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Mixer Test Results

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Mixer Test
At
Fontana/Walworth
Water Pollution Control Facilities

Performance Comparison

Mixer Test
At
Fontana/Walworth
Water Pollution Control Facilities

Performance Comparison

Comparison of the performance of two identical 24.5 horsepower submersible Landia mixers operating simultaneously in a circular biosolids storage tank with the operation of one submersible 30.2 horsepower EMU mixer operating in the same tank during different time periods.

This report includes the results of the biosolids storage tank submersible mixer testing conducted recently at the Fontana/Walworth Water Pollution Control Facilities (F/WWPCF). The purpose of the testing was to compare the performance of two identical 24.5 horsepower (hp) submersible Landia mixers operating simultaneously in a circular biosolids storage tank with the operation of one submersible 30.2 hp EMU mixer operating in the same tank during different time periods. A comparison of the technical data for each mixer type is included in Table 1.

Background Information

The F/WWPCC operates this wastewater treatment facility that serves residences, businesses, and public institutions in the Villages of Fontana and Walworth, as well as Kikkoman Foods, Inc. The facilities have been in operation since 1986 and consist of mechanical screening followed by influent pumping, oxidation ditch-activated sludge, final clarification, seasonal chlorination/dechlorination, and postaeration. Liquid polymer is added to the final clarifiers to assist in meeting the stringent effluent biochemical oxygen demand (BOD) and total suspended solids (TSS) limits of 10 mg/L.

Phosphorus removal facilities began operation in mid-1999 to comply with new state-imposed effluent phosphorus limits. Phosphorus removal is accomplished by the addition of ferric chloride solution upstream of the oxidation ditches that results in precipitation of the phosphorus in the form of a chemical sludge. The chemical sludge cosettles along with the biosolids in the final clarifiers.

Excess biosolids/chemical sludge (hereinafter referred to as biosolids) is wasted to two circular storage tanks. Biosolids thickening is accomplished by gravity thickening/decanting within each tank. Biosolids are disposed by injection into Commission-owned adjacent farmland, typically in the spring before planting and in the fall after harvest. Proper mixing of the biosolids within the tank is essential prior to land disposal so that the equipment conveying the biosolids can operate properly and the biosolids can be evenly distributed on the farmland.

Test Tank Configuration

The mixer testing was conducted in an 85-foot-diameter symmetrical concrete biosolids storage tank. The tank has a sidewall depth of approximately 19.7 feet and slopes at approximately 8.3 percent to the 6-inch-diameter pipeline located at the centerline of the tank. (The pipeline is used to fill and empty biosolids from the tank.) The depth from the centerline of the tank floor to the top of the wall is approximately 23.3 feet.

Mast assemblies for guiding/securing the submersible mixers are located at the northmost and southmost points of the interior concrete wall. The test tank configuration and mixer location(s) for each mixer test are shown in Figures 1 and 2.

Schedule Summary

The preparation for mixer testing began on Friday, August 17, 2001, when F/WWPCC staff started both 24.5 hp Landia mixers, so that the biosolids, which had been stored (and unmixed) since spring 2001, could be initially mixed. Both mixers were then shut down on Wednesday, August 22, to allow the biosolids to settle for 6 days prior to beginning the mixer testing.

Mixer Test 1 began on Tuesday morning, August 28, 2001, when biosolids samples were collected at the top, middle, and bottom depths at the westmost and eastmost positions along the tank wall prior to mixer start-up. The biosolids depth at the sidewall measured 11.3 feet. (Given the tank configuration described earlier, the calculated biosolids volume existing in the tank during the testing period was approximately 530,000 gallons.) The mixers were then started and sample rounds were conducted each hour for the first 8 hours after start-up as well as at 24 hours (August 29) and 48 hours (August 30). Amp draw readings were recorded for each of three-phase wires at the completion of each sampling event. Both Landia mixers were then shut down immediately following the 48-hour sampling. The Landia mixer in the south position was then removed from the tank by a Commission-hired crane. The 30.2 hp EMU mixer was then installed on the existing rail system in the south position, started briefly to confirm correct wiring/rotation, and then lowered to within approximately 2 feet of the tank floor. The tank again remained undisturbed for 6 days.

Mixer Test 2 began on Wednesday morning, September 5, when biosolids samples were collected at the top, middle, and bottom depths at the same wall locations. The mixer was then started and samples were again collected at 1, 2, 3, 4, 5, 6, 7, 8, 24, and 48 hours after start-up as performed previously for Mixer Test 1. Amp draws were also recorded for each phase wire at the completion of each sampling event. The EMU mixer was then shut down on September 7, thus ending Mixer Test 2.

Sample Collection/Testing Procedures

Biosolids samples were collected at the westmost and eastmost tank wall locations, at top, middle, and bottom depths using a Wildco sampler with a graduated rope. The top sample was collected just below the biosolids surface. The middle sample was collected at mid-depth of the biosolids, while the bottom sample was collected just above the tank floor. A supplemental 14-pound weight was retrofitted onto the bottom of the sampler to allow the sampler to pass vertically down through the thickened biosolids and to minimize velocity effects on the sampler. The sampler contained a "messenger" that traveled down the rope triggering the sampler to close, thus allowing collection of samples at the specific depths.

Samples were collected into 250 ml plastic containers leaving minimal headspace and immediately preserved in an ice-filled cooler. The sampler was decontaminated between sample collections by thoroughly rinsing with well water supplied through a garden hose. Samples were sent to CT Laboratories in Baraboo, Wisconsin (Wisconsin DNR Certification No. 15-7066030), for total solids analysis by Standard Method SM 2540. Total solids results are presented in Tables 2 and 3 for each mixer test. The original laboratory reports are included in Attachment A.

Duplicate samples were collected from the sampler for quality assurance/quality control (QA/QC) purposes. A comparison of the "regular" results with the duplicate results is presented in Table 4. The maximum deviation between the two sample results was approximately 17 percent with the remaining deviations less than approximately 10 percent. These QA/QC results show good reproducibility, particularly given the inherent spatial variability for biosolids in the 2 to 3 percent total solids range.

Amp draw readings were taken of each three-phase wire lead at the completion of each sampling round (6 samples per round) and recorded. The amp meter used was an Amprobe Model RS-3. The amp reading for each wire as well as an average amp reading is presented in Tables 5 and 6 for each mixer test.

Results Discussion

Mixer Test 1

A. Total Solids Results

The initial total solids results prior to start of the Landia mixers indicated total solids concentrations in the 5.4 to 6.4 percent range with no noticeable stratification. An approximate 6-inch-thick surface scum was present in the tank with a green tint indicating algal growth.

Upon start-up of the mixers, the total solids content dropped substantially in the 2.5 to 3.2 percent range. Observations made by personnel performing the sampling indicate the surface scum layer was likely entrapped in the sampler as it passed through this layer to collect the middle and bottom depth samples. Therefore, the total solids concentration of the initial samples collected in Mixer Test 1 is believed to be more representative of the total solids concentration in the surface scum rather than the solids concentration at the lower depths.

There is no noticeable stratification pattern from top to bottom at either wall sampling location based on the total solids results. The highest concentration of total solids appears to vary randomly between top, middle, and bottom depths during each sample round. The difference between the highest to lowest total solids concentration within each sampling round generally follows an overall decreasing trend at the east wall sampling location. The west wall sampling results do not appear to show any definable trend with respect to the total solids differences as the sampling progressed.

B. Visual Observations

Based on visual observations of the biosolids surface mixer testing, the scum surface layer initially began to "break up" beginning at the west wall and continuing clockwise approximately 10 minutes following start-up of the mixers. The first surface area to begin showing turbulence was immediately downstream of the south mixer which was approximately 7 feet above the tank floor.

The surface area at the east wall then began to "break up" and show turbulence approximately 20 minutes after start-up, and at 30 minutes, an approximate 4-foot-wide turbulent area had formed around the entire wall perimeter with the remaining circular scum layer in the tank center rotating clockwise.

By 2 hours after start-up, the rotating scum layer had broken up into smaller "islands," and a less turbulent zone was observed in the tank center. At 6 hours after start-up, only a few minor scum "islands" remained, and the tank surface exhibited a clear clockwise rotation with an obvious stagnant zone in the tank center.

C. Amp Draw Readings/Electrical Operating Cost

Initial amp draw readings averaged 26.6 and 25.0 at the north and south mixers, respectively, immediately following start-up. The south mixer exhibited an overall decreasing trend in average amp draw while the average amp draw for the lower north mixer was erratic. Additionally, the south mixer's average amp draw readings were lower when compared to the north mixer's average amp readings.

Converting the average amp draw to kilowatts and utilizing an electrical cost of $0.036 per kilowatt-hour yields the electrical operating cost of each Landia mixer as shown in Table 5. The electrical operating cost over the 48-hour test period for the north and south mixer's is calculated to be $32.65 and $28.50, respectively. Thus, the total electrical operating cost for both mixers during the test is $61.15.

Mixer Test 2

A. Total Solids Results

The initial total solids results prior to start-up of the EMU mixer indicated total solids concentrations in the 1.5 to 2.8 percent range. An approximate 6-inch-thick surface scum was again present in the tank with a green tint indicating algal growth. However, sampling personnel removed surface scum at both sampling locations to allow the sampler to pass through this area freely and avoid the interference experienced during the initial sampling of Mixer Test 1.

Therefore, the initial sampling results of Mixer Test 2 are believed to be more representative of actual total solids conditions existing below the surface scum layer when compared with Mixer Test 1 initial sampling results.

Upon start-up of the mixer, the total solids concentrations increased to between 2.7 and 6.7 percent. Subsequent sampling rounds indicate that again the highest total solids concentration appears to vary randomly between the top, middle, and bottom depths. The difference between the highest to lowest total solids concentrations within the first three sampling rounds shows a greater variability when compared to the first three rounds of Mixer Test 1. However, the difference between the highest to lowest total solids concentrations in subsequent rounds appears to stabilize between 0.05 to 0.28 percent. By comparison, the same sampling rounds in Mixer Test 1 showed differences between 0.07 to 0.40 percent.

Additionally, the high-to-low difference in total solids concentrations from the west wall sampling location to the east wall sampling location during Mixer Testing 2 was very comparable beginning with the 3-hour sampling. Thus, it appears the east wall was being subjected to the same mixing intensity as was the west wall location, which was directly downgradient of the mixer flow.

B. Visual Observations

Based on visual observations of the biosolids surface during the mixer testing, the scum layer initially began to "break up" beginning along the southwest portion of the wall approximately 10 minutes following the mixer start-up. This first surface area to begin showing turbulence was immediately downstream of the mixer located at the south wall, which was approximately 2 feet above the tank floor. This turbulent surface area was observed to get progressively larger and at 2.5 hours after start-up, the majority of the tank perimeter was exhibiting surface turbulence with larger scum "islands" beginning to break up and rotate clockwise.

At 8 hours after start-up, a few minor scum "islands" remained, and the tank exhibited a clear clockwise rotation with an obvious stagnant zone in the tank center.

C. Amp Draw Readings/Electrical Operating Cost

Initial amp draw readings averaged 33.4. The average amp draw for this mixer exhibited a decreasing trend throughout the test period with the exception of the final 48-hour reading which rose slightly.

Converting the average amp draw to kilowatts and using an electrical cost of $0.036 per kilowatt-hour yields the electrical operating cost shown in Table 6. The electrical operating cost over the 48-hour test period for the EMU mixer is calculated to be $30.55.

Conclusions

- The mixer test with the two Landia mixers (located 2 feet and 7 feet above the tank floor) dissipated the 6-inch-thick surface scum approximately 2 to 3 hours sooner than the mixer test with the single EMU mixer (located approximately 2 feet above the tank floor). Earlier dissipation of the surface scum during the Landia test was assisted by the higher south mixer, which created a turbulent surface zone within 10 minutes of start-up.

- Based on the total solids results, the Landia mixer test appears to provide a well-mixed product (excluding the surface scum) within 2 hours after start-up of the mixer. The EMU mixer test appears to provide a well-mixed product within 3 hours after start-up (again, excluding the surface scum).

Achieving a well-mixed product for land disposal will typically require a longer mixing period since the biosolids are stagnant in the storage tank for up to 6 months between hauling periods. This "stagnant" period for conducting the mixer tests was limited to 6 days.

- Considering the total solids results from 3 to 48 hours after start-up, the EMU test appears to exhibit a more consistent product from top to bottom when compared to the Landia test. The tank center, visually observed to be more stagnant on the surface, was not sampled during either test and could prove to be the limiting factor in achieving a "well- mixed" product.

- The total average horsepower applied per 1,000 cubic feet of biosolids for the Landia mixers (0.68 HP/1,000 CF) was nearly double that of the single EMU mixer (0.35 HP/1,000 CF) during the respective 48-hour test periods.

- The calculated electrical operating cost of the two Landia mixers (approximately $61 over the 48-hour test period) is double that of the single EMU mixer (approximately $31 over the 48-hour test period).

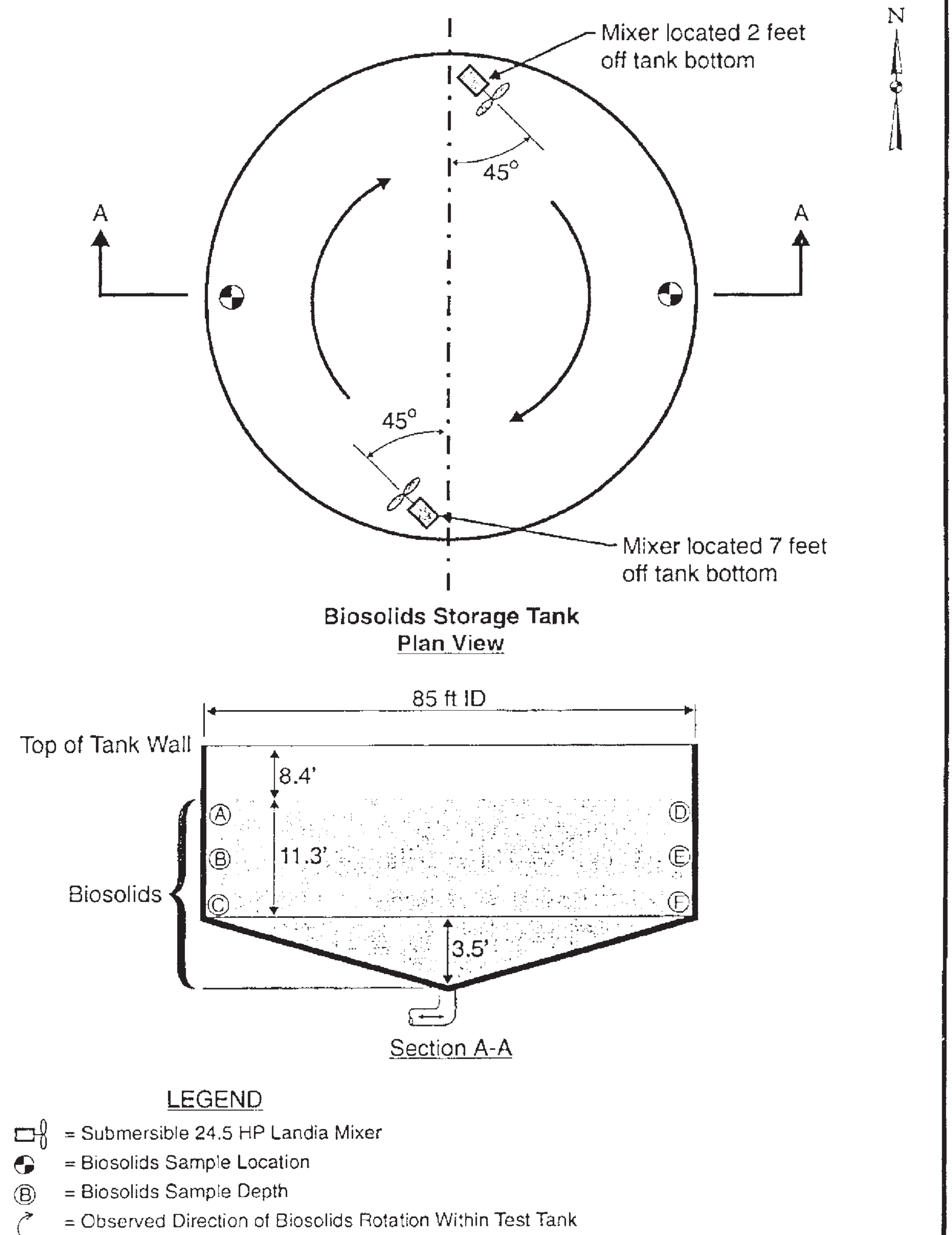


Figure No. 1 1-179-310	Fontana / Walworth Water Pollution Control Facilities Biosolids Storage Tank Mixer Testing Mixer Test 1	STRAND ASSOCIATES, INC.

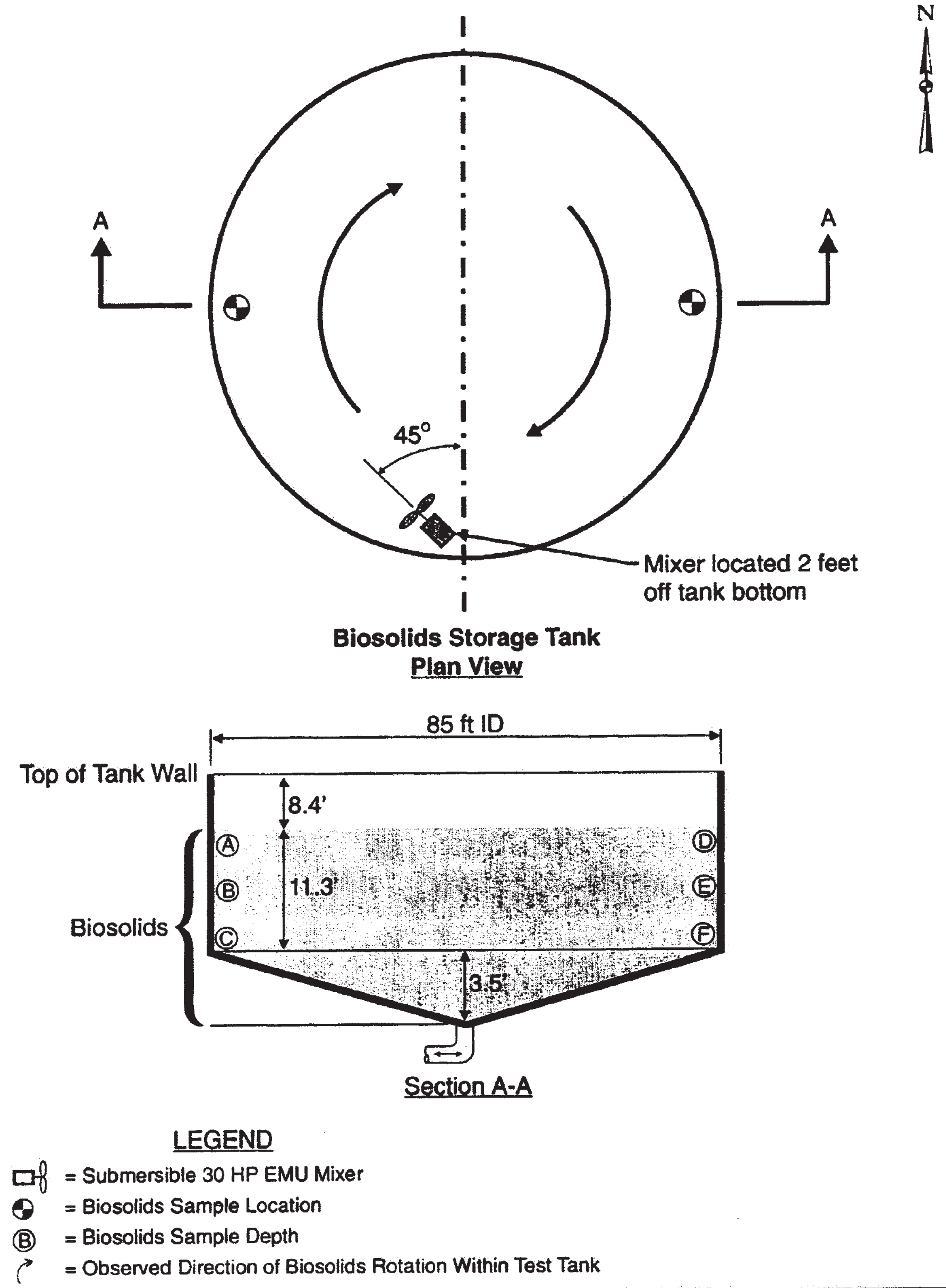


Figure No. 2 1-179-310	Fontana / Walworth Water Pollution Control Facilities Biosolids Storage Tank Mixer Testing Mixer Test 2	STRAND ASSOCIATES, INC.

Table 1

FONTANA/WALWORTH WATER POLLUTION CONTROL FACILITIES
BIOSOLIDS STORAGE TANK MIXER TESTING
MIXER DATA

Mixer Data	Landia Submersible Mixer[1]	EMU Submersible Mixer[2]
Manufactured (Year)	1998	2000
Model	POP-I	TR80-1
Weight (lbs)	517	668
Flow (gpm)	23,800	21,900
Propeller Diameter (in)	33	30.9
Propeller Speed (rpm)	360	331
Propeller Material	Stainless Steel	Curved Polyurethane for Efficiency
Propeller Blade	3	3
Motor Data		
Motor Manufacturer	Landia	EMU Unterwasserpumpen GmbH
Size (HP)	24.5	30.2
Speed (rpm)	1740	1740
Voltage (V)	460	460
Phase (⌀)	3	3
Frequency (Hertz)	60	60
Starting Current (amps)	159.6	200
Operating Current (amps)	28.5	39.5
Power Factor	0.86	0.84
Transmission Data		
Type	Planetary Gear	
Reduction Ratio	5:1	5.3:1

Table 2

FONTANA/WALWORTH WATER POLLUTION CONTROL FACILITIES
BIOSOLIDS STORAGE TANK MIXER TESTING (WITH TWO 24.5 HP SUBMERSIBLE LANDIA MIXERS)
TOTAL SOLIDS RESULTS (%)

		Sample Location							
		Westmost Location Along Wall				Eastmost Location Along Wall			
Date-Time[1]	Time after Start-up (hrs)	A (Top)	B (Middle)	C (Bottom)	Difference	D (Top)	E (Middle)	F (Bottom)	Difference
08/28/01-0745	0	5.50	**5.65**	5.36	0.29	**6.42**	6.17	5.66	0.76
08/28/01-0950	1	2.66	**2.72**	2.54	0.18	**3.15**	2.61	2.87	0.54
08/28/01-1049	2	2.54	**2.86**	2.83	0.32	2.52	**2.81**	2.58	0.29
08/28/01-1149	3	2.63	2.73	**2.77**	0.14	**3.03**	2.66	2.84	0.37
08/28/01-1250	4	**2.79**	2.66	2.58	0.21	2.75	2.50	**2.83**	0.33
08/28/01-1349	5	**2.82**	2.47	2.54	0.35	2.74	2.79	**2.92**	0.18
08/28/01-1450	6	2.52	2.64	**2.65**	0.13	**2.90**	2.53	2.88	0.37
08/28/01-1549	7	2.51	**2.91**	2.81	0.40	2.56	**2.63**	2.53	0.10
08/28/01-1649	8	2.37	2.47	**2.57**	0.20	2.57	**2.59**	2.48	0.11
08/29/01-0850	24	2.66	2.64	**2.78**	0.14	2.70	2.64	**2.71**	0.07
08/30/01-0848	48	2.70	**2.76**	2.70	0.06	2.76	2.73	**2.82**	0.09

Notes: The two Landia submersible mixers were located at the northmost and southmost tank wall points. The north mixer was set approximately 2 feet above the tank floor while the south mixer was set approximately 7 feet above the tank floor.

[1] Indicates time sampling round began.

Bold face results indicate the highest total solids concentration detected within the sampling round at each location.

Table 3

FONTANA/WALWORTH WATER POLLUTION CONTROL FACILITIES
BIOSOLIDS STORAGE TANK MIXER TESTING (WITH ONE 30.2 HP EMU MIXER)
TOTAL SOLIDS RESULTS (%)

		Sample Location							
		Westmost Location Along Wall				Eastmost Location Along Wall			
Date-Time[1]	Time after Start-up (hrs)	A (Top)	B (Middle)	C (Bottom)	Difference	D (Top)	E (Middle)	F (Bottom)	Difference
09/05/01-0755	0	**2.77**	1.52	2.72	1.25	2.62	**2.68**	2.65	0.06
09/05/01-0916	1	**3.41**	2.92	2.71	0.70	**6.71**	2.74	3.26	3.97
09/05/01-1015	2	2.73	**2.78**	2.77	0.05	3.05	2.53	**9.98**	7.45
09/05/01-1115	3	2.77	2.69	**2.86**	0.17	**2.81**	2.67	2.68	0.14
09/05/01-1216	4	2.68	2.69	**2.77**	0.09	2.72	2.66	**2.78**	0.12
09/05/01-1315	5	2.68	2.70	**2.80**	0.12	2.74	**2.87**	2.79	0.13
09/05/01-1415	6	2.73	**2.79**	2.69	0.10	2.70	**2.77**	2.67	0.10
09/05/01-1515	7	2.70	**2.73**	2.68	0.05	2.77	**2.87**	2.70	0.17
09/05/01-1615	8	2.68	**2.81**	2.74	0.13	**2.76**	2.60	2.64	0.16
09/06/01-0815	24	2.88	**2.95**	2.83	0.12	**2.86**	2.79	2.70	0.16
09/07/01-0815	48	2.46	2.52	**2.60**	0.14	**2.33**	2.05	2.23	0.28

Notes: The EMU submersible mixer was located at the southmost wall point and set approximately 2 feet above the bottom of the tank.

[1] Indicates time sampling round began.

Bold face results indicate the highest total solids concentration detected within the sampling round at each location.

Table 4

FONTANA/WALWORTH WATER POLLUTION CONTROL FACILITIES
BIOSOLIDS STORAGE TANK MIXER TESTING - QUALITY ASSURANCE PROGRAM
TOTAL SOLIDS RESULTS (%)

Test 1 Samples	Regular	versus	Duplicate	Deviation (%)
4F	2.83		2.54	-10.2
6A	2.52		2.66	+5.6
8B	2.47		2.89	+17.0
24C	2.78		2.80	+0.7
48D	2.76		2.76	0.0

Test 2 Sample	Regular	versus	Duplicate	Deviation (%)
2E	2.53		2.51	-0.8

Table 5

FONTANA/WALWORTH WATER POLLUTION CONTROL FACILITIES
BIOSOLIDS STORAGE TANK MIXER TESTING (WITH TWO 24.5 HP SUBMERSIBLE LANDIA MIXERS)
AMP DRAW READINGS

Time	North Wall[1] Mixer Location	Average	Operating Cost ($)[4]	South Wall[2] Mixer Location	Average	Operating Cost ($)[4]
Start-up on 08/28/01 at 0849	26.0/26.1/27.8[3]	26.6	----	25.2/24.7/25.2[3]	25.0	----
1 hour after start-up	26.1/26.0/26.5	26.2	$ 0.68	24.0/24.5/25.1	24.5	$ 0.64
2 hour after start-up	26.0/25.5/26.1	25.9	0.67	23.8/23.9/24.0	23.9	0.62
3 hour after start-up	26.8/27.0/26.5	26.8	0.68	23.5/23.0/24.0	23.5	0.61
4 hour after start-up	26.8/26.1/26.1	26.3	0.68	23.1/22.9/23.5	23.2	0.60
5 hour after start-up	26.3/26.9/27.2	26.8	0.68	23.1/22.5/22.9	22.8	0.59
6 hour after start-up	27.1/27.7/27.5	27.4	0.70	24.7/23.5/24.1	24.1	0.60
7 hour after start-up	27.2/27.5/27.2	27.3	0.70	23.5/23.2/24.1	23.6	0.61
8 hour after start-up	28.0/26.7/27.8	27.5	0.70	23.5/23.2/24.0	23.6	0.61
24 hours after start-up	26.0/26.1/27.1	26.4	11.09	22.1/22.9/23.1	22.7	9.52
48 hours after start-up	25.8/25.2/26.0	25.7	16.07	22.7/23.0/23.2	23.0	14.10
		Total:	$32.65			$28.50

Notes:
1 Mixer located along north wall is approximately 2 feet above bottom of tank.
2 Mixer located along south wall is approximately 7 feet above bottom of tank.
3 Amp draw readings for each of the three-phase wires.
4 Electrical operating cost calculated based on the average amp draw readings and an electricity cost of $0.036 per kilowatt hour using the following formula:

kilowatts = (voltage) * (amperage) * (motor power factor) * (1.73)/1000

Table 6

FONTANA/WALWORTH WATER POLLUTION CONTROL FACILITIES
BIOSOLIDS STORAGE TANK MIXER TESTING (WITH ONE 30.2 HP SUBMERSIBLE EMU MIXER)
AMP DRAW READINGS

Time[1]	South Wall[1] Mixer Location	Average	Operating Cost ($)[3]
Start-up on 09/05/01 at 0815	34.1/32.8/33.3[2]	33.4	----
1 hour after start-up	27.0/27.0/27.5	27.2	$ 0.76
2 hour after start-up	27.1/27.1/27.1	27.1	0.68
3 hour after start-up	26.9/26.9/26.9	26.9	0.68
4 hour after start-up	27.0/27.0/26.8	26.9	0.68
5 hour after start-up	26.9/26.0/27.5	26.8	0.67
6 hour after start-up	27.0/26.1/26.9	26.7	0.67
7 hour after start-up	26.9/26.0/26.2	26.4	0.67
8 hour after start-up	26.0/26.0/26.5	26.2	0.66
24 hours after start-up	24.2/24.7/24.7	24.5	10.19
48 hours after start-up	24.5/25.1/25.1	24.9	14.89
		Total:	$30.55

Notes:
1 Mixer located along south wall approximately 2 feet above bottom of tank.
2 Amp draw readings for each of the three-phase wires.
3 Electrical operating cost calculated based on the average amp draw readings and an electricity cost of $0.036 per kilowatt hour using the following formula:

kilowatts = (voltage) * (amperage) * (motor power factor) * (1.73)/1000

Mixer Test 1

Landia 24.5 HP Mixer in North Position

Biosolids in Tank (gal)	530,000
KW hour charge	$0.036
Motor Power Factor	0.86

Time	Avg Amp Draw	Avg Amp Draw over Time Period	KW	HP	HP/1000 CF	KW-hours	Cost ($)
0	26.6						
1	26.2	26.4	18.9	25.3	0.36	18.9	$0.68
2	25.9	26.1	18.6	24.9	0.35	18.6	$0.67
3	26.8	26.4	18.8	25.2	0.36	18.8	$0.68
4	26.3	26.6	19.0	25.4	0.36	19.0	$0.68
5	26.8	26.6	19.0	25.4	0.36	19.0	$0.68
6	27.4	27.1	19.4	25.9	0.37	19.4	$0.70
7	27.3	27.4	19.5	26.2	0.37	19.5	$0.70
8	27.5	27.4	19.6	26.2	0.37	19.6	$0.70
24	26.4	27.0	19.2	25.8	0.36	307.9	$11.09
48	25.7	26.1	18.6	24.9	0.35	446.5	$16.07
				Avg	0.36	Total	$32.65

Landia 24.5 HP Mixer in South Position

Biosolids in Tank (gal)	530,000
KW hour charge	$0.036
Motor Power Factor	0.86

Time	Avg Amp Draw	Avg Amp Draw over Time Period	KW	HP	HP/1000 CF	KW-hours	Cost ($)
0	25.0						
1	24.5	24.8	17.7	23.7	0.33	17.7	$0.64
2	23.9	24.2	17.3	23.2	0.33	17.3	$0.62
3	23.5	23.7	16.9	22.7	0.32	16.9	$0.61
4	23.2	23.4	16.7	22.4	0.32	16.7	$0.60
5	22.8	23.0	16.4	22.0	0.31	16.4	$0.59
6	24.1	23.5	16.7	22.4	0.32	16.7	$0.60
7	23.6	23.9	17.0	22.8	0.32	17.0	$0.61
8	23.6	23.6	16.9	22.6	0.32	16.9	$0.61
24	22.7	23.2	16.5	22.2	0.31	264.5	$9.52
48	23.0	22.9	16.3	21.9	0.31	391.6	$14.10
				Avg	0.32	Total	$28.50
			Combined Total		0.68	Comb. Total	$61.16

Mixer Test 2

EMU 30.2 HP Mixer in South Position

Biosolids in Tank (gal)	530,000
KW hour charge	$0.036
Motor Power Factor	0.84

Time	Avg Amp Draw	Avg Amp Draw over Time Period	KW	HP	HP/1000 CF	KW-hours	Cost ($)
0	33.4						
1	27.2	30.3	21.1	28.3	0.40	21.1	$0.76
2	27.1	27.2	18.9	25.4	0.36	18.9	$0.68
3	26.9	27.0	18.8	25.2	0.36	18.8	$0.68
4	26.9	26.9	18.8	25.2	0.35	18.8	$0.68
5	26.8	26.9	18.7	25.1	0.35	18.7	$0.67
6	26.7	26.8	18.7	25.0	0.35	18.7	$0.67
7	26.4	26.6	18.5	24.8	0.35	18.5	$0.67
8	26.2	26.3	18.3	24.6	0.35	18.3	$0.66
24	24.5	25.4	17.7	23.7	0.33	282.9	$10.19
48	24.9	24.7	17.2	23.1	0.33	413.5	$14.89
				Avg	0.35	Total	$30.54

Mixer Tests Conducted at The Charlotte MUD's McDowell Creek WWTP (Anoxic Zone Mixers)

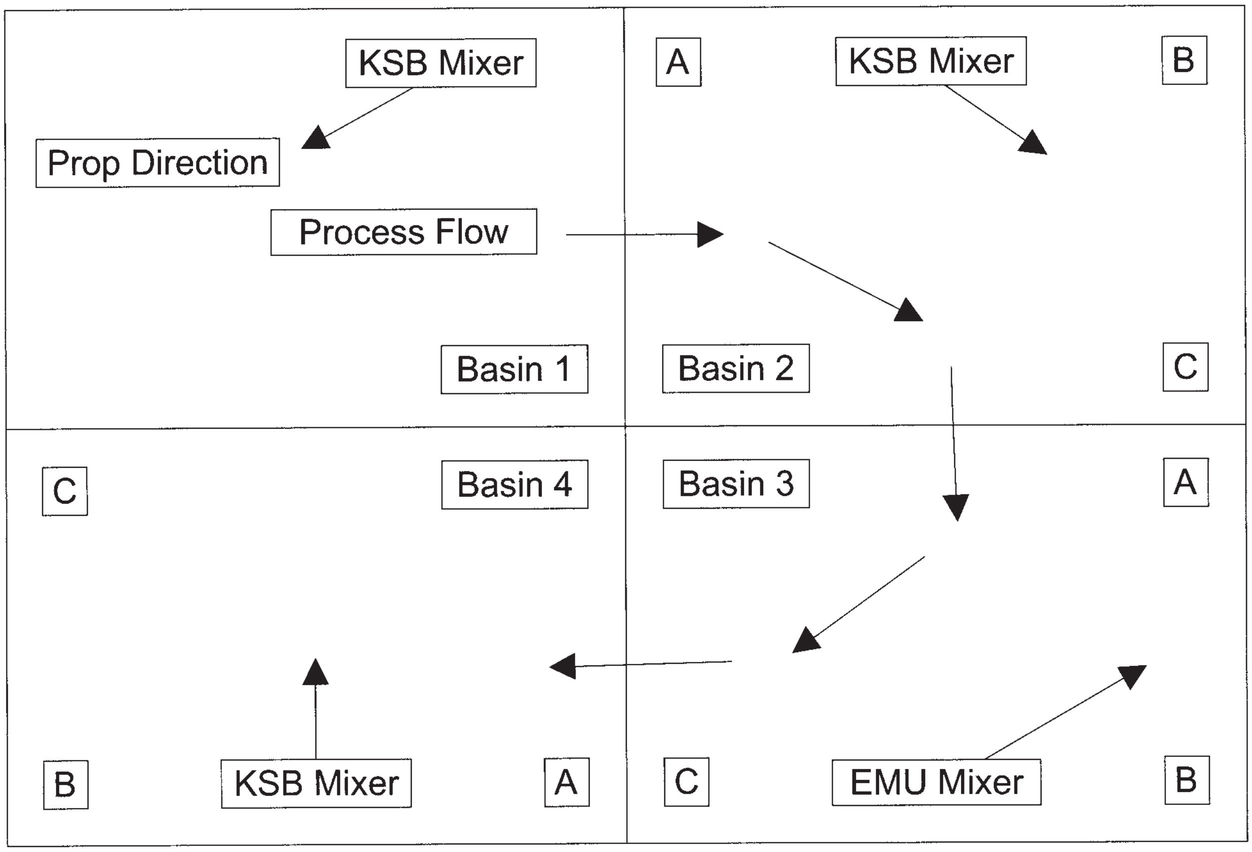
Test Results

Mixer Tests Conducted at The Charlotte MUD's McDowell Creek WWTP (Anoxic Zone Mixers)

Test Results

Actual Basin measurements of SOUR and TSS conducted as shown on July 24, 2000.

TEST ARRANGEMENT



"A", "B", & "C" denotes points where measurements were taken in each basin.

Each Letter denotes that Sampling was done at two locations High and Low in each basin near the surface and then near the bottom of the basin.

ACTUAL MEASUREMENTS

Actual Basin measurements of SOUR and TSS conducted as shown on July 24, 2000. Tests conducted at the Charlotte MUD's McDowell Creek WWTP, Anoxic Zone Mixers.

Basin 2 (with KSB Mixer)

	SOUR*			TSS*		
	Position A	Position B	Position C	Position A	Position B	Position C
High	27.7	24.68	18.62	885	990	1010
Low	39.03	47.11	35.54	695	405	775

Basin 3 (with EMU Mixer)

	SOUR*			TSS*		
	Position A	Position B	Position C	Position A	Position B	Position C
High	21.92	24.51	23.72	965	986	1100
Low	23.49	25.86	26.84	660	935	870

Basin 4 (with KSB Mixer)

	SOUR*			TSS*		
	Position A	Position B	Position C	Position A	Position B	Position C
High	24.32	34.8	31.86	1075	975	975
Low	40.29	33.24	26.53	1105	1005	930

*SOUR is Defined as "Standard Oxygen Uptake Rate" (MG/HR/GR)

*TSS is Defined as "Total Suspended Solids" (PPM)

RESULTS

Mixing effect should be measured by the CONSISTENCY of the readings at each location in each basin. The IDEAL mixing model would have all the values EQUAL at every point of measurement in the basin.

Therefore, the lower the spread of measurements from location to location in the basin can be defined as better mixing in that zone.

	Range of SOUR* Readings	Range of TSS* Readings**
Basin 2	28.49	605
Basin 3	4.92	440
Basin 4	15.97	175

CONCLUSION

Clearly Basin 3 with the lower spread of readings indicates more homogenious mixing than basins 2 or 4. The actual installed horsepower for basin 3's EMU mixer is exactly half that of basins 2 and 4's KSB mixers.

*SOUR is Defined as "Standard Oxygen Uptake Rate" (MG/HR/GR)

*TSS is Defined as "Total Suspended Solids" (PPM)

** the Sequential flow from one zone to the next means that what occurs in each zone affects all the zones down stream from this point. Therefore, starting out with a large spread of TSS readings means that there is poor mixing going on in the first basin.

Also, higher SOUR values indicates that Oxygen is being "taken" up in basins 2 and 4, while this value is very low in Basin 3. The higher the Sour value, the more oxygen is being distributed into the Anoxic/Anerobic zones which are supposed be "without oxygen".

Mixer Tests Conducted at The Michelson Water Reclamation Plant of The Irvine Ranch Water District

Test Results

Mixer Tests Conducted at The Michelson Water Reclamation Plant of The Irvine Ranch Water District

Test Results

Side-by-Side Aeration-Tank Comparisons of EMU and Flygt Submersible Mixers, Testing Power Consumption and Corresponding Suspended-Solids Compliance

Side-by-Side Aeration-Tank Comparisons of EMU and Flygt Submersible Mixers, Testing Power Consumption and Corresponding Suspended-Solids Compliance

Abstract

A 12-week, side-by-side test of EMU and Flygt mixers compared the power consumption of both mixers. Because power consumption is in direct correlation to resulting energy costs, this test effectively compared operational energy costs of the two submersible mixers. In addition, because suspended solids must be maintained throughout the reactor basins for the overall effectiveness of aeration processes, the side-by-side test also took into consideration the reliability of suspended-solids maintenance of both mixers.

The test determined that the EMU mixer consumed on average 56.02% less power than the Flygt mixer. The test also determined that the EMU mixer produced suspended-solids levels comparable to that produced by the Flygt mixer across a range of locations and depths within the control basin and the test basin, as described in the Procedures section of this report.

1. Objective

1.1. Central objective

The central objective of the side-by-side aeration-tank Power Consumption Study was to compare power consumption of the EMU and Flygt submersible mixers.

1.2. Necessity for measuring suspended-solids levels

The side-by-side test also took into consideration the effectiveness and reliability of suspended-solids maintenance of the two mixers. Such maintenance was required to be taken into account because even should one of the mixers have proven to be lower in power consumption, the findings could not have been considered significant if the mixer had not proven at least comparable in performance to the other mixer, and had not complied with suspended-solids level requirements.

2. Procedure

2.1 Duration and location of test

The side-by-side Power Consumption Study took place over a twelve-week period from 8/22/2000 to 11/16/2000, at the Michelson Water Reclamation Plant of the Irvine Ranch Water District in California, located approximately 35 miles southeast of Los Angeles.

2.2. Method of comparison

At the Michelson facility, two aeration basins were selected for the test: aeration basin #5 (designated in the test as "AT5"), which served as the control basin; and aeration basin #6 (designated in the test as "AT6"), which served as the test basin. AT5 (the control basin) was equipped with four Flygt submersible mixers throughout the 12-week duration of the test. The four Flygt mixers were placed at their normal locations in AT5. For convenience in the reporting of data, the Flygt mixers in AT5 were designated as follows: AT5 Mixer 1, AT5 Mixer 2, AT5 Mixer 3, and AT5 Mixer 4.

AT6 (the test basin) also was equipped with four mixers throughout the duration of the test, with the locations of the mixers within AT6 identical to the mixer locations in AT5. The four mixers in AT6 were designated: AT6 Mixer 1, AT6 Mixer 2, AT6 Mixer 3, and AT6 Mixer 4.

2.2.1. Description of the relocation of EMU mixer

In AT6, three of the mixers were manufactured by Flygt, with the fourth manufactured by EMU. At two-week intervals throughout the 12 weeks of the test, the EMU mixer in AT6 was systematically relocated among the four previously described mixer locations. During the first two-week period, the EMU mixer was in the AT6 Mixer 4 location; during the second two-week period it was in the AT6 Mixer 3 location; during the third and fourth two-week periods it was in the AT6 Mixer 2 location; and during the fifth two-week periods it was in the AT6 Mixer 1 location. During the final two-week period, the EMU mixer was removed from AT6, leaving the AT6 Mixer 1 location without a mixer. During the fourth two-week period, the Flygt mixer in the AT6 Mixer 1 location was removed.

The systematic relocation of the EMU mixer between the four AT6 mixer locations enabled removal of numerous potential variables in the comparisons between the performance of the Flygt mixers and the EMU mixer. These variables included: possible performance variances due to irregularity of shape of the basin in different locations, possible performance variances due to irregularity of current-flow caused by the location of mixer, possible irregularity of current-flow within the basin caused by the angle of the mixer in different locations, etc.

2.2.2. Description of the alternating depths of mixers

In addition, each day of the test the mixers were not repositioned. The suspended sediment samples were collected from bottom, mid-depth and surface of the tank using a portable sampler. These three depths in each basin were designated as, for convenience in the reporting of data: Bottom, Mid-Depth, and Surface.

The sample retrieval protocol further enabled removal of variables from the test, including: possible performance variances due to irregularity of shape of the basin at different depths, possible performance variances due to irregularity of current flow caused by depth of mixer, possible irregularity of current-flow within the basin caused by the angle of the mixer.

The performance of the EMU mixer could thus be directly compared to the performance of the Flygt mixers in two specific categories: 1. location within the basin, and 2. depth within the basin.

2.2.3. Recording of suspended-solids levels

As mentioned in the "Objective" section at the beginning of this report, suspended solids must be maintained for the overall effectiveness of the aeration process. To measure and compare the effectiveness of the Flygt and EMU mixers in this regard, the levels of suspended solids within the basins were recorded for all the variable mixer locations and depths within the test and control basins (AT5 and AT6, respectively).

It should be reiterated at this point in the discussion of procedure that the ultimate goal of the side-by-side test was to measure and compare the power consumption of the Flygt and EMU mixers in identical operational situations—and to assure that comparable compliance of performance was maintained by both mixers. The suspended-solids levels at all locations and depths within AT5 and AT6 were measured and compared solely to assure that "Identical operational situations" and "Comparable compliance of performance" were indeed achieved between the Flygt and EMU mixers.

2.2.4. Reporting of numerical data

Each day of the test, SS levels were measured for each mixer in AT5 and AT6 at three different depths: Bottom, Mid-Depth, and Surface. The SS sample data for the three depths for each mixer were then averaged. These numerical data were recorded in the "Numerical Data Results" table. As an example, SS samples for AT5 Mixer 1 were as follows for 8/22/2000:

Numerical Data Results

DATE	AT5 Mixer 1 Bottom	AT5 Mixer 1 Mid Depth	AT5 Mixer 1 Surface	Average
8/22/2000	2276	2314	2986	2519

2.2.5. Reporting of compliance data

When a particular mixer's Bottom, Mid-depth, and Surface SS samples all were verified as being within a 110% to 90% range of the average (as reported in the Numerical Data Results), 100% compliance of the particular mixer's performance was assumed. When only two of the SS samples fell within the 110%-90% range, compliance was recorded as 66%. When only one of the SS samples fell within the 110%-90% range, compliance was recorded as 33%. And when none of the SS samples fell within the range, compliance was recorded as 0%. This verification of compliance effectively measured and helped identify undue discrepancies in either the measuring process of samples or in mixer performance for a particular day at a specific depth.

Compliance data was recorded daily throughout the test as in the following "Compliance Data Results" table for AT5 Mixer 1:

Compliance Data Results

DATE	AT5 Mixer I, Depth Average	AT5 Mixer I, 110% Depth Average	AT5 Mixer 1, 90% Depth Average	AT5 Mixer I, % Compliance
8/22/2000	2519	2771	2267	100

The above table can be read as follows (reading the columns from left to right): On 8/22/2000, the average of the Bottom, Mid Depth, and Surface SS samples for AT5 Mixer 1 was 2519 (mg/l). The number '2771' is 110% of the average. The number '2267' is 90% of the average. The compliance for Mixer I was 100%, meaning that the SS samples for all three depths of AT5 Mixer 1 on that date fell within the specified 110%-90% interval.

2.2.6. Effective direct comparison of mixer performance

Using the Numerical Data Results (2.2.5.) and the Compliance Data Results (2.2.6), direct comparisons can be made between mixer performance in terms of SS in similar positions in AT5 and AT6. In particular, when the EMU mixer was in the AT6 Mixer 4 location during the first week of the test, its performance could be compared directly with the Flygt mixer's performance in the AT5 Mixer 4 location. Similarly, when the EMU mixer was in the AT6 Mixer 3, AT6 Mixer 2, and AT6 Mixer 1 locations throughout subsequent weeks of the test, its performance could be compared directly with the Flygt mixers' performances in comparable AT5 locations.

With the performance baselines established, the power consumption of the EMU and Flygt mixers could be averaged and directly compared, with the certainty that "Identical operational situations" and "Comparable compliance of performance" were indeed achieved between the Flygt and EMU mixers

3. Results

3.1. Results of power consumption comparison

Throughout the twelve-week duration of the test, the power consumption for the two types of mixers was as follows:

The Flygt mixers consumed 8.830 KW on the average.

The EMU mixer consumed 3.883 KW on the average.

Therefore, stated in terms of proportion, the EMU mixer on average throughout the test consumed 3.883/8.830, or 43.98%, of the power consumed by a Flygt mixer. Stated in terms of difference, the EMU mixer consumed on average 56.02% less power than a Flygt mixer.

3.2. Numerical Data Results

The Numerical Data Results, as described in Section 2.2.5. of this report, were as follows for the EMU mixer and the comparably located Flygt mixer during the two-week intervals of the test:

3.2.1 Comparison in Mixer 4 Positions of AT5 and AT6

Numerical Data Results
EMU Mixer in AT6 Mixer 4 Position

DATE	AT6 Mixer 4 Bottom	AT6 Mixer 4 Mid Depth	AT6 Mixer 4 Surface	Average
8/22/2000	1700	2296	2816	2271
8/23/2000	2176	2096	1756	2009
8/24/2000	2634	2134	2066	2278
8/29/2000	1444	1796	1720	1653
8/30/2000	778	1932	1732	1482
8/31/2000	1946	1980	1944	1957
Average	1780	2039	2006	

Numerical Data Results
Flygt Mixer in AT5 Mixer 4 Position

DATE	AT5 Mixer 4 Bottom	AT5 Mixer 4 Mid Depth	AT5 Mixer 4 Surface	Average
8/22/2000	1906	2052	3044	2334
8/23/2000	2014	2018	2058	2030
8/24/2000	2206	2194	1028	1809
8/29/2000	1158	1610	1632	1467
8/30/2000	1110	1456	1726	1431
8/31/2000	1738	1796	1668	1734
Average	1689	1854	1859	

3.2.2. Comparison in Mixer 3 Positions of AT5 and AT6

Numerical Data Results
EMU Mixer in AT6 Mixer 3 Position

DATE	AT6 Mixer 3 Bottom	AT6 Mixer 3 Mid Depth	AT6 Mixer 3 Surface	Average
9/6/2000	1822	1828	1816	1822
9/7/2000	1588	2030	1614	1744
9/8/2000	1370	2174	2106	1883
9/12/2000	1152	1556	1788	1499
9/13/2000	1768	1732	1776	1759
9/14/2000	1870	1908	2042	1940
Average	1595	1871	1857	

Numerical Data Results
Flygt Mixer in AT5 Mixer 3 Position

DATE	AT5 Mixer 3 Bottom	AT5 Mixer 3 Mid Depth	AT5 Mixer 3 Surface	Average
9/6/2000	2528	2528	1930	2329
9/7/2000	1898	1722	1854	1825
9/8/2000	1214	2034	1750	1666
9/12/2000	1506	1736	1848	1697
9/13/2000	1798	1680	1768	1749
9/14/2000	1984	1776	1898	1886
Average	1821	1913	1841	

3.2.3 Comparison in Mixer 2 Positions of AT5 and AT6

Numerical Data Results
EMU Mixer in AT6 Mixer 2 Position (1st two-week interval)

DATE	AT6 Mixer 2 Bottom	AT6 Mixer 2 Mid Depth	AT6 Mixer 2 Surface	Average
9/19/2000	1668	1714	1744	1709
9/20/2000	1572	1624	1548	1581
9/21/2000	1652	1714	1724	1697
9/26/2000	2104	2044	2096	2081
9/27/2000	2520	2388	2402	2437
9/28/2000	2302	2274	2366	2314
Average	1970	1960	1980	

Numerical Data Results
EMU Mixer in AT6 Mixer 2 Position (2nd two-week interval)

DATE	AT6 Mixer 2 Bottom	AT6 Mixer 2 Mid Depth	AT6 Mixer 2 Surface	Average
10/3/2000	1734	1670	1626	1677
10/4/2000	1710	1774	1820	1768
10/5/2000	1664	1656	1612	1644
10/10/2000	1850	1956	1864	1890
10/11/2000	2090	2190	2034	2105
10/12/2000	2310	2086	2148	2181
Average	1893	1889	1851	

Numerical Data Results
Flygt Mixer in AT5 Mixer 2 Position (1st two-week interval)

DATE	AT5 Mixer 2 Bottom	AT5 Mixer 2 Mid Depth	AT5 Mixer 2 Surface	Average
9/19/2000	1662	1706	1744	1704
9/20/2000	1568	1616	1630	1605
9/21/2000	1774	1598	1716	1696
9/26/2000	2134	2058	2036	2076
9/27/2000	2450	2404	2414	2423
9/28/2000	2376	2322	2342	2347
Average	1994	1951	1980	

Numerical Data Results
Flygt Mixer in AT5 Mixer 2 Position (2nd two-week interval)

DATE	AT5 Mixer 2 Bottom	AT5 Mixer 2 Mid Depth	AT5 Mixer 2 Surface	Average
10/3/2000	1790	1874	1740	1801
10/4/2000	1828	1846	1832	1835
10/5/2000	1706	1686	1668	1687
10/10/2000	1916	1932	1954	1934
10/11/2000	2088	2128	2088	2101
10/12/2000	2164	2194	2158	2172
Average	1915	1943	1907	

3.2.4. Comparison in Mixer 1 Positions of AT5 and AT6

Numerical Data Results
EMU Mixer in AT6 Mixer 1 Position

DATE	AT6 Mixer 1 Bottom	AT6 Mixer 1 Mid Depth	AT6 Mixer 1 Surface	Average
10/17/2000	2284	2040	2042	2122
10/18/2000	1970	2012	1990	1991
10/19/2000	1806	1998	2016	1940
10/24/2000	3170	2364	2218	2584
10/25/2000	2084	2120	2060	2076
10/26/2000	2082	2058	2008	2049
Average	2227	2099	2056	

Note: the EMU mixer was removed from the tank during the sixth two-week interval of the test (10/31/2000-11/16/2000).

Numerical Data Results
Flygt Mixer in AT5 Mixer 1 Position

DATE	AT5 Mixer 1 Bottom	AT5 Mixer 1 Mid Depth	AT5 Mixer 1 Surface	Average
10/17/2000	2150	2082	2088	2107
10/18/2000	1974	2034	2012	2007
10/19/2000	2002	2020	2014	2012
10/24/2000	2302	2278	2314	2298
10/25/2000	2444	2154	2098	2232
10/26/2000	2370	2064	2028	2154
Average	2207	2105	2028	

3.3. Compliance Data Results

The Compliance Data Results, as described in Section 2.2.6. of this report, were as follows for the EMU mixer and the comparably located Flygt mixer during the two-week intervals of the test:

3.3.1. Comparison in Mixer 4 Positions of AT5 and AT6

Compliance Data Results
EMU Mixer in AT6 Mixer 4 Position

DATE	AT6 Mixer 4, Depth Average	AT6 Mixer 4, Mid Depth Average	AT6 Mixer 4, Surface Average	AT6 Mixer 4, % Compliance
8/22/2000	2271	2498	2044	33
8/23/2000	2009	2210	1808	66
8/24/2000	2278	2506	2050	66
8/29/2000	1653	1819	1488	66
8/30/2000	1481	1629	1333	33
8/31/2000	1957	2152	1761	100

Compliance Data Results
Flygt Mixer in AT5 Mixer 4 Position

DATE	AT5 Mixer 4, Depth Average	AT5 Mixer 4, Mid Depth Average	AT5 Mixer 4, Surface Average	AT5 Mixer 4, % Compliance
8/22/2000	2334	2567	2101	66
8/23/2000	2030	2233	1837	100
8/24/2000	1809	1990	1628	0
8/29/2000	1467	1613	1320	33
8/30/2000	1431	1574	1288	33
8/31/2000	1734	1907	1561	100

3.3.2. Comparison in Mixer 3 Positions of AT5 and AT6

Compliance Data Results
EMU Mixer in AT6 Mixer 3 Position

DATE	AT6 Mixer 3, Depth Average	AT6 Mixer 3, Mid Depth Average	AT6 Mixer 3, Surface Average	AT6 Mixer 3, % Compliance
9/6/2000	1822	2004	1640	100
9/7/2000	1744	1918	1570	66
9/8/2000	1883	2072	1695	33
9/12/2000	1499	1649	1349	33
9/13/2000	1759	1935	1583	100
9/14/2000	1940	2134	1746	100

Compliance Data Results
Flygt Mixer in AT5 Mixer 3 Position

DATE	AT5 Mixer 3, Depth Average	AT5 Mixer 3, Mid Depth Average	AT5 Mixer 3, Surface Average	AT5 Mixer 3, % Compliance
9/6/2000	2329	2562	2096	100
9/7/2000	1825	2007	1642	100
9/8/2000	1666	1833	1499	33
9/12/2000	1697	1866	1527	66
9/13/2000	1749	1924	1574	100
9/14/2000	1886	2075	1697	100

3.3.3. Comparison in Mixer 2 Positions of AT5 and AT6

Compliance Data Results
EMU Mixer in AT6 Mixer 2 Position

DATE	AT6 Mixer 2, Depth Average	AT6 Mixer 2, Mid Depth Average	AT6 Mixer 2, Surface Average	AT6 Mixer 2, % Compliance
9/19/2000	1709	1880	1538	100
9/20/2000	1581	1739	1423	100
9/21/2000	1697	1866	1527	100
9/26/2000	2081	2289	1873	100
9/27/2000	2437	2680	2193	100
9/28/2000	2314	2545	2083	100
10/3/2000	1677	1844	1509	100
10/4/2000	1768	1945	1591	100
10/5/2000	1644	1808	1480	100
10/10/2000	2046	2251	1841	100
10/11/2000	2105	2315	1894	100
10/12/2000	2181	2399	1963	100

Compliance Data Results
Flygt Mixer in AT5 Mixer 2 Position

DATE	AT5 Mixer 2, Depth Average	AT5 Mixer 2, Mid Depth Average	AT5 Mixer 2, Surface Average	AT5 Mixer 2, % Compliance
9/19/2000	1704	1874	1534	66
9/20/2000	1605	1765	1444	66
9/21/2000	1696	1866	1526	100
9/26/2000	2076	2284	1868	100
9/27/2000	2423	2665	2180	100
9/28/2000	2347	2581	2112	100
10/3/2000	1801	1981	1621	100
10/4/2000	1835	2019	1652	100
10/5/2000	1687	1855	1518	100
10/10/2000	2150	2365	1935	100
10/11/2000	2101	2311	1891	100
10/12/2000	2172	2389	1955	100

3.3.4. Comparison in Mixer 1 Positions of AT5 and AT6

Compliance Data Results
EMU Mixer in AT6 Mixer 1 Position

DATE	AT6 Mixer 1, Depth Average	AT6 Mixer 1, Mid Depth Average	AT6 Mixer 1, Surface Average	AT6 Mixer 1, % Compliance
10/17/2000	2122	2334	1910	100
10/18/2000	1991	2190	1792	100
10/19/2000	1940	2134	1746	100
10/24/2000	2584	2842	2326	66
10/25/2000	2076	2284	1868	100
10/26/2000	2049	2254	1884	100

Note: the EMU mixer was removed from the tank during the sixth two-week interval of the test (10/31/2000-11/16/2000).

Compliance Data Results
Flygt Mixer in AT5 Mixer 1 Position

DATE	AT5 Mixer 1, Depth Average	AT5 Mixer 1, Mid Depth Average	AT5 Mixer 1, Surface Average	AT5 Mixer 1, % Compliance
10/17/2000	2107	2317	1896	100
10/18/2000	2007	2207	1806	100
10/19/2000	2012	2213	1811	100
10/24/2000	2298	2528	2068	100
10/25/2000	2232	2455	2009	66
10/26/2000	2154	2369	1939	66

4. Conclusion

4.1. General results

The EMU mixer consumed less power than the Flygt mixers, with comparable performance in the maintenance of suspended-solids levels throughout a range of basin locations and depths, as recorded and compared in Section 3 of this report. Moreover, with the exception of the first two weeks of testing, both mixers showed consistently solid compliance at all locations and depths.

4.2. Numerical results

The Flygt mixers consumed 8.830 KW on the average throughout the test. The EMU mixer consumed 3.883 KW on the average throughout the test. Therefore, the EMU mixer on average consumed 3.883/8.830, or 43.98%, of the power consumed by the Flygt mixer. This means that the EMU mixer consumed on average 56.02% less power than the Flygt mixers.

4.3. Discussion

The EMU mixer utilized in the test operated at 5.6 horsepower., while the Flygt mixers operated at 9-10 horsepower. However, comparable performance was achieved. **This is the notable finding of this study**. The horsepower difference is due to the divergent engineering approaches used by the two manufacturers. That is to say the Flygt mixer design uses a direct-drive approach, whereas the EMU mixer design uses a planetary gearing approach.

This finding suggests that where a reduction in power consumption is desired, the EMU mixer is the more appropriate mixer.