Impact Analysis of the High TDS Strategy on the Bituminous Mining Industry

presented to the PA DEP WRAC TDS Subcommittee
September 22, 2009

Objective: Assess Functional, Logistic, Economic and Environmental Impacts of the TDS Strategy on the mining sector

- ✓ Using a conservative interpretation, evaluate how the mining industry would comply with the proposed limits
- ✓ Evaluate how potential solutions would be implemented, infrastructure needs, time to complete
- ✓ Evaluate the economic cost of potential solutions, both direct and indirect cost to communities
- ✓ What, if any, environmental impacts may result from implementation and compliance with proposed standards, unintended consequences

Background PA Coal Industry

- Pennsylvania is the 4th leading coal producing state, mining 68 million tons in 2008.
- Federal Energy Information Administration (EIA) estimates that Pennsylvania has 27 billion tons of bituminous coal reserves.
- 571 active mining permits were on record as of Jan. 2009.
- The industry employs 7,649 employees, for a total of 54,000 direct and indirect jobs.
- Total payroll exceeds $2.2 billion, with paid tax revenues of $749 million.

Operations Affected:

- **NEW and EXISTING OPERATIONS**
  - Underground Mines
  - Coal Preparation Plants
  - Coal Refuse Disposal Sites
  - Surface Mines
  - They have approved NPDES Discharges that were issued to insure water quality standards were met.
  - With regard to water treatment, the economics of these operations were predicated on meeting the requirements of 40 CFR 434.

Operations Affected cont.

- **REMINING**
  - The program as set forth in PA law, regulations and 40 CFR 434 is predicated on pollutional loading not being increased, but hopefully in long run decreased.
  - The program was designed to improve water quality and encourage remining in areas previously impacted by mining and reduce pressure on areas not previously mined.
  - Under the regulations, TDS and sulfate levels would be tied to pollutional loading, not end-of-pipe effluent limitations.

Operations Affected cont.

- **LEGACY MINE DRAINAGE TREATMENT**
  - Companies have completed mining, but as a result of operations are now obligated to treat water long-term.
  - Costs of maintaining these operations will increase significantly and place these operations in jeopardy, resulting in State having to treat.

Operations Affected cont.

- **ABANDONED MINE DRAINAGE**
  - Projects involving wetland treatment of mine drainage are designed to passively treat to provide low iron, low manganese and a pH of 6-9.
  - Projects no longer viable if they have to achieve TDS effluent levels.

Operations Affected cont.

- **MINE DRAINAGE**
  - Studies have been conducted to use mine water for low-flow augmentation.
  - In some cases, water would have been treated using passive treatment technology or minimal treatment requirements, but were not considering treating for TDS and sulfates.
  - Companies have looked at mine pools to supplement stream flow as a means of insuring adequate stream base flow while withdrawing the equivalent amount of water for power generation.

PCA Membership Survey

- Pennsylvania Coal Association (PCA) conducted a survey to gauge the scope of ongoing treatment activities and estimate potential effects of proposed rule making.
- 85% of Pennsylvania‘s total bituminous coal production is represented by PCA.
- Survey information is representative of the industry, but it is not comprehensive. The total number of discharges and water quality data is incomplete due to time limitations and the nature of existing NPDES permit limits.
- Data was received concerning 41 permitted discharges related to 8 surface and 16 underground coal mines.

PCA Membership Survey cont.

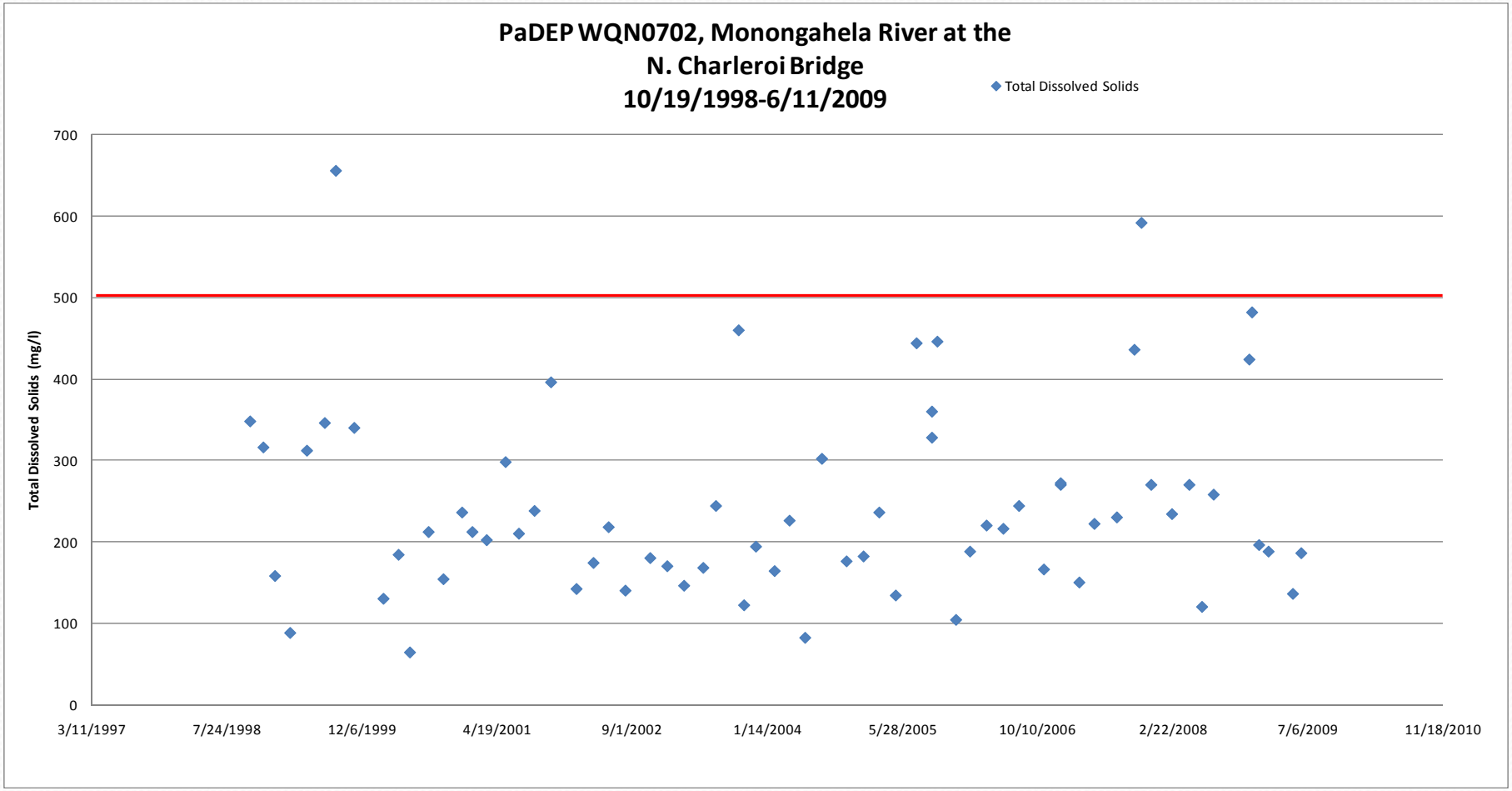
- The combined maximum flow from these discharges is approximately 26,725 gallons per minute (gpm).
- 96% (26 of 27 reporting TDS) report a maximum TDS concentration > 500 mg/l.
- 4% (1 of 27 reporting TDS) had a maximum TDS concentration < 500 mg/l.
- 78% of all discharges (32 of 41) failed to meet at least one of the proposed chapter 95 standards at the end of the pipe.

PCA Analysis of PA DEP Data Response

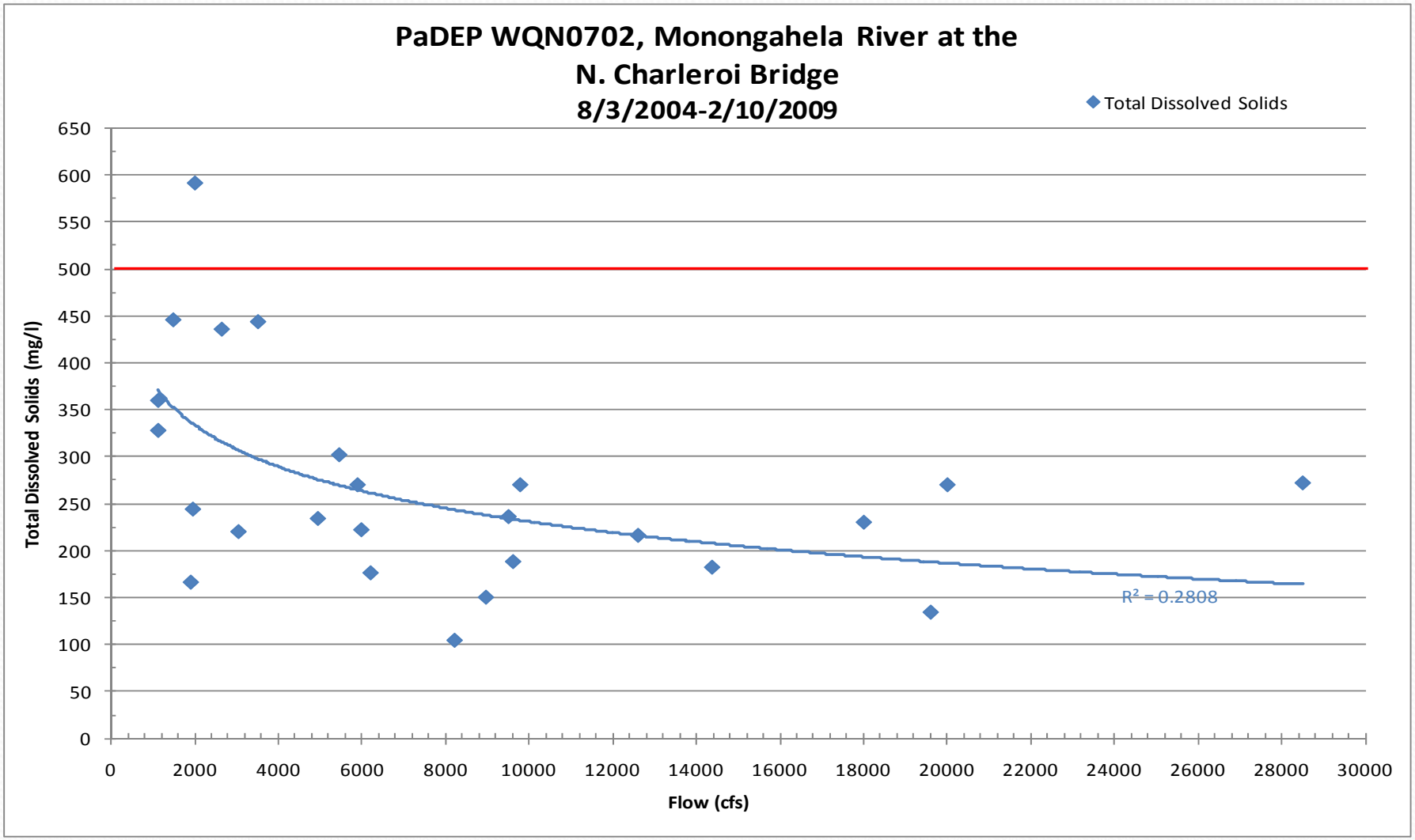
- PCA requested list of waters at risk for sustained elevated concentrations of TDS, sulfates and chlorides
  - 28 WQNs considered 'at risk' and 8 were not
  - Of 28 WQNs, only 6 had TDS and/or sulfate concentrations that occasionally exceeded the proposed effluent limits. None had chloride concentrations > 250 mg/l.
  - Sampling at these 36 WQNs not conducted on regular basis
  - Sampling ceased in December 2008
  - Analytical method used to determine TDS for the Monongahela sampling is not an EPA-approved method.
  - Data provided by DEP is insufficient to support its claim that watersheds statewide are impaired by high concentrations of TDS, sulfates and chlorides.

Monongahela Water Quality Trends

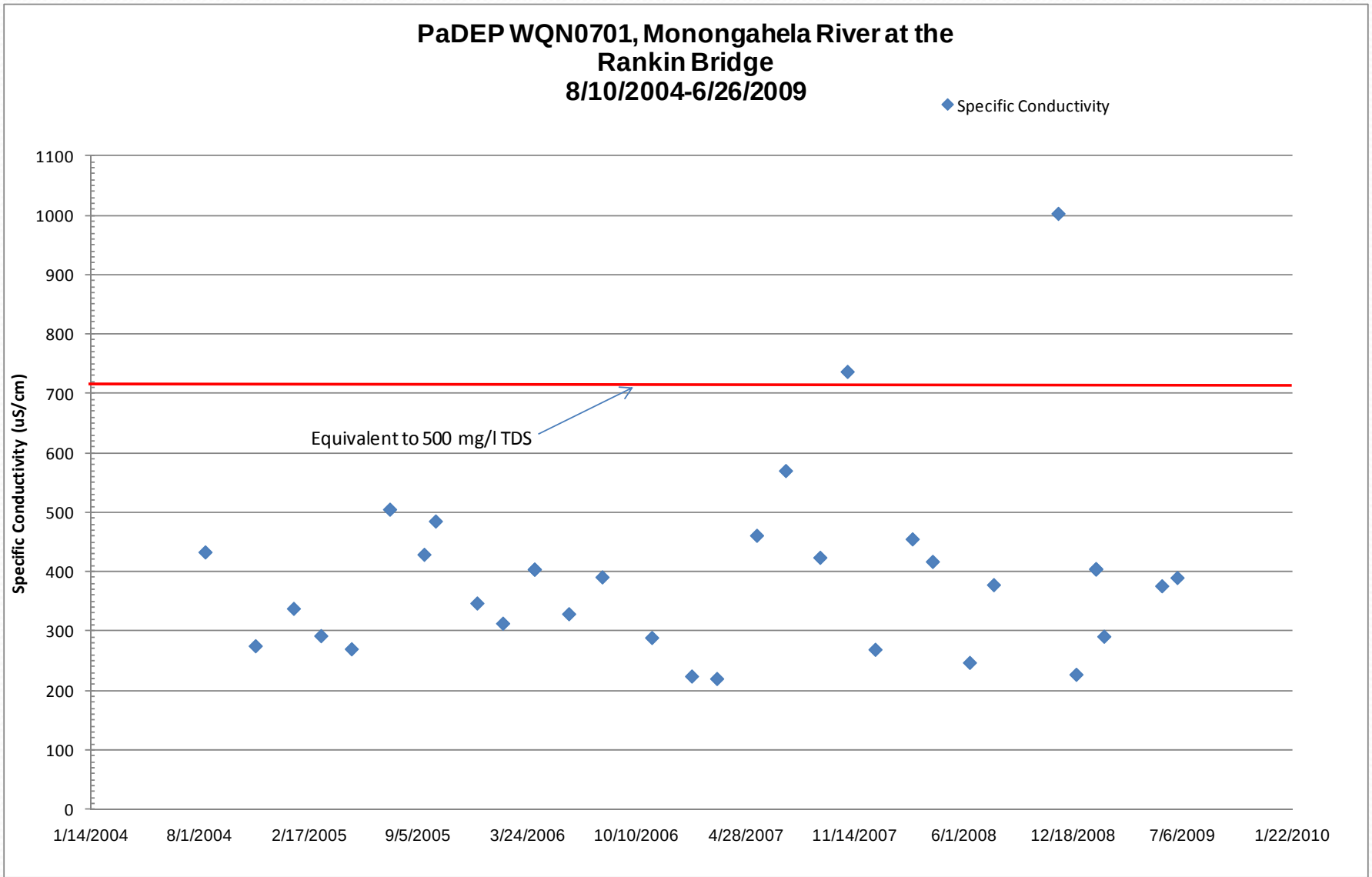
- Most Comprehensive Collection of PaDEP Mon. River Data from Site WQN0702
- Long-Term Data Indicates Exceedances of 500 mg/l TDS Limit are Sporadic
- TDS Exceedances Correspond to Low Flow Conditions



Monongahela Water Quality Trends cont.

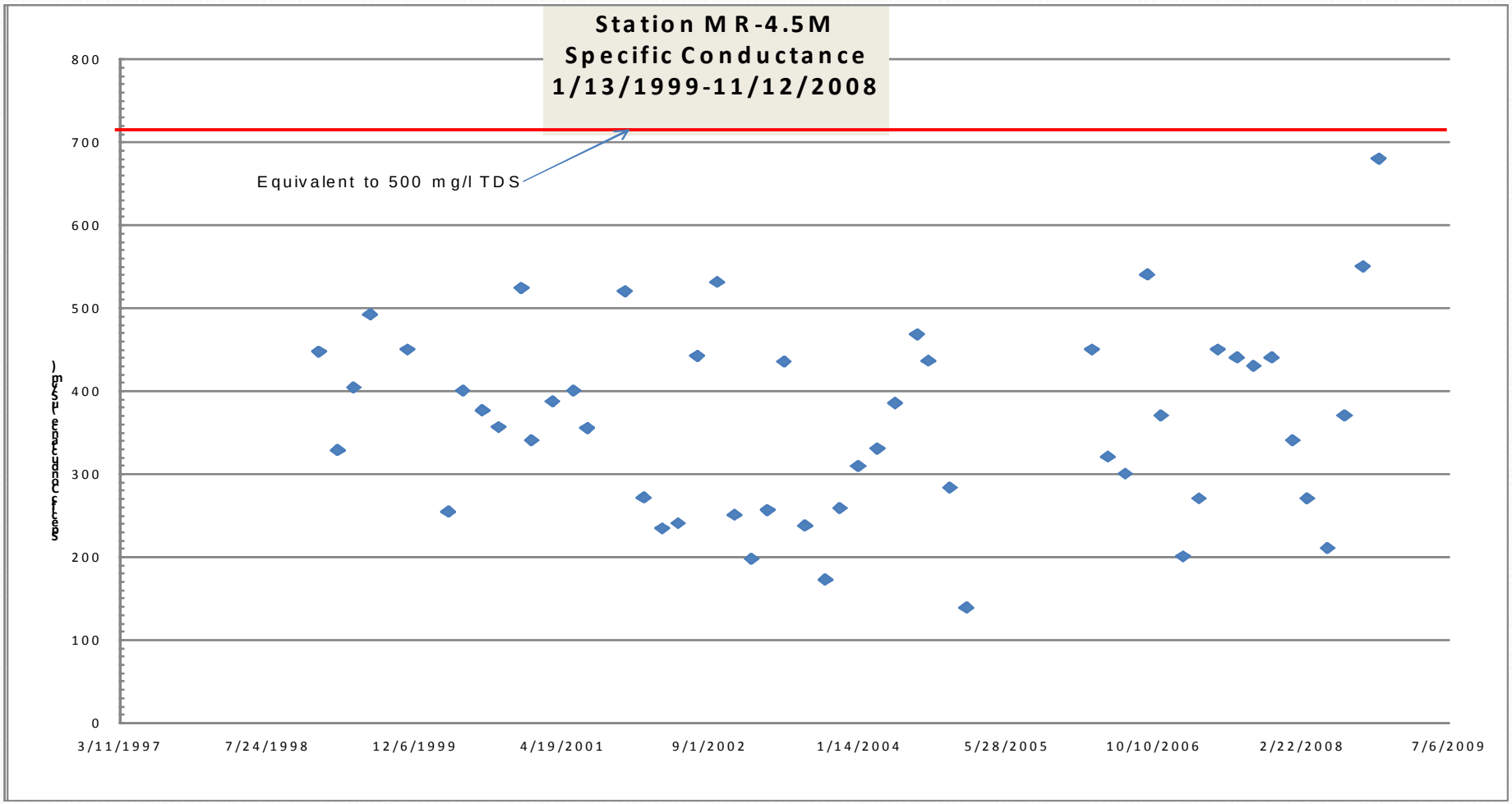


Monongahela Water Quality Trends cont.



Monongahela Water Quality Trends cont.

- Long-Term Specific Conductivity Data From Near Pittsburgh Location Suggests No TDS Exceedances



TDS Treatment Alternatives

- A variety of treatment alternatives were examined, moving from low-intensity alternatives to high-intensity approaches:
  - Managed Discharge / Utilization of assimilative capacity
  - Managed Treatment / Protection of assimilative capacity
  - Electro-dialysis
  - Precipitation
  - Liquid-Liquid Extraction
  - Reverse Osmosis (RO)
  - Evaporation Crystallization

TDS Treatment Alternatives cont.

- Managed Discharge / Real Time Monitoring Network
  - This approach would primarily utilize holding capacity or mine pool storage to reduce or eliminate AMD treatment discharges during low-flow periods of the year when water quality attainment is at risk.
  - Facilities would actively discharge during high-flow periods when excess capacity exists and TDS levels are at seasonal lows.
  - Advantages – protects designated stream uses, utilizes existing capital assets with little modification, low-cost alternative, limited impact on the states economic competitiveness, avoids value chain cost implications
  - Disadvantages - not suitable for all mining activities, cyclic drought conditions may affect “normal” discharge operations, dependent upon dilution, may adversely affect water quality, potential loading shift

TDS Treatment Alternatives cont.

- Managed Treatment / Real Time Monitoring Network
  - This approach would utilize a limited treatment capacity during low- flow periods of the year when water quality attainment is at risk.
  - Facilities would only operate and actively discharge during low flow periods when excess assimilative capacity is lacking and TDS levels are increasing.
  - Advantages – protects designated stream uses, decreases capital requirements and cost exposure though the use of smaller treatment facilities, targeted solution focusing on problem times, decreased secondary waste streams
  - Disadvantages - not suitable for all mining activities, significant capital impact on smaller operators, unknown operational impacts on treatment plants shuttered for long periods, solids disposal

TDS Treatment Alternatives cont.

- Electro-dialysis
  - This approach utilizes selectively permeable membranes and applied current to promote the movement of soluble ions, separating them by their electric charge.
  - Well suited to soluble ions but not iron, manganese or hydrogen sulfide
  - Does not remove non-polarized ions and molecules
  - More expensive than RO at volumes greater than 1000 gpm and typically exhibits problems with membrane fouling in calcium- and magnesium- enriched waters
  - Not appropriate for the treatment of mine waste waters in Pennsylvania

TDS Treatment Alternatives cont.

- Precipitation
  - This approach is an option for discharges high in sulfate, removing the sulfate through the precipitation of gypsum.
  - Well suited to conventional AMD treatment as a post metals removal step
  - ph is increased and excess calcium is added to create a super saturated condition with respect to gypsum, which then precipitates as a solid removing sulfate from the water.
  - Well suited to high sulfate waters associated with some types of mining
  - Unable to remove sulfate to proposed effluent limits of 250 mg/l, or address other contributors to elevated TDS
  - Rejected as a suitable treatment approach

TDS Treatment Alternatives cont.

- Liquid – Liquid Extraction
  - This is an approach where acid mine drainage water laden with sulfate and iron feeds into a treatment circuit where it sequentially contacts, in a counter-current flow path, an extractant solution formulated to efficiently pull these ions from the aqueous phase solution into the extractant phase solution.
  - The extractant, now containing the iron and sulfate ions, overflows an exit weir from the treatment circuit to another chamber where it separates cleanly from the water phase, which underflows the same weir and exits as a separate stream with proportionately less iron and sulfate.
  - Experimental / pilot stage of development
  - Only recently resolved intellectual property litigation
  - Untried on a commercial scale
  - Costs and reliability on a commercial scale unknown
  - Rejected as a suitable treatment option

TDS Treatment Alternatives cont.

- Reverse Osmosis (RO)
  - RO is process where pressure is used to force a solution through a permeable membrane in order to separate the solute from the solution.
  - It's an effective treatment for TDS with concentrations less than 40,000 mg/l. (Some manufacturers claim higher concentrations, but pressures are limited by membrane strength.)
  - Requires a rigorous pretreatment process to remove scaling agents (metals, hardness) and biological films which produces a solid waste
  - Units should be designed for the unique chemistry of the water they will treat, not an off-the-shelf, out-of-the-box fix.
  - Certain applications require corrosion resistant specialty metals with long lead times for delivery.

TDS Treatment Alternatives cont.

- Reverse Osmosis (RO) Cost Estimate
  - Aqua Tech 500 gpm 2000 mg/l TDS single unit
    - Design, permit, construct $ 4,140,000
    - Operation and Maintenance $ 1,062,000
    - This value does not include concentrated waste disposal or an evaporation crystallization step.
  - Concentrated Disposal Circuit: Evaporation & Crystallization
    - 60 gpm evaporator /crystallizer $ 12,000,000
    - Design, permit, construct $ 8,700,000
    - Operation and Maintenance $ 2,266,000
  - Total Cost Combined System w/O&M
    - RO system $ 5,202,000
    - Evaporator Crystallizer $22,966,000
    - Total $28,168,000
    - Ten year total O&M after construction (yrs 2 – 11) $33,280,000

TDS Treatment Alternatives cont.

- Reverse Osmosis (RO) Cost Estimate
  - Major RO Vendor
    - Design parameters: 800 gpm at 6000 ppm TDS with evaporation circuit
    - Capital Equipment $ 13,000,000
    - O&M Cost system design, permit, construct $ 19,000,000
    - Annual operation cost $ 1,712,000
    - Solid waste generated (t/yr) 13,140
    - Waste disposal cost (90% availability @ $64/t) $ 756,000
  - Total System Cost
    - Turnkey system installation $34,468,000
    - Ten year total O&M after construction (yrs 2-11) $24,680,000

TDS Treatment Alternatives cont.

- Time Frames for Reverse Osmosis Implementation
  - Due to variation in water quality a feasibility study would need to be conducted for **each** source to be treated
  - This would then be followed by system design, site layout, permitting and special materials acquisition
  - The following estimated time frames are for the tasks listed below
    - Feasibility study — 6 months
    - Design — 6 months
    - Permitting — 12 months
    - Equipment acquisition & construction — 18-24 months
    - Total Estimated Time Frame — 2.5 - 3 years
      - This assumes no difficulty in obtaining corrosion resistant specialty metals, additional time could range from 12 to 24 months, delaying construction
  - Difficulty obtaining bonds in trust fund situation

TDS Treatment Alternatives cont.

- Estimated Industry Cost Impact
  - Three cost estimates were obtained for a 500 gpm zero liquid discharge (ZLD) treatment system, RO combined with evaporation and crystallization
  - These three estimates were averaged to obtain an order of magnitude technology cost, which was applied to a per gallon cost
  - **The Result: $46,000/gpm to treat, $3,600/gpm for O&M annually**
  - Treating just the volume of water reported in the PCA survey would cost the mining industry $1.325 **Billion** dollars in capital expenditures
  - O&M costs are estimated as $133 **Million** dollars annually
  - Bonding for a 500 gpm ZLD treatment system is $134 **Million** dollars using the AMD treat and bond/trust fund calculation spreadsheets

TDS Treatment & Environmental Concerns

- Handling of resultant waste streams and their impact
  - Estimates of "average" water quality applied to just the reported discharge volume results in approximately 650 tons of solid waste per day in need of disposal
  - Estimated at 237,000 tons annually, without a proven disposal location/option, and representing a 38% increase in production of industrial waste water treatment sludge in PA
  - Resultant solid wastes will be highly soluble and difficult to landfill without significant leachate generation.
- CO_2 emissions Cap and Trade
  - Electricity for RO, evaporator/crystallizer and pumps 5362 tonne/yr
  - Trucking solid waste 255 tonne/yr
  - Pretreatment hydrated lime use 1183 tonne /yr
  - Total (not life cycle, excluding steel & concrete) 6798 tonne/yr
  - At $20/tonne carbon credit total cost $136,000/yr/plant

Conclusion

- Available water quality data indicate that in-stream TDS concentrations are strongly influenced by volumetric flow.
- Consistent and widespread exceedance of secondary non-health based MCL's is not occurring, i.e. the Monongahela is **not** affected from the WV border to the point at Pittsburgh.
- The only equipment that may work to treat TDS is either RO or evaporation/crystallization or a combination of both.
- The cost of a ZLD approach for TDS treatment makes this approach **economically infeasible** for the mining industry or the state for its legacy obligations.

Conclusion cont.

- Safe viable disposal options for the secondary waste streams generated from the use of RO / Crystallization are in question, creating the potential for secondary environmental impacts.
- Carbon emissions from the thermal portion of the treatment process have environmental and economic implications for air quality attainment.
- The PCA membership consensus is that, given the lack of pervasive water quality impairment, incomplete understanding of TDS fate and actual toxicity to aquatic life, and significant economic burden and waste disposal issues, the proposed rulemaking is not feasible or justified and should be withdrawn.

Questions??