

Table 1. Summary of literature based values for aerator efficiency ratings.

Source	Aerator Type	Efficiency (lbs/kWh) <sup>1</sup>	Efficiency (%)
Boon and Chambers 1986	Diffused air: fine bubble (< 5 mm)	3.3 – 7.9	-
Boon and Chambers 1986	Diffused air: course bubble (> 5 mm)	2.0 – 2.6	-
Boon and Chambers 1986	Mechanical surface aerators	2.6 – 5.3	-
Boyd 1990	Shallow pond air diffusers	0.7 – 1.2 (0.9)	
Lindenschmidt and Hamblin 1997	Hypolimnetic aeration – air diffusers	1.2 <sup>2</sup>	16%
Kortmann, et al. 1994	Hypolimnetic aeration – air diffusers	3.2 / 4.8 <sup>3</sup>	-
Mobley and Brock 1995	Reservoir aeration – pure oxygen	Unknown <sup>4</sup>	90% <sup>5</sup>
Beutel and Horne 1999	Hypolimnetic aeration – air diffusers	-	12% -50%
Beutel and Horne 1999	Hypolimnetic aeration - pure oxygen	-	60% - 80%
Prepas et al. 1997	Hypolimnetic aeration - pure oxygen	Unknown <sup>4</sup>	90%
Weiss et al. 1994	Hollow fiber membranes	Unknown	90%-100%
Speece 1996	U-tube – pure oxygenation	-	75% - 90%

Notes:

- Data not available to calculate efficiency, or not applicable.

<sup>1</sup> Values given as range (mean) unless otherwise noted. Single values are reported mean values unless otherwise noted.

<sup>2</sup> Calculated based on reported airflow rate, oxygen transfer rate, and diffuser depth from standard compressor power consumption equation.

<sup>3</sup> Reported as calculated average efficiencies of tests on hypolimnetic aeration / layer aeration.

<sup>4</sup> Information not available. However, expansion of liquid oxygen generates pressure and gas flow to the diffusers resulting in minimal power consumption.

<sup>5</sup> Efficiency reported in Beutel and Horne 1999.

Aeration Performance Survey at RR Bridge

Oct. 3, 2001

Aerator On

Water Temperature (Deg. F)

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.	72.3	73.0	73.2	73.2	73.2	73.2	72.7	72.7	72.7	73.6	73.9	74.3	72.1
1.0m	72.3	72.7	72.0	72.3	72.3	73.0		72.1	72.1	72.7	72.6	72.0	71.8
2.0m	72.1	72.1	71.8	71.8	72.1	72.1		72.0	72.3	72.1	72.1	71.8	71.8
3.0m	72.0	71.8	71.6	71.8	72.0	72.1		72.1	72.1	71.8	72.0	71.6	71.6
4.0m		71.8	71.6	71.6	71.8	72.0		72.1					
5.0m			71.6	71.6	71.8	72.0							
6.0m				71.6	71.8	72.0							
7.0m					71.8	71.8							
8.0m													
9.0m													

Dissolved Oxygen (mg/L)

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.	7.07	6.78	7.56	7.54	7.50	6.93		7.25	6.97	7.72	8.37	9.06	5.87
1.0m	6.80	7.22	6.40	6.29	7.33	6.26		6.38	6.68	7.17	6.75	6.43	5.90
2.0m	6.71	6.68	5.99	6.31	6.78	6.32		6.39	6.70	6.90	6.52	5.93	5.65
3.0m	6.54	5.98	5.57	5.67	6.66	6.11		6.42	6.46	6.44	6.05	5.78	5.53
4.0m		5.71	5.53	5.71	6.50	6.07		6.35					
5.0m			5.47	5.62	6.46	6.00							
6.0m				5.64	6.31	6.00							
7.0m					6.24	5.93							
8.0m													
9.0m													

pH

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.	7.60	7.58	7.71	7.70	7.70	7.65		7.76	7.66	7.74	7.90	7.99	7.53
1.0m	7.52	7.62	7.55	7.54	7.60	7.56		7.54	7.63	7.63	7.61	7.57	7.49
2.0m	7.50	7.56	7.50	7.51	7.54	7.55		7.54	7.58	7.57	7.58	7.57	7.47
3.0m	7.48	7.50	7.46	7.47	7.53	7.53		7.54	7.56	7.53	7.53	7.50	7.48
4.0m		7.50	7.45	7.47	7.51	7.53		7.54					
5.0m			7.45	7.46	7.52	7.53							
6.0m				7.47	7.50	7.53							
7.0m					7.50	7.52							
8.0m													
9.0m													

Turbidity (NTU)

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.	32.3	25.6	24.9	25.1	27.1	27.1		27.5	26.2	24.8	23.4	24.2	33.3
1.0m	32.2	24.5	30.3	30.9	27.3	28.6		29.6	28.2	26.8	27.9	31.1	33.2
2.0m	31.6	27.3	35.8	31.7	29.6	29.3		30.0	27.6	29.2	29.5	35.5	38.9
3.0m	35.9	33.9	44.0	40.7	30.5	30.4		29.9	29.2	31.7	34.4	39.5	11.8
4.0m		35.9	43.1	40.5	31.8	31.5		31.2					
5.0m			47.9	42.0	31.6	32.2							
6.0m				39.3	33.4	33.3							
7.0m					33.0	33.6							
8.0m													
9.0m													

Electrical Conductance (µS/cm)

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.		649	659	657	659	665		662	663	662	664	667	673
1.0m	645	671	667	661	663	667		665	665	662	669	671	674
2.0m	655	669	669	671	666	665		668	664	669	668	671	676
3.0m	656	665	677	673	666	666		668	666	671	671	674	676
4.0m	665	671	676	675	671	668		668					
5.0m			678	676	670	669							
6.0m				674	672	670							
7.0m					672	672							
8.0m													
9.0m													

Velocity (ft/sec)

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.	0.8	0.8	0.8	0.7	0.6	0.4		0.3	0.3	0.4	0.5	0.7	0.8
1.0m	0.7	0.8	0.8	0.6	0.6	0.2		0.3	0.3	0.4	0.4	0.5	0.5
2.0m	0.8	0.8	0.6	0.6	0.6	0.3		0.3	0.3	0.3	0.3	0.5	0.4
3.0m	0.8	0.7	0.6	0.5	0.6	0.3		0.3	0.3	0.3	0.3	0.5	0.2
4.0m		0.6	0.4	0.5	0.6	0.3		0.3					
5.0m		0.0	0.4	0.4	0.6	0.2							
6.0m				0.3	no data	no data							
7.0m					no data	no data							
8.0m													
9.0m													

Aeration Performance Survey at RR Bridge

Oct. 3, 2001

Aerator Off

Water Temperature (Deg. F)

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.	72.1		73.4		73.4				73.2		73.6		73.2
1.0m	71.8		71.6		73.6				73.2		72.0		72.0
2.0m	71.6		71.6		72.3				73.0		71.6		71.8
3.0m	71.4		71.4		72.3						71.6		71.6
4.0m	71.4		71.4		72.1								
5.0m					71.6								
6.0m					71.6								
7.0m													
8.0m													
9.0m													

Dissolved Oxygen (mg/L)

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.	8.3		7.7		8.2				7.8		8.2		8.3
1.0m	5.8		5.9		7.3				7.8		5.5		6.2
2.0m	5.4		5.8		6.9				7.5		5.5		5.5
3.0m	5.3		5.2		6.7						5.3		5.3
4.0m	5.2		5.1		6.2								
5.0m					5.6								
6.0m					5.6								
7.0m													
8.0m													
9.0m													

pH

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.	7.8		7.8		7.8				7.8		7.9		7.9
1.0m	7.5		7.5		7.7				7.8		7.5		7.6
2.0m	7.5		7.5		7.6				7.9		7.5		7.5
3.0m	7.4		7.4		7.6						7.5		7.5
4.0m	7.4		7.4		7.6								
5.0m					7.5								
6.0m					7.5								
7.0m													
8.0m													
9.0m													

Turbidity (NTU)

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.	24.2		23.9		22.6				24.1		23.7		24.4
1.0m	33.5		29.1		24.2				24.1		31.6		33.3
2.0m	38.8		30.8		25.7				26.0		31.9		35.7
3.0m	41.3		39.2		26.8						35.4		36.4
4.0m	44.2		39.8		29.0								
5.0m					30.5								
6.0m					31.3								
7.0m													
8.0m													
9.0m													

Electrical Conductance (µS/cm)

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.	670		673		673				673		677		676
1.0m	671		673		668				673		677		673
2.0m	676		679		671				676		675		676
3.0m	680		683		670						680		678
4.0m	685		684		671								
5.0m					679								
6.0m					681								
7.0m													
8.0m													
9.0m													

Velocity (ft/sec)

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.	0.8		0.8		0.6				0.4		0.7		0.7
1.0m	0.7		0.8		0.7				0.4		0.5		0.5
2.0m	0.7		0.8		0.7				0.4		0.6		0.4
3.0m	0.8		0.8		0.7						0.5		0.3
4.0m	0.6		0.6		0.7								
5.0m					0.8								
6.0m					0.7								
7.0m													
8.0m													
9.0m													

Aeration Performance Survey at RR Bridge  
 Oct. 3, 2001  
 Comparison (Aerator ON - Aerator OFF)

Water Temperature (Deg. F)

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.	0.2		-0.2		-0.2				-0.52		0.3		-1.1
1.0m	0.5		0.4		-1.3				-1.1		0.6		-0.2
2.0m	0.5		0.2		-0.2				-0.7		0.5		0
3.0m	0.6		0.2		-0.3						0.4		0
4.0m			0.2		-0.3								
5.0m					0.2								
6.0m					0.2								
7.0m													
8.0m													
9.0m													

Dissolved Oxygen (mg/L)

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.	-1.23		-0.14		-0.7				-0.83		0.17		-2.43
1.0m	1		0.5		0.03				-1.12		1.25		-0.3
2.0m	1.31		0.19		-0.12				-0.8		1.02		0.15
3.0m	1.24		0.37		-0.04						0.75		0.23
4.0m			0.43		0.3								
5.0m					0.86								
6.0m					0.71								
7.0m													
8.0m													
9.0m													

pH

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.	-0.2		-0.09		-0.1				-0.14		0		-0.37
1.0m	0.02		0.05		-0.1						0.11		-0.11
2.0m	0		0		-0.06				-0.32		0.08		-0.03
3.0m	0.08		0.06		-0.07						0.03		-0.02
4.0m			0.05		-0.09								
5.0m					0.02								
6.0m					0								
7.0m													
8.0m													
9.0m													

Turbidity (NTU)

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.	8.1		1		4.5				2.1		-0.3		8.9
1.0m	-1.3		1.2		3.1				4.1		-3.7		-0.1
2.0m	-7.2		5		3.9				1.6		-2.4		3.2
3.0m	-5.4		4.8		3.7						-1		-24.6
4.0m			3.3		2.8								
5.0m					1.1								
6.0m					2.1								
7.0m													
8.0m													
9.0m													

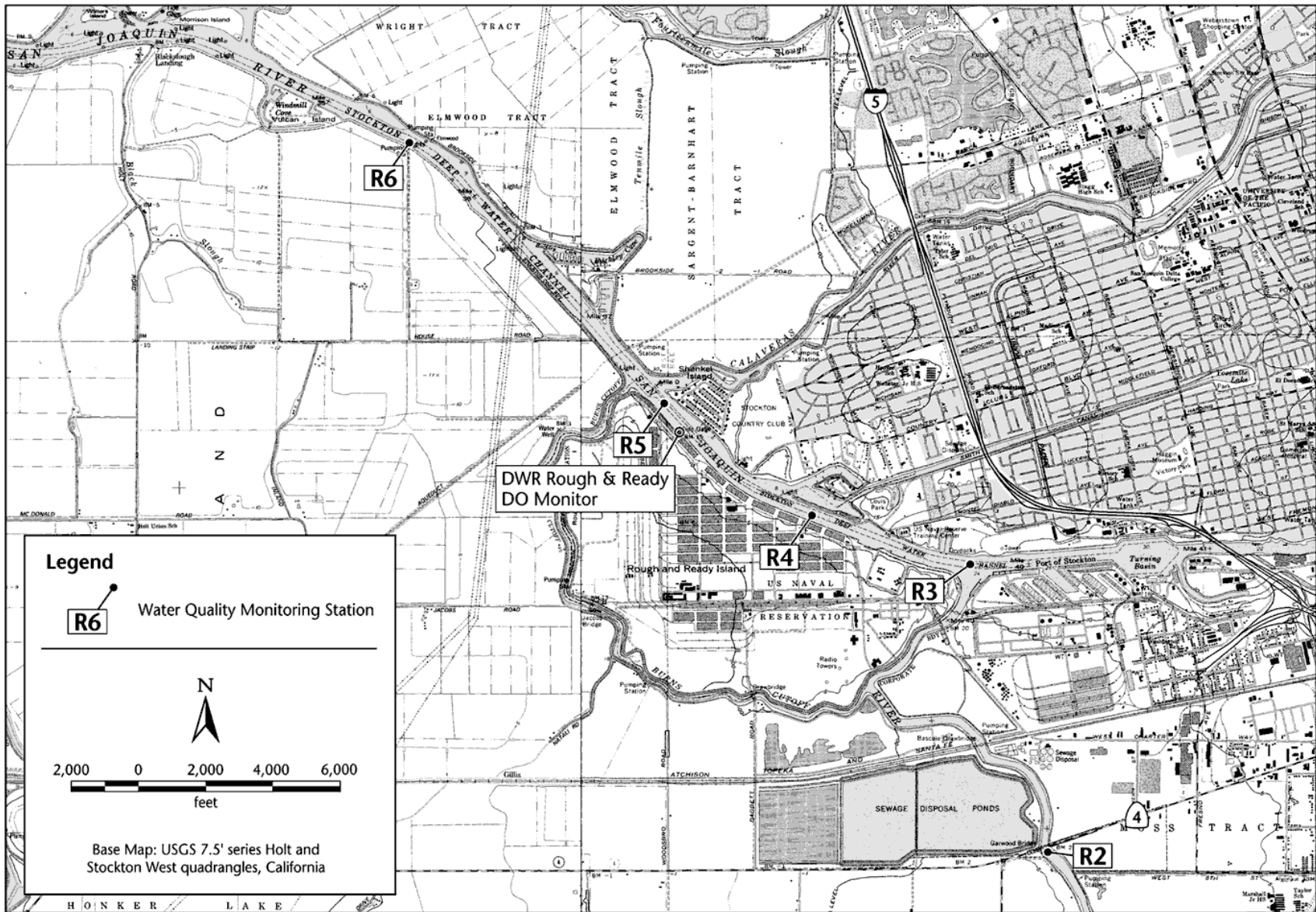
Electrical Conductance (µS/cm)

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.			-14		-15				-10		-13		-3
1.0m	-26		-6		-5				-8		-8		1
2.0m	-21		-10		-5				-12		-7		0
3.0m	-25		-6		-4						-9		-2
4.0m	-20		-8		0								
5.0m					-9								
6.0m					-9								
7.0m													
8.0m													
9.0m													

Velocity (ft/sec)

	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m
Surf.	0		0		0				-0.1		-0.2		0.1
1.0m	0		0		-0.1				-0.1		-0.1		0
2.0m	0.1		-0.2		-0.1				-0.1		-0.3		0
3.0m	0		-0.2		-0.1						-0.2		-0.1
4.0m			-0.2		-0.1								
5.0m					-0.2								
6.0m													
7.0m													
8.0m													
9.0m													

Table 2. Measured DO Mass flux reduction from Aerator on to aerator off was 740 lbs/day.



**Figure 1**  
**Stockton Deep Water Ship Channel Water Quality Stations**

Figure 2. DO Minimum and Maximum Measured at Rough & Ready DO Monitor During 2001

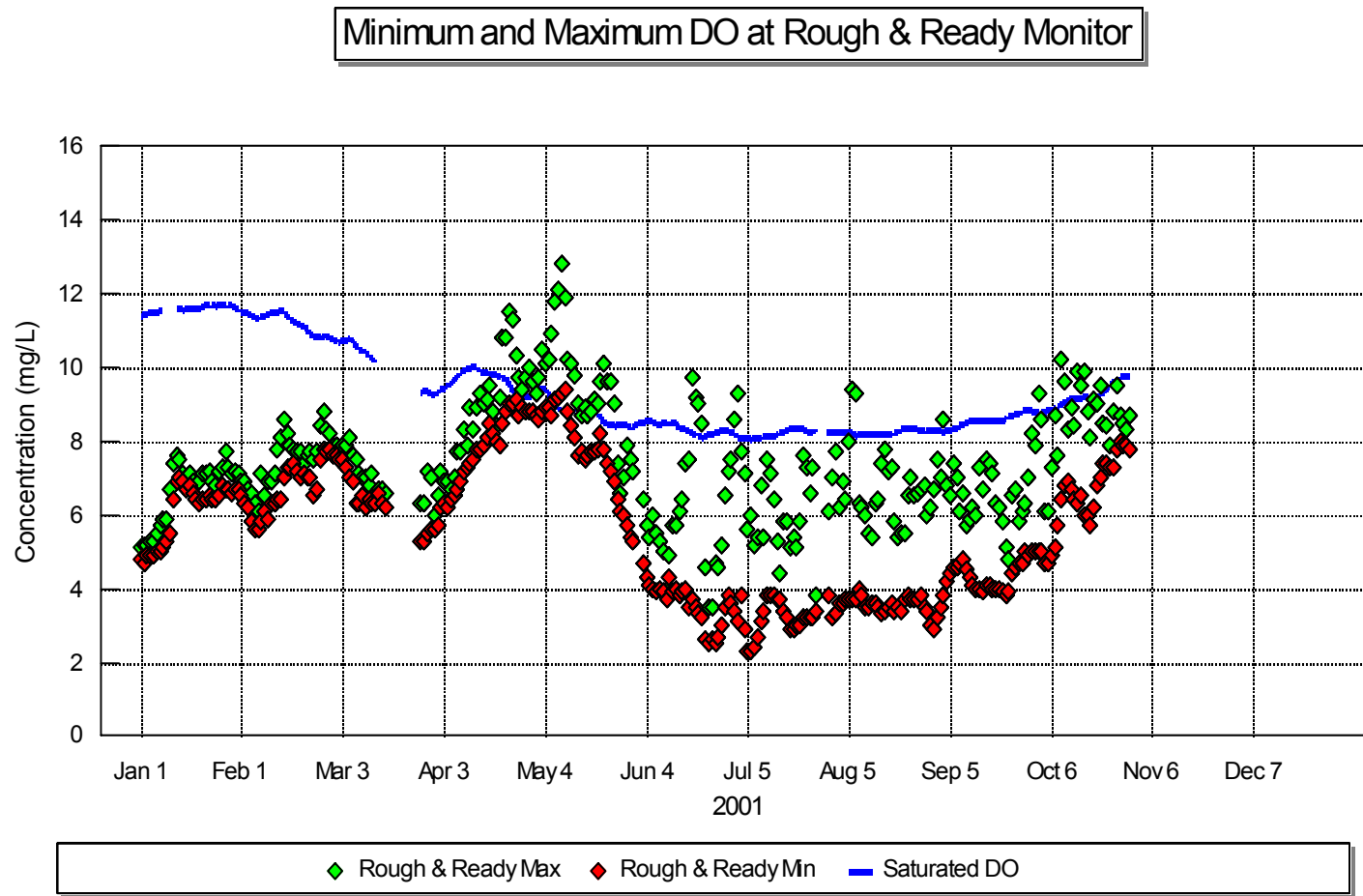


Figure 3. Simulated Effects of Waterfall Aeration on DO Concentrations in the DWSC

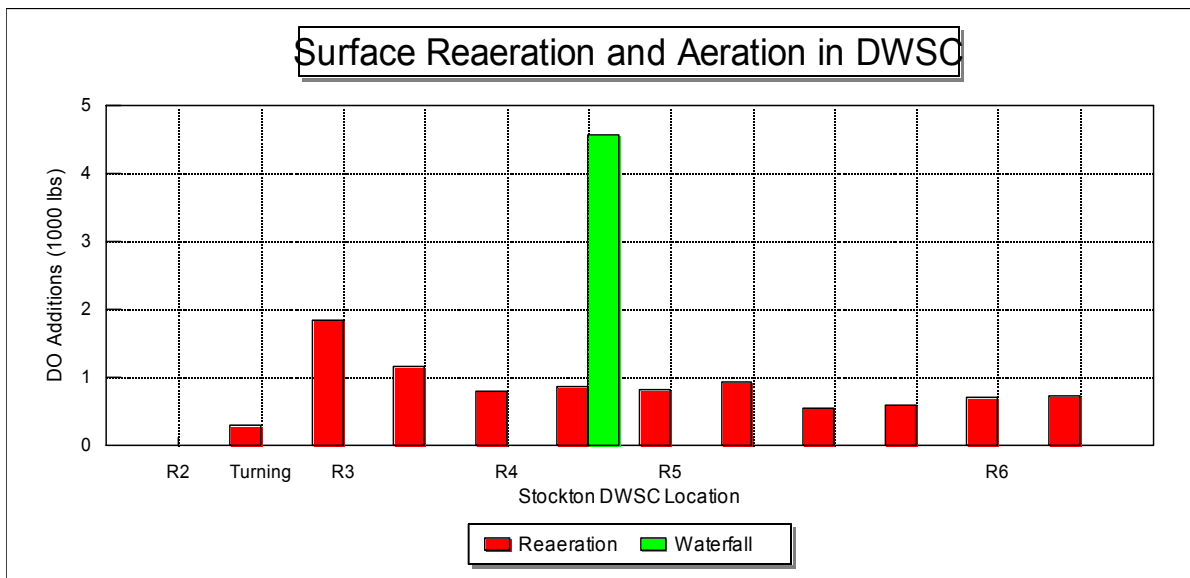
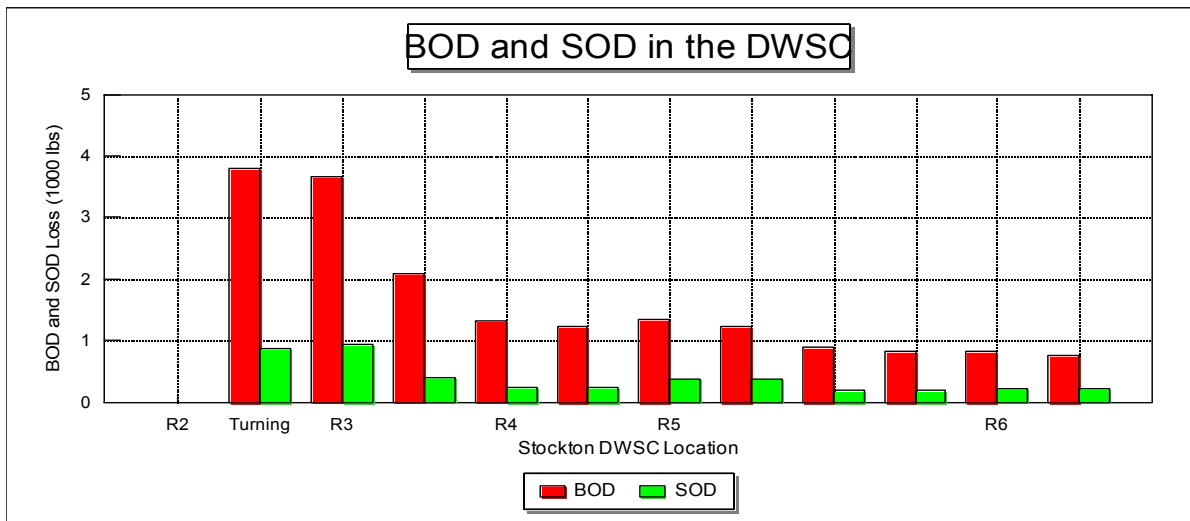
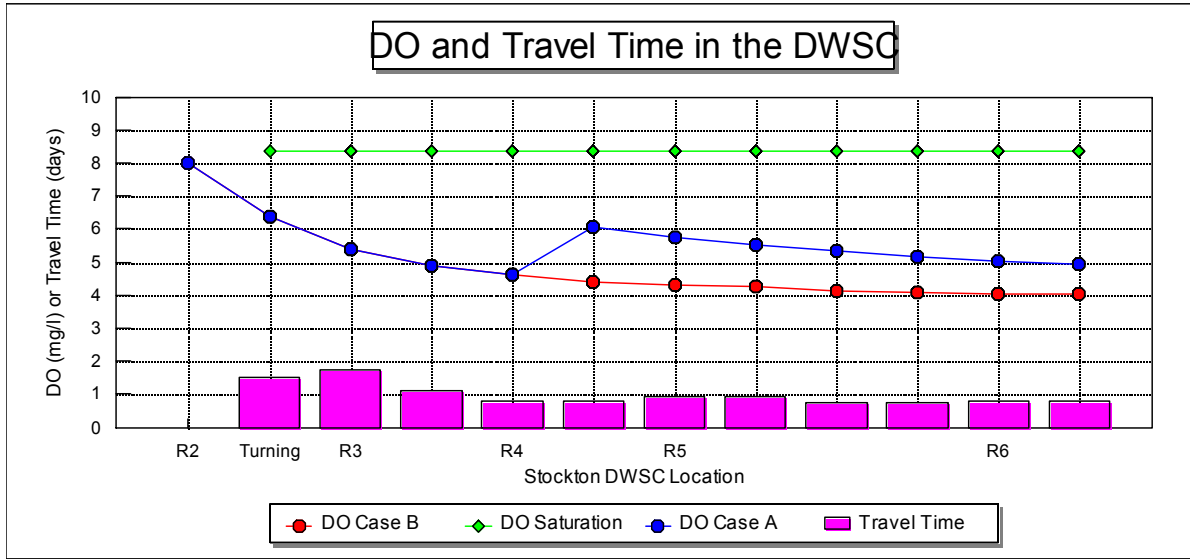


Figure 4. Layout of Near-Field Upwelling flow-Away Current Measurements for North and South Bubble-Jets of Corps of Engineers Stockton Aerator

