

ADVANCED WASTEWATER TREATMENT PROCESS EVALUATION WORKSHOP

Spokane, Washington

August 16, 2006

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Notes Format

Section One - The first section is a narrative summary of each presentation and related discussion.

Section Two - The second section contains detailed notes made during each presentation and related discussion. These notes are not verbatim, but are intended to represent the context and content of presentations and discussion. In this second section, presentation notes are in un-italicized font. *Discussion notes are in italics.*

Appendix - Appended to these notes are the individual presentation slides and other related supplemental information provided by the presenters.

Overall Summary

- Results of phosphorus removal at many plants were presented. In general, the best results were in the 20-30 ug/L range and were being achieved by a variety of processes. There were some exceptions that were achieving better results: two very small plants with very limited data and two plants in Breckenridge, Colorado. The reasons for the differences in performance need to be better understood.
- There is substantial variability in P removal performance and in the chemical analysis for P that must be considered when establishing treatment performance requirements.
- Plants with no sludge processing on-site produce lower effluent P concentrations.
- Reported effluent P concentrations are lower in smaller plants. Potential reasons include the simpler (or absent) solids handling processes generally used in smaller plants (less recycle) and the fact that small plants may not be sampled each day. Some data from larger plants where the effluent was sampled each day illustrated how routine equipment maintenance and day-to-day process variability can impact the effluent total phosphorus and elevate the average reported phosphorus concentrations. Such events are generally not detected when effluents are sampled periodically rather than daily.
- There is a long learning curve in starting up the operation of new P removal plants that must be considered when establishing treatment performance requirements.

- The removal of colloidal, refractory P is a potentially fertile area for research and may be needed to address what appears to be in many instances a refractory level of about 20 ug/L P.
- Status of DOE plans for carrying out the Managed Implementation Plan was described.
- Spokane and Inland Empire Paper described their pilot plant plans, Spokane County described the status of their planning.
- There is a willingness to share data as work proceeds.
- A desire was expressed to reconvene the group next year.

Section One

Summary of Presentations and Discussion

Objective of Workshop

Identify, update, and discuss the state-of-the-art in treatment technology for extremely low effluent phosphorus. Utilize the workshop to address technology development, readiness, pilot testing, technology issues, and other development requirements for applicability to Spokane River dischargers. Summarize conclusions and recommendations from the treatment technology workshop for use by Spokane River dischargers in site-specific plant process selection evaluations.

Introduction and Boundary Conditions for Discussion (8:00 am to 8:30 am)

Gordon Culp (Smith Culp Consulting) and Group

Dischargers were asked what they wanted to accomplish in the workshop. In summary, the agencies present for the workshop said they wished to accomplish the following:

- Build body of knowledge
 - Collaborate on how to apply technology
 - Create a transparent process for all concerned
 - Share results from pilot testing and plans for future pilot testing
 - Discuss available technology for next phase
 - Share information from visits to plants producing low effluent phosphorus
 - Identify peer review opportunities
 - Discuss timing of Idaho requirements
 - Discuss Washington permitting schedule
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Update on Spokane River TMDL and Managed Implementation Plan (8:30 am to 9:00 am)

Richard Koch and Len Bramble (Washington State Department of Ecology) See Appendix A for slides.

The Managed Implementation Plan (MIP) is perhaps the most critical item to be addressed by Ecology and the dischargers. A formal agreement is expected in the fall of 2006. The key steps in the MIP are:

- 20 year implementation
- 10 year check-in
- 20 year compliance
- Units of mass versus units of concentration
- Definition of the “delta items”.

Ecology is working on how to calculate interim limits, final limits, and delta projects. Ecology anticipates issuing permits in first half of 2007. The earliest date for NPDES permits is April 1, 2007 but most likely it will be May. Three permits expire June 30, 2007. Ecology's goal is to have everything issued by then. Ecology is attempting to coordinate with EPA's work in Idaho. Pilot testing, engineering reports, decisions, establishing milestones, etc., takes time and will help guide both the regulated and the regulators.

Concern was expressed by participants that in Idaho there is a compliance requirement on a 4.5 year schedule, not the 10 years spelled out in the MIP. Ecology responded that both Idaho and Washington permits establish a time period to get good data, so that when 10 year assessment is made in the MIP, there will be data.

Definition of the delta projects and how they are credited to an agency will probably show up in the second 5 years. Ecology is discussing internally how delta projects are defined and how credits can be managed and traded among the dischargers. Ecology is not sure there is anything to trade until data establish that there is enough of a delta for a discharger to trade.

Ecology's envisions the "oversight group" will oversee the phosphorus trading accounting, rules, and tracking water quality improvement in river, Long Lake, etc.

The "fundamental concepts" talked about a seasonal average and Ecology is honoring that.

Overview of Candidate Treatment Processes for Extremely Low Effluent Phosphorus (9:00 am to Noon)

EPA Evaluation of Phosphorus Removal at WWTP's Across the Country - Status Report by Brian Nickel (U.S. Environmental Protection Agency) See Appendix B for slides.

The purpose of the study is to get more information into the public domain and give dischargers a good reference on the shelf when faced with a low P limit. EPA has visited several wastewater treatment plants (WWTPs) to assess phosphorus removal. More visits are planned. Data analysis is underway and a draft report is expected by September, 2006. EPA wants staff at the WWTPs to review the draft to make sure data are represented correctly. EPA is not currently planning other reviews.

WWTPs visited include:

- Washington – 1 plant
- Oregon – 2 plants
- Massachusetts – 2 plants
- Colorado – 3 plants
- Virginia – 3 plants
- New York – 2 plants

The common processes observed were secondary treatment with chemical addition and filtration and biological nutrient removal with chemical addition and filtration. Unique concepts include Procept (Blue Water) filtration, membrane bioreactor (MBR), and CoMag. Capacity and performance ranges from 0.5 mgd to 80 mgd. Some plants are reporting effluent P as low as 7 µg/L with several less than 100 µg/L. EPA recognizes that there are phosphorus detection limits issues related to treatment performance requirements as detection limits are in the range of 6 µg/L.

Dave Clark Presentation – See Appendix C for slides.

This report surveyed plants across the country known to provide high degrees of phosphorus removal. The report analyzed trends in size and technologies by evaluating daily data on plant performance, and presented statistical analysis of performance. Ten plants were studied ranging in size from 0.5 mgd to 91 mgd. Treatment processes included biological nutrient removal supplemented with chemical treatment and various types of effluent filters and MBR supplemented with chemical treatment. Analyses of plant performance showed the following log normal mean effluent total phosphorus concentrations:

- Las Vegas 2004 – 0.190 mg/L; 2005 - 0.141 mg/L; 2006 – 0.192 mg/L
- Durham 2005 – 0.080 mg/L; 2006 – 0.107 mg/L
- Rock Creek 2004 – 0.090 mg/L; 2005 – 0.070 mg/L
- Cauley Creek 2004 – 0.110 mg/L; 2005 – 0.086 mg/L
- Walton 2005 - 0.008 mg/L; 2006 – 0.007 mg/L
- Stamford 2005 - 0.012 mg/L; 2006 – 0.008 mg/L
- Alexandria 2003 – 0.13 mg/L; 2004 – 0.90 mg/L
- Lone Tree 2003 – 0.040 mg/L; 2004 – 0.030 mg/L
- Iowa Hill 2003 – 0.009 mg/L; 2004 – 0.008 mg/L
- Pinery 2003 – 0.030 mg/L; 2004 – 0.030 mg/L

Some values at Walton are as high as 50 µg/L. Yet, the log normal mean is very low. The phosphorus analysis at Walton was done by labs certified by NY EPA.

Some trends were noted. Smaller plants tended to produce lower effluent phosphorus concentrations. The smaller plants tended to use newer technology, had limited solids processing on site and had limited sampling and testing. In general, plants with less intensive solids processing (or no solids processing) produced effluents with lower phosphorus concentrations. Plants using chemical clarification by filtration tended to produce similar effluent phosphorus concentrations as MBR plants. There was considerable variation in plant performance above and below their mean values and performance limits will require use of some long-term averaging period.

Dave Reynolds Presentation – See Appendix D for slides

Rock Creek is the largest plant with less than 100 µg/L effluent P. Rock Creek has been removing P for 20 years. Data were reviewed from 2001 through 2003 when the effluent limit was 0.070 mg/L total phosphorus. The limit was increased to 0.100 mg/L in 2004. Process adds alum ahead of primaries and ahead of final effluent filtration. The effluent phosphorus log normal mean concentrations were found to be:

- 2001 = 60 ug/L
- 2002 = 53 ug/L
- 2003 = 50 ug/L
- 2004 = 80 ug/L
- 2005 = 70 ug/L

Rock Creek quantification limit is 25 µg/L. One great month may not give you a good indication of long term performance. For example, in one month there were no values over 50 ug/L but over several months there were some points above 100 ug/L. For 2003, the log normal mean was 50 ug/L, the weekly maximum was 68 ug/L and the daily maximum was 89 ug/L. There are seasonal trends. Effluent total phosphorus varies and

performance requirements must use statistics. Achievable phosphorus concentrations can't be determined from existing WWTPs because their performance is influenced by the permit requirements.

Consider pilot testing over a full P season since pilots never start-up perfectly, the pilot might need a season to work properly and to establish chemical doses, loading ranges, etc. Multiple points of chemical addition may be needed to achieve the lowest phosphorus concentrations. Select a size that provides for reliable scale up. Consider the effects of solids handling and recycle flows. Pilot tests will provide information for desk top analyses but often leave many questions unanswered.

Two labs provided analytical P measurement in pilot testing at Spokane. There was substantial variation between results from the same samples. The level of uncertainty in measuring phosphorus, if not resolved, will be an issue for treatment plants and regulators

Decision making will be challenging when dealing with incomplete, imperfect, and conflicting information. Build a flexible facility. Recognize time required for learning curve. Beware of weird science – be skeptical of processes that are not based on sound science.

Report from Site Visits to Colorado Plants – Larry Esvelt (10:00 to 10:30) See Appendix E for slides and supplemental report.

Several wastewater plants in the Denver and Breckenridge, Colorado area that provide phosphorus removal were visited in November-December, 2005. The plants visited were:

- Aurora WWTP – Scalping plant. Design flow of 5 mgd. Normal flow 2.5 – 3 mgd. Primary clarifiers, biological treatment, filters, UV. No sludge handling. Residuals back to interceptor.
- Breckenridge, Iowa Hill – Scalping plant. 1.5 mgd. Normal flow 0.5 to 1.0 mgd. Activated sludge, nitrification, chemical precipitation, filtration (upflow, continuous backwash), disinfection. Residuals go to Farmers Korner plant.
- Breckenridge, Farmers Korner – Design flow of 3.0 mgd. Normal flow 0.5-1.0 mgd. Conventional flocculation. Activated sludge. Filtration. Alum dose of 150-200 mg/L.
- Frisco, CO – Design flow 1.7 mgd. Normal flow of 0.4-0.8 mgd. Recycle all sludge from effluent polishing back to headworks. Alum dose of 85 mg/L.
- Snake River Plant – High winter flows during ski season. Design flow of 2.6 mgd with normal flow of 0.7 mgd. Inclined plate settler. Conventional media, deep bed filter. Alum dose average 70 mg/L.
- Pinery Plant – Design flow of 2 mgd. Normal flow of 0.65 mgd. Biological nutrient removal supplemented with chemical precipitation, filtration. Clarifier is sorption clarifier with upflow and downflow media similar to system Inland Empire Paper will use on a larger scale. Alum dose 90 to 100 mg/L.

Although there are a variety of treatment processes used in these plants, there is not a big difference in the effluent phosphorus concentrations produced with results of 30-50 ug/L P being typical. The two Breckenridge plants produced lower P concentrations with 50th percentile values of 10 ug/L. All of the plants were operating at 50% or less of design capacity. Performance appeared to have a lot to do with chemical dosing. Cost per pound of P removed should be evaluated with the selection of treatment technology.

Most of the plants combine secondary and tertiary solids and dewater for disposal. The P does not appear to re-enter the process and stays adsorbed. All plants are removing sludge within 3 days. If you wait a week, P recycles back.

Report from EPA Tour of Reference Plants (Syracuse, Blue Plains, Concord/Alexandria) – Lars Hendron (City of Spokane) and Mark Laquidara (Metcalf and Eddy) Gerry Shrope (not presenting) (10:30 to 11:00) See Appendix F for slides.

The goal was to visit plants that are large (> 30 mgd), have practiced P removal for an extended period of time, have flow variations due to wet weather and process solids onsite to determine their performance and O&M experiences. The visits also provided a way to improve communication with a large group by offering city council, regulatory and environmental participants an opportunity to see the facilities in operation. Plants visited were Blue Plains (Washington, D.C), Alexandria, and Syracuse.

Blue Plains reported effluent annual average of 110 µg/L TP. Permit limit is an annual average of 180 ug/L with a maximum day limit of 350 ug/L. The Blue Plains plant has an average flow of 370 mgd with peaks of 740 mgd. Ferric chloride is added and multi-media filtration is provided.

Alexandria, VA reported effluent annual average of 50 ug/L TP with a weekly maximum of 160 ug/L and a daily maximum of 300 ug/L. They add both alum and ferric chloride after primary clarifiers, in secondary clarifiers, and ahead of rapid mix flocculation tanks. The plant has a design capacity of 54 mgd with peak wet weather capacity of 90 mgd.

Syracuse, NY reported effluent typical effluent concentrations of 140-160 ug/L TP. They are using ferric and polymer in Actiflo® to achieve P removal. The plant has an average rated capacity of 85 mgd with peak wet weather flows of 126 mgd.

The three plants produced effluents with 50 to 150 µg/L TP. All permits used time averaging. All required extended operation shake-down periods. All have extensive SCADA or automation. Unstable flows tended to upset the high level treatment unit processes and flow equalization may be needed to stabilize performance. High level treatment processes tend to require a lot of operator attention. The plant personnel reported using one season to optimize plant (6 – 8 month optimization period).

The tour participants also heard a presentation on a new technology (CoMag) which is essentially ballasted sedimentation with magnetite. Magnetite is denser than sand and magnetite that carries over from the sedimentation process is removed with a magnet on the final effluent line. A two-year pilot plant with flows of 0.07-0.2 mgd is being tested at Concord, MA. It is reported that 50 µg/L TP was achievable during the pilot testing. Alum, ferric, pH adjustment were evaluated.

Report from Water Environment Research Foundation (WERF) March 10-11, 2006 Workshop on Low Effluent Nutrients – JB Neethling (11:00 to 11:20) See Appendix G for slides.

The focus of the workshop was on achieving nitrogen < 3 mg/L and phosphorus < 0.1 mg/L. There were about 200 participants in the workshop. Lower effluent phosphorus concentrations than would be predicted by solubility theory are being achieved in treatment plants. Solubility limit previously was thought to be around 40 µg/L. It appears that lower concentrations are being achieved due to adsorption on metal hydroxide flocs.

Tests at Gwinette County showed little difference between the P concentrations produced by membranes and granular media filters with both producing TP in the range of 30 ug/L. Membranes give a little better performance (better solids capture).

Evaluation of results from the Berlin MBR showed an 80th percentile value of less than 50 µg/L. They concluded that there is 20 µg/L of refractory phosphorus leading them to conclude that < 20 ug/L is unachievable. Their graphing does not shown any data below 20 which appears to have led them to conclude that it is not possible to achieve less than 20 ug/L P. This appears to be a leap of faith without scientific back-up. However, the nature and amount of refractory nitrogen and phosphorus is an important question.

Design issues that surfaced from the workshop included:

- Design for recycle streams at 15% to maximums of 50-75 % P return.
- Design flexibility into sizing of anaerobic and aerobic zones in biological nutrient removal facilities.
- Provide sufficient aeration in first aerobic zone.
- Provided backup systems for chemical, volatile fatty acid addition, etc.
- Provide flexibility in systems for chemical dosing.

Questions during WERF workshop were related to glucose accumulating organisms versus phosphorus accumulating organisms. There is a difference that needs to be understood.

*Las Vegas/Clark County Area Low Effluent Investigations -- JB Neethling (11:20 to 11:45)
See Appendix H for slides*

The City of Las Vegas ran pilot tests to evaluate achieving a range of potential future effluent TP limits of 0.2 mg/L, 0.09 mg/L and 0.02 mg/L. The tests compared unfiltered Ortho-P, filtered Ortho-P, and TP for tertiary treatment options of single and two stage filtration of the effluent from the existing BNR treatment plant. Full scale experience has shown that increasing the ferric chloride feed to the primary clarifiers and the polishing alum dose to the effluent filters can achieve slightly less than 0.10 mg/L TP so the existing process would meet the 0.2 mg/L target. Single stage filtration with increased alum feed ahead of the effluent filters provided a mean TP of about 0.06 mg/L and two stage filtration provided a mean of about 0.04 mg/L TP. They concluded that membrane treatment would be required to meet the 0.02 mg/L target. The City also found that filter backwash and centrate are significant sources of phosphorus that could be reduced by separate side stream treatment.

Clark County, NV has conducted extensive studies on a BNR activated sludge followed by tertiary treatment. Optimization of activated sludge and tertiary chemical addition has produced effluent TP concentrations of 90 µg/L. Analysis of the causes of spikes in effluent TP concentrations showed that they were typically related to mechanical issues such as aeration shut-down, broken header, alum shut down, etc. A lesson learned is that as conditions change, effluent changes and that there will be variability from control problems, mechanical breakdowns, etc. EPA pointed out that NPDES regulation states that mechanical breakdowns cannot be a defense for a failure to treat unless the best engineering practice would not typically require a back-up for the mechanical breakdown. Sludge management practices also impact the variability of P removal. Water treatment engineers talk about 2 or 3 barriers to prevent pathogens from breaking through the treatment process. Perhaps the same strategy is needed for wastewater P removal.

Report from City of Spokane Pilot Studies – Larry Esvelt (presenting) Lars Hendron (not presenting) (11:45 to 12:00) See Appendix I for slides and supplemental report.

The City conducted pilot testing of Trident[®], Trident[®] HS (high solids version of Trident), Dynasand[®] D2, ZeeWeed[®], and Actiflo[®] in 2005.

The Trident and Trident HS plants appeared to have better and more consistent performance when comparing the 99th percentile results. All of the pilot plants, except one, appeared to meet a 99th percentile value of 100 ug/L. The 99th percentile values for TP (range due to variations in results from different labs): Dynasand – 29-73 ug/L; ZeeWeed – 54-61 ug/L; Trident – 33-38 ug/L; Trident HS – 32-36 ug/L; Actiflo – 165 ug/L. All of the alum doses for the pilots were relatively equal. All of the pilot plants except Actiflo met the TMDL draft implementation plan TP objective of 50 ug/L at the 95th percentile values. None of the pilot plants even at the log mean level met the TMDL objective of 10 ug/L. The ZeeWeed membrane system did not appear to provide performance superior to the more conventional granular media filters.

Caution needs to be used in applying pilot plant results because:

- Recycle streams were not being processed in the pilot plants
- The residuals from the pilot plants are not imposed on the overall system
- Scale up factors are important – most of the pilot plants operated at 10 gpm or less
- All pilot facilities were being optimized by experienced operating technicians

The difference in measurements of effluent P concentrations between the treatment plant lab and the Anatek lab, both certified labs, is a significant issue.

Report from Coeur d'Alene Pilot Studies – Mario Benisch (12:45 to 1:00) See Appendix J for slides.

The objectives were to determine P removal capacity for effluent TP targets of < 50 µg/L and < 10 µg/L, design parameters, operations parameters, sizing and cost. The processes tested were Zenon ZeeWeed ultrafiltration (UF), Parkson dual sand filtration, Trident HS and Blue Water dual sand filters. The Parkson tests were run later than the other tests and Parkson data are not yet available. There was a period of problems with the Zenon chemical control system. Chemical doses were 25 mg/L and 15 mg/L as alum for the two stages respectively on the Dynasand[®], 6 mg/L and 6 mg/L as ferric on the Bluewater Technology, and 80 mg/L to 100 mg/L as alum for the USFilter and the Zenon system.

Other than the period of Zenon's chemical control problem, performance for all pilot units was about the same for TP with average values of 18-21 ug/L for the three systems. It appears that a target of 50 ug/L TP can be reliably met. Colloidal P passes through UF and there is not much difference between UF and sand filter results. Neither UF or granular filtration achieved the 10 ug/L target.

There was substantial variability of lab analysis of TP (plant lab and commercial lab) even though both labs use a method from Standard Methods. Variability was up to 100%.

Update August 23, 2004 Workshop Assessment of Candidate Treatment Processes – Group Discussion (1:00 pm to 1:55 pm)

Review and Update the August 2004 Assessment – Glen Daigger See Appendix K for slides.

The purpose of the 2004 workshop was to determine what technologies are ready for full scale applications. An organized methodology applying a set of criteria to each technology was used. Criteria included the understanding of scientific principles for a technology, understanding of the engineering principles for a technology, the feasibility of obtaining the resources to construct and operate the technology, and the level of proven demonstration. The technology must be capable of achieving a 30-day median TP of 50 ug/L.

Screened out:

- Nanofiltration (without chemical addition).
- Direct filtration with alum or ferric addition
- Contact clarifier with granular media filter with alum for polishing
- Ion exchange
- Distillation
- Evaporation
- MBR followed by reverse osmosis

Ten technologies survived the 2004 screening and were evaluated. Data collected since the 2004 assessment leads to the following conclusions about the technologies from that list of 10 that may meet a 50 ug/L TP target:

- Tertiary clarification plus granular filtration with alum addition can probably meet 50 ug/L on a median basis
- Dual sand filtration with alum addition can probably meet 50 ug/L on a median basis
- MBR with biological phosphorus removal and chemical addition can maybe meet 50 ug/L on a median and average basis
- MBR with biological phosphorus removal, chemical addition followed by microfiltration can meet 50 ug/L on an average and median basis and probably on a not-to-exceed basis
- Post lime treatment can meet 50 ug/L on a median basis and maybe on an average basis

One technology sometimes gets less than 10 µg/L - microfiltration followed by reverse osmosis.

To reduce P concentrations by three orders of magnitude, you will need more than one step because each process step gives you 90%: 5 mg/L >> 0.5 >> to 0.05 >> ?? Controlling the upstream concentration is as important as tertiary treatment. Control of colloidal solids may be key to go from 50 to 20 µg/L TP.

There are three areas to look to potentially meet 10 µg/L TP without reverse osmosis.

1. Optimize the upstream system so that you enter the tertiary system with relatively low P (under 100 µg/L).
2. Control of colloidal solids may be a key. Rock Creek data and other plants show Ortho-P down to 20 µg/L, never lower.
3. Ortho-P. Models in literature tell us that minimum soluble Ortho-P is 10-15 µg/L. Precipitation is in competition with sorption. Like activated sludge process, can get enhanced biology through retention time or through higher mixed liquor.

Pilot testing often produces more questions than it answers.

The ability of the operators and the facility capabilities must be taken into account when establishing effluent limits.

Large plants are sampled daily. Small plants sample less frequently and often are not required to sample daily. Often the small plants exercise flexibility in determining when to collect samples and may not sample when there are operating problems in the plant or maintenance tasks are occurring. So, the results from the small plants may not be a true indication of process performance.

Phosphorous bans are effective but limited to a certain level. The place where phosphorous reductions can be effective may be in the separation of urine from the waste stream.

Technology Development Requirements -- Group Discussion (2:15 pm to 3:10 pm)

Pilot Testing/Demonstration Project Needs and Objectives

Other Technology Development Requirements

Start-up and Full-Scale Operational Development for Spokane River Dischargers

This portion of the program was an open discussion of the above issues. The following notes summarize comments made by the workshop participants.

Diurnal flow and diurnal influent P loadings affect full scale plant performance but are difficult to replicate in pilot testing.

With such large capital programs, City/County councils must be involved in decision making and weighing risks.

Inland Empire Paper (IEP) has purchased a 1 mgd Trident[®] HS unit for large scale testing. Membrane manufacturers would not guarantee membrane life for IEP. Membranes are about 10x cost of other systems for IEP. Some technologies would not give guarantee to IEP on flows since pilot could only be scaled up to equivalent of 800,000 gpd plant and scalability can be problematic for some technologies.

Plants will operate well when operator is very attentive as is usually the case in pilot plant tests.

(1) Important to realize that pilot is not a smaller version of full scale plant.

(2) Use piloting as an opportunity to understand the science. By buying packages right away, you are forgoing some time to understand the science. Pilot testing can help explain the science, but it is difficult to scale a pilot to full scale plant size, since so many other variables are introduced. You will learn more by operating on a plant scale.

DBO contractors present said that piloting would not normally be done on a DBO project. However, the fact that the County will need to strive for lower P, means that DBO contractors like Veolia would like to pilot.

Vendors with pilot systems that they attempt to operate remotely show poor performance or excursions as evidenced by the results for Parkson at IEP and Zenon at Coeur d'Alene.

Rates associated with the increased treatment requirements are a political aspect which public officials must handle. The rate increases required to reach the phosphorus levels defined in the Managed Implementation Plan will be significant.

Adjusting pH downward to the 6.0 range to optimize phosphorus removal by coagulation has been practiced in the past but did not seem to get much attention in some of the pilot tests discussed today. Generally, a discharge of a pH of 6.0 is not a problem.

Plant-Specific Application of Advanced Technologies -- Group Discussion (3:10 pm to 4:00 pm)

Candidate Processes Scheduled for Demonstration Testing by the City of Spokane – Dale Arnold and Lars Hendron (Larry Esvelt presenting) See Appendix L for slides.

The City is planning further pilot testing. Their goal is to have an open, transparent process with input and participation by others. The plan is to have a peer review committee made up of technical experts and an oversight committee made up of regulatory and environmental community and public representatives.

Treatment systems to be tested must be usable in a large (40 mgd) plant and be likely to approach an effluent goal of 10 ug/L TP. Likely will require two compatible stages of treatment.

Preliminary specific process considerations include:

- Chemical coagulation, flocculation, sedimentation, 2 units, 0.5 mgd or more each with inclined plant settler and ballasted sedimentation to be tested
- Downflow granular media filter.
- Upflow continuous backwash filter.
- Membrane filter
- Each filter will accept influent from each of the two sedimentation units.

Timeline

- Fall 2006 for concept design, peer review and oversight review started.
- Winter 2007 for procurement, contracting, installation.
- Spring 2007, start-up and peer/oversight review.
- Summer of 2007 through Spring 2008, ongoing operations and peer/oversight review
- Summer of 2008, continue operation of pilot and develop final reporting and recommendations with peer/oversight review.

In making a process recommendation, the City will consider cost, site compatibility, effects on all pollutants, compatibility with other policies such as the delta alternatives and flexibility for further improvements.

The City is looking for input from people to help with the evaluations and review the compatibility with other policies (“delta” approach defined in Managed Implementation Plan).

The City has budgeted \$2-\$4 million for the pilot tests.

Comments were then offered by others on plant specific applications.

Spokane County is planning to finish the wastewater facility plan by January. Spokane County will look at alternative delivery methods. If there are pilot tests, and if conventional design-bid-build is used, pilot tests will be done next year.

Ecology thinks that the pilot testing insight gained today fits the MIP and collaboration process. Ecology allocated 2 years for that (2006-2007).

According to EPA, the rules say, “Thou shall put in average monthly limit and average weekly limit unless impracticable.” In the context of nutrient limits, some regions have determined this to be impracticable and it makes more sense to have limits averaged over a longer period of time.

If you are going to do reuse, it is effective in middle of summer when it makes more of a difference in the reservoir. Ecology has discussed this internally and needs to discuss this with dischargers. More modeling is needed, but Ecology is intrigued by the notion and wonders how receptive the stakeholders would be.

Summarize Conclusions and Recommendations – Group Discussion (4:00 pm to 5:00 pm)

Some general comments were *offered by participants*.

Spokane County notes that this is second collaborative workshop that has been conducted amongst the regional group. This has been beneficial and it would be a good idea to have another workshop in the future. The next one may need to be a year from now.

The region is on the leading edge of phosphorous removal by setting the lowest level in the country.

A desire was expressed to reconvene group next year.

Summary from Gordon Culp:

Summary comments:

- Meeting goals identified by participants at start of session were accomplished.
- Richard and Len provided status of Ecology's plans for carrying out the Managed Implementation Plan.
- Results of phosphorus removal at many plants were presented. In general, the best results were in the 20-30 ug/L range and were being achieved by a variety of processes. There were some exceptions that were achieving better results: two very small plants with very limited data and two plants in Breckenridge, Colorado. The reasons for the differences in performance need to be better understood.
- There is substantial variability in P removal performance and in the chemical analysis for P that must be considered when establishing treatment performance requirements.
- There is a long learning curve in starting up the operation of new P removal plants that must be considered.
- Several design issues raised in WERF report were described.
- The removal of colloidal, refractory P is a potentially fertile area for research.
- The City of Spokane and Inland Empire Paper described their pilot plant plans, Spokane County described the status of their planning.
- There is a willingness to share data as work proceeds.

Detailed Notes

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Introduction and Boundary Conditions for Discussion (8:00 am to 8:30 am)

Gordon Culp (Smith Culp Consulting) and Group

Dischargers were asked what they wanted to accomplish in the workshop with the following responses:

Bruce Rawls (Spokane County):

- *This workshop started as Spokane County workshop. Then changed to a limited invitation. Later opened the workshop, so more people could benefit.*
- *Goal is to build a body of knowledge.*
- *Motivated as discharger to get as low P as possible with technology at most cost-effective way and come together as a collaborative group to share information.*
- *Up to now, we've been collaborating on the TMDL process, now as a group we should be collaborating on technology.*
- *The workshop in 2004 was a closed workshop and this caused problems. We've learned that this process needs to be open and transparent.*
- *After this workshop we need to decide where do go from here. Do we have another workshop to update the group on continued testing and data gathering? Do we have additional pilot testing?*
- *August 2007 could be another workshop to bring results of pilot tests and information about what we've learned.*

Tom Agnew (Liberty Lake Sewer District):

- *Just finishing WWTP upgrade.*
- *New facility from 1 mgd to 2 mgd WWTP.*
- *Next phase is low effluent P.*
- *Pilot testing might include joint pilot testing with Spokane County.*
- *Today, looking to get idea of technology to begin to talk about next phase.*
- *Small contributor to problem, but contributor nonetheless. We need answers.*

Lars Hendron (City of Spokane):

- *City is in attendance to share what they have learned. Both of our engineering consultants are here as well as other City participants.*
- *City of Spokane will be doing more pilot testing over the next 18 months. City plans to share what they are doing and enlist participation (oversight and peer review).*

Doug Krapas (Inland Empire Paper):

- *Inland Empire Paper (IEP) has a unique situation as a pulp and paper plant.*
- *IEP is ahead of everyone else having pilot tested 6 technologies.*
- *IEP will share information about problems in this workshop and IEP is interested in others' experiences.*
- *Based on their studies, there are many problems in trying to get low P. Chemistry is not straightforward. The nature of IEP's influent requires high chemical dosages for P removal which generates a lot of sludge. One piloted technology (Trident High Solids filtration system) had risen to the top. IEP is now proceeding with full scale installation.*

Bud Leber (Kaiser):

- *Want to get an understanding of what is available and applicable. Groundwater remediation, river intake, groundwater intake are issues of concern to them. They have 6 internal outfalls to consider in developing a compliance plan.*

Dave Clark (Consultant for Coeur d'Alene):

- *Coeur d'Alene has expressed some concern over the EPA's suggested timing on permit limits in Idaho versus the schedule across the border in Washington.*

Paul Klatt (Consultant for Hayden):

- *Echo Dave Clark's comments. Wants information on technology and timing of permits.*

Terry Werner (Post Falls):

- *Timelines in draft permit are difficult for this fast growing community..*

In summary, the agencies present for the workshop wish to accomplish the following:

- Build body of knowledge
- Collaborate on how to apply technology
- Create a transparent process for environmental groups and regulatory agencies
- Share results from pilot testing and plans for future pilot testing
- Discuss available technology for next phase
- Share info from visits to plants producing low effluent phosphorus
- Identify peer review opportunities
- Discuss timing of Idaho requirements
- Discuss Washington permitting schedule

Update on Spokane River TMDL and Managed Implementation Plan (8:30 am to 9:00 am)

Richard Koch and Len Bramble (Washington State Department of Ecology) See Appendix A for slides.

Presentation Topics:

General Update on Spokane River TMDL

Managed Implementation Plan (MIP)

Effluent requirements and schedule

- Local Jurisdiction Consideration and Hopefully Approval
- Update Draft DO TMDL
 - Draft release for public comment Fall 2006
 - Submission to EPA Winter 2006
 - EPA approval expected Spring 2007
- Managed Implementation Plan Formal agreement expected Fall 2006

Basis for NPDES permitting

- Focus on collaboration.
- Initial Phase was a long process, but beneficial. Brought many folks out of corners of the “ring” and into ideas, perceptions, etc. Have now arrived at local jurisdictions endorsing the collaboration.
- However, the initial phase leads to much more work.
- Ecology has hired a new Spokane River TMDL lead

- MIP is perhaps one of the most critical items to us in the room. “Rubber meets the road.” How do we define the paths to achieve the goals?
 - 20 yr implementation
 - 10 yr check-in
 - 20 yr compliance
 - Units of mass versus units of concentration
 - Define the delta, actions other than effluent P reduction that will reduce the P load to the Spokane River
- Part of delta identifies “target pursuits actions.” Make-up of delta items, includes pollutant trading, Non-Point Source and Point Source control, conservation, reuse, etc.
- We need to get our arms around treatment technology. Technology workgroup has identified 120 facilities around the country as sources of information. This meeting, future meetings, pilot testing, etc. will be very interesting to Ecology in making a decision that may not be easy.
- It has not been decided how this TMDL will be addressed in engineering reports and WWTP permits.
- Ecology is paying attention to what EPA is doing in Idaho. We would love to be consistent, but on some things we cannot.
- Ecology is struggling with how to calculate interim limits, final limits, and delta projects. Ecology is working on how to calculate the delta P reduction.
- For the implementation and compliance schedule, Ecology anticipates issuing permits in first half of 2007. Ecology will try to not stay too far behind EPA in Idaho. Pilot testing, engineering reports, decisions, milestones, etc., take time and help guide both the regulated and the regulators.
- Idaho facilities have done some pilot testing. Ecology compliance schedule will include some pilot testing. The Managed Implementation Plan includes development of a technology selection protocol so everyone understands expectations. Then, move into engineering reports.
- Idaho and Washington permits are comparable on schedule.
- “Fundamental Concepts” doesn’t have delta elimination plan.

Q&A

Sid Fredrickson (Coeur d’Alene):

- *EPA is not playing the game. In Idaho, there is a compliance requirement on a 4.5 year schedule, not 10 year.*

Richard Koch:

- *We are not with EPA. However, facilities will be 50 µg/L or less effluent P within this first permit cycle in Wahsington. We need a permit period that allows dischargers to get there.*
- *Need good, reliable data that shows how close we are to 50 µg/L effluent TP.*
- *Both ID and WA permits have a good time period to get data, so that when 10 yr assessment comes, we have data to use.*
- *Could find that 50 ug/L TP is a challenge and operators will have a learning curve. EPA only talks about the first 5 years, but Ecology recognizes parallels on how the process is envisioned. This is outlined in “fundamental concepts.”*
- *Ecology has found it difficult to set limits on how technology is performing. This influences how to approach the delta projects.*
- *Definition of the delta projects and how they are credited to an agency will probably show up in 2nd 5 years based on actual data.*

Bruce Rawls:

- *Does the delta elimination program for one discharger allow trading only within their program?*

Richard Koch:

- *Ecology is discussing internally how Delta projects are defined and how credits are managed amongst dischargers. This will leave some room to trade. Ecology is not sure there is anything to trade until we find enough of a delta for a discharger to trade.*

Bruce Rawls:

- *My understanding is that each discharger could do what they can to remove P from river and then find difference in trading. This process has the chance of getting convoluted.*

Richard Koch:

- *We need to figure out how to manage this process as well as the calculations. As we move forward, we will be looking for potential bombs.*

Doug Krapas (IEP):

- *How do you see the NPDES permit cycle? Are you planning on working on NPDES permits while this is going on? When will you want engineering reports submitted?*

Richard Koch:

- *Submittal of engineering reports will be difficult until we figure out how to calculate load reductions. For example, how do you estimate P removed by sewerage septic systems? Ecology has looked at timing of NPDES permits. April 1, 2007 is earliest - most likely May. Three permits expire June 30, 2007. Ecology's goal is to have everything done and issued by then. If we get done early, then good, but processes must be followed.*

Dave Clark:

- *Bruce's comment has gotten me to think about accounting associated with trading. In discussion of the TMDL lead - Is Ecology's vision that Ecology will do the accounting, or will dischargers account? Who?*

Richard Koch:

- *Our thought is that the "oversight group" will oversee the P trading accounting, rules, and tracking. Everyone can see how it is going, etc. and can track water quality improvement in the river, Long Lake, etc.*

Dave Clark (HDR):

- *I notice you added tracking river water quality on the oversight group responsibilities. Seems like the oversight group is taking on a lot of management responsibility.*

Richard Koch:

- *Yes, there are dozens of simultaneous paths. These are just the initial implementation stages.*

Glen Daigger (CH2M Hill):

- *As there was a discussion of trading, East Coast is currently Nitrogen trading in Connecticut (Long Island Sound) and Virginia (Chesapeake Bay), tracking pounds discharged and exchanging money.*
- *Virginia has setup a trading organization that is funded for the administration of trading. The organization is formed by dischargers. I mention this to say that there are some models out there. These are larger scale organizations. However, all dischargers are in the State or watershed. I believe we can learn something from these ongoing activities..*

Mark Laquidara (Metcalf and Eddy):

- *P load bank helps tracking.*

Richard Koch:

- *There is also the possibility of applying credits for meeting goals ahead of the compliance schedule. For a treatment plant that has difficulties in achieving appropriate funding, they could "pay the bank" in order to achieve compliance.*

Brian Nickel (EPA):

- *The actual trading of credits could be done by a 3rd party or State.*
- *Is it enforceable and are they making the reductions they say they will make? Also, at the end of the day, any scheme must meet the water quality standards or reduction goals of TMDL, even when looking at opportunities for trading outside discharge limits. There are a lot of ways to get there.*

Glen Daigger:

- *In Connecticut, the state holds the permit which has brought forward a number of interesting legal liabilities. Not sure what happens if the State is not in compliance. The State holds the general permit for Connecticut.*

Dave Clark:

- *Richard is the only one who has seen the permits in Washington. For Idaho, in the Region 10 draft, there are daily values and maximum weekly values. What about Washington?*

Richard Koch:

- *The “fundamental concepts” talked about a seasonal average. Ecology is honoring that.*
- *Secondly, pick a target. The TMDL says 10 µg/L P. The delta elimination plan (DEP) is not yet written. Details of how to review and implement are forthcoming.*
- *There is still a large unknown. Idaho does not have a DEP, so EPA is approaching their compliance differently. Dischargers will make comment at the appropriate time.*

Len Bramble:

- *Obviously, the subject of trading could have its own workshop.*

Brian Nickel (EPA):

- *EPA’s trading workshop is 3 days.*

Len Bramble:

- *This just shows how difficult the paths are to select.*

Overview of Candidate Treatment Processes for Extremely Low Effluent Phosphorus (9:00 am to Noon with Break 10:00 am to 10:15 am)

EPA Evaluation of Phosphorus Removal at WWTP’s Across the Country - Status Report by Brian Nickel (U.S. Environmental Protection Agency) See Appendix B for slides.

- No numbers today. Haven’t analyzed DMR data yet.
- The EPA has visited 15 WWTPs. More visits coming.
- With the initial Site visits wrapped up, EPA is collecting and analyzing DMR data and onsite data to interpret actual removal performance.
- EPA wants WWTP folks to review the draft to make sure data are represented correctly.
- WWTPs visited include:
 - Washington and Oregon
 - Quil Ceda Village WWTP (4 mgd) – MBR. No P limit. MBR is being considered for plants in the Boise River. Advanced WWTP.
 - Rock Creek Advanced WWTP
 - Durham Advanced WWTP
 - Hayden WW Research Facility
 - Massachusetts
 - Colorado
 - Virginia
 - New York
- Common themes for wastewater treatment technologies. Secondary plant with coagulant/polymer addition, BNR, filtration. Both large and small plants.
- Unique concepts include Procept, MBR, and CoMag.
- Capacity and performance. 5 mgd to 80 mgd. Collecting P data now. All plants are removing P. Some producing effluent TP concentrations as low as 7 µg/L. All within 0.1 – 0.2 mg/L range. Performance analysis to come. Some are getting well below effluent limits. Not a gauge of what is actually achievable.
- EPA will issue a draft report in September.

Q&A

Bruce Rawls:

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- *What is the intended purpose of the study?*

Brian Nickel:

- *Get more info out there. Some reports are good, but tough to find a comprehensive reference of technologies, reference plants, etc. Dischargers need a good reference on the shelf when faced with a low P limit. Technology transfer type of document.*

Lars Hendron:

- *There was discussion of peer review of the report. Is there consideration for this?*

Brian Nickel:

- *WWTPs will review. Not sure of other reviews.*

Sid Frederickson:

- *Observation – Seeing results reported in 7 µg/L. “Standard Methods” detection limit is 6. I am skeptical of averages less than 10.*

Brian Nickel:

- *Agree there are detection limit issues. EPA is not sure how to address this. Could be compounded by fact that permit limits for the majority of the plants visited are for less than 1 mg/L, so there is no need for lower measurements. As long as the low P measurement is below the permit limit, then regulators are not compelled to question or be skeptical of the measurement. Likewise, there is no reason for dischargers to focus in on the accuracy of these extremely low measurements when they are an order of magnitude lower than the permit limit.*

JB Neethling (HDR):

- *Have you considered design capacity versus actual flows?*

Brian Nickel:

- *Not sure how authors will discuss. May address that plants operate below capacity.*

Update on Review of Exemplary Plants from November 2005 – Dave Reynolds and Dave Clark (9:15 -10:00) See Appendices C and D for slides.

Dave Clark’s Presentation:

- *Presentation will cover many of the plants Brian mentioned that EPA will review.*
- *This report surveyed plants across country known to be exemplary in terms of P removal and captured trends in size and technologies by looking at daily data on plant performance.*
- *Then, present statistical analysis along the lines of a regulatory agency for performance.*
- *10 plants were studied.*
- *Update from meeting in Dec 2005 - we’ve identified factors that we feel are important for performance and issues of interest.*
- *It is difficult to get daily data from some of the plants. Some had 2004 data and part of 2005. Bottom line is that these are really terrific WWTPs. These plants provide an order of magnitude lower effluent P concentrations than average plants. Of interest is the broad range of technologies.*
- *As an update on plant performance, we’ve added data from the fall of last year, plus rest of 2005, and the start of 2006 to determine if there have been any changes from last fall. There was one data glitch from Walton last summer. Generally, 2004 data in year 1, partial 2005 in year 2. Update includes all 2005 and part of 2006.*
- *Note that the permits are not always written the same way. For example, Tualatin permits have been relaxed.*

Q&A

Bonnie Beavers:

- *Are you using process control data or DMR data?*

Dave Clark:

- *This is daily lab data used for calculating DMRs. These are certified lab data. Individual dots are not reported in DMR. Some plants have multiple datasets because they do quick analyses for process control. Everything shown here is used for permit reporting.*

Bonnie Beavers:

- *Do you have new data since November report?*

Dave:

- *Yes, additional data to get into 2006.*

Doug Krapas (and others):

- *I question the reliability of reporting numbers with averages as low as what is being reported.*

Glen Daigger:

- *As said earlier, when plants are an order of magnitude below their permit limit, than few people question the number.*

Dave Clark continued presentation:

- *Walton 2005 – Log Normal Mean = 0.008 mg/L*
- *Walton 2006 – Log Normal Mean = 0.007 mg/L*
- *Performance is extraordinary. This is a small plant with contract operation. They only have a couple samples per week, so we don't see, perhaps, the daily variability.*
- *Note some values at Walton are as high as 50 µg/L. Yet, log normal mean is very low.*
- *Stamford 2005 – Log Normal Mean = 0.012 mg/L*
- *Stamford 2005 – Log Normal Mean = 0.012 mg/L*
- *Good performance. Notice variation from mean.*

Q&A

Doug Krapas.:

- *That is why I question testing methods. We could send samples to 3 different labs and get 100% variability.*

Dave Clark:

- *New York DEQ has certified some labs. This is analysis done at certified labs, NY EPA has certified these labs.*

Doug Krapas:

- *But you don't know methods.*

Dave Clark:

- *Testing methods were not provided or available, but the state of NY has bought into certifying the lab.*

Sid Frederickson:

- *There is an absorbic acid method that gets you to 3-4 µg/L range.*

Bonnie Beavers:

- *Why are they spending the money to get these tests?*

Dave Clark:

- *Original testing was for drinking water quality protection.*

Glen Daigger:

- *When numbers are below permit, they might not be the right numbers. Lesser QC on data when numbers are below permit limits.*

Brian Nickel:

- *Yyou are reporting" less than value" as that value. By definition, they are getting less.*

Dave Clark:

- *Yes, the less than 50 could be 5.*

Brian Nickel:

You can handle values less than detection limit a number of ways. You can say value is 0, as long as it meets the detection level.

Dave Clark continued presentation:

- Made some comparisons of 10 plants and performance. Performance was similar in larger plants, even if technology was different. Plants with lower concentrations were smaller and less solids processing on site.
- Less intensive solids processing (or no solids processing) results in lower P. Solids recycle influences P removal performance.

Q & A:

- *Do we have influent data?*

Dave Clark:

- *Mostly had effluent. When we had the influent data, it was around 3-7 mg/L.*

Bonnie Beavers:

- *My observation was quality of plant operation made a big difference. Alexandria reported to Sierra Club 50 µg/L. They take pride in the plant.*

Dave Clark:

- *Mario will be commenting on attention by plant operator to P removal.*

Dave Reynolds Presentation:

- Rock Creek pilot testing and data analysis, lab challenges. Rock Creek is the largest plant producing an effluent with less than 100 µg/L TP. Effluent limits were relaxed in 2004.
- Process adds alum ahead of primaries and ahead of filtration.
- Eff TP 2001 = 60 µg/L
- Eff TP 2002 = 53
- Eff TP 2003 = 50
- Eff TP 2004 = 80
- Eff TP 2005 = 70
- Limits have been relaxed. Rock Creek has been removing P for 20 years.
- Performance represents their experience. At end of 2003, log normal average was 50 µg/L.
- Rock Creek quantification limit is 25 µg/L. One great month may not get you a good indication of performance. Some points above 100 µg/L. There are seasonal trends. Monthly, weekly, and daily averages can be quite different – be careful with statistics.

Q&A

Richard Koch:

- *How long should we look at pilot testing?*

Dave Reynolds:

- *Might need to go over a full P season. However, remember that pilots never start-up perfectly. Sometimes the pilot might need a season to work properly and to dial in the process by adjusting chemical doses, loading ranges, etc.*

Sid Frederickson:

- *Pilot testing does not incorporate the effects of diurnal and seasonal peak flow variations. In a Trickling Filter/Solids Contact plant, as temperature changes, so does the settleability of solids. We wanted to capture swing. Treatment process has a lot to do with setting up pilot test and challenges in getting good numbers.*

Doug Krapas:

- *Plants need the ability to conduct the low level testing that can be conducted in their own lab in order to get real time data to make process changes rather than waiting up to a week to get process data.*

Dave Reynolds continued presentation:

- Effluent for 2003: Log normal avg – 50 µg/L
- Coefficient of Variation: 0.48
- 95th percentile compliance
- Monthly max (20 samples) 59 µg/L
- Weekly max (5 samples) 68 µg/L
- Daily max (1 sample) 89 µg/L
- Lessons learned. Total phosphorus varies. Watch statistics. Multiple feed points of chemical addition provide good treatment flexibility.

- Analytical P measurement is an issue. Data from pilot testing at Spokane from two labs showed significant differences between results from same samples.
- Analytical issue needs to be investigated before pilot testing. Low P levels induce higher variability in testing.
- Variability in testing needs to be understood before pilot testing or NPDES permitting.
- Training approaches are needed. If not resolved, regulators need to recognize that this will be an issue for treatment plants, especially small WWTPs.

Doug Krapa comment.:

- *Need improved analytical methods.*

Dave Reynolds continued presentation:

- Pilot testing compares side-by-side processes and provides a means to evaluate chemical requirements. It is only an approximation.
- Pilot testing allows evaluation of unit process loading rates. Put processes together, might use to identify minimum achievable Total Phosphorus.
- May also evaluate alternate operating/control strategies.

Q & A

Sid Frederickson:

- *We don't test the effects of diurnal flow variation and diurnal influent P load in pilot testing.*

Dave Reynolds:

- *Considerations for pilot tests – Length of time, statistics, seasonal variation, size, etc. How much do you know about the process and what will I learn by making it bigger?*
- *Will you have an ability to scale up? What is the feasibility of piloting processes together? Solids handling and recycle? Cost (equipment, operation, data, etc)?*
- *Results – Site specific data. Chemical requirements. Requires interpretation by qualified engineers who don't often agree. Some questions will be unanswered, but often many more questions will arise.*

Dave Reynolds continued presentation:

- Concluding remarks – Decision making will be frustrating. Data will be incomplete, imperfect, and conflicting. Build flexible facility. Recognize learning curve in starting up a new plant or process. Beware of weird science – be skeptical of processes without a sound scientific basis.

Q&A

Tom Agnew (Liberty Lake):

- *Mentioned that data in graphs appear to defy statistical probability with consistency and low level of P removal performance. Additionally, a flat line of data is impossible which adds further question to the measurement validity. If we are skeptical about the numbers, then are we saying that we don't have good data and we need to develop our own data?*

Dave Clark:

- Numbers are questionable, but we can learn from the plants and the data give us trends.

JB Neethling:

- Flat line of data is not problematic because the level measured is at the detect level which means that data points are actually below this line. The problem occurs when testing occurs on the same effluent with different labs and plants receive different measurements. This provides difficulty in interpreting results.

Report from Site Visits to Colorado Plants – Larry Esvelt (10:00 to 10:30) See Appendix E for slides and supplemental paper.

Site visits were driven by P limits in Moscow, ID. Plants were selected that would fit into Moscow's objectives.

- Aurora WWTP – Scalping plant. 5 mgd. Normal 2.5 – 3 mgd. Primary clarifiers, biological treatment, filters, UV. No sludge handling. Residuals back to interceptor. Used data in analysis that are used for compliance reporting.
- Moscow shows consistent curve. Aurora, sand creek shows 50 µg/L eff TP. Moscow is around 500 µg/L eff TP. Seasonal variations – students coming and going. Can't take "one-size-fits-all" because we are starting in a different place.
- Medical Lake, WA. Uses 50th percentile or higher because of reporting. Adding chemicals in secondary clarifiers.
- Breckenridge, Iowa Hill – Scalping plant. 1.5 mgd. Normal flow 0.5 to 1.0 mgd. Activated sludge, nitrification, chemical precipitation, filtration (upflow, continuous backwash), disinfection. Alum dose = 150 to 200 mg/L. Discharge to Blue River (Dillon Reservoir owned by Denver Metropolitan Water District). Distinct improvement through each step. 10 µg/L through 50th percentile.
- Breckenridge, Farmers Korner – Conventional flocculation. Activated sludge. Filtration. 7 µg/L. Arithmetic mean used versus log mean (there is a difference).
- Frisco, CO – Design flow 1.7 mgd. Not doing quite as well. Recycle all sludge from effluent polishing back to headworks. Appears that they may be getting dual adsorption onto chemical floc.
- Snake River Plant – Arapaho Basin. High winter flows during ski season. 2.6 mgd. (See slides.) Inclined plate settler. Conventional media, deep bed filter. Doing best of treatment plants per dollar basis.
- Pinery Plant – 2 mgd. Normal 0.65 mgd. BNR, flow equalization, package units for effluent polishing. Clarifier is sorption clarifier with upflow and downflow media, similar to system IEP will use on a larger scale. Log mean is 30 µg/L. BPR is very similar to Aurora and Medical Lake. Moscow data looks better than previous data.

Summary:

- In the plants studied, there is not a big difference in what they can achieve with results of 30-50 ug/L P being typical. Performance has a lot to do with chemical dosing. Cost per pound of P removed should be evaluated with the selection of treatment technology.

Q&A

Doug Krapas:

- How are they dewatering fine chemical flocs?
- How will reject stream be handled? Concern with re-assimilation of phosphorous.

Larry Esvelt (Esvelt Engineering):

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- For the ones that are dewatering, they are sending it to a closed mine. Belt filter presses and centrifuges are used for dewatering to achieve. 15% solids after dewatering. Bring back solids to headworks and settle in primary.

Bonnie Beavers:

- Eastern plants are doing this.

Larry Esvelt:

- Most the plants reviewed combine secondary and tertiary solids and dewater for disposal. The P does not appear to re-enter the process but stays adsorbed.

Remy Newcombe:

- We do that at Hayden and we get no re-entry of phosphorous. Solids settle in primary. Iron settles better than alum.

Larry Esvelt:

- All of these plants use alum as the coagulant.

Sid Frederickson:

- Concern when we dewater, belt press, centrifuge, etc, Filtrate or centrate should be removed from treatment stream because when you send it back to headworks, you are re-introducing P load.

Larry Esvelt:

- All of these plants are removing sludge within 3 days. If you wait a week, it recycles back. The process optimization requires some trial and error.

Report from EPA Tour of Reference Plants (Syracuse, Blue Plains, Concord/Alexandria) – Lars Hendron (City of Spokane) and Mark Laquidara (Metcalf and Eddy) Gerry Shrope (not presenting) (10:30 to 11:00) See Appendix F for slides.

- Goal was to visit plants that are similar to Spokane in age, flows, and processing of solids onsite.
- Also, get council members involved as we move forward.
- Improve communication with large group by offering regulatory and environmental participants an opportunity to see same.
- Plants >30 mgd. (Blue Plains, Alexandria, and Syracuse)

Blue Plains – DC Water and Sewer Authority.

- Effluent is managed secondary flow. Other outflow for wet weather. Single point addition of ferrous chloride upfront of primaries. Add methanol for denitrification with multi-point feed capability. Wet weather management diverts flows around secondaries to manage the peaking factor.
- Reported averages around 110 µg/L TP. Permit limit is 180 ug/L with maximum days of 350 ug/L.
- Algae was issue with some of the filters. Provide NaOCl for disinfection upstream of filters.

Alexandria, VA

- Ferric and alum added at 3 points – after primary clarifiers, in secondary clarifiers, and ahead of rapid mix floc tanks. Claim they can meet 50 µg/L TP on a semi-continuous basis. Well run plant.

Doug Krapas:

- Why use both ferric and alum as coag?

Mark Laquidara:

- Safety. Did not want to add ferric upstream of UV.

JB Neethling:

- Las Vegas does same. Ferric upfront for odor.

Glen Daigger:

- Ferric is less expensive in east. Alum is less expensive in west.

Syracuse, NY

- Avg 85 mgd. Peak 126 mgd.

- Using ferric and polymer in Actiflo® to achieve P removal. Primary plant, activated sludge (attached growth), followed by Actiflo®.
- Start-up issues. Ferric addition was impacting UV equipment (staining). Some quartz carry-over that looked like it was etching the UV equipment. Operations has since solved some of those issues, such as cleaning products for UV. Piloting Parkson Dynasand® after Actiflo®. Seasonal UV disinfection – solved some algal problems (remove sunlight).

Summary

- Plants performed very well at 50 to 150 µg/L TP. All permits used time averaging.
- All required extended operation shake-down periods, learning curves, lessons learned.
- Syracuse reported plant engineering and coordination issues. They feel this should have been corrected.
- “Water treatment” technology being applied to wastewater industry.
- Piloting and further optimization is still needed.
- Facilities have extensive SCADA or automation (or at least included in upgrade).
- High level treatment, flow equalization in large plants. High level treatment processes tend to require a lot of attention/witness (operator awareness).

New technology – CoMag.

- Not advocating this, but information was presented during the tour. Concord, MA has been operating a pilot plant with flows of 0.07 to 0.2 mgd. 50 µg/L TP achievable during pilot. Tested alum, ferric, pH adjustment.
- Essentially ballasted sedimentation with magnetite. Remove microsand with magnets. Solids recycle to form larger particle. Coagulants used are alum or ferric, pH adjustment, polymer, and magnetite. Option to provide a polishing magnet on final discharge line to pull out magnetic carryover from process without the headloss that would occur in a filter.

Q&A

Bruce Rawls:

- *What length of time is necessary to optimize and collect enough data to analyze? How low can you go?*

Gerry Shrope (CTE Engineers):

- *The plants that they visited historically were using one season to optimize plant (6 – 8 month optimization period).*
- *The amount of time to collect enough data to discover a confident 95% level of P depends on treatment process and level of removal. Magnetite filtration was a unique process.*
- *In the CoMag process, the polishing step of magnetic attraction does add some removal of floc that’s attached to the fine pass-through sand from the process.*

Richard Koch:

- *The interesting point about CoMag was the applicability of footprint reduction because the magnetite media allows for faster settling than sand used in other ballasted flocculation processes.*

*Report from Water Environment Research Foundation (WERF) March 10-11, 2006
Workshop on Low Effluent Nutrients – JB Neethling (11:00 to 11:20) See Appendix G for slides.*

- Focus in the workshop was on Nitrogen < 3 and Phosphorus < 0.1
- Every process is unique and not one technology fits all.
- Dissolved oxygen is the key to biological processes.
- Ballasted sedimentation with magnetic separation. High alum dose (>100 mg/L) with reported effluent TP of 0.02 mg/L.

- Alum to P ratio shows solubility will run out at some point.
- Solubility limit previously was thought to be around 40 µg/L. Some adsorption of P on metal hydroxide flocs to get better removal.

Gwinette County (Porter).

- Interesting plant expansion.
- No clarifier/filter option.
- Go with plate settler to UF.
- Membranes are believed to be more reliable and robust.
- Data show granular media filter and membrane filtration provided similar effluent P concentrations.
- Membrane gives a little better performance (better solids capture).
- Still good removal with just the filter.

Berlin MBR.

- BPR and Nitrogen Removal.
- Based on distribution of effluent TP, they concluded that < 20 ug/L is unachievable.

Design issues

- Design recycle streams at 15 to 75 % return.
- Provide flexibility in design. Kalispell plant shows multiple reactors either aerobic or anaerobic. Profile of P through plant shows switching aerobic or anaerobic cells allows P to go lower. Point is to design flexibility into facility to accommodate changes in treatment.

Sid Frederickson:

- *Ortho P appeared to be extremely high in the Kalispell graph.*

JB Neethling:

- *The graph represents the Ortho-P release during the biological process. The numbers appear in the range seen in the industry. Numbers as high as 30 mg/L are not unusual at this stage in the process. It is important that you have enough time in your biological process to up-take the released P or the plant will really be in bad shape.*
- Be careful of tertiary release of P.
- Questions during WERF workshop were related to glucose accumulating organisms versus phosphorus accumulating organisms. There is a difference that needs to be understood.

Stealth Bio-P at the Rock Creek plant

- Chemical process, but believe that some Bio-P is happening.
- How to capitalize on day in and day out?
- Control pH in solids.
- Some question about kinetics of P removal.
- Both N and P might have refractory components.

Q&A

Doug Krapas:

- *How was the conclusion made in Berlin that there is a refractory component phosphorous of 20 ug/L that can not be removed?*

JB Neethling:

- *Unknown. The graphing does not shown any data below 20, therefore it appears a leap of faith without scientific back-up.*

- *The theory is that the biological process becomes phosphorous limited at some point. This is backed up with other data that has been measured in outside pilots.*

Las Vegas/Clark County Area Low Effluent Investigations -- JB Neethling (11:20 to 11:45)
See Appendix H for slides.

- Focus on 2 plants – Las Vegas and Clark County, NV.
- Data from full scale testing, pilot testing, and plant data.

Las Vegas

- At 91 mgd, need to meet 70 µg/L P. 3 TF plants. Add ferric to primaries prior to activated sludge for nitrification with coagulant addition to tertiary filters. 1 BNR plant. Combine effluent from BNR and TF plants prior to filtration.
- Compare unfiltered Ortho-P, filtered Ortho-P, and TP. Ortho-P is in 40 µg/L range.
- Pilot tested two stage filtration. After 2 filtration cycles, TP is at 40 µg/L. Ortho-P is around 30 µg/L range.
- Recycle streams are important sources of recycled P. Filter backwash and centrate are significant sources. If it comes back, you must treat it again.
- During period of upset, upped ferric dose to primaries and increased alum to filters. As ferric and alum were turned up, effluent TP turned down. Result less than 0.1 mg/L.

Clark County

- Doug Drury has conducted extensive studies on a BNR activated sludge followed by tertiary treatment.
- Secondary effluent splits between central plant and advanced wastewater treatment plant.
- Central plant has direct filtration. Advanced wastewater treatment plant has floc basin, tertiary clarifiers, and filtration.

AWT & Central Plant Outfall.

- TP 7/02 to 7/06 shows the start of optimization of activated sludge. Optimization of activated sludge and tertiary chem addition got to 90 µg/L P in final effluent.
- Lesson learned is that as conditions change, effluent changes. When designing facility, provide for features that allow flexibility to do optimization.
- When looking at excursions up close (daily data) you can see high variability.
- Documentation of reasons for excursions shows aeration shut-down, broken header, alum shut down, etc. You can see short term changes and the resulting variability in effluent data.
- Things happen. Operators need to take care of it.
- Recognize there will be variability in effluent quality when setting limits.
- Water treatment engineers talk about 2 or 3 barriers to prevent pathogens. Perhaps we should use the same strategy for wastewater P.

Q&A

Jim Hagstrom:

- *Temperature and growth are thought to be part of the recent P removal break down. Also, the vigilance of the operators and Doug Drury at Clark County is high.*

Bonnie Beavers:

- *What is the need to protect Las Vegas wash?*

Gordon Culp:

- *The wash is simply a dry drainage way (when effluent is not flowing through) that conveys the effluent eleven miles to discharge into Lake Mead. Protecting water quality in Lake Mead is the driver for P removal.*

Question:

- *Sludge management practices impact on variability of P removal.*

JB Neethling:

- *Interestingly, it depends on the treatment process of the plant, operations practice, and characteristics of the influent for the impact on the P removal.*

Brian Nickel:

- *NPDES regulation states that mechanical breakdowns cannot be a defense for a failure to treat unless the best engineering practice would not typically require a back-up for the mechanical breakdown.*

Report from City of Spokane Pilot Studies – Larry Esvelt (presenting) Lars Hendron (not presenting) (11:45 to 12:00) See Appendix I for slides and supplemental paper.

- *Pilot testing of Trident[®], Trident[®] HS, Dynasand[®] D2, ZeeWeed[®], Actiflo[®].*
- *Data presented are by treatment plant laboratory. There are other lab data available and Ecology has some data, too.*
- *Existing RPWRF constructed in 1977 removed P with chemical addition to activated sludge aeration basin effluent to final clarifiers. Chemical addition for P removal. Chemical precipitate recycles with RAS. Pilot plant results predicted 120 mg/L alum to 150 mg/L to get 85% P removal. However, now dosing at 80 mg/L alum and better than 85% removal.*
- *Trident[®] log mean is slightly above 10 µg/L.*
- *Manufacturer's task was to achieve lowest P possible.*
- *Parkson Dynasand[®] D2 unit. First filter 2 meters deep. Second filter 1 meter deep.*
- *First filter did not have great P removal, but after 2nd filter, P removal good. Perhaps achieve TMDL objectives.*
- *ZeeWeed[®]. About same effluent P as others. (Just less than 20 µg/L for 50 percentile)*
- *Actiflo[®] doesn't quite compare because treatment plant stopped its biological P removal during their test. So, take this into consideration when reviewing data. Also, this unit ran for a shorter period. Projected statistical result on a sparse data set indicates similar potential to others.*
- *All pilots together produced effluent TP of 15 to 20 µg/L at 50 percentile and 20 to 50 µg/L at 80 percentile. Once you look at amount of recycle and controlling side streams, this will be an interesting exercise.*
- *Notice the difference in measurements between treatment plant lab and Anatek lab. Both are certified labs. This difference is a significant issue.*

Q&A

Question:

- *Alum dose on each plant was about the same?*

Larry Esvelt:

- *All of the Alum doses for the pilots were relatively equal. The actual dose is not available.*

JB Neethling:

- *It appeared that the variation in laboratory measurements on the statistical charts showed that the certified lab readings were generally higher than the plant measurements, but how did the measurements compare when shown on an X-Y graph.*

Larry Esvelt:

- *The result was not consistent and the plot was scattered.*

Report from Coeur d'Alene Pilot Studies – Mario Benisch (12:45 to 1:00) See Appendix J for slides.

- Week to setup pilot plants, week to optimize.
- Parkson is still at plant.
- Suggest screening manufacturers first, then proceed with longer term testing.
- Parkson scheduling did not work out. They were not going when other pilots proceeded.
- Objectives < 50 µg/L. Can we get < 10 µg/L? Also to gather information for design parameters, operations parameters, facility cost.

Zenon UF.

- Single barrier process.
- One level of treatment.
- Option of turning into MBR if combine with activated sludge.

Blue Water.

- Similar to Parkson Dynasand®.
- Dual barrier.
- 2 sand filters in series.
- Tests at other facilities show promise.

Parkson Dynasand® D2.

- Dual barrier.

Trident® HS.

- Three treatment stages. Cationic polymer and option for adding chlorine in mixed media to reduce fouling.

Results

- Large excursion in Zenon data.
- Zenon operated remotely. Bad chemical feed. Took a couple days to react.
- Taking out excursion, all are about the same for TP.
- For OrthoP, most values near detection limit, except Zenon. For Zenon, it is suspected to be a control issue and more chem. is needed.
- Parkson data not yet available.
- Colloidal P passes through UF. Not much difference between UF and sand filter results.

Summary;

- Total Phosphorus for all of the technologies in the same ballpark.
- By eliminating control issue with Zenon pilot, Zenon would show lowest.
- Could require further chem. feed for further alkalinity supplement. TDS was not increased much (< 10% increase).
- Variability of lab analysis was an issue (plant lab and commercial lab get different results).
- Both use a method from Standard Methods.
- Variability was up to 100%.
- Resolution is only up to 10%.
- Can get less than 10 µg/L, but not using Standard Methods.
- This is an issue that needs to be addressed.
- All pilots had some amount of automation and each pilot needed some amount of attention.
- Training is required, too, to operate these processes. For instance, there is no flow pacing of chem. feed.
- All technologies produce about the same effluent quality.

- With any of these technologies, we seem to be able to do 50 µg/L or less.
- Full scale will need some high level of process automation, especially for chemical feed.
- Will need to run pilots on a diurnal basis to get a better indication of performance.
- Longer time to optimize could potentially get better results as shown by the slow improvement in P removal over time.
- Also, there is a question of whether the improvement in P removal is equated to process operation or simply a change in water chemistry?

Q&A

Larry Esvelt:

- *What is your experience in on-line P monitoring.*

Mario Benisch (HDR):

- *In Hayden, they've tested on-line with some issues. Trying to pilot online monitoring in Cour d'Alene but did not make it into pilot testing.*
- *There are different theories on control of chemicals based on location of P monitoring. As seen in Coeur D'Alene, a brief period of chemical error caused an extended upset in P removal.*

Remy Newcombe:

- *What were the chemical doses for the pilots.*

Mario Benisch:

- *25 mg/L and 15 mg/L as alum for the two stages respectively on the Dynasand®*
- *6 mg/L and 6 mg/L as ferric on the Bluewater Technology,*
- *80 mg/L to 100 mg/L as alum for the USFilter and the Zenon.*
- *This resulted in the alkalinity change. The alkalinity change was not reflected in the Zenon numbers for the chemical error period.*

Doug Krapas:

- *Was acid used for pH control?*

Mario Benisch:

- *Acid was used at the end of the pilot.*

Dave Reynolds:

- *What did you learn from the pilot and how would you change your design process based on the pilot? It appears that a pre-conceived opinion that the Zenon technology would fare better swayed the opinion to correct the numbers and keep Zenon in the running of comparable technologies.*

JB Neethling:

- *The pilot has helped us in understanding the process better and shows us the level of treatment pluses and minuses based on each system specific to the Coeur D'Alene WWTP influent.*

Mario Benisch:

- *The piloting also involved some slug loading of phosphorous in the form of sodium phosphate in a 5 mg/L concentration.*
- *The full analysis is not complete, however, in general, the Zenon appeared to allow the phosphorous through as shown by a spike in the measurement.*
- *The other technologies appeared to have better results showing little increase in the phosphorous in the effluent.*

Update August 23, 2004 Workshop Assessment of Candidate Treatment Processes – Group Discussion (1:00 pm to 1:55 pm)

Review and Update the August 2004 Assessment – Glen Daigger. See Appendix K for slides.

- *Folks involved in 2004 workshop were “usual suspects.”*

- Proven technologies and some minor deviations evaluated
- Restricted to processes capable of reaching 50 µg/L TP.
- The goal was to identify what technologies are ready for full scale applications. Organized methodology was used to compare technologies.
- Set of criteria. Do we understand the scientific principles? Do we understand the engineering principles? Can the owner get the construction and operating resources?
- For each, we established a scale (0-10). 0 is uncertain. 10 is certain.

Evaluation process:

- Identify AKART (all known and emerging technologies)
- Screen to remove obviously less acceptable or inappropriate technologies (pair wise ranking)
- Final scoring and ranking of the remaining technologies.
- Assess P removal capability of each technology.
- Look at relative cost.

Screened out:

- Nanofiltration (w/o chem. addition).
- Direct filtration with ferric or alum for polishing
- Contact clarifier and filtration with alum for polishing
- Ion exchange
- Distillation
- Evaporation
- MBR with chemicals followed by reverse osmosis
- Did not distinguish between aluminum and metal salts.
- Final weighted score for new technologies. – Not best technologies, but indication of which technologies are the most ready versus the least ready technologies.
- Next, reviewed technologies for no, yes, and maybe can achieve 50 µg/L P or less.
- One technology gets less than 10 µg/L sometimes; MF/RO.
- Assessed relative capital costs with relative understanding, not detailed costing. For example, MF/RO is a lot of money.
- Since 2004, took Dave Clark and Dave Reynolds data. Many tertiary filters, 2 dual sand, 2 MBR, and 2 BNR plants. Assessment took first two columns and answers “not to exceed” question for 50 and 10 µg/L. Second two columns answer median or average for 50 µg/L or less.
- Both dual sand filter plants meet 50 µg/L or less. A few tertiary filter plants do this. One MBR facility meets median 50 µg/L or less.
- Low limits for P removal are extremely difficult. To reduce P concentrations by three orders of magnitude, any chemist in the process industry would say, “each process step gives you 90%.” Don’t try to do this in a single step. 5 =>> 0.5 =>> to 0.05 =>> ??
- Controlling the upstream concentration is as important as tertiary treatment.
- Control of colloidal solids may be key to going from 50 to 20 µg/L. Can do with conventional treatment, but there is an advantage for membranes. Example, MBR discharge into Chesapeake Bay. Owner is spending \$180 million on it. Primary treatment to MBR. Anaerobic =>> Anoxic =>> Swing =>> Aerobic (larger part) =>> Anoxic with methanol =>> Aerobic/Membrane.
- Plant is under construction, but pilot results less than 10 mg/L TN. Methanol pushed levels down. Phosphorus influent 6-7 mg/L range. Can see progression of alum dosage and TP levels to around 10-20 µg/L. Effluent turbidity was around 0.02. Effluent P was likely ortho P. Benefit of membranes is the control of the colloidal fraction.

Learning curve.

- Experience is 4-5 years for learning curve. Sometimes effluent quality, sometimes cost influence rate of learning. Understanding science and experience with systems, Three areas to look to meet 10 µg/L without RO.
1. Upstream system. Come into tertiary system with relatively low P (under 100 µg/L).

2. Colloids. Rock Creek data and other plants show Ortho-P down to 20 µg/L, never more. Can have 100 to 150 to 200 µg/L colloidal solids. It's not Ortho-P bleeding through, it is the colloidal solids. Granular media filtration does well, but water treatment industry is going more with membranes for control of colloidal solids.
3. Ortho-P. JB showed data, but models in literature tell us that minimum soluble Ortho-P is 10-15 µg/L. However, we are measuring values that are lower. Science is still evolving. The model in most treatment folks mind is of metal salt precipitation. Alum or ferric salts and aluminum phosphate or ferric phosphate. A chemist at CH2M says ferric and aluminum phosphates do not precipitate. Right now, there is an on-going competition for developing a sorption mechanism. Precipitation is in competition with sorption. Mixing conditions, when you apply chemicals, as well as the nature of the chemical floc and contact time between chemical floc and liquid are things which determine the level of dissolved P that can be produced. Empirical models now. Need to pay lot of attention to mixing conditions. What of floc units? Like activated sludge process, can get enhanced biology through retention time or through higher mixed liquor. Throwing more chemicals at the process might enhance the P removal, but it might be the stupid way to do it (environmental perspective, as well as economic).
 - This group is not the only group looking at P removal. There are pockets of active pursuits around the world looking at P removal.

Q&A

Remy Newcombe:

- *It appears that you screened out single filtration in the study and rankings. If you saw the single filtration that had numbers as effective, would you consider adjusting your study.*

Glen Daigger:

- *Yes.*

Remy Newcombe:

- *I'll get with you after the workshop.*

Remy Newcombe:

- *At Hayden, they have achieved 10 µg/L by optimizing multiple removal steps.*

Richard Koch:

- *How do you improve learning curve?*

Glen Daigger:

- *Pilot testing is limited, but it often produces more questions than it answers. We need systems in the ground that will be the best that we can do at the time, but it will need to be optimized and learned upon through the years of experience. Once those systems are in place, physical modifications will need to be added over time. Designers will design flexibility into the new systems.*

Sid Frederickson:

- *This learning curve will be enormous. Sid has had trouble hiring a certified operator in a year's time, let alone optimize a complex tertiary treatment system in a year's time. We're doomed to failure if the ability of the operators and the facility operation capabilities are not taken into account when designing and fixing effluent limits.*

Glen Daigger:

- *There is a reason that small plants have better performance than large plants. The large plants are sampled daily, and the small plants sample less frequently. Often the smaller plants do not sample when trouble events are occurring as a factor of reality. The operators are typically focused on fighting the fires or the operator does not push the plant in a different operational manner or perform major maintenance on the day that they are required to sample.*

Question:

- *Commercial/residential phosphorous bans and their effectiveness?*

Glen Daigger:

- *Phosphorous bans are effective but limited to a certain level. The place where phosphorous reductions can be effective may be in the separation of urine from the waste stream.*

Technology Development Requirements -- Group Discussion (2:15 pm to 3:10 pm)

Pilot Testing/Demonstration Project Needs and Objectives

Other Technology Development Requirements

Start-up and Full-Scale Operational Development for Spokane River Dischargers

Open Group Discussion

Sid Frederickson:

- *If I had unlimited resources, I would pilot test diurnal flow and diurnal influent P concentrations, as well as solids stream and impact. Not sure how to do that without building full scale or partial scale and that costs a lot of money. In picking processes, risk comes into play. Spokane has brought in their council, and we will, too, especially in picking selection criteria for selecting a technology.*

Doug Krapas:

- *IEP tested alum, ferric chloride, and polyaluminum chloride. IEP found no difference in coagulants. Parkson has stated that they have found better results with polyaluminum chloride versus ferric chloride.*
- *IEP has purchased a 1 mgd Trident High Solids unit for plant scale testing.*
- *IEP is pulp and paper, not municipal. All changes with pulp and paper. 400 to 600 ppm coagulant to get to 100 µg/L P level.*
- *High, non reactive soluble P compound. IEP is currently studying.*
- *Have extended BOD tests to look at P level.*
- *Has the non reactive component been identified? Is it quantifiable?*
- *Color, processing of wood chips results in light colored tea to tap water. Calcium products. Fillers, whiteners, brighteners, etc. Lots compete for coagulant.*
- *Each pilot study had downfalls and advantages. Because of high coagulant feed, high solids overload =>> sand filters did not perform well.*
- *Membrane manufacturers would not guarantee membrane life. High duty application. Need redundancy. Membranes are about 10x cost of other systems.*
- *IEP likes the advantages of sand filters and Actflo because of continuous rejects.*
- *For membrane, IEP would need to shut down the system to clean.*
- *Trident[®] HS has advantages. What were the best performers? Trident[®] 1 mgd unit must backflush through filter (2,400 gpm to wastewater treatment system). Huge impact.*
- *We would rather have continuous reject removal, but the technology did not perform well enough to recommend to management.*
- *Will put Trident[®] HS in fullscale system and will report back to the group.*
- *Determine scalability for flows. Some technologies would not give guarantee on flows since pilot was equivalent to 800,000 gpd plant. Grab versus composite sampling is an issue..*
- *Plants will operate well when operator is standing there. Over course of day, you'll see peaks and valleys.*
- *IEP would like an open process involving technology workgroup and technology sharing as well as involvement by WSU lab, IEP lab, and commercial lab.*

Larry Esvelt:

- *Permitting?*

Doug Krapas:

- *DO TMDL is based on mass flow in pounds per day. Plan to discharge less, from 5 mgd to 1 mgd. 4 mgd will be reclaimed water. Not sure about if they can achieve zero discharge.*

Glen Daigger:

- *(1) Important to realize that pilot is not a smaller version of full scale plant.*
- *(2) Pilot is black box. Look at parts that work well. Do your own system. Use piloting as an opportunity to understand the science. If you buy a package from a vendor, you are going to start understanding piece by piece. By buying it right away, you are forgoing some time to understand the science. Yet, you will learn more by operating full scale.*

Bruce Rawls:

- *Question for Veolia. Is it valuable to do pilot testing before DBO?*

Sean Haghighi (Veolia):

- *Perhaps you would have DBO teams pilot their own technology, but not pilot before DBO selection. If there are data, we'd like to see it. But giving them data is not much value, unless we can do our own testing.*

Bruce Rawls:

- *Would you normally pilot on a DBO?*

Sean Haghighi:

- *No.*

Bruce Rawls:

- *Does the fact that we'll strive for lower P, does that mean you'd like to pilot more?*

Sean Haghighi:

- *Yes.*

Doug Krapas:

- *Parkson was going to operate remotely on our pilot. They had lots of problems and never got it operating properly. Too bad, because we'll never know what their technology could do.*

Sid Frederickson:

- *Echo. Zenon was not manned. You saw results Mario presented.*

Doug Krapas:

- *Zenon was manned at IEP and they performed well.*

Brian Nickel:

- *Seems to me that everyone in the watershed is in the same boat. Large reductions in P. IEP is very different. Yet, as we go forward and determine what works and what doesn't, continued communication and not reinventing the wheel is very valuable. On some level, everyone has the same goals.*

Jim Hagstrom:

- *Follow up to Glen. Let's understand the science. Pilot plant isn't necessarily the best place to develop new science. So many things happen, it is extremely difficult to know exactly what is happening. Somewhat limiting. Extremely valuable for staff to get familiar with systems. Membrane versus granular media filter, for example. For design, understand science.*
- *Under DBO type approaches, many times, an extended pilot occurs during the design phase. During design, we will run a membrane plant throughout the design process because it reduces conservatism and risk during design and reduces cost.*

Gordon Culp:

- *I was recently an expert witness on a water plant with extended period pilot testing and the full scale plant failed. Raw water quality changed from what was piloted.*

Dave Stensel:

- *What can we get for full scale plants from pilot tests? Treatability tests? Series of jar tests, then membrane filtration. We could learn a lot about water characteristics. What kind of chemical dose does it take to get to say a pilot plant goal 9 µg/L? Add diurnal variations. Need to look at bench testing to understand how P compounds are removed and then look at pilot plants.*

Sun-nan (Veolia):

- *Hydraulics are difficult to simulate on pilot. Same problem for Actiflo® in drinking water. Scale from 0.1 mgd to 1 mgd? Same situation for wastewater in Syracuse. It was scalable. Scalability depends on technology. If simple, you can easily scale it up.*

JB Neethling:

- *For a while I was worried that we were saying pilot testing cannot give you answers.*
- *If you want dosing, go to the lab. If you want optimization, go more towards full scale.*
- *Set the objective of the pilot. Ask, "Why are we doing this?"*
- *If you know everything, just go design it.*
- *If you know what is missing then, choose the right tool to fit the missing component. If it is a scientific question, keep it scientific (lab).*
- *If it is a less scientific question, it shifts more toward full scale.*
- *When we think about pilot testing, we are usually thinking about technology demonstration. "Here is the black box and will it work?" as opposed to "there is something missing and I must figure it out."*
- *We are still trying to figure out what to do to get to the bottom of treatability. That is where we are pushing it back to the lab. How close can we approach the ideal?*

Other:

- *Great examples of using technology. I haven't seen anything in the examples that get us to 10 ug/L TP. If the limit is 10, shouldn't the target really be 0, so we have leeway to get to 10? Do pilots have to be on a grand scale or small scale?*

Dave Reynolds:

- *It is a good idea to have an operator there to assist in pilot testing. You really don't want to pick processes on the capability of a manufacturer's representative and their lack of attention. You need to establish protocols on how much attention an operator can provide.*
- *In full scale, you won't necessarily have someone standing there to watch the unit process. Right now, technologies don't get to 10 ug/L TP. Pocketbook might be better served by focusing on other things. There might be other approaches to reducing P discharges such as water reuse that have multiple benefits.*

Bruce Rawls:

- *I agree and this whole thing has to be cost effective. As we grow, we'll need more delta projects. What happens over time?*

Dave Reynolds:

- *We can be at 20-30 ug/L TP a lot of the time. Maybe we should finance UW to do studies instead of consulting engineers.*

Len Bramble:

- *We don't have unlimited time to select treatment technologies. Richard Koch and myself will be bugging you to get going. Ecology will want to clearly place timeframe in permits issued next June.*

Brian Nickel:

- *The other side of the coin... Loading and increasing the sorts of "delta management" things... As you have more time to optimize the treatment technology, you can reduce P. There will be a limit.*
- *Certainly, I understand the debate. There are some plants that are getting below 10 reliably*
- *Pilots are showing us that the achievable level is 20, 30, 40 range. It depends on how you average.*
- *At the end of the day, from a legal defensibility standpoint, the water quality standard to meet DO standard in Lake Spokane is 10 µg/L. This would be difficult to relax. I would not underestimate the importance of keeping your eye on that prize.*

Dave Stensel:

- *What do we mean by pilot plant and how big does it need to be to get large enough to mean something?*

JB Neethling:

- *It depends on technology.*

Dave Clark:

- Coeur d'Alene was 60 gpm. Zenon was running at 6 gpm. Not the same size as pilot testing at King County.

JB Neethling:

- You want enough to give you a good representation. If you only want treatability, do a bench scale test.

Glen Daigger:

- From an insider and outsider perspective, the MIP agreement is a very enlightened agreement. You never have all the answers. At the end of the MIP, we'll learn much more. You are not falling off a cliff, you are taking a big step. You have to just take a deep breath and do it.
- Building is the next step. You will not be done when the plant is built.
- Previous comment about 10 µg/L, think of treatment. 80% removal. If you want to produce 10 ug/L, shoot for 5ug/L. 3 orders of magnitude 5 to 0.5 to 0.05 to 0.005.

JB Neethling:

- There is an importance in not taking the wrong first step. If permit writers say BOD and TSS, build TFSC. But 5 years down the line you need to remove N, bad first step. We are faced with technologies where the second step is not clear. What do I build now? What will help me in the future? The dilemma lies in the first step. We've kept adding on in the past. We have a peek at what the future looks like and we don't know what to do in the meantime.

Bruce Rawls:

- There is a political aspect that us public folks have to deal with. Rates. Rates will go up about \$9/month for Spokane County. Considering the average income, a \$9 rate increase will cause people to go berserk. That is why every step we take needs to be the best step possible. If I come back and say, "We did pretty good, but we didn't do quite good enough.", that will not work.

Bruce Rawls:

- If I move forward with a DBO, I'm most likely going to ask for a guaranteed number and add incentives to produce lower TP.
- Also, reuse is a burr in my hindside. If we go to 50 µg/L at 2 lbs per day. Look at water and convert number of acres needed to do this. Reuse is great, but P is too low to do this. It makes reuse unfeasible.

Sid Frederickson:

- I want to jump on bandwagon with public concerns. In Coeur d'Alene - to meet the permit, I've told my council that we will be lucky if we get through the process and only double the existing rate. Now let me change hats with my other role on school district board that says 48% of students are on the free and reduced lunch program for poverty. I am going to spend \$60 million on a treatment plant when half of my kids are below poverty. Think about it.

Dave Reynolds:

- What is the next step? It could be reverse osmosis that approaches potable reuse. You don't want to make bad decisions, but do the engineering analysis to answer what will work before you go down the road of pilot testing. John Spencer's comment was that we spent a whole lot of money on piloting and we didn't use any of it.

Brian Nickel:

- I heard some discussion of the role of pH on chemical removal of P. Is there a lower bound to better optimize chemical use?

Doug Krapas:

- We tried without acid and with acid. We were able to get lower P levels. If we had a pH of 6.0, we'd have to add caustic to raise pH. I was surprised that other pilots did not lower pH to 6.0 to 6.2.

Glen Daigger:

- Pinery used to adjust pH religiously. We are still learning the chemistry.

Brian Nickel:

- Frequently, it is easier to not give pH in mixing zone and generally they are not needed. It is an option. Generally, a discharge of 6.0 is not a problem.

Question:

- Has anyone used flow equalization for the treatment process?

Gerry Shrope:

- The Moody plant in Prince William is using a large flow equalization facility.

Glen Daigger:

- Isn't pilot testing a simulation of flow equalization to create a constant flow treatment process?

Brian Nickel:

- Would a lower level pH assist in removing phosphorous?

Doug Krapas:

- Yes. We saw that removal was greater when pH was lower. 6.0-6.2 was optimum for IEP.

Plant-Specific Application of Advanced Technologies -- Group Discussion (3:10 pm to 4:00 pm)

Candidate Processes Scheduled for Demonstration Testing by the City of Spokane – Dale Arnold and Lars Hendron (Larry Esvelt presenting) See Appendix L for slides.

Lars Hendron:

- City of Spokane, beyond report from Larry on last year, we've been thinking about how we'd pilot our procurement. I think it would be helpful for people to hear about our process.

Larry Esvelt:

- Many people in room will be expected to contribute to Spokane's work. We would like to get feedback on how to redirect the pilot study for Spokane. So far, everything has been in small group discussion. It's time for the group to expand.
- The underlying principle is to have an open and transparent process.
- We want to involve citizens and stakeholder representatives (including environmental, regulatory, and governmental).
- Use pilot results to date and data and experience from other locations to guide pilot process selection.
- Need to look at unique needs and sizes for scale up.
- The farther you scale, the bigger the risk, the greater the cost. Look at larger pilot scale unit than was used at Coeur d'Alene and in Spokane previously.
- Peer review, protocol and results. Independent project guidance and qualified operation of pilot units.
- Peer review committee. All ideas and are preliminary. First attempt at writing them down.
- Oversight committee. Regulatory, environmental community, and public representatives. Review objectives, public interest and impact, and public acceptance.
- We want processes that can be implemented on a large scale.
- City of Spokane will be the largest discharger in the foreseeable future.
- Spokane County will get a facility. Want to look at systems that approach 10 µg/L objective.
- Unlikely that a single stage process will achieve results of 10 ug/L. "One order of magnitude per stage" as discussed earlier. Need to drop two orders of magnitude more. Therefore, pilot test more than one stage.

Preliminary specific process considerations.

- Chem coag, floc, sedimentation.
- Chem coag, floc, inclined plate settler.
- Chem coag, floc, ballasted sand.
- Pilot clarifiers will operate in parallel. Scale is around 0.5 mgd for scalability.
- Physical removal of solids in precipitate. Conventional base unit. Downflow granular media filter.
- We will also look at upflow continuous backwash filter and membrane.

➤ Anticipation is that each of these filters will accept influent from each of the two sedimentation units.
Operation and monitoring.

- Track flow and quality for each unit. Solids production. Quality: BOD, P, DO.
- We know regulatory community will be developing a TMDL for metals, temperature, and PCBs.
- IEP did some tracking of PCBs.

Doug Krapas:

- *PCBs went up during treatment. Coagulants? Inks from old newspaper? Inks could be a by-product from the ink manufacturer.*

Continued presentation:

- Hope to have outside contract lab for QA of data.
- Timeline looks like fall 2006 for concept design, peer review and oversight review started.
- In winter, procurement, contracting, installation.
- Spring 2007, start-up and peer review involvement.
- Summer of 2007 through Spring 2008, ongoing operations.
- Summer of 2008, continue operation of pilot and develop final reporting and recommendations.
- A number of recommendations will be required in fall of 2008 for final process selection.
- We will analyze life cycle costs and delivery methods
- The City of Spokane is looking for input from people to help with the evaluations and review the compatibility with other policies (“delta”). Need flexibility for further improvements. When designing, you need a place to plug in new technologies.

Q&A

Lars Hendron/Dale Arnold:

- *City budgeted \$2-\$4 million for pilot testing..*

Larry Esvelt:

- *This will take a big space. There will be three treatment plants operating at the same time.*

Richard Koch:

- *This is an ambitious plan. Are there some things you’ll want to do to learn more about the individual technologies?*

Larry Esvelt:

- *This is a first cut prepared for today. We’ll be adapting the plan.*

Glen Daigger:

- *If you were to measure other parameters, look at TOC and endocrine disruptors. There is a yeast assay that can indicate those classes of compounds. When looking for a solution to a complex problem, go too far in your thinking and then back off.*

Larry Esvelt:

- *Dave could be involved with other people participating.*

Bruce Rawls:

- *The County’s approach to treatment technology selection protocol certainly depends on how we move forward.*
- *We are planning to finish the wastewater facility plan by January.*
- *We will also look at alternative delivery. Assuming we are going to pilot test, and if it is DBB, pilot test next year.*
- *Need pilot testing done next year to develop an engineering report and hit 2011-2012 to be online. If it is DBO, there could be a different schedule and when pilot testing gets done. Pilot testing will probably be done by a DBO and not the County.*

Dave Clark:

- *We are in a mode of amending the Spokane County facility plan. We will need to account for what was in the last facility plan.*

- *Our discussions in the near term will determine whether we are open to other candidate treatment processes.*
- *Then, we are back to Bruce's comment on procurement and need to do pilot testing. We'll see where we end up on the facility plan in the next few weeks.*

Lee Melish:

- *We just spent \$12 million doing phase 1 and we are nowhere near 10 µg/L. We want to fine tune treatment plant for six months and then we may know what it can do. It will be a while to get our plant "up to snuff." After that, if we have the money, we'll see what we can do to get something done.*

Larry Esvelt:

- *Comment to Lee, 6 months is very optimistic. Moscow is doing better now. Were 0.5 mg/L and now 0.2 mg/L just with familiarization and optimization. It takes a while to learn that when you make a mistake, it costs you and what those mistakes are.*

Tom Agnew:

- *How does this pilot testing insight gained today compromise the MIP and collaboration process?*

Len Bramble:

- *I think it fits well. We allocated 2 years for that (2006-2007).*
- *Some folks think 6 months is plenty and others think 18 months to 2 years is better.*
- *We are waiting to see what people propose and we can look to see if it is appropriate.*

Richard Koch:

- *Once the treatment plants are in operation, we'll have a learning period before we can do an assessment of performance. Glad to see the City is thinking this way.*
- *It takes some discussion to see what the protocols will be. We want good data around the time the permits are written.*

Paul Klatt:

- *Question for EPA. Idaho permits written in next few months. Seasonal limits? EPA typically writes permits with max day, max week, or average month and max week in month. Is there flexibility in the approach from EPA.*

Brian Nickel:

- *The rules say, "Thou shall put in average monthly limit and average weekly limit unless impracticable."*
- *In the context of nutrient limits, some regions have determined this to be impracticable and it makes more sense to have limits averaged over a longer period of time.*
- *This becomes a problem for a discharger. The short answer is that we should always do average monthly and average weekly unless there is a reason not to do it.*

Bruce Rawls:

- *The difference between Washington and Idaho is that EPA is requiring different standards in shoulder months. This gets to reuse. If you are going to do reuse, it is effective in middle of summer when it makes more of a difference in the reservoir.*

Len Bramble:

- *We have discussed this internally and we need to discuss this with dischargers. We'd need to do more modeling, but are intrigued by the notion and wondering how receptive the stakeholders would be.*

Richard Koch:

- *We are also accounting for a delta. We have policies for the delta. The first part of the period is to get treatment plants built. In the second part, look at other issues.*

Bonnie Beavers:

- *It seems the EPA is treating the shoulder months differently in its draft permits.*

Brian Nickel:

- *One discharger has made investments in land application. This seems to be a viable strategy. I think that guided our thinking to come up with scenarios for permit limits. How much does it help? How*

much does it decrease? We were able to come up with a set of limits that work (step up/step down approach).

- *Whether that will work with the MIP and larger dischargers, I cannot answer. It was an attempt to recognize the unique situation of land dischargers and that they cannot land apply their flow outside the summer.*

Glen Daigger:

- *This question of seasonally variable limits has been addressed elsewhere in this EPA region. In the Tualatin River Basin in Oregon, the regulators have modified permit requirements as improved treatment is put in place and with improved understanding of the receiving waters. This is within this EPA region.*

Summarize Conclusions and Recommendations – Group Discussion (4:00 pm to 5:00 pm)

Document Status of Process Considerations at Specific Plants, Candidates under Consideration, etc.

The group was asked if they had any closing comments with the following responses:

Lars Hendron:

- *The City of Spokane would not like to add much.*
- *We will move forward with sampling on Long Lake to get a handle on water quality parameters.*
- *We need to all continue to work together while the regional municipalities work through these issues.*

Bruce Rawls:

- *This is second collaborative workshop that has been conducted amongst the regional group. This has been beneficial and it would be a good idea to have another workshop in the future.*
- *The next one may need to be a year from now.*

Brian Nickel:

- *EPA people working on the TMDL language have visited plants and technologies in the East.*
- *This may be a good place to start for smaller municipals to get their hands around the issues they must address..*

Tom Agnew:

- *Why is this process and piece of the industry so user unfriendly for such a critical piece of the Country's infrastructure.*

Bonnie Beavers:

- *The region is on the leading edge of phosphorous removal by setting the lowest level in the country.*

Summary from Gordon Culp:

The desire of the participants in the workshop were:

- Build body of knowledge.
- Collaborate on how to apply technology
- Transparent process.
- How to share pilot results.
- Available technology for next phase.

- Share trip information
- Identify peer reviewers.
- Sharing of pilot tests.
- Timing of Idaho requirements.
- Washington permitting schedule.

Body of knowledge has been expanded.

We've collaborated on technology application.

The process and data has been transparent to everyone involved.

Pilot results are being shared with discussion of future workshops to continue the discussion.

Available technology for next phase has been discussed, but the science is still out.

Trip information has been discussed amongst the group.

Didn't identify specific peer reviewers but invitation is on the table.

Discussed timing of Idaho permitting briefly.

Discussed Washington permit timing.

Summary comments:

- Meeting objectives identified at start of session were accomplished.
- Richard and Len provided status of DOE plans for carrying out the Managed Implementation Plan.
- Results of phosphorus removal at many plants were presented. In general, the best results were in the 20-30 ug/L range and were being achieved by a variety of processes. There were some exceptions that were achieving better results: two very small plants with very limited data and two plants in Breckenridge, Colorado. The reasons for the differences in performance need to be better understood.
- There is substantial variability in P removal performance and in the chemical analysis for P that must be considered.
- There is a long learning curve in starting up the operation of new P removal plants that must be considered.
- Several design issues raised in WERF report were described.
- The removal of colloidal, refractory P is a potentially fertile area for research.
- Spokane and Inland Empire described their pilot plant plans, Spokane County described the status of their planning.
- There is a willingness to share data as work proceeds.

Richard Koch:

- Is existing research on-going to develop science towards removal of refractory components such as colloidal phosphorous?

JB Neethling:

- WERF is very interested in directing a program towards investigating this topic. However, nitrogen is leading the way in industry treatment funding.

Glen Daigger:

- WERF is interested but believes funding is directed towards nitrogen. WERF may not be the best location to ask for funding. If science is going to be done, the money will need to occur from Northwest funding. One or two pilot studies would go a long way toward funding science-based studies and other investigations.

APPENDICES

- A. General Update on Spokane River TMDL, Len Bramble and Richard Koch
- B. Phosphorus Removal Technology Project Status Update, Brian Nickel
- C. Review of Exemplary Plant Phosphorus Performance – Update, Dave Clark
- D. Update on Exemplary WWTPs, Dave Reynolds
- E. Site Visits to Colorado Plants, Larry Esvelt

- F. Facility Tour of Blue Plains, Alexandria and Syracuse, Lars Hendron, Mark Laquidera, Gerry Shrope
- G. Report from Water Environment Research Foundation March 10/11 Workshop on Low Effluent Nutrients, J.B. Neethling
- H. Las Vegas/Clark County Area Low Effluent Investigations, J.B. Neethling
- I. City of Spokane Pilot Studies in 2005, Larry Esvelt
- J. Report from Coeur d'Alene Low-P Pilot studies, Mario Benisch
- K. Review and Update of August 23, 2004 Advanced Wastewater Treatment Technology Workshop, Glen Daigger
- L. City of Spokane Pilot Studies 2007, Larry Esvelt