Pump Performance and Energy Efficiency Improvement Through Pump Refurbishment and Internal Coatings of Horizontal Split Case (HSC) Pumps

Presented By: Paul Maier
Co Authors: Richard Metzger & Chris King

Monroe County Water Authority (MCWA)
Rochester, New York

Effects on Flow and Headloss of Internal Tuberculation on Water Supply Cast Iron Pipelines well Known, Documented and Calculable

- **Hazen Williams Formula (C-Factor)**
- **Darcy-Weisback**
- **Manning's Formula**
- **Velocity Profile**
- **Head Loss Gradient**
- **Hydraulic Slope**
- **Pressure Loss**
- **Pitot Tubes**
- **Etc, Etc, Etc.**

Effects of Tuberculation Inside Pumps? Not so well Documented - 400 HP, 12x16 HSC Pump Installed 1962

- Does the inside Tuberculation impact Pump Flow, Head, Efficiency and/or Energy Consumption and by how much?

- Can any Loss of Pump performance be restored and/or Energy Consumption reduced by cleaning and coating the interior of the pump casing?

Why is this Important?

Pumping systems account for nearly 20% of the world's electrical energy demand[1]. Any technology which produces even moderate gains in pump performance and pumping efficiency can lead to substantial savings in terms of worldwide energy use, costs and the associated greenhouse gas emissions.

[1] US Dept of Energy Office of Industrial Technology, "Pump Life Cycle Costs: A Guide to LCC Analysis for Pumping Systems:, Dec.2000

400 HP Pump After Sandblasting, Metal Filler and Ceramic Topcoat Application

MCWA Performed Pilot Study looking at the effects of Coating Interior Pump Casings.

- Rebuilt (wear rings, sleeves, bearings) and Cleaned & Coated two Horizontal Split Case Pumps.
- 100 HP 8”x 8” HSC Pump
- 75 HP 5” x 8” HSC Pump
- Both Cases pump efficiency had dropped by more than 15% from manufacturer’s specifications.
- Estimated increase of pump efficiency through cleaning and coating approximately 10%

Based on the results of the pilot study, the MCWA applied for and received grant funding from the New York State Energy and Research Development Authority (NYSERDA)

- 18 pumps to be rebuilt, cleaned and coated.
- Performance enhancement from pump rebuild and coating evaluated independently.
- Pumps selection criteria (all HSC)
  - HP and size, 20 HP to 1750 HP
  - Specific Speed, 1050 – 3850 ($Ns=RPM(Q^{1/2})/H^{3/4}$)
    - A European study indicated that potential performance enhancement through coating was related to a pump’s specific speed.

Steps in the Pump Coating Process

- Performance Testing
- Disassembly
- Sandblasting
  - Aggressive White Metal Blast SP-5 White Metal
- Metal Filler if Required
  - Trowlable Epoxy Ceramic material with a high filler content
- Top Coating (2 coats)
  - NSF Approved Brushable Ceramic Epoxy Top Coating
  - Quite frankly not as easy to apply as you might think, coatings are very viscous and it is similar to painting with “honey”.
- Reassembly
- Performance Testing

Pump Performance Testing

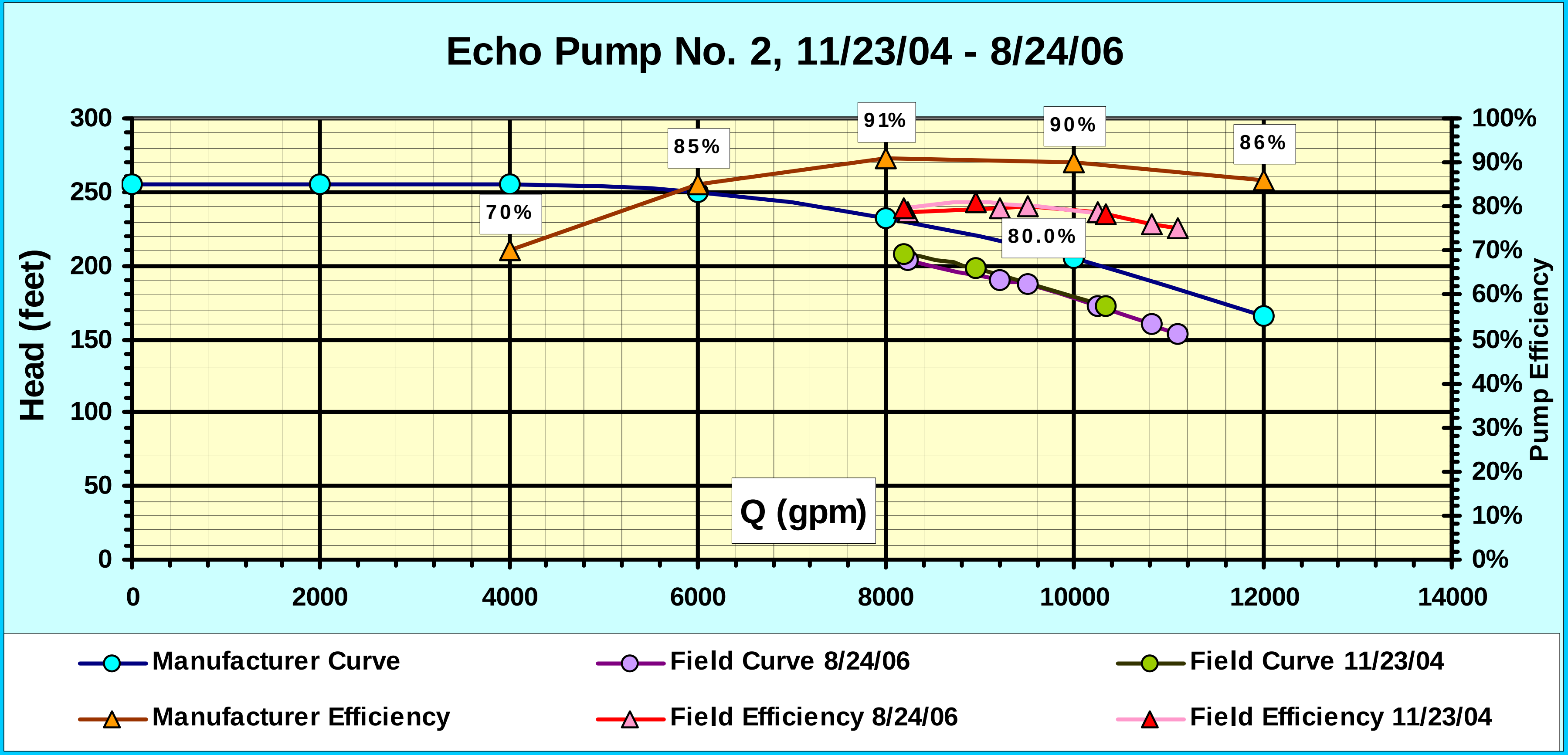
Equipment Accuracy

- Power Monitor Accuracy (kW) ±(0.15% Reading + 0.025% Full Scale
- Pressure Recorder Accuracy (psi) ±0.25% Full Scale
- Mag Meter Accuracy (gpm) 0.5% over entire flow range
- Venturi Meter Accuracy (gpm) 0.5% - 2.0%
- Stroboscope Accuracy (rpm) 0.05%

Procedure For Testing

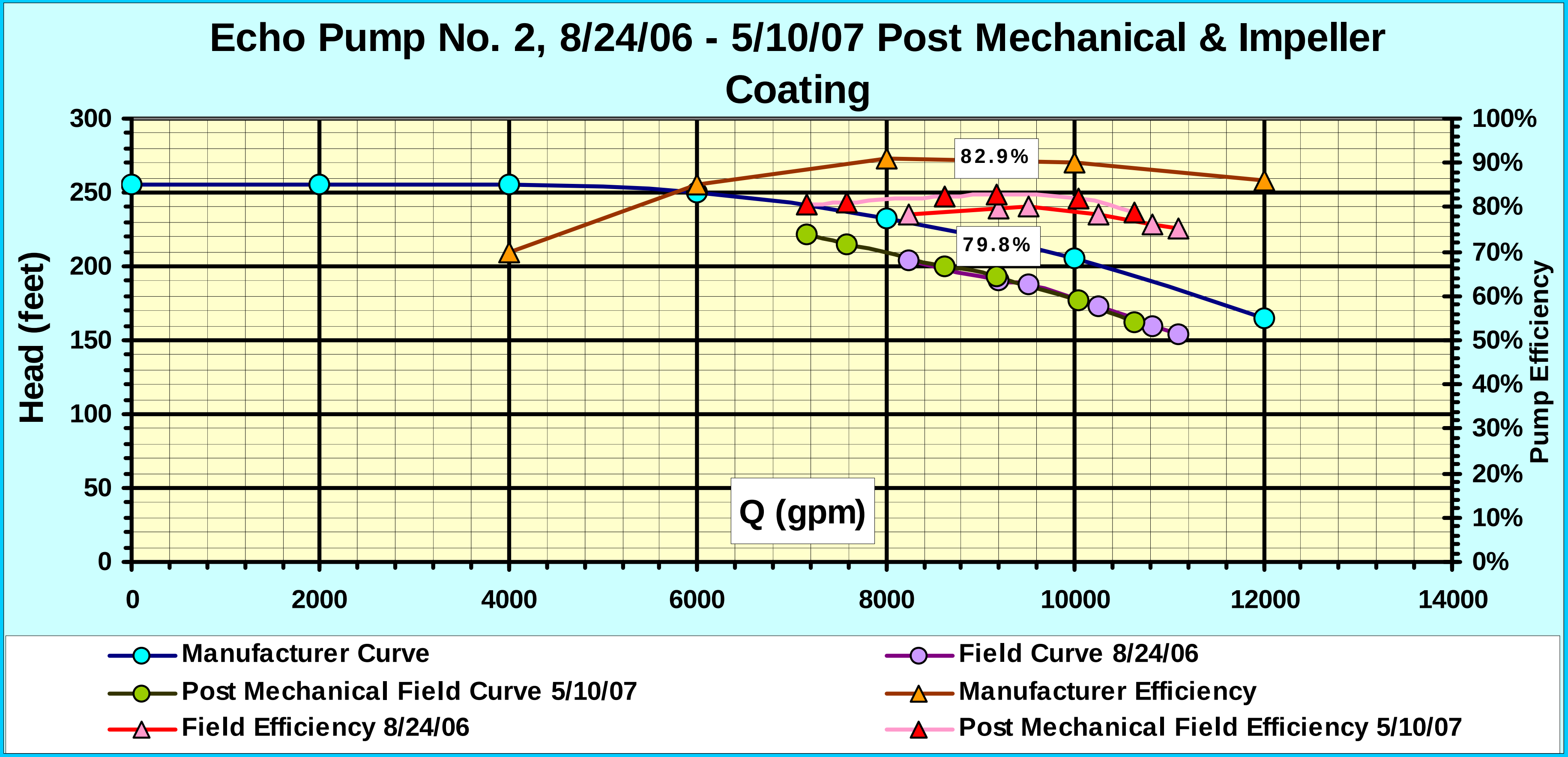
1. Record flow, Suction psi, discharge psi, kW, and speed (rpm) for 5 Points on the Pump Curve.
2. Each point achieved by either opening by-pass valve/hydrant (points to the right of normal operation) or throttling the discharge valve (points to the left of normal operation).

600 HP, 18x16 Bottom Suction HSC Pump, Installed 1990, Pre Rebuild/Pre Coating Performance Analysis
(25' Loss of Head, 10% loss of Efficiency)



Pre Work Internal Inspection

Pump Performance Post Mechanical Refurbishment
(Slight Increase in Head, Efficiency Increased 3.2%)



Post Sandblasting

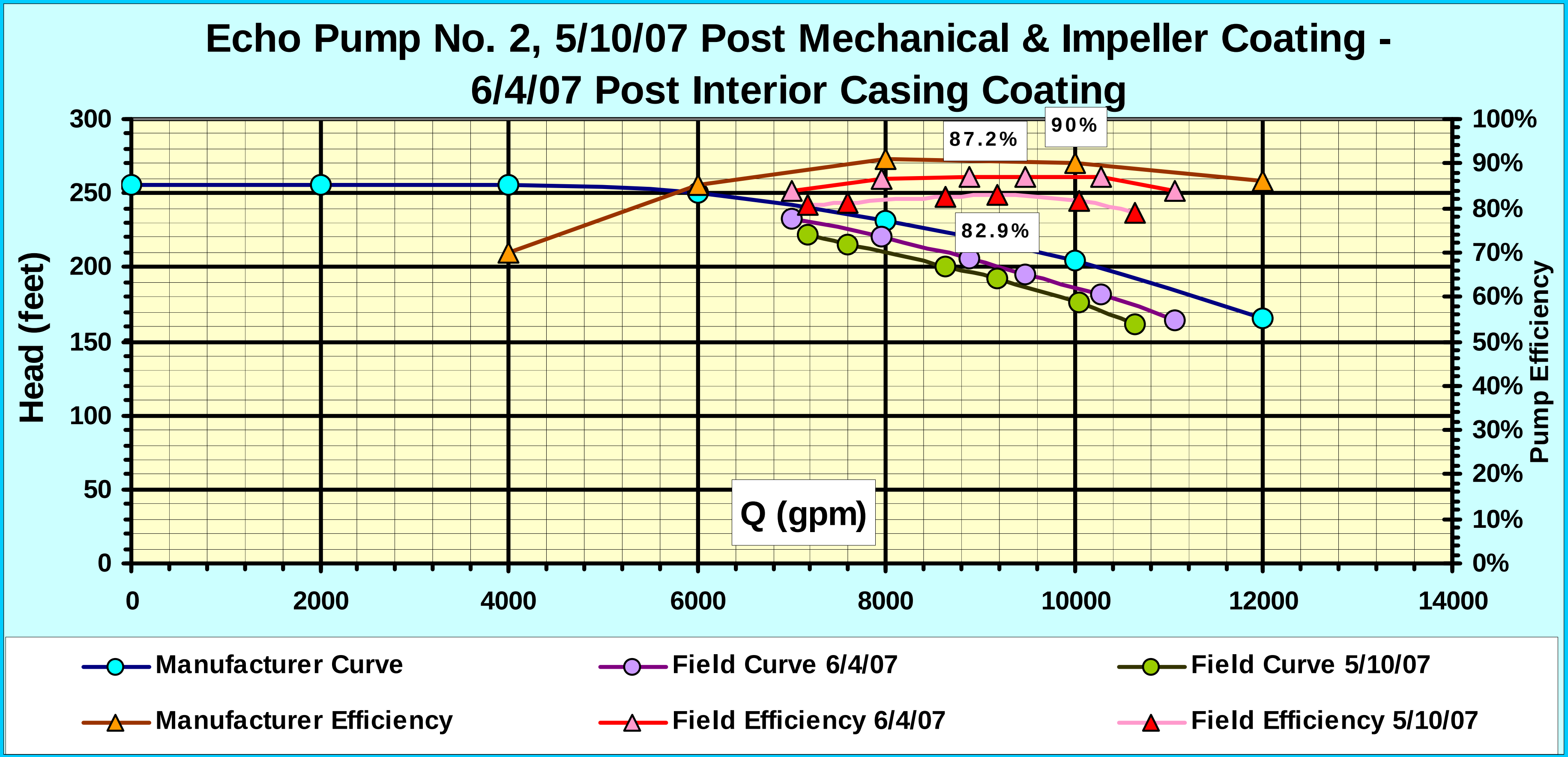
Post Metal Filler

Post Topcoat

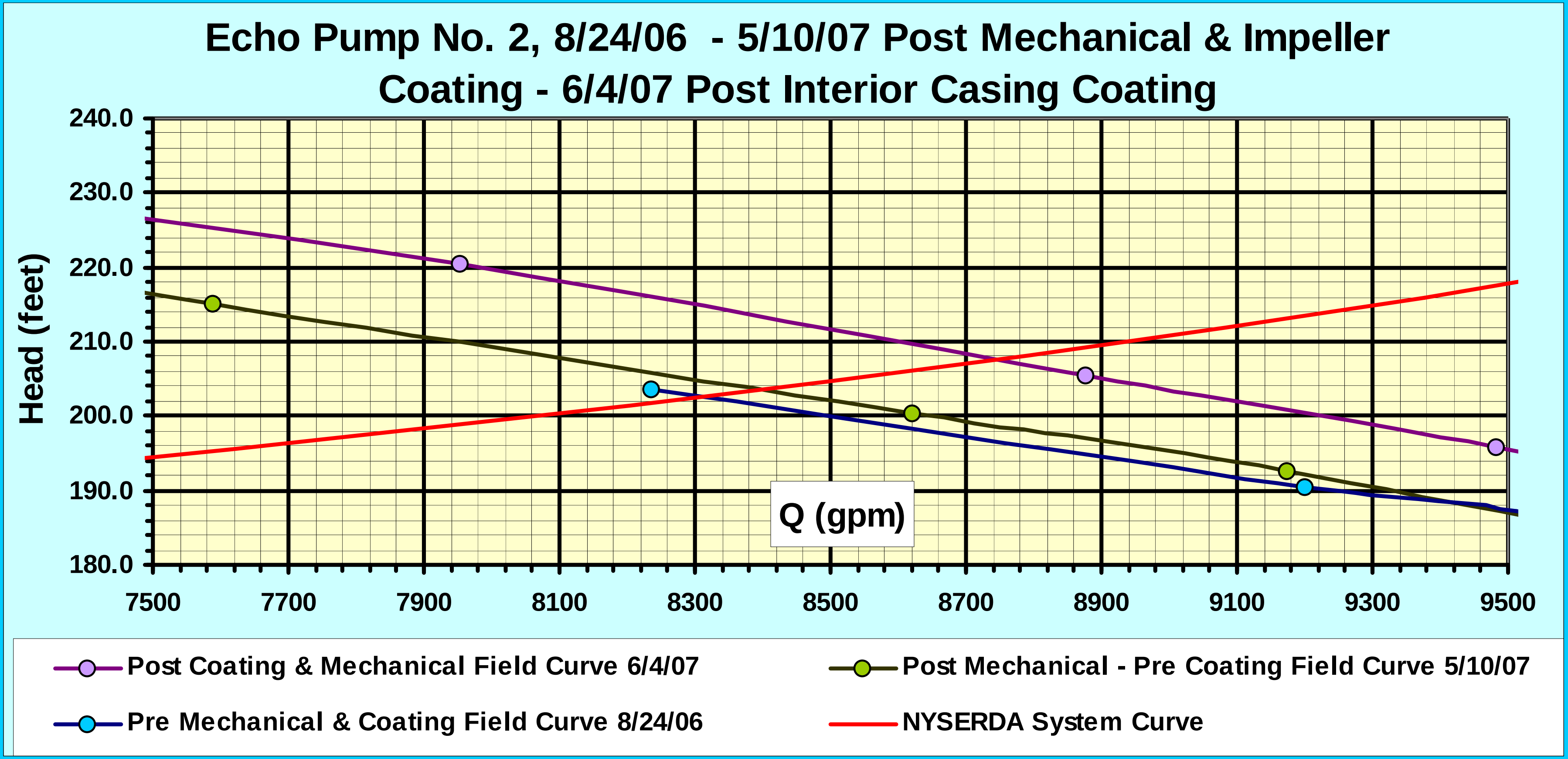
Echo Post Interior Coating vs. Post Mechanical Refurbishment Performance Comparison

Increase 10' of Head, Increase of 5% Efficiency

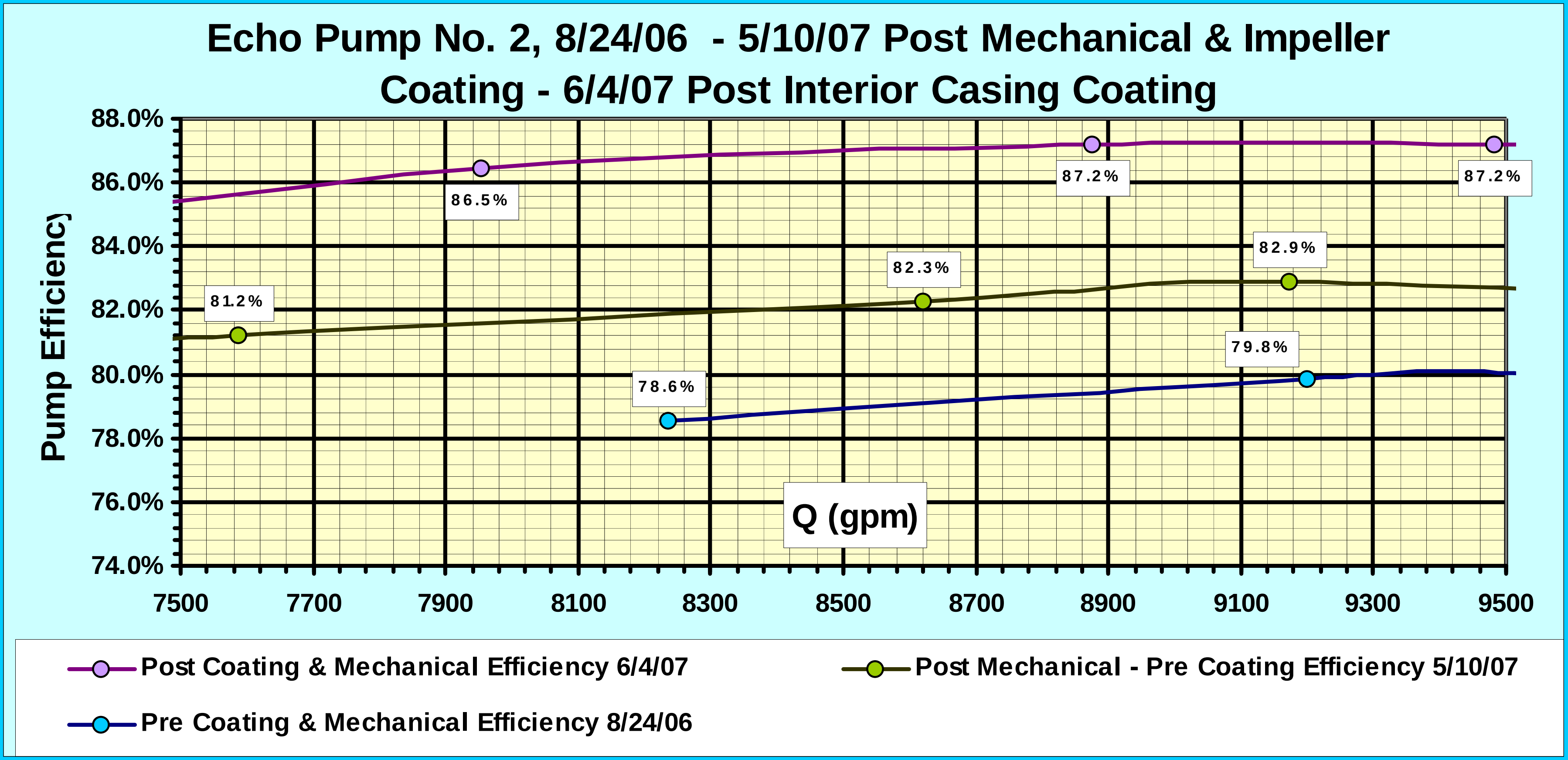
Total Efficiency Increase from Mechanical & Coating 8.2%



Performance Improvement (Head & Flow) From Mechanical Refurbishment & Interior Cleaning & Coating



Performance Enhancement (Pump Efficiency) From Mechanical Refurbishment & Interior Cleaning & Coating



Pump Performance Improvement, Prior Continuous Operation (364 mg/month) @ $10/kW & $0.085/kWH

Pre Mechanical	
Head (ft)	202
Flow (gpm)	8300
Efficiency	78.8%
Hours Operation/month	730
BHP	537
kW (Assumes Motor Eff 95%)	421.9
kW Demand Charge	$4,219
kwh cost	$26,180
Total Monthly kWH	307,997
Monthly Cost	**$30,398.86**

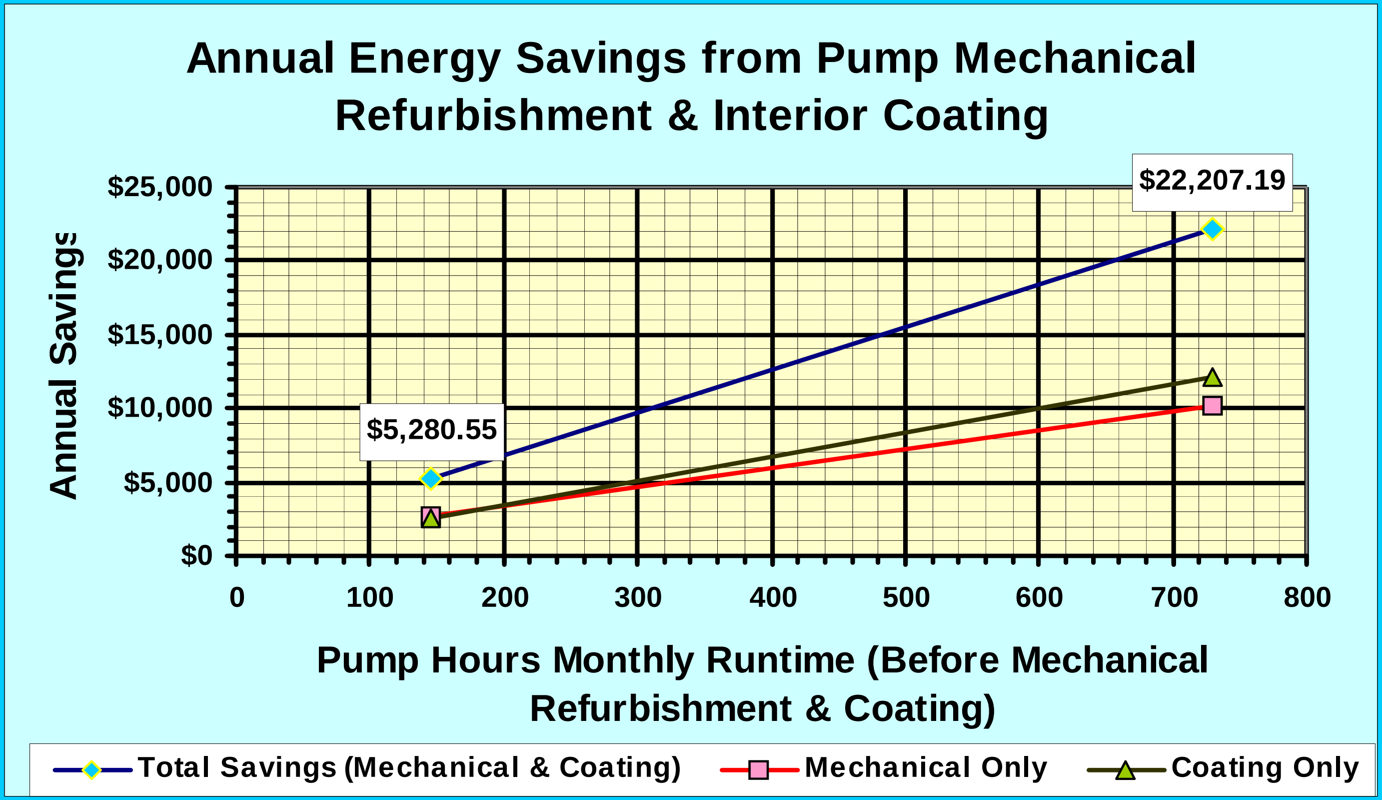
Post Mechanical	
Head (ft)	204
Flow (gpm)	8403
Efficiency	82.0%
Hours Operation/month	721
BHP	528
kW (Assumes Motor Eff 95%)	414.5
kW Demand Charge	$4,145
kwh cost	$25,407
Total Monthly kWH	298908
Monthly Cost	**$29,552.61**

Post Casing Coating	
Head (ft)	208
Flow (gpm)	8715
Efficiency	87.0%
Hours Operation/month	695
BHP	526
kW (Assumes Motor Eff 95%)	413.2
kW Demand Charge	$4,132
kwh cost	$24,417
Total Monthly kWH	287253
Monthly Cost	**$28,548.26**

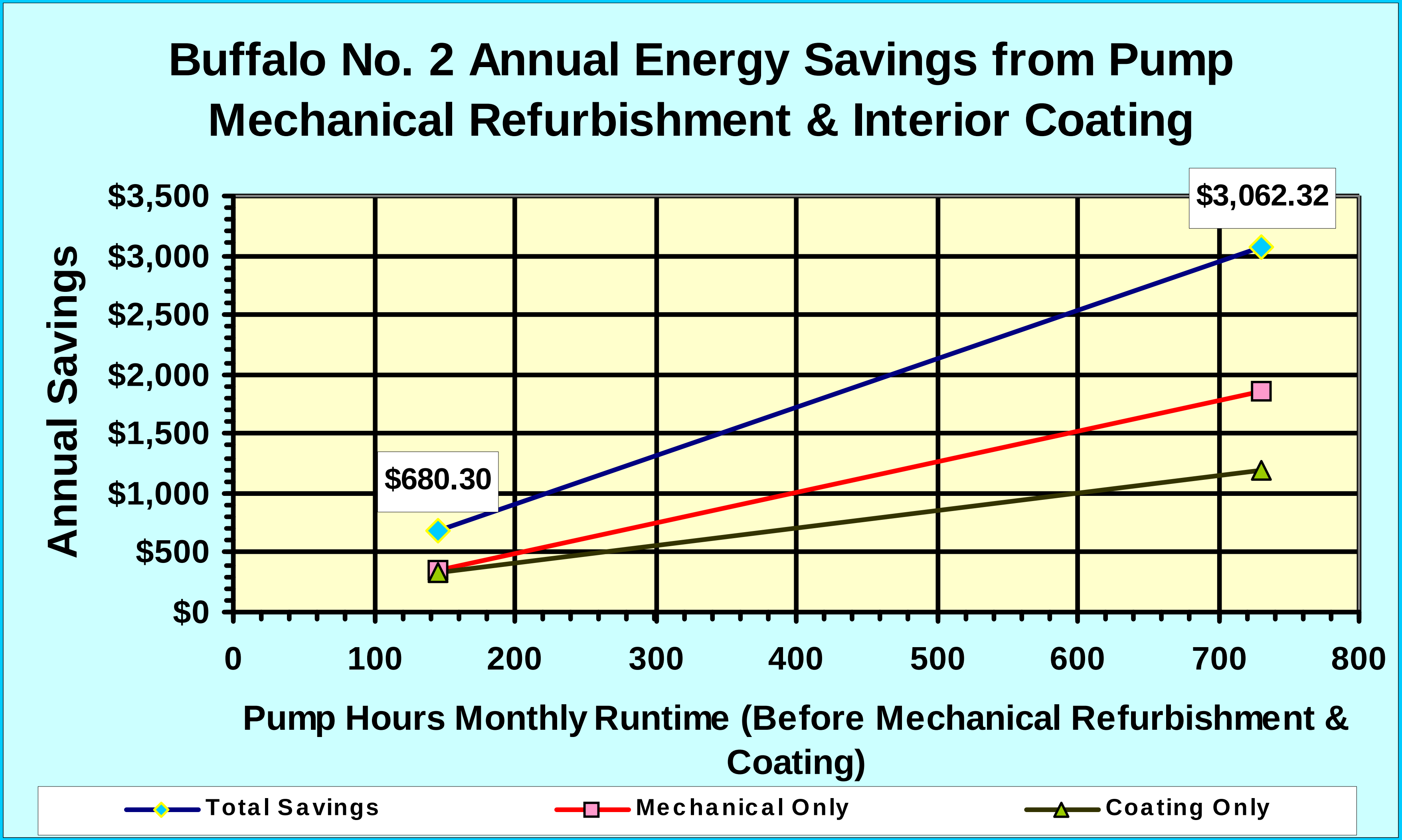
Total Energy Savings Pre Mechanical to Post Interior Coating Comparison	
Monthly Savings	**$1,851**
Annual Savings	**$22,207**
5 Year Savings	**$111,036**
kW Demand Reduction	**8.74**
Monthly kwh Savings	**20743**
Yearly kwh Savings	**248921**

Estimated Energy Savings

- $10/kW Demand Charge and $0.085/kwh Cost
- Estimated Cost of work $8,500 ($4500 in wear rings)
- Payback Period Mechanical Refurbishment & Coating
  - 0.38 years continuous running pump (730 hours/month)
  - 1.61 years for 20% operation (146 hours/month)

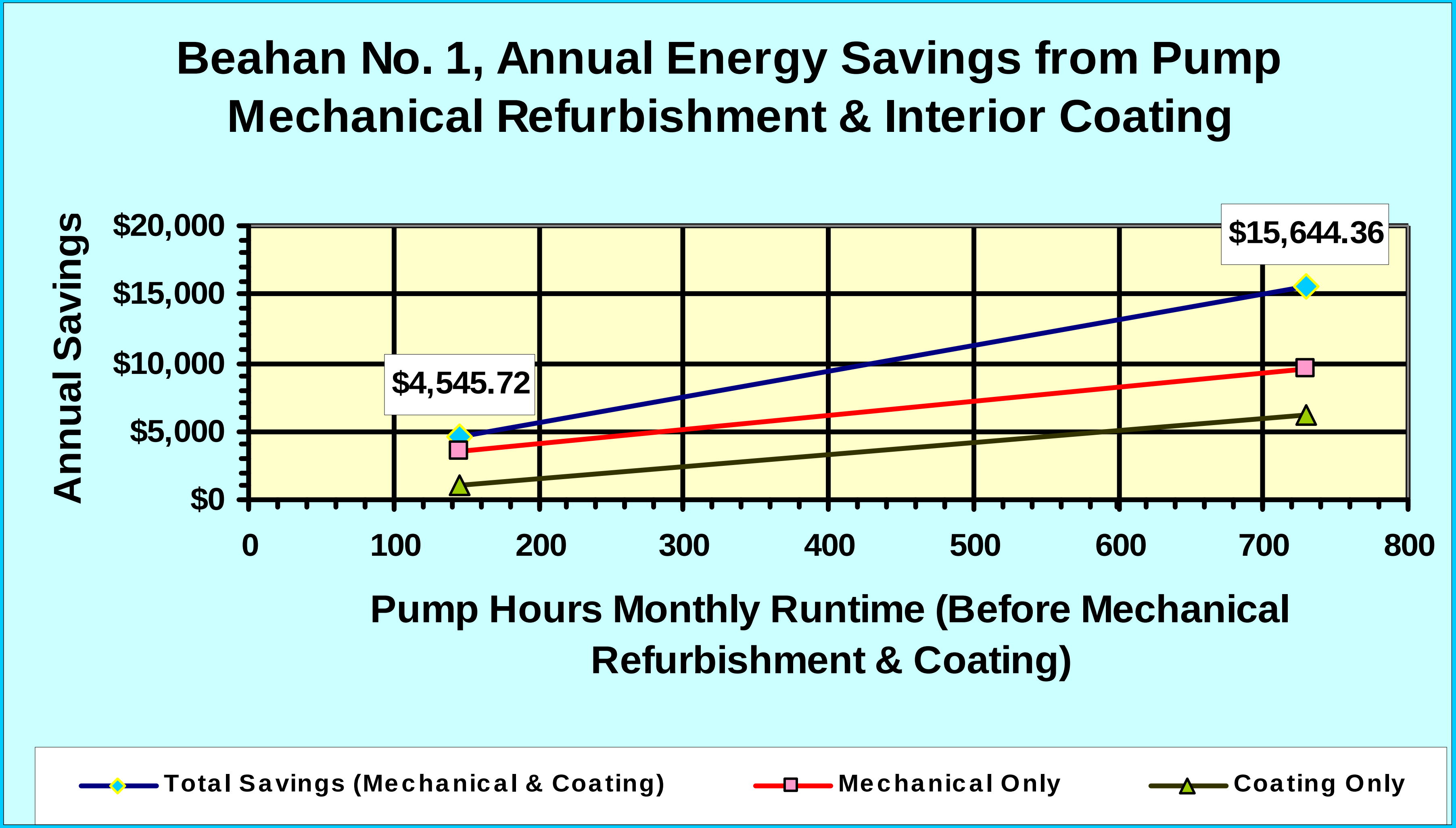


30 HP



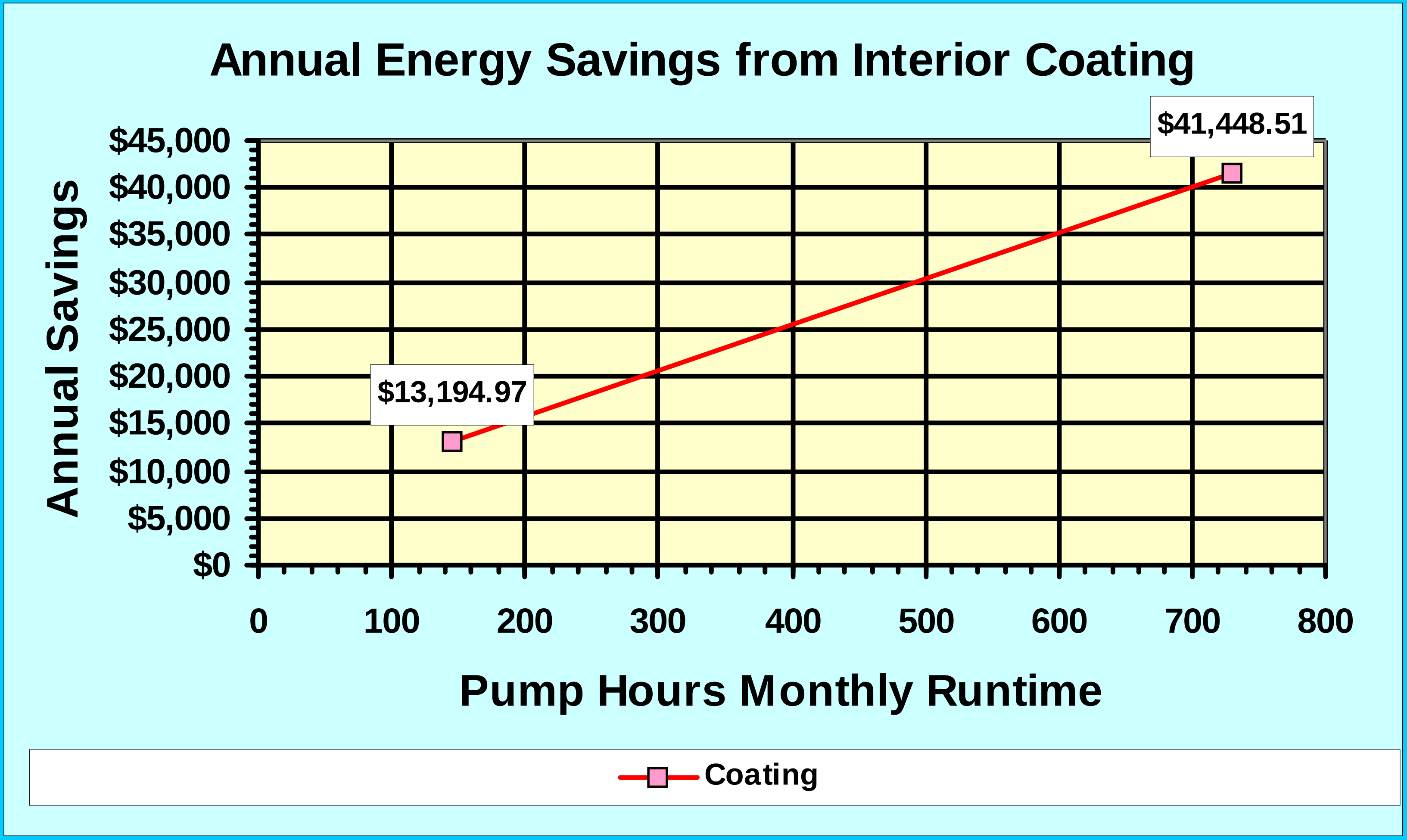
Buffalo No. 2 Annual Energy Savings from Pump Mechanical Refurbishment & Interior Coating
$3,500
$3,000
$2,500
$2,000
$1,500
$1,000
$500
$0
Annual Savings
0
100
200
300
400
500
600
700
800
Pump Hours Monthly Runtime (Before Mechanical Refurbishment & Coating)
$3,062.32
$680.30
Total Savings
Mechanical Only
Coating Only

300 HP



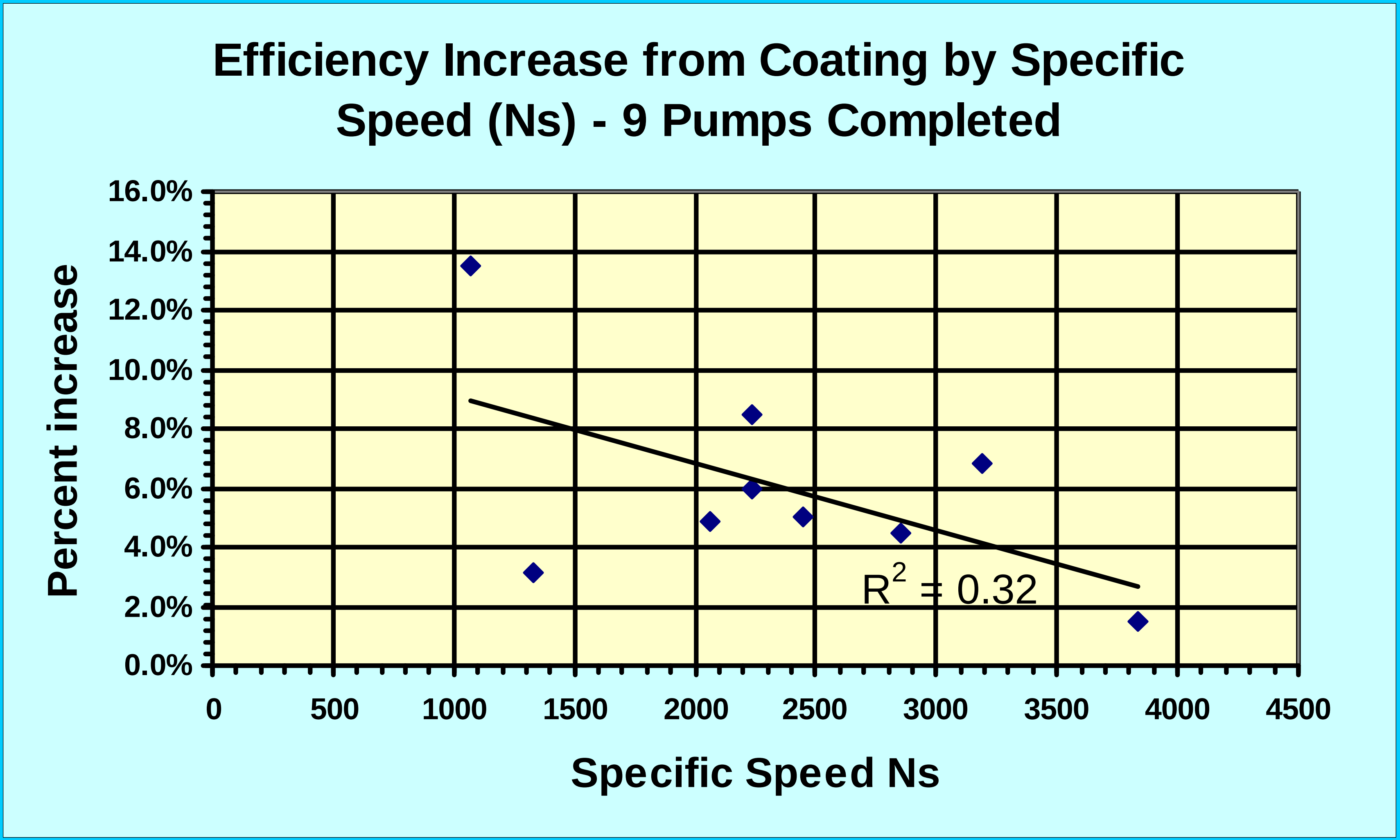
Beahan No. 1, Annual Energy Savings from Pump Mechanical Refurbishment & Interior Coating
Annual Savings
$20,000
$15,000
$10,000
$5,000
$0
$4,545.72
$15,644.36
0
100
200
300
400
500
600
700
800
Pump Hours Monthly Runtime (Before Mechanical Refurbishment & Coating)
Total Savings (Mechanical & Coating)
Mechanical Only
Coating Only

1750 HP



Annual Energy Savings from Interior Coating
Annual Savings
$45,000
$40,000
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$0
0
100
200
300
400
500
600
700
800
Pump Hours Monthly Runtime
$13,194.97
$41,448.51
Coating

Preliminary Findings of the Specific Speed Ns Relationship



Preliminary Conclusions and Recommendations

- Cleaning and coating the interior of HSC pumps seems well worth the effort in terms of Pump Performance and Energy Savings.

- Pumps should be coated by the pump manufacturer at the time of purchase rather than after the fact as part of a maintenance or refurbishment program.
  – Internal coating of pumps is now part of the MCWA pump spec.
  – Most pump manufacturers seem to prefer powder coating applications rather than brush on applications.

- Creativity in selection of equipment and support materials for coating applications is essential.
  – Pumps both large and small were not designed with the intent of being brush coated on the inside.
  – Coating manufacturers should be more than willing to help (advice and training) to get pump coating programs going.

Preliminary Conclusions & Recommendations, Cont.

- The most important unknown at this point of the NYSERDA study is the longevity of the coating, will it hold up?
  - Pilot study coatings have been very durable and show minimal signs of failure, (pumps inspected annually). Pump performance for those pumps coated in the pilot study have shown no signs of decline (approx. two years of run time) that could be attributed to coating failure.
  - Pumps that are part of the NYSERDA study will be field tested every six months and the inside inspected annually over the next five years to monitor pump performance and coating durability

- Pump efficiency/performance improvement in excess of the manufacturer's stated pump efficiency from the pump curve through coating of a new pump is nice, but not the goal of the coating process. The MCWA goal of pump coating is to "***prevent or at least significantly delay what seems to be the inevitable decline of pump performance over a relatively short period of time (less than 5 years) through internal corrosion and the resulting tuberculation build up***".

The End

Thank you to the Texas A&M Turbomachinery Laboratory, and Good Luck to All!