Appendix U. Phase III Demonstration Study – Additional Cost Analyses of Options

Capital, O&M, and 20-year net present value costs were developed for the following two pH adjustment strategies for WBA treatment:

- Hydrochloric acid addition to lower the pH to 6.0, followed by caustic (NaOH) addition to raise the pH to 7.7 – 8.0 to achieve a positive Langelier Saturation Index (LSI) and Calcium Carbonate Precipitation Potential (CCPP) for corrosion control.
- Carbon dioxide (CO_2) addition to lower the pH to 6.0, followed by aeration to raise the pH to 7.7 – 8.0 for corrosion control.

Table A-1 summarizes the costs for each pH adjustment system for a 500 gallon per minute (gpm) system. The costs for each pH adjustment system are based on the following assumptions:

- Pre- and post-pH adjustment requirements are based on the design water quality listed in Table 5-6 of the report.

HCl Addition:

- Capital costs include two chemical feed pumps (one duty, one standby), a 2,250 gallon double-walled HDPE storage tank, and a static mixer. No equipment installation costs are included.

- O&M costs for HCl addition are based on $0.39/lb of 32% solution based on a December 2011 quote from Brenntag and continuous feed of 281 mg/L.

CO_2 Addition

- Capital costs include a CO_2 feed system to provide 300 mg/L CO_2 and 14 days of storage (14-ton storage), two CO_2 feed water pumps (one duty, one standby), and a static mixer. No equipment installation costs are included.

- O&M costs are based on addition of 300 mg/L CO_2 at $0.07/lb. Electricity costs ($0.10/kWh) to operate the CO_2 feed water pump (75 gpm carrier water at 80 psi) are also included.

NaOH Addition

- Capital costs include two chemical feed pumps (one duty, one standby), a 2,250 gallon double-walled HDPE storage tank, and a static mixer. No equipment installation costs are included.

- O&M costs for NaOH addition are based on $0.27/lb of 30% solution based on a December 2011 quote from Brenntag and continuous feed of 300 mg/L.

Aeration w/ Off-Gas Treatment

- Capital costs include a 10-ft aluminum forced draft aerator, with a blower (1,500 cfm; 3:1 air-to-water ratio [cfm/gpm]), air distribution tray and piping. Capital costs for off-gas treatment assume inclusion of exhaust blowers (1,500 cfm), two (2) vapor-phase GAC adsorbers in series with a heater. No equipment installation costs are included.

- O&M costs for aeration include electricity to operate the supply and exhaust blowers and heater. Annual operating costs associated with VPGAC replacement are based on replacement every 1.5 months at a cost of $5,000/vessel.

- Capital and O&M costs associated with a booster pump are also included based on the assumption that booster pumping could be required to provide additional pressure to lift the WBA effluent 15-ft for aeration at some systems. Capital costs for booster pumps are based on addition of two pumps (one duty, one standby) to provide an additional 15-ft of pressure head. No equipment installation costs are included. O&M costs are based on 70% pumping efficiency and a $0.10/kWh electricity cost.

Table A-1: Estimated Costs for pH Adjustment Systems for WBA Pre-Treatment and Corrosion Control in Finished Water for a 500 gpm System

pH Adjustment System	Design Criteria	Capital Costs[(1)]	Annual O&M	20-Year NPV[(2)]	Capital + 20-Year O&M
Pre-Treatment to Achieve pH 6.0					
HCl Addition	281 mg/L of 32% HCl solution; 14 days of storage	$25,000	$751,000 [(3)]	$12,579,000	$12,604,000
CO_2 Addition	300 mg/L	$207,000	$50,000 [(4)]	$837,000	$1,044,000
Post-Treatment to Achieve pH 7.7 – 8.0 (LSI > 0)					
NaOH Addition	300 mg/L of 30% NaOH solution; 14 days of storage	$22,000	$592,000 [(3)]	$9,916,000	$9,938,000
Aeration w/ VPGAC off-gas treatment	3:1 air: water ratio (scfm/gpm)	$183,000	$106,000 [(5)]	$1,775,000	$1,957,000

(1) Capital includes the equipment costs per vendor quotes and does not include equipment installation costs.

(2) 20-year net present value costs for each system are based on a 4.5% discount rate and 2.5% inflation.

(3) O&M includes acid or caustic chemical consumption. Chemical feed pump power consumption is negligible.

(4) O&M includes carbon dioxide chemical consumption and carbon dioxide pump power consumption.

(5) O&M includes energy for aeration supply blowers, exhaust blowers and heater, and VPGAC replacements.

Table A-2 compares the capital, O&M, and 20-year NPV costs for pre- and post-pH adjustment for a 500-gpm system using HCl and caustic addition vs. CO_2 addition with aeration. For the design water quality (Table 5-6 of report), CO_2 addition combined with aeration is the more cost-effective approach for pH control for WBA treatment. Note that the cost-benefit analysis will vary depending on source water quality. Systems with lower source water pH and alkalinity will require less HCl and NaOH for pH adjustment. For these systems and potential changes in chemical costs, HCl and NaOH addition could be more cost-competitive with the use of CO_2 and aeration for pH control.

Table A-2: Comparison of pH Adjustment Strategies for a 500-gpm System

pH Adjustment Strategy	Capital	Annual O&M	20-Year NPV[(1)]	Capital + 20-Year O&M
HCl and NaOH Addition	$47,000	$1,343,000	$22,495,000	$22,542,000
CO_2 Addition and Aeration w/ VPGAC off-gas treatment	$390,000	$156,000	$2,612,000	$3,001,000

(1) 20-year net present value costs for each system are based on a 4.5% discount rate and 2.5% inflation.