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December 10, 2007

VIA HAND DELIVERY

Ms. Beth O'Donnell
Executive Director
Public Service Commission
211 Sower Blvd.
Frankfort, KY 40601

Re: ***Application of Kentucky-American Water Company, a/k/a Kentucky American Water for Certificate of Convenience and Public Necessity Authorizing Construction of Kentucky River Station II ("KRS II"), Associated Facilities, and Transmission Line;*** **Case No. 2007-00134**

Dear Ms. O'Donnell:

We have enclosed, for filing, the original and eleven (11) copies of Louisville Water Company's Post-Hearing Response to Requests for Information.

Thank you, and please call me if you have any questions.

Very truly yours,

DINSMORE & SHOHL LLP

John E. Selent

JES/bmt
Enclosure
cc: All parties of record (Case No. 2007-00134) (w/ encl.)
Barbara K. Dickens, Esq. (w/ encl.)

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COMMONWEALTH OF KENTUCKY
BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

THE APPLICATION OF KENTUCKY-AMERICAN WATER COMPANY FOR A CERTIFICATE OF CONVENIENCE AND NECESSITY AUTHORIZING THE CONSTRUCTION OF KENTUCKY RIVER STATION II, ASSOCIATED FACILITIES AND TRANSMISSION MAIN	))))))	**CASE NO. 2007-00134**

LOUISVILLE WATER COMPANY'S POST-HEARING RESPONSE TO REQUESTS FOR INFORMATION

The Louisville Water Company ("LWC"), by counsel, hereby responds to the requests for information made during the hearing of the Public Service Commission of the Commonwealth of Kentucky (the "Commission") in the above-captioned matter.

REQUESTS FOR INFORMATION

Request No. 1

How much storage capacity (in MGD) has LWC added to its system since 2002?

Responsible Witness: **Greg Heitzman**

RESPONSE: LWC has added 2.56 MG of storage to its system since the beginning of 2002.

Request No. 2

Provide a copy of the post-2002 Black & Veatch study.

Responsible Witness: **Greg Heitzman**

RESPONSE: Please see the attached.

Request No. 3

Provide a copy of the document entitled "Louisville Water Company Proposal for a Louisville to Lexington Pipeline Along I-64."

Responsible Witness: **Greg Heitzman**

RESPONSE: The document entitled "Louisville Water Company Proposal for a Louisville to Lexington Pipeline Along I-64" is copied into the Greg Heitzman Rebuttal Testimony filed October 1, 2007, at pages 4-7. Therefore, a copy already has been provided to all parties and the Commission.

Request No. 4

Identify any system development charge(s) associated with, or to be imposed by, the LWC proposal.

Responsible Witness: **Greg Heitzman**

RESPONSE: See Greg Heitzman Rebuttal Testimony filed October 1, 2007, at page 7, line 9: "LWC will waive the System Development Charge for this delivery point."

Request No. 5

Provide all hard-copy and electronic spreadsheets underlying the table located at LWC0002.

Responsible Witness: **Greg Heitzman**

RESPONSE: An electronic spreadsheet responsive to this request is available and will be provided to any authorized recipient pursuant to the terms of the Confidentiality/Non-Use Agreement, upon receipt by LWC of an agreement executed by the authorized recipient.

Counsel for LWC previously provided electronic copies of the Confidentiality/Non-Use Agreement to counsel for parties in this matter. No hard copy spreadsheet exists.

Request No. 6

Please state whether LWC adjusts (as opposed to reviews) its annual demand factors in each of its annual cost of service studies.

Responsible Witness: Greg Heitzman

RESPONSE: LWC typically adjusts its annual demand factors in each of its annual cost of service studies. During the past five years, Louisville Water Company has adjusted its demand factors in 2003, 2005, 2006, and 2007. Louisville Water Company reviewed but did not adjust its annual demand factors in 2004.

Request No. 7

Provide an explanation for R. W. Beck's disagreement with Walker's six identified assumptions (p. 8, lines 1-40 of his rebuttal testimony) and the 11 dollar amount disagreements he identified at the hearing.

Responsible Witness: Ed Wetzel

RESPONSE:

Assumption No. 1: Inflation

Inflation is assumed to 3.00% for both operating Expenses and capital costs. This rate is based on the long term average rate of inflation of 3.0%.

R. W. Beck Report used inflation of 2.4% for most operating expenses and 3.0% for wholesale rates. The R. W. Beck report also used 3.1% inflation for capital costs based upon the

Handy Whitman Water Treatment rate of 3.0%, Handy Whitman Mains rate of 2.97% and ENR CCI rate of 3.1%.

Response

R. W. Beck's estimate of inflation of 2.4% is based on the Blue Chip Economic Indicator Report (BCEIR) at the time of the report. Based on R. W. Beck experience this report is a valid and reputable source used specifically to estimate the rate of inflation and other economic indicators. While 3% is sometimes used as a "rule of thumb," we believe the BCEIR provides for an inflation estimate that more accurately reflects current and projected economic conditions. Capital costs were escalated using the Engineering News Record Construction Cost Index to more accurately reflect the specific nature of construction costs. The Handy Whitman Index was looked at to confirm the rate of inflation indicated by the ENR CCI, and supports the number presented by the ENR CCI. Although these numbers differ slightly the impact on the present worth costs is minimal.

Assumption No. 2: KAW's Tax Exempt Debt

KAW's total tax exempt debt available for either option is $35,000,000 based on a three year construction period. This is assumed to be industrial development bonds, which KAW would be contractually responsible for.

The R. W. Beck Report did not assume any tax exempt debt for KAW.

Response

R. W. Beck is unaware of any specific source of financing being proposed which would include any tax exempt debt. If such financing were available to KAW, the net effect would be a reduction in their weighted average cost of capital (WACC) from the currently PSC-approved rate of 7.75% to something less than that.

Assumption No. 3: LWC's Wholesale Rate Increase

LWC's post-2016 wholesale rate increase above inflation is 2.%. LWC's wholesale rate is $1.71 per thousand. Based upon Mr. Heitzman's testimony, this rate is held constant through 2015. In 2016 is increased by the compounded inflation rate, which is assumed to be 3% annually, after 2016 the rate is assumed to increase by a maximum of 2% above inflation (i.e. inflation + 2%).

R. W. Beck Report used a 3.0% annual increase in wholesale rates over their study period. The R. W. Beck Report differs from Mr. Heitzman's testimony.

Response

The R.W. Beck report used an assumed 3% per year increase in the wholesale rate as a simplifying assumption to the model. The report also considered the sensitivity of the results to changes in the wholesale rate by analyzing a range of values based on a 1%, 3% and 5% increase. Under all scenarios the LWC pipeline proposal had the lowest present worth costs.

R. W. Beck submitted a supplemental analysis by letter dated November 14, 2007 which included the wholesale rate increases per Mr. Heitzman's proposal under a variety of ownership scenarios. The difference between the KAWC proposal and the LWC proposal is smaller than the baseline case, but the conclusions are still the same. See the table below under the constant flow scenario.

Scenario	KAWC [1]	42" LWC 6 MGD Flat	36" LWC 6 MGD Flat	Savings [2]
100% Public	$293,986,300	$174,025,816	$146,796,486	$147,189,814
80/20 Public/Private	$293,986,300	$185,406,487	$155,071,919	$138,914,381
50/50 Public/Private	$293,986,300	$202,477,494	$167,485,069	$126,501,232
20/80 Public/Private	$293,986,300	$219,548,501	$179,898,218	$114,088,082
100% Private	$293,986,300	$231,031,793	$188,173,651	$105,812,649

See the table below for the results under the increasing flow scenario.

Scenario	KAWC [1]	42" LWC 6 MGD Start (.5 MGD/year increase)	36" LWC 6 MGD Start (.5 MGD/year increase)	Savings [2]
100% Public	$303,899,862	$221,583,568	$196,202,921	$107,696,941
80/20 Public/Private	$303,899,862	$232,964,239	$204,478,354	$99,421,508
50/50 Public/Private	$303,899,862	$250,035,246	$216,891,504	$87,008,358
20/80 Public/Private	$303,899,862	$267,106,253	$229,304,653	$74,595,209
100% Private	$303,899,862	$280,438,228	$237,580,087	$66,319,775

Assumption No. 4: BWSC's Debt Term

BWSC's debt issue term is assumed to be 25 years. A 25 year term was used in order to have the life of the financial capital approximate the life of the underlying long lived assets. The result of combining the debt's term life with a conservative balloon payment enables the life of the financial capital to be comparable to the life of the underlying long lived assets.

The R. W. Beck Report used a term of 20 years.

Response

R. W. Beck used a 20 year bond issue and Mr. Walker proposed a 25 year "balloon bond" with a 2nd 25 year bond to follow to pay the remaining portion of unpaid debt. R. W. Beck is of the opinion that a 20 or 25 year bond would both be reasonable terms, but 20-year bonds are the standard of the industry, with more than 85% of municipal bonds issued last year having 20-year terms. In this instance, 20 years is also the timeframe in which the assets being constructed run out of capacity. This means that the ratepayers who gain the benefit of the assets will be the ones who pay off the debt. Future ratepayers will need to construct and pay for future assets to serve their needs.

R. W. Beck also disagrees that having a "balloon bond" is a more reasonable assumption. We know of no example where a municipal utility has issued this kind of debt, and Mr. Walker

could not site an example when asked during his testimony. Using a 25-year bond to repay 50% of the cost with the remaining 50% to be refinanced for another 25 years is considered by R.W. Beck inconsistent from most common utility practices and would result in higher interest expense. This is like comparing a 30 year mortgage to a 30 year balloon mortgage, only paying ½ the principal, then refinancing the remaining principal for another 30 years, resulting in more interest expense and adding an unnecessary burden to rate payers.

Assumption No. 5: BWSC's Debt Payment Frequency

BWSC's Debt issue is assumed to have two payments annually to match the requirements of a typical municipal bond payment.

The R. W. Beck Report used a single annual payment which would be unique for a municipal bond.

Response

R. W. Beck used an annual debt payment and Mr. Walker proposes two payments annually. Both assumptions are valid for the type of analysis being performed. R. W. Beck was looking at all expenses on an annual basis. The affect of changing our debt payments to semi-annual would not affect the conclusions reached in our analysis.

Assumption No. 6: BWSC's Debts Balloon Payment

BWSC's debt issue's final balloon payment is 50%. This assumption implies that 50% of the principal is repaid prior to the final payment. The final payment is then refinanced.

R. W. Beck Report did not differentiate in balloon payments. Therefore, The R. W. Beck Report essentially recovered in rates, or the revenue requirement, the projects entire capital cost

over 20 years. That is, they recover "return on capital" over 20 years for assets with a life of 58 years.

Response

R. W. Beck disagrees that financing the cost of construction over 50 years is a more reasonable assumption. 20 year bonds are standard use within the utility industry. By reducing the principal paid to 50% over 25 years and refinancing the remaining principal for another 25years the interest expense and in turn the entire financing cost of the project is much higher, however spread over a longer period. Also a utility must look at the risk of financing a project of this size based on Mr. Walker's suggestions. The interest rate risk or the uncertainty of what future interest rates will be would be much higher under a 25 year "balloon bond" than more standard 20 or even 25 year fully amortized bonds.

Walker's 11 dollar amount disagreements

With respect to the KAWC Pool 3 proposal, Walker stated that the following categories had been *overstated* by the following amounts.

Chemical Cost	$57,099
Labor	$1,392,477
Electricity	$219,011
Property Taxes	$5,189,993
KRA Withdrawal Fees	$1,285,347
Depreciation/Capital Recovery	$19,203,489
Return on Capital	$24,485,669

With respect to the LWC Louisville Pipeline alternative, Walker stated that the following categories had been *understated* by the following amounts.

Electricity	$2,608,324
Wholesale Water	$79,220,894

Meter Charges	$9,413,221
Return on Capital	$83,700,995

Response

It is difficult to address the above discrepancies without the backup information and calculations to go along with the numbers presented. Nevertheless, we are aware of specific assumptions made by Mr. Walker and their impact on the modeling results.

KAWC Pool 3 option

Chemical costs, labor and electricity

R.W. Beck used the costs outlined in Table 4 of Ms. Bridwell's testimony regarding operating expenses for the Pool 3 plant. Mr. Walker used a slightly higher rate of inflation (3.0% vs. 2.4%) as described above, and this could account for the slightly higher life cycle costs for chemicals and electricity compared with the R.W. Beck model. The labor cost differential is larger, and may result from Mr. Walker inputting the incorrect labor costs into his model. On his Schedule 4, Page 1 of 5, he shows a total labor cost in 2007 of $542,622. Table 4 of Ms. Bridwell's testimony indicates a number of $620,382, which is the value we used in our model.

Property taxes

R.W. Beck used the property taxes shown on Table 4 of Ms. Bridwell's testimony and inflated those costs by the inflation rate over the life of the project. We further assumed that KAW would own the property in total, rather than have a split ownership of land. If KAW is afforded special consideration for property taxes by the Commonwealth of Kentucky, we were unaware of that circumstance in the development of our cost model.

KRA withdrawal fees

We know of no reason why there should be any dispute over KRA withdrawal fees, unless Mr. Walker is comparing our increasing flow model against a constant 6 MGD withdrawal. We modeled these as two separate scenarios, recognizing that there were was confusion over how KAWC intended to operate the Pool 3 facility. Under either scenario, we assumed a fee of $.05/1,000 gallons of water withdrawn.

Depreciation/capital recovery

R.W. Beck used a simplified approach to the creation of a Renewal and Replacement (R&R) fund by assuming the treatment plant assets have a 40-year life and pipeline assets have a 75-year life. This approach was used regardless of whether the assets were owned by KAWC, in which case this is treated as depreciation, or a public entity, in which case this fund is considered a capital reserve fund. It is not clear how a relatively small difference in assumption for depreciation rates could translate into a $19 million overstatement of present worth cost for the Pool 3 option. Ironically, Mr. Rubin considered the same variation in depreciation rates, and concluded that the difference resulted in an *understatement* of the Pool 3 present worth cost of only $100,000.

Return on Capital

This large difference results from the disagreement over how to determine the pre-tax cost of capital for the KAWC portion of the project. As stated in Mr. Wetzel's testimony, R.W. Beck followed the methodology provided in the exhibit to Mr. Rowe's response to the CAWS First Data Request, Item #13, in which the authorized rate of return is multiplied by the rate base and grossed up for taxes. This calculation results in a pre-tax cost of capital of 12.8%, which compares to the 10.6% shown on Schedule 6 of Mr. Walker's testimony.

LWC Pipeline

Electricity and Wholesale Water

Mr. Walker assumes a 12.5 MGD base flow rate through the LWC pipeline compared with the 6 MGD used by R.W. Beck. This is an erroneous assumption as supported by the testimony of Mr. Heitzman to the Commissioners.

Metering charges

The meter costs were provided to R.W. Beck by the Louisville Water Company, assuming an initial flow rate of 6 MGD through the pipeline. It is not clear how Mr. Walker gets to such a large difference in present worth cost, but he is assuming larger meters to be installed and charges rendered at the outset of the project.

Return on Capital

Mr. Walker assumed that the LWC pipeline would be 80% privately-owned and 20% publicly-owned, rather than the 100% public ownership from the R.W. Beck report. The additional analysis submitted by R.W. Beck on November 14, as shown on the table above, indicates that this difference should be about $45 million on a present worth cost basis, not the $84 million suggested by Mr. Walker.

Request No. 8

Provide a synopsis of R. W. Beck's response to Scott J. Rubin's three main points.

Responsible Witness: **Ed Wetzel**

RESPONSE: Mr. Rubin identifies five areas of concern as summarized on pages 1 and 2 of his testimony:

- For the Pool 3 option, KAWC's depreciation rates should be used instead of the generic assumptions made in the model.
- The R.W. Beck model assumes that 20% of the cost of the Pool 3 Project would be financed with municipal bonds. As I understand it, public entities have not made a firm commitment to the Pool 3 Project, and there is no certainty that such public financing will be used. Therefore, I have assumed that KAWC must finance 100% of the Pool 3 Project.
- The model incorrectly calculates KAWC's pre-tax cost of capital. The model applies the gross revenue conversion factor to KAWC's entire return (debt and equity). It should be applied only to the equity component of the capital structure.
- The model makes the unrealistic assumption that the LWC option would be financed entirely with public debt and that there would not be any debt service coverage requirement on such debt.
- The model's results are very sensitive to the amount of water that is needed. Making a relatively small change to the amount of water has a dramatic effect on the results.

Response

We will separately address each of Mr. Rubin's five points above.

Depreciation rates

R.W. Beck's model used a consistent average service life for the assets—40 years for treatment facilities and 75 years for pipelines—in determining the amount of renewal and replacement (R&R) reserve. This R&R reserve for public systems is the equivalent of depreciation for investor-owned utilities. Mr. Rubin points out that had we used the actual depreciation rates for the KAWC assets, the net impact would be an increase of the Pool 3 option

by $200,000 on a present worth basis. This is an insignificant difference, but one that favors the LWC pipeline option.

Private vs. public financing of the Pool 3 Project

Mr. Rubin assumes that 100% of the Pool 3 project should be financed by KAWC, as there are no firm commitments from Bluegrass member governments to help finance the project. R.W. Beck used the 80%-20% private/public split based on the tentative agreement reached between KAWC and the Bluegrass Water Supply Commission, and the fact that the treatment facilities have been upsized to 25 MGD as an option in the bidding documents prepared by Gannett Fleming. If the BWSC does not participate in the project, KAWC would provide 100% financing, but the plant would likely be the 20 MGD option at a reduced capital cost. However, if the 25 MGD project proceeds with 100% financing from KAWC, Mr. Rubin estimates that the present worth cost of the Pool 3 option would increase by about $14 million.

Pre-tax cost of capital

Mr. Rubin makes the same argument as was made by Mr. Walker that the pre-tax cost of capital is lower than the value used in the R.W. Beck analysis. As Mr. Wetzel testified to the Commission, R.W. Beck utilized the methodology outlined in Mr. Rowe's response to the CAWS First Data Request #13, in which he indicates that the revenue requirement from KAWC's customers is equal to the allowable weighted average cost of capital (currently 7.75%) times the rate base, grossed up for income taxes. This calculation results in a pre-tax cost of capital of approximately 12.8% compared with the 10.8% used by Mr. Rubin. Mr. Rubin indicates that this difference translates into a present worth cost reduction of the Pool 3 option by some $27 million.

Debt service coverage for municipal financing

Mr. Rubin first makes the statement that the project could not be 100% financed with public debt. We disagree with this statement, and believe that there are a number of entities, such as the BWSC or the Frankfort Plant Board that could own all or a portion of such a pipeline. Mr. Rubin further states that if it were 100% financed with public debt, that a debt service coverage factor of 1.5 should be applied to the debt service cost in the model. Mr. Wetzel testified to the Commission that R.W. Beck strongly disagrees with Mr. Rubin's assumption.

Debt service coverage is not a direct cost to any project, but rather a test of the financial health of the borrower. Coverage provides assurance to the bondholders that they will get paid, but the monies in reserve used to comply with a coverage requirement are never spent on the project. An analogy that was used by Mr. Wetzel at the Commission hearing is a mortgage. The cost of the house is represented by the principal and interest on the bank loan. Coverage is the financial equivalent of the income needed by the borrower to qualify for the loan. Mr. Rubin estimates that a 1.5 coverage factor would increase the cost of the LWC pipeline by $40 million.

In the event debt service coverage was considered part of the cost of a project, using a 1.5 factor is not realistic. Most revenue bond issues require coverage in the 1.1 to 1.3 range. Low interest programs like those offered through the State Revolving Loan Funds or the Kentucky Infrastructure Authority require coverage in the 1.0 to 1.2 range. We should also point out that the R&R reserve fund established in the R.W. Beck model provides for a coverage factor of 1.1.

Amount of water needed

Mr. Rubin correctly recognizes that the model is sensitive to the amount of water purchased, although we would not consider a doubling of the usage a "relatively small change". He evaluated scenarios under which water usage increased by 1.0 MGD and 1.25 MGD per year, rather than the 0.5 MGD in the R.W. Beck model. Under the 1.0 MGD per year increase, he

calculates that the Pool 3 option cost increases by about $10 million on a present worth basis, while the LWC pipeline option increases by $47 million, or a net increase for the LWC pipeline of $37 million. R.W. Beck agrees with this assessment, but must point out that under the 1.0 MGD and 1.25 MGD scenarios, both project options run out of capacity by the years 2020 and 2018, respectively. At the point capacity is exhausted, additional infrastructure will be needed to meet the demands of Central Kentucky water customers. The net impact is that higher water usage increases will drive the program to the R.W. Beck Phase 2 sooner than 2030, but the financial comparison remains the same.

Request No. 9

Provide a copy of LWC's most recent bond resolution, including rate covenants and the level of revenues required for those rates.

Responsible Witness: **Greg Heitzman**

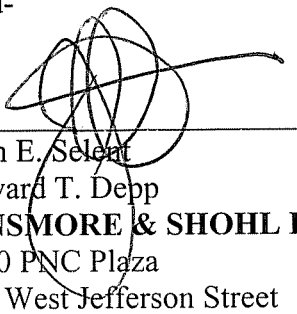
RESPONSE: Please see the attached.

Respectfully submitted,

Barbara K. Dickens
Vice President and General Counsel
Louisville Water Company

550 South Third Street
Louisville, KY 40202

-and-



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Counsel to Louisville Water Company

CERTIFICATION

I hereby certify that I have supervised the preparation of Louisville Water Company's responses to the post hearing data requests and that the responses contained herein are true and accurate to the best of my knowledge, information, and belief formed after reasonable inquiry.

Gregory C. Heitzman,
President of Louisville Water Company

Date: 12/7/07

CERTIFICATION

I hereby certify that I have supervised the preparation of Louisville Water Company's responses to the post hearing data requests and that the responses contained herein are true and accurate to the best of my knowledge, information, and belief formed after reasonable inquiry.

Ed Wetzel, Executive Vice President
R.W. Beck, Inc.

Date: 12/7/07

CERTIFICATE OF SERVICE

I hereby certify that a copy of the foregoing was served by was served via first-class United States mail, sufficient postage prepaid, on the following individuals this 10th day of December, 2007:

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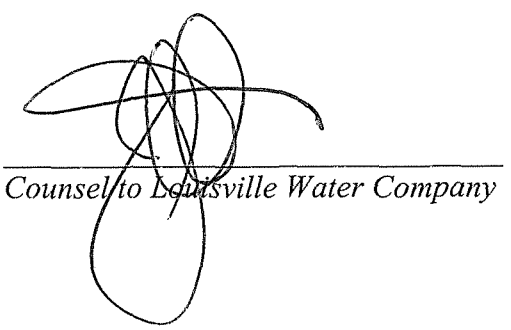


Counsel to Louisville Water Company

Crescent Hill Filter Plant
Advanced Treatment Technology Steering Group
Mission Statement

The purpose of the Crescent Hill Filter Plant Advanced Treatment Technology Steering Group is to consider advanced treatment technologies and combinations thereof, necessary to meet future drinking water regulations and customer expectations for water quality. The Steering Group must reach a consensus decision on the best treatment technology to construct for the Crescent Hill Water Treatment Plant over the next five years. Technology vital to the future of the Louisville Water Company may require a capital investment of over $100 million. The Steering Group's recommendation will be presented to Board of Water Works in the fall of 2005.

The Steering Group is comprised of the following members: Mr. Greg Heitzman, Mr. John Huber, Mr. Rick Johnstone, Mr. Gerald Martin, Mrs. Marita Willis, and Mr. Joe Wise. Louisville Water Company staff, Black and Veatch, Jordon Jones and Goulding Engineers, and United States Geological Survey will help facilitate the process by providing information specific to the Louisville Water Company. Information necessary for consideration includes: advanced treatment technology options and combinations; current and future federal and state regulations; Crescent Hill Filter Plant water quality goals, measures, and results; unique criteria for new and retrofit technologies at Crescent Hill Filter Plant; capital, operations, and maintenance costs; constructability; and customer trust and expectations.

LOUISVILLE WATER COMPANY
CRESCENT HILL FILTRATION PLANT
ADVANCED TREATMENT STUDY

Steering Group Meeting No. 1
January 25, 2005

Outline

I. OPENING COMMENTS / INTRODUCTIONS *John*

II. LWC INFORMATION *Greg*

A. Background and History
B. Operating Philosophy and Practices
C. Customer Expectations

III. 2002 – 2021 FACILITIES PLAN *Larry*

IV. GOALS OF THE ADVANCED TREATMENT STUDY PROJECT *Larry*

A. Establish Water Quality Goals
B. Evaluate Drinking Water Regulations
C. Determine Recommended Process Modifications

V. DRINKING WATER REGULATIONS *Bruce*

VI. POTENTIAL TREATMENT TECHNOLOGIES AND OPTIONS *Bruce*

VII. FUTURE STEERING GROUP MEETINGS *Greg*

VIII. QUESTIONS *All*

Steering Group Meeting No. 1

Louisville Water Company

Crescent Hill Filtration Plant Advanced Treatment Study

January 25, 2005

BLACK & VEATCH

Opening Comments and Introductions

John Huber

BLACK & VEATCH

Louisville Water Company Information

Greg Heitzman

BLACK & VEATCH

LWC Information

A. Background and History
B. Operating Philosophy and Practices
C. Customer Expectations

BLACK & VEATCH

2002 – 2021 Facilities Plan

Larry Gaddis

BLACK & VEATCH

2002 – 2021 Facilities Plan

Components:

A. Business / Finances
B. Customer Service
C. Operations
D. Infrastructure
E. Demand Projections
F. Regulatory Assessment
G. Water Supply and Treatment Facilities
H. Delivery and Storage Facilities
I. Capital Improvement Program

BLACK & VEATCH

2002 – 2021 Facilities Plan

Key Treatment Recommendations

- RBF considered viable for CHFP, if the following assumptions confirmed:
  - Sustainable capacity
  - Costs
  - Geological conditions
  - Property acquisition
  - Water quality

BLACK & VEATCH

2002 – 2021 Facilities Plan

Recommended Capital Improvement Program

- $912 million total
- $140 million for advanced treatment at Crescent Hill and B. E. Payne
  - By 2007:
    - RBF at B. E. Payne
    - UV disinfection at Crescent Hill
  - By 2011:
    - RBF at Crescent Hill
    - UV disinfection at B. E. Payne

BLACK & VEATCH

Advanced Treatment Study Goals

Larry Gaddis

BLACK & VEATCH

Advanced Treatment Study Goals

A. Establish Water Quality Goals
B. Evaluate Applicable Regulations
C. Determine Compliance Ability of CHFP
D. Select Feasible Treatment Options
E. Recommend Improvements

BLACK & VEATCH

Advanced Treatment Study Goals

A. Establish Water Quality Goals
   1. Existing, pending, and proposed future Federal and State regulations (B&V)
   2. LWC customer expectations (LWC)
   3. Internal LWC goals (LWC)

BLACK & VEATCH

Advanced Treatment Study Goals

B. Evaluate Applicable Regulations
   1. Establish status of regulations
   2. Determine applicability and impact for LWC

BLACK & VEATCH

Advanced Treatment Study Goals

C. Determine Compliance Ability of CHFP
   - Treatment Performance / Finished Water Quality
   - Discussions with LWC staff
   - Evaluate areas of need

BLACK & VEATCH

Advanced Treatment Study Goals

D. Select Feasible Treatment Options
   - Preliminary options
   - Initial screening
   - Determine evaluation criteria
   - Plant investigation and constructability review
   - Process Workshop

BLACK & VEATCH

Advanced Treatment Study Goals

E. Recommend Improvements
   - Detailed evaluation
   - Recommended process option(s) selection
   - Summary report

BLACK & VEATCH

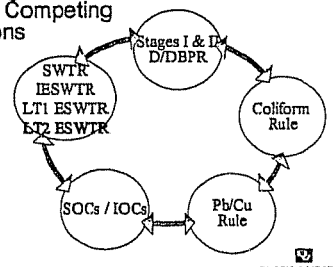
Drinking Water Regulations

Bruce Long

BLACK & VEATCH

Drinking Water Regulations

Safe Drinking Water Act – Range of Competing Regulations



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Drinking Water Regulations

- SDWA Regulations Are Directing Us Towards...
  - Increased disinfection effectiveness/efficiency
    - Enhanced particulate removal
    - Improved inactivation
  - Minimized formation of DBPs

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Regulations Are Requiring Higher and Higher Treated Water Quality

Parameter	1980	1990's	2002	Beyond
Turbidity (NTU)	>1	0.5	0.3	<0.1
THMs (ug/L)	NA	100	80	80*
HAAs (ug/L)	NA	NA	60	60*
Target Organism	Bacteria	*Giardia* Viruses	*Crypto-sporidium*	*Emerging Pathogens*

*LRAA

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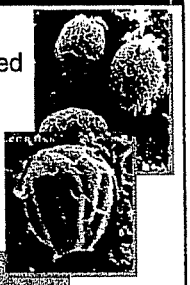
Drinking Water Regulations

- "Disinfection" Is Comprised of Two Processes
  - Physical Removal
  - Inactivation
    - Chemical
    - Irradiation



Disinfectant-Resistant Organisms

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Drinking Water Regulations

- Enhanced Particulate Removal Is Accomplished By…
  - Conventional treatment -- improved performance of:
    - Coagulation/flocculation
    - Solids capture - sedimentation/flotation
    - Granular media filtration
      - new media configurations
      - improved operational practices
  - Membrane processes
  - Riverbank Filtration

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Drinking Water Regulations

- Enhanced Particulate Removal
  - Lower filtered water turbidity (particle counts)
  - Lower levels of (Log removal considerations)
    - *Giardia*
    - *Cryptosporidium*
    - Enteric viruses
    - Other microbials
  - Must be achieved independent of raw water quality

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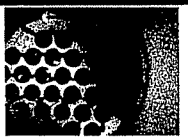
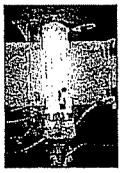
Drinking Water Regulations

- Increased Microbial Inactivation
  - Use of stronger disinfectants and combinations
    - Ozone
    - Chlorine dioxide
    - Chlorine
    - Chloramines
  - ***UV irradiation***





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Drinking Water Regulations

- Minimizing DBP Formation
  Precursors + Disinfectant ⇒ DBPs
- Reduce precursors level by
  - Enhanced coagulation/softening
  - Powdered activated carbon
  - Anionic exchange resins
  - Physical separation - membranes
- Shift to alternative disinfectant(s)

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Drinking Water Regulations

- LT2ESWTR Will Be Based On a Technology "Toolbox"
  - Raw Water Microbial Quality
    - Determines your "Bin"
    - Bin level determines removal/inactivation requirements
  - Toolbox Holds Compliance Alternatives
    - Source water control
    - Pretreatment
    - Treatment

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Drinking Water Regulations

Bin Position Determined By *Cryptosporidium* Concentration

Bin Number	Average Cryptosporidium Concentration	Additional treatment requirements for systems with conventional treatment that are in full compliance with IESWTR
1	Cryptosporidium<0.075/L	No action
2	0.075/L≤Cryptosporidium <1.0/L	1-log treatment (systems may use any technology or combination of technologies from toolbox as long as total credit is at least 1-log)
3	1.0/L≤Cryptosporidium< 3.0/L	2.0 log treatment (systems must achieve at least 1-log of the required 2-log treatment using ozone, chlorine dioxide, UV, membranes, bag/cartridge filters, or in-bank filtration)
4	Cryptosporidium≥3.0/L	2.5 log treatment (systems must achieve at least 1-log of the required 2.5-log treatment using ozone, chlorine dioxide, UV, membranes, bag/cartridge filters, or in-bank filtration)

Drinking Water Regulations

- LT2 (Microbial) Toolbox
  - Cryptosporidium removal/inactivation
    - 3.0-log conventional treatment credit
      - IESWTR: 2-log credit for lower turbidity
    - Bin number requires 0, 1, 2, or 2.5-log additional treatment
      - Watershed control
      - Alternative source
      - Pretreatment
      - Improved treatment
      - Improved disinfection
      - Peer review/performance validation

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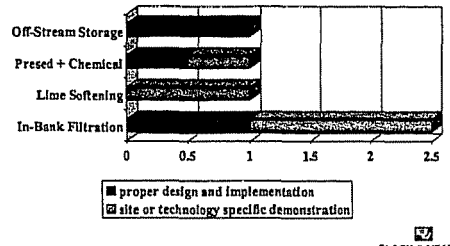
Drinking Water Regulations

- Pretreatment Tools



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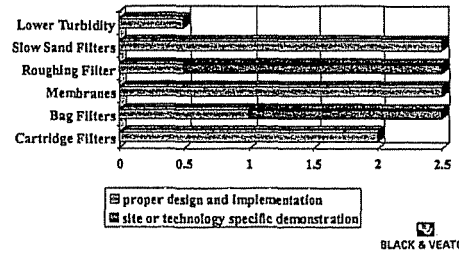
Drinking Water Regulations

- Improved Treatment Tools



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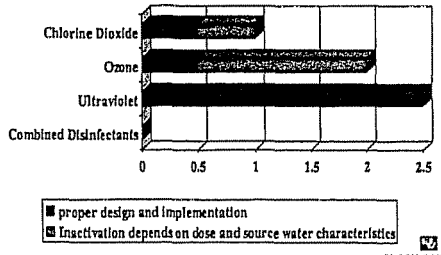
Drinking Water Regulations

- Improved Disinfection Tools



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Drinking Water Regulations

- Additional contaminants are looming
  - Expanded list of disinfection byproducts
  - Endocrine disruptors
  - NDMA
- Increased focus on distribution system issues

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Potential Treatment Technologies

Bruce Long

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Compliance Options Require Holistic Approaches

Supply — Treatment — Distribution

- Source water quality considerations
- Treatment process enhancement
  - Operational
  - Facility design
- Distribution system management
- Multiple barrier considerations are central to these approaches
  — EPA's "toolbox" of additive solutions

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Potential Treatment Technologies

- Source Water Quality
- Enhanced Solids Capture
- Disinfection Byproduct Precursor Removal
- Oxidation / Disinfection Processes

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Potential Treatment Technologies

Source Water Quality

- Surface water vs. groundwater
- Source water protection
- Riverbank filtration

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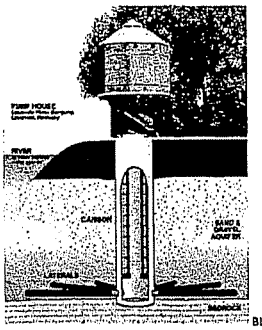
Potential Treatment Technologies

Riverbank Filtration



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Potential Treatment Technologies

Enhanced Solids Capture

- Lamella plates
- Dissolved air flotation
- Ballasted flocculation
- Superpulsator clarifiers
- Membrane processes

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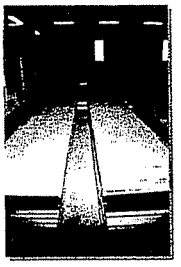
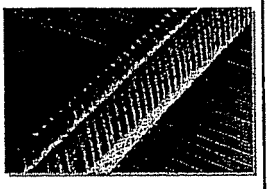
Potential Treatment Technologies

Lamella Plates





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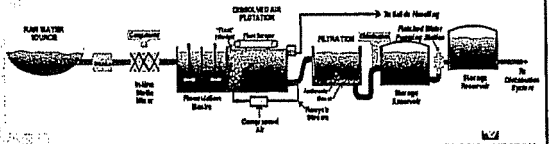
Potential Treatment Technologies

Dissolved Air Flotation

- Gaining Favor in the US
  - Largest 75 mgd, Greenville, SC
- Typically used on high quality water



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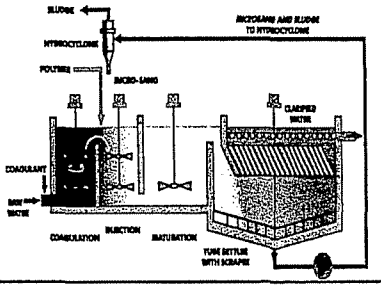
Potential Treatment Technologies

Ballasted Flocculation Process



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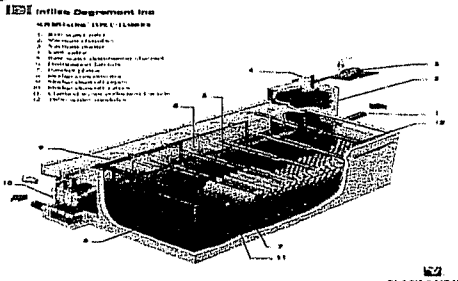
Potential Treatment Technologies

Superpulsator Clarifiers



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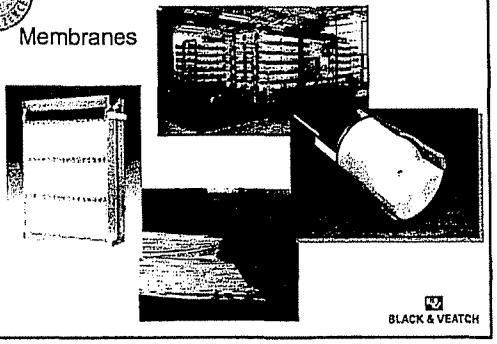
Potential Treatment Technologies

Membranes



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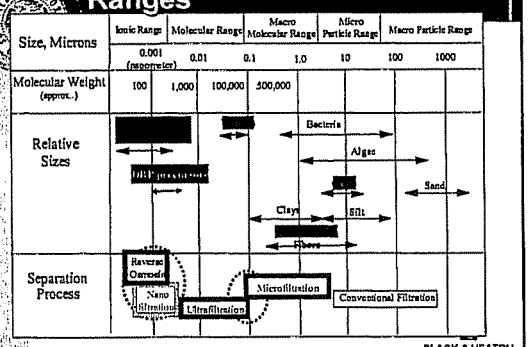
Membrane Removal Size Ranges



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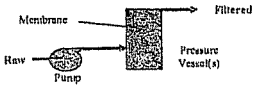
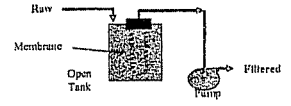
Potential Treatment Technologies

Cartridge Membrane System



Pump supplies positive pressure to DRIVE water through membrane media.

Submerged Membrane System



Pump suction PULLS water through membrane media.

Potential Treatment Technologies

DBP Precursor Removal

- Reduce precursor level by:
  - Enhanced coagulation / softening
  - Powdered activated carbon
  - Anionic exchange resins
  - Physical separation (membranes)
- Shift to alternate disinfectants

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Potential Treatment Technologies

Oxidation / Disinfection Processes

- Potassium permanganate
- Chlorine dioxide
- Ozone
- Chlorine
- Chloramines
- Ultraviolet (UV)

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Future Steering Group Meetings

Greg Heitzman

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Future Steering Group Meetings

Meeting No. 2

- Riverbank Filtration Information (Jordan, Jones & Goulding)

Meeting No. 3

- Water Quality Goals
- Regulatory Status
- Crescent Hill FP Performance
- Potential Treatment Options

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Future Steering Group Meetings

Meeting No. 4

- Preliminary Treatment Options and Screening
- Plant Investigation and Constructability Review
- Outcome of Process Workshop

Meeting No. 5

- Improvements Evaluation and Recommendations

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Open Discussion and Questions

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Louisville Water Company

Minutes

Crescent Hill Advanced Treatment Technology Steering Group

January 25, 2005

Present: Kay Ball, Larry Gaddis (Black & Veatch), Steve Greseth (Black &Veatch), Greg Heitzman, John Huber, Rick Johnstone, Bruce Long (Black & Veatch), Gerald Martin, Bob Miller, Jim Smith, Karla Teasley, Steve Tucker, Jack Wang, and Joe Wise.

Absent: Marita Willis.

The meeting began at 12:20pm.

Opening Comments / Introductions – John Huber

John Huber opened the meeting with introductions and a brief overview of LWC's current treatment systems.

LWC Information – Greg Heitzman

Greg Heitzman provided the group with some highlights of LWC's background and history. Greg explained some challenging water treatment scenarios that have occurred with treating Ohio River source water, such as industrial spills, algae blooms, and pathogen removal. LWC must deliver a safe, high quality product to its customers on a continuous basis. The Crescent Hill facility is nearly 100 years old and will require significant investment to maintain the facility and also to prepare it to meet new and increasingly stringent water quality requirements. LWC is proud of its history to keep ahead of EPA regulations. LWC wants to invest in technology that is appropriate to achieve regulatory compliance and high customer satisfaction.

The treatment technology considerations have been broken into the following phases:

Phase I: B.E. Payne Demonstration Well (1999)
Phase II: B.E. Payne Tunneling Project (2005)
Phase III: Selection of Advanced Treatment Technology for Crescent Hill (2005)

The total budget for Phase III is $107 million. The Steering Group will need to determine if this budget is appropriate for the technology chosen. LWC needs a reliable system to meet security requirements and provide the necessary water quality and water quantity (pressure and flow). Energy requirements and full life-cycle costs (capital and operating costs for the life of the technology) will also be considered.

Black & Veatch will provide an overall review of treatment options from a planning prospective. Jordan, Jones & Goulding (JJ&G) will provide conceptual projections using the Riverbank Filtration (RBF) technology for Crescent Hill. USGS will provide information on the Louisville aquifer and the suitability of using the aquifer for supply to the Crescent Hill treatment plant.

The Steering Group will have four additional meetings. These meetings will occur every five to six weeks, from January through July 2005.

2002-2021 Facilities Plan – Larry Gaddis

Larry Gaddis presented a summary of the 2002-2021 Facilities Plan developed by Black & Veatch. Larry reviewed the various components addressed in the plan and key treatment recommendations (RBF and UV disinfection) for both Crescent Hill and B.E. Payne. These recommendations are potential preliminary options to consider. Bruce Long explained that UV disinfection was recommended because it effectively inactivates cryptosporidium.

Goals of the Advanced Treatment Study Project – Larry Gaddis

Larry Gaddis reviewed the objectives of the Advanced Treatment Project, which are to establish water quality goals, evaluate applicable regulations, determine the compliance ability of Crescent Hill treatment plant, select feasible treatment options, and recommend improvements. LWC staff will develop consensus on treatment options in an upcoming spring workshop. The results of this workshop will be presented to the Steering Group for consideration.

Drinking Water Regulations – Bruce Long

Bruce Long presented regulations resulting from the Safe Drinking Water Act (SDWA). LWC can anticipate the introduction of new drinking water regulations and increased requirements for existing regulations as detection capability improves. Enhanced particulate removal, improved inactivation, and minimized formation of disinfectant byproducts (DBPs) will be required to continue LWC's long tradition of providing safe, quality drinking water.

Bruce informed the group of potential issues that LWC may face in the future, such as impacts from pathogens (giardia and cryptosporidium). Future regulations will likely limit the allowed amounts of DBPs produced from a combination of pretreatment and treatment strategies. Synthetic and organic compounds will also be regulated. Water utilities must be prepared for natural disasters, as well as potential source water contamination, treatment operational errors, and intentional threats to the water supply.

Questions/Comments

Do treatment requirements change with changes in the bin category?
Yes, removal and inactivation requirements depend on the bin level of source water. Bin levels are determined by the cryptosporidium concentration in the source water. LWC's source water, the Ohio River, is categorized at a bin level of 2. LWC's source water is also considered "flashy", meaning its conditions are highly variable, so LWC needs to be prepared to treat for multiple scenarios.

What is the location used to sample and measure for cryptosporidium when determining LWC's bin level?
The Ohio River is used for surface water sources, while the B.E. Payne collector well is used for groundwater source.

What will LWC do if regulations change sampling location (i.e. from the collector well to the river)?
This remains to be determined, based upon regulation.

What is the finished water quality at the RBF well versus at B.E. Payne and CHFP, considering that the water quality is different at the receiving stage for each location?
The RBF well water is of high quality, more stable, with a reduced range of temperature variation. An analysis of RBF vs. Ohio River source water will be presented at the next Steering Group meeting.

What are the long- and short-term health effects LWC must consider?
A short-term, or acute, issue would be intestinal illness resulting from ingestion of pathogens. A possible long-term condition would be cancer resulting from extensive exposure to DBPs. This is based on laboratory prediction studies. LWC currently complies with all standards regulating Trihalomethanes (THMs) and Haloacetic Acids (HAAs), known DBPs, with the current treatment methodology (chloramine application); however this treatment strategy could be at risk in the future. Bruce Long believes LWC will be able to continue using chloramine, but at reduced quantities because of the resulting DBPs. Therefore, LWC would need to consider combination techniques, stronger disinfectants, or other methodologies (i.e. UV) to effectively treat the water. UV disinfection is very effective against oocysts (i.e. cryptosporidium and giardia); it is not effective treating against viruses.

In the past, water samples would be taken from several locations within the distribution system and the results would be averaged to determine compliance. Now LWC is responsible at all points in the distribution system for water quality. Consider that coliform can result at any point in the distribution system, not just at the treatment plant. Adequate water pressure and flow must be maintained to prevent stagnation, and thus bacteria growth.

Are pesticides and herbicides considered organic compounds?
Yes, pesticides and herbicides are considered synthetic organic chemicals.

Potential Treatment Technologies and Options – Bruce Long

Bruce gave an overview of the different technologies and options available along with a brief description of how these technologies work and their treatment effectiveness.
LWC can change its source water from surface water to ground water, but the rules change and LWC must consider aesthetic issues. Manganese and iron cause taste and odor problems. Drinking water needs to be both healthful and aesthetically pleasing to assure high customer satisfaction.

Several new technologies were discussed, including:

Lamella settling plates are an alternative to conventional sedimentation. The narrowly spaced plates are inclined on a 55 degree angle, to reduce the time for particles to settle. The plates work by uniform hydraulic distribution, and smaller settling distances. Less space is required to accommodate this treatment technology, hereby reducing construction costs.

Membranes work well because the membrane pores are much smaller than the organisms to be filtered out. The water can be "pushed" or "sucked" through the membrane. A siphon can be used to suck water through the membrane and it requires less power than the "push" method, resulting in reduced energy costs. Greg stated that membrane technology was not a viable option when the Facilities Plan was developed because of LWC's large capacity needs. However, now membrane plants in the 100 MGD range are operational. LWC may want to reconsider this as an option since the technology and costs have improved over the past several years.

UV technology can be very expensive from a capital standpoint if retrofitting in an existing facility. In order to accommodate UV technology at Crescent Hill, the area between the filter galleries and the distribution pipes would need to be modified, or a separate external structure, housing the UV reactors, would need to be constructed. UV effectiveness increases positively with water clarity, therefore is a good companion treatment technique to bank filtration systems, or other processes.

Additional Questions/Comments

Should LWC consider strategies that do not require chloramine, considering that chloramine may not be available for use in the future?
Bruce believes it is highly unlikely that chloramines will be dispelled as a basis for treatment. Chloramines are a positive barrier in the distribution system. However, reducing dependence on chloramines merits attention and LWC should evaluate alternatives to chloramines. Free chlorine is more effective against "superbugs".

Does Black & Veatch recommend any insurance against toxins begin dumped in LWC source water?
Some technologies will have more advantages and will be less vulnerable to terrorist acts than others.

What happens to our old technology?
If Riverbank Filtration wells are chosen, LWC will likely continue to operate the Zorn Pump Station as a back-up operation. If new technology can be integrated with and complement existing technology, which would be figured in the life-cycle costs, LWC may experience overall reduced costs or at least alleviate the cost of removing old technology.

How will LWC communicate to customers that all customers pay the same rate for water that is treated with different technologies?
This will not be a problem if the water quality is the same irregardless of the technology used to treat it. Issues will occur if the water quality from B.E. Payne differs from Crescent Hill. Larry Gaddis advised that LWC would not be pioneers in this aspect. Cincinnati has two separate treatment scenarios and has not experienced any resulting issues. It is important that both plants produce the same high level of water quality.

If the B.E. Payne plant went down, how would LWC supply its respective customers with water?
John Huber advised that there is an interconnection between B.E. Payne and Crescent Hill, so limited service to all customers could be provided. The Crescent Hill plant produces enough water to supply our entire customer base on an average day, however B.E. Payne cannot.

It would help to know the definitions of the terms and acronyms being used in this process. Something similar to what was provided to Board Members in orientation would be helpful.

Bruce Long will provide a glossary of terms and acronyms that will be used. Some of the terms and acronyms from this meeting are listed below for reference.

- *DBPs - disinfectant byproducts that form when precursors and disinfectants react. For example, Organic Carbon + Chlorine = DBP(s).*
- *Cl_2 – chlorine*
- *NH_2Cl - chloramine*
- *Pb/CU Rule - Lead and Copper Rule*
- *SWTR – Surface Water Treatment Rule*
- *Turbidity – the measure of how much particulate matter is present in water. Measured by the amount of light that can pass through. Bacteria are the target organism.*
- *THMs – Trihalomethanes. A compound that forms when chlorine enters water and reacts with organisms.*
- *HAAs – Haloacetic acids. A byproduct of chlorine. Usually occurs when increasing amounts of chlorine are used for treatment (i.e. treatment of giardia).*

Future Steering Group Meetings

Greg Heitzman distributed a proposed schedule for future Steering Group meetings. The schedule outlines the topics that will be addressed at each meeting. He asked that members advise him of any scheduling conflicts.

For the second meeting, Jack Wang will bring data showing RBF finished water quality, to include particle counts, in comparison to river water. JJ&G will present on the B.E. Payne treatment strategy concept at CHFP.

At the third meeting, Black & Veatch will return to provide more technological detail and specific objectives and goals in regard to water quality, design capacity, etc. Black & Veatch will also present additional information regarding regulations so the group can identify potential gaps between LWC finished water quality and anticipated regulations with focus on two to four scenarios.

The fourth meeting will be used to define options. A decision methodology will be used for critiquing the recommendations. A life-cycle cost analysis will be conducted.

A fifth meeting may or may not be necessary depending on how the aforementioned meetings progress.

Recommendations from the Steering Group will be presented to the full Board of Water Works (BOWW) in August or September. This should allow ample time to work with the 2006 budget and make any necessary borrowing preparations.

Greg committed to providing high level, pre-read material in advance of the meeting. Ultimately, we will narrow technology options down to two or three considering both acute and long-term risks. LWC wants to invest wisely in anticipation of regulation changes.

WATER WORKS
LWC 150
1854 - 2004

LOUISVILLE WATER COMPANY
CRESCENT HILL FILTRATION PLANT
ADVANCED TREATMENT TECHNOLOGY

Steering Group Meeting No. 2
March 10, 2005
Agenda

I.	OPENING COMMENTS / INTRODUCTIONS	*Greg Heitzman*
II.	HISTORY OF LOUISVILLE AQUIFER	*Kay Ball*
III.	ADVANCED TREATMENT PHASE I	*Kay Ball and Jack Wang*
IV.	ADVANCED TREATMENT PHASE II	*Kay Ball*
V.	LOUISVILLE AQUIFER CHARACTERISTICS	*Mike Unthank, USGS*
VI.	ZORN RBF TUNNEL ALTERANTIVE	*David Haas, JJ&G*
VII.	OPEN DISCUSSION AND QUESTIONS	*All*
VIII.	WRAP UP	*Greg Heitzman*

Advanced Treatment Technology Steering Group

WATER WORKS LWC 150 1854 - 2004

River Bank Filtration

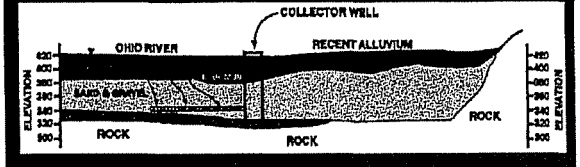
Presented by Kay Ball and Jack Wang, Ph.D.
March 10, 2005

River Bank Filtration Program

River Bank Filtration (RBF) is a water purification process that takes advantage of the natural aquifer along the river bank.

Using a pump and well system, river water is filtered through the sand and gravel in the river bank.

Cross Section View of the Louisville Aquifer



RBF Advantages

- Provides additional barrier for pathogen removal such as cryptosporidium & giardia
- Reduces risk associated with
  - [illegible]
  - [illegible]
  - [illegible]
- Stabilizes water temperature, reducing water main breaks
- Reduces potential water quality problems in the distribution system
- Provides stable incoming water for treatment to insure consistent finished water quality
- Environmentally friendly solution using the natural sand and gravel in the riverbank as a filter to remove contaminants

History of the Louisville Aquifer and Louisville Water Company's River Bank Filtration Program

The 1940s

- United States Geological Survey (USGS) commissioned to investigate a means of providing more aesthetically pleasing water supply
- R. L. Rorabaugh, USGS, established a connection between the Ohio River and the adjacent groundwater
- Landmark hydrogeology
- Estimated infiltration supplies could be developed to the extent of 280 million gpd over a 6.1 mile stretch from Beargrass Creek to Harrods Creek

1970s

- EPA regulates Disinfection By-Products (DBPs)
- Pilot well study at Zorn to investigate the RBF as a method for reduction of
  - trihalomethane formation potential (THMFP)
  - total organic carbon (TOC)
  - synthetic organic contaminants (SOC)
- Resulted in significant (about 50%) reduction of THMFP and TOC
- A significant reduction of SOC occurrence, but the low levels found in the river and the aquifer made the reduction difficult to quantify

1990s

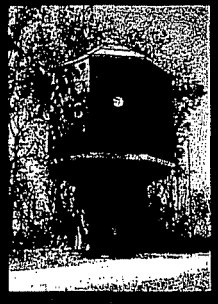
- 1993 Milwaukee Cryptosporidium Outbreak
- Increased awareness of the risk of microbial disease
- LWC re-activated pilot well at Zorn Pump *Station*
- Up to 2.4 logs of removal of particle and 50% removal for organic matter were achieved using RBF

River Bank Filtration Program

- Board of Water Works granted authorization to investigate River Bank Filtration as a source supply water on December 12, 1995
  - Phase I – 15 MGD Demonstration Well at BEP
  - Phase II – Additional 45 MGD at BEP
  - Phase III – Evaluate advanced treatment technologies for 180 MGD at Zorn Ave

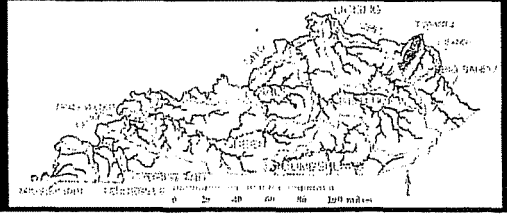
Phase I – River Bank Filtration

- Install 15 MGD demonstration well at B.E. Payne Water Treatment Plant (BEPWTP)
- Placed in service in 1999
- Average pumping of 17 MGD
- Exceeds expectations for water quantity and quality



Wellhead Protection Program

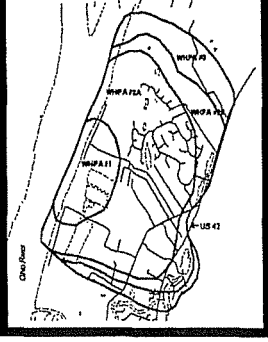
Wellhead protection is the prevention of groundwater contamination by management of potential contaminant sources within a designated land area around a well or a spring.



Wellhead Protection Program

Delineate Wellhead Protection Areas

LWC used groundwater modeling software to depict the geologic conditions of the aquifer supplying the collector well, and the groundwater flow through the aquifer.



Wellhead Protection Program

The RBF collector well is located at the B. E. Payne Water Treatment Plant (BEPWTP) near Prospect, Kentucky.

The Wellhead Protection Area covers only a small portion of the county.

The Wellhead Protection Plan was approved by the Kentucky Division of Water (KDOW) in November 2004.

Quality of the River Bank Filtration Water

Typical Water Quality – Chemical

CATEGORY	OHIO RIVER	RBF @ BEP	Percent Reduction
TOC	3.4 mg/L	1.5 mg/L	50%
Hardness	144 mg/L	230 mg/L	(60%)
Iron	0.005 mg/L	0.005 mg/L	
Manganese	0.005 mg/L	0.35 mg/L	

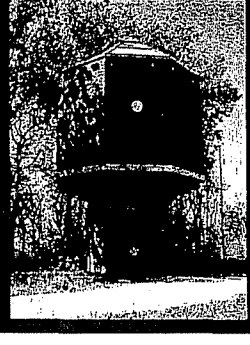
Typical Water Quality – Microbial

CATEGORY	OHIO RIVER	RBF CUBE	LOG REDUCTION
Turbidity	61.3 NTU	0.1 NTU	2.5
Algae	1.2E+7 100L	ND	7.6
Diatoms	6.7E+6 100l	ND	7.4
Pollen	3.5E+3 100l	ND	4.5
Spores	1.1E+4 100L	2.6E+0	3.6
Cryptosporidium	30 100L	0.3 100L	2

Ohio River vs. RBF Water

Public Input and Response

- Original concept
  - 15-20 collector wells on towers
  - Scenic Byway of River Road
  - Impact on viewscape along River Road



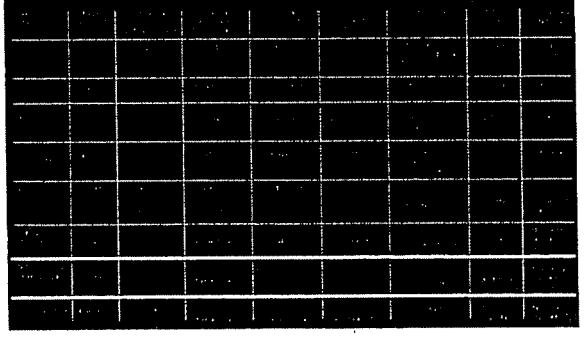
Technical Advisory Committee (1998 – 1999)

- Members
  - Dr. Thomas Crawford, University of Louisville
  - Tom Fitzgerald, KY Resource Council
  - Dr. Anna Huang, MD, University of Louisville
  - Dr. Melinda Rowe, MD, Health Department
  - Meme Sweers Runyon, River Fields
- Facilitator
  - Joan Riehm

Technical Advisory Committee

- Identify the need for Alternative Treatment Technology at LWC and determine the appropriate alternative in terms of efficiency and affordability and community impact
- TAC first met in December 1998
- Recommended RBF tunnel as the treatment technology to meet current and future regulations (December 1999)

Comparison of Alternative Treatment Technologies (1999)



Phase II – River Bank Filtration

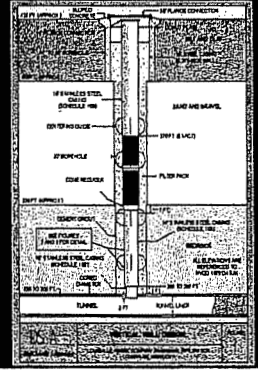
- Provide additional 45 MGD for a total of 60 MGD capacity at BEPWTP
- Board authorized Preliminary Design Phase of RBF tunnel in December 1999
- Subsurface investigations began to determine suitability for tunnel

Phase II – River Bank Filtration at INAAP

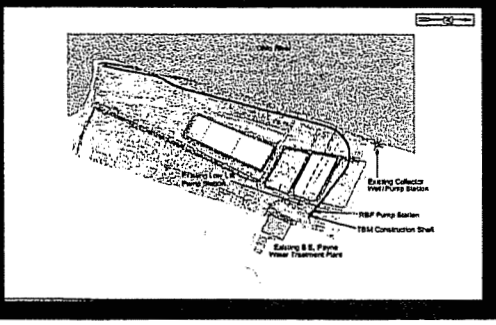
- July 2000 - LWC and Aqua Source began discussions about purchasing lease rights to Indiana Army Ammunitions Plant (INAAP) Wellfield including the purchase of Goshen
- May 2001 - LWC entered into an agreement with Aqua Source and began due-diligence process
  - Aquifer – well yield
  - Potential INAAP contaminants
  - Kentucky – Indiana regulatory and water rights issues
- February 2002 – staff presented results of due-diligence to the BOWW and recommended to pursue RBF on the Kentucky side of the Ohio River

Phase II – River Bank Filtration

- BOWW authorized Final Design Phase in November 2002 for a below-grade solution
- 31 vertical wells capped at grade
- Connected to a 8600 foot long, 10 foot diameter tunnel
- Pump station within the secured area of the plant



Phase II – River Bank Filtration Tunnel Alignment



Phase II – River Bank Filtration

- Bid on March 2, 2005
  - Engineers estimate $31,000,000
  - Apparent low bid $48,375,000
- Bid analysis currently underway with LWC and Jordan, Jones & Goulding (JJ&G)
- Recommendation planned for March 15 BOWW meeting

USGS
science for a changing world

Summary of Available Hydrogeologic Data for the Alluvial Deposits between Beargrass Creek and Harrods Creek, Louisville, Kentucky

Presented to the Louisville Water Company Steering Group

March 10, 2005

Mission of the USGS Water Resources Program:

Provide reliable, impartial, timely information that is needed to understand the Nation's water resources.

Actively promote the use of this information by decision makers to:

- Minimize loss of life and property as a result of water-related natural hazards.
- Effectively manage ground-water and surface-water resources for all uses.
- Protect and enhance water resources for human health, aquatic health, and environmental quality.
- Contribute to wise physical and economic development of the Nation's resources for the present and future generations.

Sources of information and data

- U.S. Geological Survey – current ground-water monitoring programs, well inventories and water-quality data base, and previous investigations
- Louisville Water Company – pump test project files and riverbank infiltration studies
- Kentucky Geological Survey – Kentucky Ground-Water Repository
- Kentucky Division of Water – project files and misc. records
- Area ground-water users – well field records, drilling logs, water-quality sampling

USGS

Purpose and scope

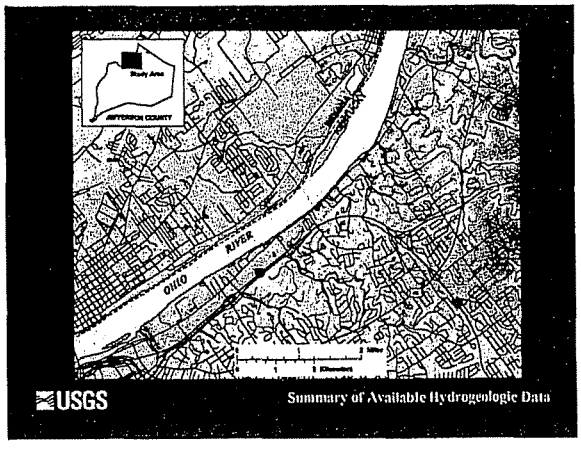
- Summarize the available information on ground water for the northeast portion of the alluvial aquifer in Jefferson County
- Present the information in a form suitable to assist with the future development and use of the area's ground-water resources
- Final publication will be an electronic USGS Open-File Report available on the USGS web site

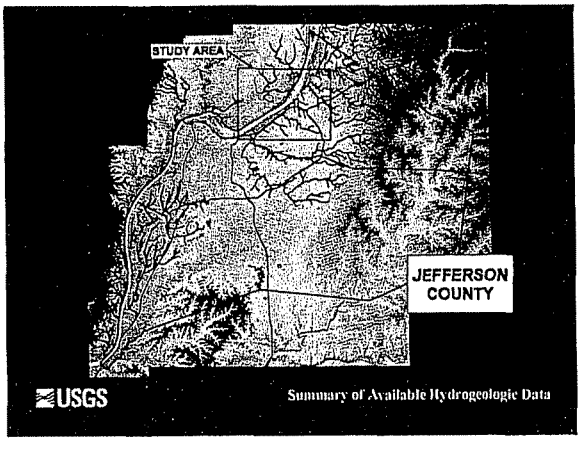
USGS

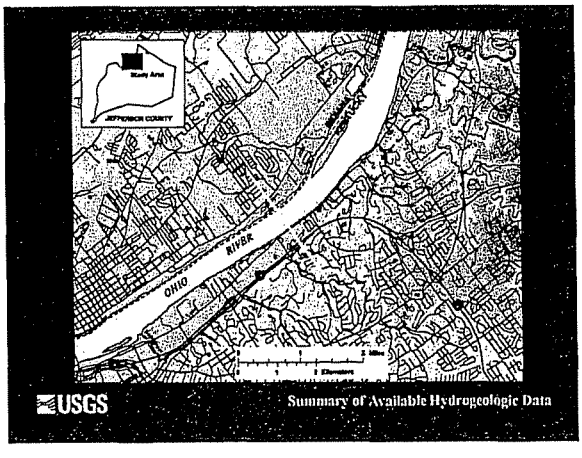
Data compilation targets

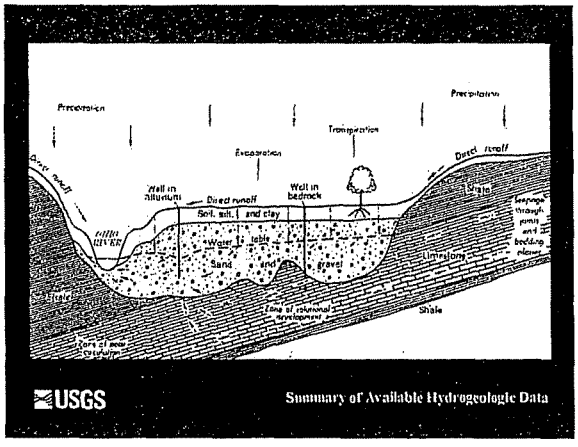
- Movement of water – Where is the water coming from, where is it going, and how best to gather it
- Quantity of water – How much of the resource can be safely developed
- Quality of water – What will the quality of the water be initially and over an extended period of withdrawal

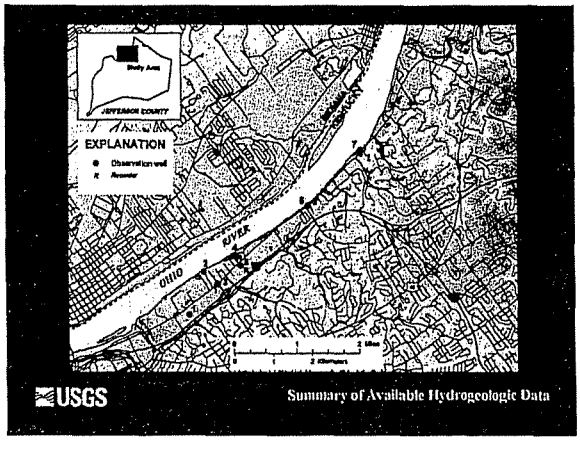
USGS

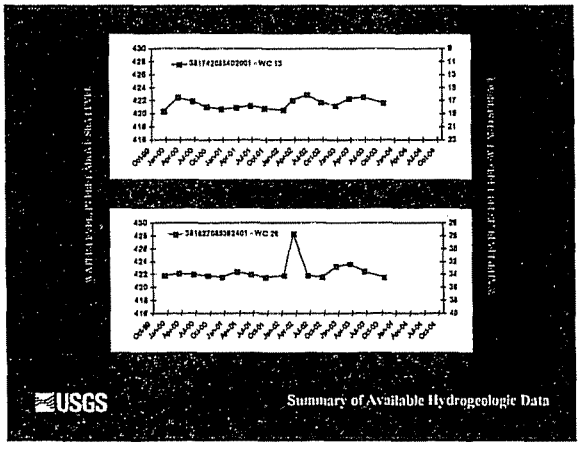

Study Area
JEFFERSON COUNTY
OHIO
RIVER
USGS
Summary of Available Hydrogeologic Data

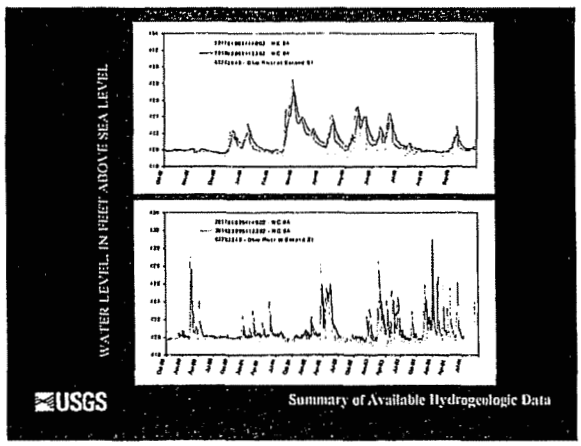

STUDY AREA
JEFFERSON COUNTY
USGS
Summary of Available Hydrogeologic Data

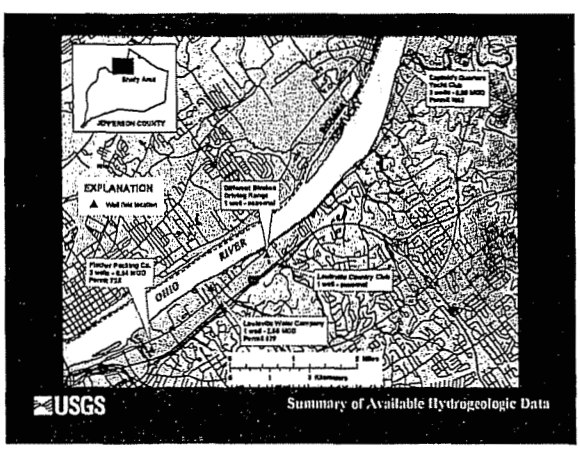

Study Area
JEFFERSON COUNTY
OHIO
RIVER
USGS
Summary of Available Hydrogeologic Data

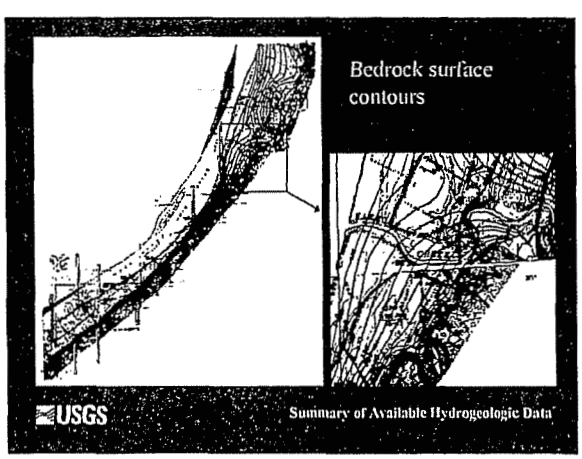

Precipitation
Evaporation
Transpiration
Direct runoff
Well in alluvium
Well in bedrock
Sand, silt, and clay
Water table
Sand and gravel
Limestone
Shale
USGS
Summary of Available Hydrogeologic Data

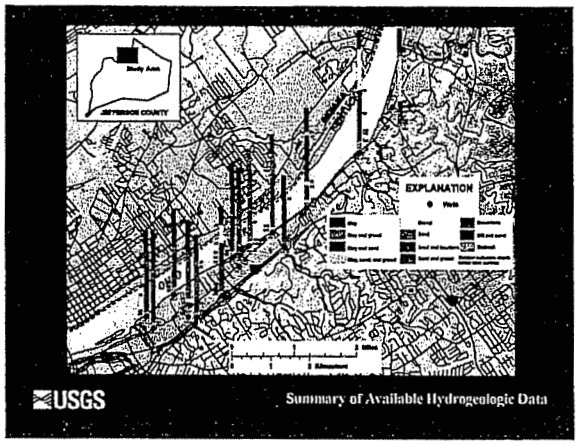

Study Area
JEFFERSON COUNTY
EXPLANATION
Observation well
Recorder
OHIO RIVER
USGS
Summary of Available Hydrogeologic Data

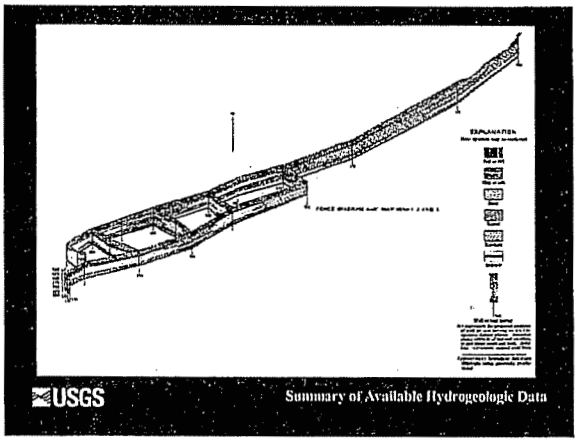

WATER-LEVEL ELEVATION
PRECIPITATION
USGS
Summary of Available Hydrogeologic Data

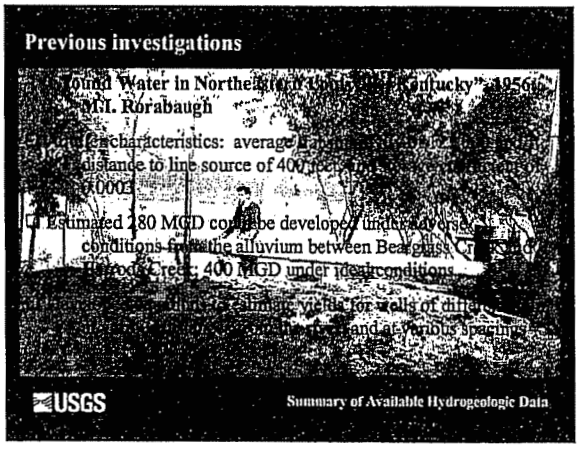

WATER LEVEL, IN FEET ABOVE SEA LEVEL
USGS
Summary of Available Hydrogeologic Data

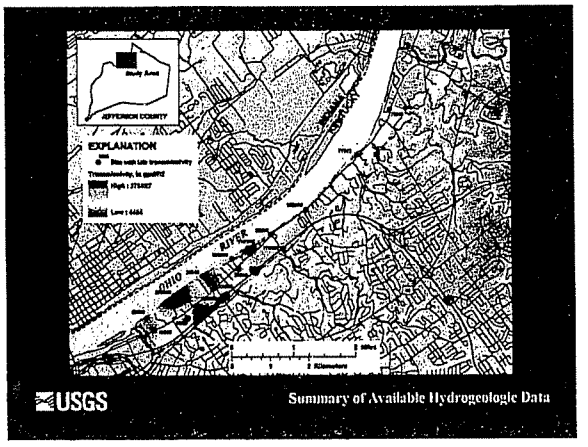

JEFFERSON COUNTY
EXPLANATION
RIVER
OHIO
USGS
Summary of Available Hydrogeologic Data

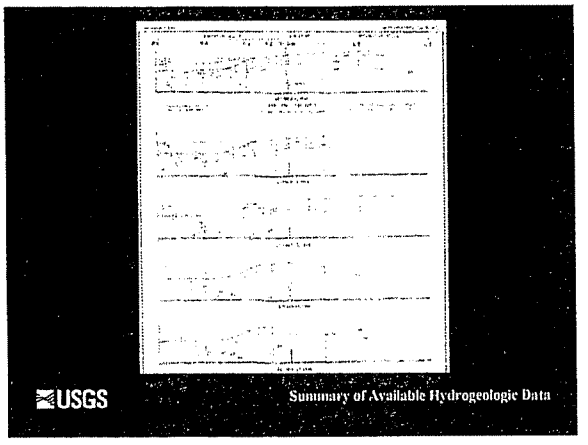

Bedrock surface contours
USGS
Summary of Available Hydrogeologic Data

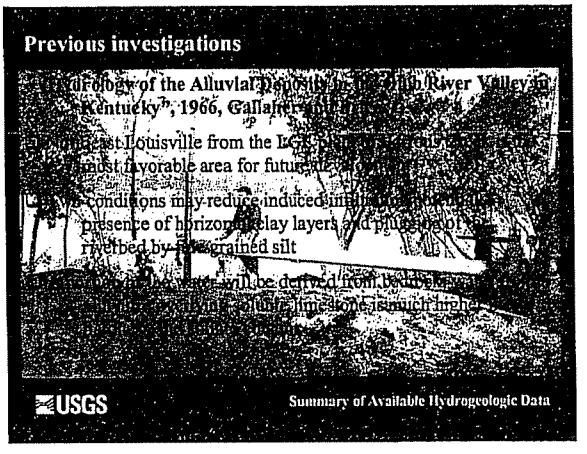

Study Area
JEFFERSON COUNTY
EXPLANATION
Wells
USGS
Summary of Available Hydrogeologic Data

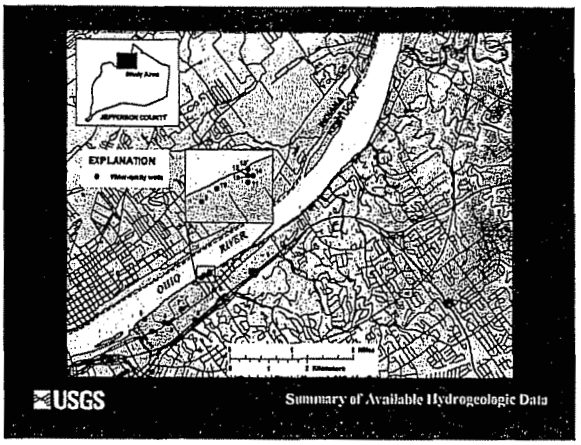

USGS
Summary of Available Hydrogeologic Data


Previous investigations
Ground Water in Northeastern Jefferson County, Kentucky" 1956
M.I. Rorabaugh
Estimated 280 MGD could be developed under adverse conditions from the alluvium between Beargrass Creek and Harrods Creek; 400 MGD under ideal conditions
USGS
Summary of Available Hydrogeologic Data


Study Area
JEFFERSON COUNTY
EXPLANATION
OHIO
RIVER
USGS
Summary of Available Hydrogeologic Data


USGS
Summary of Available Hydrogeologic Data


Previous investigations
USGS
Summary of Available Hydrogeologic Data



Previous investigations

"Ground Water in the Bedrock beneath the Glacial Outwash in the Louisville Area, Kentucky", 1944, Hamilton

- Limestones are highly susceptible to jointing and form large conduits that supply water to the alluvium
- Water in the limestones is considered to be of good quality; lowering the water table in the alluvium will increase the amount of recharge from the bedrock
- Water quality is dependent on contact time with limestone – the longer the contact, the higher chance of becoming mineralized

Previous investigations

"Availability of ground water in Bullitt, Jefferson, and Oldham Counties, Kentucky", 1960, Palmquist and Hall

- Louisville limestone may contain water that is high in salt and hydrogen sulfide
- The alluvium in the northeast portion of Jefferson County is exposed to the Laurel dolomite and rocks of the Osgood formation
- Water in the Osgood formation is thought to be highly mineralized, but there is little of data and information regarding its extent and contact with the alluvium

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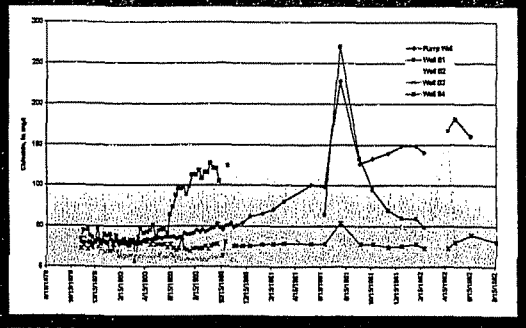
Chloride Results at Zorn Avenue – 1979 to 1982



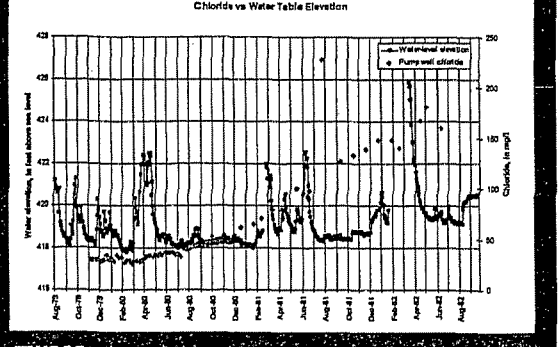
USGS

Comments regarding the 1979 to 1982 Zorn Avenue Pump Test

Taken from "Organics Reduction Riverbank Infiltration at Louisville", by S.A. Hubbs, Louisville Water Company

- Organic content of the river is reduced by 50% as a result of riverbank filtration; the reduction is obtained through removal of suspended sediment in the river
- Chloride concentrations were affected by a secondary source – the underlying limestone bedrock
- A relatively low contribution of water from the underlying bedrock could significantly affect the water quality of a ground-water withdrawal system

USGS



USGS

Water-quality results from Zorn Avenue pump test – 1995 to 1997 (KY Ground-Water Repository)

Sample date	Alachor 0.002 (Primary)	Arsenic 0.01 (Primary)	Chloride 250 (Secondary)	Iron 0.3 (Secondary)	Manganese 0.05 (Secondary)	Thallium 0.002 MCLs in mg/l (Primary)
25-Apr-95	0.033	0.005	368	4.599	0.827	0.123
25-Jul-95	<0.00002	0.011	323	3.8	0.817	<0.068
15-Nov-95	<0.00002	<0.001	308	4.01	0.876	<0.068
13-Aug-96	Not tested	0.0082	310	2.2	0.666	0.103
9-Oct-96	<0.00006	0.0298	331	3.94	0.824	<0.056
4-Feb-97	<0.00006	0.0115	327	4.48	0.863	<0.056
15-Jul-97	<0.00005	0.01	342	2.43	0.859	Not tested
3-Dec-97	<0.00005	0.011	281	4.31	0.851	Not tested

All values are reported in mg/l

Summary

- Water-supply potential exceeds 280 MGD
- Aquifer characteristics have been quantified for the alluvium at Zorn Avenue
- Detailed drillers' logs are available throughout the area: information includes depth to bedrock and lithology of the deposits
- Contribution of water from the bedrock needs to be quantified
- Water-quality data outside of the Zorn Avenue area is lacking
- Current monitoring network provides water-level data and flow system responses to various stresses

Advanced Treatment Technology – Bank Filtration

Steering Group Meeting 2
March 10, 2005
Jordan, Jones & Goulding, Inc.

Purpose of the Phase 3 Study

- Perform preliminary feasibility study of proposed RBF tunnel expansion from Harrods Creek to Zorn Avenue by evaluating:
  - Geological and hydrogeological data
  - Aquifer yield
  - Water quality data
  - Sites of potential environmental concern
- This phase of study does not include evaluation of bedrock conditions for tunneling purposes

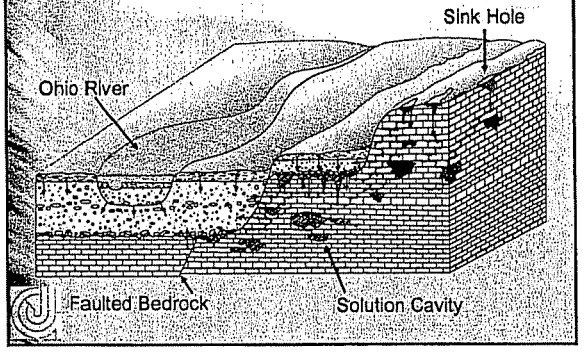
Geological and Hydrogeological Data

- Consistent geology (thickness, permeability, structure) along alluvial plain from B.E. Payne Water Treatment Plant to Zorn Avenue RWPS.
- Bedrock formations in the area are jointed and faulted forming large conduits capable of supplying groundwater to the alluvial aquifer.

Geological and Hydrogeological Data

- Bedrock faults may transmit natural gas as well as groundwater.
- Alluvial aquifer is narrow (~900 ft) near Beargrass Creek and may impact groundwater yield (no significant impacts are anticipated)

Conceptual Hydrologic Model Showing Groundwater Flow Paths



Aquifer Yield

- 26,400 LF total length of additional tunnel
- Assume 132 vertical wells on 200 ft centers
- 750 to 1,000 gpm each
- Estimated yield = 140 to 190 MGD

Water Quality Evaluation

- Relatively large number of existing wells identified, mostly located near Zorn Avenue RWPS.
  - 82 wells identified within one mile of tunnel alignment (KGS and USGS)
  - 13 of these wells have existing water quality information (12 located near the Zorn pumping station and 1 well located by the Payne Plant)
  - Phase 1 collector well data

Water Quality – Static Conditions

- Data is fairly consistent. The following parameters were of note:

Parameter	Range (mg/L)	Regulatory Limit (mg/L)
Arsenic	0.005 – 0.026	<0.01
Hardness	280 – 500	<150
Chloride	9 – 44	<100
Iron	0.1 – 6	<0.1
Manganese	0.3 – 2.1	<0.01
TDS	630	<500

Water Quality – Pumped Well at Zorn Avenue

- Pumped at 2,000 gpm from 1979 to 1982 and again pumped from 1995 to 1997. Data were consistent with static (unpumped) well water with the following exceptions:

Parameter	Range (mg/L)	Regulatory Limit (mg/L)
Chloride	Up to 388	<100
Thallium	Up to 0.123	<0.002
TDS	860 – 1,000	<500

Sites of Potential Environmental Concern

- 14 sites of potential concern identified along tunnel alignment
- 10 sites located in the industrial area southwest of Zorn Avenue
- Specific site conditions and potential impacts to tunnel not known at this time

Water Quantity

Issue:

- Aquifer yield in narrow region

Data Needs:

- Conduct 2 to 4 pumping tests to further evaluate river and aquifer properties
- Groundwater modeling to predict yield

Water Quality

Issues:

- Limited data from one well near industrial area
  - Chloride and thallium in pumped well
  - Arsenic in pumped and static wells
- Unknown details of sites of potential environmental concern

Water Quality

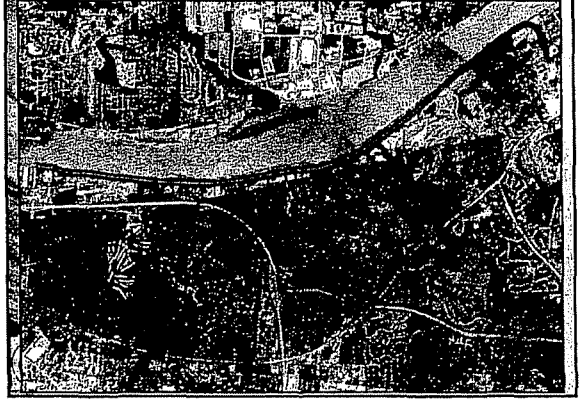
Data Needs:

- Evaluate source of chloride and thallium
- Additional sampling of existing wells
- File reviews of sites of potential environmental concern

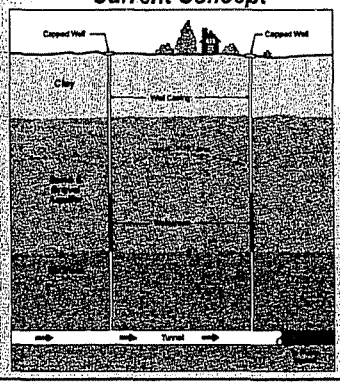
Other Factors

- Property availability for wells and proposed tunnel alignment
- Wellhead protection
- Constructability
  - Occurrence of natural gas (origin/quantity/extent)
- External constituencies
  - Planning and zoning
  - Metro parks
  - River Fields
  - Property owners
  - KY Division of Water

RBF Phase 3 Concept



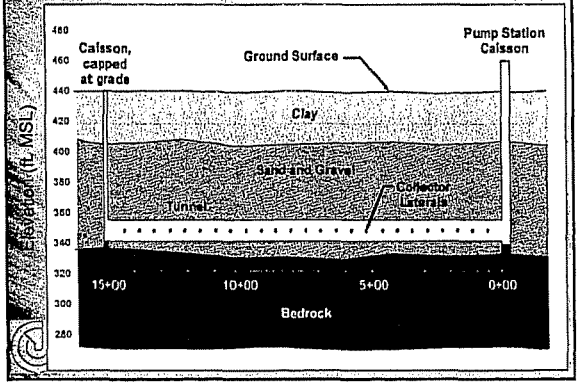
RBF Tunnel and Vertical Collectors – Current Concept



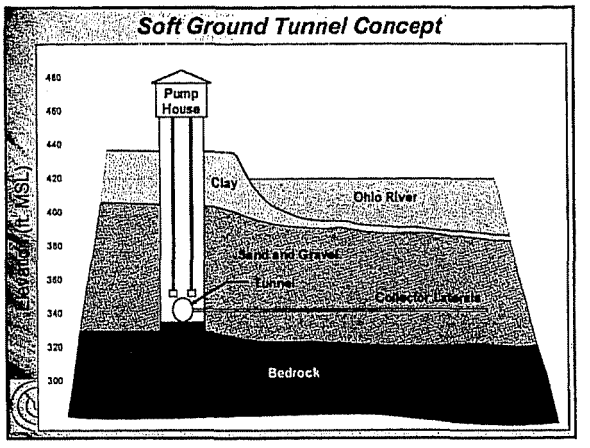
Other Below Grade Concepts for RBF

- Soft ground tunnel with horizontal or vertical collectors
- Bedrock tunnel with horizontal collector capped at grade
- Below-grade horizontal or vertical wells connected by transmission main

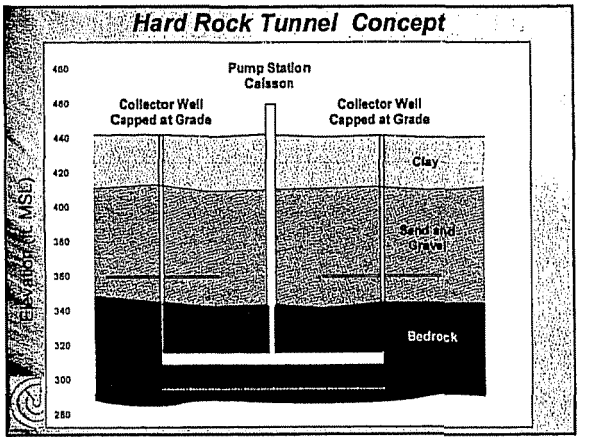
Soft Ground Tunnel Concept



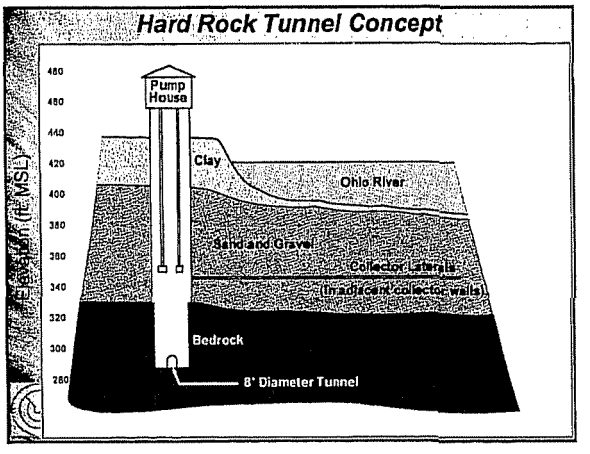
Soft Ground Tunnel Concept



Hard Rock Tunnel Concept



Hard Rock Tunnel Concept



Preliminary Recommendations for RBF Phase 3

- Assumptions
  - Based on same tunnel/well concept as Phase 2
  - New raw water pump station at Zorn (180 MGD)
  - 132 vertical wells on 200 ft centers (750 to 1,000 gpm each)
  - 26,400 LF of tunnel extension in bedrock
  - 3 construction shafts
  - Estimated cost: $150 to $177 million
  - Cost estimate is being refined based on Phase 2 results

Louisville Water Company

Minutes

Crescent Hill Advanced Treatment Technology Steering Group

March 10, 2005

Present: Kay Ball, Larry Gaddis (Black & Veatch), Steve Greseth (Black & Veatch), David Haas (Jordan, Jones & Goulding), Greg Heitzman, John Huber, Rick Johnstone, Gerald Martin, Bob Miller, David Schafer (David Schafer & Associates), Jim Smith, Karla Teasley, Steve Tucker, Mike Unthank (United States Geological Survey), Jack Wang, David Wilks (Jordan, Jones & Goulding), and Marita Willis.

Absent: Joe Wise.

Riverbank History of The Louisville Aquifer – Kay Ball and Dr. Jack Wang

Kay Ball provided a presentation on LWC's River Bank Filtration (RBF) Program and the history of the Louisville aquifer from the 1940s to the 1990s. The presentation included an overview of the Phase I Demonstration Well project. The 15 MGD collector well has been in service since 1999, and has exceeded expectations for water quality and quantity. Kay also provided information on the Wellhead Protection Program, the Technical Advisory Committee on Alternative Treatment (1998-99), LWC's evaluation of the Indiana Army Ammunition Plant well field, and a summary of future phases of RBF. Dr. Jack Wang provided a summary of the quality of Ohio River source water compared to water from the demonstration collector well. The well supply provides significant removal of turbidity, algae, diatoms, pollen, and cryptosporidium. A copy of the PowerPoint presentation will be filed with these minutes.

USGS Presentation of The Louisville Aquifer Hydraulic Characteristics – Mike Unthank

Mike Unthank provided a brief summary of the United States Geological Survey (USGS), their mission, and role in providing information regarding the nation's water resources. He then presented a summary of the various historical records and evaluation of the hydrogeologic data for the Louisville aquifer between Beargrass Creek and Harrods Creek. He presented information on water quality and water quantity for this section of the aquifer. His findings included information on chloride, sulfate, and iron levels found in the aquifer, as well as past studies on the effectiveness of organics removal using the natural river bank filtration process. In summary, USGS concluded the water supply from the aquifer exceeds 280 MGD and the aquifer needs further study to determine the contribution of water from the bedrock and potential impact from the presence of chlorides found in the limestone bedrock. A copy of the PowerPoint presentation will be filed with these minutes.

Advanced Treatment Technology-Bank Filtration – David Haas and David Schafer

David Haas and David Schafer of JJG Engineers provided a presentation on the feasibility of utilizing an RBF tunnel for the source water for Crescent Hill Water Treatment Plant. The presentation opened with a computer simulated video of the aquifer from Oldham County to downtown Louisville. The video provided an aerial snapshot of the aquifer, the tunnel alignment, and potential sites of environmental contamination.

Following the video presentation, JJG Engineers presented a review of the hydrogeologic data, the aquifer yield potential, the water quality data, and sites of potential environmental concern. The geology between Zorn Avenue and Harrods Creek is consistent in terms of thickness, permeability, and structure. The limestone bedrock contains large, jointed faults that carry water to the aquifer. These faults may also carry natural gas or other contaminants such as chlorides. The aquifer narrows as it approaches Beargrass Creek. The aquifer yield ranges from 140 to 190 MGD. A summary of the aquifer water quality was provided.

JJG Engineers also presented information on potential areas of environmental concern, including former industrial sites and the Edith Avenue landfill. Their investigation did identify potential concerns with chloride and thallium that require further study and evaluation.

JJG Engineers presented various tunnel concepts for Phase III to supply Crescent Hill, including both hard and soft rock tunnel alternatives. Using results from the March 2005 bid for Phase II River Bank Filtration Tunnel, the estimated cost for the Zorn Tunnel concept ranges from $150 to $177 million. This scope would include 26,400 feet of hard rock tunnel, three tunnel access shafts, 132 vertical wells, and a new 180 MGD pump station at Zorn Avenue. A copy of the PowerPoint presentation will be filed with these minutes.

Questions/Comments

For the tunnel design, does ground water leach through the aquifer on its own?
Pumping is used to provide the suction head which drives the water flow through the aquifer.

What is turbidity?
Turbidity is a measure of the amount of suspended particles in water.

Has there been any oil detected in the existing BEP well (resulting from the Kentucky River oil spill in January 2005)?
No, USGS is currently collecting samples from monitoring wells around the collector well for analysis.

Are radon and arsenic potential constituents of concern?
Yes, they have been detected at BEP, but the levels are treatable with the current technology.

Are any odors present in the river found in the collector well?
We have never detected geosmin in the well.

Why do we soften at BEP?
We soften to remove manganese and reduce hardness from the well water.

What is our target hardness?
150 mg/L as Calcium Carbonate, which is customer driven.

Will we discuss other treatment technologies?
Yes, in future meetings we will present information on UV disinfection, GAC adsorption, ozone, membranes, and other new water treatment technologies.

Which Bin will LWC be subjected to?
Following LT2ESWTR, LWC will likely be placed in Bin 2.

Will EPA require the sampling point to be at the well?
We will have the choice. If we sample at the river, the aquifer will meet the log removal requirement set by EPA. If we sample at the well, we will likely be considered in Bin 1 for treatment considerations.

Also, analytical methods for detecting cryptosporidium and giardia will improve with time and may indicate increased pathogen concentrations in the future.

When LWC reviewed the Indiana Army Ammunition Plant well field, was the problem yield relative to cost?
Yes. There were also concerns with yield and potential groundwater contamination from the manufacturing processes at the ammunitions facility.

Is porosity a description of transmissivity?
Not completely, but porosity is an indicator of transmissivity. Porosity is the volume of pore space while transmissivity is the relative ease at which a liquid flows through a porous medium.

The 140 MGD to 190 MGD indicated for aquifer withdrawal at CHFP is in addition to the 60 MGD at BEP?
Yes. The design target for both plants is 240 MGD (180 MGD for CHFP and 60 MGD for BEP)

Is the 140 MGD to 190 MGD a function of 132 wells at 200 foot intervals for the tunnel concept for CHFP?
Yes, the well spacing and size will determine the ultimate yield of the well system.

Do the proposed tunnels for CHFP and BEP have to be connected?
No, but connecting the tunnels will provide more flexibility for operations and maintenance.

Is river bottom clogging a problem?
Resistance from the river bottom becomes worse with time. River leakance is important. Steve Hubbs is completing his Ph.D. dissertation on river leakance and the ability of the Ohio River to scour and clean the aquifer interface to avoid clogging.

How confident is JJG/Schafer on the assumption that 90% of the proposed well water will be from the river?
From their modeling of the BEP Phase II well design, they are confident that 90% of the well capacity will come from the river. If the tunnel concept is pursued, a groundwater hydraulic model will be developed to confirm their assumptions.

What is the current Ranney well source contribution?
70% of the contribution is from the river and 30% is from the aquifer, conservatively.

Would LWC pump from the river if wells were constructed?
We plan to keep the Zorn Pumping Station and intake as a backup source water supply.

Can existing monitoring and pumping wells in the subject area be used for groundwater testing?
Existing well data can be used, but additional wells must be drilled for data collection and further testing.

Upstream of Harrods Creek there has not been much dredging, while downstream dredging could be an issue.
Yes, fine sediment infill resulting from dredging may present a problem with clogging and water quality.

Greg Heitzman advised that the Technical Group (LWC staff) will review additional treatment technologies with Black & Veatch in the coming month. The Technical Group will develop water quality goals and criteria for rating the various technologies. This information and progress from the group will be provided in future meetings. In the end, life cycle costs will be considered to make a recommendation to the Steering Group by August 2005.

John Huber added that an important issue with an aquifer solution is that easement and property acquisition will impact constructability and the timeline of a tunnel and aquifer solution. JJG Engineers noted their experience with tunneling in Atlanta under high value properties.

The next meeting of the Steering Group will be held April 21, 2005 at 12:00 pm. The minutes and agenda will be provided in advance of the meeting.

WATER WORKS
LWC 150
1854 - 2004

LOUISVILLE WATER COMPANY
CRESCENT HILL FILTRATION PLANT
ADVANCED TREATMENT TECHNOLOGY

Steering Group Meeting No. 3
April 21, 2005
Agenda

I.	OPENING COMMENTS / INTRODUCTIONS	*John Huber*
II.	MEETING AGENDA AND PURPOSE	*Greg Heitzman*
III.	WATER QUALITY GOALS	*Larry Gaddis*
IV.	CHFP COMPLIANCE WITH GOALS AND REGULATIONS	*Bruce Long*
V.	TREATMENT OPTION EVALUATION CRITERIA	*Bruce Long*
VI.	POTENTIAL TREATMENT TECHNOLOGIES • Filtration – Granular Media and Membranes • Granular Activated Carbon and Power Activated Carbon Adsorption	*Bruce Long*
VII.	STEERING GROUP MEETING NO. 4 • June 7	*Greg Heitzman*
VIII.	OPEN DISCUSSION AND QUESTIONS	*All*

Steering Group Meeting No. 3

Louisville Water Company

Crescent Hill Filtration Plant Advanced Treatment Study

April 21, 2005

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Opening Comments and Introductions

John Huber

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Meeting Agenda and Purpose

Greg Heitzman

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Water Quality Goals

Larry Gaddis

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Water Quality Goals

- Existing, pending, and proposed future Federal and State regulations
- LWC customer expectations
- Internal LWC goals

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Internal LWC-Developed Goals

Turbidity
Chlorine Residual
Disinfection By-Products
Corrosion / Scale
TOC Removal
MIB / Geosmin

Spill / Pesticide Remediation
Iron / Manganese
Radon
Fluoride
Distribution Stability
Flexibility for Treatment of Emerging Pathogens

Simultaneous Compliance

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Purpose of Goals

Goals will be utilized to:

- Assess performance of CHFP
- Establish design basis for treatment options

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Subsequent Project Tasks

- Evaluate CHFP finished water quality and operational performance ✓
- Determine evaluation criteria for treatment options ✓
- Select preliminary treatment options ✓
- Plant investigation and constructability review
- Process Workshop
- Detailed evaluation of options

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CHFP Compliance With Goals and Regulations

Bruce Long

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LWC Turbidity Goals

- Individual Filter Turbidity (IFT) Shall Be <0.10 NTU 95% of the Time
- Max IFT ≤0.30 NTU
- Combined Filter Turbidity (CFT) < 0.08 NTU 95% of the Time

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CHFP Turbidity Goal Compliance

- Maintaining <0.10 NTU IFT will be difficult for most surface water plants
- ≤0.09 NTU - ≤0.15 NTU for 95% of individual filter samples
  (Aug 2003 – Dec 2004 data; 4 hr sample intervals)
- Average 0.075 NTU CFT: <95% value = 0.109 NTU
- May be able to reduce turbidity further w/process, operational enhancements

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LWC Chlorine Residual Goal

- Initial Distribution Combined Chlorine Residual 2 – 4 mg/L
- Goal Being Achieved (2.1 – 3.3 mg/L)

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LWC DBP Goals

- Instantaneous DBPs Will Not Exceed 75% of MCL At Any Time
  - 60 ug/L TTHMs
  - 45 ug/L HAA5
- Max DBP Levels*
  - TTHMs: 57 ug/L
  - HAA5: 32 ug/L

*2002 – 2004 Data Reported

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LWC DBP Compliance Status

- Average DBPs Will Be <50% of MCL
  - 40 ug/L TTHMs
  - 30 ug/L HAA5
- Average DBP Levels Well Below 50% of MCL*
  - TTHMs: 26 ug/L
  - HAA5: 8 ug/L

*2002 – 2004 Data Reported

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LWC Corrosion Control Goals

- Hardness ≤150 mg/L
- pH > 8.0
- Goals Currently Being Achieved Hardness ≤150 mg/L, pH > 8
- Lead and Copper Below EPA "Action Levels" During 1999, 2003

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CHFP TOC Removal Goals

- Meet or exceed regulatory mandated TOC removal
- Regulatory Requirement is on average ~ 26%
- Average Reduction in 2004 was 31.5%

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LWC Geosmin / MIB Goals

- Geosmin < 5 ng/L At All Times
- MIB < 5ng/L At All Times

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LWC Spill / Pesticide Remediation Goals

- Concentration of All Regulated Pollutants Shall be ≤50% of MCL
- Non-Regulated Contaminants Concentrations Shall be ≤50 ug/L and Shall Not Result in Any T&O Thresholds
- Atrazine ≤1.5 ug/L
- Atrazine < 0.1 – 0.7 ug/L Detected (2002 – 2004 data)
- Other Regulated SOCs & VOCs Typically Not Detected in Finished Water

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LWC Iron / Manganese Goals

- Fe ≤50 ug/L
- Mn ≤20 ug/L
- Goals Currently Being Achieved

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LWC Radon / Fluoride Goals

- Radon < 150 pCi/L
- Fluoride: Maintain 1 mg/L Residual
- Both Goals Being Achieved

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LWC Distribution Stability Goals

- Minimize Regrowth Within Distribution System
- Ensure CHFP Finished Water is Compatible with BEP Water
- Consider AOC, Nitrification Impacts

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Challenges to Equal BEP

- Microbials – inactivation/removal
- T&O reduction
- Equivalent DBPs
- Equivalent AOC
- SOCs
- Nuisance organisms (zebra mussels, asiatic clams)
- Emerging contaminants
- Public perception
- Consistency

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Treatment Option Evaluation Criteria

Bruce Long

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Treatment Option Evaluation Criteria

- Cost
- Finished water quality
- Operational considerations
- Social / Environmental Issues
- Other considerations

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Evaluation Criterion: Cost

- Capital cost
- Operation and maintenance cost
- Depreciated assets

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Evaluation Criterion: Finished Water Quality

- Regulatory compliance
- Ability to consistently achieve LWC goals
- Compatibility with BEP

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Evaluation Criterion: Operational / System Considerations

- Operability
- Flexibility
- Reliability
- Residuals management
- Constructability
- Schedule

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Evaluation Criterion: Social / Environmental

- Public perception
- Visual impact
- Noise / odor
- Risk management - safety

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Evaluation Criterion: Other Considerations

- Multiple treatment barriers
- Risks / uncertainties
- Compatibility with future RBF

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Potential Treatment Technologies

Bruce Long

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Challenges to Equal BEP

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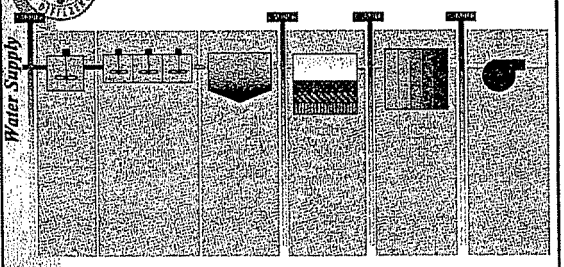
Water Treatment Plants Consist of Several Process Steps



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Challenges to Equal BEP

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Enhanced Particulate Removal-Microbial Reduction

- Improved pretreatment performance
  - Coagulation / flocculation
  - Solids capture – sedimentation / flotation
- Granular media filtration enhancements
  - new media configurations
  - improved operational practices
- Membrane processes
- Riverbank Filtration

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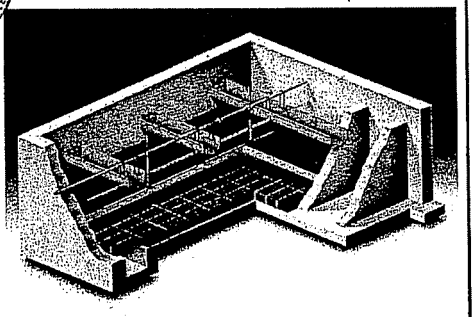
Granular Media Filter Cutaway



Filtration Theory

- Particles adhere to filter media grains because they are "sticky"
- Strength of attachment to media depends on preceding chemistry
- Straining (screening) of large particles is not an important removal mechanism
- Each grain is a "collector"

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Filter Media Size and Filter Performance

- Small sizes trap particles more effectively but large particles have lower head loss
- For dual media, sizes of sand and anthracite or GAC must be compatible for filter backwash
  - Media density and grain size must be considered
- The key is to provide maximum particle contact opportunity but not clogging the filter – increased media depths and improved flow distribution (uniformity)

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Significant Filtration Enhancements Include:

- More sensitive filtered water quality monitors
  - *Turbidimeters*
  - Particle counters
- Improved underdrain and backwash systems
- Deeper filter boxes, filter media
- These are critical to achieving increased *Cryptosporidium removal credits*

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Filtration Membranes are Gaining Favor

- High degrees (6+ log (99.9999% removal of particulates)
- Much less dependent on optimized pretreatment
- Smaller footprint for equivalent filtration capacity
- Costs (both capital and operating) are declining

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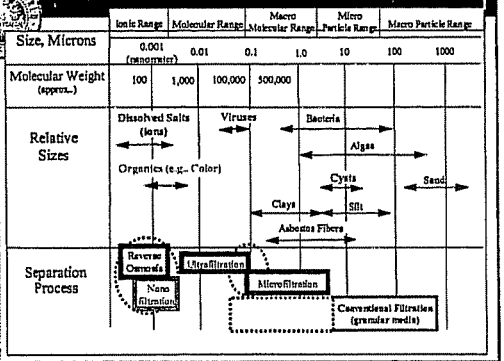
Membrane Removal Size Ranges



There are Two Principal Membrane Types:

- Tight (dissolved material rejection) Membranes – Reverse Osmosis, Nanofiltration
  - Desalination
  - Softening
  - DBP precursor rejection
- Filtration Membranes – Microfiltration (MF) and Ultrafiltration (UF)
  - Particles
  - Turbidity
  - Cysts
  - ADDED PROCESSES for dissolved material
  - Pretreatment depends on application

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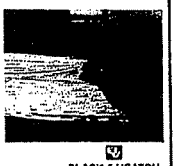
MF/UF Membranes

- Growing trend in water treatment
  - In 1994 - one plant
    Now more than 60 plants
    (greater than 1 MGD – up to 78 MGD)
- Low turbidity filtered water
  - (Less than 0.05 NTU all the time)
- Excellent cyst removal
  - (Greater than 4-log, which is 99.99%)
- Add capacity as needed
- Minimal operator attention
- Costs continue to decline



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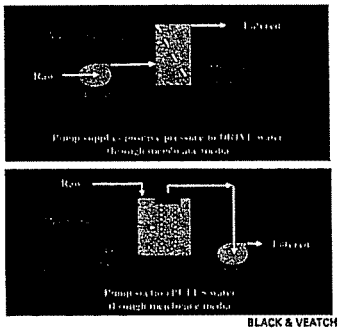
Two Basic MF/UF Membrane Configurations

- Cartridge membrane system
- Submerged membrane system



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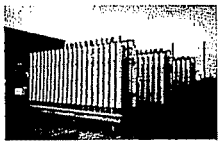
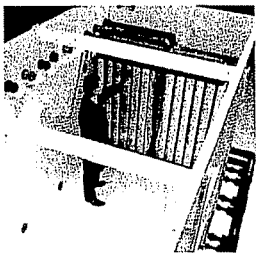


Cartridge Membranes



Submerged Membranes

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Challenges to Equal BEP

- Microbials – inactivation/removal
- T&O reduction
- Equivalent DBPs
- Equivalent AOC
- SOCs
- Nuisance organisms (zebra mussels, asiatic clams)
- Emerging contaminants
- Public perception
- Consistency

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Activated Carbon Adsorption

- Activated carbon can be used to remove organic contaminants such as taste and odor compounds, SOCs, DBP precursors, and endocrine disrupters
- Made from wood, peat, lignite and bituminous coal
- Activation process used to create vast internal pore system. Specific area of 600 to 1600 m^2 per gram
- Two forms - granular activated carbon (GAC) and powdered activated carbon (PAC)

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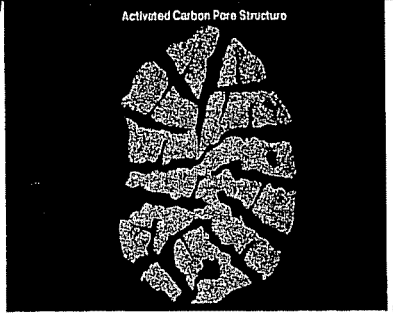
GAC Pore Structure



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Activated Carbon Adsorption – Granular Activated Carbon

- GAC is applied in a fixed bed. When bed capacity is exhausted, the media is removed and replaced with either virgin or regenerated GAC
- GAC can be applied in filter-adsorbers or post-filter contactors
- Life of GAC can be extended by adding an ozonation step before GAC (BAC)

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Factors That Affect GAC Performance

- EBCT
- Particle size, GAC material
- Influent adsorbate concentration
- Competition from other organic compounds, particularly NOM
- pH
- Pretreatment

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Advantages of GAC – Either Filter Adsorber or Post-Filtration Contactors

- Continuous protection against spills and T&O removal
  - Enhanced by adding a preceding ozonation step
- Reduced monitoring requirements
- Excellent public relations tool

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Disadvantages of GAC

- Need for regeneration
  - Cost
  - Environmental permitting
- Chromatographic effect potential
- Space (if post filtration adsorbers)
- Limits manganese removal options
- May impact CT compliance strategy

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Powdered Activated Carbon (PAC) Adsorption

- PAC is "ground up" GAC
- PAC is dosed and thus can be used intermittently and applied in doses commensurate to the concentration of the target contaminant.
- PAC is used once, no regeneration
- To be effective, must be ahead of (analytically) incoming contaminants

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Factors Affecting PAC Performance Include:

- Contact time
- PAC brand
- Interferences from other chemicals
- Targeted contaminant(s) concentration(s)

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Steering Group Meeting No. 4 (June 7,2005)

Greg Heitzman

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Steering Group Meeting No. 4

Meeting No. 4

- Preliminary Treatment Options and Screening
- Plant Investigation and Constructability Review
- Outcome of Process Workshop

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Open Discussion and Questions

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Louisville Water Company

Minutes

Crescent Hill Advanced Treatment Technology Steering Group

April 21, 2005

Present: Kay Ball, Larry Gaddis (Black & Veatch), Steve Greseth (Black & Veatch), Greg Heitzman, John Huber, Rick Johnstone, Bruce Long (Black & Veatch), Gerald Martin, Bob Miller, Karla Teasley, Steve Tucker, Jack Wang, and Marita Willis.

Absent: Jim Smith and Joe Wise.

Opening Comments / Introductions – John Huber

As we are presented with various advanced treatment technologies, we must consider if there is a "do nothing" option. Also, we want to avoid making a series of incremental decisions. Ideally, we are looking for a holistic solution that balances regulations, customer satisfaction, operability, reliability, maintenance, constructability, and cost.

Meeting Minutes and Agenda – Greg Heitzman

A correction was made to the March 10, 2005 meeting minutes. On page 3, the answer to the second question was corrected to read "150 mg/L as Calcium Carbonate, which is customer driven". An overview of the agenda was provided.

Water Quality Goals – Larry Gaddis

Larry Gaddis commented on the Glossary of Terms and Abbreviations provided by Black & Veatch as a reference tool for the attendees. The first meeting outlined established water quality goals to include current and future regulations, customer expectations, and internal goals. Internal goals focus on water quality and aesthetics. Aesthetics of drinking water is not regulated, however good aesthetics is key to customer trust and satisfaction. One issue of concern is disinfection, as the water is treated using disinfection there are disinfection by-products (DBPs) that will be increasingly regulated by EPA.

The Technical Group (comprised of LWC staff) is evaluating how close the Crescent Hill Filter Plant (CHFP) is in meeting present and future goals. Other project tasks underway include determining evaluation criteria for treatment options and selecting preliminary treatment options for consideration. The Technical Group will also conduct a plant investigation and constructability review, hold a process workshop, and develop a detailed evaluation of options for this Steering Group to consider.

CHFP Compliance with Goals and Regulations – Bruce Long

LWC is a member of the Partnership for Safe Water. The Partnership is a unique cooperative effort between EPA, American Water Works Association, Association of Metropolitan Water Agencies, National Association of Water Companies, and Association of State Drinking Water Administrators. The Partnership encourages and assists United States water suppliers to voluntarily enhance their water systems performance for greater control of Cryptosporidium, Giardia, and other microbial contaminants. LWC's annual water quality goals are established using the guidelines established by the Partnership for Safe Water. Currently, LWC has attained Phase III of the Partnership for five consecutive years. Phase III requires utilities to achieve finished water turbidity of less than 0.10 ntu 95 percent of the time for each treatment plant (composite plant average). Phase IV of the Partnership requires a utility to achieve filtered water turbidity of less than 0.15 ntu 95 percent of the time for each filter in the plant (individual filter average). LWC expects to meet the Phase IV requirement for the B.E. Payne Plant upon completion of the filter renovation project in August 2005. Crescent Hill will require renovation and upgrade of filters to achieve the Phase IV goal.

As our population ages and their respective immunity lowers, it is important that LWC strive to achieve a reduction in finished water turbidity. Turbidity is measured as the scattering and absorption of light caused by particles suspended in water. Turbidity is considered as a surrogate measurement for Giardia and Cryptosporidium, as they are considered as particles. When turbidity is lowered to less than 0.10 ntu, there is a significant reduction in the risk of Cryptosporidium and Guardia passing through the treatment process.

LWC has existing seasonal challenges in reducing turbidity. During the warm summer months, algae in the Ohio River blooms rapidly. Filtration becomes difficult with the increased algae growth and coagulant that must be removed from the water. In the cold winter months, chemical compounds used to treat the water do not react as well as they do in the warmer months. The advanced treatment technology needs to address future regulations while resolving LWC's existing treatment challenges.

Bob Miller asked that when averages are discussed, to include the data ranges so that the average results and the maximum results are considered.

LWC uses Chloramines, instead of Chlorine, as the residual disinfectant. Chloramines do not react with organic compounds as much as free Chlorine does. This allows LWC to maintain low DBP levels throughout the distribution system.

Greg Heitzman recalled information regarding statewide DBP violations. He will follow-up on the availability of this information to provide benchmarking data that can be used in a comparison analysis of LWC with smaller treatment systems in the state.

Optimization to improve filtration and coagulation processes will be necessary to maintain compliance with LT2SWTR standards. LWC has adapted existing treatment processes to reduce DBP levels as much as possible. LWC is interested in Black and Veatch's perspective on the ability to further optimize the existing treatment processes at Crescent Hill to achieve future drinking water regulations.

DBP measurement is taken from finished water, not the sludge. Correct?
Yes, this is correct.

What can we expect regarding Environmental Protection Agency (EPA) regulations governing Trihalomethanes (THMs) in the future?
TTHMs at LWC are 95 percent Chloroform. The other 5 percent is made of three additional compounds. Chloroform is not the cancer causing agent we originally thought it to be. However, the EPA will not pass a standard that is less than an established regulation.

In fact, Bromide is the component of TTHMs that has the bigger health impact. Bromide is found in the three compounds that make up the other 5 percent. John Huber recalled a study that found spontaneous abortion to be caused by Bromide when the occurrence of TTHMs exceeded 100 ug/L. Currently, LWC averages sampling results. In the future, regulations will require LWC to identify "hot spots" in the distribution system, or areas where maximum levels of DBPs occur, and report on them individually (reference IDSE in the glossary).

LWC works to maintain a water hardness range between 140 and 160 mg/L year round. This practice has positive customer benefits. If the hardness level is not controlled, customers will soften the water at their homes, which increases the sodium chloride concentration in surface water sources, as sodium chloride resulting from softener regeneration is not removed by wastewater plants. LWC softens the water to maintain customer satisfaction. This also alleviates the need for customers to have home softening devices. During the spring, hardness levels range from 100 to 110 mg/L. During the fall, hardness increases up to 200 mg/L, which results in many customer complaints related to water aesthetics. The state and federal government do not regulate hardness, however they do provide guidelines.

When Total Organic Compounds (TOCs) react with Chlorine, DBPs form. This is not an issue at the River Bank Filtration (RBF) wells. Taste and odor compound concentrations are usually in the nanogram per liter range. In comparison of measurement units (parts per million, parts per billion, and parts per trillion), nanograms per liter (ng/L) are equal to parts per trillion, and MIB and Geosmin in that level are still detectible by the human ability to smell and taste. In fact, the human nose is the best analysis tool we have in detecting taste and odor compounds.

In October 2002, LWC's finished water had Geosmin levels of approximately 10 ng/L and LWC experienced some customer complaints. Some customers can detect Geosmin at a level less than 10 ng/L. Geosmin and methylisoborneol (MIB) are not regulated by the state or federal government since they are not related to any known health issues. No treatment guidelines are provided on Geosmin or MIB. Currently, LWC reduces the impact of taste and odor from Geosmin and MIB by treating with powdered activated carbon (PAC). Advanced treatment, such as two stage PAC treatment, GAC, or River Bank Filtration is needed to completely remove Geosmin and MIB from the source water.

Atrazine is an herbicide used by farmers to control weed growth. Atrazine is cancer causing and can be found in the Ohio River source water during the spring and summer months when runoff occurs. LWC removes atrazine through adsorption by feeding PAC.

High concentrations of Iron (Fe) and Manganese (Mn) can stain laundered clothing. Currently, LWC meets the treatment goals for Fe and Mn.

Radon is a gas that is dangerous when inhaled. Customers could experience a potential risk of inhalation while showering. LWC has some low levels of Radon in the RBF well water at a level of approximately 180 pCi/L, which is a measure of concentration in liquid. The finished RBF well water had levels below 100 pCi/L. The goal is to have levels below 150 pCi/L. Radon concentrations are reduced through aeration processes.

LWC maintains a good Chloramine residual, which minimizes bacteria growth in the distribution system. Bacteria "feed on" or oxidize organic Carbon to nitrate (nitrification). Ammonia can also be oxidized to nitrate. Nuisance organisms like zebra mussels and Asiatic clams can cause a reduction in hydraulic capacity in pumps and pipelines.

Treatment Option Evaluation Criteria – Bruce Long

Bruce presented the various criteria to be considered in evaluating treatment options. He advised that the weightings of this criteria can be changed to determine if any significant changes occur in the outcomes. He also clarified a few of the terms. Operability is defined as ease of use and consistency. Flexibility is considered in terms of modification for future use and ample space for modification. Residuals management is also known as sludge management. Multiple treatment barriers are considered to take care of issues that Powder Activated Carbon (PAC) cannot.

Potential Treatment Technologies – Bruce Long

In reviewing the process steps of water treatment, Bruce pointed out that if we can't kill organisms, we must, at minimum, render them unable to reproduce within a host.

Are measurements taken at each step through the water treatment process and what process measures do we have?

Yes, process measures are taken at various points in the treatment process from the source (Ohio River) to the customers tap. The process measures provide key indicators for the effectiveness of the treatment process and include such parameters as pH, alkalinity, turbidity, chemical feed rates, water temperature, hardness, chlorine residual, coliform bacteria, etc. These process measures assure the drinking water meets all EPA regulations and achieves corporate goals for water quality.

What are the current treatment barriers used at the CHFP?

At CHFP, there are three barriers to ensure a high finished water quality which include: pretreatment, filtration, and disinfection. At B.E. Payne, the RBF serves as a fourth, additional barrier. The current advanced treatment study will evaluate whether to add an additional barrier at CHFP or work to enhance one or more of the existing three barriers.

How does conventional filtration work?

The granular media in a filter consists of layers. The top layer is made of Anthracite. Pretreated particles "stick" or are adsorbed to the Anthracite, which prevents them from passing through the filter. The next layer is made of sand, followed by a layer of gravel. An underdrain is at the bottom of the filter. As particles build up, head loss (pressure) increases across the filter until it reaches a level that requires backwashing (cleaning) of the filter. Typically, the backwash flow rate is calculated at approximately 9 gallons per minute per square foot of filter. The effectiveness of the granular media filter degrades significantly without a pretreatment process in place. Water temperature impacts effectiveness of the filter as well. Optimum performance is dependent on maximum particle contact with the filter without clogging the filter. A distinction between granular media filters and membranes is that filters capture particles whereas membranes strain them.

Do we add chemicals to undo the sticky glue in the backwash process?
No, but on rare occurrences Chlorine has been added to burn off excess polymer.

What enhancements have been made to filter monitoring and filtration methods?

Filtration monitoring enhancements include the use of turbidimeters and particle counters on each filter to monitor performance. Turbidimeters measure light scatter and are more sensitive than models of the past. Filtration has been enhanced by using a combination of air and water in the backwash process. The filters at the B.E. Payne plant have been renovated by adding additional filter bed depth and air/water backwash to enhance filter performance. Filter aides (polymer) can also be added to improve filter performance. Filtration membranes can replace conventional filters using a smaller footprint for equivalent filtration capacity.

Could LWC use membranes in the existing space at the CHFP?
Yes, however additional filter depth may be required.

Are membranes coated?
Yes, membranes are coated with a polymer. The polymer provides a porous surface with small holes. Microfiltration (MF) and Ultrafiltration (UF) membranes come in two configurations. A cartridge membrane system pushes the water through, whereas a submerged membrane system pulls the water through.

How long do membranes last?
Membranes are guaranteed to last seven to eight years.

What is GAC and what percentage of utilities using GAC is using it as a filter adsorber?
Activated carbon comes in two forms: granular activated carbon (GAC) and powder activated carbon (PAC). Activated carbon can be made from different materials (e.g. wood, peat, lignite, and bituminous coal). It is important to understand that the material used correlates with the effectiveness of the activated carbon in the outcome. A cheaper priced product does not produce the same results.

GAC has a "honeycomb" of pores that provides for an expansive surface area to capture particles. The life of GAC can be extended by adding an ozonation step. Ozonation takes large organics and breaks them into smaller pieces. Bugs are purposefully added to eat these smaller pieces. The Empty Bed Contact Time (EBCT), which is expressed in minutes, is calculated by dividing the volume occupied by granular media by the liquid flow rate. Cincinnati's EBCT is approximately 20 minutes using GAC. The chromatographic effect potential is where particles are forced back into the finished water and is one of the disadvantages of GAC.

98 percent of utilities are using GAC as a filter adsorbent, as opposed to those utilities using it as a post-filter contactor. Note that if LWC used a GAC treatment process, a PAC treatment method would still have been used to absorb the oil spill from the Kentucky River in January 2005. PAC treatment is more cost effective than GAC regeneration after petroleum contamination.

Steering Group Meeting No. 4 – Greg Heitzman

Greg reminded Steering Group members of the fourth meeting, which is scheduled for Tuesday, June 7. He asked members to advise him if they have any scheduling conflicts.

Open Discussion and Questions – All

Greg reviewed the technologies discussed at this meeting. Membrane technology is new, and prices are coming down for larger system applications. GAC / PAC methods have been used for many years. At the next meeting disinfection alternatives, such as Ultraviolet (UV), Chlorine Dioxide, and Ozone will be presented. Other topics to be presented at the next meeting include: findings from the Technical Group, emerging contaminants, and pretreatment process steps like sedimentation and solids capture. The Technical Group will use a decision science software called Criterium Decision Plus to evaluate a variety of treatment technologies. The Steering Group will look at sensitivity analysis, where criteria weightings can be adjusted with the software. Cost / benefit analysis will also be reviewed. The Steering Group will profile the alternatives based on LWC's goals, the various criteria, and software results to determine a best solution or combination of solutions. The Steering Group will then identify the technologies LWC should consider and identify recommendations to the Board of Water Works.

Where do pharmaceuticals fit in to the particles addressed in today's presentation?
Pharmaceuticals are organic compounds and some of them are also considered to be endocrine disrupting compounds that may affect the human reproductive system. More research is needed on the impacts of pharmaceuticals in drinking water.

Should we retrofit the plant or build a new one?
Ideally, if land and cost were not an issue, LWC could build a new treatment facility, switch over and abandon the existing treatment plant. Due to cost and land availability, the current plan is to supplement the existing plant with a new advanced treatment barrier or retrofit an existing process to improve treatment performance. Since RBF is a "front-end" process we can add this process easily and then optimize it later without disrupting the existing operations. LWC is

implementing RBF at the B.E. Payne plant and is upgrading the existing conventional processes to accommodate the RBF water. The B.E. Payne plant will have four barriers (RBF, chemical pretreatment, filtration, and disinfection).

Do we have a timeframe on how long it could take to implement a new technology?
The various advanced treatment methods will take five to ten years to complete construction, depending on the technology chosen and the construction procurement methods.

Should LWC consider a combination of technologies? For example, combining high capital cost with low operation cost options or vice versa.
Yes. The Steering Group will consider a variety of advanced treatment scenarios. Also, "scale up" and "scale down" operability will be considered. For example, RBF, GAC, and Ozone all require large construction contracts over a five to ten year period. Combinations of technologies will require coordination with existing operations of the CHFP to assure continuous supply of drinking water to Louisville.

Gerald Martin stated the Steering Group should prepare to present its findings to the full Board this fall, so that costs can be factored into future capital budgets. Greg advised that we can cross check costs of a new plant versus retrofitting CHFP since Black & Veatch Engineers are experienced with building new plants, as we consider the technology options. Greg also recommended Bruce include consideration of the historical character of the Crescent Hill Filtration Plant for all of the cost evaluation scenarios. Bruce has a presentation on how plants are retrofitted that he would be willing to present at the next meeting if desired. John stated that Crescent Hill is more modular with more options for rerouting water than the B.E. Payne plant. Greg asked Bruce to develop a one page historical timeline table summarizing the evolution of regulatory compliance, current regulations, current compliance by LWC, and projected regulatory targets. Jack will assist Bruce in compiling the LWC compliance data for this table.

A copy of the PowerPoint presentation will be filed with these minutes.

WATER WORKS
LWC 150
1854 - 2004

LOUISVILLE WATER COMPANY
CRESCENT HILL FILTRATION PLANT
ADVANCED TREATMENT TECHNOLOGY

Steering Group Meeting No. 4
June 7, 2005
Agenda

I.	OPENING COMMENTS / INTRODUCTIONS	*John Huber*
II.	MINUTES AND AGENDA REVIEW	*Greg Heitzman*
III.	PROJECT UPDATE AND PROGRESS SUMMARY	*Larry Gaddis*
IV.	POTENTIAL TREATMENT TECHNOLOGIES • Review of Filtration and Carbon Adsorption • Softening • Ozonation • Ultraviolet Disinfection	*Bruce Long*
V.	DECISION-MAKING SOFTWARE (Criterium Decision Plus)	*Heather Mackey*
VI.	OUTCOME OF PROCESS WORKSHOP • River Bank Filtration Option • Surface Water Option #1 • Surface Water Option #2	*Bruce Long*
VII.	STEERING GROUP MEETING NO. 5 • July 19	*Greg Heitzman*
VIII.	OPEN DISCUSSION AND QUESTIONS	*All*

Steering Group Meeting No. 4

Louisville Water Company

Crescent Hill Filtration Plant Advanced Treatment Study

June 7, 2005

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Opening Comments

John Huber

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Meeting Agenda and Purpose

Greg Heitzman

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Project Update and Progress Summary

Larry Gaddis

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Previous Steering Group Meetings

Meeting No. 1

- Review of 2002 – 2021 Facilities Plan
- Goals of Advanced Treatment Study
- Overview of Drinking Water Regulations
- Presentation of Potential Treatment Technologies

Meeting No. 2

- Presentation of RBF Option for CHFP (JJ&G and LWC)

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Previous Steering Group Meetings

Meeting No. 3

- LWC Water Quality Goals
- CHFP Compliance with Goals and Drinking Water Regulations
- Treatment Option Evaluation Criteria
- Potential Treatment Technologies
  - Filtration
  - Activated Carbon Adsorption

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Process Workshop (May 11, 12, and 13, 2005)

- Challenges to Equal BEP
- Developed Process Alternatives
- Reviewed Evaluation Criteria
- "Criterium Decision +" Software
- Weighting of Evaluation Criteria
- Scored Process Alternatives
- Screened Options

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Upcoming Project Activities

- Detailed Evaluation of Selected Process Options
- Determination of Recommended Option
- Recommendations Presentation
- Steering Group Meeting No. 5 (July 19, 2005)
- Draft Report
- Final Report

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Potential Treatment Technologies

Bruce Long

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Potential Treatment Technologies

- Review of Filtration and Carbon Adsorption
- Solids Separation
- Softening
- Ozone and Chlorine Dioxide
- Ultraviolet Disinfection

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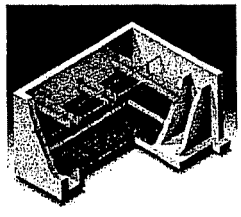
Last Meeting We Reviewed:

- Technologies for Enhanced Particle Removal
  - Granular media filtration
  - Filtration membrane processes (MF/UF)
- Granular and Powdered Activated Carbon Adsorption – to remove:
  - DBP precursor compounds (NOM or DOC)
  - T&O causing compounds
  - SOCs



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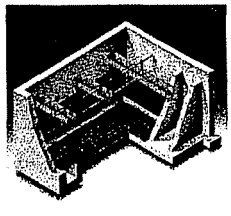
Granular Media Filtration

- Two Principal Types:
  - Monomedia
    - Sand
    - Anthracite
    - GAC
  - Dual Media
    - Anthracite-sand
    - GAC-Sand (filter-adsorber)
- All can be operated in a biologically active mode



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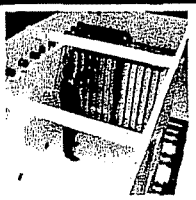
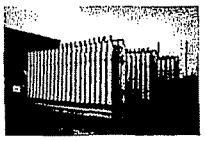
Membrane Filtration

- Two types of filtration membranes
  - Microfiltration (MF)
  - Ultrafiltration (UF)
- Applied in two modes
  - Submerged
  - Encased





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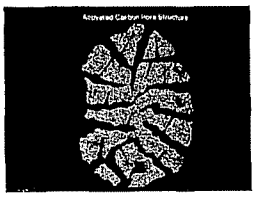
GAC and PAC Adsorption

- Activated carbon is applied in two forms:
  - Granular (GAC)
  - Powdered (PAC)
- Effectiveness depends upon:
  - Contact time
  - Compound(s) to be removed
  - Water quality at point of application



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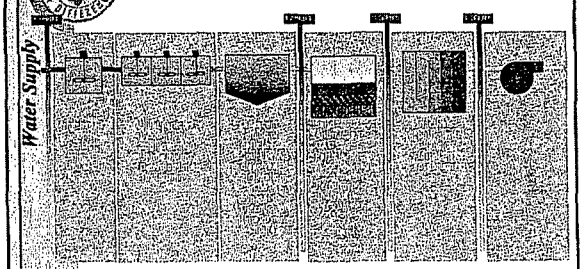
Water Treatment Plants Consist of Several Process Steps



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Enhanced Particulate Removal- Microbial Reduction

- Granular media filtration enhancements
- Membrane processes
- Improved pretreatment solids capture:
  - Improved Sedimentation
  - Dissolved air flotation
- Riverbank Filtration

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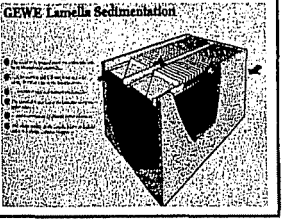
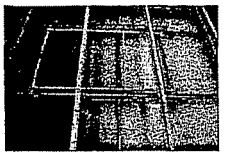
Improved Sedimentation

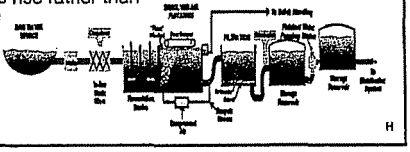
- Inclined plates
- Tubes
- Improved hydraulics – more uniform water retention
- Improved separated solids removal technologies
- Much smaller footprint required
- Especially good for retrofit projects



Dissolved Air Flotation

- Suitable for higher quality feed waters
  - Algae
  - Chemical flocs
- High-rate, small footprint process
- Solids rise rather than settle





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Softening

- Removal of principally calcium and magnesium from water
- Accomplished by:
  - Precipitative softening – lime, caustic added to raise pH and precipitate calcium and magnesium
  - Tight membrane processes – reverse osmosis, nanofiltration
- LWC's finished water hardness goal of 150 mg/L as $CaCO_3$ requires occasional softening

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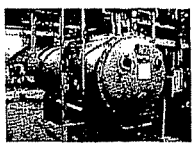
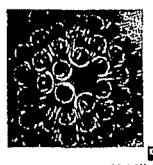
Ozonation

- Triatomic form of oxygen - O_3
- Comes from the Greek word ozein which means "to smell"
- Highly reactive
  - Generated from oxygen on site
  - Cannot be stored
  - Provides short-term residual in water so must be used in combination with a secondary disinfectant





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Why Use Ozone in Drinking Water Treatment?

- Taste and odor control
- Disinfection
- Oxidation of color, SOCs, EDCs, Fe, and Mn
- Minimize formation of regulated DBPs
- Enhances downstream BAF/BAC
- Synergistic interaction with other disinfectants (esp UV)
- These benefits are frequently concurrent

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Chlorine Dioxide

- ClO_2 as contrasted with O_3
- Must be produced on-site
- Does not react with NOM to form TTHMs or HAAs
- Effective disinfectant for viruses, bacteria, and *Giardia lamblia*
- Very effective for oxidation of Mn
- Complications occur if free chlorine is used as the distribution system disinfectant

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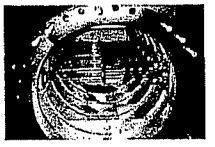
Ultraviolet Disinfection

- Now recognized as the most effective means to inactivate *Cryptosporidium*
- Does not create regulated disinfection byproducts
- Synergistically integrated with other disinfectants



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Challenges to Equal BEP

- Microbials – inactivation/removal
- T&O reduction
- Equivalent DBPs
- Equivalent AOC
- SOCs
- Nuisance organisms (zebra mussels, asiatic clams)
- Emerging contaminants
- Public perception
- Consistency

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Process Alternative Screening and Decision-Making Software

Heather Mackey

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Treatment Option Evaluation Criteria

- Cost (0.35)
- Finished Water Quality (0.35)
- Operational Considerations (0.30)
- Social/Environmental Issues (0.05)
- Other Considerations (0.05)

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Evaluation Criterion: Cost

- Capital cost (0.45)
- Operation and maintenance cost (0.45)
- Depreciated assets (0.10)

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Evaluation Criterion: Finished Water Quality

- Regulatory compliance (0.0)
- Ability to consistently achieve LWC goals (0.50)
- Compatibility with BEP (0.50)

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Evaluation Criterion: Operational / System Considerations

- Operability (0.25)
- Flexibility (0.07)
- Reliability (0.25)
- Residuals management (0.08)
- Constructability (0.35)
- Schedule (0.0)

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Evaluation Criterion: Social/Environmental

- Customer Satisfaction (0.0)
- Visual impact (0.20)
- Noise/odor (0.20)
- Risk management – safety (0.10)

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Evaluation Criterion: Other Considerations

- Multiple treatment barriers (0.50)
- Risks/uncertainties (0.30)
- Compatibility with future RBF (0.20)

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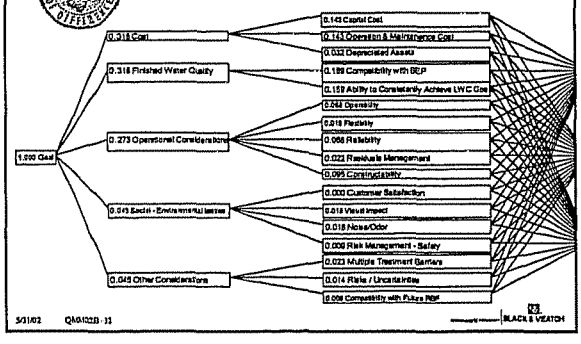
Workshop Decision Hierarchy



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Outcome of Process Workshop

Bruce Long

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Development of Process Options

- Created 10 Preliminary Treatment Alternatives
  - 7 Surface Supply Options
  - 3 RBF Supply Options
- Screening by LWC and B&V Yielded 5 Alternatives for Further Consideration

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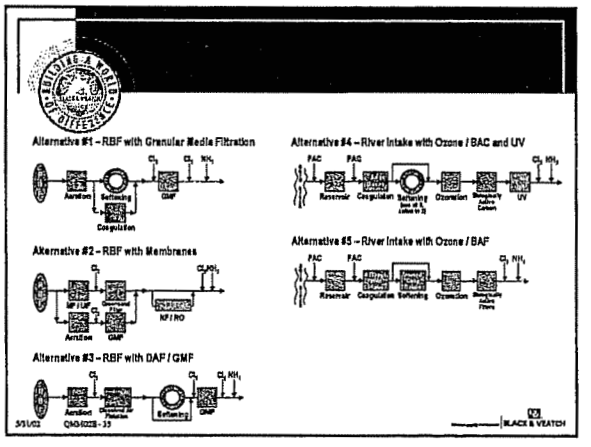
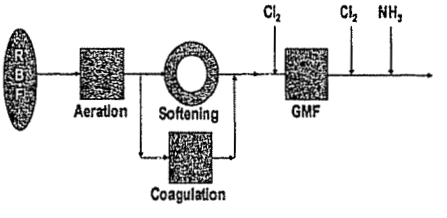


Alternative #1 – RBF with Granular Media Filtration



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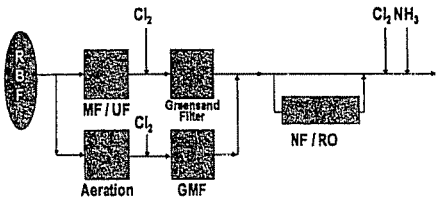
Alternative #2 – RBF with Membranes



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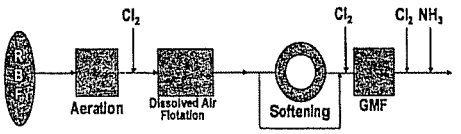
Alternative #3 – RBF with DAF / GMF



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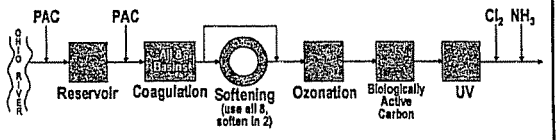
Alternative #4 – River Intake with Ozone / BAC and UV



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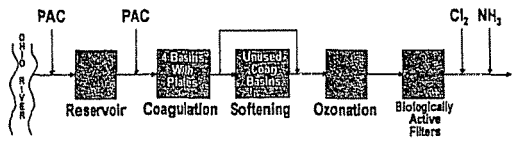
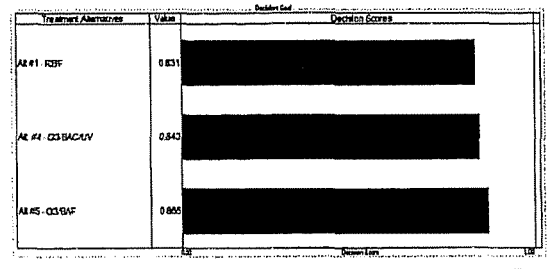
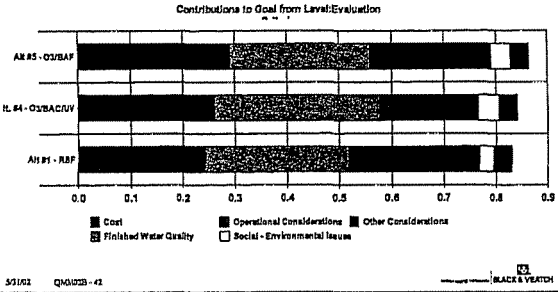
Alternative #5 – River Intake with Ozone / BAF



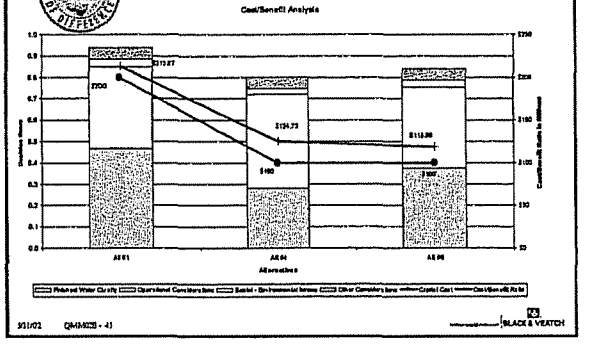
Workshop Decision Score



Workshop Contributions to Goal



Cost Benefit Analysis (Cost Not a Consideration)



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Steering Group Scoring and Results

Let's Give It a Run!

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Steering Group Meeting No. 5 (July 19, 2005)

Greg Heitzman

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Steering Group Meeting No. 5

- Detailed Improvements Evaluation
- Recommended Process Option(s)

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Open Discussion and Questions

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Louisville Water Company

Minutes

Crescent Hill Advanced Treatment Technology Steering Group

June 7, 2005

Present: Kay Ball, Larry Gaddis (Black & Veatch), Steve Greseth (Black & Veatch), Greg Heitzman, John Huber, Rick Johnstone, Bruce Long (Black & Veatch), Heather Mackey (Black & Veatch), Gerald Martin, Bob Miller, Jim Smith, Karla Teasley, Steve Tucker, Jack Wang, Marita Willis, and Joe Wise.

Absent: Susan Lehmann.

Opening Comments -- John Huber
John Huber advised the Steering Group today's presentations will provide a more in depth look at treatment technology.

Introductions / Meeting Minutes / Agenda Review – Greg Heitzman
Greg Heitzman introduced Heather Mackey of Black & Veatch. Heather worked with the Technical Group using the Criterium Decision + software.

Greg advised the Steering Group members that binders containing all of the materials distributed in the meetings to date were prepared for them.

A correction was made to the April 21, 2005 meeting minutes. On page 2, the fourth paragraph was corrected to read as follows. "Bob Miller asked that when water quality measurement averages are discussed, to include the data ranges so that the average results and the maximum results are considered." The April 21, 2005 minutes were approved with this correction.

Greg provided an overview of the agenda. Greg explained the outcome of the Technical Group's workshop were three options for the Steering Group to consider. These three options were culled from a plethora of considerations using the Criterium Decision + software. The software is dynamic in that the Technical Group could manipulate the criteria weightings to see the impact on the outcome. The evaluation criteria were established by LWC staff. All of the options were fed in to the computer program with the outcomes being River Bank Filtration Option, Surface Water Option #1, and Surface Water Option #2. After rigorous manipulation of the weightings, these same top three options resulted. These options will be fully presented today. Steering Group members will be exposed to the software program utilized to have a better understanding of how it works.

Project Update / Progress Summary – Larry Gaddis

Larry Gaddis gave a review of the Steering Group meetings leading up to today. He then discussed the Technical Group, which is comprised of the following LWC and Black and Veatch staff members.

B&V Participants	LWC Participants
John Dyksen	Jim Smith
Mike Schneiders	Steve Tucker
Steve Greseth	Phil Scott
Bruce Long	Carl Fautz
Heather Mackey	Jack Wang
Larry Gaddis	Kay Ball
	Kent Horrell
	Rengao Song
	Ruth Lancaster

The Technical Group held a three-day workshop May 11-13, 2005. On the first day, the Group determined the challenges in producing water at the Crescent Hill Filter Plant that is equal to that of the B.E. Payne plant. The second day was spent developing process alternatives and evaluation criteria. On the third day, the Group applied criteria weightings to the process options and began to evaluate the options using the Criterium Decision + software. Each option was scored by the software and screened by the Technical Group.

The evaluation criteria were developed into five main categories, with subset criteria for each. The categories and respective weightings are listed below with some elaboration. The decision hierarchy was established using three steps. The first step was to establish the evaluation criteria. The second step was to establish the subset criteria. The third step was to rank the options using the decision criteria. It is important to understand that although the weightings may not add up to 1, the computer normalizes the criteria weightings so that they do add to 1.

- Cost (0.35)
  - Capital cost (0.45)
  - Operation and maintenance cost (0.45)
  - Depreciated assets (0.10)
- Finished Water Quality (0.35)
  - Regulatory compliance (0.0) *A weighting of 0.0 was applied to this subset criterion because LWC not only meets, but exceeds regulatory requirements for compliance.*
  - Ability to consistently achieve LWC goals (0.50)
  - Compatibility with B.E. Payne (0.50)
- Operational / System Considerations (0.30)
  - Operability (0.25) *This criterion is related to the ease in which we are able to achieve our goals.*
  - Flexibility (0.07)

    - Reliability (0.25) *The ability to perform maintenance over the life of the equipment is included in this subset criterion.*
    - Residuals management (0.08)
    - Constructability (0.35)
    - Schedule (0.0) *This subset criterion is weighted as 0.0 because it is considered in another category and would therefore create a redundancy if also considered here.*
- Social Environment (0.05)
    - Customer satisfaction (0.0) *Customer satisfaction is addressed in the subset criterion of Ability to consistently achieve LWC goals (0.50) under the Finished Water Quality (0.35) category.*
    - Visual impact (0.20)
    - Noise / odor (0.20)
    - Risk management – safety (0.10)
- Other Considerations(0.05)
    - Multiple treatment barriers (0.50)
    - Risks / uncertainties (0.30)
    - Compatibility with future RBF (0.20)

The Technical Group experimented with many different weighting combinations, but continuously had the same three resulting options in the outcome, which gave the Group a high degree of confidence in these results. The Group then began a detailed analysis on the top three options.

Larry advised the Steering Group of the activities that will occur between this point and the production of the final report. These activities include: conducting a detailed evaluation of the selected process options; determining a recommended option; developing a presentation of the recommendation; conducting a fifth Steering Group meeting; writing a draft report; and producing the final report.

Potential Treatment Technologies – Bruce Long

Bruce Long reviewed treatment technologies, which include: filtration and carbon adsorption, solids separation, softening, ozone and chlorine dioxide; and ultraviolet disinfection. Bruce remarked on Heather Mackey's expertise in the implementation of ultraviolet disinfection at large facilities.

Jack Wang brought a sample collected from the Ohio River today to exhibit how water can appear treated yet possess a pungent odor. The sample was passed around the room. Jack explained that this sample is a fine example of why LWC treats for taste and odor, even thought it is not regulated by federal or state law.

John Huber explained that currently LWC uses chloramine to reduce bacteria growth before the water reaches our filter media. However, with filtration we would want to grow bacteria on filter media and the "hungry" bacteria that will ingest organic matters as the water passes through the filter.

Carbon is thermally activated, meaning it is heated in an airless environment, which creates a porous surface area useful for adsorption. Granular activated carbon (GAC) is continuously used, while powdered activated carbon (PAC) is used and then disposed through sludge.

There are several process steps in a water treatment plant, all of which begin with a water supply. LWC's water supply can come directly from the Ohio River or from the River Bank Filtration well.

Lamella plates are great for improved sedimentation because they have lots of surface area. This makes Lamella plates good for retrofit projects, like conversion of an old basin. If LWC chose to use Lamella plates, the plates would replace the existing sedimentation method. Lamella plates would require 1/5 of the space compared to our coagulation basins to equate to the same production capacity. These processes are very efficient, but because the water moves through the basins much quicker there is not much reaction time should an error occur.

Dissolved air flotation is good when solids tend to be algae or chemical floc.

Does dissolved air flotation work well over a wide range of temperatures?
Yes. However, depending on the temperature one may need more saturation time. Keep in mind that sludge floats in this process versus settling to the bottom.

Softening is principally the removal of calcium and magnesium from the water. This can be accomplished by precipitative softening, which is the process of adding lime and/or caustic soda to raise the pH and precipitate calcium and magnesium. Another method for softening is utilization of tight membrane processes like reverse osmosis or nanofiltration.

Ozonation is highly reactive. The ozone must be generated on site. It is too costly to store, because it must be refrigerated. Ozone is created by sending oxygen and electricity sparks through many glass tubes. Ozone is not as effective on cold water at inactivating cryptosporidium oocysts. Ozone breaks large organic molecules into smaller ones so bacteria can eat them. This is why we intentionally place biofiltration like biologically active carbon or anthracite filters after ozonation. Ozone with ultraviolet disinfection is a viable combination for LWC to consider.

Chlorine dioxide, like ozone, must also be produced on site. It is very reactive and is not effective against cryptosporidium.

Ultraviolet disinfection (UV) is effective against cryptosporidium, but not effective against viruses. It is very inexpensive to power UV – approximately the same cost to power lights.

How do you measure inactivation of oocysts?
One must apply a specified does of radiation to an oocyst to see how much reproduction occurs. Then, set the UV to that level.

Bruce reviewed the challenges to having Crescent Hill Filter Plant achieve results equal to B.E. Payne. One challenge is consistency – our ability to provide the same water quality irregardless of how flashy the supply is.

Decision-Making Software -- Heather Mackey

Heather reviewed the treatment option evaluation criteria, which is noted in detail at the beginning of these minutes. Heather demonstrated the software for the Steering Group. She performed criteria weighting adjustments for the Group to demonstrate the process and outcome results.

Outcome of Process Workshop -- Bruce Long

Ten preliminary treatment alternatives were created: seven surface supply options and three RBF supply options. Screening by LWC and B&V reduced the number of alternatives for consideration to five. These five alternatives were fed through the software, resulting in three outcomes. The final top three outcomes, all utilized the RBF well as the water supply followed by aeration, whereas the other two used raw river water with ozonation. Green sand was recommended for removal of manganese.

Score	Alternative
0.865	River Intake with Ozone / Biologically Active Filters (BAF)
0.843	River Intake with Ozone / Biologically Active Carbon (BAC) and Ultra Violet (UV)
0.831	RBF with Granular Media Filtration
0.823	RBF with Membranes
0.815	RBF with Dissolved Air Flotation / Granular Media Filtration

How do you determine the variables, like cost for example? Do you use a dollar amount?
We use relative, not absolute, ranking. We will use actual numbers in the final evaluation. Right now, we are working in reverse. Example: low capital cost = high rating and high capital cost = low rating. Numbers were not applied until the top five alternatives were reached. The numbers applied were relative to the cost ranges.

Do preliminary numbers factor in the bid cost?
Yes. We used the preliminary bid costs for these, which is between 128 and 200 million dollars.

Is the software capable of performing a sensitivity analysis without using numbers?
Yes. We can use the slide bar to make changes on a criterion and all other criteria are automatically recalculated.

John Huber asked Heather to change the weighting for overall cost (capital, operations and maintenance, and depreciation) to .5. As cost was increased, RBF became less attractive. Heather remarked that one can also change the weightings on the sub criteria with this software. Energy costs were also considered.

As you created the alternatives, was there any consideration for the operational soundness of the equipment? For example, consideration of new equipment versus retrofitted equipment.

When we are considering a capital investment of 100 to 200 million dollars to update an existing facility, it would be nice to know how much it would cost to do a new plant with the same technology. Consideration for premium cost to operate an existing facility versus the premium cost to run a new facility. We need to answer the question: "Is a retrofit solution appropriate?" We can look at a new plant, but new piping would be required because Crescent Hill is at the heart of the transmission system and this would mean significant cost increases to re-plumb the system, therefore all alternatives are retrofits, modifications, or additions to the existing CHFP facility.

Are there more uncertainties we can put values on?
Yes, some are blatant. Example: What is the sustainable yield from RBF? We have a value assigned to the category of risks and uncertainties.

Gerald Martin requested to see the criteria staff considered as the most important.

This software should be used to screen alternatives, not to select the appropriate technology for LWC to implement.

Separately, we (Greg Heitzman, Kay Ball, Jack Wang, Rengao Song, Kent Horrell, John Azzara, and Jordan, Jones, and Goulding staff) are conducting a value engineering workshop for the B.E. Payne riverbank infiltration tunnel in parallel. Results of the workshop will be loaded in to the software for evaluation.

It appears that cost and finished water quality are highly correlated. Does the software provide a correlation coefficient for these two variables?
It can, but we haven't used it that way yet. Between now and the next meeting, we need to better define our relative rankings.

When deciding weightings, how much was determined with consensus and how much with compromise?
A little of both, but for the most part determinations were made by consensus. The issues are very broad and complex and opinions vary on the ranks assigned. In the end, the group feels strongly about the final three options and much tinkering was done with weightings.

Because of the configuration of CHFP, it is difficult to implement a post-treatment technology.

Are you, the Steering Group members, comfortable with the approach of taking these three alternatives and proceeding with a detail analysis of them or do you want to go back and do more initial sensitivity analysis on the other options?
Joe Wise agreed to proceed with the detail analysis of the final three alternatives. Gerald Martin did not. Gerald commented that data will be revised to be more accurate, so why proceed with a decision just yet. We may get a better, more accurate outcome by evaluating all

five alternatives. Greg suggested the Group proceed with the final three options because they are not sensitive to the other alternatives to scale. After we complete the next step we could go back to validate the final alternative against all the others. Gerald is concerned that the Group is making a lot of assumptions. Greg said we can determine if the similarity is relative to the cost sensitivities to validate. Gerald remarked that the Board of Water Works will make the final decision. Do we want to make that judgment ourselves regarding the five criteria used in the evaluation? Joe Wise commented that he is comfortable with the top five criteria.

Would it help if we created a sensitivity table that provides the ranges and effects on the outcomes?
Bob Miller commented that from a public perception we need to justify how good the water quality is. Gerald remarked that less than one percent of the water produced is actually consumed, but is 100 percent of customer satisfaction.

We've look purposefully at options that are futuristic in order to document justification as to why they may not be appropriate to implement at this time.

Is compatibility with B.E. Payne redundant with attempting to meet LWC goals?
We must meet B.E. Payne quality due to public perception. Customers are charged the same so the quality must be the same.

Greg commented that staff is confident with the process, however the Steering Group members may not be. We can create a matrix with some scenarios that have been fed through the software to present to them. This will help determine if there is another solution we are not considering now that would be considered if our assumptions/criteria weightings changed.

The "green field" perspective of building a new treatment plant should be considered or at least compared. We should look at the best option without considering cost initially, just for the sake of knowing the best option. Risks and uncertainties should be considered more strongly in the next step.

Greg explained the purpose of the value engineering workshop is to change construction plans to reduce costs within budget and also to consider connecting tunnels and wells versus pipe and wells. The goal is to get a River Bank Filtration construction solution within our budget. The workshop should be completed in August.

Would it be worthwhile to provide an interim report to the full Board of Water Works explaining we will now proceed with our intensive analysis of the final three options?
The Steering Group agreed the Board should be updated on the status of the project, the ranking criteria, and the final three options.

Steering Group Meeting Number Five – Greg Heitzman
It is unlikely that we will have a conclusion from the value engineering workshop by the next meeting scheduled for July 19. We should look at two or three alternative dates and schedule an additional meeting. We can also use this time to look at the green field alternative. We can use

the July 19 meeting to review capital and operational costs. It is necessary to consider cost sensitivity. After considering August 16, 18, 23, and 25, it was concluded that August 16 would be the best date. Christy Ray was asked to follow up with the Steering Group via email to confirm the date of August 16. It was also decided that the July 19 meeting would be cancelled since there would not be enough material ready for presentation by that date. The presentation will be distributed after the meeting, since hard copies were not available.

A copy of the PowerPoint presentation will be filed with these minutes.

WATER WORKS
LWC 150
1854 - 2004

LOUISVILLE WATER COMPANY
CRESCENT HILL FILTRATION PLANT
ADVANCED TREATMENT TECHNOLOGY

Steering Group Meeting No. 5
August 16, 2005
Agenda

I.	**OPENING COMMENTS**	*John Huber*
II.	**AGENDA AND MINUTES REVIEW**	*Greg Heitzman*
III.	**REVIEW OF FINAL THREE TREATMENT OPTIONS**	*Bruce Long*

A 9. Ohio River + PAC + Inclined Plate Settlers + Lime Softening + Ozone + Biologically Active Filters + Chlorine/Chloramines

A 6. Ohio River + PAC + Conventional Sedimentation + Lime Softening + Ozone + Biologically Active GAC Filters + UV + Chlorine/Chloramines

A 1. Riverbank Filtration + Aeration + Lime Softening and Conventional Sedimentation + Existing Filtration and Disinfection

IV.	**RESULTS OF DETAILED EVALUATION**	*Bruce Long*
V.	**RECOMMENDATIONS**	*Bruce Long*
VIII.	**OPEN DISCUSSION AND QUESTIONS**	*All*

Steering Group Meeting No. 5

Louisville Water Company

Crescent Hill Filtration Plant Advanced Treatment Study

August 16, 2005

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Opening Comments

John Huber

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Agenda and Minutes Review

Greg Heitzman

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Project Update

Larry Gaddis

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Final Three Alternatives

Bruce Long

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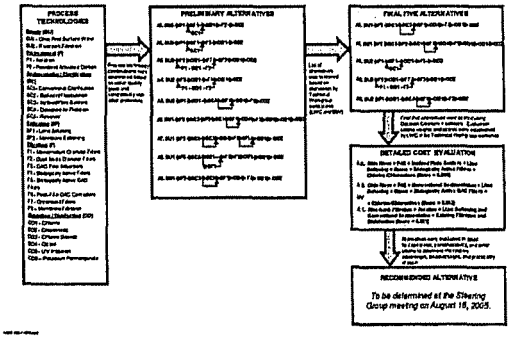
EXHIBIT 2
LOUISVILLE WATER COMPANY
CHPP – ADVANCED TREATMENT STUDY
TREATMENT OPTION SELECTION PROCESS



How Did We Arrive at the Final Three Alternatives?

- Established Water Quality Goals
- Evaluated Applicable Regulations
- Determined Compliance Ability of CHFP
- Selected Multiple Feasible Treatment Options
- Evaluated the Alternatives Using Decision-Facilitating Software

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Establish Water Quality Goals

- Existing, pending, and proposed future Federal and State regulations
- LWC customer expectations
- Internal LWC goals

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Evaluate Applicable Regulations

- Establish status of regulations
- Determine applicability and impact for LWC

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Determine Compliance Ability of CHFP

- Treatment Performance / Finished Water Quality
- Discussions with LWC staff
- Evaluate areas of need

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Select Feasible Treatment Options

- Preliminary options
- Initial screening
- Determine evaluation criteria
- Plant investigation and constructability review
- Process Workshop

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Challenges to Equal BEP

- Microbials – inactivation/removal
- T&O reduction
- Equivalent DBPs
- Equivalent AOC
- SOCs
- Nuisance organisms (zebra mussels, asiatic clams)
- Emerging contaminants
- Public perception
- Consistency

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Treatment Option Evaluation Criteria Were Established

- Cost (0.35)
- Finished water quality (0.35)
- Operational considerations (0.30)
- Social/Environmental Issues (0.05)
- Other considerations (0.05)

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Evaluation Criterion: Cost

- Capital cost (0.45)
- Operation and maintenance cost (0.45)
- Depreciated assets (0.10)

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Evaluation Criterion: Finished Water Quality

- Regulatory compliance (0.0)
- Ability to consistently achieve LWC goals (0.50)
- Compatibility with BEP (0.50)

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Evaluation Criterion: Operational/System Considerations

- Operability (0.25)
- Flexibility (0.07)
- Reliability (0.25)
- Residuals management (0.08)
- Constructability (0.35)
- Schedule (0.00)

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Evaluation Criterion: Social/Environmental

- Customer Satisfaction
- Visual impact (0.20)
- Noise/odor (0.20)
- Risk management -- safety (0.10)

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Evaluation Criterion: Other Considerations

- Multiple treatment barriers (0.50)
- Risks/uncertainties (0.30)
- Compatibility with future RBF (0.20)

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Based On DCP Analysis the Final Three Alternatives were Determined to be:

- A9 - River intake with ozone and BAF
- A6 - River intake with ozone, BAC and UV
- A1 - RBF with granular media filtration

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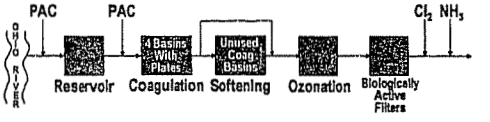
Alternative #A9 – River Intake with Ozone / BAF



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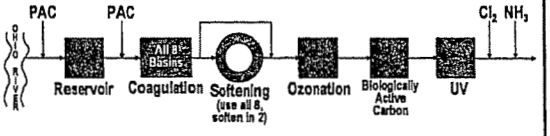
Alternative #A6 – River Intake with Ozone / BAC and UV



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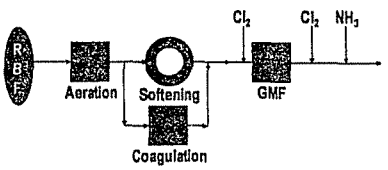
Alternative #A1 – RBF with Granular Media Filtration



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Cost Comparison for the Final Three Alternatives:

Cost (in Millions of Dollars)

Alternative	Capital Cost	O&M	PW
A9 – RI/BAF	$138	$6.96	$233
A6 – RI/BAC	$122	$8.79	$241
A1 – RBF	$237	$7.23	$335

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Based on Refined Costs the Relative Rankings become:

- A9 - RI with BAF 0.801
- A6 - RI with BAC/UV 0.776
- A1 - RBF option 0.741
- Based on these evaluations, the recommended alternative is River Intake with BAF (Alt A9)
- HOWEVER, based on PW values, Alternatives A9 and A6 are too close to call

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Recommended Next Steps

- Pilot testing of the A9 process train:
  - Ozone demand and decay
  - Bromate formation and control
  - BAF – loading rates, EBCT, AOC reduction, filtered water turbidity
- Pilot one BAC filter in parallel with the BAF filter(s)
  - Filtered water quality (turbidity, AOC, T&O)
  - Quality versus EBCT

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Recommended Next Steps (cont'd)

- Begin water quality monitoring for your Zorn Avenue test well
- RBF cost numbers for BEP are still being refined
- Quality data can reduce uncertainties on treatment requirements
- Consider additional test wells to verify quality and quantity

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Recommended Next Steps (cont'd)

- Verify direction to reconstituting the CHFP capacity at 180 MGD vs downrating and constructing new plant southwest

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