that corresponding to Ina centrate plus centrate from a 20 MGD Roger (IFAS NdeN) operation.

2b. HPO will be converted to nutrient removal plant by adding fixed film carriers and an anoxic zone, the HPO will receive 25MGD and the BNRAS will receive 12.5 MGD and the centrate will be that corresponding to Ina centrate plus centrate from a 50 MGD Roger (IFAS NdeN) operation.

The BNRAS volumes will be consistent with the operation of 4 of 5 trains. The HPO volumes will be consistent with the first reactor in each reactor as an anoxic reactor and the second two reactors as aerobic reactors. All IFAS modeling will use a suspended carrier media with the following properties:

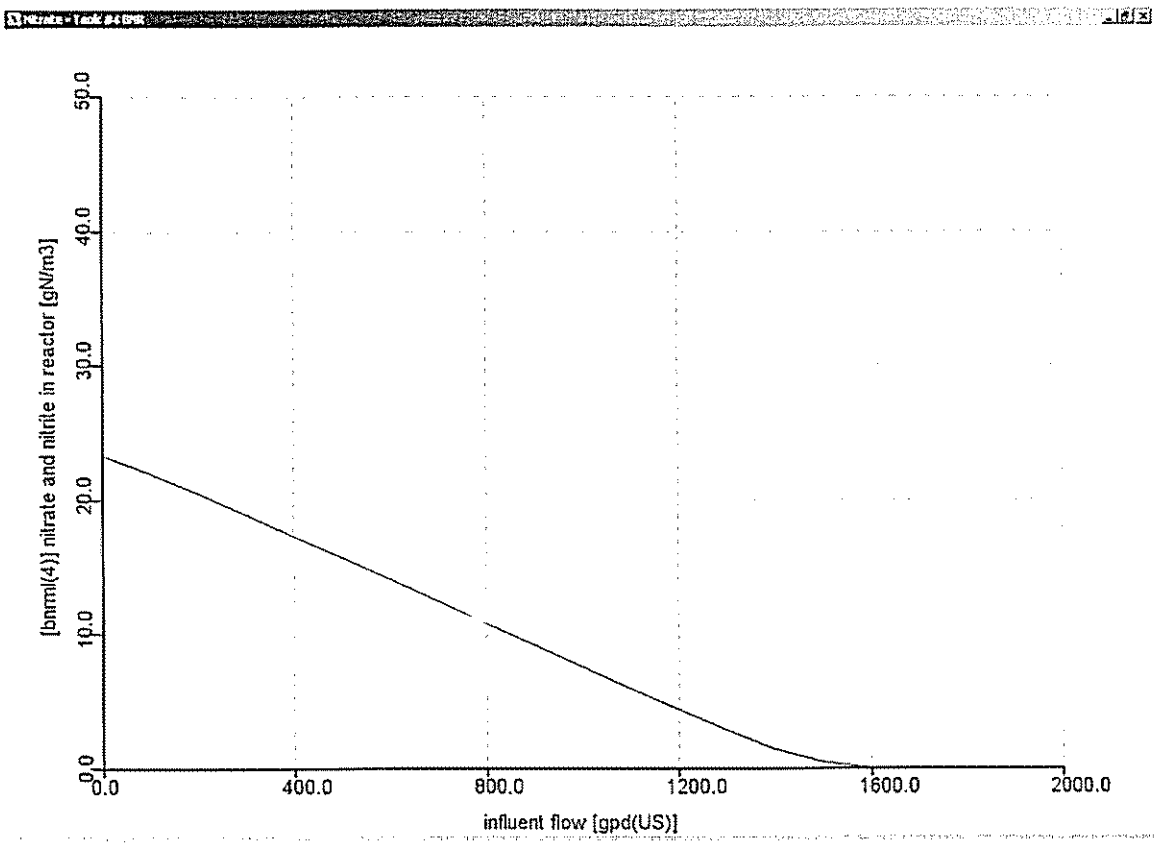
1) ***1200 m2/m3 specific surface area,***
2) ***biofilm thickness of typically 0.2 mm.,***
3) ***12% (volume) displacement of water at 50% fill,***
4) ***specific density of 0.99-1.02 kg/m3 for the media.***

Dennis Froehlich

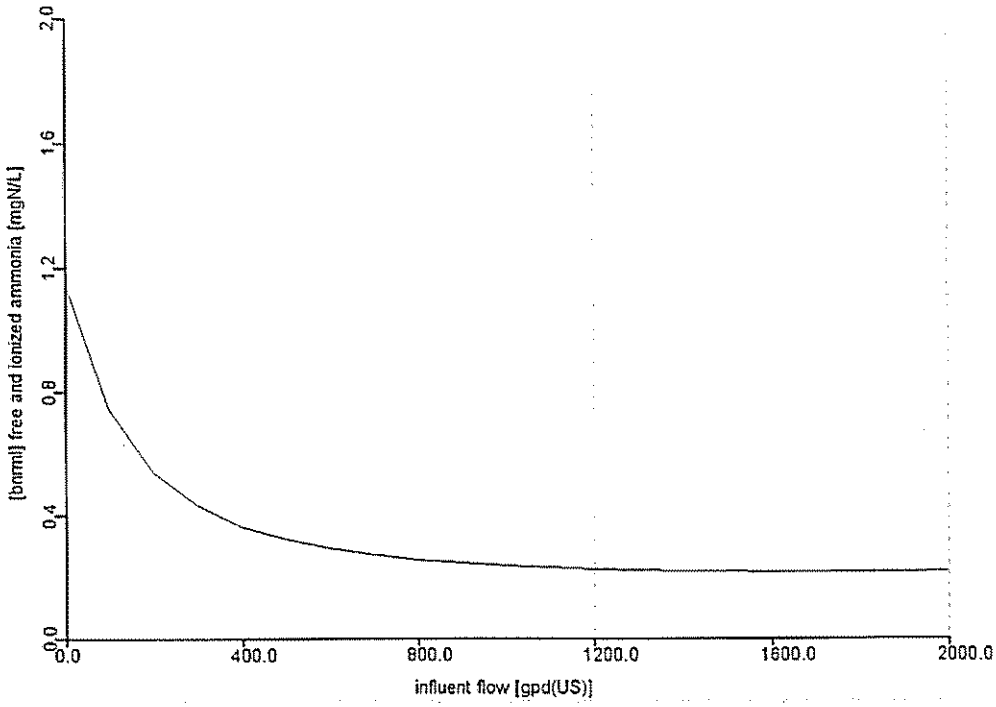
Sensitivity Analysis # 1: Plant Performance vs. Methanol Addition

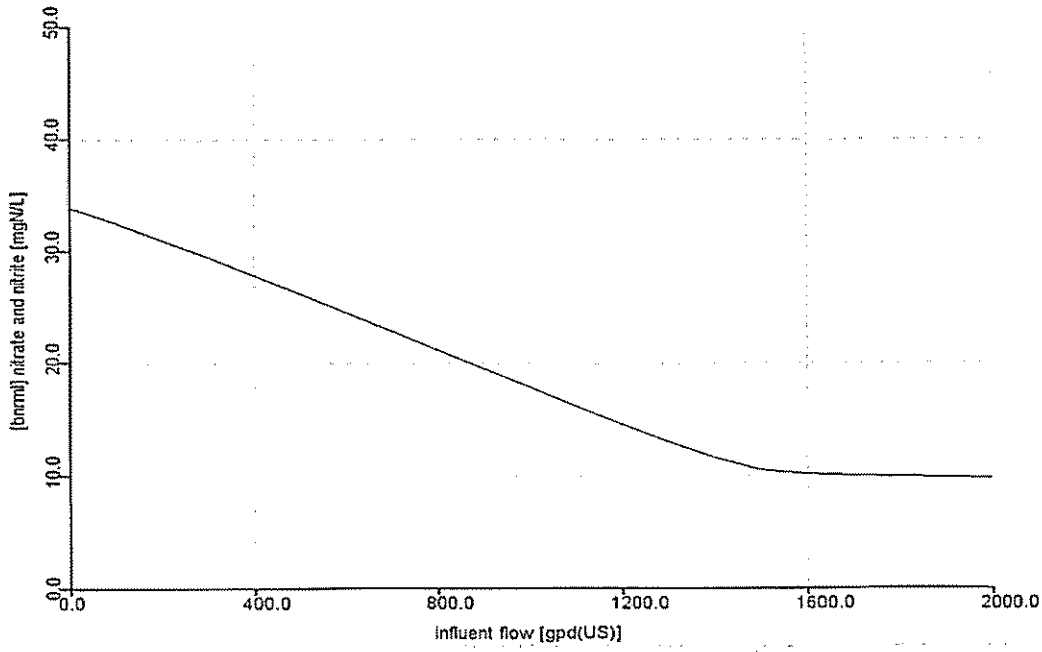
1) HPO FLOW = 25 MGD
2) BNR FLOW = 12.5 MGD
3) CENTRATE FLOW = 200,000 gpd(US)
4) **METHANOL FLOW = 0-2000 gpd(US) (varied on the x-axis)**
5) BNR INTERNAL RECYCLE = 34.4 MGD

Nitrate Concentration – Tank #4 - BNR

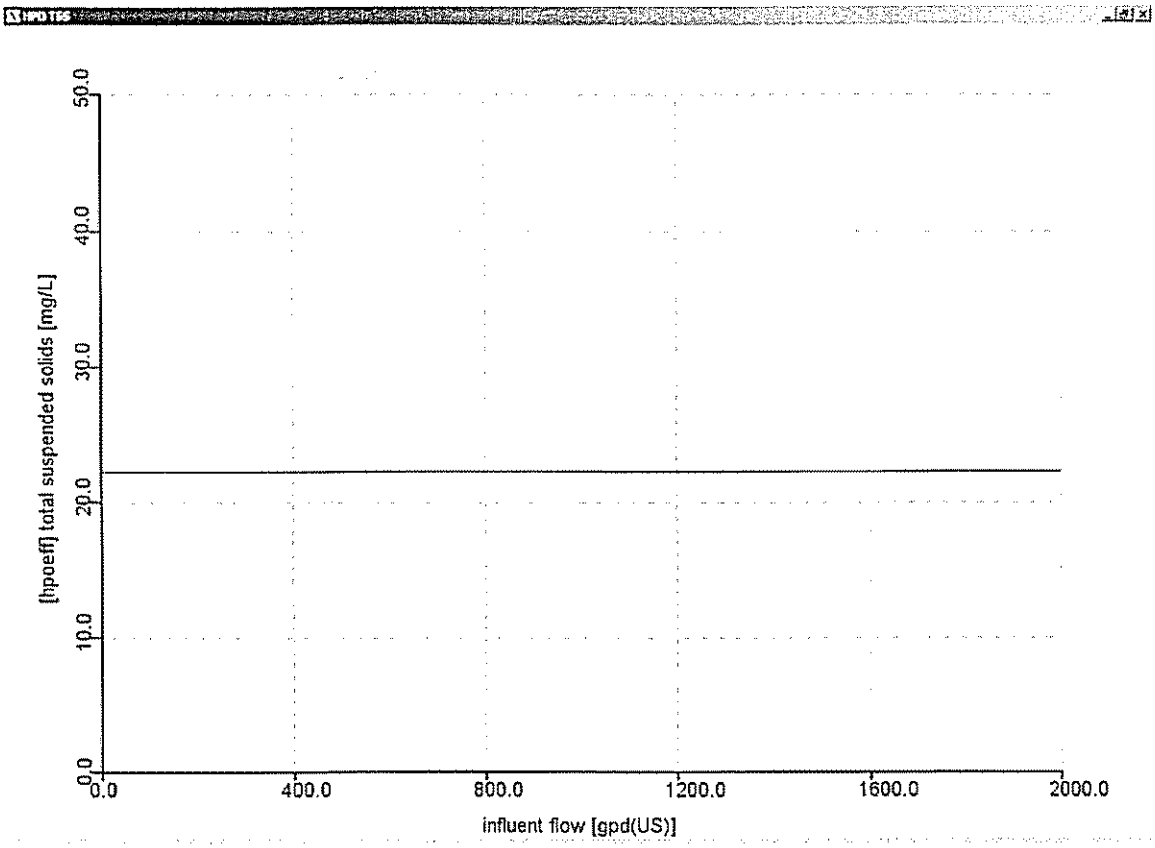


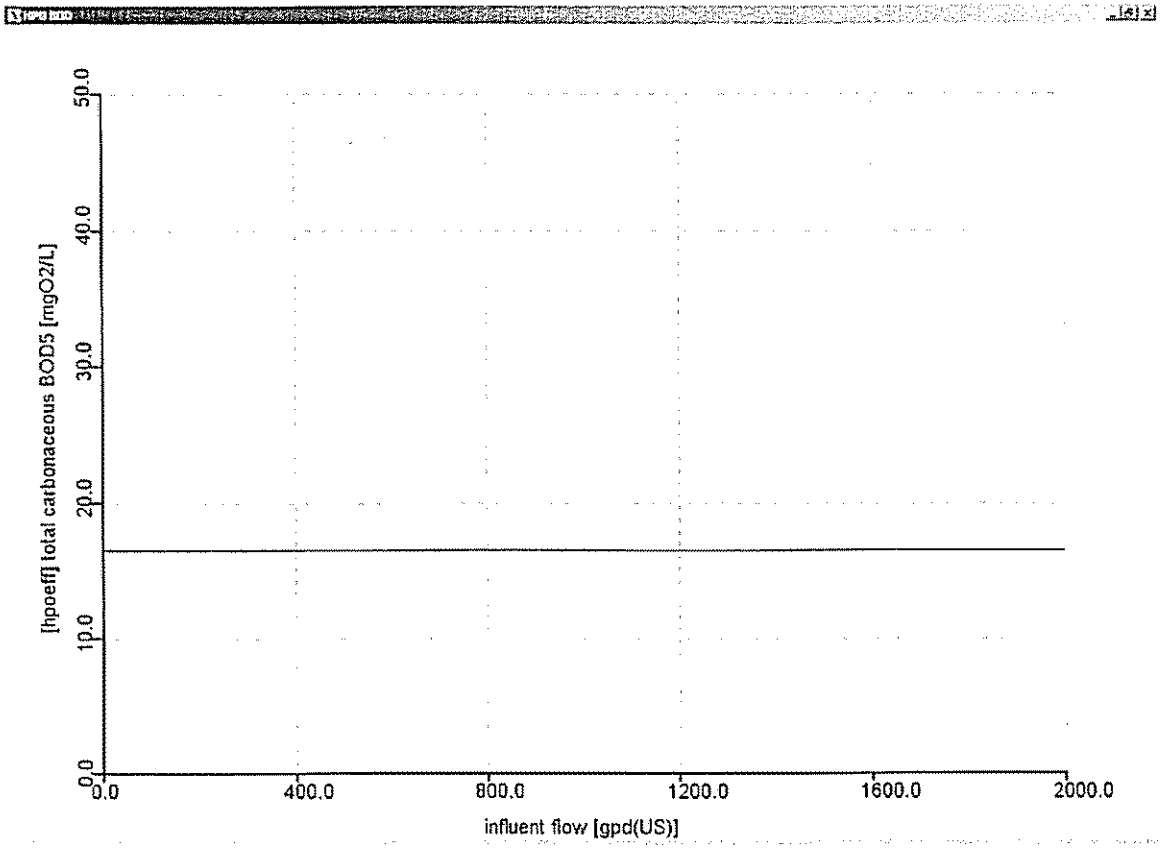
BNR Mixed Liquor Effluent – Ammonia & Nitrate Concentration





HPO Final Effluent – TSS, BOD5, TN, Ammonia, Nitrate

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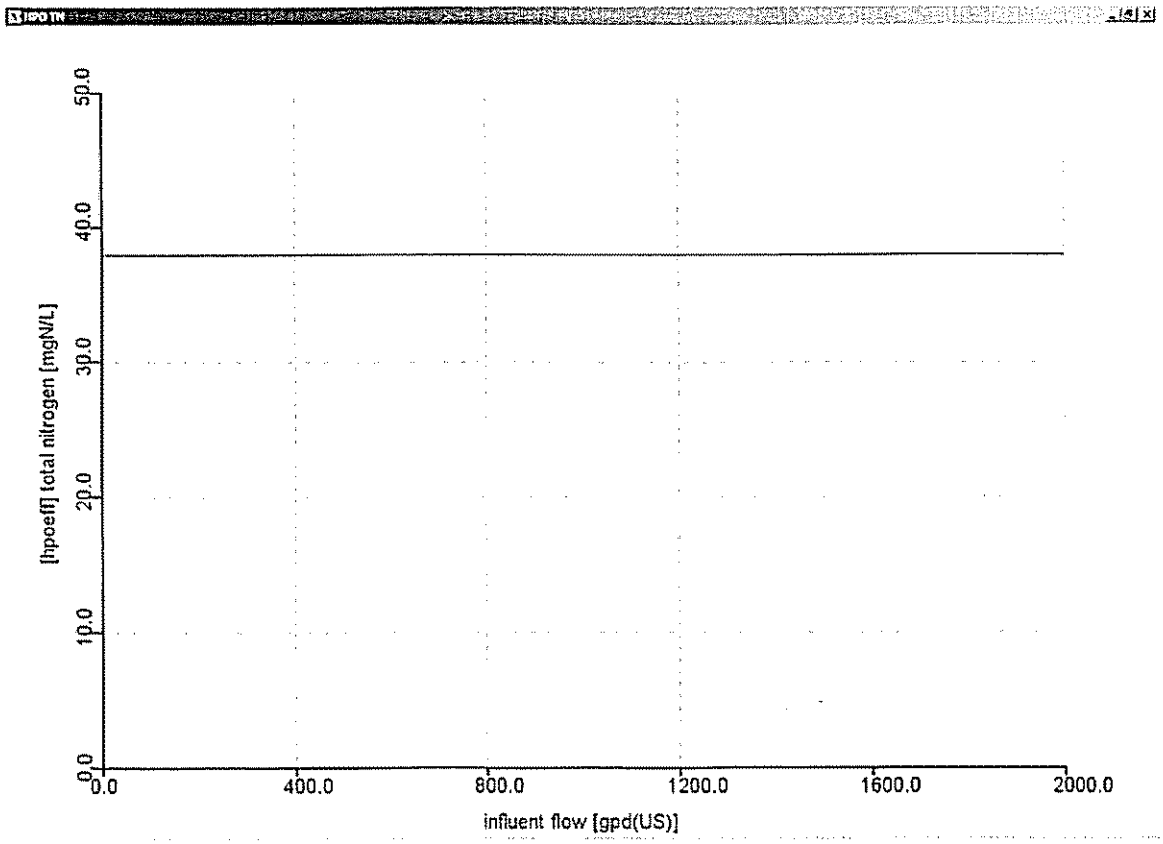
800.0
1200.0
1600.0
2000.0
influent flow [gpd(US)]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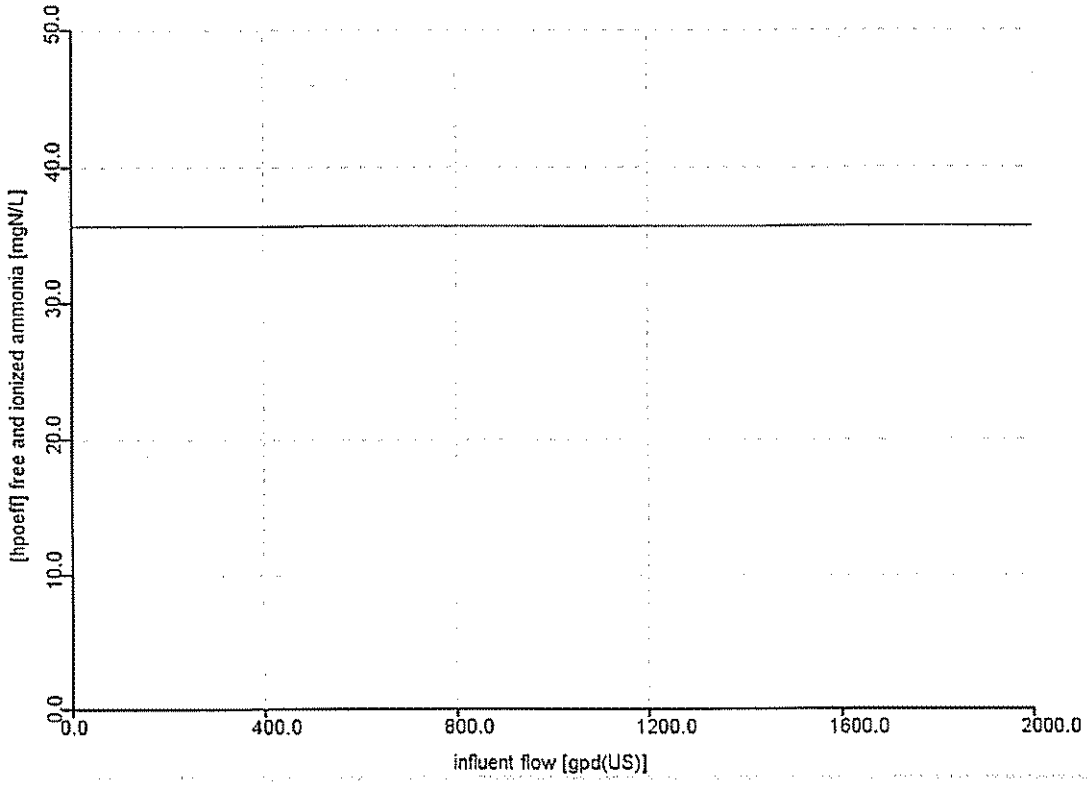
2000.0
influent flow [gpd(US)]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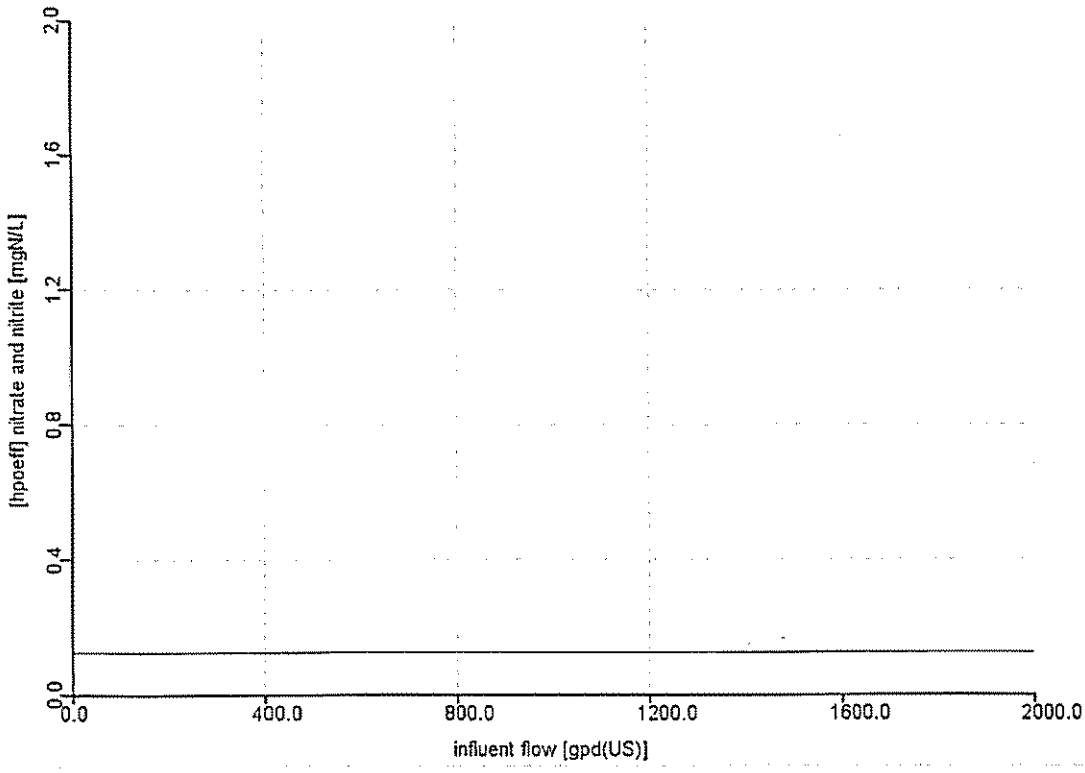
1600.0
2000.0
influent flow [gpd(US)]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1.6
2.0
0.0
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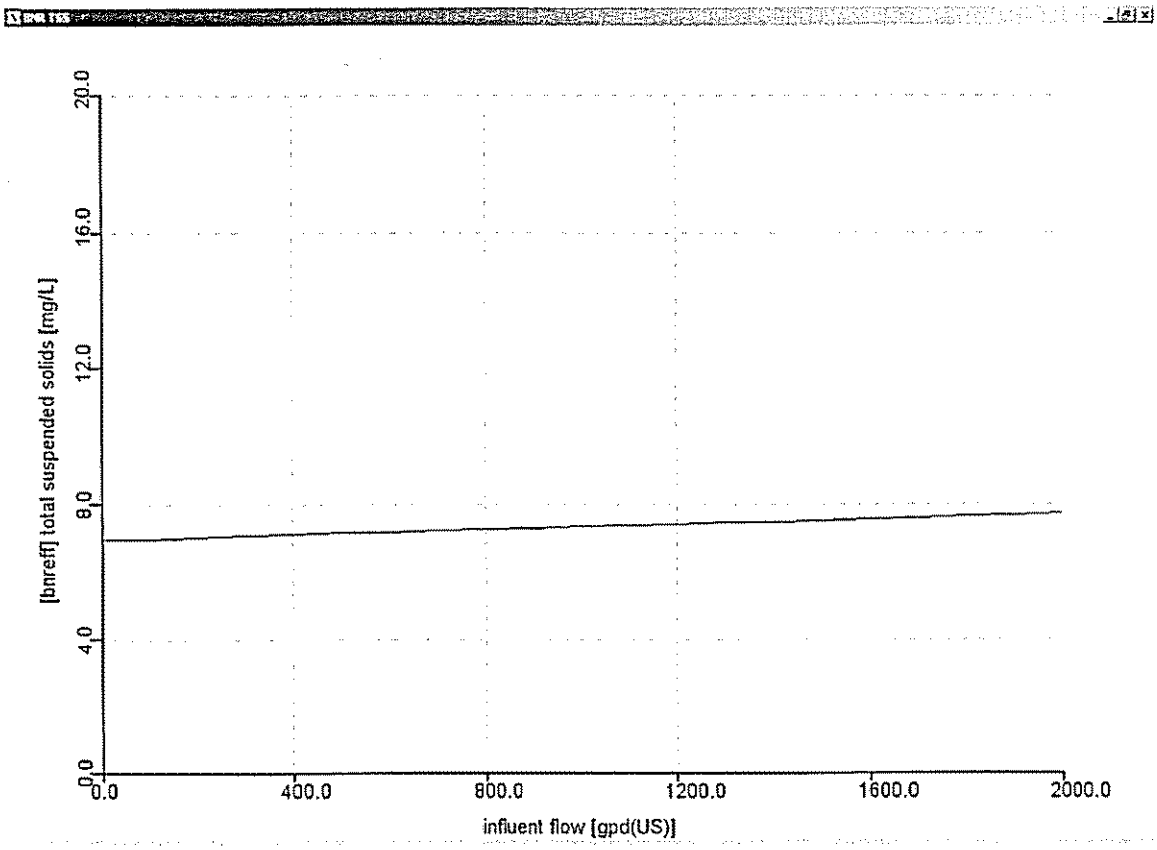
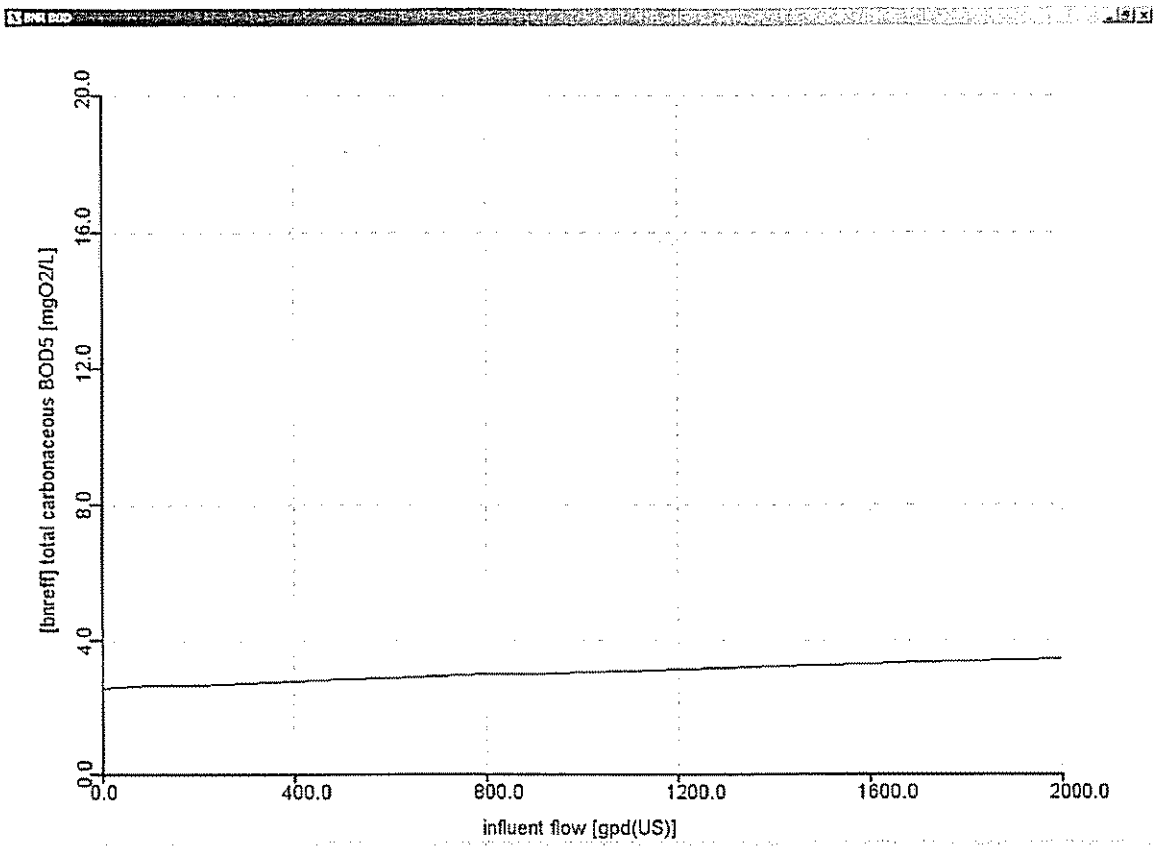
1600.0
2000.0
influent flow [gpd(US)]

BNR Final Effluent – TSS, BOD5, TN, Ammonia, Nitrate

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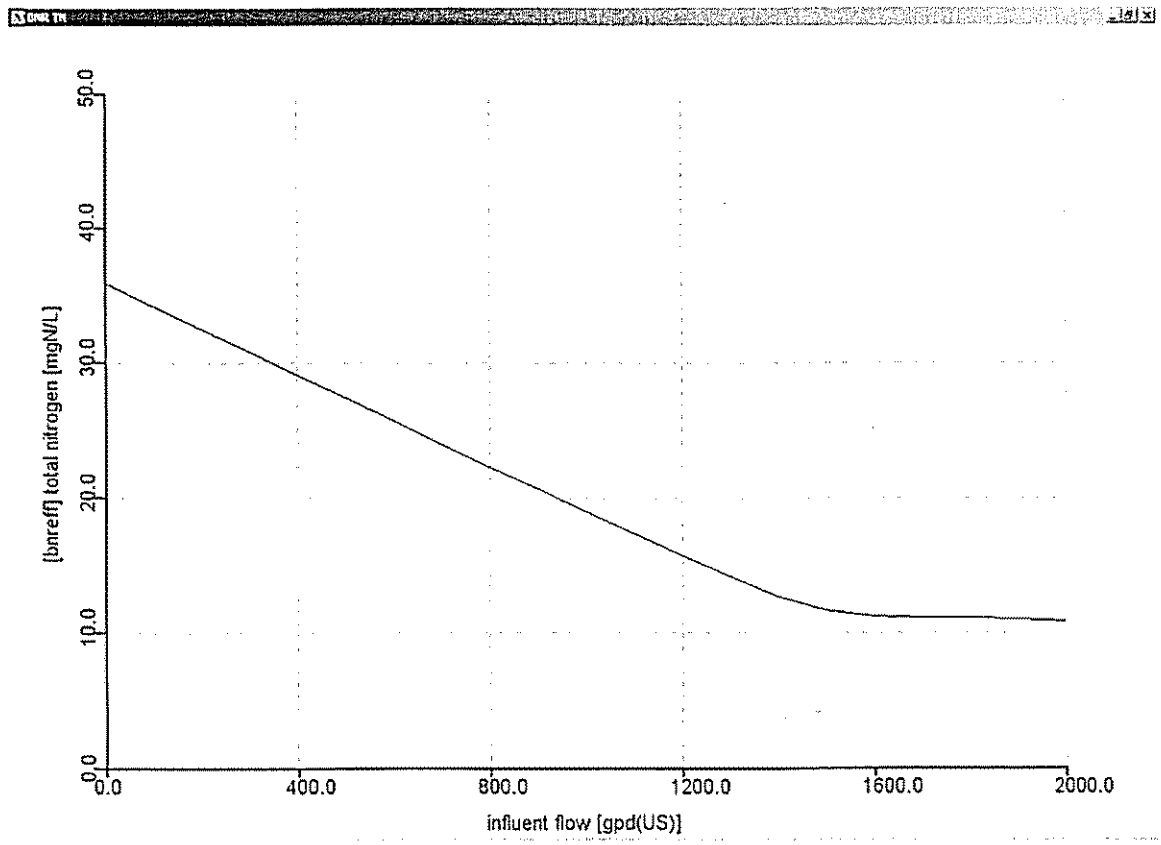
1600.0
2000.0
influent flow [gpd(US)]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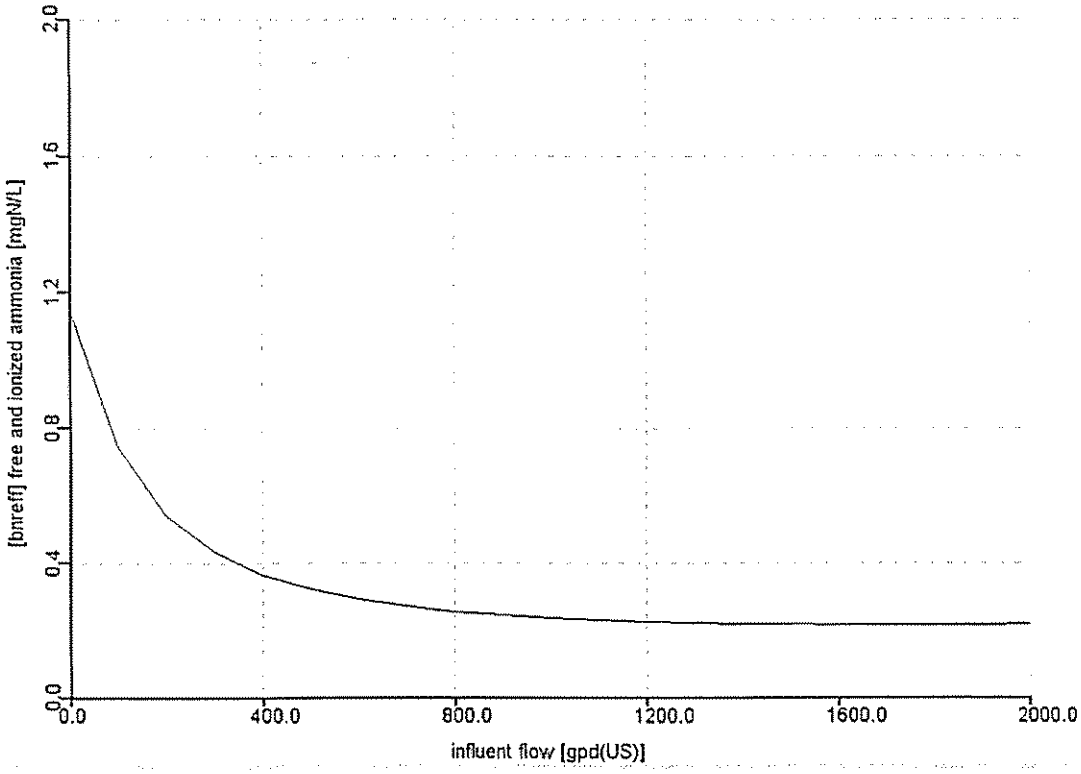
2000.0
influent flow [gpd(US)]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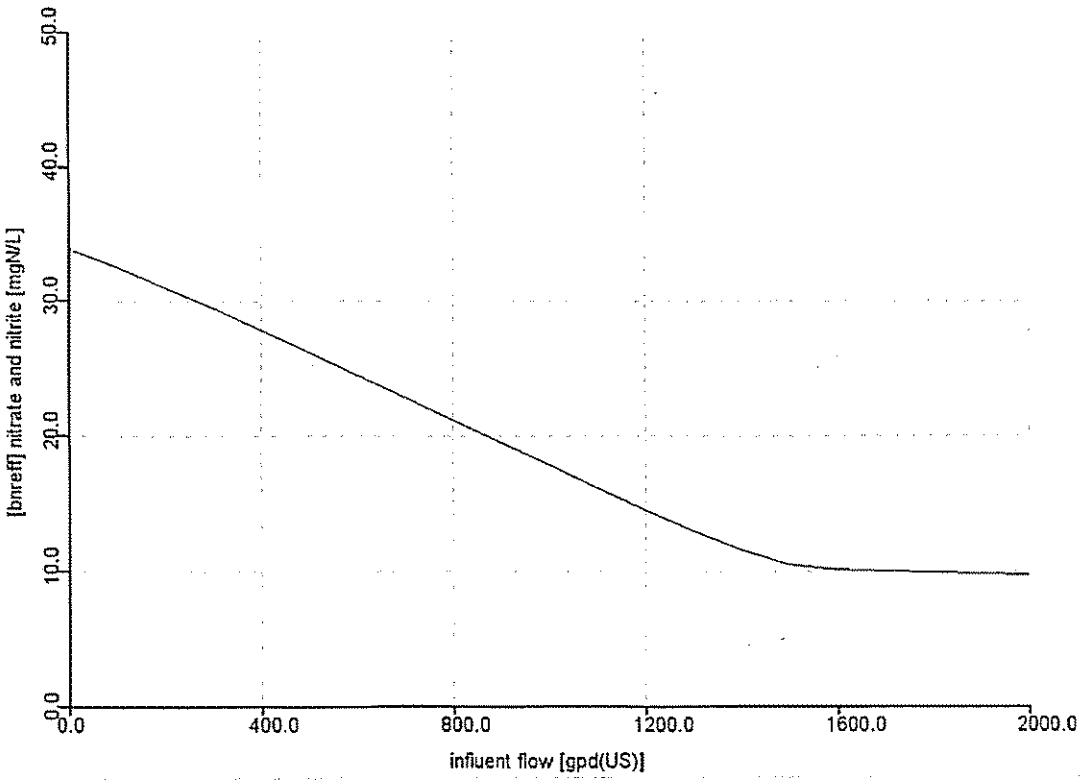
2000.0
influent flow [gpd(US)]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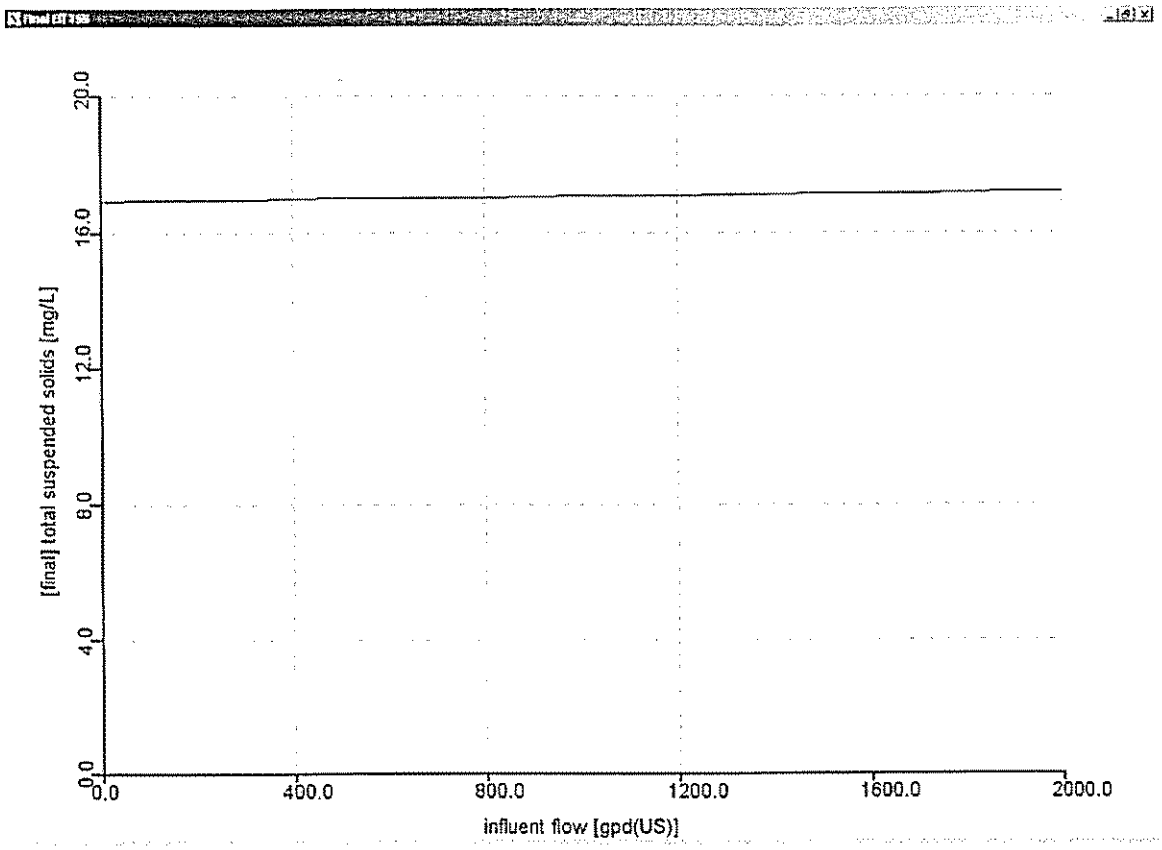
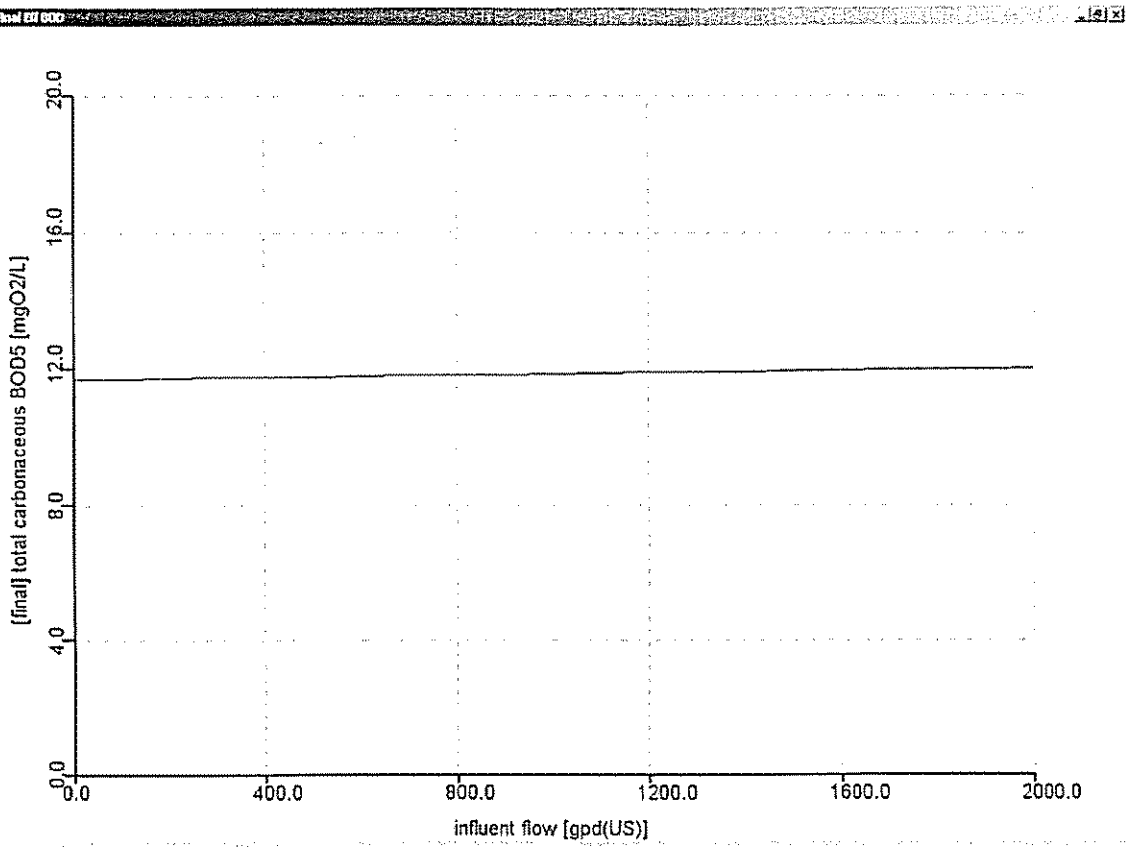
1600.0
2000.0
influent flow [gpd(US)]

Combined Final Effluent – TSS, BOD5, TN, Ammonia, Nitrate

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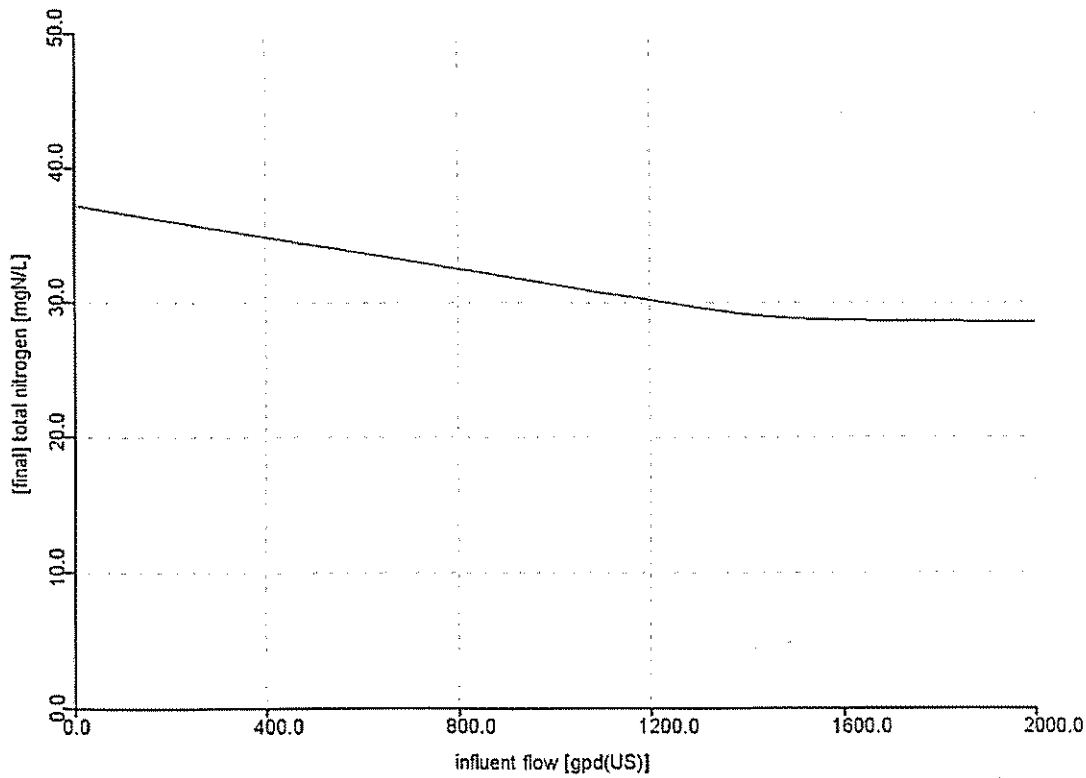
800.0
1200.0
1600.0
2000.0
influent flow [gpd(US)]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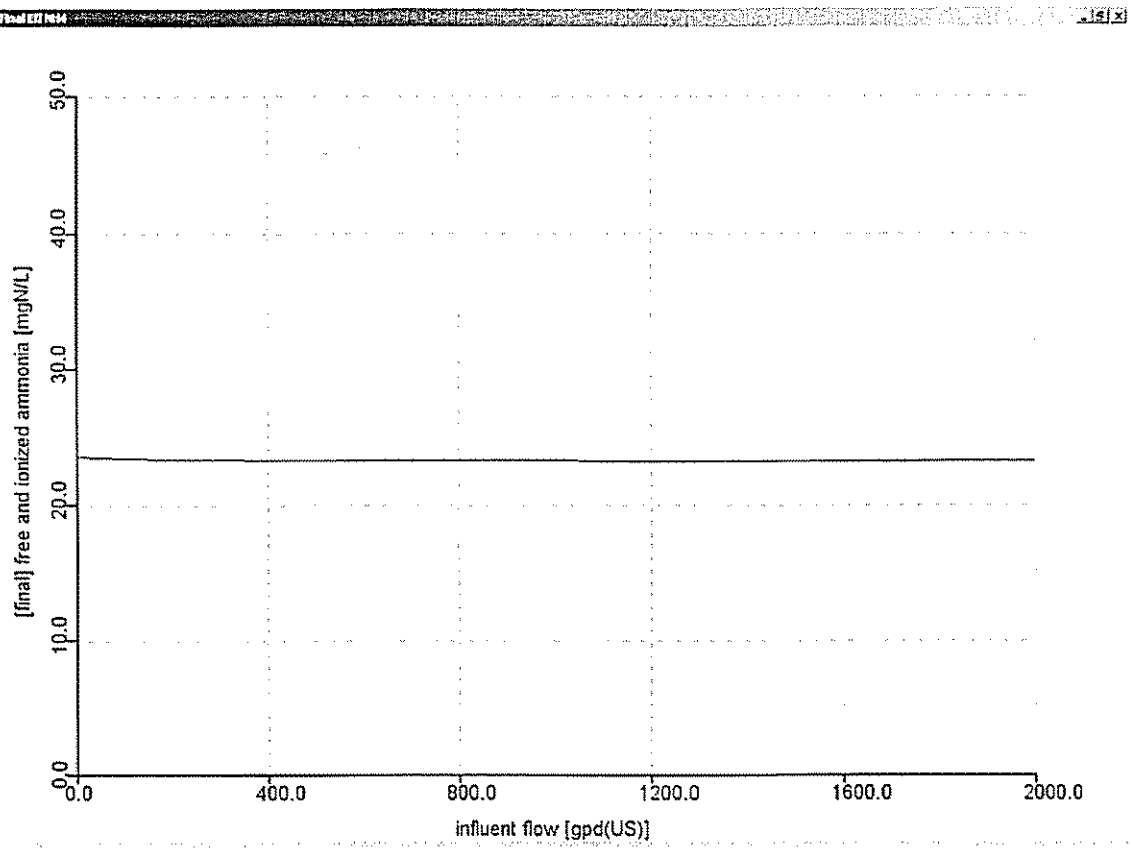
1200.0
1600.0
2000.0
influent flow [gpd(US)]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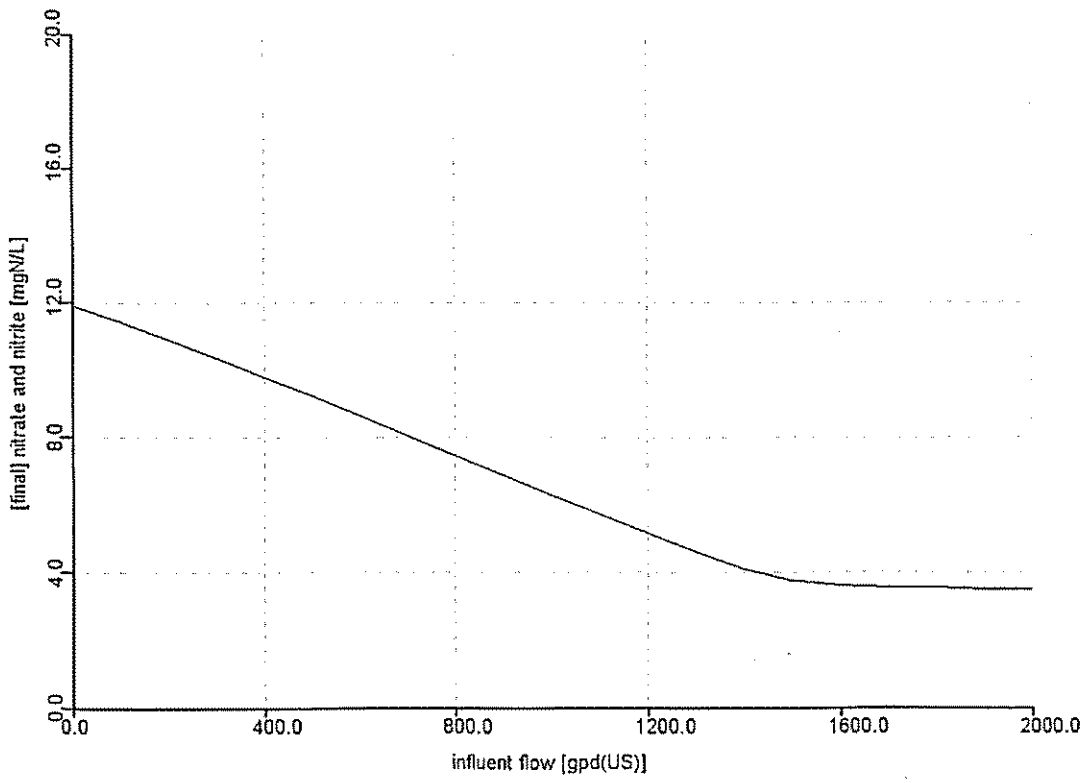
1200.0
1600.0
2000.0
influent flow [gpd(US)]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16.0
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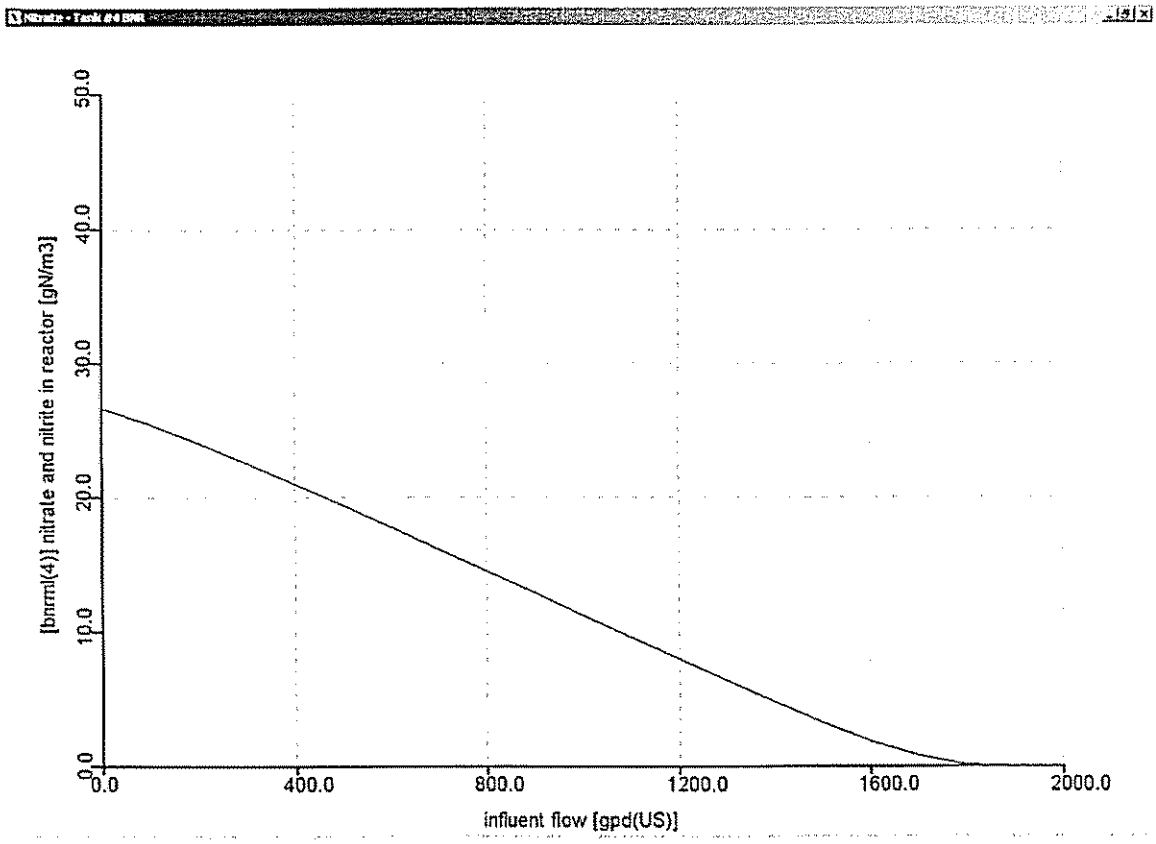
0.0
400.0
800.0
1200.0
1600.0
2000.0
influent flow [gpd(US)]

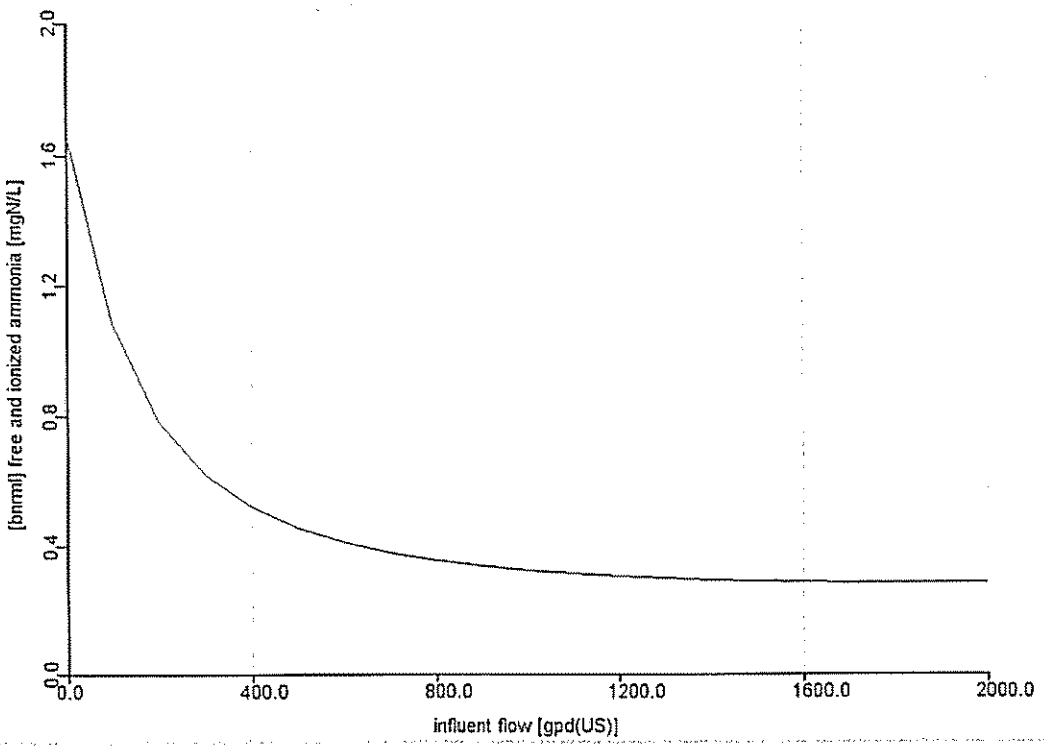
Sensitivity Analysis # 2: Plant Performance vs. Methanol Addition and Maximum Internal Recycle Rate

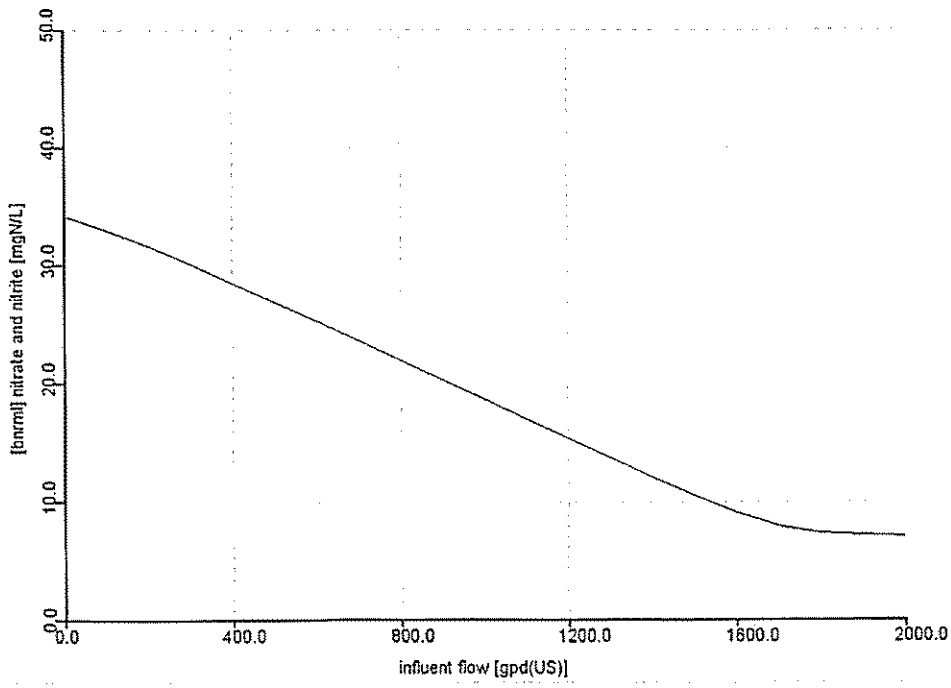
1) HPO FLOW = 25 MGD
2) BNR FLOW = 12.5 MGD
3) CENTRATE FLOW = 200,000 gpd(US)
4) **METHANOL FLOW = 0-2000 gpd(US) (varied on the x-axis)**
5) BNR INTERNAL RECYCLE = 56.2 MGD

Nitrate Concentration – Tank #4 - BNR

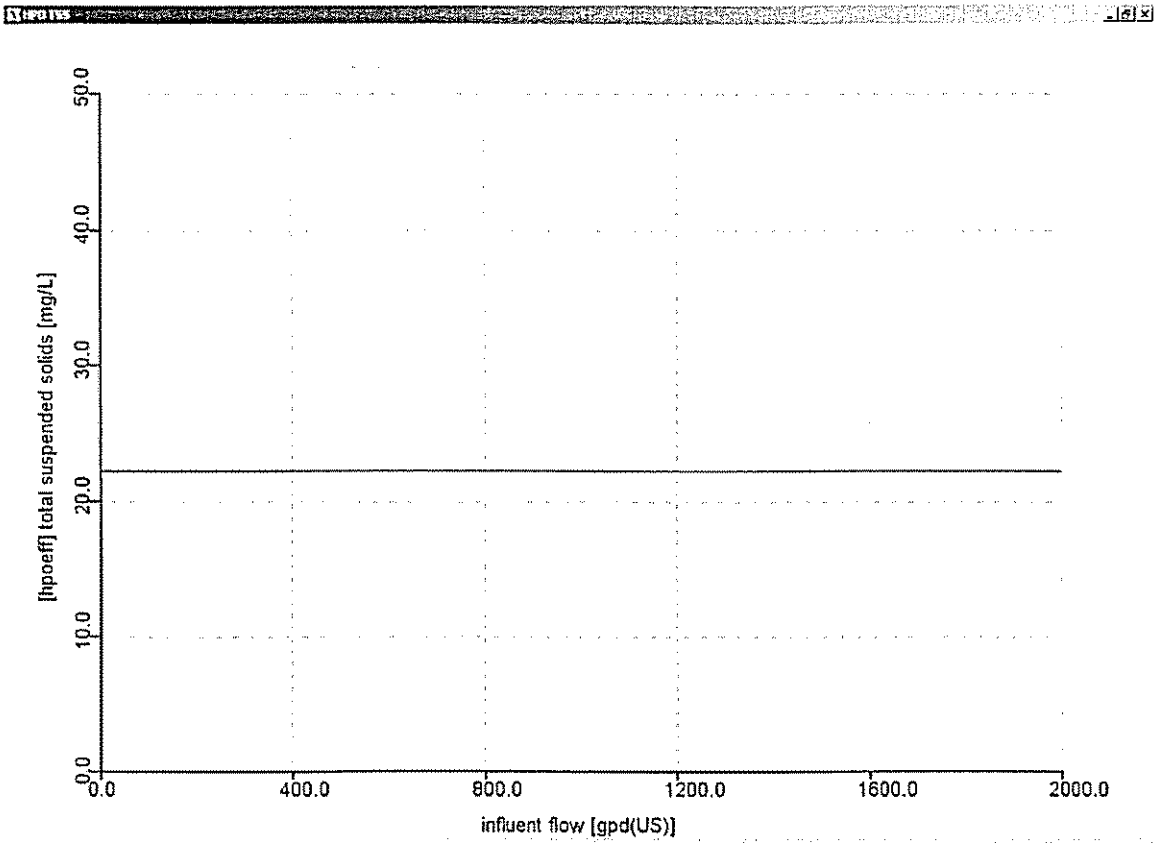


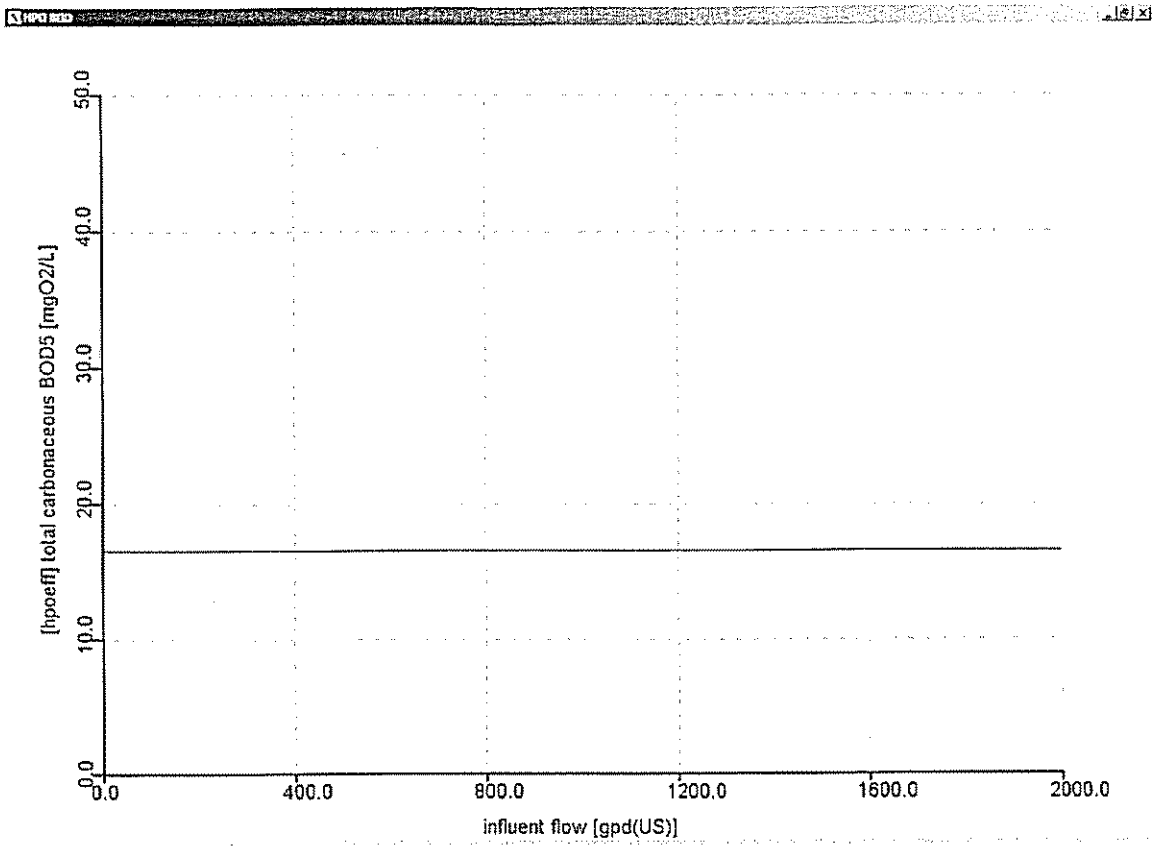
BNR Mixed Liquor Effluent – Ammonia & Nitrate Concentration





HPO Final Effluent – TSS, BOD5, TN, Ammonia, Nitrate

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40.0
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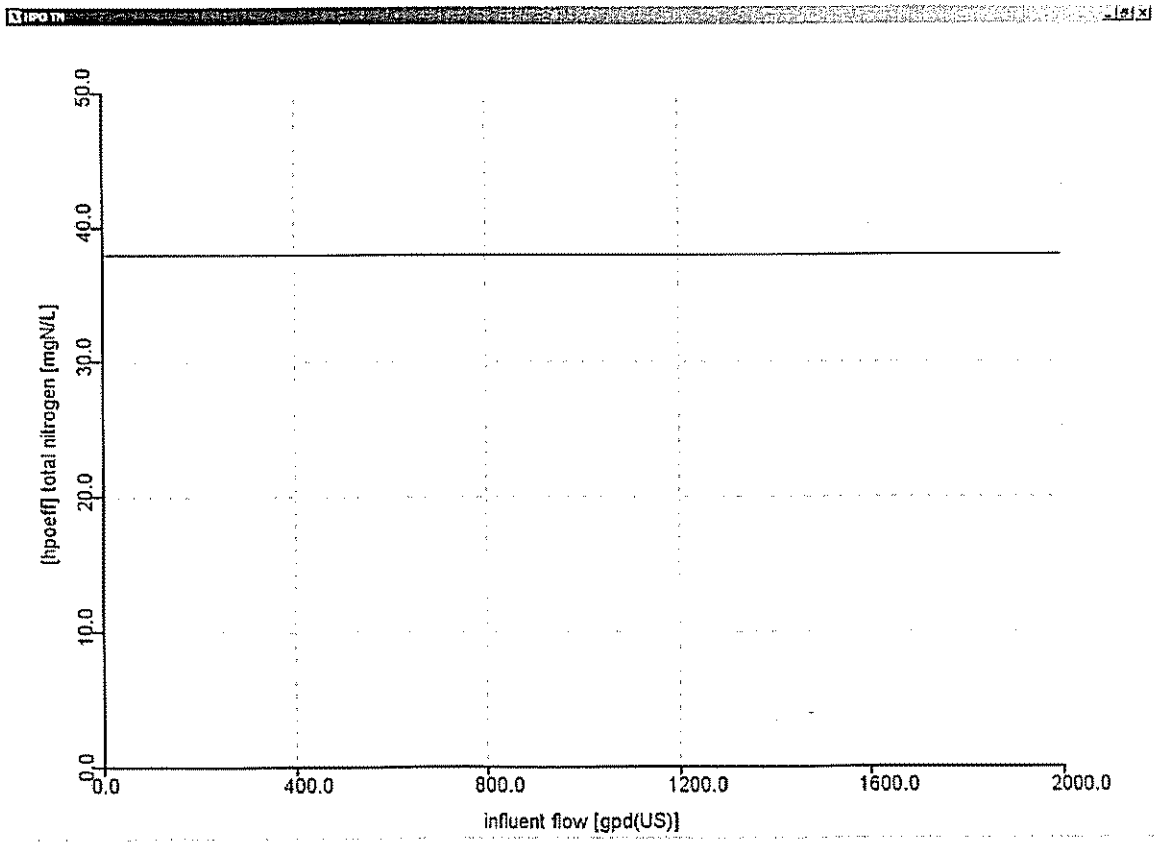
0.0
400.0
800.0
1200.0
1600.0
2000.0
influent flow [gpd(US)]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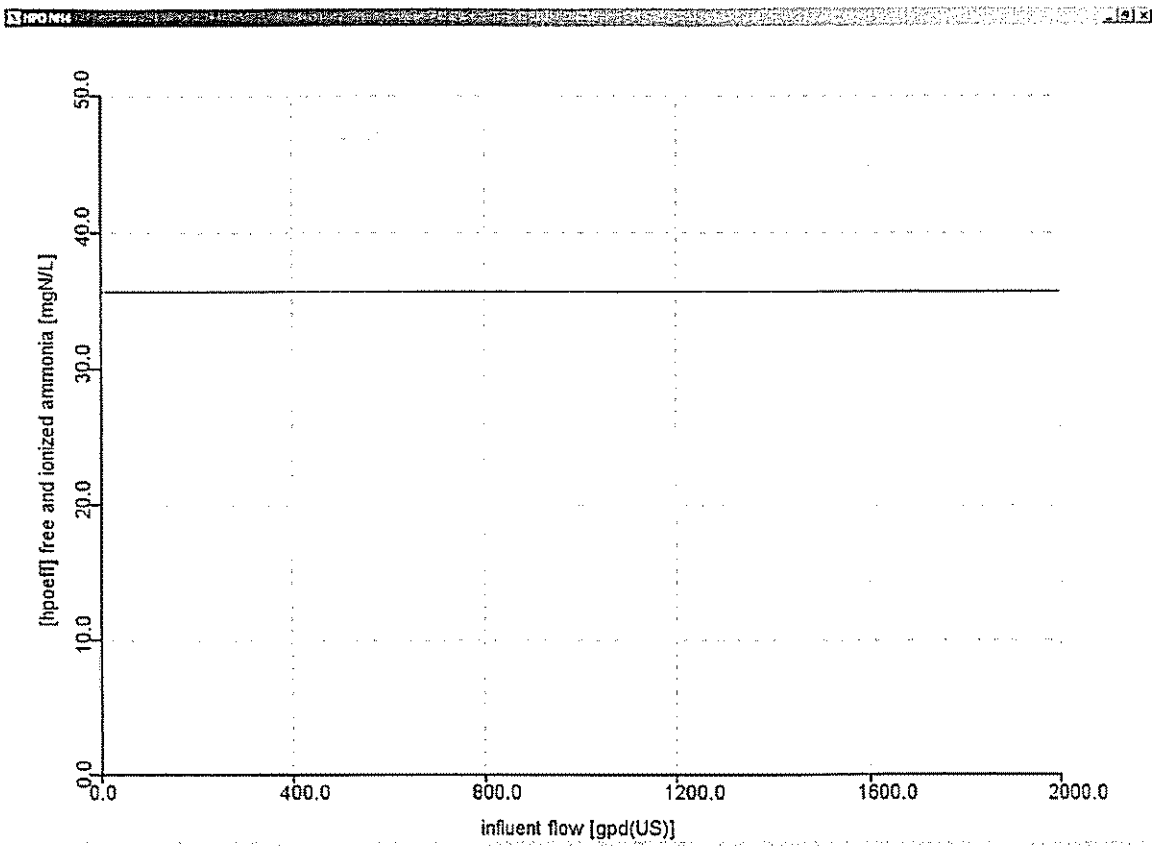
800.0
1200.0
1600.0
2000.0
influent flow [gpd(US)]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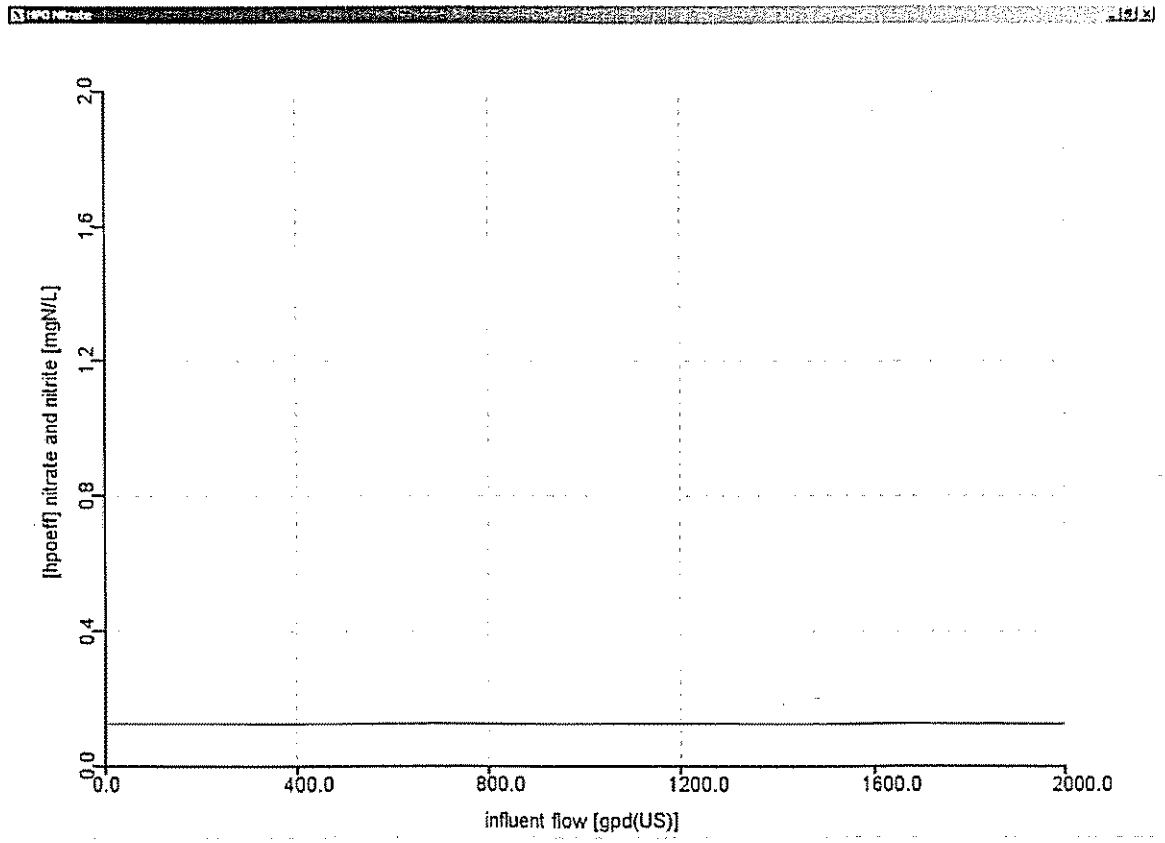
1200.0
1600.0
2000.0
influent flow [gpd(US)]


[hpoeff] nitrate and nitrite [mgN/L]
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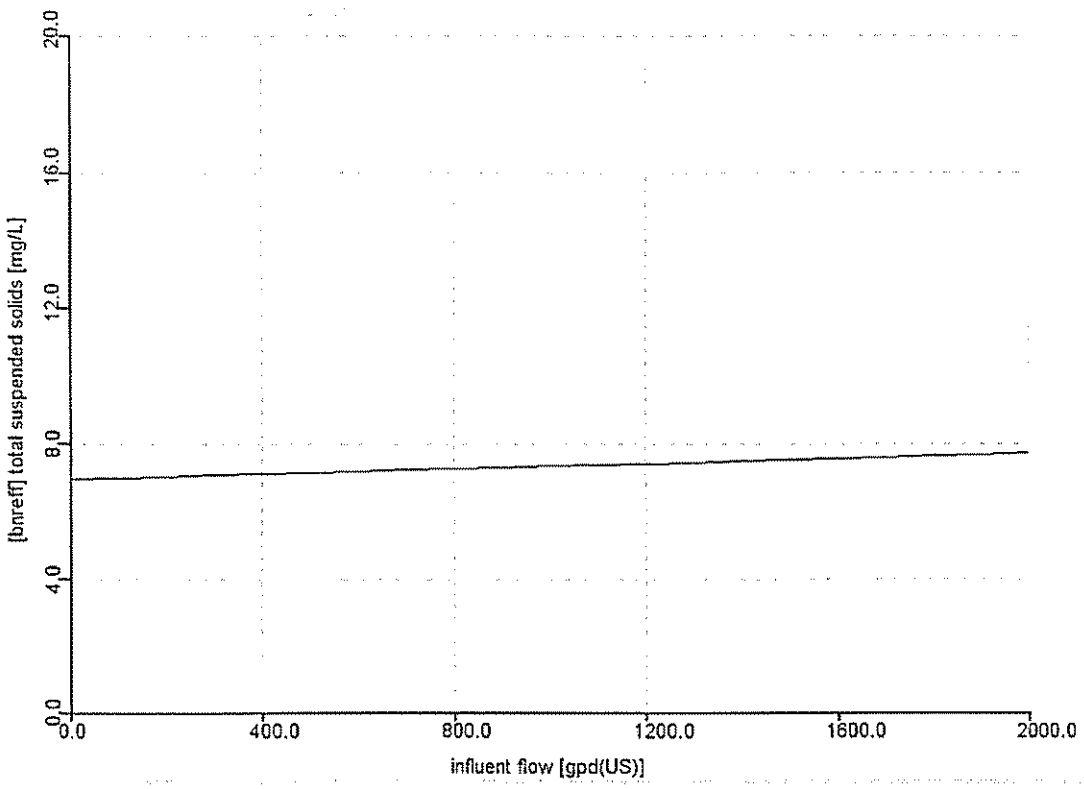
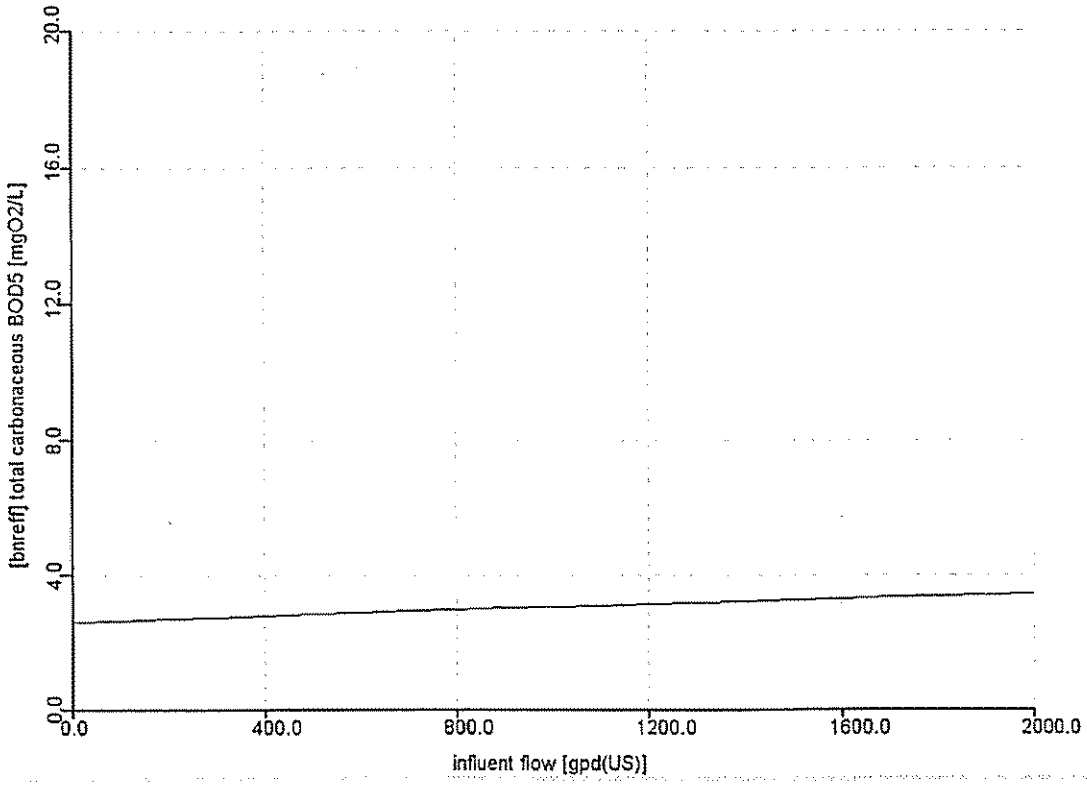
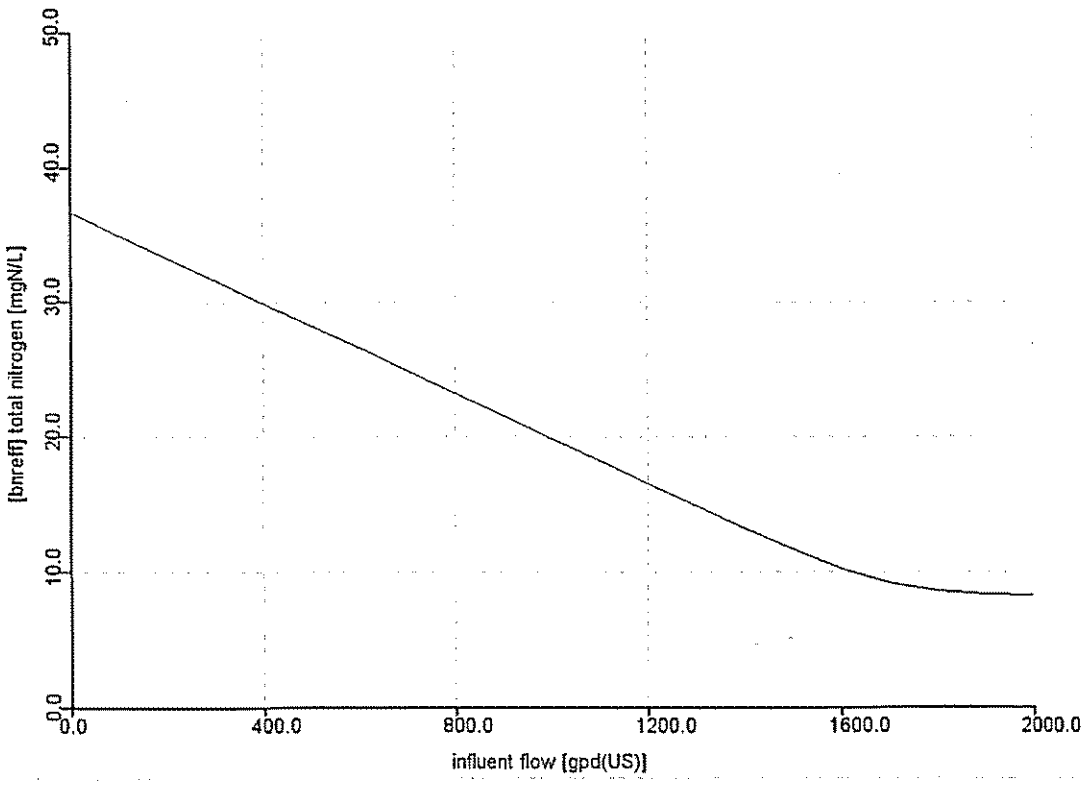
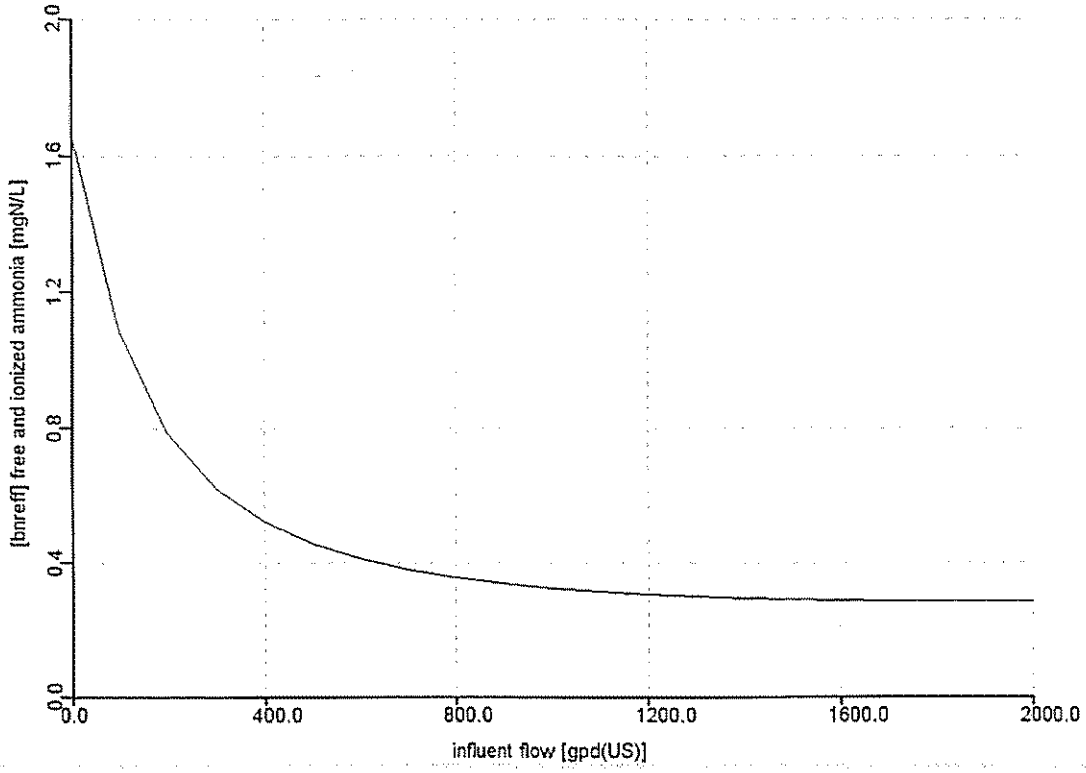
0.8
1.2
1.6
2.0
0.0
400.0
800.0
1200.0
1600.0
2000.0
influent flow [gpd(US)]

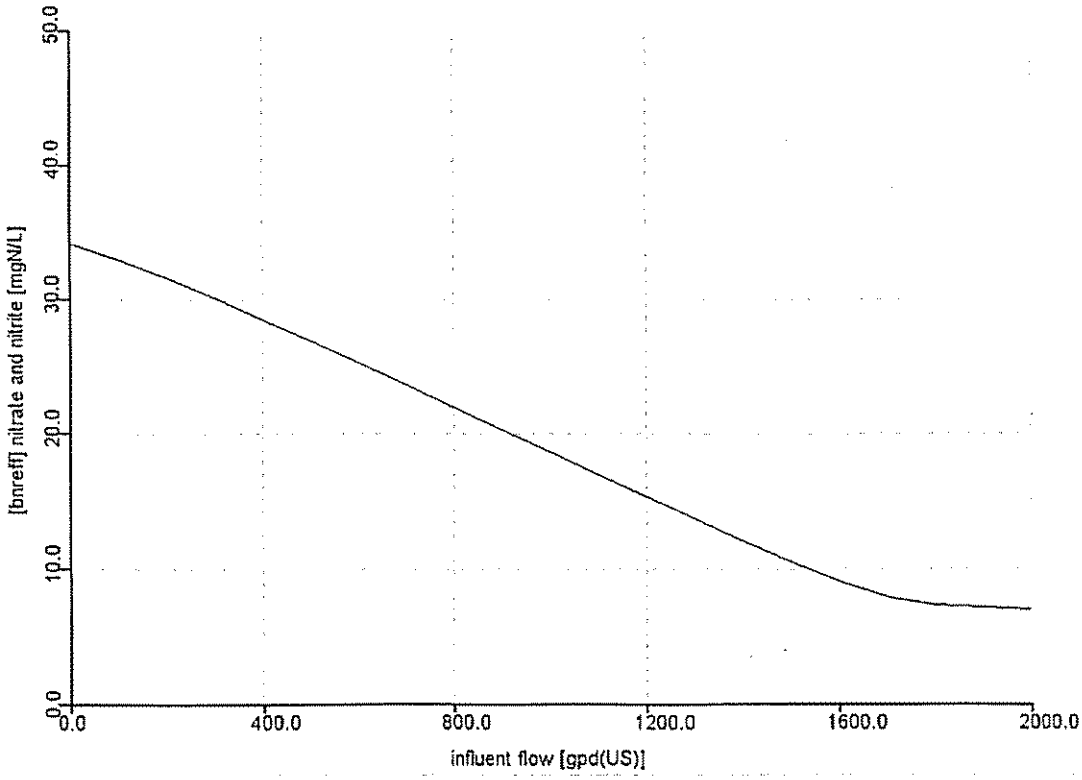
BNR Final Effluent – TSS, BOD5, TN, Ammonia, Nitrate




[bnreff] total carbonaceous BOD5 [mgO2/L]
0.0
4.0
8.0
12.0
16.0
20.0
0.0
400.0
800.0
1200.0
1600.0
2000.0
influent flow [gpd(US)]


[bnreff] total nitrogen [mgN/L]
0.0
10.0
20.0
30.0
40.0
50.0
0.0
400.0
800.0
1200.0
1600.0
2000.0
influent flow [gpd(US)]


[bnreff] free and ionized ammonia [mgN/L]
0.0
0.4
0.8
1.2
1.6
2.0
0.0
400.0
800.0
1200.0
1600.0
2000.0
influent flow [gpd(US)]


[bnreff] nitrate and nitrite [mgN/L]
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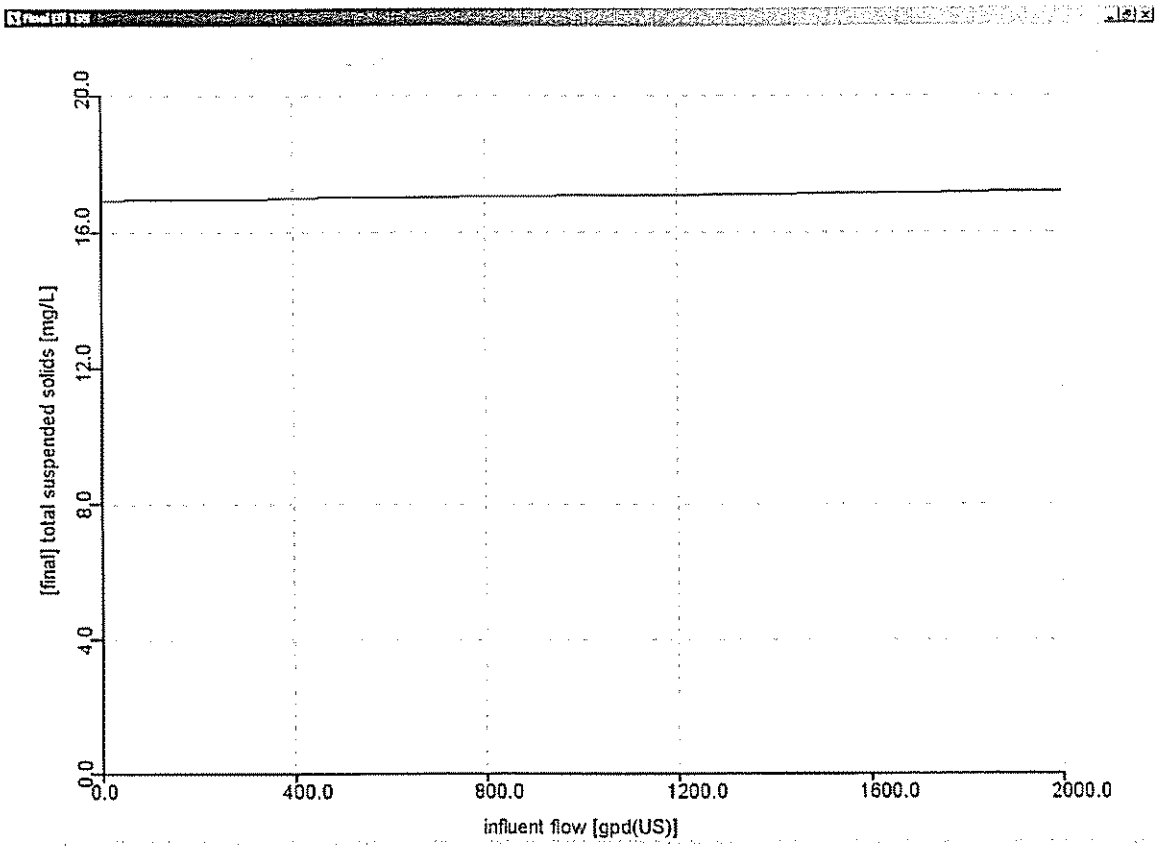
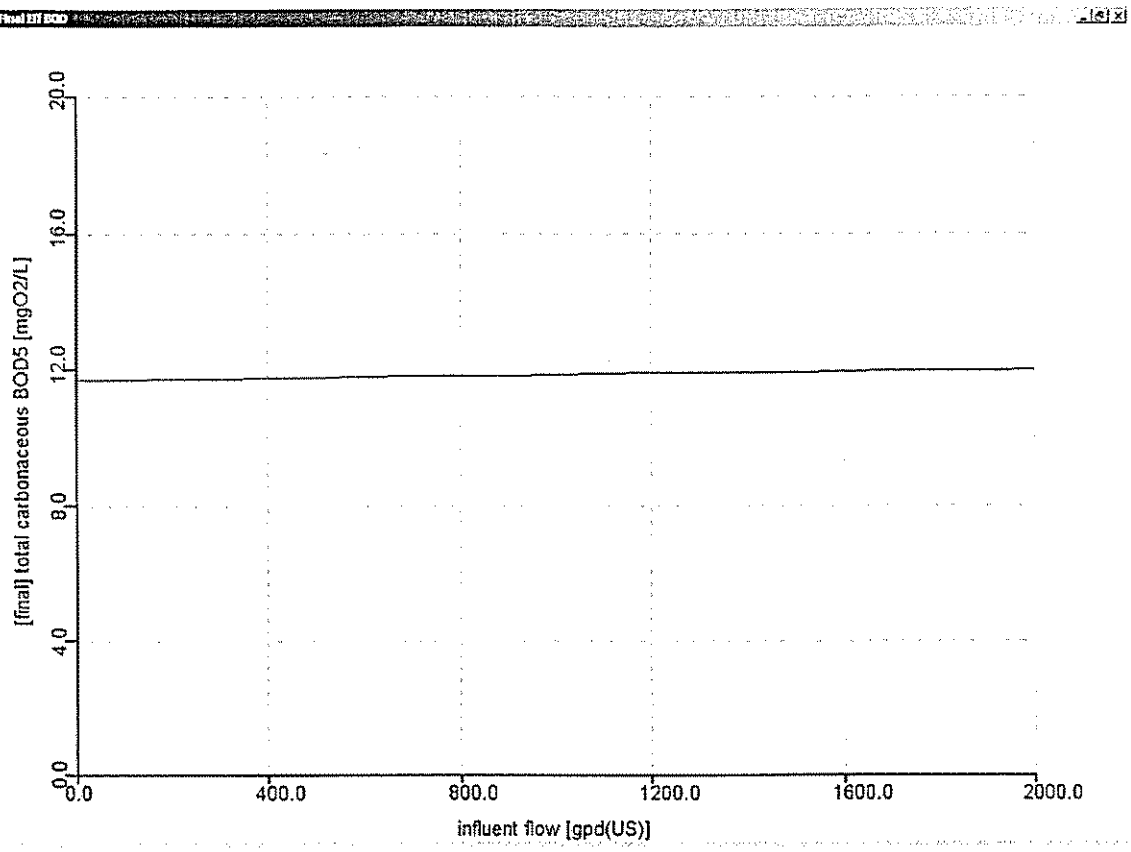
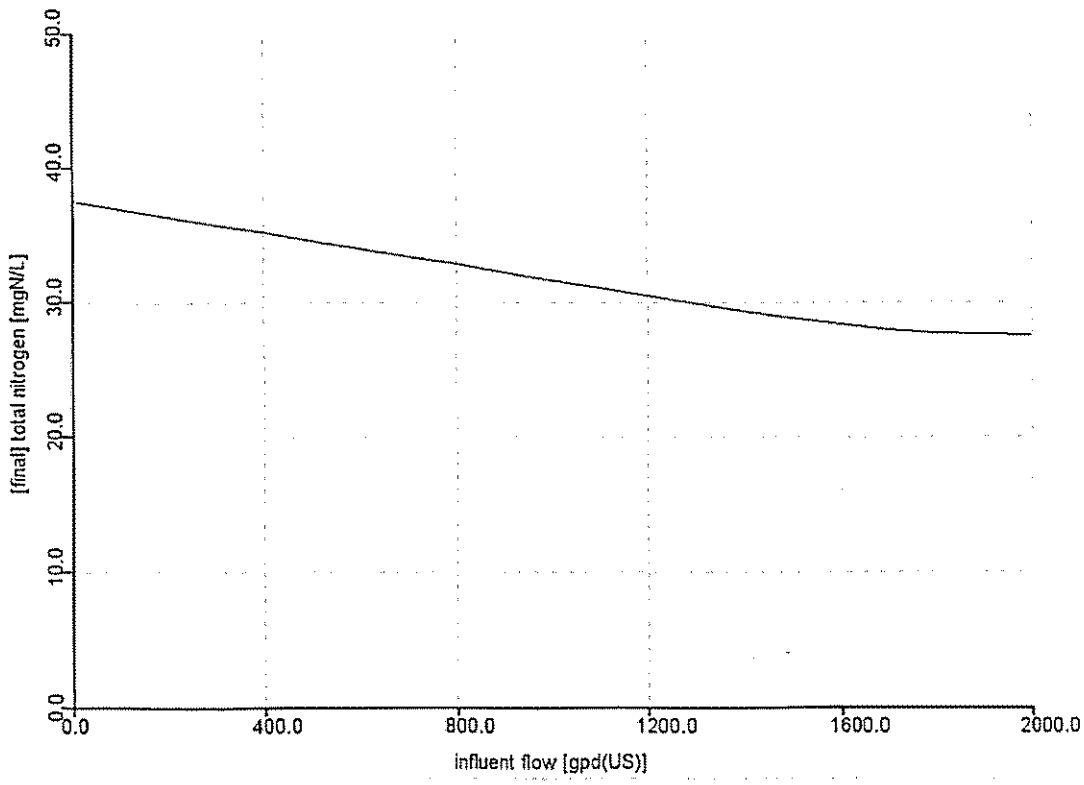
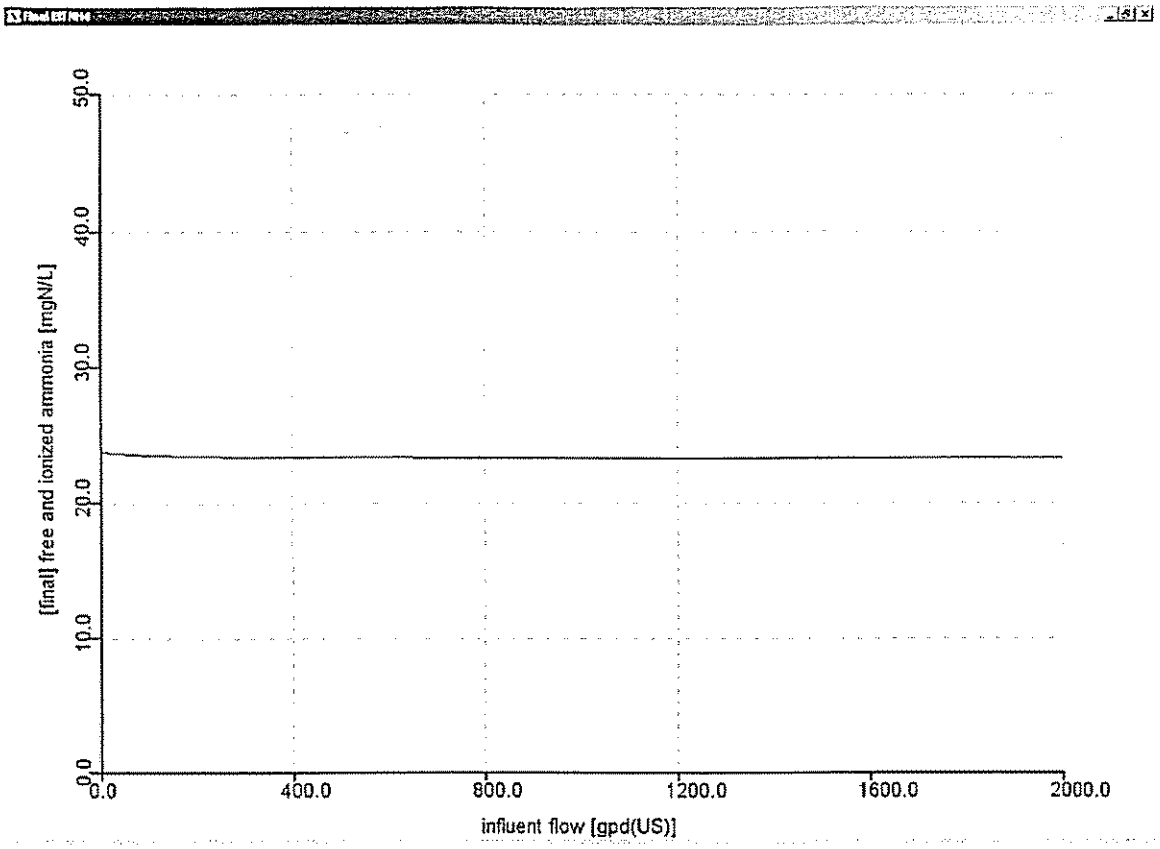
10.0
20.0
30.0
40.0
50.0
0.0
400.0
800.0
1200.0
1600.0
2000.0
influent flow [gpd(US)]

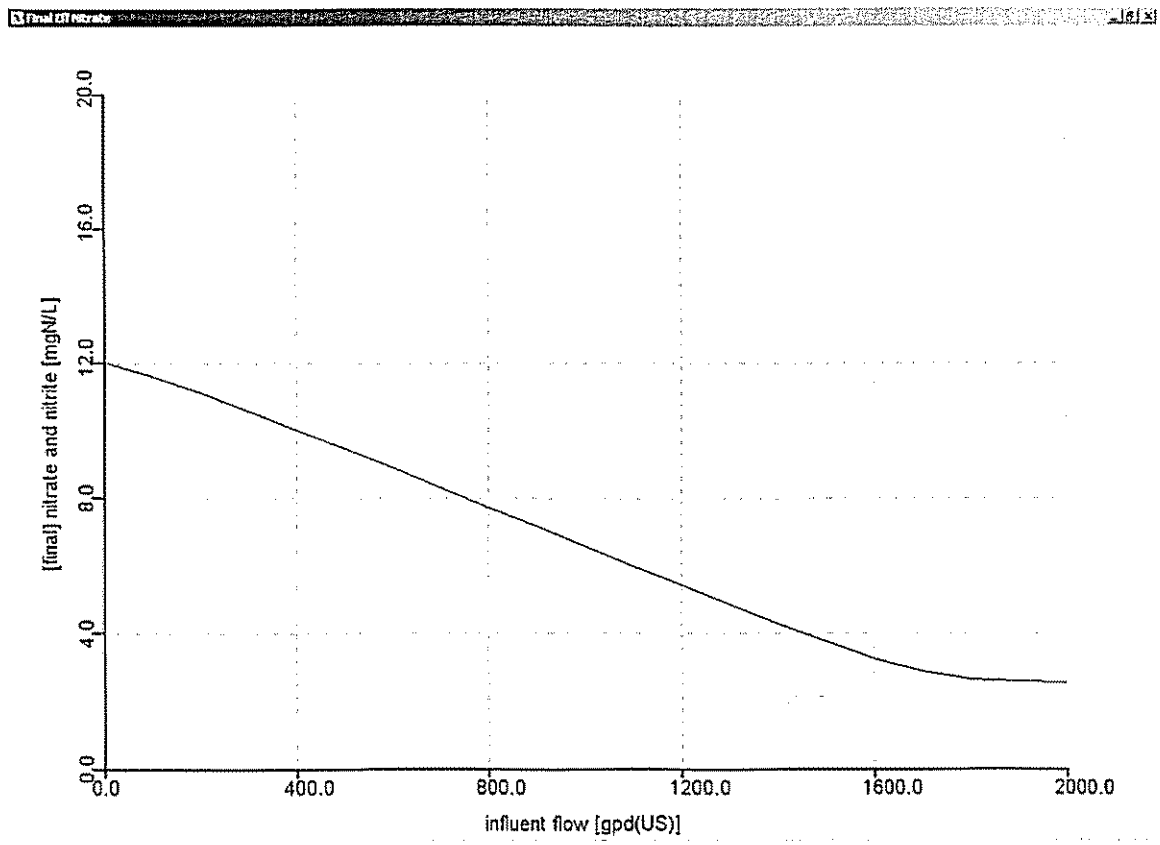
Combined Final Effluent – TSS, BOD5, TN, Ammonia, Nitrate




[final] total carbonaceous BOD5 [mgO2/L]
0.0
4.0
8.0
12.0
16.0
20.0
0.0
400.0
800.0
1200.0
1600.0
2000.0
influent flow [gpd(US)]


[final] total nitrogen [mgN/L]
0.0
10.0
20.0
30.0
40.0
50.0
0.0
400.0
800.0
1200.0
1600.0
2000.0
influent flow [gpd(US)]

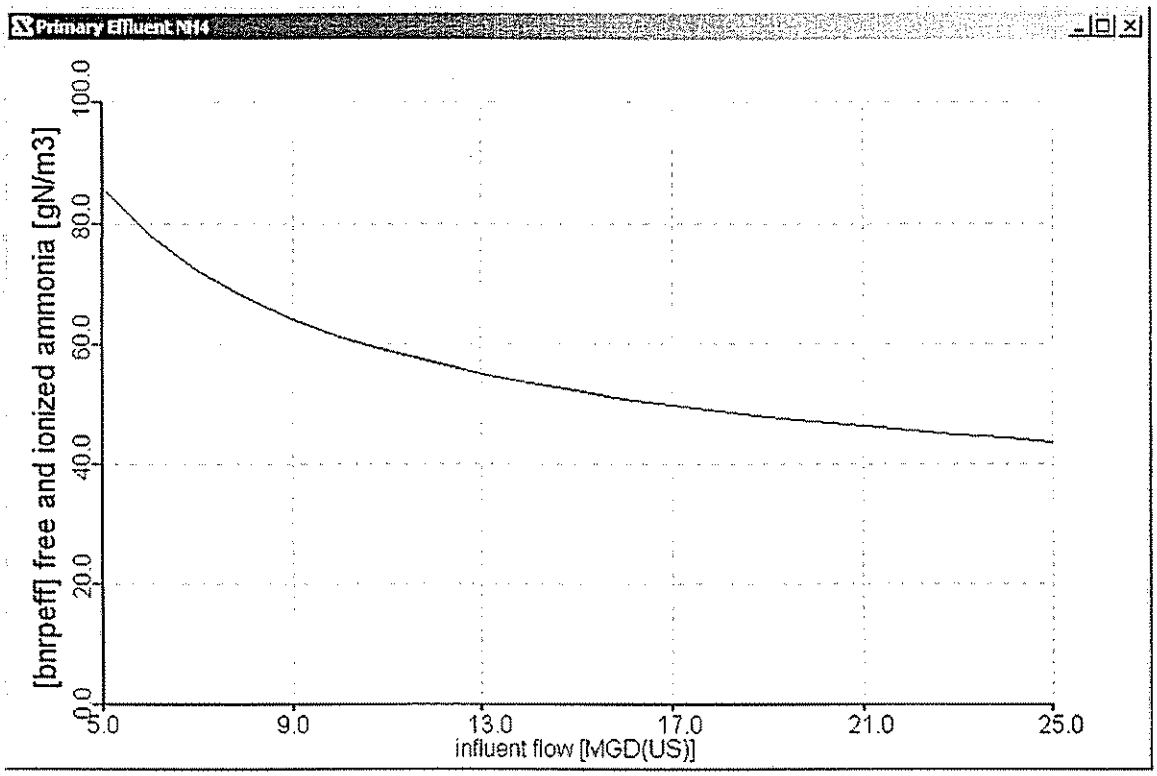

[final] free and ionized ammonia [mgN/L]
0.0
10.0
20.0
30.0
40.0
50.0
0.0
400.0
800.0
1200.0
1600.0
2000.0
influent flow [gpd(US)]


[final] nitrate and nitrite [mgN/L]
0.0
4.0
8.0
12.0
16.0
20.0
0.0
400.0
800.0
1200.0
1600.0
2000.0
influent flow [gpd(US)]

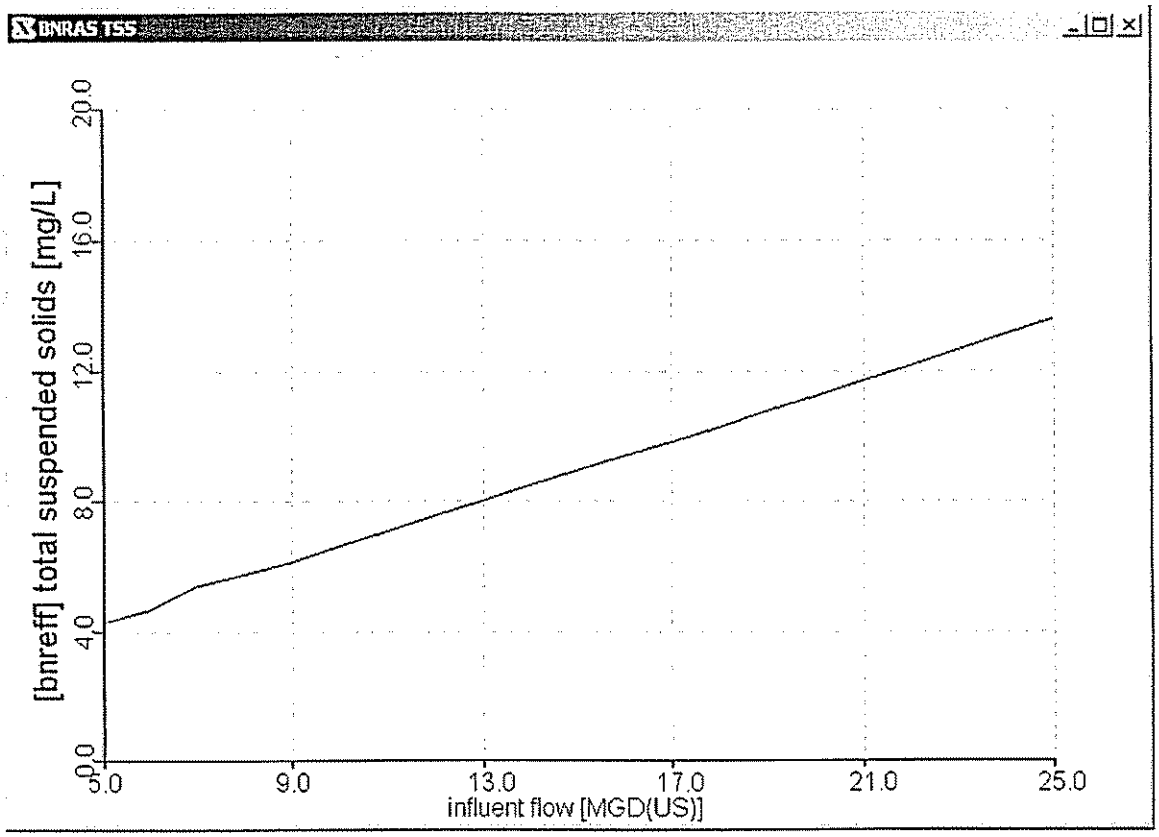
Sensitivity Analysis # 3: Plant Performance vs. BNRAS Raw Influent Flow

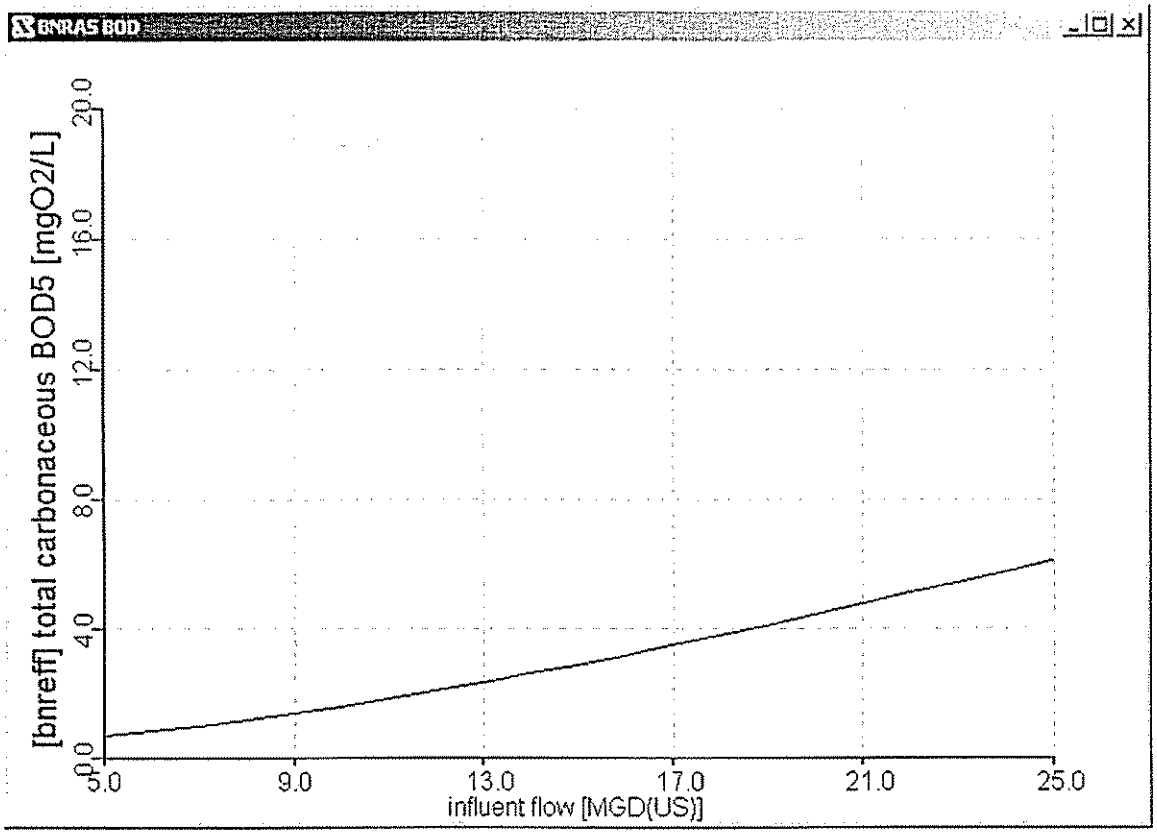
1) HPO FLOW = 25 MGD
2) **BNR FLOW = 5-25 MGD (varied on the x-axis)**
3) CENTRATE FLOW = 200,000 gpd(US)
4) METHANOL FLOW = 0 gpd(US)
5) BNR INTERNAL RECYCLE = 34.4 MGD

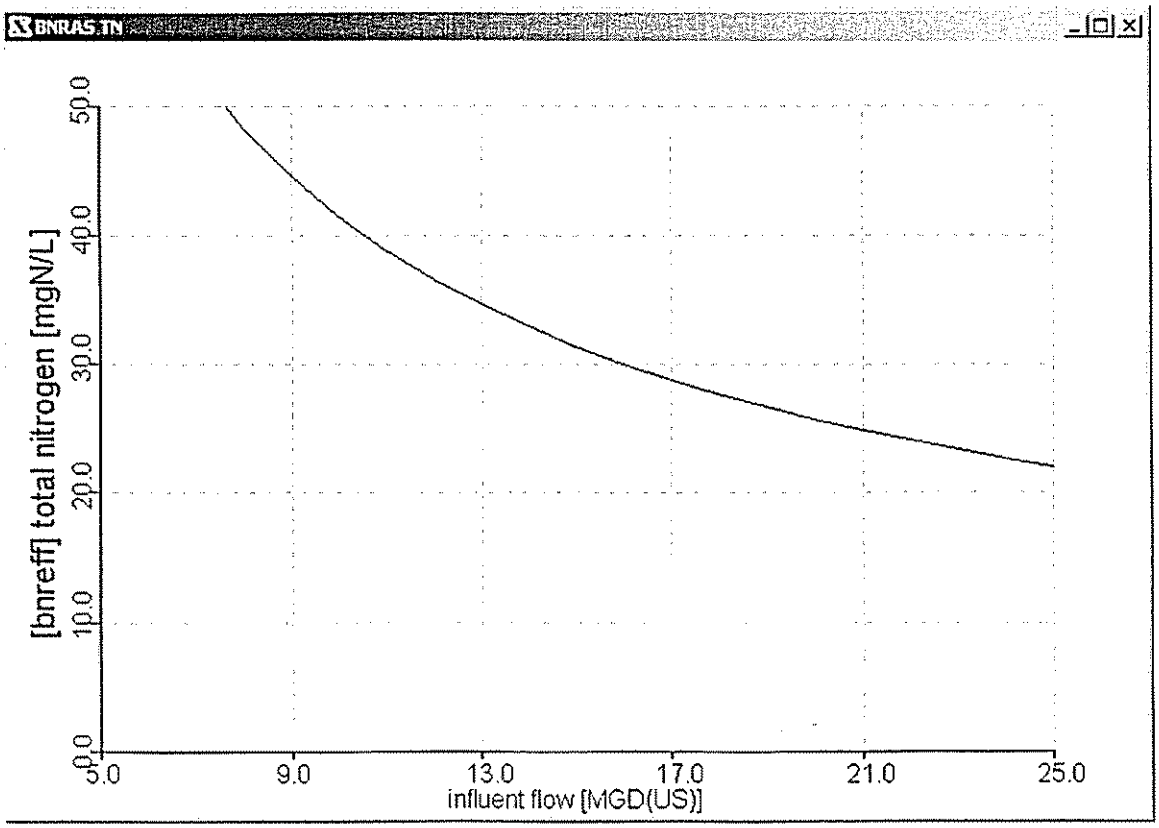
BNR Primary Effluent – Ammonia Concentration

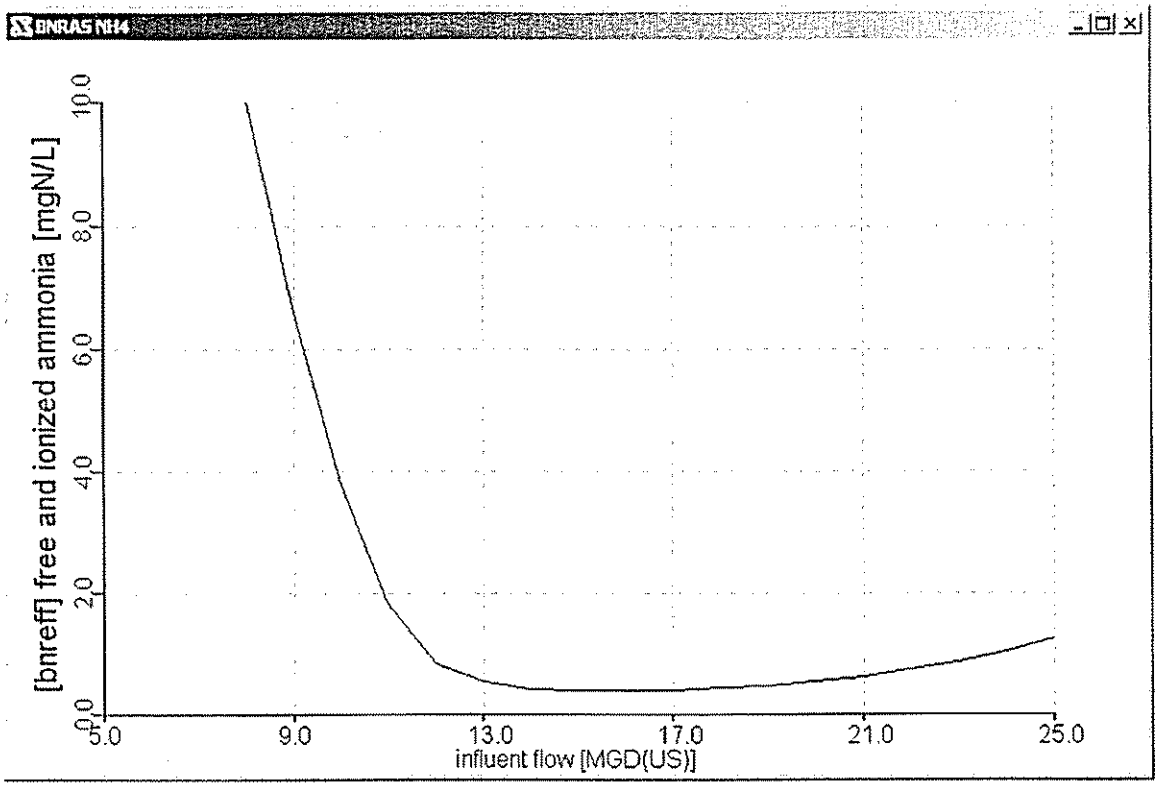


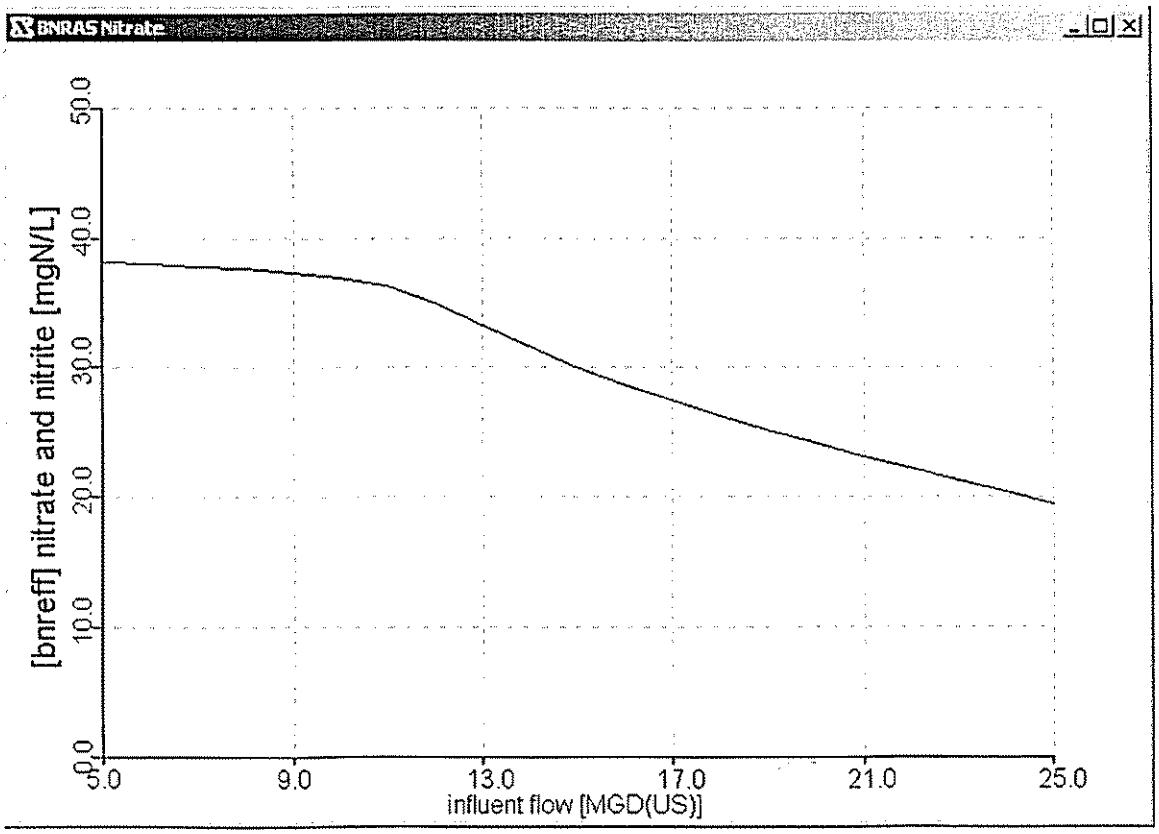
BNR Final Effluent – TSS, BOD5, TN, Ammonia, Nitrate




BNRAS BOD
[bnreff] total carbonaceous BOD5 [mgO2/L]
0.0
4.0
8.0
12.0
16.0
20.0
5.0
9.0
13.0
17.0
21.0
25.0
influent flow [MGD(US)]


BNRAS TN
[bnreff] total nitrogen [mgN/L]
0.0
10.0
20.0
30.0
40.0
50.0
5.0
9.0
13.0
17.0
21.0
25.0
influent flow [MGD(US)]


BNRAS NH4
[bnreff] free and ionized ammonia [mgN/L]
0.0
2.0
4.0
6.0
8.0
10.0
5.0
9.0
13.0
17.0
21.0
25.0
influent flow [MGD(US)]


BNRAS Nitrate
[bnreff] nitrate and nitrite [mgN/L]
0.0
10.0
20.0
30.0
40.0
50.0
5.0
9.0
13.0
17.0
21.0
25.0
influent flow [MGD(US)]

Hydromantis, Inc.
Consulting Engineers

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L8S 1G5
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Fax: (905) 522-0031
E-mail: belia@hydromantis.com

Technical Memorandum

To:	Pima County
From:	Hydromantis, Inc.
Date:	15 April 2005
Subject:	Additional Modeling of Ina Road and Roger Road WWTP - Final
Project:	799-01

1. INTRODUCTION

Hydromantis Inc., was retained by Pima County to provide additional modeling services for the Ina and Roger Road WWTP. This technical memorandum summarizes the results of a simulation-based analysis of the two plants.

The results were based on the calibrated and preliminary models developed in a number of projects and described in the following reports:

1. Modeling of Ina Road WWTP – Final, 30 August 2003
2. Modeling of Ina Road WWTP HPO – Final, 30 June 2003
3. Modeling of Roger Road WWTP – Final, 26 July 2004
4. Additional Modeling of Ina Road and Roger Road WWTP - Final, 9 February 2005

The scope of work for the additional simulation scenarios resulted from conversations with PIMA County and it included:

Ina Road WWTP

Task 1: HPO Scenario - Nitrification Activated Sludge

The existing system with no aeration limitation (DO maintained at selected concentrations) will be run to see if the HPO plant can nitrify 20 MGD. The calibrated gas exchange will be implemented and there will be no inhibition due to pH. The current operational DO levels will be used as targets. Since only the DO at the exit of the HPO trains is measured the concentrations maintained in Tanks 1 and 2 have been selected as 8 mg/L. The target DO concentration for Tank 3 will be identical to the currently measured concentration of 14 mg/L.

The target MLSS levels will be the same as the concentrations maintained during the nitrification study, around 2000 mg/L. The current raw influent flow to RAS flow ratio of 0.6 will be used. Lastly, the model will be run under diurnal flow conditions.

Task 2: HPO Scenario - Nutrient Removal with IFAS

With an upgraded aeration system (DO can be maintained at selected concentration) and conversion to an IFAS process, the HPO plant model will be run to see if it can treat 25 MGD to a total nitrogen (TN) concentration of less than 8 mgN/L. A 2 million gallon two CSTR in series anoxic basin filled with biofilm chip will be added directly upstream of the existing hybrid tank. The plant will use Biochip with a specific surface area of 1200 m2/m3. The calibrated gas exchange will be implemented and there will be no inhibition due to pH. The following target DO concentrations will be maintained: Tank 1: 25 mg/L, Tank 2: 15 mg/L, Tank 3: 6 mg/L. The target MLSS levels will be ~ 3000 mg/L. The current Qinf/Qras ratio of 0.6 will be used. If a carbon limitation is observed then methanol will be added. The internal recycle flow will be limited to 75MGD (3 x influent flow). Lastly, the model will be run under diurnal flow conditions.

Task 3: HPO Scenario - Nutrient Removal with MBBR

With an upgraded aeration system (DO can be maintained at selected concentration) and conversion to an MBBR process, the HPO plant model will be run to see if it can treat 25 MGD to a total nitrogen (TN) concentration of less than 8 mgN/L. A 2 million gallon two CSTR in series anoxic basin filled with biofilm chip will be added directly upstream of the existing hybrid tank. The plant model will use Biochip with a specific surface area of 1200 m2/m3. The calibrated gas exchange will be implemented and there will be no inhibition due to pH. The following target DO concentrations will be maintained: Tank 1: 25 mg/L, Tank 2: 15 mg/L, Tank 3: 6 mg/L. The RAS flow will be zero. If a carbon limitation is observed then methanol will be added. The internal recycle flow will be limited to 75MGD (3 x influent flow). Lastly, the model will be run under diurnal flow conditions.

Task 4: BNRAS Scenario – 0.5 MGD Centrate Addition

With the design aeration system (a total installed airflow of 28,000 cfm), the BNRAS plant model will be run to see if it can treat 12.5 MGD of raw flow and 0.5 MGD of centrate flow with a methanol feed to the anoxic basin. The model will be run under diurnal flow conditions.

Roger Road WWTP

Task 1: Biofilter Effluent Scenario - Nutrient Removal with MBBR – 41 MGD

With an upgraded aeration system (DO can be maintained at selected concentration) and conversion to an MBBR process, the RRWWTP model will be run to see if it can treat 41 MGD to a total nitrogen (TN) concentration of less than 8 mgN/L. The plant model will use Biochip with a specific surface area of 1200 m2/m3. The following target DO concentrations will be maintained: Tank 1: 0 mg/L, Tank 2: 4 mg/L, Tank 3: 4 mg/L, Tank 4: 4 mg/L (i.e. ¼ of the existing tank volume will be anoxic). The sludge blanket height will be maintained at ~ 1 ft. The RAS flow will be zero. If a carbon limitation is observed then methanol will be added. Lastly, the model will be run under diurnal flow conditions.

Task 2: Biofilter Effluent Scenario - Nutrient Removal with MBBR – 50 MGD

With an upgraded aeration system (DO can be maintained at selected concentration) and conversion to an MBBR process, the RRWWTP model will be run to see if it can treat 50 MGD to a total nitrogen (TN) concentration of less than 8 mgN/L with a post-denitrification filter. The plant model will use Biochip with a specific surface area of 1200 m2/m3. The following target DO concentrations will be maintained: Tank 1: 0 mg/L, Tank 2: 4 mg/L, Tank 3: 4 mg/L, Tank 4: 4 mg/L (i.e. ¼ of the existing tank volume will be anoxic). The sludge blanket height will be maintained at ~ 1 ft. The RAS flow will be zero. If a carbon limitation is observed then methanol will be added. Lastly, the model will be run under diurnal flow conditions.

Task 3: No Biofilter Scenario - Nutrient Removal with MBBR – 41 MGD

With an upgraded aeration system (DO can be maintained at selected concentration) and conversion to an MBBR process, the RRWWTP model will be run bypassing the flow from the primary tanks directly to the MBBR to see if the plant can treat 41 MGD to a total nitrogen (TN) concentration of less than 8 mgN/L. The plant model will use Biochip with a specific surface area of 1200 m2/m3. The following target DO concentrations will be maintained: Tank 1: 0 mg/L, Tank 2: 4 mg/L, Tank 3: 4 mg/L, Tank 4: 4 mg/L (i.e. ¼ of the existing tank volume will be anoxic). The sludge blanket height will be maintained at ~ 1 ft. The RAS flow will be zero. If a carbon limitation is observed then methanol will be added. Lastly, the model will be run under diurnal flow conditions.

Task 4: No Biofilter Scenario - Nutrient Removal with MBBR – 50 MGD

With an upgraded aeration system (DO can be maintained at selected concentration) and conversion to an MBBR process, the RRWWTP model will be run bypassing the flow from the primary tanks directly to the MBBR to see if the plant can treat 50 MGD to a total nitrogen (TN) concentration of less than 8 mgN/L with a post-denitrification filter.. The plant model will use Biochip with a specific surface area of 1200 m2/m3. The following target DO concentrations will be maintained: Tank 1: 0 mg/L, Tank 2: 4 mg/L, Tank 3: 4 mg/L, Tank 4: 4 mg/L (i.e. ¼ of the existing tank volume will be anoxic). The sludge blanket height will be maintained at ~ 1 ft.

The RAS flow will be zero. If a carbon limitation is observed then methanol will be added. Lastly, the model will be run under diurnal flow conditions.

The objective of this memorandum is to convey the results of the requested scenario simulations to Pima County and is not intended as a recommendation of any particular course of action at the Ina Road WWTP. It is important to note that this study does not take into account any limitations imposed by the existing structures at the plant nor does it take into account any hydraulic limitations which may exist at increased plant flow rates.

2. REVIEW OF INA ROAD WWTP PLANT MODEL DESCRIPTION

The following sections detail the HPO and the BNRAS model set-up.

2.1. Model Set-Up

The plant layout was constructed from the following process units:

a) **Influent**: For the HPO primary influent, a COD/TSS based influent model was implemented with the major data inputs being COD, TSS and TKN. For the BNRAS primary influent, a COD based influent model was implemented with the major data inputs being COD and TKN. A third influent object was included in the layout to simulate centrate addition to the BNRAS facility. A BOD based model was used for the centrate. A forth influent object was included to simulate methanol addition to the BNRAS facility for specific scenarios where carbon was limited.

b) **Primary Clarifiers:** For the HPO plant, the four (4) primary clarifiers were combined into one single unit with an equivalent surface area. For the BNRAS plant, the two (2) primary clarifiers were combined into one single unit with an equivalent surface area. The clarifiers were modeled with the one dimensional settler model that uses the double exponential settling equation.

c) **HPO**: The HPO tank was modeled as a single, plug flow unit consisting of three (3) completely mixed tanks-in-series. The mathematical model used to simulate the biological conversions in the activated sludge process was ASM2d. ASM2d was implemented to provide the option to evaluate phosphorous removal.

d) **BNRAS**: The BNRAS was modeled as a single, plug flow unit, consisting of eight (8) completely mixed tanks-in-series with an internal recycle flow connecting tank No.8 with tank No. 1. The mathematical model used to simulate the conversions in the activated sludge process was ASM2d, allowing for future phosphorous removal evaluation.

e) **Final Clarifiers:** For the HPO clarifiers, the four (4) secondary clarifiers were combined into one single unit with an equivalent surface area. For the BNRAS plant, the three (3) secondary clarifiers were combined into one single unit with an equivalent surface area. The clarifiers were modeled with the one dimensional settler model that uses the double exponential settling equation. This model is used to describe the vertical suspended solids profile from the sludge blanket to the weir under dynamic conditions.

2.2. Plant Raw Influent and Centrate Characteristics

The detailed profile used to model the Ina Road influent streams was based on the data obtained during an intensive sampling campaign in March 2003. Table 2.1 shows the average influent characteristics included in the model for both the HPO and BNRAS streams. The characteristics of the centrate have also been included.

Table 2.1 – Raw Influent and Centrate Characteristics – Averages for March 2003

Stream	Flow (MGD)	COD (mg/L)	$cBOD_5$ (mg/L)	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	NH_4-N (mg/L)
HPO Stream	25	600	300	270	220	57	37
BNRAS Stream	12.5	600	300	270	220	57	37
Centrate	0.5	3230	240	2350	1760	1740	1480

The stoichiometric ratios implemented in the raw influent models as well as the centrate are shown in Table 2.2.

Table 2.2 – Raw Influent and Centrate Stoichiometry

Stoichiomtetric ratio	HPO	BNRAS	Centrate
VSS/TSS	0.8	0.8	0.75
Soluble fraction of total COD	0.27	0.27	0.50
Inert fraction of soluble COD	0.33	0.33	0.85
COD content of VSS (XCOD/VSS)	1.9	1.9	1.6
BOD_5/BOD_{ult}	0.68	0.68	0.35

2.3. Ina Road WWTP Model Parameters

Table 2.3 summarizes the physical characteristics of the HPO model.

Table 2.3 – HPO Model Physical Parameters

Unit Object	Diameter (ft)	Total Surface Area (ft^2)	SWD (ft)	Total Volume (ft^3)	Gas Headspace Volume (ft^3)	SVI (mL/g)
Primary Clarifiers	-	34,560	8	-	-	-
Four trains	-	-	-	255,552	139,719	-
Final Clarifiers	115	41,548	14	-	-	150

Note: (-) in the table indicates that parameter is not required as model data entry.

Table 2.4 summarizes the physical characteristics of the BNRAS model.

Table 2.4 – BNRAS Model Primary Clarifiers

	Dimensions per Clarifier (ft)	Total Surface Area (ft^2)	SWD (ft)	Total Volume (gal)	Underflow Rate (gpm)	SVI (mL/g)
Primary Clarifiers	220 x 40	17,600	10	1,316,576	100	-
Anoxic: 4 trains with 4 stages	Each train: 112x28x21	-	-	263,424 (ft3)	-	-
Aerobic: 4 trains with 4 stages	Each train: 264x28x20	-	-	591,360(ft3)	-	-
Final Clarifiers	-	42,942	18	-	8,500 – 39,000	150

In addition to the information included in Tables 2.3 and 2.4 the following were also used in the model:

- BNRAS Train: Internal recycle pumps with an installed capacity of 4x13,000 gpm (1 standby). Operating range: 250-300% of AAF (AAF = 12.5 MGD, 31.25 – 37.5 MGD, average 275% = 34.4 MGD)
- BNRAS Train: The target MLSS concentration for the BNRAS train quoted in the CDM design tables was 3,000 mg/L.
- The maximum specific growth rate (μ_a) of the autotrophic group was 0.9 d^{-1} (@ 20°C) and the decay rate (b_a) was 0.17 d^{-1} (@ 20°C).
- BNRAS Aeration: The design tables provided by Pima County gave the diffuser distribution and blower capacity. The alpha and beta values used in the model were left at the defaults. The SOTE values were assumed to be the same as the target SOTE values shown in the US Filter Clean Water Oxygen Transfer Tests, August 2002. Table 2.5 shows the parameters used to model the aeration system of the BNRAS Train.

Table 2.5 – Ina Road BNRAS Train Aeration System Parameters

Parameter	Ina Road Model Values
α	0.6 - 0.8
β	0.95
θ	1.024
Total air flow installed (cfm)	28,000
Air flow distribution (% of total - stages 5 to 8)	48, 27, 17, 8
Specific oxygen transfer efficiency (% - stages 5 to 8)	31%, 31%, 29.5%, 29.5%

The HPO model set-up in this project did not consider the addition of liquid oxygen. The available oxygen feed was assumed to be provided by the PSA system only.

3. SIMULATION SCENARIOS AND RESULTS FOR THE INA ROAD WWTP PROCESS STREAM

3.1. Ina Road Tasks - Results

The following operational parameters, detailed in Table 3.1 were used.

Table 3.1 – Ina Operational Parameters

Scenario	Influent Flow (MGD)	Centrate Flow (MGD)	DO Aerobic Tanks (mg/L)	MLSS (mg/L)	WAS Flow (gpm)	RAS Flow (MGD)	Internal Recycle (MGD)	Methanol Flow (gpd)
Task 1	20	N/A	8,8,14	2150	200	12	N/A	N/A
Task 2	25	N/A	25,15,6	2920	220	15	75	3200
Task 3	25	N/A	25,15,6	140	220	0	75	3200
Task 4	12.5	0.5	N/A	3480	380	12.5	56.2	8000

Table 3.2 shows the average results for the final effluent.

Table 3.2 – Ina Final Effluent

Scenario	TSS (mg/L)	BOD_5 (mg/L)	$sBOD_5$ (mg/L)	COD (mg/L)	sCOD (mg/L)	TN (mg/L)	NH_4–N (mg/L)	Nitrate (mg/L)
Task 1	20	14	1	89	63	39	2	35
Task 2	26	12	1	93	63	12	0.5	10
Task 3	21	12	1	88	64	14	0.9	11
Task 4	7	7	3	64	55	12	0.4	10

For all tasks, WAS flow was manipulated to maintain a target MLSS concentration in the HPO/BNRAS tanks. Internal Recycle flow was manipulated to ensure that the DO levels in the anoxic tanks were minimized (i.e. ~ 0 mg/L). Methanol flow was manipulated to eliminate carbon limitations, while ensuring that the effluent soluble BOD did not exceed acceptable levels.

4. REVIEW OF THE ROGER ROAD WWTP PLANT MODEL DESCRIPTION

The following sections detail the Roger Road model set-up.

4.1. Model Set-Up

The plant layout was constructed from the following process units:

a) **Influent**: A BOD based influent model was implemented with the major data inputs being TSS, BOD and TKN. A second influent object with a BOD based model was included in the layout to simulate all return streams.

b) **Primary Clarifiers:** The six (6) primary clarifiers were simulated as three units, each with the equivalent surface area of two primary tanks. The clarifiers were modeled with the one dimensional settler model that uses the double exponential settling equation.

c) **Biofilters:** The two biofilters were simulated as one unit with the equivalent surface area. The biological model used was **Mantis**, modified to include diffusion in the biofilm.

d) **Aeration Tanks**: Each aeration train was modeled with a single, plug flow object, representing one (for AS 1-2) and four (for AS 3-6) completely mixed tanks-in-series. The bioreactor kinetics were modeled using the **Mantis** model, a modified version of ASM1. This kinetic model is capable of describing BOD-removal, nitrification and denitrification.

e) **Final Clarifiers:** The nine (9) secondary clarifiers were grouped into two units with an equivalent surface area. The clarifiers were modeled with the one dimensional settler model that uses the double exponential settling equation. This model is used to describe the suspended solids profile from the sludge blanket to the weir under dynamic conditions.

Figure 5.1 shows the plant layout in GPS-X. The following sections detail the physical and operational parameters used in the plant model for each of the unit processes.

4.2. Plant Raw Influent Characteristics

Table 5.1 shows the influent characteristics used in the model as determined by field measurements from January 2001 to March 2001. No recycle streams are included in these measurements.

Table 5.1 – Roger Road WWTP Model Influent Characteristics

COD (mg/L)	sCOD (mg/L)	BOD_5 (mg/L)	$sBOD_5$ (mg/L)	TSS (mg/L)	VSS (mg/L)	NH_4-N (mg/L)	TKN (mg/L)
585	261	231	115.5	228	180	25.7	39

From the data in Table 5.1, the following stoichiometric ratios were calculated (Table 5.2).

Table 5.2 – Raw Influent Stoichiometry

Parameter	Values in model - winter
VSS/TSS	0.79
Ammonia/TKN	0.66
Soluble substrate/BOD_{ult}	0.50
XCOD/VSS	1.80
BOD_5/BOD_{ult}	0.50

4.3. Roger Road WWTP Model Parameters

Table 5.3 summarizes the physical characteristics of the Roger Road model.

Table 5.3 – Roger Road WWTP Model Physical Parameters

Unit Process	Diameter /Unit (ft)	Total Surface Area (ft^2)	SWD (ft)	Total Volume (gal)
Primary Clarifiers 5-8	105	34,620	8	-
Primary Clarifiers 9-10	120	22,608	12	-
Biofilters	165	42,744	26	-
Aeration tanks 1, 2 (2 single stage basins)	-	264x41	15	151,000 x 2
Aeration tanks 3-6 (4 two-pass basins)	-	115x25	16.3	94,000 x 4
Final Clarifiers 1, 2	100	15,700	9	-
Final Clarifiers 3, 4	105	17,310	8	-
Final Clarifiers 5, 6	105	17,310	11	-
Final Clarifiers 7, 8, 9	105	25,965	12	-

In addition to the information included in Tables 5.2 and 5.3 the following were also used in the model:

- The raw flow split between the two sets of primary clarifiers was assumed to be 33.4% to PSTs 9-10 and 66.6% to PSTs 5-8.
- A 50% - 50% flow split between aeration trains 1-2 and 3-6 was assumed.
- The maximum specific growth rate (μ_a) of the autotrophic group was 0.9 d^{-1} (@ 20°C) and the decay rate (b_a) was 0.17 d^{-1} (@ 20°C).
- Aeration tanks 1 and 2 send flow to final clarifiers 1 to 4 and aeration tanks 3 to 6 send flow to final clarifiers 5 to 9.

Table 5.4 shows the values used in the model for the aeration system. No design information was available for the parameters included in Table 5.4.

Table 5.4 – Aeration System Parameters

Parameter	Roger Road Model Values
α	0.6-0.8
β	0.95
θ	1.024
DO Levels (mg/L – stages 1-4)	0,4,4,4

5. SIMULATION SCENARIOS AND RESULTS FOR THE ROGER ROAD WWTP

5.1. Roger Road Tasks - Results

The following operational parameters, detailed in Table 5.1 were used.

Table 5.1 – Roger Operational Parameters

Scenario	Influent Flow (MGD)	MLSS (mg/L)	DO Tanks 1-4 (mg/L)	WAS Flow (MGD)	RAS Flow (MGD)	Internal Recycle (MGD)	Methanol Flow (gpd)
Task 1	41	140	0,4,4,4	1.8	0	20	8500
Task 2	50	140	0,4,4,4	2.1	0	20	6600
Task 3	41	120	0,4,4,4	1.8	0	5	1100
Task 4	50	130	0,4,4,4	2.1	0	5	800

Table 5.2 shows the results for the final effluent.

Table 5.2 – Roger Final Effluent

Scenario	TSS (mg/L)	BOD_5 (mg/L)	$sBOD_5$ (mg/L)	COD (mg/L)	sCOD (mg/L)	TN (mg/L)	NH_4–N (mg/L)	Nitrate (mg/L)
Task 1	15	13	5	58	37	12	0.5	7
Task 2	17	17	7	63	41	12	0.7	6
Task 3	15	13	6	60	40	13	0.6	8
Task 4	16	16	8	65	43	13	0.7	7

For all tasks, Internal Recycle flow was manipulated to ensure that the DO levels in the anoxic tanks were minimized (i.e. ~ 0 mg/L). Methanol flow was manipulated to eliminate carbon limitations, while ensuring that the effluent soluble BOD did not exceed acceptable levels.

Appendix G Water Management Legal and Regulatory Issues

WATER MANAGEMENT LEGAL AND REGULATORY ISSUES

Southern Arizona Water Rights Settlement Act:

Southern Arizona Water Rights Settlement Act (SAWRSA) of 1982 impacts treated effluent. Under this Act, the Tohono O'odham Indian Tribe has entitlement to 28,200 acre-feet AF per year of water of adequate quality for agricultural use. The actual source of this water is as yet undetermined, but the U.S. Secretary of the Interior has an agreement with the City of Tucson whereby the Secretary is to receive 28,200 (AF) MGD of treated effluent.

Groundwater Management Act (GMA)

To address long-term groundwater overdraft problems occurring in many areas of the State of Arizona, the Arizona Groundwater Management Act was passed by the State in 1980 which established four active management areas (AMA), including the Tucson AMA. It was recognized by the State Legislature that the international issues of the southern portion of the Upper Santa Cruz Valley Sub Basin were tremendously different than those issues facing the metropolitan Tucson area, and in 1994, the Santa Cruz AMA was carved out of the southern portion of Tucson AMA.

The objectives of the Groundwater Management Code are:

1. To control severe groundwater depletion.
2. To provide the means for allocating Arizona's limited groundwater resources.
3. To augment Arizona's groundwater reserves through supply development.

The primary goal for three of the AMAs, including the Tucson AMA, is the attainment of "safe yield by 2025". The Groundwater Code defines safe yield as "to achieve and thereafter maintain a long-term balance between the annual amount of groundwater withdrawn in an AMA and the annual amount of natural and artificial groundwater recharge in the AMA" A.R.S. § 45-561 (12). The realization of this goal was set to be achieved incrementally using five management periods. The Tucson AMA is currently in the Third Management Plan (TMP) for the period of 2002 to 2010.

Third Management Plan (TMP)

The Arizona Department of Water Resource's (ADWR) strategy for the TMP is:

- Continuing equitable water conservation requirements for all groundwater users.

- Increasing financial assistance, technical assistance and increased public education efforts on new water conservation methods, augmentation, recharge and monitoring efforts.
- Identifying areas of critical groundwater level decline, rapidly increasing decline, extremely limited availability, potential land subsidence and poor quality groundwater.
- Identifying existing and projected overdraft conditions and identifying potential changes in ADWR strategy to achieve safe yield.
- Improving monitoring, updating ADWR's hydrologic groundwater models and expanding available databases; changes yearly, and is based on Tucson Water's operation and maintenance costs.
- Increasing the use of available renewable supplies while decreasing the dependency on groundwater resources.
- Encourage efforts of coordination between the agencies affecting water policy and providing assistance to local and regional water planning efforts.

ADWR projects that the Tucson AMA will not achieve safe yield by 2025 without considerably more effort in water conservation measures and the full utilization of renewable water supplies.

Assured Water Supply (AWS)

The AWS program was initiated in 1973 as a consumer protection act requiring developers to obtain a determination from the State of Arizona regarding the availability of water to subdivided lots prior to the marketing of these lots. Upon passage of the 1980 Groundwater Management Act and the creation of the Active Management Areas (AMA), prohibiting the sale of subdivided lots without the availability of sufficient water of adequate quality for one hundred years strengthened AWS rules in the AMAs. The current AWS program rules became effective February 7, 1995 and further strengthened the program by requiring that the Management Plan criteria be met, or in other words, requiring the use of renewable resources.

The current AWS rules have tremendous implications to cities, towns, private water companies, and developers/landowners located within the Tucson AMA. In order to sell or lease subdivided lands within the Tucson AMA, a demonstration of an assured water supply must be made prior to the approval of the final plat and issuance of a public report from the Arizona Department of Real Estate. (A subdivision is defined as six or more parcels with at least one parcel having an area less than 36 acres.) ADWR makes the determination of whether an AWS exists. If an AWS does not exist, the land may not be subdivided. Those areas without an AWS would eventually be forced to stop urban development.

There are two methods to achieving an Assured Water Supply, a Designation of Assured Water Supply (DAWS) or a Certificate of Assured Water Supply (CAWS). Cities, towns, and private water companies may choose to obtain a DAWS if they have sufficient renewable water resources to meet anticipated demand of their service area. A developer of a subdivision located within the water service area of a city, town, or private water company with a DAWS is not required to obtain a CAWS. If a city, town, or private water company does not obtain a DAWS, the developer/landowner/subdivider must apply for a CAWS to continue with the planned land development. In both cases the applicant is required to have a water service agreement with the water provider that has the water service area right in which the proposed development is located and, for a certificate, must demonstrate that their subdivision has sufficient renewable water sources to meet demand for 100 years.

The AWS program is a significant commitment by Arizona to protect its groundwater resources. The AWS program is expected to cause water service providers to shift from groundwater to renewable resources, such as surface water and effluent. An applicant for an assured water supply must prove five conditions to ADWR's satisfaction. These are:

1. Physical Availability of a 100-year Water Supply

The physical availability criterion requires the applicant to show that it has enough water resources to meet projected (current and committed) demands for 100-years. For cities, towns, and private water companies the assured water supply demand is determined by using their current water demand and the estimated build-out demand from undeveloped subdivided lands within their service area. For applicants of a certificate of assured water supply, the projected demand is the estimated build-out water demand of their subdivision over a 100-year period. Water supplies must be shown to be legally and continuously available.

If groundwater is used as a supply, ADWR will analyze whether its use will cause the depth-to-static water level (measured from the surface of the earth) to exceed the 1,000 feet after 100 years of pumping. This is a serious concern for water providers located in the Tucson AMA. The amount of groundwater available to Tucson area water providers for purposes of demonstrating an assured water supply is limited.

2. Water Quality

Applicants for an AWS must prove to ADWR that its supplies will meet federal and state water quality standards for the proposed use. It is expected that surface water processed at water treatment plants will meet the water quality requirement. Depending on the prevailing contamination levels of the aquifer underlying the Tucson AMA, groundwater, recovered effluent and recovered surface water credits may eventually require treatment in order to pass the water quality requirement.

3. Consistency with the Management Plan

Tucson AMA cities, towns and private water companies seeking or maintaining a DAWS must be in compliance with ADWR's water conservation regulations, including lost and unaccounted for water as described in the Tucson AMA Third Management Plan. Developers, sub-dividers, and landowners seeking a CAWS whose water use may likely cause a water provider to violate its conservation requirement will still be allowed to obtain a CAWS. In this instance, the water provider will be warned of potential compliance problems resulting from providing water service to the new certificate holder.

4. Consistency with the Management Goal

ADWR does allow applicants for an AWS to use a limited allocation of mined groundwater in proving physical availability and consistency with the management goal. The amount of mined groundwater allowed for each applicant is calculated using a formula prescribed in AWS rules and is also constrained by the physical availability criteria.

For those that receive a groundwater allocation, the allocation may be "banked" for use during any time within the 100-year assured water supply period.

In the counties eligible for CAP water, the Central Arizona Groundwater Replenishment District (CAGRD) was created to help water providers and developers achieve the Management Goal of using renewable supplies. The CAGRD works by "replenishing" groundwater pumped by member lands or member service areas. Member lands are those subdivisions enrolled into the CAGRD

at the time a land developer is applying for a CAWS. A Member Service Area is a water provider that has enrolled its entire service area into the CAGRD.

5. Financial Capability

Cities and towns seeking DAWS must demonstrate that financing is available in their respective five-year capital improvement plans for major system improvements, such as storage or treatment facilities. If the platting authority (e.g., county, city, or town) has adequate bonding requirements to insure the installation of the necessary facilities, an applicant for a certificate may not be required by ADWR to provide evidence of financial capability. Private water companies can use the State of Arizona Corporation Commission approval as evidence of financial capability.

Options for Obtaining an Assured Water Supply

A city, town or private water company will have to decide two key points: first, does the water provider have sufficient amounts of renewable water resources; and second, does the water provider have adequate financial resources to demonstrate financial capability? Table 1 provides a summary of the options.

In Case 1, where the water provider has sufficient renewable water resources and can demonstrate financial capability, the DAWS option would be advisable because it simplifies the AWS documentation process and it is more supportive of the AMA's groundwater management goals. A provider may get designated based on groundwater availability and membership in the CAGRD, if groundwater is available.

In Case 2, where the water provider lacks sufficient renewable water resources, but can demonstrate financial capability, the water provider has the following three choices. The water provider could attempt to:

1. Acquire the water resources needed and apply for a DAWS
2. Join the Central Arizona Groundwater Replenishment District (CAGRD) and apply for a DAWS, or
3. Place the burden of securing additional water resources on the developer. If the water provider chooses the latter, the developer may attempt to acquire the water resources needed for their development. If successful, the developer could pledge the resource to the water provider, and the water provider would apply to ADWR for a DAWS. If the developer is not successful in acquiring additional water resources, the developer may apply to ADWR for a CAWs, upon enrollment of the property in the CAGRD, providing sufficient groundwater is available.

In Case 3, where the water provider has sufficient renewable water resources, but is not able to demonstrate financial capability, the water provider may want to explore the possibility of placing the burden of paying the construction of water-related infrastructure on the developer through development fees.

In Case 4, where the water provider lacks the needed renewable water resources and is not able to demonstrate financial capability, all of the aforementioned options need to be explored.

Assured Water Supply, Recharge and CAGRD Issues Relating to Aquifer Draw-down

ADWR has questioned whether the 1,000-foot physical availability criterion is adequate to prevent permanent irreversible damage to the aquifer due to land subsidence. ADWR has identified two critical groundwater decline management areas in the Tucson area, the City of Tucson's Central Wellfield and the area of metal mine pumping in the Green Valley/Sahuarita area. Additionally,

evidence of land subsidence, fissuring and aquifer compaction has been observed in the northern Avra Valley. Subsidence monitoring will continue in the Tucson AMA to improve the understanding of the extent and degree of subsidence.

In developing a water resources strategy for the Tucson AMA, there are three key issues that need to be understood: first, ADWR's groundwater model projects severe decline and dewatering in the Tucson AMA aquifer, unless renewable water resources are more widely used; second, the CAGRD does not guarantee that a member will be granted an assured water supply. The water provider is still subject to the 1,000 feet depth-to-static water level physical availability limitations of the aquifer on which they rely. Third, new wells used to pump groundwater or recover stored water credits are subject to ADWR's rules regarding drawdown of the aquifer. Currently, recovery wells are subject to a 4-feet per year drawdown limit, unless the well is within the area of impact of a recharge facility. Table 6.x.x presents the applicability of ADWR's AWS, recharge and CAGRD requirements to various types of water produced from wells.

Table 6.x.x AWS, Recharge and CAGRD Rules Related to Aquifer Drawdown

Requirement	Providers that Have AWS Designation (with or without CAGRD)
1,000 Ft. Drawdown	
Incidental recharge	Yes, subject to 1,000 ft. drawdown
Groundwater account	Yes, subject to 1,000 ft. drawdown
Recovery of credits inside hydro-impact area	No, not subject to 1,000 ft. drawdown
Recovery of credits outside hydro-impact area	Yes, subject to 1,000 ft. drawdown
Pump water to be replenished by GRD	Yes, subject to 1,000 ft. drawdown
4 Ft. Per Year or More Draw-Down	
Incidental recharge	No, not subject to the 4 ft. per year drawdown
Groundwater account	No, not subject to the 4 ft. per year drawdown
Recovery of credits inside hydro-impact area	No, not subject to the 4 ft. per year drawdown
Recovery of credits outside hydro-impact area	Yes, subject to the 4 ft. per year drawdown
Pump water to be replenished by CAGRD	No, not subject to the 4 ft. per year drawdown

Each water provider seeking a DAWS must show that it will be in compliance with these requirements. Similarly, if Tucson AMA water providers plan to store and/or recover CAP water from the aquifer, they must also comply with the assured water supply and recharge requirements.

Table 6.x.x Assured Water Supply Options

	Case #1	Case #2	Case #3	Case #4
Water Resources	Yes	No	Yes	No
Financial Capability	Yes	Yes	No	No
Options	Seek DAWS or join the CAGRD and seek digestion	Join CAGRD and Seek DAWS or make developer obtain water resources or join CAGRD and obtain CAWs	Make developer pay for water related infrastructure and seek DAWS	See cases #2 and #3

1995 Water Consumer Protection Act (WPCA)

In total, the Tucson AMA is sub-contracted for 215,333 AF of Central Arizona Project (CAP) water, with the largest sub-contractor being the City of Tucson/Tucson Water. Tucson Water is the largest water provider in the Tucson AMA serving over 75% of the population within the Tucson AMA. The direct delivery of CAP, the largest renewable water resource in the Tucson AMA, is currently not available to residents in City of Tucson because of the 1995 Water Consumer Protection Act (WPCA). In 1992, Tucson Water began the direct delivery of treated CAP water. This was discontinued in 1993 because of "brown water" problems. The brown water problem was attributed to the loosening of corrosion materials in older infrastructure throughout the water distribution system because of the chemical differences in the CAP. In addition to prohibiting the direct use of CAP, the 1995 WPCA requires that CAP water be used solely for sale, exchanged or recharged and to replace groundwater used by agriculture, industry and landscape irrigation. The WPCA also does not allow the direct injection of CAP water into the aquifer, further limiting the areas where water may be recharged.

Although recharge of CAP is helping the overall water balance in the Tucson AMA, the restrictions of the WPCA force recharge to occur outside the areas with severe water level declines. Additional factors that limit recharge in areas of severe decline are the cost of land, geology, existing contamination sites and potential sources of contamination.

Appendix H Regulations for Production of Class A and Class B Biosolids

REGULATIONS FOR PRODUCTION OF CLASS A AND CLASS B BIOSOLIDS

The federal Clean Water Act Part 503 regulations identify two classes of pathogen reduction:

Class A

Class A biosolids undergo a "Process to Further Reduce Pathogens (PFRP)." Pathogens are reduced to a level similar to the native soil and environment. Class A biosolids products can be used on home lawns and gardens, parks and golf courses, and other places where public contact is likely. Class A biosolids products include composted biosolids, lime pasteurized biosolids, and fertilizer pellets. Class A biosolids products are sometimes ingredients in soil amendments, potting soils, and slow-release fertilizers.

Class B

Class B biosolids undergo a "Process to Significantly Reduce Pathogens (PSRP)." This means that while pathogens are significantly reduced to levels, which are often below, those found in animal manures, additional best management practices ("BMPs") are required at the site where they are used. In New England, Class B biosolids are used in bulk as fertilizers in agriculture and forestry and to reclaim barren lands. Site permits are required for Class B biosolids use.

Currently both Roger Road WWTP and Ina Road WPCF wastewater treatment facilities produce biosolids with Class B pathogen reduction. Land application of Class B biosolids requires extensive monitoring, reporting, and record keeping. There are restrictions on the crop harvesting, animal grazing, and public contact when Class B biosolids are used on farmland. Moreover, there is a growing public perceptions of concern associated with the use of Class B biosolids throughout the United States. These factors may ultimately diminished the agricultural community's enthusiasm in accepting biosolids as a soil amendment.

Summary of Class A and Class B Pathogen Reduction Requirements

Class A: In addition to meeting the requirements in one of the six alternatives listed below, fecal coliform or Salmonella sp. bacteria levels must meet specific density requirements at the time of biosolids use or disposal or when prepared for sale or give away.

Alternative 1: Thermally treated biosolids - Biosolids must be processed through one of the four time-temperature regimes (described in 40CFR503).

Alternative 2: Biosolids treated in a high pH-high temperature process - Biosolids must meet specific pH, temperature, and air-drying requirements.

Alternative 3: Biosolids treated in other processes - Demonstrate that the process can reduce enteric viruses and viable helminth ova, and maintain operating conditions used in the demonstration after pathogen reduction.

Alternative 4: Biosolids treated in unknown processes - Biosolids must be tested for pathogens - Salmonella sp. or fecal coliform bacteria, enteric viruses, and viable helminth ova - at the time the biosolids are used, or disposed, or in certain situations, prepared for use or disposal.

Alternative 5: Biosolids treated in a PFRP - Biosolids must be treated in one of the Processes to Further Reduce Pathogens (PFRP).

Alternative 6: Biosolids treated in a process equivalent to PFRP - Biosolids must be treated in a process equivalent to one of the PFRPs, as determined by the permitting authority.

The following requirements must be met for all the above Class A pathogen alternatives. Either:

- The density of fecal coliform in the biosolids must be less than 1,000 most probable number (MPN) per gram total solids (dry-weight basis).

OR

- The density of Salmonella sp. bacteria in the biosolids must be less than 3 MPN per 4 grams of total solids (dry-weight basis).

The following are the processes to "further reduce pathogens (PFRP)" to produce Class A Biosolids listed in Appendix B of 40CFR503:

Class B: The requirements in one of the three alternatives below must be met.

Alternative 1: Monitoring of indicator organisms - Test for fecal coliform density as an indicator for all pathogens at the time of biosolids use or disposal.

Alternative 2: Use of PFRP - Biosolids are treated in one of the Processes to Significantly Reduce Pathogens (PSRP).

Alternative 3: Use of processes equivalent to PSRP - Biosolids are treated in a process equivalent to one of the PSRPs, as determined by the permitting authority.

1. Composting - Using either the within-vessal composting method or the static aerated pile composting method, the temperature of the biosolids is maintained at 55 degrees C or higher for three days. Using the windrow composting method, the temperature of the biosolids is maintained at 55 degrees C or higher for 15 days or longer. During the period when the compost is maintained at 55 degrees C or higher, the windrow is turned a minimum of five times.

2. Heat Drying - Biosolids are dried by direct contact with hot gases to reduce the moisture content of the biosolids to 10 percent or lower. Either the temperature of the biosolids particles exceeds 80 degrees C or the wet bulb temperature of the gas in contact with the biosolids as the biosolids leave the dryer exceeds 80 degrees C.

3. Heat Treatment - Liquid biosolids are heated to a temperature of 180 degrees C or higher for 30 minutes.

4. Thermophilic Aeorbic Digestion - Liquid biosolids are agitated with air or oxygen to maintain aerobic conditions, and mean cell residence time of biosolids is 10 days at 55 degrees C to 60 degrees C.

5. Beta Ray Irradiation - Biosolids are irradicated with beta rays from an accelerator at dosages of a least 1.0 megarad at room temperature (ca. 20 degrees C).

6. Gamma Ray Irradiation - Biosolids are irradiated with gamma rays from an accelerator at dosages of at least 1.0 megarad at room temperature (ca. 20 degrees C).

7. Pasteurization - The temperature of biosolids is maintained at 70 degrees C or higher for 30 minutes or longer.

Appendix I Capitalization of Infrastructure Growth, Replacement and Regulatory Compliance

Infrastructure rehabilitation is an ongoing capital expense necessary to maintain the operational integrity of the system as components reach, or exceed, their useful operational life. As Pima County is still in a growth mode and build out is not presently foreseen in the next twenty years, capital expenses for expansion of both the conveyance and treatment systems will continue to be ongoing. At this point in time the three most costly components are: upgrading the Roger and Ina facilities to include denitrification of all effluent, upgrading biosolids treatment at all facilities, and implementing CMOM practices in the operations of the conveyance system.

All projects in excess of $100K are eligible to be capitalized and have their completed costs added to the value of PCWWM facilities in service. The addition of new facilities to meet regulatory issues is easily determined as additions to the value of the plant in service. Likewise, major facilities and conveyance rehabilitation/replacement are easily identified as increasing the value of the plant in service. What is more difficult to quantify are the smaller projects individually less than $100,000 that replace segments or components of the system, increasing the life expectancy of the components replaced.

If PCWWM were a private utility, it would be in PCWWM's best interest to capitalize as much improvement work as possible because it would add to the book value of the utility. It also has long-term tax benefits as capital assists are depreciated while expensing projects provide for a one-time tax deduction and show no improvement to the utility's book value.

With the advent of GASB-34 (Government Accounting Standards Board – Statement No. 34), public utilities are encouraged to track assets more like private utilities. It is in PCWWM's best interest to maintain or increase its book value as a reflection of PCWWM's commitment to maintain the infrastructure. Additionally, with the constant pressure to contain O&M costs there is an incentive to capitalize replacement/rehabilitation work when possible, and much of this work could be done with bond funding verses limited available SDF cash.

One example of this type of maximization of capital improvements of small individual projects would be the replacement of deteriorated manholes. For example, each manhole on a section of the conveyance system may average $15,000 each to replace. If done individually, the projects would most likely be expensed. However, if there are 40 manholes requiring replacement the combined work could be completed as follows:

- Establish a $600,000 project to replace these manholes.
- Each replaced manhole increases the useful life over the old manhole it replaces.
- The project meets PCWWM capitalization guidelines.
- The remaining value of the old manhole can be identified and removed from the facilities in service, say $50,000 net.
- The new value can be added to the facilities in service with an overall increase of $550,000.

Similar examples can be demonstrated for the pipes and facilities within the treatment plants.