Turbo Blowers improve energy efficiency at an oxidation ditch wastewater treatment plant

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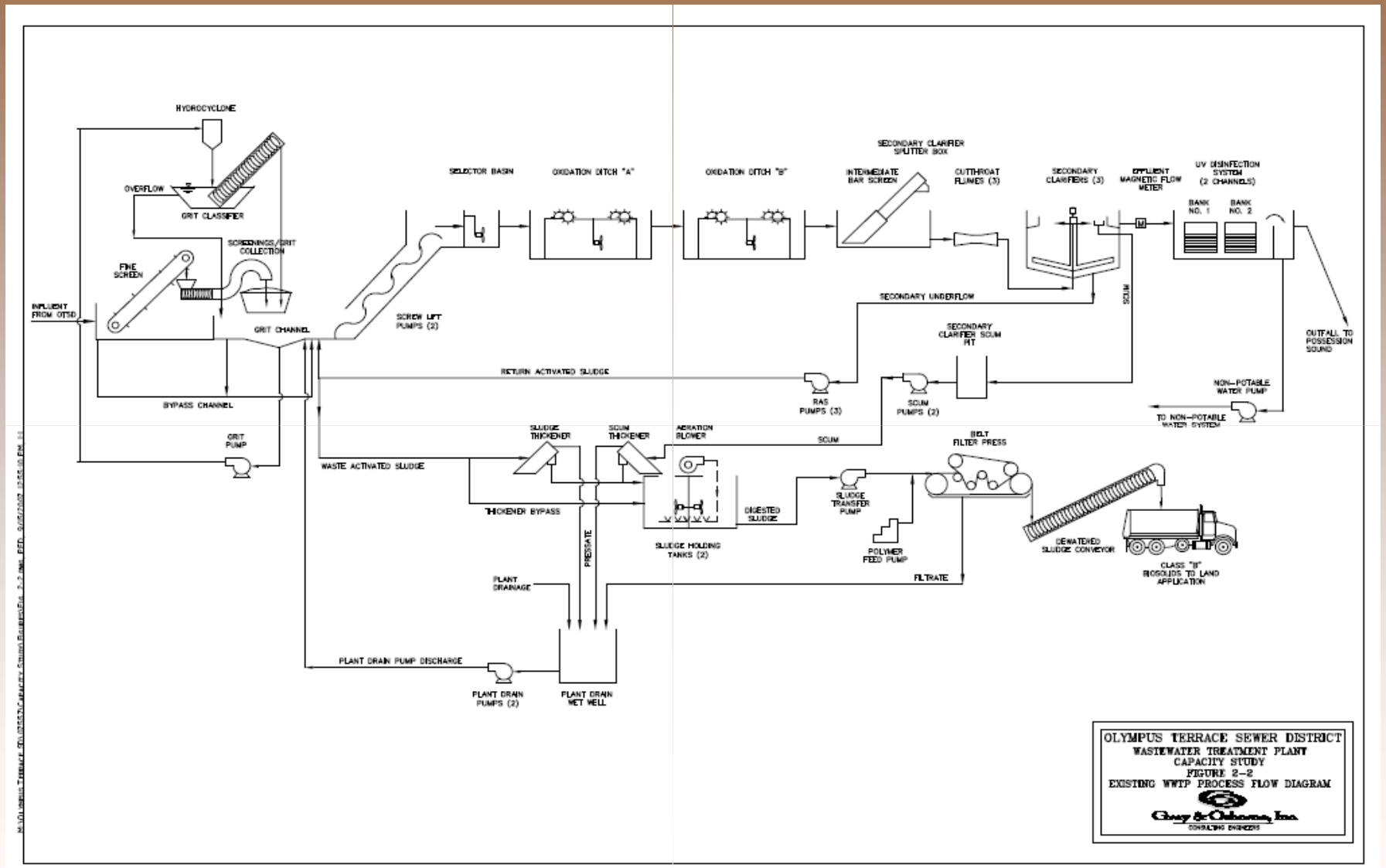
Introduction

- Mukilteo Water & Wastewater District's Big Gulch Wastewater Treatment Facility
- Oxidation ditch activated sludge plant with brush rotor aeration
- Capacity expansion study: turbo blowers with diffused aeration gave significant energy efficiency improvement

Big Gulch Wastewater Treatment Facility

- Originally built in 1970; Upgrades in ‘84, ’89
- Oxidation-ditch secondary treatment

Hydraulic Profile of the Big Gulch WWTF



Don’ t Always Focus On Your Rear-end

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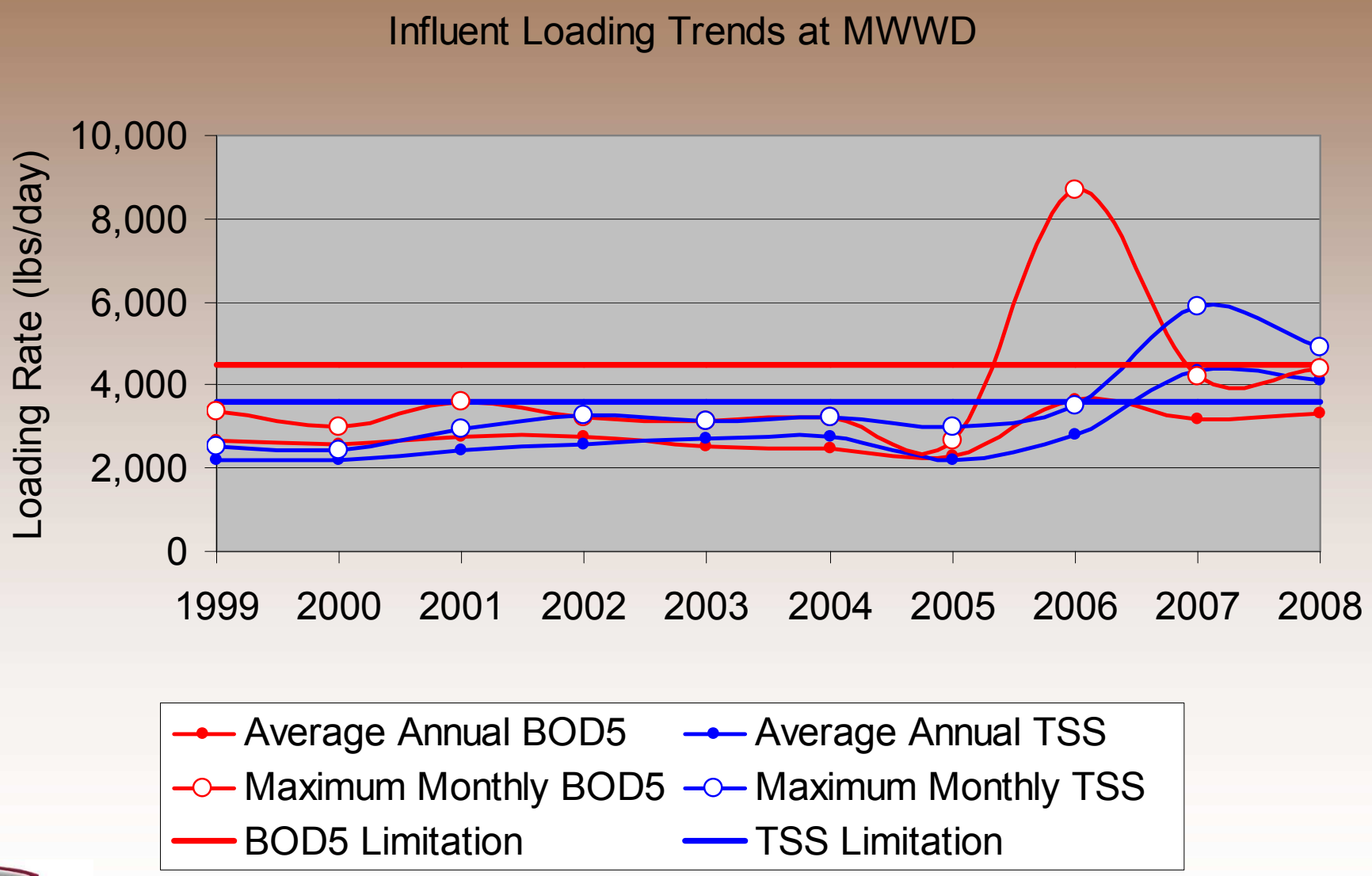
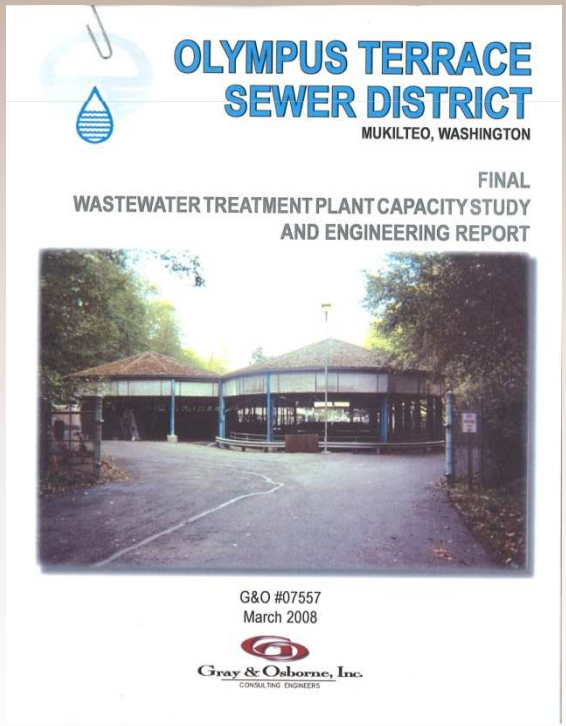


Capacity Study and Engineering Report

- Intermittent soluble BOD loading spikes in 2006
- New sampler revealed TSS loadings much higher than previously measured
- Long-term trend of increasing loading rates



Capacity Study and Engineering Report

Report Recommendations:

- Loading source investigations in collection sys.
- Grit removal improvements
- **Activated sludge aeration capacity expansion**
- Aerobic digester aeration capacity expansion

Activated Sludge Aeration Alternatives

1. Additional brush rotor

2. Converting one oxidation ditch to diffused aeration with positive displacement blowers

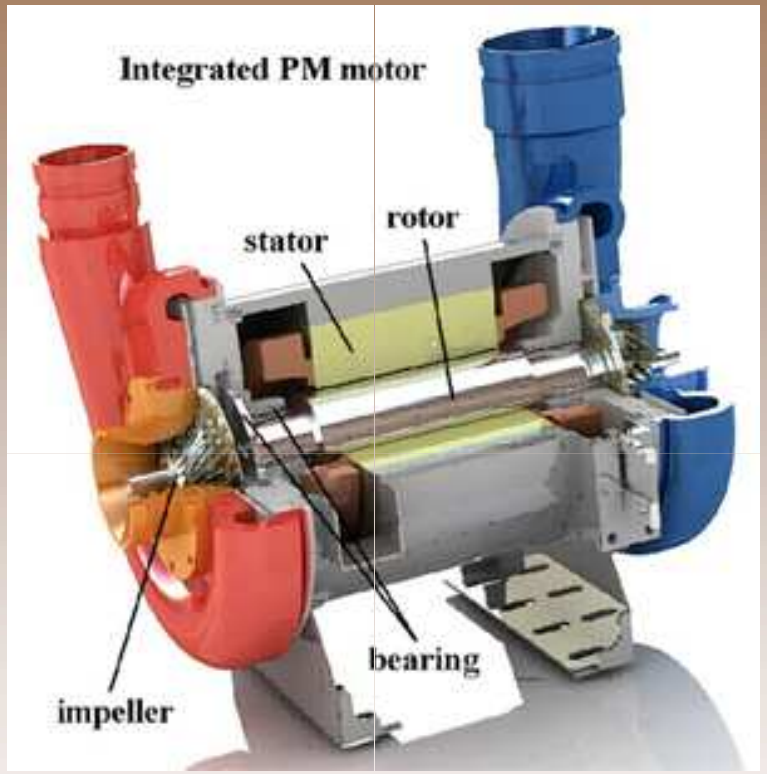
3. Converting one oxidation ditch to diffused aeration with turbo blowers

Fundamentals of Turbo Blowers

- Introduced to U.S. market in past two years
- Single-stage centrifugal blower
- Integrated high-frequency VFD

K-Turbo blower at Mukilteo WWD

Fundamentals of Turbo Blowers



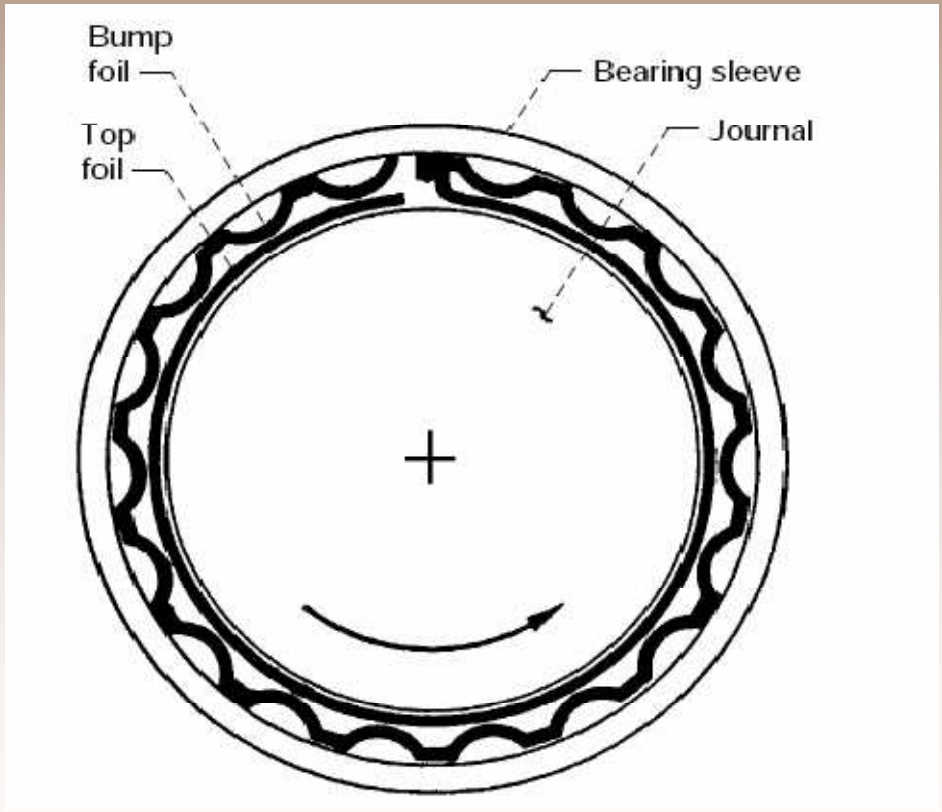
Impeller directly mounted on motor shaft

High-speed permanent magnet motor (up to 60,000 rpm)

Image per K-Turbo Inc.

Fundamentals of Turbo Blowers

Contact-less airfoil journal bearing



- 10 times larger diameter than oil bearing
- 10 times length than oil bearing
- Light load only
- Bump structure and Flexible top foil gives maximum supporting force
- Dry lubricant coating protect bearing surface during On/Off (20,000 time with Teflon)

Image per K-Turbo Inc.

Fundamentals of Turbo Blowers

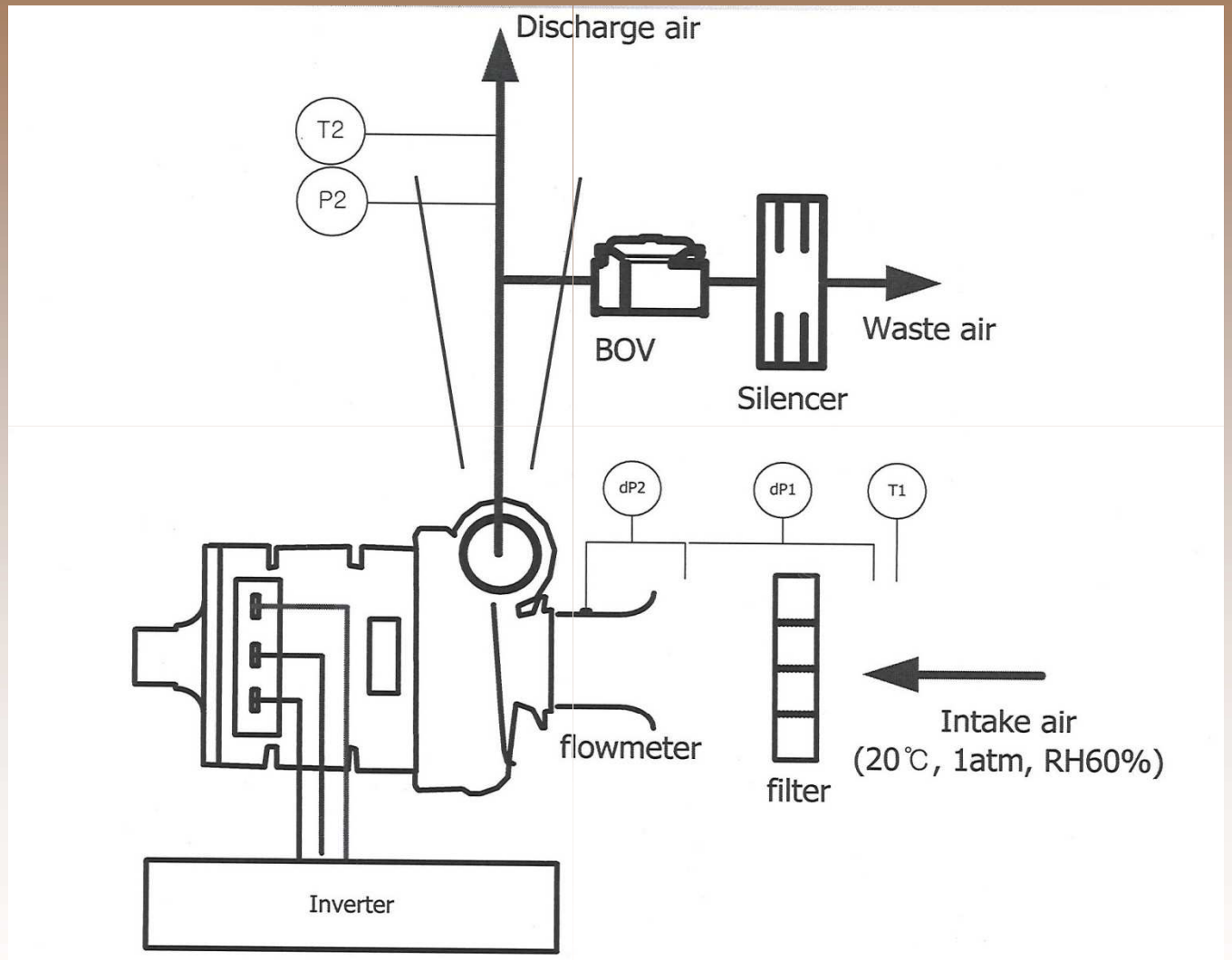


Image per K-Turbo Inc.

Fundamentals of Turbo Blowers

- Reduced owner maintenance: no maintenance required for seals, lubrication, etc.
- Low power at motor start
- Can run unloaded at 1% of rated power

Comparison of Aeration Alternatives

Oxidation Ditch "A" peak energy consumption

Parameter	Aeration Method		
	Brush Rotors	Diffused Aeration with PD Blower	Diffused Aeration with Turbo Blower
Actual Oxygen Demand (lb/day)	4,527	4,527	4,527
Standard Oxygen Demand (lb/day)	6,658	7,611	7,611
Diffuser Air Flow Rate (scfm)	N/A	1,300	1,300
Max. Motor Power (hp)	115	60	50
Max. Motor Power (kW)	86	45	37
Power Savings at Max. Load vs. Brush Rotor (%)		48%	57%
Power Savings at Max. Load vs. PD Blower (%)			17%

Comparison of Aeration Alternatives

Oxidation Ditch "A" annual avg. energy consumption

Parameter	Aeration Method		
	Brush Rotors	Diffused Aeration with PD Blower	Diffused Aeration with Turbo Blower
Actual Oxygen Demand (lb/day)	2,440	2,440	2,440
Diffuser Air Flow Rate (scfm)	N/A	665	665
Average motor power req'd (hp)	58	28	21
Avg. Annual Power Consumption (kWH)	380,000	183,000	137,000
Annual Power Savings (kWh)		197,000	243,000
Annual Power Cost Savings ($)		$13,800	$17,000
Annual Power Savings vs. brush rotor (%)		52%	64%
Annual Power Savings vs. PD blower (%)			25%

Comparison of Aeration Alternatives

Oxidation Ditch "A" annual O&M costs

	Item	Quantity		Unit Price	Amount
A. Brush Rotor Alternative					
	Power	380,000	kWH	$0.07	$26,600
	Repair and Maintenance	1	LS	$2,300	$2,300
	Total				$28,900
B. Diffused Air with PD Blower Alternative					
	Power	183,000	kWH	$0.07	$12,800
	Repair and Maintenance	1	LS	$2,100	$2,100
	Total				$14,900
C. Diffused Air with Turbo Blower Alternative					
	Power	137,000	kWH	$0.07	$9,600
	Repair and Maintenance	1	LS	$1,800	$1,800
	Total				$11,400

Comparison of Aeration Alternatives

Oxidation Ditch "A" lifecycle cost comparison

Alternative	Total Construction Cost	Annual O&M Cost Estimate	20-year Net Present Value
Brush Rotor Alternative	$261,000	$28,900	$808,000
Diffused Air with PD Blower Alternative	$279,000	$14,900	$507,000
Diffused Air with Turbo Blower Alternative	$321,000	$11,400	$490,000

Comparison of Aeration Alternatives

- Selected alternative: Diffused air with turbo blower
- Despite higher capital cost, energy efficiency resulted in a payback period of 4 years
- Lowest 20 year lifecycle costs (3% lower than PD blower)
- 65% energy savings compared to brush rotors
- 25% energy savings compared to PD blower

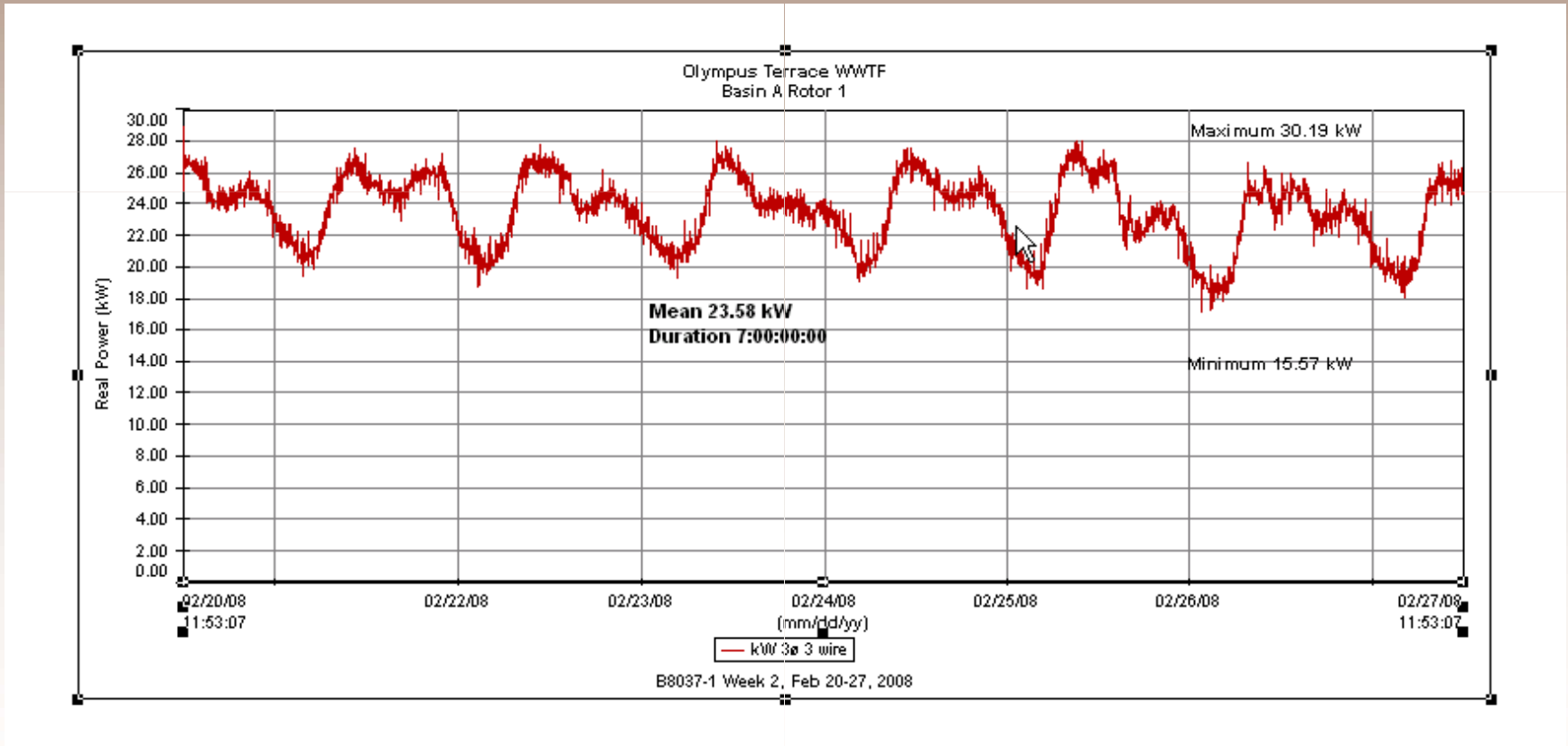
Electric utility rebate

- Snohomish County PUD No. 1 monitored electricity consumption before and after Ditch "A" project construction
- Rebate for construction costs equal of $0.17/kWH of annual electricity savings

- District to receive PUD Incentive Rebate of $39,171

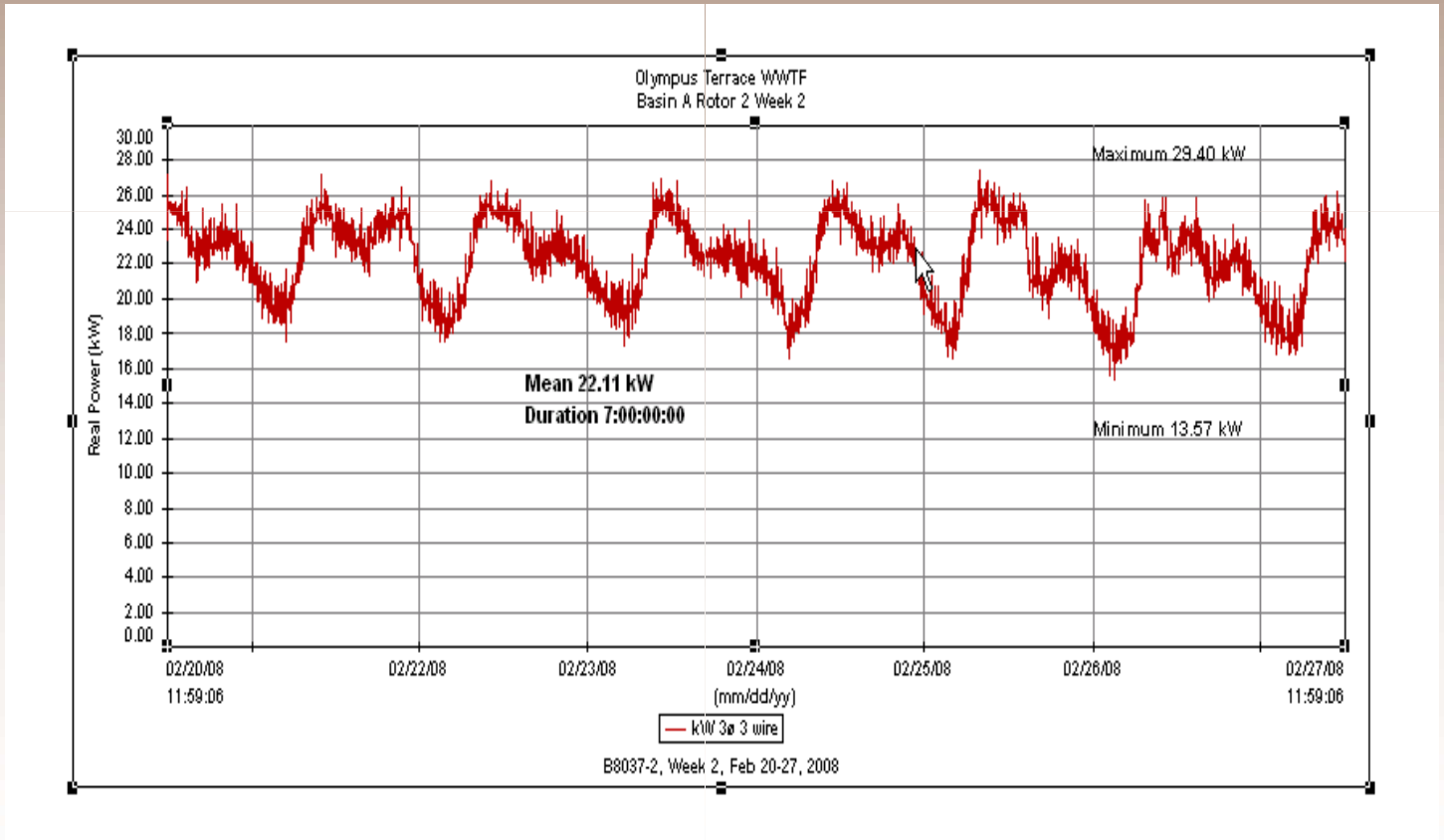
Electric utility rebate

Pre-Metering Results: Ditch "A" Week 2 Rotor 1



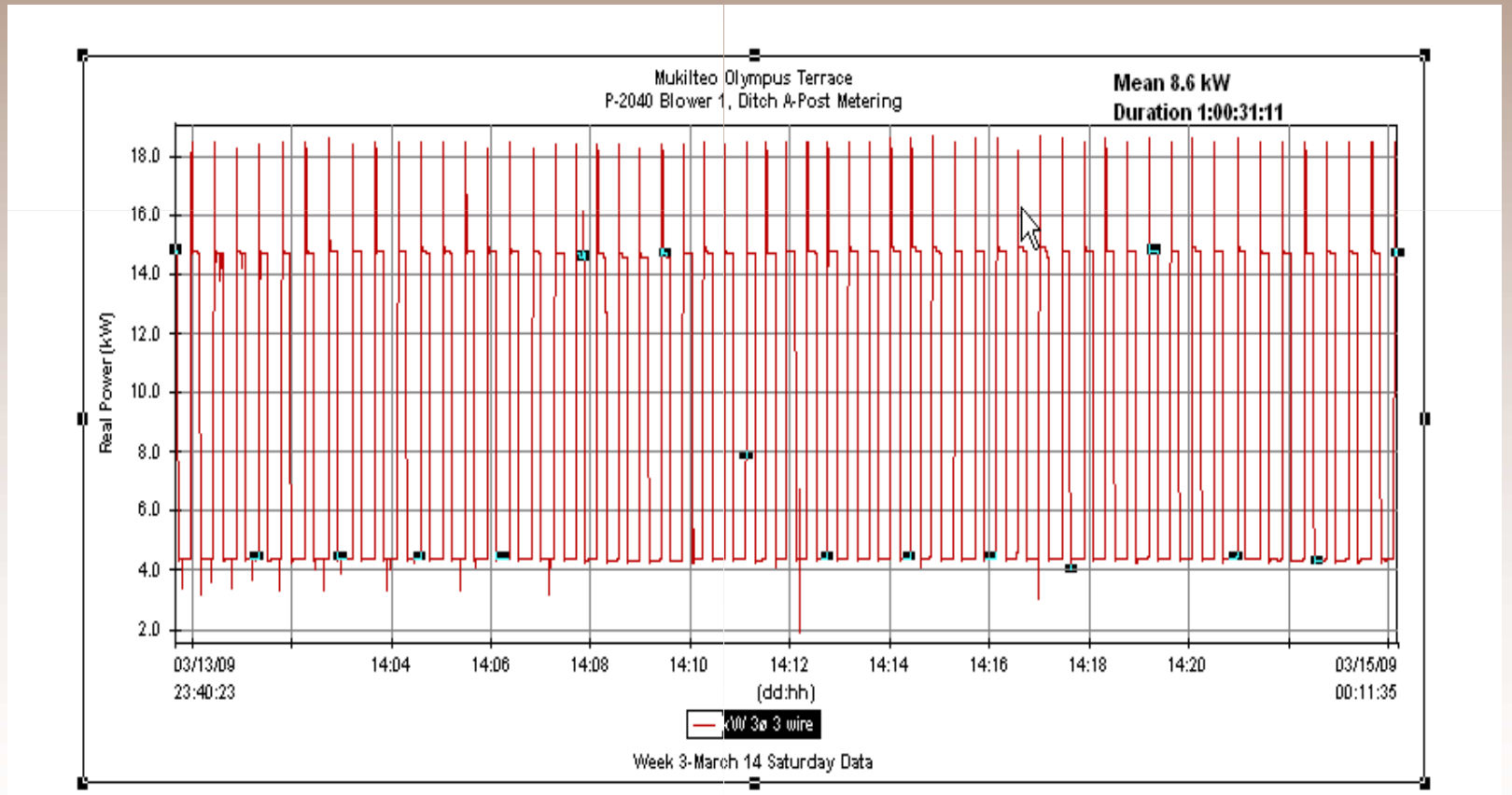
Electric utility rebate

Pre-Metering Results: Ditch "A" Week 2 Rotor 2



Electric utility rebate

Post-Metering Results: Ditch "A" Blower



Installation of Blower & Diffusers

- Dewatering of Existing Tankage
- Removal /Disposal of Accumulated Grit and Debris
- Demolition/Removal of Old Equipment
- Locating Plumbing and Electrical
- Installation of New Equipment
- Testing of New Equipment

Installation of Blower & Diffusers

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Installation of Blower & Diffusers

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Installation of Blower & Diffusers

- Demolition/Removal of Old Equipment

Installation of Blower & Diffusers

- Locating Plumbing

Installation of Blower & Diffusers

- Locate Electrical

Where is that empty conduit?

Installation of Blower & Diffusers

- Installation

- And Protection of New Equipment

Installation of Blower & Diffusers

- Testing of New Equipment

Operational Considerations Brush Aerators vs. Turbo Blower With Fine Bubble Diffusers

- Ease of Repair
- Hydraulic Limitation
- DO Transfer Efficiency
- Need for Submersible Mixer
- Lubrication Required
- Aerosol Production
- Noise

Operational Considerations
Brush Aerators

Pro

- Simple "In-House" Repair
- Submersible Mixer Not Needed

Con

- Limits Hydraulic Level
- Damages Floc Structure
- Lubrication Required
- Exposes Operators to Aerosols
- Energy inefficient
- Difficult to Control D.O.

Operational Considerations Turbo Blower With Fine Bubble Diffusers

Pro

- Unlimited Hydraulic Level
- No Damage to Floc Structure
- No Lubrication Required
- Minimal Maintenance
- Minimal Aerosols
- Energy Efficient
- Good D.O. Control
- Low Noise

Con

- Needs Submersible Mixer
- Blower Repairs Proprietary
- Diffuser Inspection/Repair Requires Dewatering of Basin

Conversion of Ditch "B"

- District is converting Oxidation Ditch "B" to diffused air with turbo blowers
- Operational advantages; consistency
- 35% reduction in annual energy consumption for the oxidation ditch system

Conversion of Ditch "B"

- Removal of four 30-hp brush rotors (120 hp total)
- Installation of two additional 50-hp turbo blowers (one duty, one standby)
- Installation of two new 6-hp submersible mixers

- Equipment has been pre-purchased
- Construction is underway with startup in October

Conversion of Ditch "B"

Conclusion

Blowers and diffused air may be advantageous for oxidation ditch operation:

- Significant energy savings
- Operational flexibility

Turbo blowers offer further energy savings in comparison with positive displacement blowers (25% in the case of Mukilteo)