American Water Works Service Company, Inc.

1025 Laurel Oak Road • P.O. Box 1770 • Voorhees, New Jersey 08043 • (609) 346-8201 • Fax (609) 346-8360

March 4, 1998
BP 92-12

(A copy of this has been sent to the attached list of consultants)

Re: Kentucky-American Water Company
Bluegrass Water Project

Dear Colleague:

Enclosed are two copies of Addendum No. 1 for the referenced project. Changes to the original pages are highlighted by a vertical line in the left hand margin with additions in blue italic print and deletions in red strike-through print. The addendum number is also indicated in the top margin of each page which contains revisions. Please note that some pages do not include any revisions and are only being submitted in order to keep the pages in proper sequential order.

This addendum primarily incorporates the easement scope of work into this project as well as addressing other questions from the pre-proposal meeting. Following the pre-proposal meeting, Kentucky-American carefully reviewed alternatives to provide each Consultant with equitable consideration on the work currently being proposed. Considering that the field work for the easements has not yet started, Kentucky-American Water Company and the easement consultant (GRW/Quest Engineers) have agreed to cancel their current contract allowing the easement scope of work to become part of the design scope of work. These changes are expected to help expedite the project and eliminate the coordination that would be needed with separate easement and design consultants. Kentucky-American is appreciative of the cooperation from the GRW/Quest team to help provide an opportunity to complete the work in a manner that is most cost effective for their customers.

Specifically, this addendum includes the following:

- Revisions to the entire Request for Proposal.
- Revisions to the Design Concept (Attachment A) for pages DC - 2, 3, 4, 5, 6, 12, 18, 19, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, and 47.
- New page DC - 48 for the Design Concept (Attachment A).

- Revisions to the cover page of Attachment C.
- An "Example Plan and Profile Pipeline Drawing" for Attachment C.
- Revisions to the cover page of Attachment D.
- A "Tie In Point at the KAWC Distribution System" drawing for Attachment D.

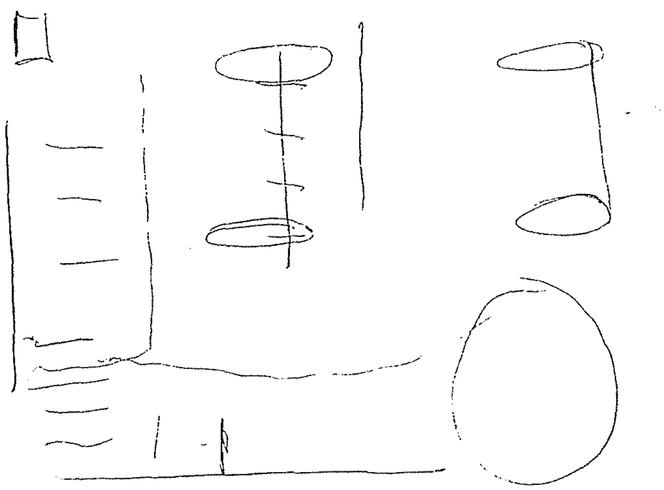
Please replace the original pages in your documents with the revised pages and add each of the new pages.

The proposal due date has also been extended one week to Thursday, March 26, 1998. All other requirements for submittal of your proposal remain unchanged from the original documents which were sent to you on February 18, 1998. Should you have any questions regarding this addendum, please contact me by phone at (609) 346-8278 or by e-mail at dreves@amwater.com.

Sincerely,

David M. Reves, P.E.
Senior Design Engineer

c: L.C. Bridwell - KAWC (w/att) + 5 additional copies
T.A. Friley - KAWC (w/att)
N.O. Rowe - KAWC (w/att)
K.A. Willis - Louisville Water Company (w/att) + 1 additional copy.



KENTUCKY-AMERICAN WATER COMPANY
BLUEGRASS WATER PROJECT

List of Consultants

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801 Corporate Drive
Lexington, KY 40503
Attn: Ron D. Gilkerson
(606) 223-3999

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Quest Engineers, Inc.
881 Corporate Drive
Lexington, KY 40503
Attn: Mr. Charles R. Scroggin

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Montgomery Watson
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Attn: Mr. Richard G. Atoulikian

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Attn: W. Kirk Corliss, Jr.
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Attn: Mr. Raymond W. Ihlenburg

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Attn: Anthony P. Izzo

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6040 Dutchmans Lane
Louisville, KY 40205
Attn: Bernard F. Maloy
(502) 452-1700

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Photo Science, Inc.
2670 Wilhite Drive
Lexington, KY 40503
Attn: Mr. Mark Meade

?/

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February 18, 1998
BP 92-12

(A copy of this has been sent to the attached list of consultants)

Re: Kentucky-American Water Company
<u>Bluegrass Water Project</u>

Dear Colleague:

Enclosed are two copies of a Request for Proposal and Design Concept for the referenced project for your review. We request your submission of separate lump sum proposals for this project for engineering design, bidding, and construction administration services as detailed on the following pages.

The scope of work for this project consists of approximately 52.5 horizontal miles of 36-inch pipeline, a retention basin for flushing, and two booster stations to allow for the transfer of finished water from the Louisville Water Company (LWC) distribution system to the Kentucky-American Water Company (KAWC) distribution system. Pipeline route selection and easement acquisition for the pipeline, which includes stray current, soils corrosivity, wetlands, and archeological investigations and permitting, is currently underway and is <u>not</u> a part of this project's scope of work. All design work required within the LWC service area in Jefferson County, which will primarily consist of pipeline improvements, is also <u>not</u> a part of this Request for Proposal and will be administered separately by LWC. However, a surge analysis of the proposed pipeline, including the pipeline within Jefferson County, is part of this Request for Proposal.

Kentucky-American Water Company is an operating subsidiary of American Water Works Company, an investor-owned water utility with corporate offices in Voorhees, New Jersey. The design for this project will be managed by the Engineering Department of American Water Works Service Company, Inc., also a subsidiary of American Water Works Company. All reference in the attached documents to the "Water Company" shall be inclusive of American Water Works Service Company and Kentucky-American Water Company personnel.

There will be a pre-proposal on the morning of Tuesday, February 24, 1998 beginning at 9:00 a.m. at the Water Company's main office located at 2300 Richmond Road, Lexington, Kentucky. It is expected that the meeting will be complete by noon. Please feel free to invite any of your team members or sub-consultants to attend the meeting as you feel necessary. No site visits are planned as part of this pre-proposal meeting.

Proposals must be submitted no later than 4:00 p.m. on Thursday, March 19, 1998. The original proposal plus three (3) copies shall be addressed and sent to:

Ms. Linda C. Bridwell
Kentucky-American Water Company
2300 Richmond Road
Lexington, Kentucky 40502

Two (2) additional copies of the proposal shall be forwarded to:

Mr. David M. Reves
American Water Works Service Company, Inc.
1025 Laurel Oak Road
P. O. Box 1770
Voorhees, New Jersey 08043

No other copies of the proposal are required. Faxed copies of the proposal will not be accepted.

Should you have any questions prior to the pre-proposal meeting, or are unable to attend the meeting or submit a proposal, please contact me by phone at (609) 346-8278 or by e-mail at dreves@amwater.com.

Sincerely,

David M. Reves, P.E.
Senior Design Engineer

c: L.C. Bridwell - KAWC (w/att) + 5 additional copies
T.A. Friley - KAWC (w/att)
N.O. Rowe - KAWC (w/att)
K.A. Willis - Louisville Water Company (w/att) + 1 additional copy

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BLUEGRASS WATER PROJECT

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Attn: Mr. Mark Meade

Revised per Addendum No. 1

KENTUCKY-AMERICAN WATER COMPANY
BLUEGRASS WATER PROJECT

Request for Proposal

KENTUCKY-AMERICAN WATER COMPANY
BLUEGRASS WATER PROJECT

REQUEST FOR PROPOSAL

Table of Contents

Page

I. SCOPE OF SERVICES

A. Design 1
- 1. Schedule 1
- 2. Meetings 2
- *3. Easements* *2*
- *4*~~3~~. Land Surveys .... *3*~~2~~
- *5. Environmental Activities* *4*
- *6*~~4~~. Geotechnical Investigations .... *4*~~2~~
- *7*~~5~~. Interaction with Utility Companies .... *4*~~2~~
- *8*~~6~~. Permits .... *4*~~3~~
- *9*~~7~~. Project Narrative Description .... *5*~~3~~
- *10*~~8~~. Design Memorandum .... *5*~~3~~
- *11*~~9~~. Design Drawings .... *5*~~3~~
- *12*~~10~~. Technical Specifications .... *7*~~5~~
- *13*~~11~~. Cost Estimates .... *8*~~6~~
- *14*~~12~~. Submission of Design Information .... *8*~~7~~
- *15*~~13~~. Reproducibles .... *9*~~7~~
- *16*~~14~~. Electronic Communications .... *9*~~7~~

B. Bidding .... *9*~~7~~
- 1. Reproducibles .... *10*~~8~~
- 2. Preparation of Addenda .... *10*~~8~~
- 3. Plan Holders List .... *10*~~8~~
- 4. Pre-Bid Meeting .... *10*~~8~~
- 5. Distribution of Documents .... *10*~~8~~
- 6. Alternative Bid Evaluation .... *10*~~8~~

C. Construction Administration .... *10*~~9~~
- 1. General Construction Administration .... *11*~~9~~
- 2. Shop Drawings .... *11*~~9~~
- 3. Change Orders .... *11*~~9~~
- 4. Supplemental Working Drawings .... *11*~~9~~
- 5. I&C Engineer Services .... *11*~~9~~
- 6. Start Up .... *11*~~9~~
- 7. Record Drawings .... *11*~~10~~
- 8. O&M Manual .... *12*~~10~~

Page

9. Post Construction Meeting .... *12~~10~~*
10. Six Month Inspection .... *12~~10~~*
11. Affidavit .... *12~~10~~*

II. INFORMATION TO BE SUBMITTED WITH THE PROPOSAL ... *12~~11~~*

1. Design Critique .... *12~~11~~*
2. Fees .... *13~~11~~*
3. Hourly Rates .... *14~~12~~*
4. Estimate of Permitting Related Manhours .... *14~~12~~*
5. Project Understanding .... *14~~12~~*
6. Geotechnical Investigation Estimates .... *15~~13~~*
7. Listing of Drawings and Specifications .... *15~~13~~*
8. Permit Listing .... *15~~13~~*
9. Power Study Software .... *15~~13~~*
10. Survey Staffing Plan .... *15~~13~~*
11. Preliminary Schedule .... *15~~13~~*
12. Identification of Responsibilities and Work History ...... *15~~1~~3*
13. Project Organizational Chart .... *15~~13~~*
14. Resumes .... *16~~14~~*
15. Drafting Standards .... *16~~14~~*
16. Concurrence With Terms .... *16~~14~~*
17. Exceptions .... *16~~14~~*

III. ATTACHMENTS .... *16~~14~~*

A. Design Concept
B. Design Memorandum Requirements
C. American Water Works Service Co., Inc. Standards and Examples
D. Miscellaneous Preliminary Project Information
E. Drawing Standards
F. Agreement for Professional Engineering Services

KENTUCKY-AMERICAN WATER COMPANY
BLUEGRASS WATER PROJECT

REQUEST FOR PROPOSAL

I. SCOPE OF SERVICES

IA. Design

A separate lump sum proposal for project design must include the following services. Coordination and review of the design will be managed by David M. Reves of American Water Works Service Company, Inc., your primary contact throughout the design phase of the project. Any changes in the scope of services during the design phase must be addressed by the Consultant before the work is performed in the form of a Task Order in accordance with Article II of the "Agreement for Engineering Services" found in the Attachments.

1. Preparation and maintenance of a progress schedule throughout the duration of the design contract. The schedule shall be in Gantt chart form and include all work items as defined in this Request for Proposal. At least one week shall be allotted in the schedule for review of information by the Water Company prior to any meeting. The schedule shall compare actual to scheduled activities and be updated monthly once an award of contract is made.

   It is anticipated that a contract for design services will be awarded by April 1, 1998. ~~The final pipeline route information (including field staking, and stray current, wetlands, and archeological investigations and permitting) will be provided by the Water Company in segments as it becomes available beginning at the end of April, 1998 and continuing through the end of July, 1998.~~ The completion of specific design activities must conform with the following schedule:

   October 1, 1998
   - Division of Water (DOW) permit application complete and forwarded to the Water Company for submittal.
   - Booster station design drawings and specifications complete from a hydraulic and process standpoint (i.e. electrical and instrumentation design does not need to be complete).
   - Plan and profile drawings of the entire pipeline route complete.
   - Electronic steady state and surge model results submitted.
   - Interbasin transfer notification made to DOW.

   December 1, 1998
   - DOW permit received.
   - All required permits identified.

- Any required 404 permits for any navigable stream crossings received.

January 15, 1999

- Design complete including incorporation of all comments from the final design review meeting, all remaining permit applications completed and forwarded to the Water Company for filing, and ready to bid.

April 1, 1999

- Bids received.

2. Periodic meetings at the Water Company's main office in Lexington. It is anticipated that seven (7) meetings encompassing a total of ten (10) days will be required including an initial project meeting, a meeting to review the electrical and instrumentation requirements, a meeting to review the design memorandum, an intermediate meeting to review the first draft of design drawings and specifications and to prepare for permit submittals, and a final meeting to review the completed design drawings and specifications and to prepare for the bidding and construction phase of the project. The Consultant's proposal shall include two (2) meetings associated with the design scope of work to be defined as needed.

3. *Easement acquisitions along the entire pipeline route. The minimum activities that are required are as follows:*

   a. *Identification and verification of owners along the pipeline route. This will also include property owners at the proposed booster station and retention basin sites once the optimal locations for these facilities have been identified. This will include research at each county PVA office to determine all corridor owner's names, property and mailing addresses, and Deed Book/Page of Record showing latest transfer, which is to be copied from the County Clerk's office.*

   b. *Identification of any anode beds for the existing gas pipeline and the associated radius of influence. This can be performed in conjunction with the Ductile Iron Pipe Research Association (DIPRA), or you may elect to utilize a consulting corrosion engineer. Along with the stray current evaluation, a soils analysis along the entire pipeline should also be performed to determine external corrosion potential for each of the three potential types of pipeline materials (ductile iron, steel, or concrete). If the proposed pipeline route will cross through the radius of influence of any anode bed, the pipeline will need to either be rerouted, or KAWC will work with the Gas Company to relocate the anode bed. If neither of these are possible, it will be the Consultant's responsibility to design adequate corrosion protection due to stray current. The Consultant shall assume at this time that design of corrosion protection facilities associated with stray current will not be required.*

c. *Development of recordable metes and bounds easement descriptions and drawings including all necessary survey work. The written descriptions shall be incorporated into the Water Company's standard easement document. A scaled drawing shall accompany the description and shall not exceed 8-1/2" x 14" (Note: these are required in addition to the pipeline design drawings in order to expedite the easement process). 30-foot permanent easements are required along with an additional 30-foot temporary construction easement. Amendments that may be necessary as a result of negotiating with the property owners will handled on a time and materials basis.*

d. *Easement centerline staking at 50-foot stations along with all deflection points. Elevations shall also be provided at each stake. Additional elevations shall be taken should the direction of the grade change within the 50-foot interval, or the elevations change significantly within the 50-foot intervals. Your proposal shall assume that the route will only need to be staked once. Additional stakings will be handled on a time and materials basis.*

Direct discussions and negotiations with the property owners are <u>*not*</u> *part of the Consultant's scope of work and will be handled by the Water Company or their designee. Additional information regarding preliminary work that has been completed for the easement activities can be found in the Background section of the Design Concept.*

4~~3~~. Land survey work (including sub aqueous work) as necessary to adequately *obtain easements,* complete the design, file permit applications, and provide reference points for use by the Contractor to layout the work. A topographic (2 foot contours maximum) survey is required at each booster station site, however, property surveys associated with acquisition of the properties will be handled independently by the Water Company. Ground elevations are required every ~~2~~50 feet along the pipe centerline to determine appropriate pipe pressure classes. Additional elevation data (2 foot intervals maximum) is required along the pipe centerline at all locations involving utility, roadway, railway, or waterway crossings, or unique and extraordinary pipeline support. Locations of existing structures and utilities are required at both the booster station sites, the retention basin site, and along the entire pipeline route to the extent of effect on the pipeline installation.

Permanent control establishment is required including the installation, field book references, and GPS control of 54 steel rebars with identifying caps set in concrete. The new control points will be set as intervisible pairs at approximately 2 mile intervals along the proposed pipeline route. All points shall be double-occupied in a GPS control network and tied to six HARN horizontal station, USC&GS bench marks, FEWPB and/or LFUCG control monuments.

All horizontal survey data shall be based on NAD 83, Kentucky State Plane North Zone (US Survey Foot). All vertical survey data shall be based on NAVD 88 (US Survey Foot).

5. All environmental activities as necessary to adequately obtain easements, complete the design, and file permit applications. This will include, but not be limited to, the following:

a. A wetlands delineation along the entire pipeline route including both booster station sites and the retention basin site. The Consultant shall assume at this time that wetland areas will not be encountered or that they can be avoided by rerouting the pipeline. The Consultant shall also assume that development of a wetlands mitigation plan will not be necessary.

b. An Phase I archeological survey along the entire pipeline route including both booster station sites and the retention basin site. The Consultant shall assume at this time that artifacts will not be encountered or that they can be avoided by rerouting the pipeline. The Consultant shall also assume that a Phase II survey will not be necessary.

6~~4~~. All geotechnical investigations including soil borings as necessary to adequately complete the design of the booster stations, retention basin, and any necessary pipeline supports, and allow for accurate estimating of construction earthwork. Rock investigations along the pipeline route to assist the Contractors who will bid on the project are <u>not</u> required *except at locations involving utility, roadway, railway, or waterway crossings, or unique and extraordinary pipeline support.* It will be the responsibility of the Contractors to perform a geophysical investigation and provide unclassified excavation bids *along the remainder of the pipeline.*

7~~5~~. Total interaction with all utility companies to design and specify proper service for the proposed improvements, and to coordinate the relocation of existing utilities as required. The Consultant shall also determine if any additional capital or usage fees will be imposed by any specific utility.

8~~6~~. Determining which Local, State, and Federal permits are required for this project, preparing the necessary applications, providing technical input as required in securing these permits, and attendance at public or private permit related meetings. The Consultant shall also provide the Water Company with information regarding the approximate length of review time for each permit, and any special requirements that could delay this process (e.g., public hearings). The permit applications will be formally submitted and paid for by the Water Company.

Considering the potential number of permits required and the relatively unknown amount of effort needed to secure these permits, all efforts which are directly and solely associated with permitting activities will be handled on a time and materials basis. Any work which is necessary to complete the design which is also required for permitting activities shall be part of your lump sum bid and will <u>not</u> be reimbursed on a time and materials basis. The Consultant shall submit written estimates of costs and the expected scope of work for each individual permit prior to initiating any work related to that permit.

9. Preparation of a narrative description of the operation of the proposed facilities, submitted with the Design Memorandum, including operating details of the control system and the electrical design circuits. The narrative will be used by the Water Company operations personnel to familiarize themselves with the operation, capabilities, and limitations of the proposed improvements.

10. Preparation and maintenance of a Design Memorandum. The Design Memorandum is a summary of design data presented in outline format along with other pertinent project information. The primary intent of the memorandum is to allow the Water Company to review and comment on the design before the Consultant proceeds with detailed design and drafting. The memorandum shall be updated throughout the design and submitted with permit applications as necessary. A summary of the information to be included in the Design Memorandum is outlined in the Attachments.

11. Preparation of design drawings for all disciplines as required to render a complete design including hydraulic profiles (*based on the 50-foot elevation intervals* along the entire pipeline route) and utility connections. Drawings used for permit applications and bidding require the signature and seal of a licensed professional engineer in the Commonwealth of Kentucky. The drawing sets require segregation by major discipline: site, architectural, structural, mechanical, electrical, instrumentation, etc. Drawings shall reflect only the scope of work for the current project and shall not contain extensive notes and written instructions more appropriate for the specifications. Standard detail drawings shall exclude items not applicable to the current project. The title block of each drawing shall include an American Water Works Service Company, Inc. drawing file number. For this project, 380-577-xxx will be the drawing file number with xxx representing the drawing sequence.

The drawings shall be prepared such that Contractor bids can be solicited separately for each of the following portions of the overall scope of work:

a. All work within the property lines at both booster station sites and at the retention basin site, and the required instrumentation work at the Richmond Road Station.

b. All pipeline work outside of the booster station and retention basin sites. It is expected that the Contractors will be given the option within one bid package to bid on any or all of three separate pipeline segments as follows:
   - Beginning at the Jefferson/Shelby County line and terminating approximately half the distance to the intermediate booster station site.
   - Beginning approximately half the distance between the Jefferson/Shelby County line and the intermediate booster station site and terminating at the upstream property line of the intermediate booster station site. This segment

includes the Kentucky River and Glenn's Creek crossings.

- Beginning at the downstream property line of the intermediate booster station site and terminating at the tie in point to the Kentucky-American distribution system.

Pipeline plan drawings are required along the entire route, and shall be prepared as strip maps on aerial photographs *at a scale of 1" = 50' and include centerline staking, easements, and property lines*. The aerial photographs, *which were taken in 1994 and are at a scale of 1" = 350'*, will be provided by the Water Company. Pipeline profile drawings are only required at locations involving utility, roadway, railway, or waterway crossings, or where unique or extraordinary pipeline support is necessary, *and shall be at a scale of 1"=5'*. For the purposes of the proposal, the Consultant shall assume that 10% of the pipeline route will require both plan and profile drawings. *An example pipeline drawing is provided in the Attachments.*

The Consultant shall prepare all drawings using the most current version of AutoCAD for Windows. The Water Company will not accept drawings created using an alternative CAD program, such as MicroStation, which are "converted" to AutoCAD format. The Water Company requires standard fonts, shapes, hatch patterns, line types, etc. compatible with the most current version of AutoCAD for Windows. The Consultant shall use only AutoCAD and AutoLISP routines and no vendor-furnished or third party add-in programs. *Appropriate ground control shall be established by the selected Consultant in order to convert the aerial photographs into AutoCAD format.*

The Attachments include the Water Company's standards for drawing layers, scales, text, and plotting assignments. The Water Company's standards represent the minimum requirements. The Consultant may utilize a more sophisticated set of AutoCAD standards provided it is included with the Consultant's proposal and accepted by the Water Company prior to award of contract.

With each submission of the drawing files, the Consultant shall submit a drawing list with the names of the corresponding external references, layers utilized to create the drawings, and either a plotter pen designation or a .PCP file created within AutoCAD. The consultant also shall "zoom" the drawing files to full extents and use the AutoCAD "purge" command for each submission to the Water Company.

Electrical drafting symbols shall conform to IEEE Standard 315 and 315A. Specific requirements for the design of instrumentation and controls for water treatment processes or water distribution are:

a. Conduct on-site investigations, interface with process engineers/designers, and review design materials and drawings to determine the type and location of primary sensors, control devices, panels and related instruments, and control equipment. The locations and mounting details for these devices shall be included on the drawings.

b. Prepare P&IDs in accordance with ISA Standard S5.1 and RTU interconnection drawings (input/output point lists) from the P&IDs. An example RTU interconnection drawing is provided in the Attachments and an electronic template will be provided to the selected Consultant upon request.

c. Prepare ladder diagrams to show the hard wired logic in panels. Drawings shall be prepared to show the general configuration of all new panels, consoles, and the wiring between interconnected hardware components.

d. Prepare conduit and wiring drawings showing conduit and signal wire routing using scaled drawings of all facilities. Where appropriate, the conduit and wiring drawings shall be integrated into the electrical drawings.

12~~10~~. Preparation of technical specifications, Divisions 2 through 16, in the CSI Spec-Text format and the list of required shop drawings. The Water Company will provide preprinted General Conditions booklets and its Standard Contract Documents and Division 1 General Requirements (excluding the list of shop drawings) in final electronic form for printing, copying, and binding by the Consultant. Specifications shall reflect only the scope of work for the current project. Standard specifications shall be modified to exclude items not applicable to the current project. The specifications shall be prepared such that Contractor bids can be solicited separately as described in the previous section for drawings requirements.

Specifications shall be prepared using the most current version of the 32-bit Lotus Word Pro for Windows word processor. If your standard specifications are in a format other than Lotus Word Pro (such as Corel WordPerfect or Microsoft Word), they must first be converted to Lotus Word Pro format, thoroughly checked to ensure that a complete conversion was accomplished (including all tables, charts, headers, footers, etc.), then edited for this project as appropriate within Lotus Word Pro . The text shall be 12 point Times New Roman font. An 8-digit electronic file name for each specification section shall consist of 3 letters distinguishing the project name preceding a 5-digit specification section number followed by the Lotus Word Pro file extension (.lwp). For example, BWP15115.lwp would identify specification section 15115 for the Bluegrass Water Project.

The American Water System Construction Contract Documents prohibit a Contractor from submitting substitute or "or equal" materials or equipment when a proprietary product, named manufacturer, or supplier has been specified. Provisions exist for bidders to submit alternatives to these items at bid time only. To ensure that competitive pricing is being obtained for material and equipment that is not necessary to be a sole source item, it is required that at least three (3) acceptable manufacturers or products be listed in the specifications for each of these items. If proprietary details have been used on the drawings that are based on one of the listed products, this should be noted in the specifications. Where an item is to be furnished on a sole source basis, only one (1) acceptable manufacturer or product will be listed in the specifications. If common items are included in multiple specification sections, language is to be included in the specifications that the same manufacturer is to be provided for these common products.

In general one of the two specification methods above shall be used for all process, mechanical, and electrical equipment and other materials that are unique to the design (e.g. certain piping, valve, structural, mechanical, electrical and architectural products). Other materials or products that can be specified prescriptively, by performance, or by reference to applicable standards do not need to list specific manufacturers or products unless desired by the Consultant or the Water Company.

The specific requirements for the specifications for the electrical control circuits and the instrumentation and controls for water processes or water distribution are:

a. Prepare specifications for the digital equipment and field and panel mounted instruments.

b. Prepare an input/output point list from the P&IDs.

c. Prepare instrument specification sheets in accordance with ISA Standard S20.

d. Prepare specifications for the software functions including detailed written control strategies (functional descriptions), graphic display descriptions, alarm strategies, historical database trends, and report definition. The Consultant shall interface with the Water Company in developing these software functions. Additional information regarding these items is provided in the Attachments.

e. Provide narrative descriptions of all electrical control circuits. These descriptions shall describe in detail the operation of these circuits in the various operating modes (manual, auto, remote, etc.) and shall provide information relating to the purpose of each device (relays, timers, lights, etc.) included in the circuit.

13~~11~~. Preparation of a preliminary budget construction cost estimate for each of the four (4) potential contracts broken down by major work item, and a detailed construction cost estimate broken down by CSI division and major process components. The preliminary estimates shall be submitted with the Design Memorandum, and the final estimates shall be submitted for the final design review meeting. The preliminary estimates shall be used by the Water Company to evaluate the adequacy of the budget for this project. The final estimates shall be used for evaluation of project costs and subsequent Contractor bids.

14~~12~~. Submission of all final design information at the completion of design which has not been previously submitted. The information shall include all design notes and calculations, the Design Memorandum, drawings, and specifications. Where electronic information exists (drawings, specifications, etc.), it shall be submitted in both electronic format and hard copy. Electronic information, submitted at the end of or during the project, can be forwarded directly by e-mail, on magnetic tape, or on CD.

15~~13~~. Distribution of eight (8) sets of Design Memoranda, drawings, and specifications prior to each design review meeting. Some individuals may prefer to receive certain information in electronic format, and if so, this information will be conveyed to the Consultant prior to making each submittal. All hard copy drawing submittals for review purposes shall be half size.

16~~14~~. Maintaining electronic communication capabilities throughout the design, bidding, and construction phases of the project. American Water Works utilizes both an Internet World Wide Web site and electronic mail to facilitate project communications. Access to the Web and the ability to send and receive e-mail across the Internet is mandatory for this project, as a minimum, for the overall project manager and each design sub-consultant's project manager (does not include survey or soil boring sub-consultants). These electronic communication capabilities shall be in place for each required member of your team prior to the initial design kickoff meeting.

The Web browser that you utilize must be capable of handling file attachments, and your e-mail must be MIME (Multipurpose Internet Mail Extensions) compatible in order to send file attachments without the need to encode/decode. The most current versions of both Microsoft Internet Explorer and Netscape Navigator include these features. Additionally, all electronic data files (word processing documents, spreadsheets, etc.) prepared by American Water Works Service Company will be in 32-bit Lotus SmartSuite 97 format, and the Consultant must have the ability to read these file formats. It is preferred, but not mandatory, that the consultant also create all data files that may need to be shared via the Web or e-mail in 32-bit Lotus SmartSuite 97 format.

IB. <u>Bidding</u>

The bidding phase of the project will begin following incorporation of all comments from the final design review meeting and completion of all permit applications for submittal by the Water Company. A Water Company Construction Engineer will assume responsibility at that time for the bidding phase of the project. The Consultant will report to and receive direction from the designated Construction Engineer for all bidding related activities.

A separate lump sum proposal for project bidding must include the services described below. These services will be required for two separate bid packages, namely 1.) All work within the property lines at both booster station sites and at the retention basin site, and the required instrumentation work at the Richmond Road Station, and 2.) All pipeline work outside of the booster station sites. It is expected that the Contractors will be given the option to bid on any or all of three (3) separate pipeline segments as previously described in the requirements for the preparation of the design drawings and specifications.

1. Provide a total of twenty five (25) sets of contract documents, *for each of the two bid packages,* with drawings on vellum or sepia reproducibles and specifications in loose leafbinders to both Contractors invited to bid on the project and others who will be identified at bid time by the Water Company.

2. Responding to Contractors' or potential Equipment Suppliers' questions and preparation of addenda as required to document design changes or clarifications. Addenda requiring revisions to the technical specifications shall be prepared by direct revision of the specification and re-issuance of the effected pages. Each revised page shall have the following header: "Revised Per Addendum No. ___", and the specific additions and/or deletions shall be highlighted using the revision marking capabilities of Lotus Word Pro and submitted electronically. If additional addenda are required, the information from the previous addendum shall be incorporated into the specifications (without highlighting) and only the new information shall be highlighted. Addenda requiring drawing revisions shall be made by direct revision and re-issuance of the electronic copy of the effected drawings unless otherwise approved by the Construction Engineer. The use of words in an addendum to revise drawings is strictly prohibited. If time does not allow for drawing revisions, the Construction Engineer may allow supplemental sketches to depict drawing revisions. Drawing revisions shall be clearly marked or highlighted. As additional addenda are required, only the current changes shall be marked or highlighted.

3. Maintain the official plan holders list.

4. Attendance of the Design Project Manager/Engineer at a pre-bid meeting. The Design Project Manager/Engineer shall be thoroughly familiar with the design and be prepared to explain the technical aspects of the project and respond to questions from attendees.

5. Provide the list of bidders to potential equipment suppliers and construction information services as requested. Drawings and specifications, excluding sets provided at no cost to all listed bidders, will be purchased through the Consultant.

6. Provide a written evaluation of all alternative equipment offered by the bidding Contractors as to whether each alternative satisfies the design requirements of the project, and based on objective and/or subjective criteria, provide a recommendation as to the acceptability of each alternative submitted.

IC. Construction Administration

Following receipt of bids and all permits, the Water Company will file for a Certificate of Convenience and Necessity for which approval from the Kentucky Public Service Commission is needed before construction could begin. It is expected that project construction would begin in a time period between September, 1999 and January, 2000. Overall construction management of the project will be handled by the designated Water Company Construction

Engineer which will include all direct dealings with the Contractors. The Consultant will be part of the construction management team and will report directly to the designated Construction Engineer. All contact on the project, including submittal of invoices for professional services, would also be through the designated Construction Engineer.

A separate lump sum proposal for construction administration must include the following services for an assumed eighteen (18) month period. The Consultant shall assume at this time that there will be three (3) separate pipeline contracts and one (1) booster station contract encompassing both booster stations, the retention basin, and the instrumentation work at the Richmond Road Station.

1. General construction administration, including attendance at monthly construction meetings, resolution of construction problems related to the design, and review and interpretation of the design.

2. Shop drawing review and approvals including review and approval of resubmittals. Maintenance of a shop drawing log indicating dates received and returned and status is also required.

3. Review of Contractor pricing of change orders and written recommendation to the Water Company of the reasonableness of the cost. Drawing and/or specification revisions required for change orders shall meet the same criteria as described above for preparation of addenda during the bid phase, including submittal in electronic format.

4. Preparation of supplementary detailed working drawings, specifications, and written instructions or meetings as necessary throughout the construction period to interpret the contract plans and documents and resolve changes brought about by actual field conditions encountered.

5. Services of the I&C Staff Engineer or Sub-Consultant to attend an instrumentation and control "kick-off meeting" and witness an on-site factory acceptance test of the assembled I&C system at the booster station. Additionally, provide the services of the I&C Staff Engineer for site visits to review and inspect the instrumentation and wiring of field mounted instruments, resolution of problems, initial calibration and testing, and system startup.

6. Services of the Design Project Manager/Engineer who will participate in and observe initial operation of the project (startup) and review operation and performance tests required by the contract specifications. At least three (3) trips totaling six (6) days should be allotted for on-site startup services and resolution of initial operating problems associated with the booster station contract. Engineers from all of the engineering disciplines shall be made available to resolve startup issues as required, and also to resolve problems which may arise during the construction period. The Design Project Manager/Engineer will assist the Resident Project Representative in the preparation of the punch list and recommend acceptance of the facilities by the Water Company.

7. Preparation and submittal of electronic record drawings within two (2) months after startup. The drawing files shall meet the requirements for submission of design information previously outlined in this document. Data, information, sketches and working drawings, to be incorporated with the record drawings, shall be provided by the Resident Project Representative. The record drawings shall include all above and below grade changes from the original design drawings for all engineering disciplines. Changes made to reflect the as-installed conditions shall be made in the same level of detail and to the same degree of drafting quality as the original design drawings.

8. Six (6) copies of an operation and maintenance manual containing operating, maintenance, and repair information from manufacturer's submittals. The O&M manual shall also contain the final narrative description of the operation of the proposed facility, and a complete description of startup and shut-down procedures. The O&M manual shall be bound in 3-ring binders and indexed with tabs according to major process designations in the order of the treatment process. An initial draft of the O&M manual, without manufacturer's data, shall be submitted for review at approximately the 50% point of construction completion. The complete O&M manual containing all manufacturer's data shall be submitted at the 95% point of construction completion but no later than one (1) month before scheduled startup.

9. Services of the Design Project Manager/Engineer to attend a one (1) day post-construction meeting at each booster station site immediately following demobilization by each contractor.

10. Services of the Design Project Manager/Engineer for a one (1) day inspection of all the facilities approximately six (6) months after they are all placed into operation.

11. An affidavit confirming the construction of the facility is in accordance with the approved plans and specifications, when required by regulation.

Your construction supervision proposal shall be prepared with the understanding that the services of Resident Project Representatives (inspectors) from your firm will be requested at the time of construction. A separate Request for Proposal for these services will be issued by the Water Company once the Certificate of Convenience and Necessity is received. These fees for Resident Project Representatives are <u>not</u> to be included in your current proposal for this project.

II. INFORMATION TO BE SUBMITTED WITH THE PROPOSAL

The following minimum information must be submitted with your proposal for it to be accepted:

1. A brief critique of the design concept to determine what modifications to the concept may result in a more cost effective project, simplified construction, and/or improved operating procedures. <u>Although this is not required as part of your proposal, selection of</u>

a Consultant will be weighted heavily on any alternate ideas or concepts that are proposed which are deemed to be appropriate and feasible. For each item you may choose to critique, the following information must be provided:

a. A detailed description of the item.

b. A comparison of the item to that proposed in the attached Design Concept highlighting non-cost advantages or disadvantages, if any.

c. An estimate of the proposed construction cost savings. The estimated savings must by justified by comparing the critiqued item to the proposed item with one or more of the following.

- a budgetary cost estimate.
- actual cost information from previous projects.
- manufacturer or contractor quotations.

d. An estimate of any potential operational cost savings. The estimated savings must by justified by a detailed cost analysis comparing the critiqued item to the proposed item. Additionally, if any proposed capital cost savings will result in additional operational costs, these added operational costs must also be identified.

2. Separate lump sum fees for design, bidding, and construction services. The Consultant's lump sum fee shall assume that 10% of the pipeline route will require both plan and profile drawings. Fees for construction services shall *be based on current 1998 rates. These rates shall be renegotiated at the time of* ~~reflect the~~ expected construction ~~time period~~ (beginning between September 1999 and January 2000, and ending between March 2001 and June 2001). Also provide itemized lump sum fee adjustments (+/-) for:

a. Any critiqued items offered if the associated design, bidding, or construction fees will be different from that in your base lump sum fees.

b. A separate unit cost for attendance at each construction meeting additional to that specified in the Scope of Services required for construction administration.

c. Engineering costs per *drawing*~~horizontal foot~~ for differences in the assumed 10% of the horizontal pipeline length (27,700 ft) that will require both plan and profile drawings if the total horizontal length of the pipeline does not change. For example, if the actual horizontal length requiring plan and profile drawings changes to 30,000 or 25,000 feet, without changing the total length of the pipeline, your add/deduct would be $____ per *drawing*~~horizontal ft~~.

d. Engineering costs per *drawing*~~horizontal foot~~ for differences in the total estimated horizontal pipeline length (277,000 ft). For example, if 10,000 horizontal feet of pipeline length, which would require only plan drawings, is added or deducted from the project, your add/deduct would be $____ per *drawing*~~horizontal feet~~. If 10,000 horizontal feet of pipeline length, which would require both plan and profile drawings, is added or deducted from the project, your add/deduct would be $____ per *drawing*~~horizontal feet~~.

e. *Restaking costs per stake (stakes are required every 50 feet) should restaking of portions of the pipeline become necessary.*

f. *Additional costs to re-photograph the entire pipeline route. If this is desired by the Water Company, notice to proceed to perform this activity will be given at the time of award of contract on April 1, 1998.*

Fees associated with the Preliminary Engineering Studies discussed in the Design Concept shall not be included in your design lump sump fee but shall instead be provided as one (1) separate lump sum fee encompassing *all three*~~both~~ studies.

3. Supplemental hourly rates for staff members by discipline (in 1998 rates) which would be applicable to determine adequate compensation for changes in the scope of work. Additionally, provide specific hourly rates for all permitting related activities. Rates should be provided for various levels of expertise (junior, mid-level, senior, etc.). Expenses will be reimbursed directly with appropriate documentation.

4. Your estimate of the total number of man hours that are expected to be expended for all permitting related activities. The Water Company reserves the right to request lump sum fees for these activities should it be possible to define a firm scope of work at a later date.

5. Your understanding of the scope of work conveyed by way of the following minimum information:

   a. Preliminary, rough sketches of each booster station layout and the retention basin site.

   ~~b. One (1) representative example pipeline drawing (plan and profile) reflecting the specific requirements of this document.~~

   b~~c~~. Preliminary, rough sketches showing the Kentucky River crossing and 1,000 feet of pipeline both upstream and downstream demonstrating your expected design approach and method of construction in this area (profiles supplemented with plans if necessary). Please note that receipt of the permit for this crossing is required by December 1, 1998.

   c~~d~~. A typical air valve manhole detail.

Sketches submitted with the proposal shall be no larger than 11" x 17". It is acceptable and encouraged to provide supplementary text with any of the above to assist in demonstrating your understanding of the required scope of work.

6. The anticipated scope of geotechnical exploration including number and depth of all soil borings.

7. A listing of drawings and specifications required for this project, with titles for each drawing.

8. A listing of all expected Federal, State, and local permits required for design, construction, and operation of the proposed facility. The listing must state the name of the permit, the respective regulatory agency or municipality, a brief description of the purpose of the permit, and the typical or legal review time required by each respective agency.

9. Identification of the power study software that will be utilized on this project per the requirements of the Electrical section of the Design Scope.

10. A brief but specific description of how you plan to accomplish the requested survey activities on this project. Include method of survey and staffing requirements as a minimum.

11. A preliminary schedule from date of award in Gantt chart form. If the time of completion desired by the Water Company is not acceptable, it shall be explicitly stated in the proposal. The schedule shall reflect the requirements previously requested for monthly schedule updates.

12. Identification of each consulting firm that is part of your team, a description of that firm's specific responsibilities on this project, and a company work history of recent projects for each Consultant which is reflective of the specific scope of work they will be performing. This is required for both the primary Design Consultants on your team as well as survey, soils, and any other Sub-Consultants. A minimum of three (3) and a maximum of five (5) references are required including a specific contact person and a phone number.

13. A project team organizational chart headed up by the primary design project manager and including all other personnel who are expected to be directly associated with this project. Your primary project manager shall be the Water Company's direct contact throughout the design and bidding phases for all aspects of the project. It is not acceptable to name several primary project managers (points of contact) for various portions of the design work from various consulting firms. The project manager shall be fully capable of discussing all technical and administrative aspects of the project. It is acceptable to name a second project manager and different project team members for the construction phase of the project, and if so, this information shall also be provided with your proposal. For each individual named in your organizational chart(s), also include

the name of the company they are affiliated with.

14. Résumés and a work experience history of each individual identified in the project team organizational chart(s). The résumé of the proposed project manager is of particular importance and must demonstrate their experience in project management as well as design of potable water pumping and piping systems. The resume of your hydraulic engineer must show experience in utilizing both the University of Kentucky KYPIPE and SURGE hydraulic models. The resume of the individual who will perform the finite element analyses specified in the Design Concept is also of particular importance.

15. Specifics of your drafting standards if they are more sophisticated than the Water Company's minimum requirements.

16. Concurrence that you have read the Agreement for Engineering Services in the Attachments and are prepared to sign this contract should your proposal be accepted by the Water Company.

17. Specifics of any exceptions which are taken to items requested in this document. If no exceptions are taken, it is not necessary to reiterate the information presented in the Scope of Services Required.

III. ATTACHMENTS

See Below.

ATTACHMENT A

Design Concept

KENTUCKY-AMERICAN WATER COMPANY
BLUEGRASS WATER PROJECT

DESIGN CONCEPT

I. BACKGROUND

Kentucky-American Water Company (KAWC) provides potable water service to over 90,000 customers and nearly 250,000 people in seven communities within central Kentucky. The primary source of supply for KAWC is the Kentucky River which is supplemented by Jacobson Reservoir. Two surface water treatment plants process and distribute finished water through over 1,200 miles of main. The larger of the two plants is referred to as the Kentucky River Station (KRS) and has a rated capacity of 40.0 MGD. The second treatment plant is referred to as the Richmond Road Station (RRS) and has a rated capacity of 25.0 MGD.

In 1988, extremely dry weather produced very low flows in the Kentucky River during the early summer months which dramatically emphasized the need to supplement existing sources of supply. Peak day demands during that period also exceeded the combined rated capacity of the two existing treatment plants at that time. Since 1988, a number of alternate source, production, and conservation measures have been extensively evaluated. Ultimately, on August 21, 1997, the Kentucky Public Service Commission ordered KAWC to "take the necessary and appropriate measures to obtain sources of supply so that the quantity and quality of water delivered to its distribution system shall be sufficient to adequately, dependably, and safely supply the total reasonable requirements of its customers under maximum consumption through the year 2020".

Based on the numerous alternatives which have been evaluated over the past ten years to resolve the source of supply and production deficits, KAWC has concluded that purchasing finished water from the Louisville Water Company (LWC) is the best and most economical solution. LWC currently has adequate source and treatment capacity to meet the KAWC projected deficits, and only distribution system improvements would be required within the existing LWC system. KAWC's responsibility, which encompasses the scope of work for this project, would consist of approximately 52.5 horizontal miles of 36-inch pipe beginning near the Jefferson/Shelby County line which is capable of transferring a maximum of 23.0 MGD from the LWC distribution system to the KAWC distribution system. Two booster stations would also be required to convey the water at safe operating pressures along with a retention basin to aid in the flushing of the pipeline as necessary.

LWC's responsibilities, which will basically include piping improvements within their system, will be administered separately by LWC and are not a part of the scope of work associated with this Request for Proposal. However, a surge analysis of the proposed pipeline, including the pipeline within Jefferson County, is part of the Design Scope of work associated with this RFP as described subsequently in this document.

All background information related to this project, including existing or historical data, and preliminary efforts which have been initiated or completed to date, are presented below to assist the Consultant in preparing a proposal and completing the detailed design:

1. LWC Pipeline Route - LWC's existing 10 MG English Station tank will set the gradient for the proposed pipeline. The tank is located approximately 6 miles west of the Jefferson/Shelby County line just off of US 60. LWC's pipeline through Jefferson County, which is not a part of the design scope of work for this project, is generally expected to follow US 60 for approximately 3-1/2 miles, then parallel an existing railroad track to the Jefferson/Shelby County line. LWC's pipeline will continue past the county line for approximately 0.4 miles to the first KAWC booster station located near I-64. LWC's responsibilities will end at this first booster station. The booster station itself, as well as all other piping and pumping facilities from this point into Lexington, are the responsibility of KAWC and are a part of the Consultant's Design Scope of work associated with this RFP as described subsequently in this document. LWC's expected pipeline route is shown on U.S.G.S. map sections for Jeffersontown and Fisherville which can be found in the Attachments.

2. KAWC Pipeline Route - A route evaluation was initially performed in 1990, and the current tentative route is shown on the U.S.G.S. map sections in the Attachments. At this time, it is expected that the proposed KAWC pipeline will begin near I-64 approximately 0.2 miles east of the Jefferson/Shelby County line where the first booster station will be located. The pipeline will travel south easterly, for approximately 1 mile where it will begin to parallel an existing gas transmission main across Shelby and Franklin Counties. The pipeline will then cross the Kentucky River into Woodford County, deviate from the parallel gas main route for a short distance to avoid a plateau, then continue to parallel the gas transmission main up to Route 60. At this point, the pipeline will travel northeast and parallel an existing overhead power line until reaching US 421 (Leestown Road). The main will head east along US 421, cross into Fayette County, continue to follow US 421, and connect with the KAWC distribution system at Route 4 (New Circle Road). A map of the KAWC distribution system in the area of the proposed tie in is also provided in the Attachments.

   The total horizontal length of the pipeline is approximately 277,000 feet (52.5 miles). Eleven U.S.G.S. quad maps encompass the pipeline route including Fisherville, Simpsonvile, Shelbyville, Waddy, Frankfort West, Lawrenceburg, Tyrone, Versailles, Midway, Georgetown, and Lexington West, KY. Aerial photographs of the pipeline route are available for inspection at the KAWC main office, and will be provided to the selected Consultant.

3. Easements - *Identification of all property owners in Shelby and Franklin counties only has been completed (per the requirements of Item 3a in the RFP). This information will be provided to the selected Consultant.* ~~The Water Company has retained a pipeline Easement Consultant who will provide a metes and bounds description, centerline staking every 50 feet, and projection of the metes and bounds on existing aerial maps. The~~

~~Easement Consultant's scope of work will also include the following:~~

~~a. Identification of any anode beds for the existing gas pipeline and the associated radius of influence. This will be performed in conjunction with the Ductile Iron Pipe Research Association (DIPRA). If the proposed pipeline route will cross through the radius of influence of any anode bed, it is the Easement Consultant's responsibility to either reroute the pipeline, or work with KAWC and the Gas Company to relocate the anode bed. If neither of these are possible, it will be the Design Consultant's responsibility to design adequate corrosion protection due to stray current. The Design Consultant shall assume at this time that design of corrosion protection facilities associated with stray current will not be required.~~

~~b. A wetlands delineation along the entire pipeline route (including both booster station sites and the retention basin site), development of a mitigation plan, and preparation of applicable permits associated with wetlands as needed.~~

~~c. An archeological survey along the entire pipeline route (including both booster station sites and the retention basin site). This includes both a Phase I and Phase II assessment as necessary. Again, the Easement Consultant will attempt to reroute the pipeline to avoid areas which would require a Phase II assessment.~~

~~The centerline staking is expected to begin at the end of April, 1998 and be complete by the end of July, 1998. It should be noted that other factors beside those listed above may result in the need to reroute sections of the pipeline. The Consultant's proposal shall be based on the current expected route, and a change to this route which effects the scope of work may be just cause for renegotiation of fees.~~

4. Deficits - The projected peak day demand and source of supply deficits are presented below. No water sales along the pipeline route have been formalized at this time, and reserve capacity in the pipeline is not required. Water from the pipeline to meet the projected peak day demands per the schedule below is expected to be required for no more than a 5-15 day period during the summer months. Water from the pipeline to meet projected source of supply deficits is only expected to be required should a drought of record occur during the respective year. If the drought of record would occur, the source of supply requirements presented below would be needed over an approximate 183-day period.

Year	**Peak Day Demand Deficit (MGD)**	**Source of Supply Deficit (MGD)**
2000	7.73	14
2005	11.24	16
2010	**14.76**	**19**
2015	18.02	21
2020	21.28	23

The design scope of work associated with this project will be based on year 2010 deficits (with the exception of chemical storage) with consideration to facilitate expansion to meet year 2020 deficits. Additionally, where future expansion would significantly disrupt operations or not make economic sense, the design of those components in the proposed facilities shall be based on year 2020 deficits as discussed further in the Design Scope. Since the peak day and source of supply deficits are infrequent occurrences, flow in the pipeline will be driven the majority of the time by water quality concerns. This would include the need to maintain adequate flows to ensure adequate water quality while minimizing purchased water costs. It may also include the ability to occasionally flush the line at maximum rates. Additional discussion regarding the need to maintain adequate water quality in the pipeline is presented in subsequent sections.

5. Pipeline Sizing - Based on the ultimate source of supply deficit of 23.0 MGD, the proposed pipeline has been sized at 36-inch. This results in a velocity of 5.0 ft/sec at 23 MGD which is generally the desired limit in terms of surge control. Since the typical daily flow in the pipeline will be driven by the need to maintain adequate water quality, increasing the size of the pipeline beyond 36-inch is not desired as any operational savings resulting from lower pressures will be more than offset by the additional capital and purchased water costs (i.e. a higher minimum flow rate would be needed to maintain adequate water quality in a larger diameter pipeline).

6. Water Quality Compatibility - Typical finished water quality data for both the KAWC and LWC systems is presented below and reflects what can be expected at the extremes of each respective distribution system. This data has been extensively evaluated in terms of the concerns associated with the blending of the two waters as well as in terms of the ability to maintain adequate disinfectant residual in the proposed pipeline and avoiding nitrification. These evaluations have included both discussions with chemical suppliers as well as laboratory jar testing. In general, the two waters are relatively compatible.

		Kentucky-American			Louisville Water Company		
Parameter	**Units**	**min**	**avg**	**max**	**min**	**avg**	**max**
pH	units	7.2	7.3	7.5	6.9	8.4	8.9
Alkalinity	mg/L	40	69	88	36	84	100
Hardness (as $CaCO_3$)	mg/L	120	156	238	94	163	220
Orthophosphate	mg/L	0.61	0.98	1.40	< 0.1	< 0.1	< 0.1
Total Chlorine Residual	mg/L	1.5	1.7	2.1	2.1	2.6	3.4
Free Chlorine Residual	mg/L	0.0	0.0	0.0	< 0.05	< 0.05	< 0.05
Free Ammonia	mg/L	0.04	0.08	0.12	0.04	0.43	0.56
Nitrite	mg/L	<0.002	<0.002	<0.002	< 0.1	< 0.1	< 0.1
Zinc	mg/L	0.128	0.168	0.186	0.2	0.2	0.2

KAWC has concluded that the blending of the two water would result in the loss of a phosphate residual and precipitation of zinc. To alleviate this concern, it is first recommended that the zinc orthophosphate corrosion inhibitor currently utilized by KAWC be replaced with a non-zinc phosphate inhibitor (Calgon C-4 or comparable). Feed capabilities should then be provided at the beginning of the proposed pipeline at the first booster station to stabilize the water and prevent calcium carbonate deposition. This inhibitor will work well at the higher pH levels and also alleviate concerns with zinc residuals in waste streams.

In terms of maintaining adequate disinfectant residual in the pipeline, KAWC has performed a series of jar tests with LWC water to determine chloramine decay under simulated storage tank and pipeline scenarios. The results are shown below:

Total Chlorine (mg/L)	**Warm Temperature, Covered, Slow Stir (Simulated Tank)**	**Cold Temperature, Covered, Slow Stir (Simulated Pipeline)**
Day 1	2.50	2.70
Day 2	2.30	2.70
Day 3	2.30	2.50
Day 4	unavailable	unavailable
Day 5	2.10	2.30
Day 6	1.85	2.20
Day 7	1.80	2.15
Day 8	1.70	2.10
Day 9	1.60	2.10

KAWC desires to maintain a 2.0 mg/L chloramine residual at the tie in point to the existing KAWC distribution system. It is expected that the chlorine demand in the pipeline itself will result in lower residuals than those provided in the table above. However, based on the table above, the LWC minimum total chlorine levels in the table in Item 6, and the fact that there will be no storage tanks along the pipeline route, the ability to maintain adequate chloramine residual is not expected to be a problem provided that adequate chlorine and ammonia feed capabilities are provided at the first booster station.

The practice of chloramination, however, coupled with the potential long detention times (in both the proposed pipeline and in the LWC distribution system), conducive temperatures for potentially 6 months of the year, and alkaline pH conditions, will accelerate the growth of nitrifying bacteria (nitrification). Published studies within the industry, have shown that nitrification will typically begin to occur after 7-8 days in stagnant warm water tanks. Both KAWC and LWC adequately control the free ammonia levels in their respective waters such that nitrification currently isn't a problem in either distribution system. However, the increased detention time in the proposed pipeline creates a potential concern from a nitrification standpoint which will need to be addressed in terms of minimum flow rates as discussed below.

7. Minimum Flow Requirements - Since the need for flow from the pipeline to meet projected peak demand and source of supply deficits is infrequent, typical flows will be driven by the need to maintain adequate water quality. Keeping the pipeline out of service (either full or empty) and putting it into service as needed is not an option due to a number of water quality, cost, operational, and time concerns. Thus, it will be

necessary to maintain a minimal flow through the pipeline to ensure adequate water quality. Since the cost of purchased water from LWC will be higher than the cost for KAWC to produce water, it is important that these flow rates necessary to maintain adequate water quality be minimized.

The two primary water quality concerns when attempting to minimize the flow rates are chloramine residual and nitrification. As shown above, chloramines can persist in the water for extended times even at high temperatures. Coupled with the fact that re-chloramination capabilities along the pipeline will be provided, maintaining an adequate disinfectant residual is not expected to be a problem.

The maximum detention time through the LWC system to the English Station is estimated to be 2 days. At a flow rate of 3.2 MGD, an approximate 0.5 days of detention time will exist between the English Station tank and the first booster station near the Jefferson/Shelby County line. An additional 4.5 days of detention time would exist in the proposed pipeline bringing the total detention time to approximately 7 days. Considering some detention time in the KAWC distribution system, the total detention time at approximately 3.2 MGD should not exceed 8 days. Although this does not take into account the fact that the water will be cooler in the pipeline underground, it is still expected to be the minimum flow rate in the pipeline during warm weather months. It is also expected that this flow rate can halved to approximately 1.6 MGD in cold weather months resulting in nearly 9 days of detention time in the pipeline alone. Thus, the daily flow rate to maintain adequate water quality is expected to average 2.4 MGD over an entire year.

Only actual operations of the pipeline will confirm the required minimum flow rates, however, the above numbers will dictate the minimum pumping requirements for the proposed facilities. In order to further minimize the potential for nitrification in the pipeline, breakpoint chlorination and/or the ability to maintain a higher chloramine residual must be possible with the proposed facilities. Specific details of this as well as the pumping requirements are presented subsequently in the Design Scope.

8. <u>KAWC Distribution System Analyses</u> - A hydraulic analyses of the KAWC existing distribution system has been completed in relation to the proposed pipeline. KAWC has determined that a gradient of 1170 at 23.0 MGD down to 1130 at 1.6 MGD will required to adequately distribute the water from the pipeline into the distribution system. This gradient is at the tie in point at Route 4 (New Circle Road).

   The KAWC distribution system was also analyzed in terms of generating flow backwards through the pipeline for flushing purposes. Since the Kentucky River is the only location that would be able to accept flow rates up to 23 MGD (confirmed by KAWC with the Division of Water), the last 1/3 of the pipeline would need to be flushed backward towards the Kentucky River. KAWC's analysis has shown that rates up to 10 MGD could be generated which would result in velocities of 2.2 ft/sec. Although this is not an ideal scouring velocity, it is generally expected to be adequate.

9. LWC Pipeline Hydraulics - American Water Works Service Company has performed a brief steady state hydraulic analysis of the LWC system to determine if flow by gravity from the English Station Tank past the Jefferson/Shelby county line would be possible. This consisted of identifying approximate elevations along the pipeline route every 5,000 feet and at select high and low points. The following criteria and assumptions are included in the analysis.

a. The pipe diameter is 36-inch and the overall C-factor for the entire system is 130.
b. The minimum desired operating pressure at any point in the pipeline is 20 psi.
c. The English Station Tank minimum water level is at elevation 830.
d. The English Station Tank overflow water level is at elevation 864.
e. The LWC pipeline terminates at the first KAWC booster station at I-64.

The spreadsheets in the Attachments are summarized as follows:

Pg. 1 This scenario shows the pipeline operating at the ultimate capacity (23.0 MGD) with the English Station Tank at its minimum level. Pressures at the high point are marginally acceptable.

Pg. 2 This scenario is the same as the previous scenario except that the English Station Tank level is at overflow. Pressures throughout the pipeline are acceptable.

Pg. 3 This scenario shows the pipeline operating at the absolute minimum expected flow rate (1.6 MGD) with the English Station Tank at its minimum level. Pressures at the high point are again marginally acceptable, primarily as a result of elevation and not friction loss.

Pg. 4 This scenario is the same as the previous scenario except that the English Station Tank level is at overflow. Pressures throughout the pipeline are acceptable.

LWC is currently further evaluating this proposed pipeline route within their system, but are in agreement at this time that the route is feasible. Their detailed analysis may result in modifications to the proposed route to avoid the high points where low pressures occur.

10. KAWC Pipeline Hydraulics - The results of a very rough preliminary steady state hydraulic analysis of the KAWC pipeline is included in the Attachments in the form of six spreadsheets. This again consisted of identifying approximate elevations along the pipeline route (every 5,000 feet and at select high and low points), and determining the number of booster stations required and the necessary pipe pressure class for maximum and minimum flow scenarios. The following criteria and assumptions are included in the analysis:

a. The pipe diameter is 36-inch and the overall C-factor for the entire system is 130. A 36-inch pipeline will keep velocities at 5.0 ft/sec at 23 MGD. Over sizing the pipeline is not recommended as it would result in higher minimum flow rates to maintain water quality.

b. The maximum desired operating pressure at any point in the pipeline is 300 psi. The typical daily operating pressure is desired to remain below 200 psi.

c. The minimum desired operating pressure at any point in the pipeline is 40 psi.

d. The selected pipe pressure class (assuming DIP) is one pressure class above that required to account for the margin of error in a USGS map and to provide a reasonable factor of safety. It is desired to stay below a 350 psi pressure class rating which is the normal maximum pressure class manufactured.

e. The gradient at the KAWC system is 1170 at maximum capacity and 1130 at minimum capacity.

f. If boosters in series are required, the flow rate will be controlled by a variable speed pump or a rate of flow control valve at each booster. No storage tanks are desired at any intermediate boosters as this would increase the detention time.

The spreadsheets in the Attachments are summarized as follows:

Pg. 1 This scenario shows the pipeline operating at the ultimate capacity (23.0 MGD) requiring two booster stations. Locating the second booster station just downstream of the Kentucky River and Glenn's Creek results in acceptable pressures at these low points in the pipeline. The critical pressure points are the discharge of the first booster station and a low point just downstream of the second booster station. Maintaining the minimum desired pressure of 40 psi at all points in the pipeline requires that the pressure at the suction of the second booster station be maintained slightly higher than 40 psi.

Pg. 2 This scenario is basically the same as the previous scenario except that the flow rate is 19.0 MGD which reflects the current design criteria. Except for lower pressures, the operating conditions remain the same.

Pg. 3 This scenario shows the pipeline operating at the absolute minimum expected flow rate (1.6 MGD) in a two lift scenario. The critical pressure in the first gradient moves from the discharge of the first booster to the Kentucky River crossing while the critical pressure in the second gradient remains just downstream of the second booster. Maintaining the minimum desired pressure of 40 psi at all points in the pipeline requires that the pressure at the suction of the second booster station be maintained at 74 psi or higher.

Pg. 4 This scenario is basically the same as the previous scenario except that the flow rate is 6.0 MGD. Assuming that primary and backup 3.2 MGD pumps were provided to meet the flow rate expected to maintain water quality, the 6.0 MGD rate would reflect the approximate combined output if both 3.2 MGD pumps were operated in parallel. This scenario could occur if actual operations prove that 3.2 MGD is not adequate to maintain proper water quality in warm weather conditions. Except for slightly higher pressures, the operating conditions remain the same.

Pg. 5 This scenario shows the pipeline operating at the absolute minimum expected flow rate (1.6 MGD) in a single lift scenario. The critical pressure is located at the Kentucky River crossing and significantly exceeds the daily desired maximum operating pressure of 200 psi and is approaching the absolute maximum desired pressure of 300 psi.

Pg. 6 This scenario is basically the same as the previous scenario except that the flow rate is 6.0 MGD. Again, the critical pressure is located at the Kentucky River crossing and remains just under 300 psi.

Based on the above, two booster stations are adequate even at 23.0 MGD. At the daily low flow rates, the Water Company desires to also utilize a two lift scenario to minimize daily operating pressures. Specific details of the pumping unit requirements are presented subsequently in the Design Scope.

11. Land - Three parcels of land are required for this project for the first booster station, the second booster station, and a retention basin to accept flushing water prior to ultimate disposal to the Kentucky River. Identification of potential properties is currently under way by the Water Company to confirm that adequate land is available. A minimum of 1.5 acres is being sought for the first booster station with easy access from I-64. Chemical shipments will need to be received at this location. A minimum of 1.0 acres downstream of Glenn's Creek is desired for the second booster station which will not include any chemical feed systems. A minimum of 3.0 acres is desired for a retention basin just downstream of the Kentucky River. The general areas of the three parcels of land are shown on the USGS map sections in the Attachments. The exact locations of these sites cannot be finalized until topographical data is available along the entire pipeline route such that the booster station locations can be hydraulically optimized.

12. Discussions with the Power Company - Preliminary contact has been made with both Louisville Gas & Electric (LG&E) and Kentucky Utilities (KU) regarding electric service to each of the proposed booster station sites. The LG&E contact (first booster) is Mr. David Hasch (502-429-7809) and the KU contact is Mr. Tim Smith (606-873-3146). Both contacts have indicated that electric service is currently not available at the proposed sites, and that the initial capital costs would be high. The information presented in the Design Scope reflects this, and also considers that the ratio of average usage to peak usage would be high (2.4 MGD to 23.0 MGD).

13. RRS SCADA System - Distributed Control Systems are currently in use at each of the two existing KAWC treatment plants. The systems are not in any way linked to each other. Control and monitoring for the proposed booster stations will be accomplished from the Richmond Road Station. The DCS at this location consists of Bristol Babcock Series 3300 products running ACCOL control software and Genesis for DOS at the operator workstations. The system also includes redundant data concentrators.

Additional detail regarding the control and monitoring requirements is presented subsequently in the Design Scope.

14. Construction Cost - The Water Company's estimated construction cost for this project (contractor bid price + any utility capital fees) is $35,500,000.

II. DESIGN SCOPE

The Consultant shall proceed with the design of the necessary facilities based on the background information outlined above and the following design information. As the detailed design progresses and additional information becomes available, it may become necessary to modify this Design Scope, and the Consultant is responsible for bringing this to the Water Company's attention. The information provided below is broken down into sub-sections for each of the major facility components.

In general, the design scope of work shall include a transmission main between the LWC and KAWC distribution systems, one booster station near the Jefferson/Shelby County line (Booster Station No. 1), one booster station just downstream of the Glenn's Creek (Booster Station No. 2), an earthen retention basin just downstream of the Kentucky River to facilitate flushing of the pipeline, and improvements to the existing distributed control system at the RRS to allow for remote monitoring and control of the proposed facilities. The design of all facilities through Jefferson County and up to the property line of the first booster station is the responsibility of the LWC and is not encompassed within this Design Scope, with the exception of minor monitoring requirements and a steady state hydraulic and surge analysis as discussed further below.

A. GENERAL

MODELING

1. **Steady State Hydraulic Model**: The Consultant is required to develop a steady state hydraulic model of the entire piping/pumping system utilizing the University of Kentucky's KYPIPE software. The limits of the model shall be the LWC English Station storage tank and a point within the existing KAWC distribution system to be determined by the Consultant. All storage within the existing KAWC distribution system in the area of the proposed tie in is pumped storage. The nearest floating storage tank is approximately 10 miles from the proposed tie in point. LWC will be responsible for providing data (elevations, sizes, materials, etc.) for their portion of the pipeline up to the first booster station.
2. **Surge Model**: The Consultant shall perform a complete surge analysis of the entire system utilizing the University of Kentucky SURGE 5 software. The system shall be analyzed for both normal start/stop and power failure scenarios. The facilities which are expected to be needed for surge control within the KAWC section of the pipeline (one way surge tanks at each booster station) are identified further below and should be reflected in the Consultant's proposal. The

modeling shall also be performed in an assumed scenario where the surge tanks were out of service to determine the maximum flow rate that would be possible during this period in a power failure scenario. Since flow could also be generated backwards in the pipeline to the Kentucky River for flushing, this scenario shall also be analyzed. Any physical improvements or facilities required within the LWC system which are identified by the model are the design and construction responsibility of LWC.

ACCEPTABLE EQUIPMENT MANUFACTURERS

1. **General**: Those provided in the appendices at the end of the Design Concept are manufacturers that are acceptable to the Water Company. This does not preclude the Consultant from suggesting other manufacturers. It is also the Consultant's responsibility to recommend other manufacturers when the products of the specified acceptable manufacturers are not appropriate for the specific application. It may be appropriate to write certain equipment specifications such that bids are required from more than one manufacturer. These specific items will be identified during the design phase of the project.

B. TRANSMISSION MAIN

PIPELINE

1. **Route**: The pipeline shall begin at first booster station just east of the Jefferson/Shelby County line and terminate at the KAWC distribution system near the intersection of US 421 and New Circle Road (see Attachments).
2. **No. of Mains**: One (1)
3. **Size**: 36-inch (based on future 23 MGD capacity)
4. **Materials of Construction**: Design to be based on ductile iron pipe (DIP) with DI fittings (no cast iron fittings permitted). However, contract documents shall be prepared to allow for bidding of either DIP, reinforced concrete, or steel pipe and fittings. Specifications for reinforced concrete and steel pipe shall be prepared such that they meet the design requirements specified for and inherent in DIP.
5. **Joints**: Typically push on for pipe and mechanical joint for fittings. Ball and socket pipe required for sub aqueous crossings. Special joints for thrust restraint are discussed further below.
6. **Pressure Rating**: Pressure class pipe shall be specified. The pressure class shall be a minimum of 50 psi above the worst case operating pressure for each length of pipe unless external loading controls (in addition to the 100 psi surge allowance inherent in DIP). The Consultant's hydraulic analysis shall reflect all minor losses and the expected friction factor for new pipe.
7. **Internal Corrosion Protection**: Double cement mortar lining. Epoxy coatings are not permitted. Special precautions (factory testing) need to be taken to ensure that necessary drying time of the asphalt seal coating in DIP has been achieved prior to shipment to the site due to concerns with leaching and VOCs in the water supply.

8. **External Corrosion Protection**: The Consultant shall assume at this time that the worst case scenario would only require polywrapping of the entire pipeline which requires no additional design work. Upon completion of the ~~Easement Consultant's scope of work (which includes a DIPRA~~ soils and stray current corrosion analysis~~)~~, design of additional corrosion protection, if needed, will be added to the scope of work.
9. **Thrust Restraint**: Either thrust blocking or the pipe manufacturer's positive joint restraint (e.g. U.S. Pipe's TR Flex joint) is permitted. Thrust blocking shall be poured in accordance with DIPRA specifications and neither the pipe nor the joint shall be encased in concrete. The Consultant shall provide the necessary development lengths on the drawings or in the specifications should the Contractor choose to utilize positive joint restraint. Friction type restraints (e.g. retainer glands) are not permitted.
10. **Standard Laying Conditions**: DIPRA Type 2 or 3 is expected to be required as a minimum. Type 4 or 5 to be specified by the Consultant where necessary.
11. **Bury Depth**: 3-1/2 feet of cover.
12. **Jack and Bore**: Where boring is required, do not fill the annular space between the pipe and the casing.
13. **Future Connections**: The Water Company will provide information during the detailed design phase regarding the need to accommodate potential customers (i.e. insertion of tees in the pipeline).

<u>VALVING</u>

1. **Air Valves**: Air release/vacuum relief valves shall be provided at all high points in the pipeline (changes in grade) to allow for the release of accumulated air or the inlet of air at atmospheric pressure during a pipe draining scenario. Additional air release only valves shall be provided where the spacing between air release/vacuum relief valves is greater than approximately one mile The valves shall be sized in conjunction with the surge analysis. Air release valves shall not be sized to automatically release air during a scenario where the pipe is being filled. A manual air release valve (at the high points only) shall be provided for this purpose. Manual air release valves shall be pre manufactured blowoff types (Kupferle or similar) which are flush to the ground and lockable if available in adequate sizes and pressure ratings. The automatic air valves shall be located in precast manholes with easy access for maintenance and designed to prevent freezing and accumulation of water.
2. **Shutoff Valves**: Use resilient seat gate valves only to allow for pigging in the future if necessary. Shutoff valves shall be located at a minimum spacing of approximately every one mile. Shutoff valves to be conveniently located for easy access and adjacent to air release valves where practical. Valves shall be buried with cast iron valve boxes. All valves shall open left.
3. **Fire Hydrants**: Provide one fire hydrant on the suction side of each booster station to allow for release of air during pipe filling. No other fire hydrants shall be provided at any other location along the pipeline for fire protection.
4. **Pressure Relief Valves**: None are required along the pipeline route due to

concerns associated with discharge of large volumes of chlorinated water. High pressures will instead be addressed by proper controls at the pump stations.

C. **BOOSTER STATION NO. 1** (located near the Jefferson/Shelby County Line)

PUMPING UNITS and DRIVERS

1. **Number and Capacity of Pumping Units**: The pumping units shall be sized to maintain adequate water quality at minimum flow rates, as well as being capable of meeting the projected peak day and source of supply deficit demands in the year 2010 up to a maximum of 19.0 MGD. Assuming an approximate 50% turndown, two different size pumping units will be necessary with approximate capacities and ranges as follows:
   - *Unit 1*: 1.6 to 3.2 MGD
   - *Unit 2*: 1.6 to 3.2 MGD
   - *Unit 3*: 6.0 to 12.0 MGD (estimated capacity)
   - *Unit 4*: 6.0 to 12.0 MGD (estimated capacity)

   Since the smaller pumping unit (Unit 1) will run continuously, it is desired to provide a backup unit (Unit 2). Additionally, should 3.2 MGD not be adequate to maintain water quality in warm weather months, both 3.2 MGD units could be run in parallel. The combined output is expected to approach or exceed 6.0 MGD since the friction head at these flow rates will be relatively low. The selection of the smaller pumping units will be driven by turndown (i.e. minimum pumping capability) and not capacity to ensure that pumping rates can be kept to a minimum provided that adequate water quality is maintained. The selection of the larger units will be driven by the ability to generate a flow rate of 19.0 MGD when both pumps are operating in parallel, and the flow rates specified above are estimates of their individual capacities when operating alone. Thus, a single larger pumping unit would generally be adequate to meet current peak day demands, and both units operating in parallel would generate the necessary flow rates to meet projected source of supply deficits. The Consultant is responsible for determining the acceptable operating ranges of all pumping units during the detailed design stage once additional information is available from the pump manufacturers.
2. **Operation of Pumping Units**: Pumping units at Booster Station No. 1 shall operate in series with equally sized pumping units at Booster Station No. 2. Even though it would be possible to transmit water directly from Booster Station No. 1 to the existing KAWC distribution system at the low flow rates without the need for an intermediate pumping step, pressures would approach 300 psi at the Kentucky River crossing which is not desired by the Water Company. The larger 12.0 MGD units will run infrequently and shall operate at constant speeds with an equally matched constant speed units at Booster Station No. 2. The desired system flow rate shall be maintained by a rate of flow control valves at each booster station to maintain acceptable system pressures in both gradients. Due to the infrequency of use, energy loss due to throttling would be insignificant. The

smaller 3.2 MGD pumping units will run daily to maintain water quality in the pipeline and shall operate with variable frequency drives with equally sized variable frequency units at Booster Station No. 2. The potential to operate the 3.2 MGD units at Booster Station No. 2 via variable frequency drive while operating the 3.2 MGD units at Booster Station No. 1 at constant speed shall be evaluated further by the Consultant during the detailed design stage to determine if pressures in the first gradient would be acceptable. The Consultant shall ensure the coordination of all hydraulic, electrical, and instrumentation requirements for all pump system startup, shutdown, and emergency failure operating conditions across both booster stations.

3. **Optimum Efficiency of Pumping Units**: Selected for the midpoint of the final operating range for the smaller pumps (estimated at this time to be 2.4 MGD). Selected for the capacity (estimated 12.0 MGD) of the larger pumping unit.

4. **Reliability**: Should one of the 3.2 MGD pumping units be out of service, it would still be possible to keep water flowing in the pipeline to maintain water quality with the backup unit. Should both of the smaller units need to run to maintain water quality, and one of them is out of service, a 12.0 MGD pumping unit could be utilized in a throttled mode (down to approximately 6.0 MGD). Thus, no additional redundancy is required for the smaller pumping units. In the event of a drought of record requiring the two larger pumping units to operate in parallel for an extended period of time (19.0 MGD), failure of one of these units would result in an estimated pumping capacity of only 12.0 MGD. At this time, this scenario is acceptable provided the pump station can easily be expanded in the future to provide reliability at the high pumping rates if desired (see below).

5. **Expandability**: The pump station shall be designed to accommodate both a future total capacity of 23.0 MGD, and reliability at this pumping rate. When selecting the current larger pumping units with estimated capacities of 12.0 MGD, the ability to increase their capacity by changing the impeller or adding stages shall be considered in making the final selection. Should this not be possible, the physical layout of the pump station shall be capable of accommodating larger pumping units to replace the 12.0 MGD units. Any current buried piping or piping that would be difficult to replace in the future shall be sized at this time to accommodate the ultimate station capacity of 23.0 MGD with one unit out of service. Additionally, space for a future redundant pumping unit equal in size to each of the larger pumping units shall be provided in the pump station. The only equipment or materials that should be provided at this time for this future pumping unit are under slab piping and valving that would be difficult to install once the pump station is constructed.

6. **Type and Configuration of Pumping Units**: The Consultant shall assume for the purposes of the proposal that vertical can turbines will be utilized for all of the pumping units due to the high discharge heads. The Consultant shall complete the Pumping Unit Study described in Section F before making a final recommendation for the type and configuration of pumping units.

7. **Drivers for Pumping Units**: The smaller pumping units (3.2 MGD capacity) shall be equipped with high efficiency electric motors with variable frequency

drives (approximate 250 HP). For the purposes of the proposal, the larger pumping units (estimated 12.0 MGD capacity) shall be equipped with high efficiency electric motors (approximate 1250 HP) operating at a constant speed. The Consultant shall complete the Power Study described in Section F before making a final recommendation for the driver for the 12.0 MGD pumping units.

8. **Minimum Pipeline Pressure**: When selecting and sizing the pumping units, a minimum pressure of 40 psi must be maintained under all flow scenarios. This becomes an issue at the lower pumping rates.
9. **Finite Element Analysis**: The Consultant shall perform a finite element analysis for all pumping units to ensure that the design addresses potential vibration and natural frequency concerns. The major concerns are with the variable frequency drives on the smaller pumping units, although the constant speed units shall also be analyzed. Since more than one pump manufacturer will be specified, the development of the finite element model shall begin during the design phase, and be completed after bids are received and the specific pump and motor manufacturers have been selected. Any necessary design modifications to the facility after the analysis is complete are the responsibility of the Consultant. KAWC has previously and successfully utilized the services of Mechanical Solutions, Inc. of Parsippany, NJ (Mr. Bill Marscher, 973-326-9920) for similar analyses. Should your in-house project team not include expertise in finite element analyses, Mr. Marscher is highly recommended, although you may propose an alternate qualified sub-consultant.

<u>PIPING and VALVING</u>

1. **Interior Process Piping**: Flanged ductile iron pipe preferred. Welded or flanged steel pipe permissible (due to the high pressures) if cost effective.
2. **Exterior Process Piping**: Restrained joint ductile iron pipe (e.g. U.S. Pipe's TR Flex joint). All buried piping on site shall be polywrapped. All process piping shall be sized for the future 23.0 MGD station capacity.
3. **Process Valves**: AWWA butterfly valves. Use AWWA resilient gate valves only for any buried valves < 16" and shutoff valves of the suction side of pumping units. Manual butterfly shutoff valves to be provided on the discharge of each individual pumping unit. Provide non-AWWA valves only where pressure requirements exceed that of AWWA valves.
4. **Operators for Automatic Process Valves**: Electric
5. **Pump Control Valves**: Metal seated ball or cone valves to alleviate surge conditions during a normal start/stop operating scenario. The valves shall close hydraulically upon power failure.
6. **Rate of Flow Control Valve**: Provide a of flow control valve on the common discharge of the larger 12.0 MGD pumping units.
7. **Air Release Valves**: Provided on the discharge of the pumping units where air may accumulate.
8. **Water Supply Piping**: Copper except in areas where exposed to corrosive chemicals such as chlorine where PVC piping would be required.
9. **Water Supply Valves**: Bronze ball valves unless otherwise noted.

10. **Backflow Preventers**: Reduced pressure zone type required on all individual connections to potable water.
11. **Pig Launch**: Provisions to pig the pipeline from Booster Station No. 1 to Booster Station No. 2 shall be provided. The pig launch piping facilities shall basically consist of a y-branch and valve off the main pipeline and piped to grade with a cap or solid flange

METERING and OTHER PROCESS APPURTENANCES

1. **Process Metering**: The total flow rate through the pump station shall be metered. However, considering the wide range of flows (1.6 - 19.0 MGD), each set of equally sized pumps shall be commonly metered for improved accuracy with the total station flow rate computed via software. Either venturi or full body mag meters are acceptable. Provide adequate upstream and downstream diameters per the manufacturer's recommendations, and provide no less than 12 inches of differential for venturi meters at minimum flow rates. The meters shall be located within the pump station.
2. **Service Water Metering**: All water used within the station shall be metered with either positive displacement or turbine meters.
3. **Motor Monitoring Equipment**: Required for each pump. The parameters that are expected to be monitored include winding temperature, bearing temperature, vibration, and thrust. See Electrical section for additional information.
4. **Pressure Gauges**: Provided on the suction and discharge of each individual pump.
5. **Surge Tank**: It shall be assumed for the purposes of the proposal that the means of controlling surge during a power failure shall be by means of a one way hydro-pneumatic surge tank. The tank shall be appropriately sized for a 23.0 MGD capacity such that water from the tank will continue to flow into the system to prevent the formation of a negative pressure gradient at any point in the pipeline upon loss of power. The tank shall be located above grade within the pump building. The results of the surge analysis will be required before selection of surge attenuation facilities can be finalized.
6. **Analytical Instruments**: Total chlorine, free chlorine, and pH shall be monitored continuously at the pump station. See Chemical Feed Systems section below for additional information regarding the instruments for use in chemical metering pump operations. Also provide manual sample taps upstream and downstream of all chemical feed points of application.

CHEMICAL FEED SYSTEMS

1. **Applicable American Water Standards**: T-2 (Liquid Chemical Storage, Feed, and Containment) and T-9 (Compressed Gas Feed Systems and Storage Facilities) which are provided in the Attachments.
2. **Orientation of Chemical Feed Equipment**: All rooms shall be laid out such that the need to step over piping or conduit is eliminated or minimized as much as possible. All rooms shall also be oriented similarly such that safety devices (eyewashes) are located in a common place (such as near the door) in each room.

3. **Access**: All enclosed rooms with non-bulk storage shall include double doors for loading drums or bags into and out of the room. Access into chemical containment areas shall be by stairs with railings (no ladders) up and over the wall or down into a recessed containment area.
4. **Operating Range of Equipment**: All chemical feed equipment shall be fully capable of operating over a feed range corresponding to max pumpage (19.0 MGD)/max dosage down to min pumpage (1.6 MGD)/min dosage based on the manufacturers recommended turndown ratios. If necessary, provide varying sized feed equipment in order to encompass the necessary range of operation.
5. **Operation of Equipment**: All chemical feed equipment shall be flow paced. Compound loop capabilities shall be provided as specified below. The length of sample lines supplying analytical devices which will be used for compound loop control shall be minimized to prevent loop delays.
6. **Redundancy**: All mechanical chemical feed equipment shall have 100% redundancy such that one system can be isolated while the chemical continues to be fed from the redundant system under all possible flow rates and dosages. This redundancy applies to all components of the feed system including appurtenances such as anti-siphon valves, calibration columns, etc. but does not apply to bulk and day tanks.
7. **Tank Sizing**: The required tank sizes per American Standard T-2 shall consider that the bottom and top of the tanks are typically not useful storage. The high level of the tanks (pump shutoff point) shall be set such that there is adequate time to react to the high level alarm before the tank would begin to overflow.
8. **Chemical Storage**: Storage shall be sized for 31 days based on the greater of (avg day)/(max dosage) or (max day)/(avg dosage) with space for empty containers/cylinders for non-bulk systems unless minimum shipping volumes are greater. Even though the average day demand to maintain water quality is only expected to range between 1.6 and 3.2 MGD, a flow rate of 10 MGD shall be used for the average day demand to reflect a worst case scenario summer demand. The maximum day demand to utilize in the calculations shall be 23.0 MGD.
9. **Transfer Pumps**: Sized to limit transfer time to no more than two minutes.
10. **Bulk Tank Fill Connections**: Lockable with shutoff valves and appropriately labeled. Also provide spill containment (simple sump w/grating) directly below the fill connection.
11. **Priming**: All metering pumps shall be oriented with positive suction.
12. **Flushing Systems**: Provide flushing tap at the point of chemical entry into the piping system for each feed system.
13. **Points of Application**: On the suction side of the station pumping units but outside of the building in manholes and as far upstream from the pumps as reasonably possible. Pressures on the discharge side of the pump station are expected to be too high to facilitate chemical application.
14. **Chlorine Feed System**:
    a. *Purpose*: To boost incoming disinfectant residual as needed.
    b. *Product Form*: Liquid/Gaseous
    c. *Feed Form*: Gaseous

d. *Feed Method*: Eduction. Vacuum operated system with eductors at point of application.
e. *Required Product Dosages*: 0.1 - 1.0 - 3.5 mg/L (min-avg-max)
f. *Type of Storage Required*: Ton cylinders
g. *Minimum Shipping Volumes*: Not applicable for this chemical.
h. *No. of Cylinders*: Provide space for five (5) full cylinders and three empty cylinders.
i. *Compound Loop Control*: Utilize total chlorine residual analyzer

15. **Ammonia Feed System**:
a. *Purpose*: To maintain adequate chloramine residual when disinfectant residual is boosted.
b. *Product Form*: Liquid/Gaseous
c. *Feed Form*: Gaseous
d. *Feed Method*: Eduction. Vacuum operated system with eductors at the point of application.
e. *Required Product Dosages*: 0.03 - 0.33 - 1.17 mg/L (min-avg-max)
f. *Type of Storage Required*: Permanent indoor bulk storage (*two tanks, each with a* minimum ~~2~~*1*,000 lb *capacity*~~tank~~).
g. *Minimum Shipping Volumes*: To be determined during design.
~~h. *No. of Cylinders*: Provide space for four (4) full cylinders and two (2) empty cylinders.~~
h~~i~~. *Feed Control*: Based on percentage of chlorine feed (typically 3:1 chlorine:ammonia).
i~~j~~. *Chemical Classification*: Ammonia is classified as an explosive material, and all electrical equipment shall be of explosion proof design.
j~~k~~. *Specific Point of Application*: Upstream of chlorine point of application.

16. **Corrosion Control Feed System**:
a. *General*: This feed system will be utilized to feed a corrosion inhibitor.
b. *Specific Chemical*: Non-zinc phosphate (Calgon C-4 or comparable)
c. *Product Form*: Liquid
d. *Product Density*: 11.68 lb/gal
e. *Feed Form*: Liquid
f. *Feed Method*: Metering pump.
g. *Required Product Dosages*: 2.0 - 3.0 - 4.0 mg/L (min-avg-max)
h. *Minimum Bulk Shipping Volumes*: 2,000 gallons.
i. *Type of Storage Required*: Bulk tank. Provide a minimum of 3,000 gallons to accommodate a 2,000 gallon bulk shipment.
j. *Isolation*: Located in an enclosed, heated room. Chemical is subject to stratification if freezing occurs.

17. **Chlorine Leak Neutralization System**:
a. *Purpose*: To neutralize a leak from the chlorine storage room.
b. *Required Equipment*: Chlorine scrubber system
c. *Type*: Spray tower design preferred, however, Consultant shall evaluate and recommend the most economical system.
d. *Capacity*: Capable of neutralizing the contents of a single ton cylinder.

e. *Sodium Hydroxide Storage*: Shall meet typical American Water Works requirements for bulk liquid storage in terms of piping, materials of construction, and containment. Tank to be located indoors.

18. **Ammonia Leak Neutralization System**:

a. *Purpose*: To neutralize a leak from the ammonia storage room.

b. *Required Equipment*: Ammonia scrubber system.

c. *Type*: Ejector-venturi type with water as the neutralizing chemical.

d. *Capacity*: Capable of neutralizing the contents of *one*~~the~~ entire fixed cylinder.

ELECTRICAL

1. **Electric Service to the Site**

a. *Number of Services*: 1

b. *Type of Feed*: To be determined by the Consultant. Some of the factors that will determine the type of feed include, but are not limited to:

- The service voltage available from the utility.
- A reliability analysis of overhead versus underground feed from the utility to the proposed booster station. The Consultant shall examine the outage times per year, past electric company outage history, the length of the outage, and other factors (such as frequency of recloser operation). The goal in performing a reliability analysis is to determine how often the power company service will fail. This analysis should be presented per the guidelines listed in I.E.E.E. Standard 493 (latest edition).
- Availability of rights of way from other property owners
- Flood plain considerations
- Protective relaying considerations to examine what type of protective relaying scheme will be required to protect other utility customers and the rotating equipment inside the booster station.
- Available voltage from the utility. The Consultant shall assume that 4160V will be used for starting either the estimated 250 or 1250 HP loads. This is the preferred voltage to minimize in-rush from the motors to the rest of the power system.

c. *Transformer*: Pad mounted electric company owned transformers are preferred. The Consultant shall make an economic evaluation of this option during detailed design. An economic evaluation shall consist of the following steps:

- Determine the type of transformer is to be used (oil filled versus cast coil) based on losses, resistance to power system anomalies, short circuit protection, whether the electric utility readily stocks transformers in this voltage, etc. Losses should be tabulated in the form of an annual cost per year.
- Determine whether the voltage should be measured on the primary (electric utility side of the power system) or the secondary (Water

Company side of the power system) by examining the electric company rate tariffs.

- It should be noted that a solidly grounded service is preferred on the Water Company side of the power system.

d. *Electric Meter*: The number and location of electric meters shall be determined by the Consultant. The Consultant shall determine if primary metering is a more cost effective alternative to secondary metering by contacting the electric utility and developing an economic analysis for review and approval by the Water Company.

e. *Surge Suppression*: Design using the appropriate level of transient threat as defined in ANSI/I.E.E.E. Standard C62.41. All transient voltage surge suppression equipment shall be tested in accordance with the appropriate parts of ANSI/I.E.E.E. Standard C62.45 and UL Standard 1449. The Consultant shall review the following issues and summarize their findings to the Water Company: length and amplitude of spikes caused by capacitor switching, recloser switching, or other pieces of equipment that can cause problems on a customer's power system and provide the appropriate protective equipment on the Water Company's side of the power system.

f. *Voltage Drops*: Develop a protection scheme to ensure that the transfer switch and other items (such as induction motors) are adequately protected from voltage unbalance, contact chatter, etc.

g. *Lightning Protection*: A "Faraday Cage" lightning protection scheme is preferred. Based on the size of the rotating equipment inside the facility, the Consultant shall determine what steps will be taken to conform to NFPA 780 (latest edition). Some steps include the development of air terminals, spline ball ionizers and other lightning protection details to ensure that personnel and equipment are protected.

h. *Power System Studies*: Power systems studies shall be performed via a Water Company approved computer based program. All studies will follow the guidelines of I.E.E.E Standard 399 (latest edition). The following power system studies shall be performed for this project:

- Short Circuit Studies: To determine momentary and interrupting ratings of equipment in addition to developing values of short circuit current at each bus under various loading conditions. Reports will be submitted to the Water Company at the 50% and 90% review meetings to ensure that the short circuit values have been considered. Where required, the Consultant shall use approximate data for the length of feeders or other equipment. It is expected that the Consultant will calculate both bolted three phase and unbalanced faults (depending upon the power system configuration). All assumptions associated with rotating machinery and transformer impedances will be listed with the Water Company in each submittal. The Consultant shall collect data from the electric utilities for short circuit power factor

(X/R ratio) and utility short circuit MVA, and prepare short circuit studies not only for the development of breaker/fuses but also to determine values of short circuit current under less than worst case conditions to ensure that power systems relaying will operate properly. At the end of each short circuit scenario, the consultant shall state what can be done to improve ratings of equipment (if equipment is found to be deficient) and how protective relaying and coordination will detect and trip lower values of fault current without disrupting service. A tabular summary shall be presented and include the following:

- Bus Number
- Description
- Momentary Rating
- Interrupting Rating
- Comments on Breaker Status

- Load Flow Studies: To allow the Water Company to determine where cables transformers or other power delivery devices are beyond their rated limits. The power flow study will also be used to determine the optimum distribution of existing and future loads. The consultant shall select loading conditions after the operation of the station has been determined (assume a minimum of three loading scenarios will be run). The load flow study will include a tabulation of all rotating machinery and static loads (from 480V upward). The data for the power flow study will be tabulated for each load scenario and include the following:
  - Bus Number
  - Description
  - Voltage Magnitude (P.U.)
  - Voltage Angle
  - P (Watts)
  - Q (VAR)
  - Bus Description (Swing, Load, Gen.)
  - Status (with exceeds ratings)
  - Comments

  If bus ratings are exceeded (voltage too low, VA capacity exceeded, etc.) the Consultant shall develop possible solutions to this problem (such as the installation of capacitors, the changing of taps on distribution transformers, etc.). Interpretive results shall include detailed commentary (such as busses with motors should be limited to a 3% voltage drop based on Fine Print Notes listed in the National Electrical Code. If capacitors are required, the Consultant should make recommendations for the placement and size of the capacitors. The Consultant should make a separate power study showing the effect of the capacitor on the power system. The Consultant shall be responsible for developing the total and displaced power factor based on the various loading scenarios.

- Protective Relaying and Coordination: Submitted at the 90% review meeting once the switchgear has been determined and the protective devices are selected. The purpose of this study is to ensure that all of the rotating and static power devices are adequately protected. Note that approved short circuit calculations are a prerequisites to this study. For purposes of this study, all 4160V and 480V equipment will be examined for protection and coordination. The following items will be shown on each plot:
  - The ANSI motor damage and transformer damage curve (depending upon the device being protected).
  - The time-current characteristics of each protective device (fuse or circuit breaker) immediately upstream of the equipment to be protected.
  - The time-current characteristics of the protective device upstream of an individual branch circuit. (Example: a motor control center feeder breaker would be plotted on the same time current curve as a motor control center branch circuit breaker, and motor starting characteristics)
  - Commentary will be provided as to the suggested settings, how well the device coordinates with its protected load and with upstream devices, and the time margin between device operation (when compared to recommended industry practice).
  - In order to make equipment protective margins easy to interpret, the Consultant shall list minimum safe stall time and transformer inrush on the time-current curves.
  - The Consultant shall consider the need for directional overcurrent relaying depending upon the final power system configuration.
- Motor Starting Study: Results shall be tabulated at the 50% and 90% design. The Consultant will run the motor starting study on minimum, average, and maximum load conditions. The purpose of the motor starting study is to determine what the magnitude of the voltage drop problem will be elsewhere in the power system when large motor loads are started. Output from this study includes, but is not limited to: speed, slip, electrical output torque, load current, and terminal voltage data at discrete time intervals from locked rotor to full load constant speed. The study will be used to determine the best method for motor starting, the proper motor design, and the required system design for minimizing the impact of motor starting on the rest of the power system.
- Ground Mat Analysis: Used to ensure that grounding interface will protect personnel and equipment under fault conditions. The ground

mat study will consider fault current magnitude and duration, geometry of the grounding system, soil resistively, probability of contact, human factors (such as body resistance). The end-product of a ground mat study will be a dimensioned ground grid with values of step and touch potentials at various points in the grid.

2. **Medium Voltage Power Distribution Equipment**

a *Type of Equipment*: 4160V, 3-phase, 4-wire plus ground operating at 60Hz. All components shall be UL listed and UL labeled.

b. *Materials of Construction*: All equipment will be of the Metal Clad type per definitions in the latest edition of ANSI C37 series of specifications. Metal enclosed switchgear is not acceptable.

c. *Factory Testing of Equipment*: Witnessed by the Water Company or by certified test report. This will be determined during detailed design.

d. *Enclosure Type*: NEMA 1. Consultant shall provide HVAC equipment designed for extra air filtration to ensure that particulate matter cannot track on to pieces of electrical equipment.

e. *Heat Dissipation*: Consultant shall provide for adequate heat dissipation based on guidelines listed in I.E.E.E. Standard 141, Typical Efficiencies of Electrical Equipment. Calculations shall be submitted to the Water Company prior to final design review.

f. *Maximum Design Voltage*: 4.76kV (based on a nominal 4.16kV power system).

g. *Main Bus Capacity*: Design for present connected load and future loads. Determined by the Consultant during detailed design.

h. *Momentary and Interrupting Ratings*: Determined by the Consultant during detailed design. Calculations must be supplied to the Water Company before final specifications are approved. Calculations can be computer or other Water Company approved method per the guidelines listed in I.E.E.E. 141 (latest edition). The Consultant shall provide documentation of all assumptions for machine impedances, cable impedances (both resistance and inductance), and transformer impedances to complete the computations. Since the Water Company prefers a grounded secondary service, both balanced and unbalanced fault computations will be prepared and presented to the Water Company for review and approval. Detailed final calculations will be made by the switchgear vendor during construction and shop drawing approval. The Consultant shall develop fault conditions under minimum, maximum, and average power consumption scenarios based on the way the plant is to be operated.

i. *Circuit Breaker Compartments and Circuit Breakers*:

- Horizontal metal clad vacuum circuit breakers are preferred on all main circuit breaker installations. Metal enclosed switchgear is not permitted.
- The entrance to the primary disconnecting contacts shall be covered

with metal shutters to ensure that when the circuit breaker is withdrawn from the connected position to the test or disconnected position.

- Ground bus shall be extended into the circuit breaker compartment.
- Blocking devices shall ensure that breakers of a different frame size cannot be installed into the circuit breaker cubicle.
- Ensure that one vacuum contactor breaker shall be furnished per phase. Breakers of the same type and rating shall be completely interchangeable.
- Breaker Operating Method: A stored energy (such as capacitor trip) shall be used to operate the breaker under normal conditions. The circuit breaker shall be capable of being opened or closed by means of a manual charging handle under emergency conditions.
- Provide the ability to plug in auxiliary test devices via a receptacle.
- Circuit Breaker Control Voltage: 48 VDC preferred. If a DC voltage is used for breaker control, NiCAD batteries are preferred. The Consultant shall develop ampere-hour ratings for approval by the Water Company prior to final review. The Consultant shall include a dry contact to indicate a low battery condition at the distributed control system.
- Provide a minimum of 4 (two NO, two NC contacts) available for customer use to indicate circuit breaker condition..
- Relaying: Shunt trip logic to be developed by the Consultant in concert with the Water Company during detailed design (typical each branch circuit and main). Microprocessor based relays (such as the Multi-Lin units) are preferred to molded case draw-out type. Final selection will be determined by the electric utility requirements and Water Company preferences.
- Switchgear Control Wiring: Type SIS wiring preferred; provide for a minimum of 20 percent expansion in all terminal block wiring. Terminal blocks should be rated for 600VAC. A completely separate compartment shall be provided for control wiring which shall be isolated from all medium voltage wiring via a metal barrier. A feed through terminal block (similar to a Phoenix Contact Block used in low voltage controls) is preferred; use a ring-tongue block only if absolutely necessary.

j. *Main Bus Compartment*: Tin-plated copper conductors shall be installed. Use only a bolted design; welded designs are not acceptable. The main bus ampacity will be determined by the Consultant during detailed design and shall consider ambient temperature as well as connected load.

k. *Power System Instrumentation*:

- Current Transformers: Provide for a 0-5 ampere A.C. output. Current transformer ratio tap setting determined at the time of shop drawing review. Relaying and current metering accuracy to be C100 minimum. The Consultant shall ensure that relays do not saturate under worst case conditions. Consultant shall determine wiring configuration (wye or delta) and grounding of current transformers by coordinating with the manufacturer during detailed design.

- Potential Transformers: Provide potential transformation with 120VAC as the rated secondary voltage. Potential transformers shall have a 1% accuracy at connected burdens. All potential transformers shall be placed in ground drawer mechanism to ensure that the device is always grounded.

l. *Switchgear Batteries*: Batteries are to be sized for closing and tripping ratings of the selected circuit breakers. Battery selection criteria to include but not be limited to: momentary and continuous load tabulations, the expected temperature, the specific gravity of the desired cell, battery aging factor, battery design margin factor (based on future expansion), battery temperature correction factor, and the cell's capacity rating factor. The Consultant shall develop detailed calculations and submit the to the Water Company for approval prior to final review.

m. *Power Systems Monitoring*: Power Systems Monitoring will be accomplished via Multi-Lin units on each piece of switchgear. Parameters to be monitored include: voltage, current, power factor, vars, watts, and kilowatt-hours. The Multi-Lin units will be daisy chained back to a common port on a DPC 3330. Multi-Lin equipment will be used <u>regardless</u> of the switchgear manufacturer. The Water Company will coordinate with the Consultant for the frequency which parameters will be monitored and trended back at the man-machine interface.

3. **Medium Voltage Motors**

a. *Motor Voltage*: Preliminarily set at 4160V; determined by Consultant on the basis of electric utility negotiation, affects of motor starting on power system, and the requirements of the driven loads.

b. *Motor Starting Method*: Preliminarily set based on an electronic solid state system which allows for variable acceleration and deceleration. Determined by the Consultant during detailed design.

c. *Frequency of Operation*: Motors shall be designed for continuous operation and long periods of inactivity.

d. *Sound Pressure*: Control of the sound pressure level of all equipment shall be carefully coordinated between the consultant and the vendor. The measuring and reporting of sound level data shall be in accordance with I.E.E.E Standard 85.

e. *Piping System Design Goals*:

- Proper support and protection to prevent damage from vibration or from shipment, operation, and maintenance.
- Installation adapted to the contour of the machine without obstructing access openings.
- Elimination of air pockets.

- Provision for easy removal.

f. *Maintenance Criteria*

- Major parts, such as frame components and bearing housings, shall be designed (shouldered or doweled) to ensure accurate alignment and reassembly.
- Easily removable covers will be provided for maintenance and inspection of the coil and end turns.
- Every effort shall be made to avoid requirements for special tools associated with assembly, disassembly, and routine maintenance.

g. *Load Requirements*: Load torque characteristics and total load inertia referred to the motor shaft shall conform with the latest edition of NEMA MG-1-20.42. The Consultant will be expected to furnish the following information to the motor system designer:

- The speed-torque characteristics of the load under the most stringent starting conditions.
- The speed-torque characteristics of the load during a reaccelerating condition, the length of maximum voltage interruptions or a fault related collapse, and the expected voltage at motor terminals during the reacceleration period.
- The total load inertia (WK^2) referred to the motor shaft speed (where W is the rotor weight and K is the radius of gyration). This total load inertia shall include all loads connected to the motor shaft, such as the couplings, gearbox and driven equipment.

h. *Motor Performance Data:* With their rated voltage and frequency applied, motors shall as a minimum, operate with the characteristics listed below:

- The maximum full load slip shall not exceed 3%.
- The maximum locked rotor current shall not exceed 650% of the full load current.
- The minimum locked rotor, pull-up, and breakdown torques shall be no less than the values listed in NEMA MG1-20.41.

i. *Insulation Systems*

- General Requirements: Motor shall have an epoxy-base vacuum pressure impregnated (VPI), non hygroscopic insulation system, including leads and connections to windings. When bus bars are used, they shall be insulated.
- Class F Insulation: As a minimum, the insulation system shall meet the criteria for NEMA Class F. The allowable temperature rise above 40 degrees centigrade shall not exceed that listed in NEMA MG1-20.40 for Class B insulation.
- Stator Insulation Systems shall be service proven and shall be subjected to thermal evaluation in accordance with IEEE Standard 429.

- For multi-turn stator windings, additional turn insulation shall be used as required to maintain the integrity of turn insulation in areas of coil deformation.

j. *Enclosures*

- General Requirements- Enclosures shall be made of cast or nodular iron, cast steel, or steel plate. All enclosure requirements shall have a minimum rigidity equivalent to that of sheet steel with a nominal thickness of 1/8 inch
- All enclosure's bolts, studs and other fastening devices shall be made of corrosion resistant materials.
- The enclosure shall be designed to facilitate cleaning and painting the motor's interior.
- A weatherproof Type 1 (as specified in NEMA MG1-1.25.8.1) is preferred. It shall be constructed so that any accumulation of water will drain from the motor before reaching the level of the windings or other live parts.

k. *Frame and Mounting Plates*

- Materials of construction: Cast or nodular iron or welded steel plate construction.
- Provide removable end bells or end plates to allow for removal of the rotor and facilitate replacement of the stator coils.
- The motor frame, including the transition base, if supplied with the motor, and the bearing supports, shall be designed to have sufficient strength and rigidity to limit changes of alignment caused by worst case combination of torque reaction, conduit and piping stress, magnetic imbalance, and thermal distortion to .002 inch.

l. *Terminal Boxes*:

- Materials of Construction: Cast or nodular iron, steel plate with a minimum rigidity equivalent to that of steel plate with a nominal thickness of 1/8 inch. Accessory lead shall terminate in a box separate from the motor terminal housing. Secondary connections for current and potential transformers located in the terminal housing are permitted to terminate in the terminal housing if they are separated by a suitable physical barrier to prevent accidental contact. Items inside a terminal box include, but are not limited to:
  - Thermal insulation on the interior top side
  - Space heaters
  - Adequate space for termination of shielded cables
  - Universal bushing studs
  - Arresters and surge capacitors
  - Differential and phase current transformers
  - Potential transformers
  - Ground Bus.

m. *Surge Capacitors*

- Surge capacitors shall be the last devices connected to the motor leads before the leads enter the stator.
- The connection leads to the capacitors shall be at least 4/0 AWG and shall be as short as possible.
- A low impedance ground path shall be provided between the surge protection and the stator core. This low impedance path may be provided by running a minimum of 4/0AWG wire in parallel with the motor leads. This wire will bond the motor core and the terminal box by means of compression fittings at the ground point.

n. *Differential Current Transformers:* May not be required on electric machines rated below 0.5 MVA. Consultant to coordinate with the Water Company during detailed design.

- Provide on each motor in the 4160V lineup. (Differential relaying will be done via a microprocessor based motor protective relay).
- Current transformer leads will be routed away from the high voltage motor leads and protected by a physical barrier to prevent accidental contact. Leads shall be terminated at an appropriate shorting and grounding terminal in an auxiliary box. The auxiliary box shall be accessible without removal of the stator terminal box's cover.
- Self balancing current transformers are preferred; this implies that a minimum of 6 stator leads are required.

o. *Motor Monitoring Equipment*: Bentley Nevada equipment shall be provided to monitor the following:

- Winding Temperature
  - RTD elements shall be platinum three wire elements with a resistance of 100 ohms at 32 degrees Fahrenheit.
  - Elements shall have a stranded, tinned copper wire lead of at least 22 AWG.
  - Two sensing elements per phase shall be installed and suitably distributed around the circumference of the stator winding slots.
- Bearing Temperature
- Vibration
- Thrust

p. *Protective Relaying:* Some of these Devices will not be required on small machines (defined as machines below 0.5 MVA). Consultant to coordinate with the Water Company during detailed design.

- ANSI Device 27: To protect the motor against low or loss of voltage.
- ANSI Device 46: To provide for phase unbalance protection and open phase protection.
- ANSI Device 49: Temperature detector relay to provide for overload detection by monitoring RTD's in the stator windings.
- ANSI Device 49S/50: Contains a time overcurrent unit, low set, high

dropout instantaneous unit, and a high set standard instantaneous unit.

- ANSI Device 50: Provides instantaneous overcurrent protection for the other two phases that do not have the 49S/50 device.
- ANSI Device 50GS: Protects the motor against instantaneous ground fault protection.
- ANSI Device 87: Protects the motor against phase to phase and phase to ground faults.
- ANSI Device 47: Provides for reverse phase protection and under voltage protection.
- ANSI Device 48: Provides for incomplete starting sequence.
- ANSI Device 86: Lockout relay. Used in a circuit to allow for individual relay testing with out stopping the motor.

q. *Bearing Type:* Grease lubricated ball bearing preferred. Determined with the Water Company during detailed design along with a method for bearing lubrication.

r. *Testing Requirements*: Approximately 6 weeks before the first scheduled test, the Consultant shall ensure that the vendor has submitted the following:

- Types of tests to be performed.
- Testing sequence.
- Detailed testing schedule.
- Guarantee limits such as overall vibration levels, limits of harmonic vibration components, frequency and amplification factors of critical speeds, motor efficiency noise level, and stator temperature rise.
- Data measurements to confirm guarantee limits to include but not be limited to: power (KW), speed (RPM), and torque (ft-lbs), shaft/bearing vibration, journal bearing embedded temperatures, stator winding temperatures, temperature on air inlets and outlets, voltage, current, calculated lateral speed analysis, and power factor.
- Calibration sheets for all switches, vibration probes, and proximitors.
- A listing of all alarm and shutdown levels.

s. *Training Requirements*: Will not be required in machines below 0.5 MVA driven by an electric power system. Consultant to develop detailed training requirements once the equipment has been selected. Training requirements to include but not be limited to:

- General familiarization to provide management, engineering, and maintenance personnel with a broad based familiarization of construction features, system operations, and maintenance concepts.
    - Driven equipment
    - Maintenance: Maintenance objectives, schedules, inspection, and standard practices/procedures.
    - Peripheral Equipment: (vibration detectors, temperature detectors, etc.)

- Unit operation
- Protective relaying and coordination/control system interlocks.

4. **System Grounding**
   a. *General:* Solidly grounded systems pose some limitations to the protection of equipment and clearing of ground faults. The Consultant shall examine the following issues with respect to system grounding:
      - How high arcing faults will be extinguished without undue equipment damage and risks for personnel.
      - If a High Resistance ("High R") type grounding system is to be considered to allow an orderly shut down of equipment (even under a ground fault situation).
      - What type of protective strategy should be employed with respect to the setting and selection of ground fault relaying on mains, large rotating loads (motors/generators), and power system feeders from distribution to utilization equipment.
5. **Motor Control Centers** (for use in facilities even if 4160V is used)
   a. *Power Monitoring*: Microprocessor based on the incoming main to monitor kilowatt-demand, power factor, volts, amperes, etc.
   b. *Main Circuit Breaker*: Microprocessor based with adjustable trip and delay settings for long-time and short time tripping characteristics in addition to instantaneous and I^2t (for ground fault).
   c. *Starters*: Equipped with the ability to lock out the starter for testing during maintenance. Provide in a 20" deep configuration (typical for 480 V service).
   d. *Pilot Lights*: Oil, dust, and water resistant with push to test type operation.
   e. *Bus*: Tin plated copper.
   f. *Control Power Transformers*: Sized for at least 150% of the required load to allow for future expansion.
   g. *Wiring Configuration*: NEMA Class 2B
   h. *Gasketing*: Required
   i. *Lightning Arrestors*: Provide on the incoming lines based on the isokeraunic number (number of thunderstorms per year).
   j. *Surge Arrestors*: To be provided for steep wave transients.
   k. *Basic Impulse Level (BIL) Requirements*: Consultant to coordinate to establish a protective margin based on the perceived transient threat caused by switching of capacitor banks.
   l. *Thermostats*: Consultant shall evaluate the need for the use of condensation type inside each starter to prevent moisture build-up on components.
6. **VFDs**:
   a. *Switching Technology*: Insulated Gate Bipolar Junction Transistor (IGBT) technology is preferred. Pulse width modulation is the preferred method for frequency control. The Consultant shall address the following factors

with regard to VFD selection:

- The number of power transistors per phase. This directly impacts the drives ability to allow for "graceful degradation" i.e., the ability of the drive to run with a malfunctioning switch until it can be fixed.
- The switching time associated with the transistors. This parameter has a direct effect on issues such as reflected waves through power cable, dv/dt stress on motor winding insulation, power system harmonics, etc.
- How heat will be dissipated away from the electronics. This aspect of drive design ensures that components do not dissipate heat that will shorten drive life.

b. *Bypass*: Provide the ability to operate the motor on either the VFD or a bypass in case of drive failure. Both the drive and the VFD are to be separately mounted from power distribution equipment (such as a motor control center or switchgear) to allow for ease of maintenance. In order to ensure electrical isolation, an input contactor, an output contactor and a VFD/bypass contactor will be provided. Drive bypass can be either soft start or reduced voltage auto transformer (RVAT) starting. This project detail will be developed with the consultant during detailed design. The following factors will determine the selection of the bypass starter:

- The torque-speed characteristics of the load (centrifugal pump).
- The torque-speed characteristics of the motor.
- The need for "ease of starting" based on the selected power system voltage for the pumps.

c. *Enclosure*: The drive system shall be located in an area where NEMA 1 enclosures can be used. The consultant shall ensure that heat dissipation requirements are developed for these enclosures. Calculations shall determine whether a closed loop air conditioner system is required to protect drive components.

d. *General Features*:

- Critical frequency avoidance
- Remote speed control (no PID control is required internal to VFD electronics; speed control is determined from a signal developed from the DCS via a control strategy).
- Remote speed status
- Local speed status (in units of percentage of full speed or Hertz)
- Speed profile to provide adjustable settings for start, stop, entry and slope, and minimum and maximum speed points.
- Automatic restart after drive trip
- Power loss ride through
- Transient voltage surge suppression on drive electronics
- LCD display of current, frequency, and output KW
- Parameter Settings: The following parameter settings shall be capable

of being input to the VFD:

- Independent ACCEL/DECEL rates
- Vmin, Vmax, Volts/Hz ratio
- Overload trip curve select (inverse, constant)
- Min/Max speed (frequency)
- Diagnostic features (determined during detailed design)
- Display fault type (or number)

e. *Drive System Controls*:

- Provide a HAND-OFF-REMOTE switch. With the HOR switch in the hand position, the drive shall be controlled by manual speed controls mounted on the drive door.
- With the HOR switch in REMOTE, the drive shall start when it receives a signal from the DCS. Its speed shall be regulated from a 4-20 mA DC analog signal generated by the DCS.
- Provide a selector switch to allow the user to select whether the motor is run from the drive or bypass starter. This capability shall also be operator selectable through the distributed control system.

f. *Harmonic Suppression*: The drive system shall meet the standards of I.E.E.E. 519 for the total harmonic distortion for both voltage and current at the point of common coupling. The following analysis factors should be performed during detailed design:

- The expected level of harmonic distortion shall be calculated by the Consultant and submitted to the Water Company for review and comment.
- The Consultant shall examine the following means of suppression for harmonics:
  - A drive isolation transformer (which only filters out 3rd order harmonics)
  - An L-C filter to eliminate negative sequence currents developed from the 5th, 7th, 11th, etc. harmonics. It is not expected that the Consultant size the L-C filter during detailed design as this depends upon the drive selected.
  - An evaluation of different drive technologies to help mitigate harmonics. Example: The Consultant shall consider 12 pulse drives with filters versus an 18 pulse drive for harmonic suppression and submit their analysis to the Water Company for review.

g. *System Burn-In*: Drive electronics shall be energized for a period of time coordinated between the Consultant and the manufacturer.

h. *Load Characteristics*: Consultant to determine whether the drive system is constant torque or variable torque based on the application. (variable torque is most commonly used).

i. *Minimum Guaranteed System Efficiency*: All drive equipment shall be a minimum of 95% efficient.

7. **Miscellaneous Power Distribution**
   a. *Circuit Panel*: Circuit breakers will be of the bolt-on type. Push on type circuit breakers are not allowed. Use copper type bus and ensure U.L. labeling of entire system. Provide a transient voltage surge suppresser on the main of each power distribution panel. For more specific requirements for the protection of sensitive electronic instrumentation, see Instrumentation section.
   b. *Cables*: Those rated for 480V and below shall be dual listed as XHHW type insulation listed for at least 90 degrees centigrade. In order to maintain a 90 degrees centigrade rating, all of the connectors and lugs at each end of the cable shall be U.L. listed for 90 degrees centigrade per the U.L. Green and White Books.
   c. *Lighting, Power, and Instrumentation Transformers*: Dry type to limit maintenance items. A minimum of (2) taps will be provided above rated voltage (in 2.5% increments) and a minimum of (2) taps will be provided below rated voltage (in 2.5% increments). Open type transformer cases are not allowed. All units will be of sealed type construction. Based on the effects of switching capacitor banks, the consultant shall examine the need to install transformers with a higher than average Basic Impulse Level (BIL) that is not normally required in the 480V class.

8. **Lighting Fixtures**
   a. *Fluorescent Type Fixtures*: When used, units shall be sealed and water resistant. In order to facilitate conformance with NFPA 101 (the Life Safety Code), the consultant shall ensure that emergency battery back up is placed on lighting fixtures so that the facility is still illuminated in the event of a power failure.
   b. *Exit Signs*: Low voltage type and placed inside the facility per the latest requirements of NFPA 101 (the Life Safety Code).
   c. *Exterior Lighting*: High pressure sodium, photocell type, wall mounted, vandal proof.

INSTRUMENTATION

1. **General Operation of the Booster Stations**: Control and monitoring of the booster station shall be by means of a continuous leased telephone line back to the RRS treatment plant. Additionally, the station pressure (suction and discharge) and flow rate shall also be monitored at the LWC English Station facility. The scope of work associated with the LWC monitoring requirements shall be limited to that required at the booster station only (i.e. LWC will be responsible for the necessary work at the English Station facility).

2. **General Modes of Operation**
   a. *Local/Remote Capabilities*: Each applicable piece of equipment will be equipped with a Local-Off-Remote selector switch (at the piece of equipment) to allow the location of control to be changed. In order to ensure that the RTU (in the Remote Manual or Remote Automatic Mode)

has control, a contact block will be added on the Remote leg of the selector switch. The output of the contact block will drive a digital input that will serve as a permissive in the DCS. If the DCS attempts to control a device from the RTU when it is not in the Remote mode, a failure condition will be delineated at the operator's interface.

b. *Local-Manual*: An operator at a piece of process equipment will turn the device on and off. Required for all equipment.

c. *Local-Automatic*: Controls are hardwired into pieces of equipment by a vendor (such as prepackaged pump control valves). Required where applicable.

d. *Remote Manual*: An operator in the control room turns items on and off via the operator interface connected to the DCS. Required for all applicable equipment.

e. *Remote Automatic*: The DCS turns items on and off and performs all control. Required for all applicable equipment.

3. **Specific Modes of Operation**: All pumping units shall be designed to operate in a remote manual mode where an operator at the RRS would turn pump combinations on and off and set the desired flow rates, however, the sequencing of the two pumps operating in series would be automatic. All chemical feed systems shall have the capability to operate in a remote automatic mode. Additional information regarding control logic, alarming, graphic displays, and reporting requirements can be found in the Attachments. It is the Consultant's responsibility, in conjunction with the Water Company, to modify this generic information as appropriate to meet the specific project needs.

4. **Conventional/Redundant Instrumentation**: Not required. This includes chart recorders.

5. **Remote Telemetry Units**

a. *Processors*: Bristol Babcock Distributed Process Controller (DPC) 3330 real time mode 386 processor architecture capable of interface with a 16-bit man-machine interface. Each processor shall be provided with nonvolatile memory (with lithium battery back-up).

b. *Software*: Bristol ACCOL

c. *Ports*: Four configurable ports per remote telemetry unit.

d. *Cabinets*: Shall be free standing. Include fan and heater and compact lighting fixture activated by a door switch.

e. *Keypads*: Use of remote mounted keypads is not allowed. Use integral units only.

f. *Terminal Blocks*: Vertical stacking permitted, staggered or alternating stacking not permitted.

g. *Spare Wired Terminals*: Provide in each cabinet to facilitate future expansion.

h. *Convenience Receptacles*: Use ground-fault interrupter type only.

i. *Separation of Power Cable and Signal Wires*: 120 VAC control cable shall be physically separated from 4-20 mA signals as much as practicable inside control cabinets.

j. *I/O Slots*: 12 slot boards required. 6 slot boards are not permitted.

k. *Single Density I/O Boards*: Not permitted. Use only high (double) density boards.

l. *Remote Input/Output (RIO) Boards*: not permitted.

m. *4 Wire Control*: required for all pieces of equipment (one contact for stop and one for start, etc.) except for metering pumps (which only require 1 contact for the start and the stop functions).

n. *Modulating Valves*: Require a pulsed digital output signal in lieu of an analog output for valve position from the DCS.

o. *Spare Boards*: Provide a minimum 20% installed spare boards of each I/O type with a minimum of 1 board type per RTU

6. **Operator Interface Hardware and Software**

a. *General*: No additional hardware and software or upgrades to the existing hardware and software at the RRS is necessary.

7. **Protection of Sensitive Electronic Equipment**

a. *General*: The consultant shall follow guidelines for the powering and grounding of sensitive electronic equipment listed in I.E.E.E. Standard 1100-1992.

b. *Dedicated Instrument Panel*: Required to provide 120 VAC power to all of the RTUs, analyzers, etc. that require power. No other loads (such as facility HVAC, etc.) shall be allowed on this panel. This power panel shall have a dedicated uninterruptable power supply upstream of this branch circuit panel for the purpose of voltage stabilization and some minimal forms of isolation. Consultant to evaluate whether to size the UPS for control room devices and all field RTUs or to provide individual UPSs for the control room and each field RTU. Evaluation factors to consider include but are not limited to reliability (MTBF) for battery chargers and batteries vs. MTBF for a single ferroresonant UPS, and cost differential between larger field cabinets vs. cost of a centrally located UPS.

c. *Transient Voltage Surge Suppression*: Required for all 4 wire instruments (such as a chlorine residual analyzer), and placed on the 120 VAC branch circuit and on the 4-20 mA portion of the circuit. The transient voltage surge suppression on the 4-20 mA wiring shall be located on the field side of the proposed 4 wire instrument. For all two wire 4-20 mA instruments that have signal cable running from outdoor to indoor locations (or signal wire run between buildings), transient voltage surge suppression on the field side of the 4-20 mA signal is required.

d. *Grounding*: Each RTU cabinet shall be provided with a direct connection to the ground grid via a driven rod in addition to the equipment safety ground required by the National Electrical Code. Daisy chaining of grounds is not acceptable. A grounding detail showing the interface between the RTU cabinet and the proposed grounding system is required. Instrumentation shields shall be grounded at the DCS end only. Provide grounding straps on unit lengths of conduit runs for better electromagnetic interference. The electrical grounding specifications must be cross referenced to the instrumentation and control specifications so that it is understood that the system integrator monitors the quality of system grounding from an electromagnetic and radio frequency interference (EMI/RFI) standpoint. In order to facilitate an electrically conductive ground mass, provide connections to structural steel and interface them to the grounding system.

e. *Conduit*: All signal cables shall be run in a ferrous conduit (to provide additional electromagnetic interference protection) from the instrument to the DCS.

f. *Diodes*: Shall be provided across all of the digital outputs to limit surges from switch of electromechanical devices (such as motors).

g. *Power Supplies*: Separate power supplies shall be provided for analog inputs and RTUs, and digital outputs.

h. *Conduit Spacing*: Required between power and signal/control cables as listed in I.E.E.E Standard 518-1982.

8. **Communications Equipment**

a. *Data Highway*: A fiber optic data highway will be provided between RTUs (run in a ring configuration) to allow for superior interference protection. Design shall be based around the use of Manmarc modems and IFS 62.4 micron fiber optic cable. Spare fibers will be provided in each pull to allow for the immediate connection of one RTU to another in the event that the installed connections are broken.

b. *Spare Parts*: The consultant shall confer with the Water Company for the required fiber optic spare parts associated with splitter kits, termination kits, and crimping tools. Provide a minimum of 1 spare fiber optic modem per site.

9. **Signal/Control Wiring for Corrosive Areas**

a. *Chlorine and Corrosion Inhibitor*: Use PVC coated rigid galvanized steel as the wiring method in these areas. Where possible, enclosures for control and electrical components should be located outside of the feed rooms. Where this is not possible, the enclosures shall be fiberglass NEMA 4X type enclosures.

10. **Input/Output Lists**: Those provided in the appendices at the end of the Design Concept are <u>preliminary</u> and are only provided to give a general indication of the level of monitoring and control that will be required. The Consultant is required to develop a complete I/O list based on the final design details.

<u>GENERAL BUILDING REQUIREMENTS</u>

1. **Site**

a. *Fencing*: Chain link with barb wire encompassing all facilities. Fence to be grounded if power lines cross overhead.

b. *Entrance*: Manual sliding gate.

c. *Roadways*: Asphalt. Provide concrete in chemical unloading areas where trucks may need to back up and/or turn. *The Consultant shall assume that* *the access road could be as long as 500'.*

- d. *Landscaping*: Minimal seed and shrubbery in front of pump station, natural landscaping elsewhere unless otherwise dictated by local ordinances.
- e. *Signage*: Kentucky-American name and logo at entrance
- f. *Exterior Lighting*: Provide where necessary for security purposes.

2. **Utilities and HVAC**
   - a. *Water Service*: In plant water service to be metered and individual backflow preventors provided where necessary.
   - b. *Sanitary Waste*: Septic system
   - c. *Heating*: Electric heat preferred in the chemical rooms. Need for and source of heat in the pump room to be recommended by the Consultant.
   - d. *Air Conditioning*: Not required. Provide ventilation for control of heat generated by the pumping units. Emergency ventilation for chemical feed systems shall be per American Water Standards (see Attachments).
   - e. *Telephone Service (personnel)*: Not required.
3. **Architecture**
   - a. *General*: The facility shall be designed with the understanding that it will be remote from the KAWC operations and subject to vandalism.
   - b. *Exterior*: Double wall construction utilizing either split face block or brick.
   - c. *Roof*: Flat, fully adhered membrane roof is preferred. Provide access to the roof from the interior of the building.
   - d. *Interior Walls*: Painted block.
   - e. *Wall Penetrations*: All to be provided with cages.
4. **Painting**: All mechanical equipment and other potentially corrosive surfaces to be coated. All exposed metal piping to be color coded per Ten State Standard requirements. PVC or other flexible piping shall either be purchased in the appropriate color (if available) or wrapped or striped with appropriate colored tape.
5. **Safety/Security**
   - a. *Smoke and Fire Alarms*: Provided in pump areas.
   - b. *Security System*: Keypad type provided at entrance door and tied to the distributed control system with local audible alarms.
   - c. *Motion Detectors*: Provided around the exterior of the building and tied to the distributed control system with local audible alarms.
6. **Pumping Unit Removal**: Provide monorail and electric hoist for pulling the pumps. Monorail to be exactly centered over each of the four pumps (and future fifth pump) and extend a minimum of six feet outside the building.
7. **Pumping Unit Access**: Should the height of the pumping units be such that they are not easily accessible for maintenance, provide either a two tiered structure with the cans of the pumps in a partial lower level or teed pumps with buried cans and all other equipment at ground level.
8. **Flood Plain**: Operating floor of the pump station to 3 feet above the 500-year flood elevation.

D. BOOSTER STATION NO. 2 (just downstream of the Glenn's Creek)

PUMPING UNITS and DRIVERS

1. **General**: Same requirements as for Booster Station No. 1.

PIPING AND VALVING

1. **General**: Same requirements as for Booster Station No. 1.

METERING and OTHER PROCESS APPURTENANCES

1. **General**: Same requirements as for Booster Station No. 1

CHEMICAL FEED SYSTEMS

1. **General**: None required at Booster Station No. 2. The same analytical water quality instruments proposed at Booster Station No. 1, however, are also required at Booster Station No. 2.

ELECTRICAL

1. **General:** Same general requirements as for Booster Station No. 1.

INSTRUMENTATION

1. **General**: Same requirements as for Booster Station No. 1 except there will be no chemical feed system I/O.

GENERAL BUILDING REQUIREMENTS

1. **General:** Same requirements as for Booster Station No. 1 *except that the building shall be laid out to accommodate chemical feed facilities (identical to Booster Station No. 1) if needed in the future.*

E. RETENTION BASIN (just downstream of the Kentucky River)

GENERAL

1. **Purpose**: To receive and settle water flushed through the pipeline before disposal to the Kentucky River.
2. **Type**: An earthen basin(s) similar to a lagoon. *The Consultant shall complete the Retention Basin Study described in Section F before making a final recommendation for the most economical type of facility.*
3. **Size**: Adequate to provide 4 hours of detention time at 23.0 MGD with a loading rate of approximately 0.3 gpm/sf.
4. **Liner**: None required.
5. **Effluent Discharge**: Weir structure.
6. **Dechlorination**: Will be accomplished manually utilizing existing KAWC dechlorination trailers.

PIPING

1. **Basin Discharge**: Drain pipe quality (PVC, CMP, etc.) acceptable. Terminate

with a flap gate or duck bill valve at the Kentucky River.

2. **Bottom Drain**: Normally open to prevent accumulation of rain water.
3 **Pig Retrieval**: Provisions to receive either a pig from Booster Station No. 1 or a pig which would be launched backward from the KAWC distribution system shall be provided. The pig retrieval piping facilities shall basically consist of a y-branch and valve off the main pipeline and piped to grade with a cap. The pig launch facilities at the KAWC existing distribution system shall meet the same requirements as those specified for Booster Station No. 1.
4. **Energy Dissipaters**: Provided both within the basin and at the discharge point to Kentucky River.

SITE

1. **Fencing**: Chain link with barb wire encompassing all facilities. Fence to be grounded if power lines cross overhead.
2. **Entrance**: Manual sliding gate.

E. PRELIMINARY ENGINEERING STUDIES

GENERAL

1. **Reason for Studies**: The scope of work presented in the Design Concept has been prepared based on the facilities which are expected to be the most cost effective. However, there are *three*~~two~~ areas which will require further detailed analysis before detailed design can be initiated as defined below.
2. **Schedule:** *The first two* ~~Both~~ studies shall be completed prior to initiating any work on the booster station*s*. Work associated with the pipeline can commence at any time and is not dependent on the outcome of these studies. *The third study shall be completed before initiating any work on the retention basin*
3. **Proposal Assumptions**: The Consultant's proposal shall be based on the scope of work presented in the Design Concept. Should the results of these analyses differ significantly from the defined scope of work, the Consultant will be requested to submit a revised cost proposal at that time.

PUMPING UNIT STUDY

1. **Description of Study:** To determine the optimal type and configuration of pumping units. The Design Concept currently assumes that this configuration will consist of single vertical can turbine pumps for each desired flow range.
2. **Scope of Study**: The study shall encompass and address the following as a minimum.
   - Use of horizontal split case pumps in lieu of vertical can turbines.
   - Use of more than two pumps in parallel to meet the desired higher flow rates.
   - Capital cost considerations for all related facilities beside the pumps themselves (i.e. building size, electrical equipment requirements, instrumentation I/O, etc.).
   - Operational cost considerations such as pump efficiencies, additional

maintenance requirements, etc.

The number and locations of booster stations shall not be addressed in the study. The larger pumping units do not necessarily need to be of the same type or configuration as the smaller pumping units.

ENERGY STUDY

1. **Description of Study:** To determine the optimal source and type of power, especially for the larger pumping units (two estimated 12.0 MGD capacity units in parallel at each booster station) considering that their use will be infrequent. The Design Concept currently assumes that these units will be operated via power from the electric utility.
2. **Scope of Study**: The study shall encompass and address the following as a minimum:
   - Utilization of direct drive diesel engines on all of the larger pumping units in lieu of electric motors.
   - Utilization of a diesel generator(s) for all of the larger pumping units in lieu of electric motors.
   - Utilization of VFDs on the larger pumping units (estimated 12.0 MGD capacity).
   - Utilization of 480V power in lieu of 4160V power for all of the smaller pumping units. This is of particular concern in regard to the costs for the variable frequency drives.
   - Capital cost impact on all related facilities besides the pump drivers and electrical equipment (i.e. building size, power company initial capital fees, etc.).
   - Operational considerations including electric utility demand charges associated with the large difference between average and maximum station capacity, electric utility constraints on the number of starts per period of time and when the loads can be started, and labor required to operate the facility (i.e. ability to remotely operate the selected pump drivers).
3. **4160V vs. Direct Drive Diesel Engine Considerations (Larger Pumping Units)**: The following factors shall be examined by the Consultant in the scenarios associated with the 12.0 MGD pumps installed on a 4160V (or higher voltage) power system:
   - Impact on building space requirements to accommodate the extra switchgear, relaying, etc. described previously in the Medium Voltage Motor section.
   - Impact on station reliability to determine:
     - Reliability of switchgear (number of failures expected per year, expected downtime, etc.)
     - Reliability of a 12.0 MGD motor (number of failures expected per year, expected downtime, etc.)
   - Impact on power system relaying:

- ▫ The need for differential type relaying and directional overcurrent relaying.
- ▫ Utility interface requirements due to the large service involved (as opposed to simply running 300 HP motors on a medium or low voltage power system).

- Impact on grounding system design - What additional features need to be included in the design and selection of devices to protect personnel and equipment?
- Impact on surge protection and lightning protection - What additional features must be added to large rotating machinery to protect them from excessive winding stresses caused by lightning or other anomalies? What impact does this have on space requirements, etc.
- What impact will the running of the large motors have on the need for power factor correction to ensure that demand charges are acceptable?
- What impact will the selection of large machines have on the Water Company's ability to obtain maintenance engineering and spare parts support? The Consultant must identify a minimum of two (2) NETA certified shops that can work on electrical machines of this size. In addition, the Consultant shall identify a minimum of two (2) shops capable of performing re-wind, vibration, and other mechanical testing on these machines during the evaluation phase of the design.
- What are the regulatory impacts of these units (from a sound attenuation standpoint in both motor/diesel driver scenarios and an emissions standpoint if a diesel driver is used)?
- What is the impact on system efficiency when comparing the diesel driver to an electric system? Specifically, what are the efficiencies (both electrical and mechanical) for the two alternatives at varying loads?

4. **4160V vs. 480V Considerations (Smaller Pumping Units)**: The Consultant shall evaluate the following factors when comparing the smaller at 4160V versus 480V:
   - Installed first cost
   - Impact on space requirements
   - Life cycle cost issues associated with the cost of maintenance, spare parts, etc.
   - Reliability (failures per year, the number of hours of expected downtime)
   - Efficiency requirements
   - For loads run on VFD's, the Consultant should analyze the costs, benefits and limitations of running the VFD's at 480V in the case of a 4160V system. This cost should address factors such as space, effects on the power system (as far as motor starting, harmonic suppression, etc.)

RETENTION BASIN STUDY

1. ***Description of Study:*** *To determine the most economical means for receiving, settling, and discharging water flushed through the pipeline. The Design Concept* *currently assumes that this will be accomplished with the use of an earthen lagoon type retention basin.*

2. ***Scope of Study:*** *The study shall encompass and address the following as a minimum:*
    - *Use of a vortex type separator in lieu of an earthen lagoon*
    - *Capital costs including land purchase costs*

APPENDIX A

Acceptable Equipment Manufacturers

1. PIPING, VALVING, and APPURTENANCES

Equipment Description	*Manufacturers*
Ductile Iron Pipe	American Ductile Iron Pipe Griffin Pipe Products United States Pipe and Foundry
Reinforced Concrete Pipe	Price Brothers Company
Steel Pipe	Thompson Pipe and Steel Company L.B. Foster Company
Pump Control Valves (ball or cone)	Henry Pratt Company Golden Anderson Willamette
Butterfly Valves w/Electric Operators	DeZurik Henry Pratt Company
Butterfly Valves w/Manual Operators	DeZurik Henry Pratt Company Clow Valve Company
Resilient Seat Gate Valves	Mueller Company Clow Valve Company United States Pipe and Foundry American Flow Control
Plug Valves	DeZurik Henry Pratt Company Keystone Valve Company
Air Valves	Golden Anderson Cla-Val APCO Val-Matic
Blowoff Valves	Kupferle
Surge Tanks and Related Equipment	Fluid Kinetics Corporation
Bronze Ball Valves	Conbraco Industries Watts Regulator Company
Backflow Preventers	Ames Company, Inc. Watts Regulator Company
Displacement and Turbine Meters	Sensus Technologies, Inc. Schlumberger Industries
Magnetic Meters (full body)	Sparling Instruments, Inc. Fischer and Porter Rosemont
Venturi Meters	Leeds and Northrup

	Henry Pratt Company Primary Flow Signal
Pressure Gauges (liquid filled)	Trerice

2. PUMPING EQUIPMENT and DRIVERS

Equipment Description	*Manufacturers*
Vertical Can Turbine Pumps	Byron Jackson Floway Fairbanks Morse PACO Peerless Pump Company
Horizontal Split Case Pumps	Goulds Ingersoll Dresser Patterson Pump Company Peerless Pump Company Worthington
Electric Motors	Continental General Electric U.S. Motors Siemens
Diesel Engines	Cummins Detroit Diesel Caterpillar

3. CHEMICAL FEED FACILITIES

Equipment Description	*Manufacturers*
XLHDPE Chemical Storage Tanks	Poly Processing Company Nalgene Industrial Products Group
Metering Pumps and Liquid Feed Equipment	Wallace & Tiernan Prominent Fluid Controls Pulsafeeder, Inc. JAC Milton Roy Company - LMI
Chlorinators and Gaseous Feed Equipment	Wallace & Tiernan Capital Controls Company
Chlorine Scrubbers	Environmental Systems Technology RJ Environmental Powell Fabrication and Manufacturing
Magnetic Centrifugal Transfer Pumps	March Manufacturing Inc. Iwacki Walchem
Gaseous Chemical Cylinder Scales	Force Flow Equipment
Chemical Ball Valves	Chemtrol
Fill Connections	Civacon

4. ELECTRICAL

Equipment Description	*Manufacturers*
Electric Valve Operators	Auma Actuators, Inc. EIM Limitorque Corporation
Variable Frequency Drives	Allen-Bradley Cutler Hammer/Westinghouse (Eaton) Robicon
Motor Control Centers	General Electric Allen Bradley Westinghouse/Cutler Hammer Square D
Switchgear	General Electric Westinghouse Square D
Panel Boards	General Electric Westinghouse/Cutler Hammer Square D
Outdoor Transformers	General Electric Westinghouse/Cutler Hammer Square D
Dry Type Transformers	General Electric Westinghouse/Cutler Hammer Square D
Transient Voltage Surge Suppressers	Advanced Protection Technologies
Push Button Selector Switches/Pilot Light	General Electric Allen Bradley Westinghouse/Cutler Hammer Square D
Relays	General Electric Westinghouse/Cutler Hammer Potter Brumfield
Control Relays, Timing Relays	IDEC Diversified Electronics Agastat
Power Panels	General Electric Westinghouse/Cutler Hammer Square D
Lighting	Holophane Day-Brite Benjamin

5. INSTRUMENTATION

Equipment Description	*Manufacturers*
pH Analyzers	Leeds & Northrup

	Great Lakes Instruments
Chlorine Residual Analyzers	Wallace & Tiernan Capital Controls Company Hach Company
Ultrasonic Level Probes	Endress Hauser Inventron Miltronics
Conductance Level Switches	Drexelbrook Corporation Warrick/B&W
Pressure Transmitters	Foxboro Rosemont
Pressure Switches	Mercoid/Dwyer
Solenoid Valves	Automatic Switch Company
Motor Monitoring Equipment	Bentley Nevada
Modems	Manmarc
Uninterruptable Power Supply	Best
Remote Telemetry Units	Bristol Babcock, Inc.
Signal Isolators	AGM
Terminal Blocks	Weidmuller/Phoenix Contact
RTU Cabinets	Hoffman Rittal
System Integrators	Bristol Babcock Industrial Control Systems

6. GENERAL BUILDING REQUIREMENTS

Equipment Description	*Manufacturers*
Paint	Carboline Paint Company M.A. Bruder and Sons (MAB) Sherwin Williams Company Tnemac Company, Inc.

APPENDIX B

Preliminary Input/Output List
(note: each line of description will pertain to multiple units at both booster stations as applicable)

1. PUMPING UNITS and DRIVERS

Description	*Type*	*Local Redundancy*
Pump On	DO	at motor starter
Pump Off	DO	at motor starter
Pump Motor Frequency	AO	at VFD
Pump Local/Remote Status	DI	at HOA switch
Pump On Status	DI	visual
Pump Off Status	DI	visual
Pump Motor Frequency Status	AI	at VFD
System Voltage	AI	at power monitoring equipment
System KWH	AI	at power monitoring equipment
System Amperage	AI	at power monitoring equipment
System Vars	AI	at power monitoring equipment
System Watts	AI	at power monitoring equipment
System Power Factor	AI	at power monitoring equipment
Pump Motor Bearing Temperature	AI	at motor monitoring equipment
Pump Motor Winding Temperature	AI	at motor monitoring equipment
Pump Motor Vibration	AI	at motor monitoring equipment
Pump Motor Thrust	AI	at motor monitoring equipment

2. PROCESS APPURTENANCES

Description	*Type*	*Local Redundancy*
Rate of Flow Control Valve	AO	at valve
Rate of Flow Control Valve Position	AI	at valve
Station Suction Pressure *	AI	pressure gauge
Station Discharge Pressure *	AI	pressure gauge
Station Flow Rate *	AI	at meter
Pump Control Valve Position	AI	at valve (note: control to be local only)

* to also be monitored by LWC

3. CHEMICAL FEED FACILITIES

Description	*Type*	*Local Redundancy*
Bulk Tank Level (ultrasonic)	AI	LED readout at tank and fill point
Bulk Tank High-High Level	DI	LED readout at tank and fill point
Day Tank Level (ultrasonic)	AI	LED readout at tank
Day Tank High-High Level	DI	LED readout at tank
Transfer Pump Run Status	DI	visual

Feed Equipment Local/Remote Status	DI	at HOA switch
Feed Equipment On/Off	DO	at feeder
Feed Equipment Speed	AO	at feeder
Feed Equipment Stroke	AO	at feeder
Feed Equipment Run Status	DI	visual
Containment Area Leak Detection	DI	alarm light
Eduction Water Flow Status	DI	none
Cylinder Weight	AI	dial readout at scale
Gas Leak Indication	DI	at detector
Eduction Vacuum Status	DI	pressure gauge
pH	AI	at instrument
Total Chlorine Residual	AI	at instrument
Free Chlorine Residual	AI	at instrument

4. GENERAL BUILDING REQUIREMENTS

Description	*Type*	*Local Redundancy*
Smoke and Fire Alarm	DI	at alarm panel
Intrusion Alarm	DI	at alarm panel
Motion	DI	at alarm panel

ATTACHMENT B

Design Memorandum Requirements

KENTUCKY-AMERICAN WATER COMPANY
BLUEGRASS WATER PROJECT

DESIGN MEMORANDUM REQUIREMENTS

The information provided below outlines the minimum design information that must be included in the Design Memorandum. The Consultant shall add additional information to the memorandum when appropriate to ensure that all critical design parameters are reviewed and agreed to by the Water Company before initiating detailed design and drafting. It will be necessary for the Consultant to interface closely with the Water Company in developing the Design Memorandum.

The main section of the Design Memorandum must include project design data which will be utilized in the development of drawings and specifications. This would include quantities, capacities, rates, and all other pertinent design criteria for each specific section presented in the Design Scope. A comparison of the required facilities (as calculated or as specified in the Design Scope) to the selected facilities is critical such that the Water Company can understand how the proposed facilities were selected. This information must be presented in an organized, easy to read tabular or outline format with minimal full sentence text. Two generic examples are presented below as guidance.

Example No. 1 - Pumping Facilities
General Pumping Information
Pumpage Requirements: 1.5 - 3.0 - 5.0 MGD min-avg-max
Means of Flow Control: Variable frequency drives

Pumping Unit Selection (Pumps 1, 2, and 3 are Identical)
Type of Pump: Vertical Turbine
Capacity: 3.0 MGD @ 50 ft TDH
Best Efficiency Point: 2.5 MGD @ 45 ft TDH
Minimum Capacity: 1.5 MGD @ 40 ft TDH (50% turndown)
Efficiency: 75 - 88 - 82% min-avg-max
NPSHR: 10 - 15 - 22 ft min-avg-max
NPSHA: 40 ft
Maximum HP at any Point of the Curve: 32 HP
Motor Selection: 40 HP
Capacity of any Two Pumps in Parallel: 5.2 MGD @ 63 ft TDH

Example No. 2 - Chemical Feed Systems
General Chemical Information
Chemical: Aluminum sulfate
Purpose: Primary coagulant
Product Form: Liquid
Product Concentration: 48%

Product Density: 11.10 lb/gal
Dry Weight Dosage Requirements: 2.0 - 15.0 - 50.0 mg/L min-avg-max.

Bulk Storage
Minimum Bulk Shipping Volumes: 5,000 gal (if bulk storage is utilized)
Drum Storage Size: 55 gal (if drum storage is utilized)
Total Storage Required: 31 days
No. of Drums Required (max day - avg dose): 80
No. of Drums Required (avg day - max dose): 133
Bulk Tank Size Required (max day - avg dose): 4,368 gal
Bulk Tank Size Required (avg day - max dose): 7,279 gal
125% of Minimum Bulk Shipping Volume: 6,750 gal
Bulk Storage Selection: 10,000 gal bulk tank

Day Storage
Max Transfer Time Desired: 2 min (per the Water Co.)
Bulk Tank Size Required (max day - avg dose): 141 gal
Bulk Tank Size Required (avg day - max dose): 235 gal
Transfer Pump Capacity Required (max day - avg dose): 71 gph
Transfer Pump Capacity Required (avg day - max dose): 118 gph
Day Tank Selection: 300 gal
Transfer Pump Selection: 120 gph

Feed Capabilities
Feed Form: Liquid
Feed Concentration: 100%
Feed Method: Metering pump
Point(s) of Application: Upstream of raw water static mixer
Maximum Feed Requirement (max dose - max day): 19.57 gph
Average Feed Requirement (avg dose - avg day): 2.93 gph
Minimum Feed Requirement (min dose - din day): 0.13 gph
Feeder 1 Selection: 20 - 0.2 gph (100:1 turndown)
Feeder 2 Selection: 10 - 0.1 gph (100:1 turndown)
Feeder 3 Selection: 10 - 0.1 gph (100:1 turndown)

* Provide minimal supplemental text or sketches to clarify the above as necessary.

Along with the above , it is also necessary to include the following information in the Design Memorandum. All drawings and sketches shall be no larger than 11" x 17".

a. The results of the steady state hydraulic analysis presented by way of a hydraulic profile along the entire pipeline route.

b. Results of the surge analysis (in summary format).

c. A process schematic at the booster stations showing all process units, points of chemical application, and points of on-line analytical sampling as a minimum.

d. Chemical feed system schematics.

e. Booster station survey drawings.

f. Preliminary booster station design drawings showing general layouts, sections, and architectural treatment.

g. The I/O list, functional descriptions, and graphic display, report, alarm, and historical database definition.

h. The narrative description of the operation of the proposed facilities.

i. A listing of major equipment required for the project including the manufacturer and model no. which will be used as the basis for design. If possible, at least two other alternative manufacturers shall be identified for all major equipment for inclusion in the specifications.

j. The construction cost estimate. The initial submittal of the design memorandum shall include the preliminary estimate. The final estimate shall be provided for review at the final design review meeting.

k. An update of all permit information as specified in the Information to be Submitted with the Proposal.

l. All geotechnical information. The Consultant shall summarize the information from the geotechnical investigation report in the Design Memorandum, and also include a copy of the report as an attachment.

m. A summary of any significant issues resulting from discussions with utility companies.

n. An updated project schedule.

ATTACHMENT C

American Water Works Service Co., Inc. Applicable Standards and Examples

1. T-2: Liquid Chemical Storage, Feed, and Containment
2. T-9: Compressed Gas Feed Systems and Storage Facilities
3. Generic Control Logic
4. Example RTU Interconnection Drawing
5. *Example Plan and Profile Pipeline Drawing*

AMERICAN WATER SYSTEM

ENGINEERING STANDARDS

T-9 COMPRESSED GAS FEED SYSTEMS AND STORAGE FACILITIES

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COMPRESSED GAS FEED SYSTEMS AND STORAGE FACILITIES

Table of Contents

			Page
I.	INTRODUCTION		1
	A.	BACKGROUND	1
	B.	SCOPE	1
	C.	PURPOSE	1
II.	TECHNICAL CONTENT		2
	A.	COMPRESSED GAS PHYSICAL PROPERTIES	2
		1. Chlorine	2
		2. Ammonia	2
		3. Sulfur dioxide	3
		4. Table of properties	3
	B.	COMPRESSED GAS FEED CALCULATIONS	4
		1. Vapor Pressure Table	4
		2. Withdrawal Factors	5
	C.	COMPRESSED GAS FEED SYSTEM COMPONENTS	6
		1. Scales	6
		2. Vaporizer	6
		3. Vacuum regulator/automatic switchover device	7
		4. Pressurized gas piping and appurtenances	7
		5. Gas dispensers	8
		6. Vacuum piping and valves	8
		7. Fixed throat ejectors	9
		8. Water supply line, booster pumps, and appurtenances	9
		9. Diffusers	10
		10. Analytical equipment	10
	D.	COMPRESSED GAS STORAGE AND FEED ROOM ELEMENTS	10
		1. Room materials of construction	11
		2. Access doors and cylinder handling	11
		3. Vision panels and windows	12
		4. Heating	12
		5. Lighting	12
		6. Leak detection	12
		7. Ventilation	13
		8. Safety and maintenance appurtenances	13

Page

III. RECOMMENDATIONS FOR EXISTING FACILITIES 14

IV. REFERENCES 14

V. ATTACHMENTS

A. VAPOR PRESSURE CURVE.................................. A
B. TYPICAL FEED SYSTEM SCHEMATIC .... B
C. TURBINE BOOSTER PUMP SCHEMATIC...................... C
D. TYPICAL STORAGE FACILITY LAYOUT...................... D
E. STORAGE ROOM (WITH EXTERNAL DOOR) INSTRUMENTATION SCHEMATIC .... E
F. FEED ROOM (WITH INTERNAL DOOR) INSTRUMENTATION SCHEMATIC .... F

COMPRESSED GAS FEED SYSTEMS AND STORAGE FACILITIES

INTRODUCTION

A. BACKGROUND

Disinfection and dechlorination are commonly achieved at water treatment plants with the use of gaseous chemicals. For high feed rates, the use of gaseous chemicals typically results in a more cost effective system and simplifies operations and maintenance. While these chemicals are necessary to provide a safe potable water, improperly designed feed and storage facilities present the potential for injury to humans and damage or deterioration of plant facilities. Gaseous chemicals present a two fold liability to humans in that both excessive consumption of the chemical through the drinking water and inhalation or exposure in the event of a leak can result in serious consequences.

B. SCOPE

This Standard encompasses significant design considerations for compressed gas feed systems and storage facilities for three specific gaseous chemicals commonly used in water treatment. These chemicals are chlorine, ammonia, and sulfur dioxide. Chlorine gas is the most common of the three chemicals, and is utilized primarily for disinfection and oxidation. The use of ammonia for the formation of chloramines is becoming more prevalent for disinfection by-product control. Sulfur dioxide is the least common of the three chemicals and is used when dechlorination is necessary. The use of sulfur dioxide for dechlorination may become more popular in the future as disinfection/DBP regulations become more stringent.

This Standard addresses the specific components required for both the feed systems and the storage facilities, as well as addressing the properties of the specific chemicals and the basic theories and equations used in designing these facilities. The design of feed and storage facilities for all three chemicals is similar, and the specific differences for each are addressed within this Standard. Various industry standards and practices along with other published technical literature have been reviewed, consolidated, and incorporated into this Standard as necessary. Specific State requirements are not identified within this Standard.

C. PURPOSE

An engineering standard is necessary to ensure that compressed gas feed and storage facilities are properly designed. This Standard is meant to be used by engineers and other experienced personnel as a guide in the design and modification of these facilities. Sketches and schematics are provided only to illustrate the various recommendations and should not be construed as being precisely applicable for all installations. Selection of specific equipment, sizing of components, and hydraulic analyses are examples where technical expertise is required. Manufacturer's recommendations and literature must also be consulted for all installations.

This Standard is written primarily to address the requirements for new facilities, however, guidance for incorporating these recommendations into existing facilities is also provided. The Standard is meant to provide sound technical information, and good judgment must be used in incorporating this information into the design process, especially for existing facilities. It is important that the engineer recognize the purpose of the recommendations within this Standard, and maintain the intent of the specific recommendation as opposed to attempting to comply exactly with the details. The basis behind specific recommendations is included throughout the text.

II. TECHNICAL CONTENT

A. COMPRESSED GAS PHYSICAL PROPERTIES

Chlorine, ammonia, and sulfur dioxide are supplied by chemical manufacturers in a liquid state in various size steel cylinders. The combination of temperature and pressure causes the gas to liquefy, thus permitting significantly larger volumes to be stored and shipped. At a specific temperature, the gas and liquid exist in equilibrium with a resulting pressure that allows for withdrawal and feeding of the gaseous form of the chemical. Each compressed gas has distinctive physical and chemical properties, however the requirements for feeding and storage are similar.

Exposure to chlorine, ammonia, or sulfur dioxide gases will cause irritation of the eyes, nose, throat, and lungs. Each gas exhibits a sharp pungent odor which is readily detected by the human senses. Exposure to a sufficiently high concentration of any of the three gases can be fatal. However, complete recovery should occur following a mild exposure since none of the gases produces a cumulative physiological effect on the human body.

1. Chlorine

Chlorine is a chemical element belonging to the halogen group. Chlorine gas is approximately 2 1/2 times heavier than air, thus if it escapes from its cylinder it will seek the lowest level in the room in which the leak occurred. It has a characteristic odor and is greenish yellow in color. Both chlorine gas and chlorine liquid are non-explosive and non-flammable, however, it is an oxidizer and capable of supporting combustion of certain substances. Many organic chemicals react readily with chlorine, sometimes violently. When moisture is present, gaseous chlorine is strongly corrosive to metals.

2. Ammonia

Ammonia is a compound formed by the chemical combination of the elements nitrogen and hydrogen in the molar proportion of one part nitrogen to three parts hydrogen. It is commonly referred to as anhydrous ammonia. Ammonia gas weighs approximately 1/2 as much as air, is colorless, and has a pungent odor. It is classified by the United States Department of Transportation as a non-flammable gas since it has a very narrow flammable range in air of only 16%-25% by volume. However, the National Electric Code classifies ammonia as a Class I, Group D gas which may be an explosion hazard in a confined space. Therefore, all ammonia installations must be designed with explosion proof electrical components if the specific components cannot be located outside of the room. Most common metals are not effected by dry ammonia, however, when water or water vapor is present, ammonia will attack copper and zinc or alloys containing major proportions of these metals. Mixtures of hydrogen and chlorine gas can react violently, therefore ammonia and chlorine must be kept isolated from each other.

3. Sulfur dioxide

Sulfur dioxide is a compound formed by the combination of the elements sulfur and oxygen. On a weight basis, the proportion of the elements is about one part sulfur to one part oxygen. Sulfur dioxide gas is more than twice as heavy as air, but slightly less dense than chlorine gas. It is a colorless gas with a characteristic pungent odor. Sulfur dioxide is not flammable nor explosive in either the gaseous or liquid state. Dry sulfur dioxide is not corrosive to most metals, however, in the presence of even small amounts of water, it is corrosive to most metals.

4. Table of properties

Properties of importance of the three compressed gases described above are as follows:

	Chlorine (Cl_2)	**Ammonia (NH_3)**	**Sulfur Dioxide (SO_2)**
Molecular weight	70.906	17.031	64.06
Specific gravity (air = 1.0)	2.49	0.60	2.26
Freezing point	-150° F	-108° F	-105° F
Boiling point-	-29° F	-28° F	+14° F
Vapor pressure @ 70° F	86 psi	114 psi	34 psi
Critical temperature	291° F	270° F	315° F
Critical pressure	1157 psia	1636 psia	1143 psia
Latent heat of vaporization	124 BTU/lb	588 BTU/lb	156 BTU/lb
Dangerous air concentration	40-60 ppm	2000-3000 ppm	400-500 ppm

The freezing and boiling points are defined as the respective temperatures at which the liquid state of the gas either solidifies or vaporizes at atmospheric pressure. Vapor pressure is the absolute pressure of the gas above the liquid in a closed system at a given temperature when they are in equilibrium. Critical temperature is the temperature above which the chemical can exist only as a gas no matter how great the pressure, and critical pressure is the resulting pressure at the critical temperature. The latent heat of vaporization is defined as the amount of heat required to evaporate a unit weight of the liquid state of the chemical. The dangerous air concentrations are those approximate concentrations at which continuous exposure of at least 30 minutes could be fatal. All of these properties are important in the design of the feed and storage facilities as discussed in subsequent sections.

B. COMPRESSED GAS FEED CALCULATIONS

Sustained gas withdrawal rates from chlorine, ammonia, or sulfur dioxide cylinders are dependent on several factors including the specific gas, the ambient temperature where the cylinders are located, the operating requirements of the gas dispenser system, and the size of the cylinder. The air circulation rate, the humidity in the storage room, and the amount of liquid remaining in the cylinder also effects the withdrawal rate, however, the effect is small in comparison with the other factors and can be neglected in the final withdrawal calculations.

As gas is withdrawn from a cylinder, a specific amount of heat (latent heat of vaporization) is needed to evaporate the liquid. If adequate heat is not available in the air surrounding the cylinder, the heat will be taken from the liquid resulting in a temperature drop as evidenced by a cooling of the cylinder. This temperature drop results in lower pressures within the cylinder which in turn gradually diminishes the rate of gas flow from the cylinder. If the humidity is high and moisture is present in the air, frost will form on the cylinder which will act to insulate the cylinder and further reduce the amount of heat that can be taken from the surrounding air. Circulating the air around the cylinder can improve this condition. Additionally, as the liquid in the cylinder is depleted, the area of the cylinder in contact with the liquid is lessened which reduces the transfer of heat to the liquid which also reduces the withdrawal from the cylinder.

Each specific gas dispenser system requires a minimum amount of pressure to operate properly. Most vacuum operated gas dispenser systems require approximately 12-14 psi at the vacuum regulator for proper operation which must always be verified with the manufacturer. The temperature at which this minimum required pressure is reached is referred to as the threshold temperature. The threshold temperature for a specific chlorinator can easily be found from a vapor pressure curve for the specific gas if the required pressure for the vacuum regulator to operate properly is known. Vapor pressure curves for the three gasses addressed in this standard can be found in Attachment A. A partial tabular form of the graph in Attachment A is presented below.

	VAPOR PRESSURE, psig		
AMBIENT TEMP, F	**Chlorine**	**Ammonia**	**Sulfur Dioxide**
0	14	16	-
10	21	24	-
20	28	34	2
30	37	45	7
40	47	59	12
50	59	75	18
60	71	93	26
70	86	114	34

It can be seen that the vapor pressure increases as the temperature increases. As previously shown, the pressures can exceed 1000 psi for any of the three gasses as the critical temperature is approached.

The size of the cylinder also effects the withdrawal rate since a larger cylinder has more surface area to transfer the heat from the surrounding air to the liquid. The combination of the size of the cylinder and the latent heat of vaporization for the specific gas allows for the use of a withdrawal factor to simplify the withdrawal rate calculations. Withdrawal factors for each of the specific gases and types of cylinders are as follows:

COMPRESSED GAS	WITHDRAWAL FACTOR
Chlorine	
150-lb cylinder	1.0
1-ton container	8.0
Ammonia	
100-lb cylinder	0.3
150-lb cylinder	0.4
800-lb container	3.2
Sulfur Dioxide	
150-lb cylinder	0.75
1-ton container	6.0

Therefore, the withdrawal factors for different gases having cylinders of the same geometric proportions are approximately proportional to the ratio of latent heat of vaporization values. For example, chlorine and sulfur dioxide 150-lb cylinders are approximately identical in size and shape, therefore, their withdrawal factors differ by the ratio of their respective latent heat of vaporization values. Note that this is not the case for a 150-lb ammonia cylinder since the density of ammonia is significantly less than that of chlorine or sulfur dioxide, and therefore a much larger cylinder is needed to contain 150 lbs of ammonia. The dimensions of the larger cylinder allow for more heat transfer to the liquid which results in a withdrawal factor that is higher than the ratio of latent heat of vaporization values.

Considering all of the above, the following calculation can be used to determine the maximum withdrawal rate from a cylinder, or the required room temperature to feed at a given rate:

[(Room temp, F - Threshold temp, F) x Withdrawal factor] = Maximum withdrawal rate (lbs/day)

For example, if chlorine was being fed from 150-lb cylinders with a typical vacuum operated gas dispenser system which required a gas pressure of 14 psi, and the room was heated to 70 F, the maximum withdrawal rate from a single cylinder would be: [(70 - 0) x 1.0] = 70 lbs/day. This confirms the general rule of thumb for feeding chlorine from 150-lb cylinders of 1 lb/day for each degree F the storage room is heated to. However, this rule of thumb does not hold true for other gases and various size cylinders since both the threshold temperature and withdrawal factors will be different. If the total feed requirements for a particular installation cannot be achieved with a single cylinder at a practical room temperature, other means must be taken such as manifolding multiple cylinders or providing a vaporizer. If manifolding of cylinders is pursued, care must be taken to ensure that all the cylinders are at the same temperature and pressure. Additional information regarding vaporizers is addressed in a subsequent section. Under no circumstances shall direct heat be applied to the cylinders in an attempt to increase the withdrawal rate.

C. COMPRESSED GAS FEED SYSTEM COMPONENTS

Compressed gas feed systems can be one of two types; either vacuum operated or direct feed. In a vacuum operated system, gas flow to the point of application is induced by a vacuum created from an external source. The pressurized gas exiting the cylinder is reduced to less than atmospheric pressure by means of a pressure reducing valve referred to as a vacuum regulator. In a direct feed system, gas flow is generated directly from the pressure in the cylinder. Vacuum operated systems are recommended for all installations due to the potential hazards associated with breaks in the piping between the cylinders and the point of application in a direct feed system. Additionally, vacuum operated systems safeguard against reliquification of the gas within the piping system as discussed in more detail below.

The following system components are required for the proper operation of a vacuum operated compressed gas feed system. This standard does not address direct feed systems. A schematic of a typical compressed gas feed system is also provided in Attachment B.

1. Scales

Systems utilizing storage in cylinders 1 ton and smaller shall provide appropriate means of measuring the chemical usage in the form a dual cylinder scale. Scales for 150-lb and smaller cylinders shall be of the type that cylinders can be easily rolled on and off, thereby preventing the need to locate the scale in a recessed pit. Restraint chains to keep the cylinders from tipping shall also be provided with the scale. Scales for cylinders one ton and larger shall be load cell type. They shall be bolted to the floor and provided with trunnions to allow for easy positioning of the container valves. It should be noted that 150-lb and 100-lb ammonia cylinders have diameters larger than a 150-lb chlorine cylinder, and typical 150-lb chlorine cylinder scales cannot accept cylinders of larger diameter. For manifolded cylinders, it is only necessary to provide a scale for one pair of cylinders since the withdrawal from each individual cylinder will be the same provided all the cylinders are exposed to the same ambient air temperature.

At a minimum, two sets of dual scales shall be provided to separately inventory all pre and all post chemical usage. Depending on the number of points of application and the usage at each of these points, it may also be advisable to provide additional inventory. This could be accomplished either with a dedicated dual scale or an individual gas flow meter located at the gas dispenser for each individual point of application.

2. Vaporizer

When it is not practical to manifold cylinders together to achieve the required gas withdrawal rates, a vaporizer (evaporator) shall be provided. The vaporizer receives the liquid chemical from the cylinder, supplies the necessary heat to vaporize the liquid into the gaseous state at a rate sufficient to meet the desired feed rate, and discharges the gas to the gas dispensers. Vaporizers are usually water-jacketed or steam heated. Special precautions must be taken when providing vaporizers, and manufacturer's recommendations, Chlorine Institute Pamphlet 9, and ASME codes must be consulted.

3. Vacuum regulator/automatic switchover device

A vacuum regulator is a spring-loaded pressure reducing valve which reduces the gas pressure in the storage cylinders to a constantly regulated vacuum, usually about 20" of water column. Each weighed cylinder or set of manifolded cylinders requires a vacuum regulator. The vacuum regulator should be installed as close as possible to the cylinder to minimize the length of pressurized gas piping, and must never be located outside of the cylinder storage room. For manifolded cylinders, a single vacuum regulator can be mounted on a manifold for each set of weighed cylinders unless local regulations require the vacuum regulator to be mounted directly on the cylinders. Vacuum regulators mounted on manifolds shall be located at an elevation higher than the storage cylinders to allow liquid which may form in the piping to flow back to the cylinder.. A spare, non-installed vacuum regulator shall be provided for each capacity required for the system. The vacuum regulator shall be sized for a feed rate based on maximum expected flow rate and dosage.

Automatic switchover capabilities are required for all pairs of cylinders or pairs of manifolded cylinders to provide uninterrupted operation of the chemical application. A pair of combination vacuum regulator/automatic switchover devices is recommended for this purpose. The valve on standby is held closed by a detent-type lockout. When the on-line supply is exhausted, the system vacuum rises to a higher than normal level which overcomes the latching force of the detent in the stand-by vacuum regulator causing both cylinders to be on-line which ensures complete emptying of the first cylinder. A separate automatic switchover device in combination with standard vacuum regulators is also acceptable, however, such units which require power to operate the automatic switchover device are not recommended.

4. Pressurized gas piping and appurtenances

Flexible pipe runs are recommended for all piping between the cylinders and the vacuum regulators if the vacuum regulator is not mounted directly on the cylinder. Soft seamless copper tubing is required for chlorine and sulfur dioxide service. Rubber hose with external metallic armor is required for ammonia service. Should it become necessary to use permanent rigid pressurized piping between the cylinders and the vacuum regulators, only schedule 80 high temperature seamless carbon steel piping shall be used. Permanent rigid piping shall be color coded in accordance with Ten State Standards or individual State color coding schemes. Shut off valves, if required, shall be ball type with forged carbon steel bodies.

A pressure gauge with petcock shall also be installed in the piping immediately upstream of the vacuum regulator to monitor the pressure in the cylinders. The gauge shall be rated for twice the expected operating pressure of the cylinder. The gauge shall be a diaphragm type, and the diaphragm materials of construction will vary for the specific gas. Tantalum is required for chlorine and sulfur dioxide, and stainless steel is required for ammonia. Silver is also a suitable diaphragm material for chlorine service.

Pressurized gas could reliquify within the piping if the temperature in the storage room were to drop below its normal operating temperature. Typical vacuum operated equipment is designed for gas service only and could become damaged if it comes in contact with the liquid form of the chemical. Therefore, all pressurized piping should slope towards the cylinder to allow any liquid which may form to flow back to the cylinder. If the piping cannot slope towards the cylinder, a trap (drip leg) is required just upstream of the vacuum regulator and pressure gauge. A drip leg is also required just upstream of the vacuum regulator and pressure gauge for all ton cylinder installations to collect the liquid that comes from the ton cylinder's gas eduction tube when initially opened. The trap shall be 1-inch in diameter, 18 inches long, and permanently capped at the end. Whenever a trap is used, a strainer should also be installed immediately upstream of the trap to remove entrained solids such as pipe scale. The strainer shall be a basket type of all steel construction.

5. Gas dispensers

Vacuum operated gas dispensers are required for each point of application, and shall be located in a separate room from the storage cylinders. The gas dispensers shall be sized to provide a feed rate based on maximum expected flow and dosage. A secondary gas dispenser is required for a specific point of application when the minimum expected feed rate falls within the bottom 10% of the primary unit's turndown ratio. Additionally, at least one spare gas dispenser with the capability of meeting the feed range requirements described above shall be provided in place and piped for use to all points of application. Each gas dispenser shall have isolation valves installed both upstream and downstream.

All gas dispensers shall be provided with vent lines. The vent line should slope on a continuous down gradient for chlorine and sulfur dioxide and a continuous upward gradient for ammonia to the exterior of the building to an area where gas fumes cannot cause injury to personnel. The vent lines shall terminate with a turned down plastic screen. If vent lines are manifolded from several gas dispensers, the flow area of the manifold shall be at least equal to the summation of the flow area of the individual gas dispenser vent lines. Each vent line shall have an individual shutoff valve if it is manifolded to a common header.

Gas dispensers can operate either manually, by flow proportional control, or by compound loop control. Flow proportional control is recommended when the process flow rate is not relatively constant. Compound loop control is recommended when both the process flow and influent residual are not relatively constant. Direct residual control is not recommended since the response time to varying conditions is slow. Controllers can be mounted either integral with the gas dispenser or remotely.

6. Vacuum piping and valves

Hard piped schedule 80 PVC piping or flexible plastic tubing shall be used for vacuum or solution piping downstream of the vacuum regulators. Manufacturer's literature must be consulted to determine the sizing and maximum line lengths for the specific chemical and feed rates for vacuum piping. The piping can have flanged, threaded, or solvent welded connections, and particular attention shall be taken to prevent air leaks. Vent lines from the gas dispensers shall also be constructed of schedule 80 PVC pipe or flexible plastic tubing. Valves in vacuum lines shall be ball type with PVC materials of construction. Vacuum, solution, and vent piping shall also be color coded and distinguishable from the pressurized gas piping.

A vacuum gauge shall be installed just downstream of the vacuum regulator to verify proper operation of the vacuum regulator. A typical vacuum regulator operates at approximately 20-inches of vacuum water column, and the gauge shall be a compound diaphragm type with 20-inches of vacuum as the approximate mid point in the range. The same materials of construction as recommended for the pressure gauge diaphragm apply to the vacuum gauge also. Since the gas in the piping downstream of the regulator is under a vacuum, the temperature drop required to convert this gas to a liquid is significant, and therefore traps are not required in vacuum piping.

7. Fixed throat injectors

A fixed throat injector (eductor) with integral check valve, and an operating water supply are needed for each point of application to induce the vacuum required to operate the system. The injector also serves to thoroughly mix the incoming flow of gas with the operating water. Backup non-installed injectors should also be provided for each size injector in the system. The injector shall be sized for the maximum anticipated feed rate. Chemical feed equipment manufacturers should be consulted for specific operating conditions for the eductors they supply for the specific chemical being used.

The injector should be located directly at the point of application unless site conditions prevent easy access to the point of application for maintenance of the injector. Locating the injector at the point of application provides for transport of gas under vacuum, therefore, if leaks would occur in the vacuum line during operation, the gas would not escape. Specific information regarding the water supply to operate the injector is provided below.

8. Water supply line, booster pumps, and appurtenances

The water supply line to operate the injector shall include a strainer and either a manual or solenoid valve which is the primary control for operating the system. When the available water supply is not adequate for the requirements of the injector, a booster pump and necessary appurtenances shall be provided. A complete backup on-line booster pump system shall also be provided. Booster pumps can be either centrifugal or turbine type depending on the operating requirements and local preference. The booster pumps shall be located outside of the rooms housing any of the other feed system components.

A pressure regulating valve shall be provided on the water supply line to provide a constant pressure to operate the injector. If a booster pump is provided, the pressure regulating valve shall be located downstream of the pump so as not to effect the pump's operation. The booster pumps shall be provided with suction and discharge shutoff valves and pressure gauges, a suction strainer with blowoff, and a discharge check valve, all typically recommended for water service. For turbine pumps, a needle by-pass valve shall also be provided on the pump discharge to allow for relief back to the suction line in order to adjust the operating point of the pump. A pressure relief valve shall also be provided on the turbine pump discharge and piped to the pump suction to prevent damage to the system components due to excessive pressures. Although the discharge head generated by a centrifugal pump can be no higher than its suction head plus its cutoff head, a turbine pump will continue to generate head if its discharge line is closed. A typical turbine booster pump schematic is provided in Attachment C.

It should be noted that ammonia feed systems require softened water for the injector operating water. If softened water is not used, frequent maintenance will be required for the injector due to the calcium carbonate deposition resulting from the softening reaction caused by the ammonia addition. Typical injector operating water flow rates are low enough that commercially available softening units are economical to use. The softening unit should be a dual type such that uninterrupted service is provided. The softening unit as well as all of the water supply components must be located outside of the storage and feed rooms.

9. Diffusers

It is necessary to properly distribute the chemical solution at the point of application. Chemical compatibility must be considered when choosing the location and order of the points of application. For pipeline installations with solution lines 1-inch and less, a removable type assembly is required consisting of a diffuser pipe and corporation cock. The diffuser pipe should extend into the process pipe approximately 25-50 % for proper dispersion. For larger process pipe sizes where quick dispersion of the chemical is required, a fixed main installation is required consisting of a perforated diffuser pipe extending the entire diameter of the process pipe.

For open tank distribution, a perforated diffuser pipe or spray nozzle is recommended. Either device needs to be adequately supported in the open vessel, and located at an elevation where it is submerged at all times under all operating conditions. Flexible piping shall be used near the diffuser to facilitate maintenance or removal. Manufacturer's literature should be consulted for the specific installation for either open tank or pipeline installations.

10. Analytical equipment

A continuous recording chlorine residual analyzer is required at the entrance to the distribution system for all facilities where chlorine is used for disinfection. The analyzer shall be equipped with both low and high residual alarms. Adequate facilities must be present at the site to carry the waste from the analyzer.

D. COMPRESSED GAS STORAGE AND FEED ROOM ELEMENTS

The facilities required to house the compressed gas feed equipment are extremely important in terms of operator safety and providing adequate containment in the event of a gas leak. In general, individual storage and feed rooms are recommended for all installations. The storage room should contain all elements of the feed system which are under pressure and sized for a minimum 30 day supply. It is preferred that empty cylinders not be stored outside of the storage room, however, if space prevents this, the empty cylinders must be protected from direct sunlight. Under no circumstances shall full or partially full cylinders be stored outside of the storage room.

All components of the gas system downstream of the vacuum regulator and upstream of the injector should be located in the feed room. The feed rooms shall be sized to house all of the recommended components and provide adequate clearance for the gas dispensers per the manufacturer's recommendations. Providing separate storage and feed rooms minimizes the need for an operator to be exposed to the potential dangers associated with pressurized gas. However, it is sometimes not practical to construct a separate feed room (e.g. well station). In these instances, it is acceptable to locate the feed room components within the process room (e.g. pump room) provided that room meets the requirements of the feed room in terms of leak detection and ventilation as discussed below. Attachment D is provided for guidance.

1. Room materials of construction

Standard building materials of construction including brick, block, concrete, wood, and, drywall are adequate for both the storage room and the feed room provided that they result in a totally sealed room. Since all of the chemicals are corrosive if moisture is present, no bare metal should be exposed within the room. Any metal that is exposed within the room must be painted or adequately coated. There is no need to paint or coat either the walls or the floor of the room. Roof joists or beams should be isolated with drywall or other non-metallic materials to provide an airtight seal. Should any water supply piping need to pass through either room, the materials of construction should be PVC as opposed to copper or any other type of metal. No floor drains shall be provided in either room, however, consideration should be given to installing a sump and piping at the time the room is constructed if there may be a need in the future to install a scrubber.

2. Access doors and cylinder handling

Separate manway doors shall be provided for both the storage room and the feed rooms. The storage room shall have access only from the exterior of the building. The feed room access can be from either an interior or exterior building location, however, local regulations may require only exterior access for this room also. Under no circumstances shall a door be provided between the two rooms. For large rooms, consideration should be given to providing more than one manway door when quick and easy exit by an operator may not be possible with a single door. Manway doors shall open outward and be equipped with panic hardware. All exterior doors shall be capable of being locked for security reasons. All doors shall be provided with weather strips to prevent water from entering the room or gas from escaping the room. A light shall be installed above all exterior doors for security and safety reasons.

The manway doors for storage rooms utilizing 150-lb and smaller cylinders shall be large enough to permit easy handling of the cylinders through this door. For ton cylinder installations, an equipment door to facilitate the monorail shall be provided in the storage room in addition to the manway door. If possible, the monorail shall be designed with a hinge such that it can folded back into the room when not in use as opposed to permanently extending it through the door, thus alleviating a potential source for gas to escape.

3. Vision panels and windows

Vision panels are required for both the storage room and feed rooms. The vision panels for both rooms must be located only at an interior building location. The glass panels must meet the BOCA code fire rating requirements. Additionally, a vision panel shall be provided between the two rooms. All vision panels should be a minimum of 3' x 3' and oriented such that a full view of the room is possible, especially being able to see the scale readouts and gas dispenser rotameters. The vision panel in the feed room should be located adjacent to the manway door, and could be located in the door if a full view of the room is still obtainable. Under no circumstances shall external windows be provided in either room as the heat generated from sunlight could create excessive pressure in the cylinders or piping.

4. Heating

Individual heating units are required for both the storage and the feed rooms. Only electric or hot water heat shall be permitted. Electric heating units in an ammonia room shall be explosion proof. The heaters shall be controlled by individual thermostats located in each room. The storage room shall be heated to 70 F and the feed rate calculations shall be based on this temperature. It is always necessary to perform heat leak calculations for the storage room to properly size the heater. The temperature in the feed room is not as critical since the gas pressure is low and the potential for reliquification is minimized with a vacuum operated system It is recommended that the feed room be heated to the same temperature as the storage room.

5. Lighting

Adequate lighting shall be provided for both the storage and feed rooms. Light switches shall be provided at all vision panels, including both sides of the vision panel between the two rooms to operate the lights in the opposite rooms. The lights shall automatically come on with the opening of the doors and remain on when the door closes. The lights can be turned off at the exterior of the door in conjunction with the operation of the fan as discussed in a subsequent section on ventilation. All lighting fixtures shall be corrosion resistant. Fixtures in an ammonia room shall be explosion proof. Attachments E and F show the control logic for the lighting in both rooms.

6. Leak detection

Leak detection units shall be provided for both the storage and feed rooms with the control unit located outside of the chemical rooms and the sensor inside of the chemical rooms. The unit for the storage room shall be located at the vision panel, and the unit for the feed room shall be located at the interior entrance door which is adjacent to that rooms' vision panel. Each unit shall have its sensor located within the room at an appropriate location for the specific gas away from the exhaust fan or inlet louver. Multi point sensors are not recommended for reliability reasons. In addition to the units themselves, red indicating lights shall be located at each external storage room manway door to indicate the presence of a leak. For ton cylinder installations, a leak indicating light shall also be provided at the equipment door if the equipment door can be opened without first entering the storage room through the manway door. The capability to test these remote indicating lights shall also be provided. Provisions shall also be made to remotely alert the operator of a leak. The method of accomplishing this is dependent on the specific installation and could be an audible alarm, dialing system, SCADA input, or other appropriate means. Attachments E and F show the control logic for the leak detection system.

7. Ventilation

Separate ventilation systems are required for both the storage and the feed rooms. The purpose of the ventilation system is to continually provide a fresh supply of air through the room while it is occupied, and to have the ability to control gas discharge from the room in the event of a leak. Ventilation equipment for ammonia rooms shall be explosion proof.

Exhaust fans shall be sized to provide one air change per minute. An associated intake louver shall be sized for an inlet velocity of 1 ft/sec to prevent rain from being pulled into the louver. The louver shall have spring closure upon power failure. The fan and louver shall be located at opposite ends of each room to prevent short circuiting. Since chlorine and sulfur dioxide are heavier than air, suction for the exhaust fan shall be taken as close to the floor as possible with the louver located as high as possible in the room. The opposite is true for ammonia since it is lighter than air. The exhaust from the fan shall be directed away from areas where personnel may be present and away from the intake louver. If the configuration of the storage and feed rooms limits the options for chlorine or sulfur dioxide discharge, it may be advisable to run a duct to the floor and locate the exhaust fan on the roof to provide better dispersion of the exhausted gas in the event of a leak.

The fan and louver shall automatically energize with the opening of the manway door for that specific room. The ventilation system shall remain in operation even if the door closes. Upon exiting the room, the ventilation system can be shut off by a manual push button located at the exterior of the door which is also tied to the lighting for the room. The ventilation systems shall also be capable of being manually operated from each respective vision panel (but not the vision panel between the two rooms) to allow for controlled discharge in the event of a leak. Additionally, if the exhaust fan is running and a leak is detected by the leak detection equipment, the ventilation system should shut down. In order to override this shutdown to exhaust the gas in a controlled manner, an override switch in a locked box shall be provided. Only supervisory personnel should be provided access to this override. Green indicating lights shall also be provided at each manway door and the vision panels to indicate that the ventilation system is in operation. Attachments E and F show the control logic for the ventilation system.

8. Safety and maintenance appurtenances

Several safety and maintenance related items are necessary for all compressed gas feed systems. Two self contained breathing apparati shall be provided at an accessible location outside of the storage and feed rooms but within the building away from the elements. A repair kit for the appropriate size cylinders shall also be provided and located near the storage room. Eyewash/shower stations shall be provided just outside of each manway door, and exterior doors shall have frost proof type stations. Safety chains shall also be provided for all full and empty 100 or 150-lb cylinders whether in use or not. Appropriate signage shall be provided at each door and vision panel to indicate the presence of a hazardous chemical.

IV. REFERENCES

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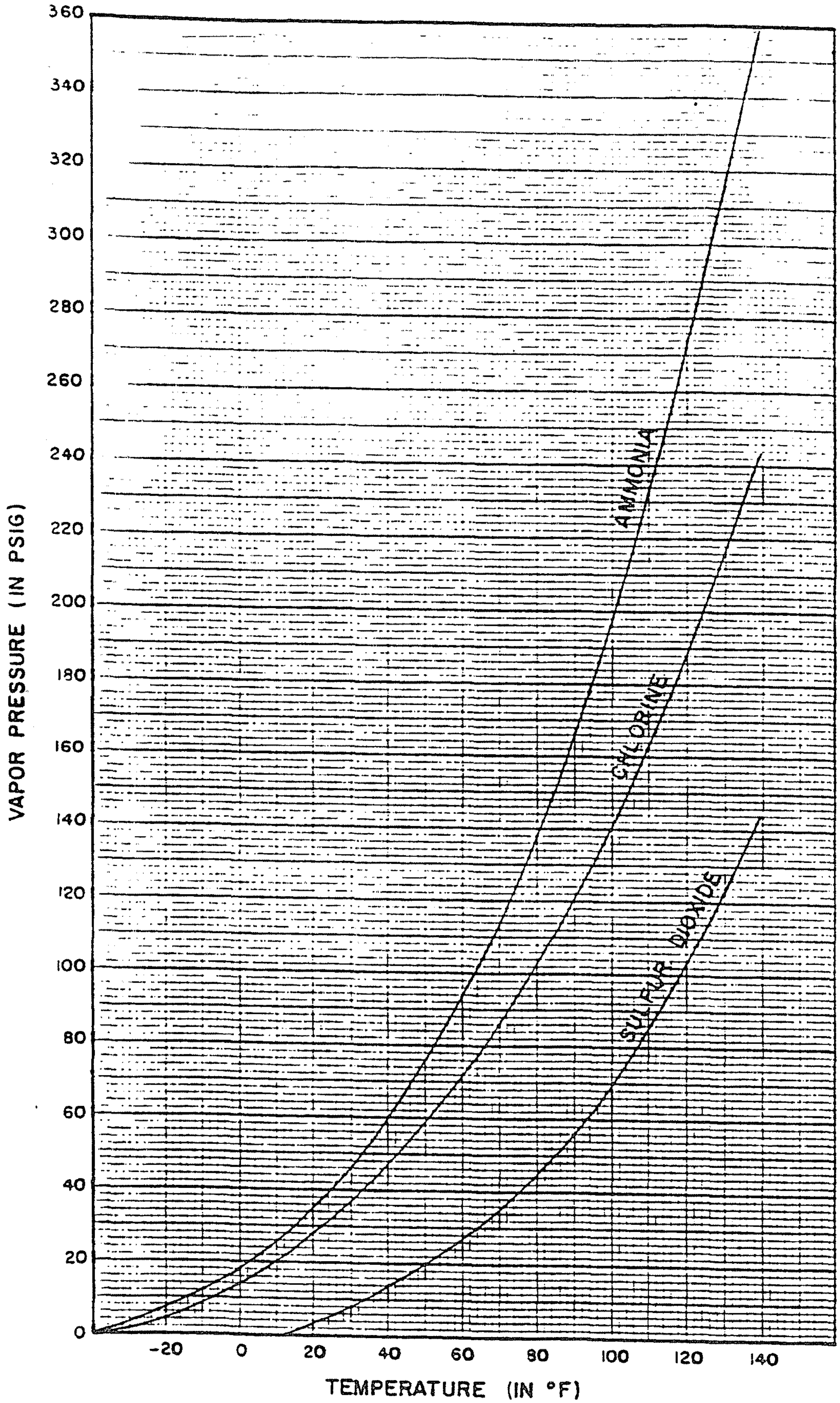
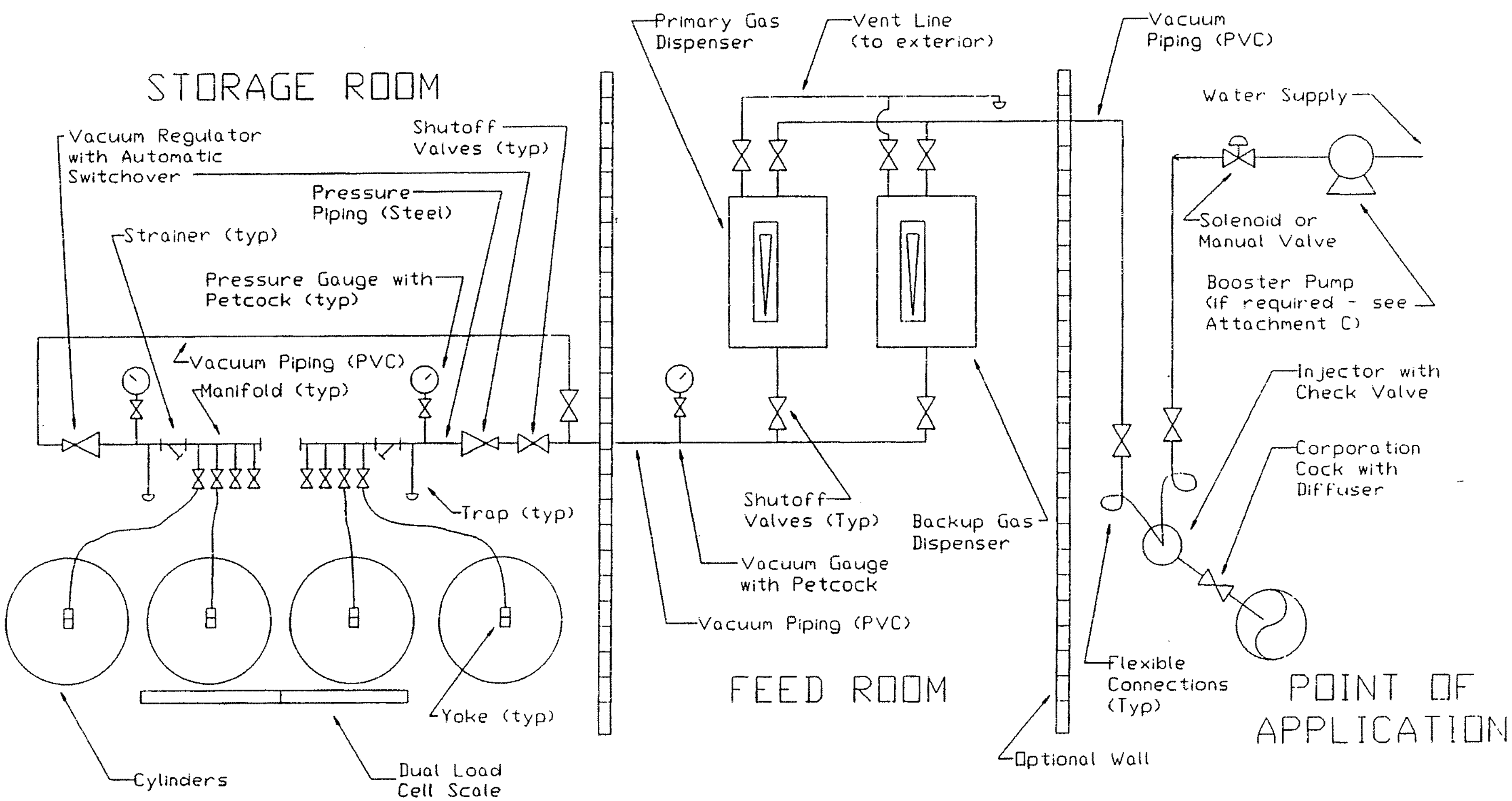
b. Chlorine Institute Manual, Edition 5, 1986
c. Compressed Gas Association Manual G-2 for anhydrous ammonia, 7th Edition, 1984
d. Compressed Gas Association Manual G-3 for sulfur dioxide, 4th Edition, 1988
e. Opflow, April 1980, "Maximum Withdrawal Rates from Chlorine, Sulfur Dioxide, and Ammonia Cylinders", Robert J. Baker
f. Fischer & Porter Technical Bulletin 70-9001 for handling chlorine, sulfur dioxide, and ammonia from supply to point of application, 1972
g. Wallace & Tiernan technical literature for Water and Wastewater Chemical Feed Equipment titled "Disinfection Equipment 1" and "Disinfection Equipment 2"
h. NFPA 70, National Electric Code (ANSI approved), latest edition
i. Chlorine Institute Pamphlet 9, "Chlorine Vaporizing Equipment", Edition 3, May 1987
j. ASME codes for Unfired Pressure Vessels and Pressure Piping
k. ASCE/AWWA "Water Treatment Plant Design" manual, second edition
l. Code of Federal Regulations, Title 29 - Labor, parts 1900-1910, Occupational Safety and Health Administration.

V. ATTACHMENTS (on following pages)



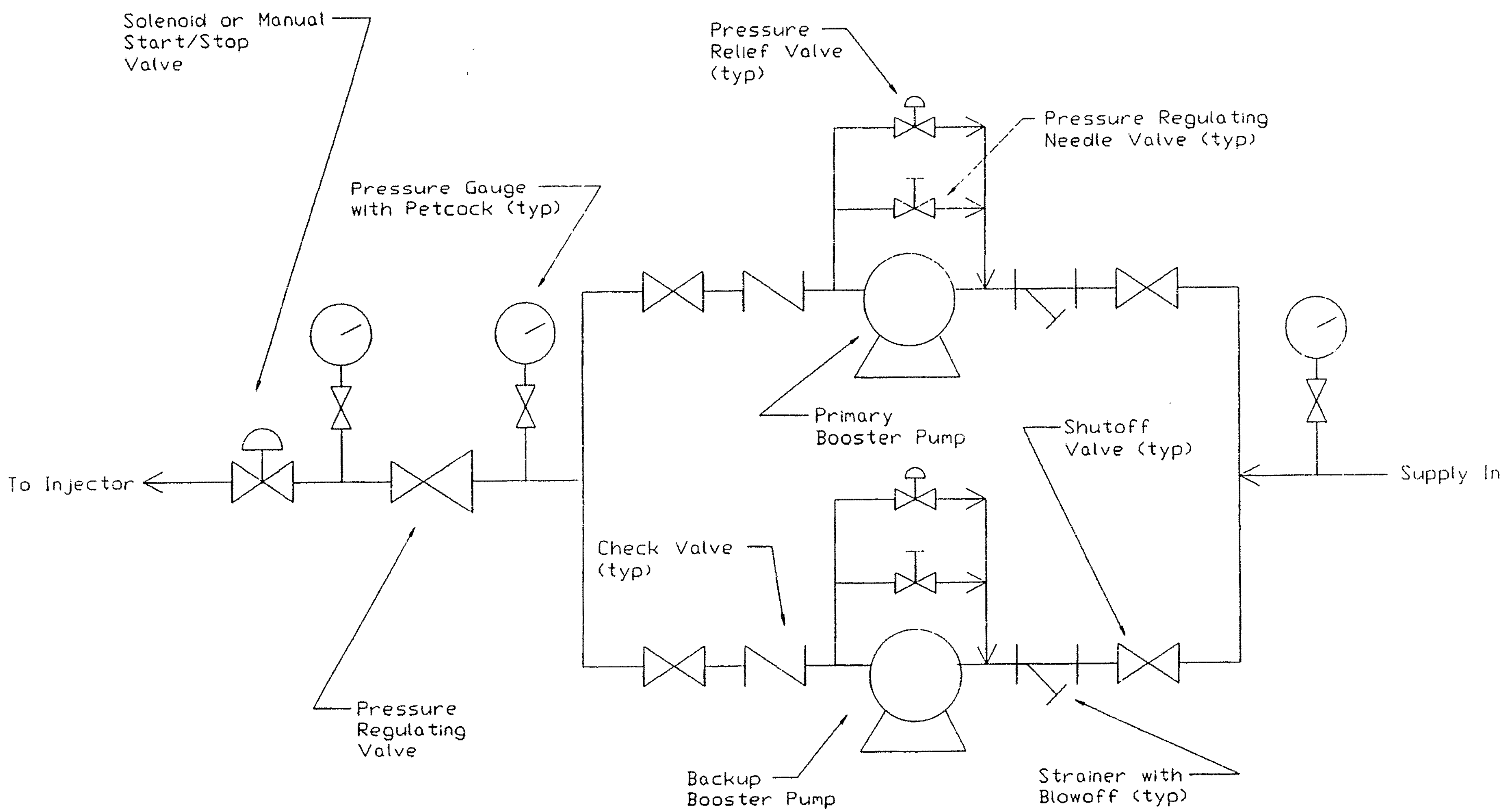
ATTACHMENT A: VAPOR PRESSURE CURVES OF LIQUID CHEMICALS

ATTACHMENT B
TYPICAL FEED SYSTEM SCHEMATIC

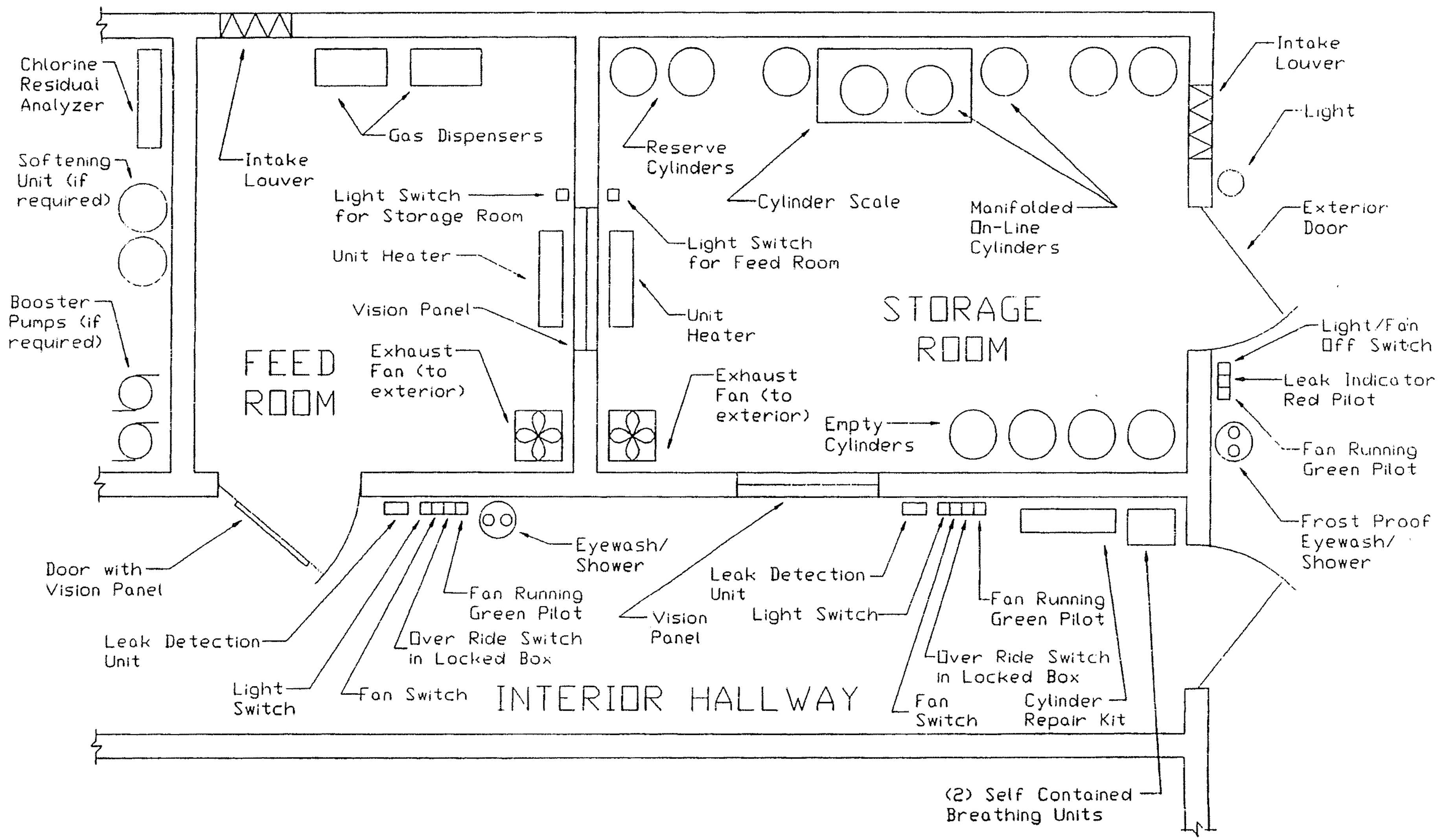


ATTACHMENT C

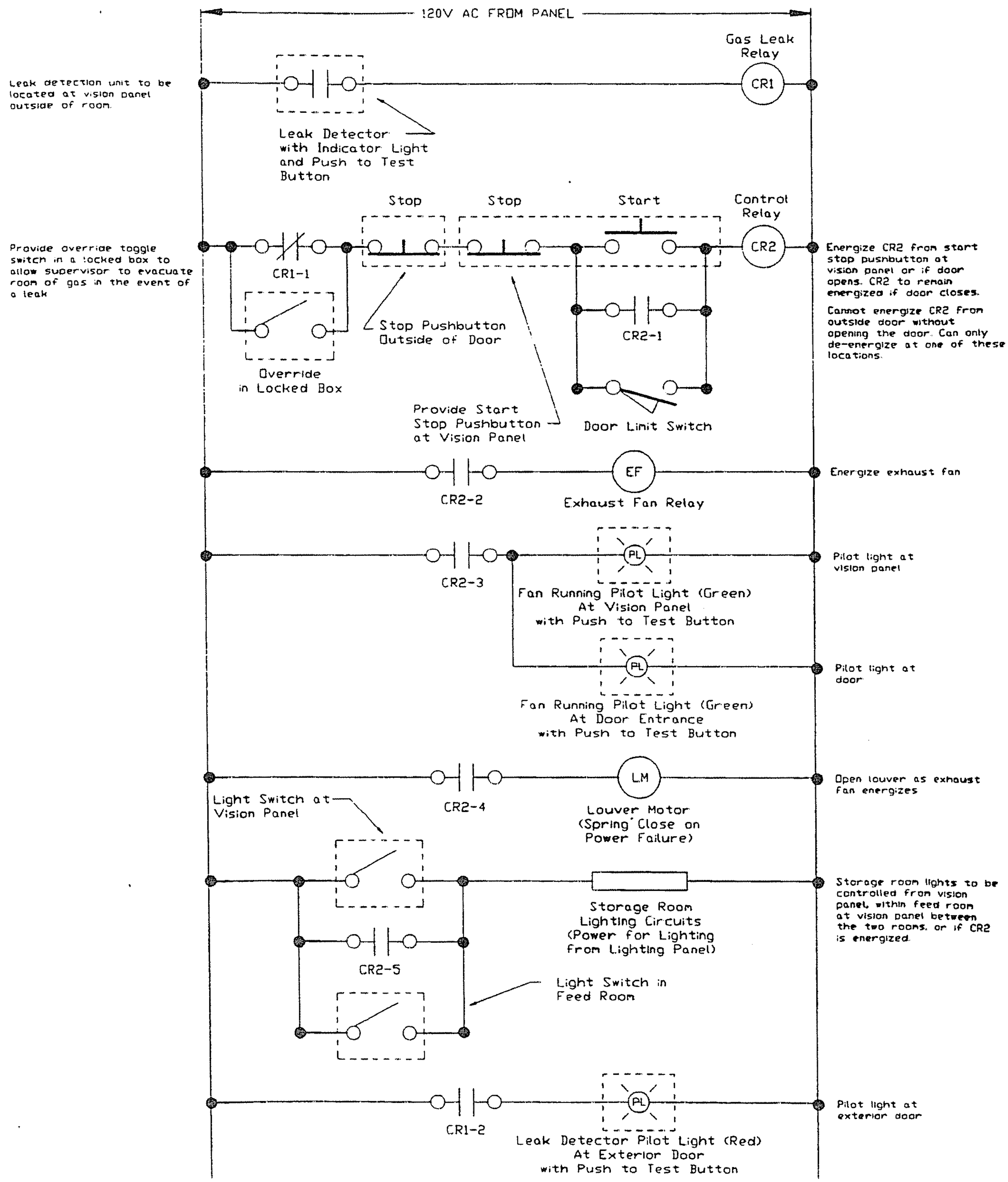
TURBINE BOOSTER PUMP SCHEMATIC



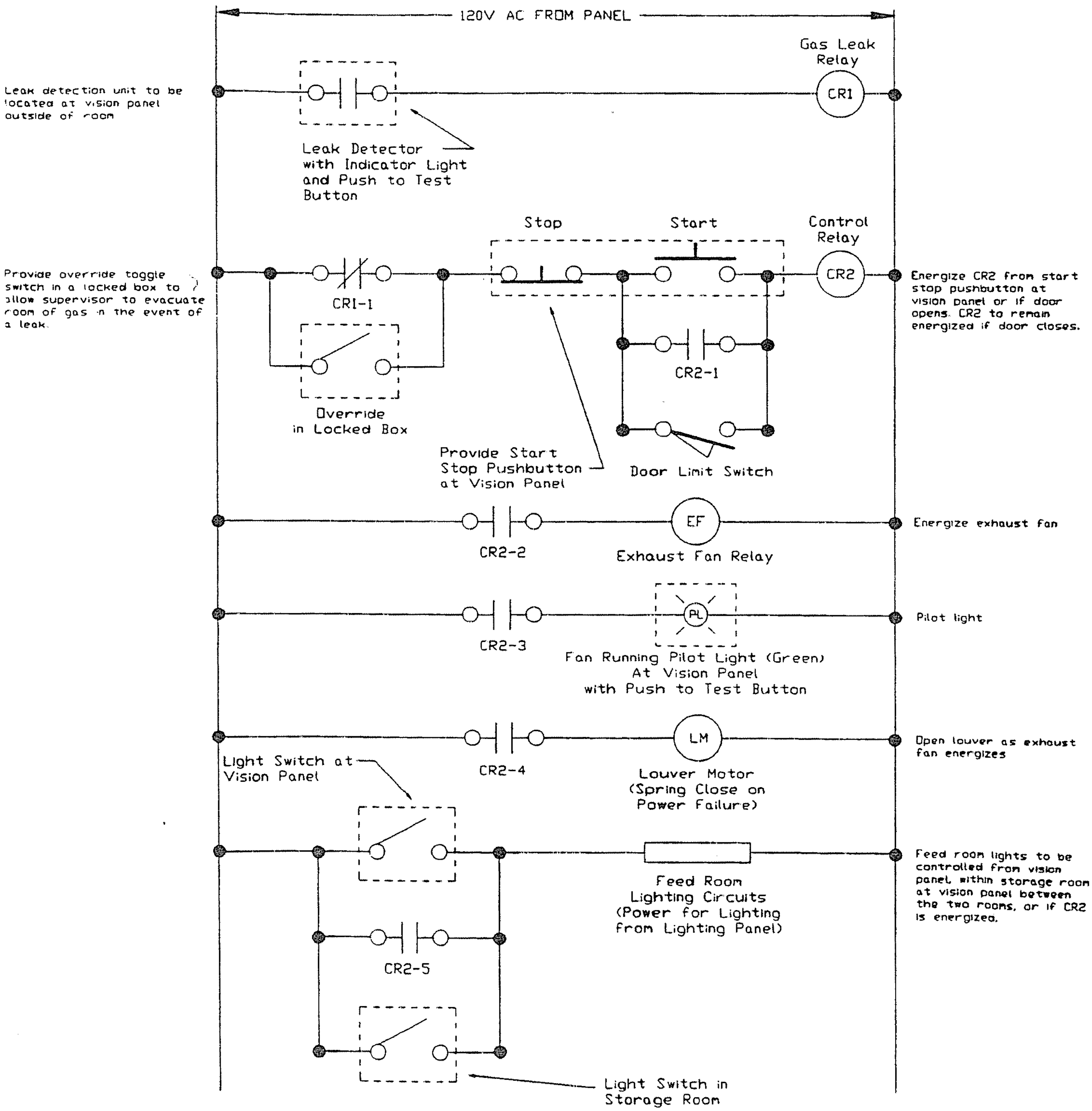
ATTACHMENT D
TYPICAL STORAGE FACILITY LAYOUT



ATTACHMENT E
STORAGE ROOM (WITH EXTERNAL DOOR)
INSTRUMENTATION SCHEMATIC



ATTACHMENT F
FEED ROOM (WITH INTERNAL DOOR) INSTRUMENTATION SCHEMATIC



AMERICAN WATER SYSTEM

ENGINEERING STANDARDS

T-9 COMPRESSED GAS FEED SYSTEMS AND STORAGE FACILITIES

Prepared by: ____________________

Director: ____________________

Vice-President: ____________________

Date: ____________________

COMPRESSED GAS FEED SYSTEMS AND STORAGE FACILITIES

Table of Contents

Page

I. INTRODUCTION 1

A. BACKGROUND 1
B. SCOPE 1
C. PURPOSE 1

II. TECHNICAL CONTENT 2

A. COMPRESSED GAS PHYSICAL PROPERTIES 2
1. Chlorine 2
2. Ammonia 2
3. Sulfur dioxide 3
4. Table of properties 3

B. COMPRESSED GAS FEED CALCULATIONS 4
1. Vapor Pressure Table 4
2. Withdrawal Factors 5

C. COMPRESSED GAS FEED SYSTEM COMPONENTS 6
1. Scales 6
2. Vaporizer 6
3. Vacuum regulator/automatic switchover device 7
4. Pressurized gas piping and appurtenances 7
5. Gas dispensers 8
6. Vacuum piping and valves 8
7. Fixed throat ejectors 9
8. Water supply line, booster pumps, and appurtenances 9
9. Diffusers 10
10. Analytical equipment 10

D. COMPRESSED GAS STORAGE AND FEED ROOM ELEMENTS 10
1. Room materials of construction 11
2. Access doors and cylinder handling 11
3. Vision panels and windows 12
4. Heating 12
5. Lighting 12
6. Leak detection 12
7. Ventilation 13
8. Safety and maintenance appurtenances 13

Page

III. RECOMMENDATIONS FOR EXISTING FACILITIES 14

IV. REFERENCES 14

V. ATTACHMENTS

A. VAPOR PRESSURE CURVE................................. A
B. TYPICAL FEED SYSTEM SCHEMATIC .... B
C. TURBINE BOOSTER PUMP SCHEMATIC...................... C
D. TYPICAL STORAGE FACILITY LAYOUT...................... D
E. STORAGE ROOM (WITH EXTERNAL DOOR) INSTRUMENTATION SCHEMATIC .... E
F. FEED ROOM (WITH INTERNAL DOOR) INSTRUMENTATION SCHEMATIC .... F

COMPRESSED GAS FEED SYSTEMS AND STORAGE FACILITIES

INTRODUCTION

A. BACKGROUND

Disinfection and dechlorination are commonly achieved at water treatment plants with the use of gaseous chemicals. For high feed rates, the use of gaseous chemicals typically results in a more cost effective system and simplifies operations and maintenance. While these chemicals are necessary to provide a safe potable water, improperly designed feed and storage facilities present the potential for injury to humans and damage or deterioration of plant facilities. Gaseous chemicals present a two fold liability to humans in that both excessive consumption of the chemical through the drinking water and inhalation or exposure in the event of a leak can result in serious consequences.

B. SCOPE

This Standard encompasses significant design considerations for compressed gas feed systems and storage facilities for three specific gaseous chemicals commonly used in water treatment. These chemicals are chlorine, ammonia, and sulfur dioxide. Chlorine gas is the most common of the three chemicals, and is utilized primarily for disinfection and oxidation. The use of ammonia for the formation of chloramines is becoming more prevalent for disinfection by-product control. Sulfur dioxide is the least common of the three chemicals and is used when dechlorination is necessary. The use of sulfur dioxide for dechlorination may become more popular in the future as disinfection/DBP regulations become more stringent.

This Standard addresses the specific components required for both the feed systems and the storage facilities, as well as addressing the properties of the specific chemicals and the basic theories and equations used in designing these facilities. The design of feed and storage facilities for all three chemicals is similar, and the specific differences for each are addressed within this Standard. Various industry standards and practices along with other published technical literature have been reviewed, consolidated, and incorporated into this Standard as necessary. Specific State requirements are not identified within this Standard.

C. PURPOSE

An engineering standard is necessary to ensure that compressed gas feed and storage facilities are properly designed. This Standard is meant to be used by engineers and other experienced personnel as a guide in the design and modification of these facilities. Sketches and schematics are provided only to illustrate the various recommendations and should not be construed as being precisely applicable for all installations. Selection of specific equipment, sizing of components, and hydraulic analyses are examples where technical expertise is required. Manufacturer's recommendations and literature must also be consulted for all installations.

This Standard is written primarily to address the requirements for new facilities, however, guidance for incorporating these recommendations into existing facilities is also provided. The Standard is meant to provide sound technical information, and good judgment must be used in incorporating this information into the design process, especially for existing facilities. It is important that the engineer recognize the purpose of the recommendations within this Standard, and maintain the intent of the specific recommendation as opposed to attempting to comply exactly with the details. The basis behind specific recommendations is included throughout the text.

II. TECHNICAL CONTENT

A. COMPRESSED GAS PHYSICAL PROPERTIES

Chlorine, ammonia, and sulfur dioxide are supplied by chemical manufacturers in a liquid state in various size steel cylinders. The combination of temperature and pressure causes the gas to liquefy, thus permitting significantly larger volumes to be stored and shipped. At a specific temperature, the gas and liquid exist in equilibrium with a resulting pressure that allows for withdrawal and feeding of the gaseous form of the chemical. Each compressed gas has distinctive physical and chemical properties, however the requirements for feeding and storage are similar.

Exposure to chlorine, ammonia, or sulfur dioxide gases will cause irritation of the eyes, nose, throat, and lungs. Each gas exhibits a sharp pungent odor which is readily detected by the human senses. Exposure to a sufficiently high concentration of any of the three gases can be fatal. However, complete recovery should occur following a mild exposure since none of the gases produces a cumulative physiological effect on the human body.

1. Chlorine

Chlorine is a chemical element belonging to the halogen group. Chlorine gas is approximately 2 1/2 times heavier than air, thus if it escapes from its cylinder it will seek the lowest level in the room in which the leak occurred. It has a characteristic odor and is greenish yellow in color. Both chlorine gas and chlorine liquid are non-explosive and non-flammable, however, it is an oxidizer and capable of supporting combustion of certain substances. Many organic chemicals react readily with chlorine, sometimes violently. When moisture is present, gaseous chlorine is strongly corrosive to metals.

2. Ammonia

Ammonia is a compound formed by the chemical combination of the elements nitrogen and hydrogen in the molar proportion of one part nitrogen to three parts hydrogen. It is commonly referred to as anhydrous ammonia. Ammonia gas weighs approximately 1/2 as much as air, is colorless, and has a pungent odor. It is classified by the United States Department of Transportation as a non-flammable gas since it has a very narrow flammable range in air of only 16%-25% by volume. However, the National Electric Code classifies ammonia as a Class I, Group D gas which may be an explosion hazard in a confined space. Therefore, all ammonia installations must be designed with explosion proof electrical components if the specific components cannot be located outside of the room. Most common metals are not effected by dry ammonia, however, when water or water vapor is present, ammonia will attack copper and zinc or alloys containing major proportions of these metals. Mixtures of hydrogen and chlorine gas can react violently, therefore ammonia and chlorine must be kept isolated from each other.

3. Sulfur dioxide

Sulfur dioxide is a compound formed by the combination of the elements sulfur and oxygen. On a weight basis, the proportion of the elements is about one part sulfur to one part oxygen. Sulfur dioxide gas is more than twice as heavy as air, but slightly less dense than chlorine gas. It is a colorless gas with a characteristic pungent odor. Sulfur dioxide is not flammable nor explosive in either the gaseous or liquid state. Dry sulfur dioxide is not corrosive to most metals, however, in the presence of even small amounts of water, it is corrosive to most metals.

4. Table of properties

Properties of importance of the three compressed gases described above are as follows:

	Chlorine (Cl_2)	**Ammonia (NH_3)**	**Sulfur Dioxide (SO_2)**
Molecular weight	70.906	17.031	64.06
Specific gravity (air = 1.0)	2.49	0.60	2.26
Freezing point	-150° F	-108° F	-105° F
Boiling point-	-29° F	-28° F	+14° F
Vapor pressure @ 70° F	86 psi	114 psi	34 psi
Critical temperature	291° F	270° F	315° F
Critical pressure	1157 psia	1636 psia	1143 psia
Latent heat of vaporization	124 BTU/lb	588 BTU/lb	156 BTU/lb
Dangerous air concentration	40-60 ppm	2000-3000 ppm	400-500 ppm

The freezing and boiling points are defined as the respective temperatures at which the liquid state of the gas either solidifies or vaporizes at atmospheric pressure. Vapor pressure is the absolute pressure of the gas above the liquid in a closed system at a given temperature when they are in equilibrium. Critical temperature is the temperature above which the chemical can exist only as a gas no matter how great the pressure, and critical pressure is the resulting pressure at the critical temperature. The latent heat of vaporization is defined as the amount of heat required to evaporate a unit weight of the liquid state of the chemical. The dangerous air concentrations are those approximate concentrations at which continuous exposure of at least 30 minutes could be fatal. All of these properties are important in the design of the feed and storage facilities as discussed in subsequent sections.

B. COMPRESSED GAS FEED CALCULATIONS

Sustained gas withdrawal rates from chlorine, ammonia, or sulfur dioxide cylinders are dependent on several factors including the specific gas, the ambient temperature where the cylinders are located, the operating requirements of the gas dispenser system, and the size of the cylinder. The air circulation rate, the humidity in the storage room, and the amount of liquid remaining in the cylinder also effects the withdrawal rate, however, the effect is small in comparison with the other factors and can be neglected in the final withdrawal calculations.

As gas is withdrawn from a cylinder, a specific amount of heat (latent heat of vaporization) is needed to evaporate the liquid. If adequate heat is not available in the air surrounding the cylinder, the heat will be taken from the liquid resulting in a temperature drop as evidenced by a cooling of the cylinder. This temperature drop results in lower pressures within the cylinder which in turn gradually diminishes the rate of gas flow from the cylinder. If the humidity is high and moisture is present in the air, frost will form on the cylinder which will act to insulate the cylinder and further reduce the amount of heat that can be taken from the surrounding air. Circulating the air around the cylinder can improve this condition. Additionally, as the liquid in the cylinder is depleted, the area of the cylinder in contact with the liquid is lessened which reduces the transfer of heat to the liquid which also reduces the withdrawal from the cylinder.

Each specific gas dispenser system requires a minimum amount of pressure to operate properly. Most vacuum operated gas dispenser systems require approximately 12-14 psi at the vacuum regulator for proper operation which must always be verified with the manufacturer. The temperature at which this minimum required pressure is reached is referred to as the threshold temperature. The threshold temperature for a specific chlorinator can easily be found from a vapor pressure curve for the specific gas if the required pressure for the vacuum regulator to operate properly is known. Vapor pressure curves for the three gasses addressed in this standard can be found in Attachment A. A partial tabular form of the graph in Attachment A is presented below.

	VAPOR PRESSURE, psig		
AMBIENT TEMP, F	**Chlorine**	**Ammonia**	**Sulfur Dioxide**
0	14	16	-
10	21	24	-
20	28	34	2
30	37	45	7
40	47	59	12
50	59	75	18
60	71	93	26
70	86	114	34

It can be seen that the vapor pressure increases as the temperature increases. As previously shown, the pressures can exceed 1000 psi for any of the three gasses as the critical temperature is approached.

The size of the cylinder also effects the withdrawal rate since a larger cylinder has more surface area to transfer the heat from the surrounding air to the liquid. The combination of the size of the cylinder and the latent heat of vaporization for the specific gas allows for the use of a withdrawal factor to simplify the withdrawal rate calculations. Withdrawal factors for each of the specific gases and types of cylinders are as follows:

COMPRESSED GAS	WITHDRAWAL FACTOR
Chlorine	
150-lb cylinder	1.0
1-ton container	8.0
Ammonia	
100-lb cylinder	0.3
150-lb cylinder	0.4
800-lb container	3.2
Sulfur Dioxide	
150-lb cylinder	0.75
1-ton container	6.0

Therefore, the withdrawal factors for different gases having cylinders of the same geometric proportions are approximately proportional to the ratio of latent heat of vaporization values. For example, chlorine and sulfur dioxide 150-lb cylinders are approximately identical in size and shape, therefore, their withdrawal factors differ by the ratio of their respective latent heat of vaporization values. Note that this is not the case for a 150-lb ammonia cylinder since the density of ammonia is significantly less than that of chlorine or sulfur dioxide, and therefore a much larger cylinder is needed to contain 150 lbs of ammonia. The dimensions of the larger cylinder allow for more heat transfer to the liquid which results in a withdrawal factor that is higher than the ratio of latent heat of vaporization values.

Considering all of the above, the following calculation can be used to determine the maximum withdrawal rate from a cylinder, or the required room temperature to feed at a given rate:

[(Room temp, F - Threshold temp, F) x Withdrawal factor] = Maximum withdrawal rate (lbs/day)

For example, if chlorine was being fed from 150-lb cylinders with a typical vacuum operated gas dispenser system which required a gas pressure of 14 psi, and the room was heated to 70 F, the maximum withdrawal rate from a single cylinder would be: [(70 - 0) x 1.0] = 70 lbs/day. This confirms the general rule of thumb for feeding chlorine from 150-lb cylinders of 1 lb/day for each degree F the storage room is heated to. However, this rule of thumb does not hold true for other gases and various size cylinders since both the threshold temperature and withdrawal factors will be different. If the total feed requirements for a particular installation cannot be achieved with a single cylinder at a practical room temperature, other means must be taken such as manifolding multiple cylinders or providing a vaporizer. If manifolding of cylinders is pursued, care must be taken to ensure that all the cylinders are at the same temperature and pressure. Additional information regarding vaporizers is addressed in a subsequent section. Under no circumstances shall direct heat be applied to the cylinders in an attempt to increase the withdrawal rate.

C. COMPRESSED GAS FEED SYSTEM COMPONENTS

Compressed gas feed systems can be one of two types; either vacuum operated or direct feed. In a vacuum operated system, gas flow to the point of application is induced by a vacuum created from an external source. The pressurized gas exiting the cylinder is reduced to less than atmospheric pressure by means of a pressure reducing valve referred to as a vacuum regulator. In a direct feed system, gas flow is generated directly from the pressure in the cylinder. Vacuum operated systems are recommended for all installations due to the potential hazards associated with breaks in the piping between the cylinders and the point of application in a direct feed system. Additionally, vacuum operated systems safeguard against reliquification of the gas within the piping system as discussed in more detail below.

The following system components are required for the proper operation of a vacuum operated compressed gas feed system. This standard does not address direct feed systems. A schematic of a typical compressed gas feed system is also provided in Attachment B.

1. Scales

Systems utilizing storage in cylinders 1 ton and smaller shall provide appropriate means of measuring the chemical usage in the form a dual cylinder scale. Scales for 150-lb and smaller cylinders shall be of the type that cylinders can be easily rolled on and off, thereby preventing the need to locate the scale in a recessed pit. Restraint chains to keep the cylinders from tipping shall also be provided with the scale. Scales for cylinders one ton and larger shall be load cell type. They shall be bolted to the floor and provided with trunnions to allow for easy positioning of the container valves. It should be noted that 150-lb and 100-lb ammonia cylinders have diameters larger than a 150-lb chlorine cylinder, and typical 150-lb chlorine cylinder scales cannot accept cylinders of larger diameter. For manifolded cylinders, it is only necessary to provide a scale for one pair of cylinders since the withdrawal from each individual cylinder will be the same provided all the cylinders are exposed to the same ambient air temperature.

At a minimum, two sets of dual scales shall be provided to separately inventory all pre and all post chemical usage. Depending on the number of points of application and the usage at each of these points, it may also be advisable to provide additional inventory. This could be accomplished either with a dedicated dual scale or an individual gas flow meter located at the gas dispenser for each individual point of application.

2. Vaporizer

When it is not practical to manifold cylinders together to achieve the required gas withdrawal rates, a vaporizer (evaporator) shall be provided. The vaporizer receives the liquid chemical from the cylinder, supplies the necessary heat to vaporize the liquid into the gaseous state at a rate sufficient to meet the desired feed rate, and discharges the gas to the gas dispensers. Vaporizers are usually water-jacketed or steam heated. Special precautions must be taken when providing vaporizers, and manufacturer's recommendations, Chlorine Institute Pamphlet 9, and ASME codes must be consulted.

3. Vacuum regulator/automatic switchover device

A vacuum regulator is a spring-loaded pressure reducing valve which reduces the gas pressure in the storage cylinders to a constantly regulated vacuum, usually about 20" of water column. Each weighed cylinder or set of manifolded cylinders requires a vacuum regulator. The vacuum regulator should be installed as close as possible to the cylinder to minimize the length of pressurized gas piping, and must never be located outside of the cylinder storage room. For manifolded cylinders, a single vacuum regulator can be mounted on a manifold for each set of weighed cylinders unless local regulations require the vacuum regulator to be mounted directly on the cylinders. Vacuum regulators mounted on manifolds shall be located at an elevation higher than the storage cylinders to allow liquid which may form in the piping to flow back to the cylinder.. A spare, non-installed vacuum regulator shall be provided for each capacity required for the system. The vacuum regulator shall be sized for a feed rate based on maximum expected flow rate and dosage.

Automatic switchover capabilities are required for all pairs of cylinders or pairs of manifolded cylinders to provide uninterrupted operation of the chemical application. A pair of combination vacuum regulator/automatic switchover devices is recommended for this purpose. The valve on standby is held closed by a detent-type lockout. When the on-line supply is exhausted, the system vacuum rises to a higher than normal level which overcomes the latching force of the detent in the stand-by vacuum regulator causing both cylinders to be on-line which ensures complete emptying of the first cylinder. A separate automatic switchover device in combination with standard vacuum regulators is also acceptable, however, such units which require power to operate the automatic switchover device are not recommended.

4. Pressurized gas piping and appurtenances

Flexible pipe runs are recommended for all piping between the cylinders and the vacuum regulators if the vacuum regulator is not mounted directly on the cylinder. Soft seamless copper tubing is required for chlorine and sulfur dioxide service. Rubber hose with external metallic armor is required for ammonia service. Should it become necessary to use permanent rigid pressurized piping between the cylinders and the vacuum regulators, only schedule 80 high temperature seamless carbon steel piping shall be used. Permanent rigid piping shall be color coded in accordance with Ten State Standards or individual State color coding schemes. Shut off valves, if required, shall be ball type with forged carbon steel bodies.

A pressure gauge with petcock shall also be installed in the piping immediately upstream of the vacuum regulator to monitor the pressure in the cylinders. The gauge shall be rated for twice the expected operating pressure of the cylinder. The gauge shall be a diaphragm type, and the diaphragm materials of construction will vary for the specific gas. Tantalum is required for chlorine and sulfur dioxide, and stainless steel is required for ammonia. Silver is also a suitable diaphragm material for chlorine service.

Pressurized gas could reliquify within the piping if the temperature in the storage room were to drop below its normal operating temperature. Typical vacuum operated equipment is designed for gas service only and could become damaged if it comes in contact with the liquid form of the chemical. Therefore, all pressurized piping should slope towards the cylinder to allow any liquid which may form to flow back to the cylinder. If the piping cannot slope towards the cylinder, a trap (drip leg) is required just upstream of the vacuum regulator and pressure gauge. A drip leg is also required just upstream of the vacuum regulator and pressure gauge for all ton cylinder installations to collect the liquid that comes from the ton cylinder's gas eduction tube when initially opened. The trap shall be 1-inch in diameter, 18 inches long, and permanently capped at the end. Whenever a trap is used, a strainer should also be installed immediately upstream of the trap to remove entrained solids such as pipe scale. The strainer shall be a basket type of all steel construction.

5. Gas dispensers

Vacuum operated gas dispensers are required for each point of application, and shall be located in a separate room from the storage cylinders. The gas dispensers shall be sized to provide a feed rate based on maximum expected flow and dosage. A secondary gas dispenser is required for a specific point of application when the minimum expected feed rate falls within the bottom 10% of the primary unit's turndown ratio. Additionally, at least one spare gas dispenser with the capability of meeting the feed range requirements described above shall be provided in place and piped for use to all points of application. Each gas dispenser shall have isolation valves installed both upstream and downstream.

All gas dispensers shall be provided with vent lines. The vent line should slope on a continuous down gradient for chlorine and sulfur dioxide and a continuous upward gradient for ammonia to the exterior of the building to an area where gas fumes cannot cause injury to personnel. The vent lines shall terminate with a turned down plastic screen. If vent lines are manifolded from several gas dispensers, the flow area of the manifold shall be at least equal to the summation of the flow area of the individual gas dispenser vent lines. Each vent line shall have an individual shutoff valve if it is manifolded to a common header.

Gas dispensers can operate either manually, by flow proportional control, or by compound loop control. Flow proportional control is recommended when the process flow rate is not relatively constant. Compound loop control is recommended when both the process flow and influent residual are not relatively constant. Direct residual control is not recommended since the response time to varying conditions is slow. Controllers can be mounted either integral with the gas dispenser or remotely.

6. Vacuum piping and valves

Hard piped schedule 80 PVC piping or flexible plastic tubing shall be used for vacuum or solution piping downstream of the vacuum regulators. Manufacturer's literature must be consulted to determine the sizing and maximum line lengths for the specific chemical and feed rates for vacuum piping. The piping can have flanged, threaded, or solvent welded connections, and particular attention shall be taken to prevent air leaks. Vent lines from the gas dispensers shall also be constructed of schedule 80 PVC pipe or flexible plastic tubing. Valves in vacuum lines shall be ball type with PVC materials of construction. Vacuum, solution, and vent piping shall also be color coded and distinguishable from the pressurized gas piping.

A vacuum gauge shall be installed just downstream of the vacuum regulator to verify proper operation of the vacuum regulator. A typical vacuum regulator operates at approximately 20-inches of vacuum water column, and the gauge shall be a compound diaphragm type with 20-inches of vacuum as the approximate mid point in the range. The same materials of construction as recommended for the pressure gauge diaphragm apply to the vacuum gauge also. Since the gas in the piping downstream of the regulator is under a vacuum, the temperature drop required to convert this gas to a liquid is significant, and therefore traps are not required in vacuum piping.

7. Fixed throat injectors

A fixed throat injector (eductor) with integral check valve, and an operating water supply are needed for each point of application to induce the vacuum required to operate the system. The injector also serves to thoroughly mix the incoming flow of gas with the operating water. Backup non-installed injectors should also be provided for each size injector in the system. The injector shall be sized for the maximum anticipated feed rate. Chemical feed equipment manufacturers should be consulted for specific operating conditions for the eductors they supply for the specific chemical being used.

The injector should be located directly at the point of application unless site conditions prevent easy access to the point of application for maintenance of the injector. Locating the injector at the point of application provides for transport of gas under vacuum, therefore, if leaks would occur in the vacuum line during operation, the gas would not escape. Specific information regarding the water supply to operate the injector is provided below.

8. Water supply line, booster pumps, and appurtenances

The water supply line to operate the injector shall include a strainer and either a manual or solenoid valve which is the primary control for operating the system. When the available water supply is not adequate for the requirements of the injector, a booster pump and necessary appurtenances shall be provided. A complete backup on-line booster pump system shall also be provided. Booster pumps can be either centrifugal or turbine type depending on the operating requirements and local preference. The booster pumps shall be located outside of the rooms housing any of the other feed system components.

A pressure regulating valve shall be provided on the water supply line to provide a constant pressure to operate the injector. If a booster pump is provided, the pressure regulating valve shall be located downstream of the pump so as not to effect the pump's operation. The booster pumps shall be provided with suction and discharge shutoff valves and pressure gauges, a suction strainer with blowoff, and a discharge check valve, all typically recommended for water service. For turbine pumps, a needle by-pass valve shall also be provided on the pump discharge to allow for relief back to the suction line in order to adjust the operating point of the pump. A pressure relief valve shall also be provided on the turbine pump discharge and piped to the pump suction to prevent damage to the system components due to excessive pressures. Although the discharge head generated by a centrifugal pump can be no higher than its suction head plus its cutoff head, a turbine pump will continue to generate head if its discharge line is closed. A typical turbine booster pump schematic is provided in Attachment C.

It should be noted that ammonia feed systems require softened water for the injector operating water. If softened water is not used, frequent maintenance will be required for the injector due to the calcium carbonate deposition resulting from the softening reaction caused by the ammonia addition. Typical injector operating water flow rates are low enough that commercially available softening units are economical to use. The softening unit should be a dual type such that uninterrupted service is provided. The softening unit as well as all of the water supply components must be located outside of the storage and feed rooms.

9. Diffusers

It is necessary to properly distribute the chemical solution at the point of application. Chemical compatibility must be considered when choosing the location and order of the points of application. For pipeline installations with solution lines 1-inch and less, a removable type assembly is required consisting of a diffuser pipe and corporation cock. The diffuser pipe should extend into the process pipe approximately 25-50 % for proper dispersion. For larger process pipe sizes where quick dispersion of the chemical is required, a fixed main installation is required consisting of a perforated diffuser pipe extending the entire diameter of the process pipe.

For open tank distribution, a perforated diffuser pipe or spray nozzle is recommended. Either device needs to be adequately supported in the open vessel, and located at an elevation where it is submerged at all times under all operating conditions. Flexible piping shall be used near the diffuser to facilitate maintenance or removal. Manufacturer's literature should be consulted for the specific installation for either open tank or pipeline installations.

10. Analytical equipment

A continuous recording chlorine residual analyzer is required at the entrance to the distribution system for all facilities where chlorine is used for disinfection. The analyzer shall be equipped with both low and high residual alarms. Adequate facilities must be present at the site to carry the waste from the analyzer.

D. COMPRESSED GAS STORAGE AND FEED ROOM ELEMENTS

The facilities required to house the compressed gas feed equipment are extremely important in terms of operator safety and providing adequate containment in the event of a gas leak. In general, individual storage and feed rooms are recommended for all installations. The storage room should contain all elements of the feed system which are under pressure and sized for a minimum 30 day supply. It is preferred that empty cylinders not be stored outside of the storage room, however, if space prevents this, the empty cylinders must be protected from direct sunlight. Under no circumstances shall full or partially full cylinders be stored outside of the storage room.

All components of the gas system downstream of the vacuum regulator and upstream of the injector should be located in the feed room. The feed rooms shall be sized to house all of the recommended components and provide adequate clearance for the gas dispensers per the manufacturer's recommendations. Providing separate storage and feed rooms minimizes the need for an operator to be exposed to the potential dangers associated with pressurized gas. However, it is sometimes not practical to construct a separate feed room (e.g. well station). In these instances, it is acceptable to locate the feed room components within the process room (e.g. pump room) provided that room meets the requirements of the feed room in terms of leak detection and ventilation as discussed below. Attachment D is provided for guidance.

1. Room materials of construction

Standard building materials of construction including brick, block, concrete, wood, and, drywall are adequate for both the storage room and the feed room provided that they result in a totally sealed room. Since all of the chemicals are corrosive if moisture is present, no bare metal should be exposed within the room. Any metal that is exposed within the room must be painted or adequately coated. There is no need to paint or coat either the walls or the floor of the room. Roof joists or beams should be isolated with drywall or other non-metallic materials to provide an airtight seal. Should any water supply piping need to pass through either room, the materials of construction should be PVC as opposed to copper or any other type of metal. No floor drains shall be provided in either room, however, consideration should be given to installing a sump and piping at the time the room is constructed if there may be a need in the future to install a scrubber.

2. Access doors and cylinder handling

Separate manway doors shall be provided for both the storage room and the feed rooms. The storage room shall have access only from the exterior of the building. The feed room access can be from either an interior or exterior building location, however, local regulations may require only exterior access for this room also. Under no circumstances shall a door be provided between the two rooms. For large rooms, consideration should be given to providing more than one manway door when quick and easy exit by an operator may not be possible with a single door. Manway doors shall open outward and be equipped with panic hardware. All exterior doors shall be capable of being locked for security reasons. All doors shall be provided with weather strips to prevent water from entering the room or gas from escaping the room. A light shall be installed above all exterior doors for security and safety reasons.

The manway doors for storage rooms utilizing 150-lb and smaller cylinders shall be large enough to permit easy handling of the cylinders through this door. For ton cylinder installations, an equipment door to facilitate the monorail shall be provided in the storage room in addition to the manway door. If possible, the monorail shall be designed with a hinge such that it can folded back into the room when not in use as opposed to permanently extending it through the door, thus alleviating a potential source for gas to escape.

3. Vision panels and windows

Vision panels are required for both the storage room and feed rooms. The vision panels for both rooms must be located only at an interior building location. The glass panels must meet the BOCA code fire rating requirements. Additionally, a vision panel shall be provided between the two rooms. All vision panels should be a minimum of 3' x 3' and oriented such that a full view of the room is possible, especially being able to see the scale readouts and gas dispenser rotameters. The vision panel in the feed room should be located adjacent to the manway door, and could be located in the door if a full view of the room is still obtainable. Under no circumstances shall external windows be provided in either room as the heat generated from sunlight could create excessive pressure in the cylinders or piping.

4. Heating

Individual heating units are required for both the storage and the feed rooms. Only electric or hot water heat shall be permitted. Electric heating units in an ammonia room shall be explosion proof. The heaters shall be controlled by individual thermostats located in each room. The storage room shall be heated to 70 F and the feed rate calculations shall be based on this temperature. It is always necessary to perform heat leak calculations for the storage room to properly size the heater. The temperature in the feed room is not as critical since the gas pressure is low and the potential for reliquification is minimized with a vacuum operated system It is recommended that the feed room be heated to the same temperature as the storage room.

5. Lighting

Adequate lighting shall be provided for both the storage and feed rooms. Light switches shall be provided at all vision panels, including both sides of the vision panel between the two rooms to operate the lights in the opposite rooms. The lights shall automatically come on with the opening of the doors and remain on when the door closes. The lights can be turned off at the exterior of the door in conjunction with the operation of the fan as discussed in a subsequent section on ventilation. All lighting fixtures shall be corrosion resistant. Fixtures in an ammonia room shall be explosion proof. Attachments E and F show the control logic for the lighting in both rooms.

6. Leak detection

Leak detection units shall be provided for both the storage and feed rooms with the control unit located outside of the chemical rooms and the sensor inside of the chemical rooms. The unit for the storage room shall be located at the vision panel, and the unit for the feed room shall be located at the interior entrance door which is adjacent to that rooms' vision panel. Each unit shall have its sensor located within the room at an appropriate location for the specific gas away from the exhaust fan or inlet louver. Multi point sensors are not recommended for reliability reasons. In addition to the units themselves, red indicating lights shall be located at each external storage room manway door to indicate the presence of a leak. For ton cylinder installations, a leak indicating light shall also be provided at the equipment door if the equipment door can be opened without first entering the storage room through the manway door. The capability to test these remote indicating lights shall also be provided. Provisions shall also be made to remotely alert the operator of a leak. The method of accomplishing this is dependent on the specific installation and could be an audible alarm, dialing system, SCADA input, or other appropriate means. Attachments E and F show the control logic for the leak detection system.

7. Ventilation

Separate ventilation systems are required for both the storage and the feed rooms. The purpose of the ventilation system is to continually provide a fresh supply of air through the room while it is occupied, and to have the ability to control gas discharge from the room in the event of a leak. Ventilation equipment for ammonia rooms shall be explosion proof.

Exhaust fans shall be sized to provide one air change per minute. An associated intake louver shall be sized for an inlet velocity of 1 ft/sec to prevent rain from being pulled into the louver. The louver shall have spring closure upon power failure. The fan and louver shall be located at opposite ends of each room to prevent short circuiting. Since chlorine and sulfur dioxide are heavier than air, suction for the exhaust fan shall be taken as close to the floor as possible with the louver located as high as possible in the room. The opposite is true for ammonia since it is lighter than air. The exhaust from the fan shall be directed away from areas where personnel may be present and away from the intake louver. If the configuration of the storage and feed rooms limits the options for chlorine or sulfur dioxide discharge, it may be advisable to run a duct to the floor and locate the exhaust fan on the roof to provide better dispersion of the exhausted gas in the event of a leak.

The fan and louver shall automatically energize with the opening of the manway door for that specific room. The ventilation system shall remain in operation even if the door closes. Upon exiting the room, the ventilation system can be shut off by a manual push button located at the exterior of the door which is also tied to the lighting for the room. The ventilation systems shall also be capable of being manually operated from each respective vision panel (but not the vision panel between the two rooms) to allow for controlled discharge in the event of a leak. Additionally, if the exhaust fan is running and a leak is detected by the leak detection equipment, the ventilation system should shut down. In order to override this shutdown to exhaust the gas in a controlled manner, an override switch in a locked box shall be provided. Only supervisory personnel should be provided access to this override. Green indicating lights shall also be provided at each manway door and the vision panels to indicate that the ventilation system is in operation. Attachments E and F show the control logic for the ventilation system.

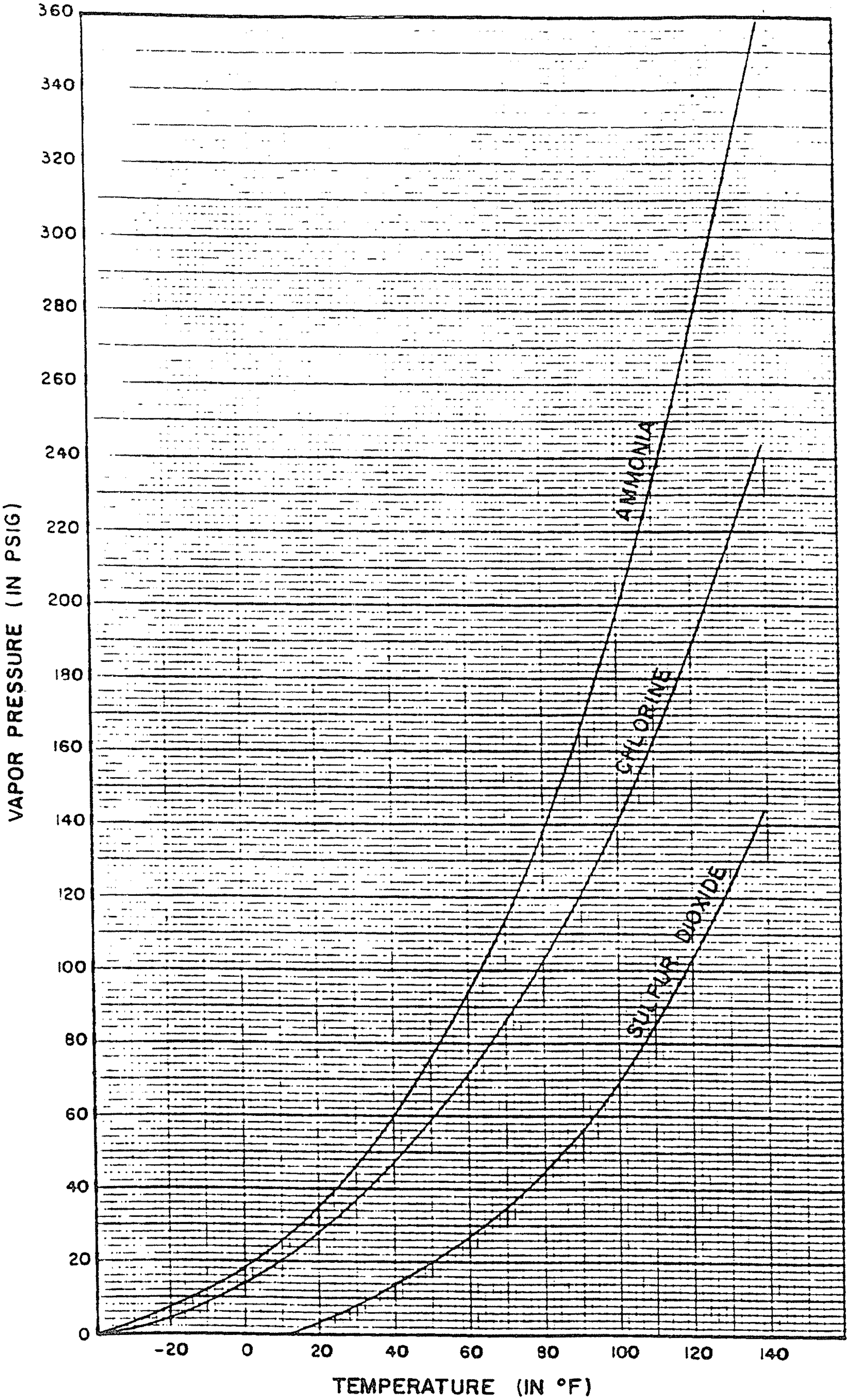
8. Safety and maintenance appurtenances

Several safety and maintenance related items are necessary for all compressed gas feed systems. Two self contained breathing apparati shall be provided at an accessible location outside of the storage and feed rooms but within the building away from the elements. A repair kit for the appropriate size cylinders shall also be provided and located near the storage room. Eyewash/shower stations shall be provided just outside of each manway door, and exterior doors shall have frost proof type stations. Safety chains shall also be provided for all full and empty 100 or 150-lb cylinders whether in use or not. Appropriate signage shall be provided at each door and vision panel to indicate the presence of a hazardous chemical.

IV. REFERENCES

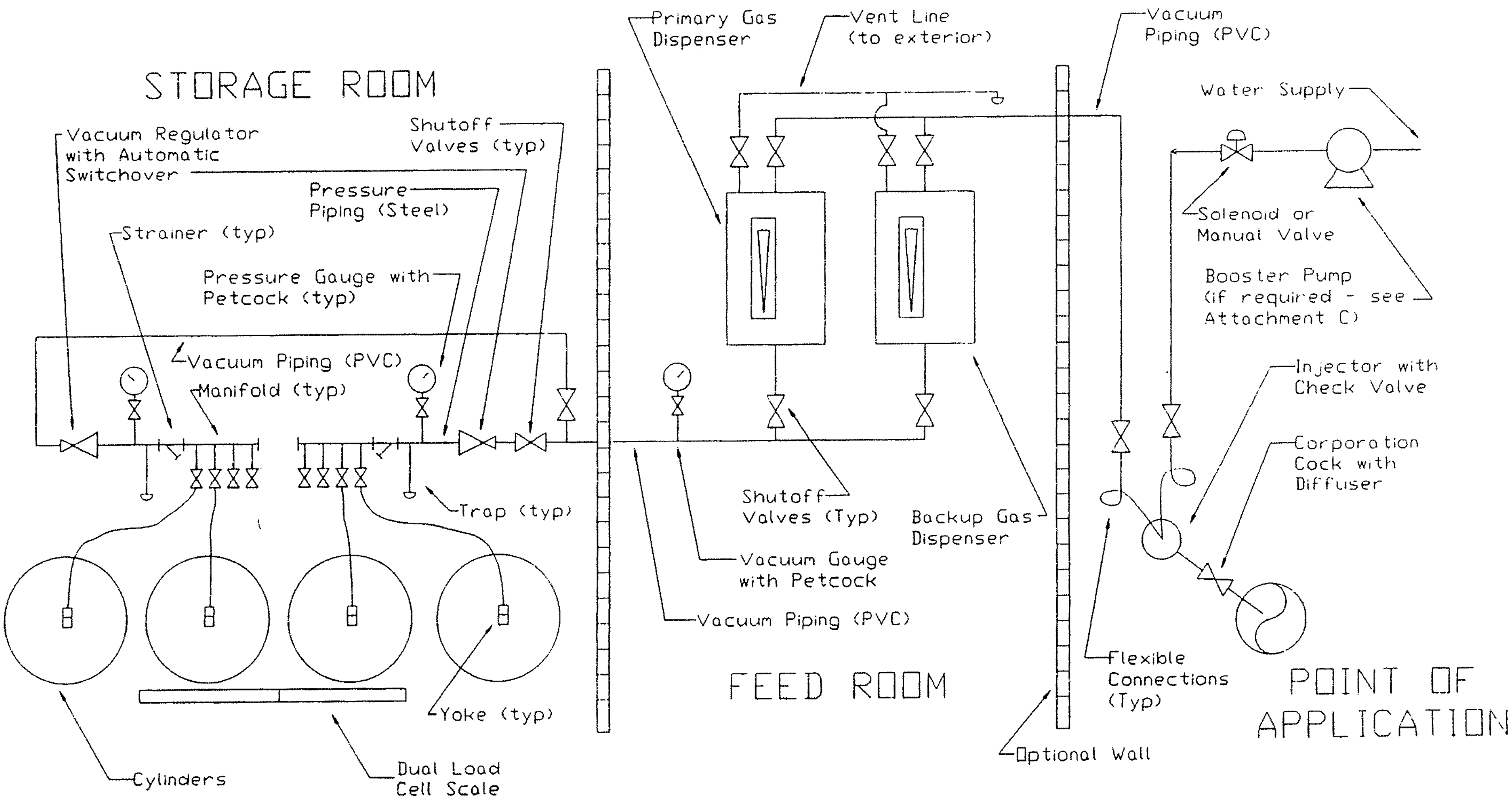
a. Recommended Standards for Water Works (Ten State Standards), 1992
b. Chlorine Institute Manual, Edition 5, 1986
c. Compressed Gas Association Manual G-2 for anhydrous ammonia, 7th Edition, 1984
d. Compressed Gas Association Manual G-3 for sulfur dioxide, 4th Edition, 1988
e. Opflow, April 1980, "Maximum Withdrawal Rates from Chlorine, Sulfur Dioxide, and Ammonia Cylinders", Robert J. Baker
f. Fischer & Porter Technical Bulletin 70-9001 for handling chlorine, sulfur dioxide, and ammonia from supply to point of application, 1972
g. Wallace & Tiernan technical literature for Water and Wastewater Chemical Feed Equipment titled "Disinfection Equipment 1" and "Disinfection Equipment 2"
h. NFPA 70, National Electric Code (ANSI approved), latest edition
i. Chlorine Institute Pamphlet 9, "Chlorine Vaporizing Equipment", Edition 3, May 1987
j. ASME codes for Unfired Pressure Vessels and Pressure Piping
k. ASCE/AWWA "Water Treatment Plant Design" manual, second edition
l. Code of Federal Regulations, Title 29 - Labor, parts 1900-1910, Occupational Safety and Health Administration.

V. ATTACHMENTS (on following pages)

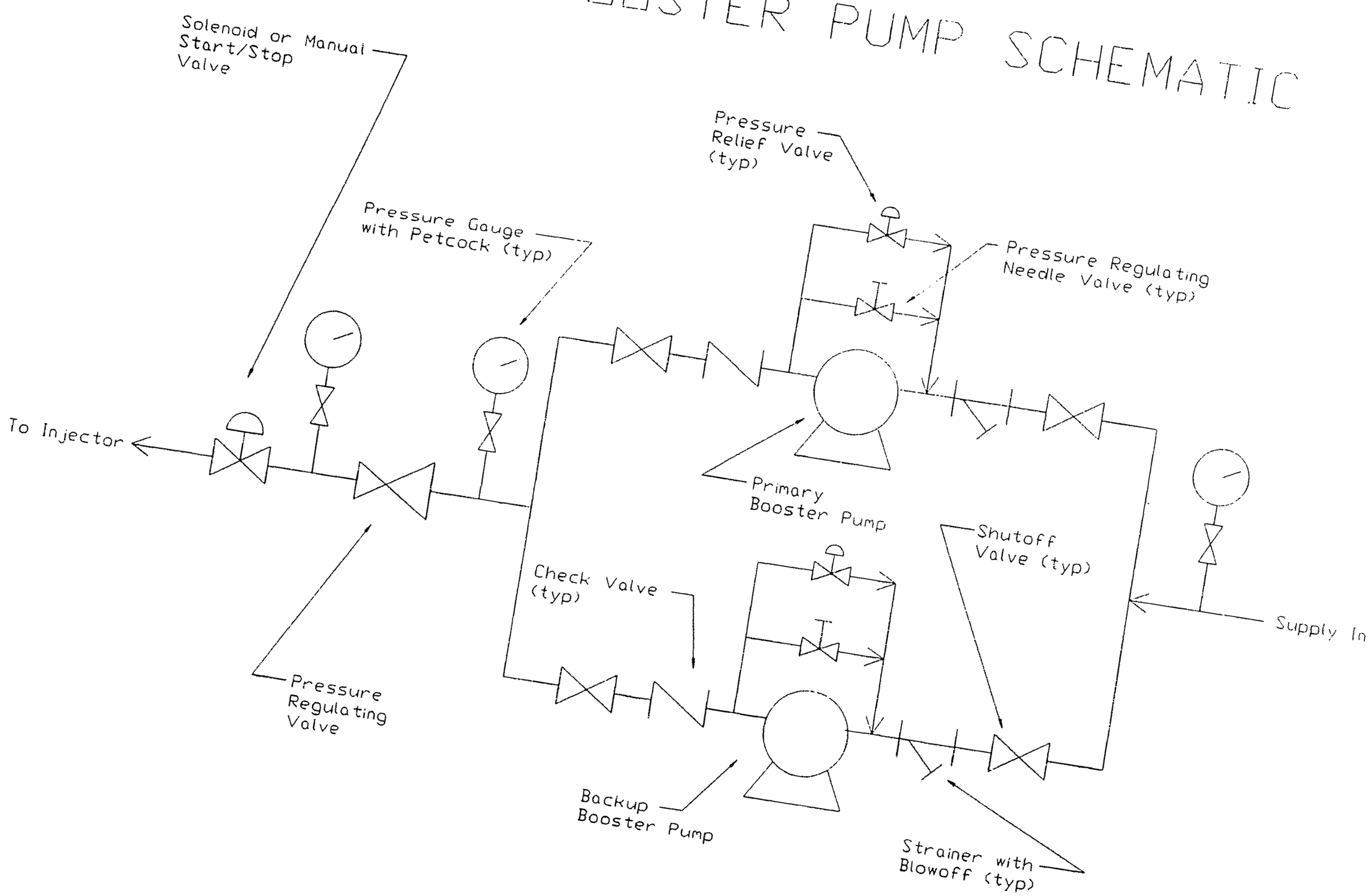


ATTACHMENT A: VAPOR PRESSURE CURVES OF LIQUID CHEMICALS

ATTACHMENT B
TYPICAL FEED SYSTEM SCHEMATIC

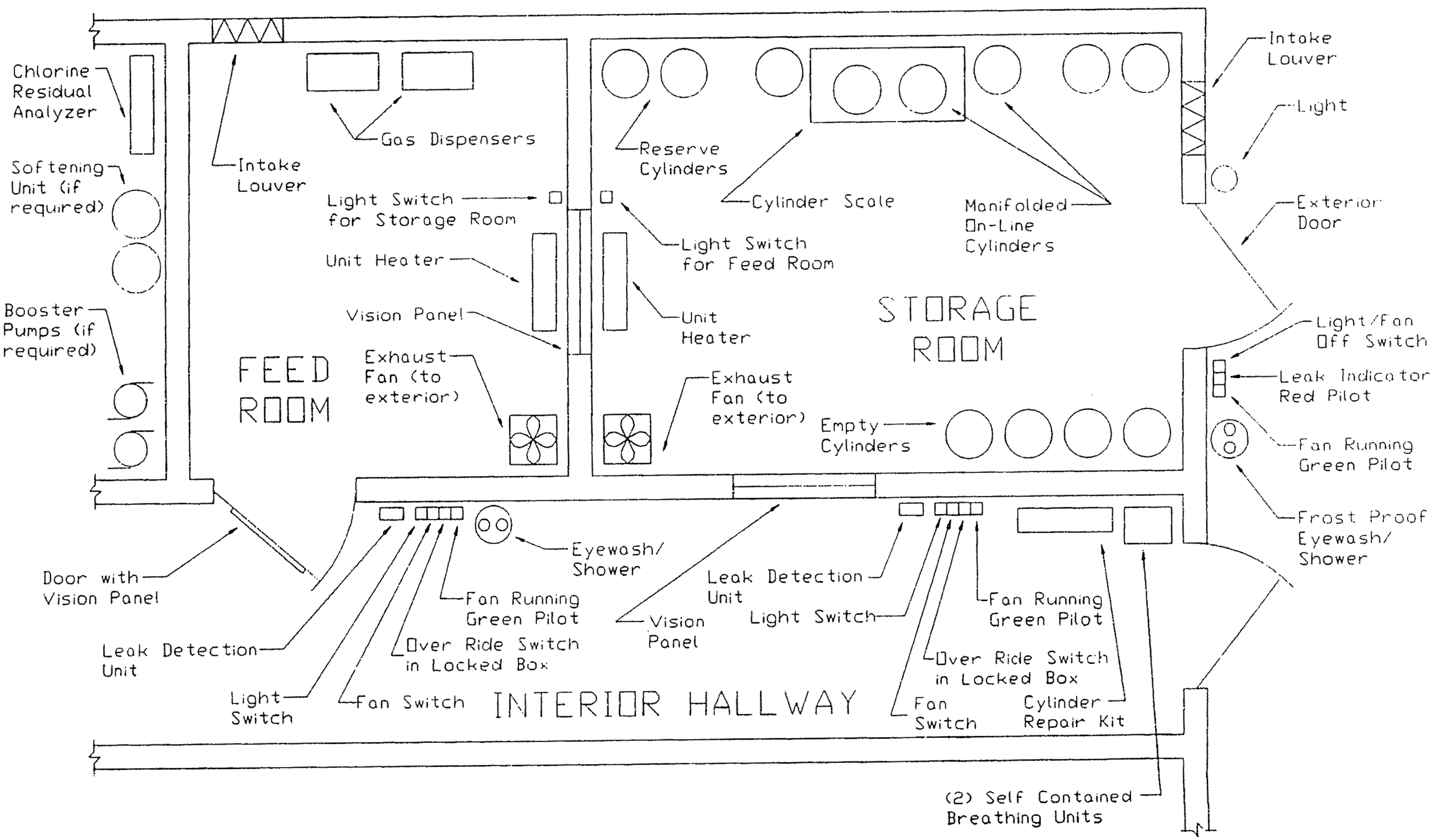


ATTACHMENT C
TURBINE BOOSTER PUMP SCHEMATIC

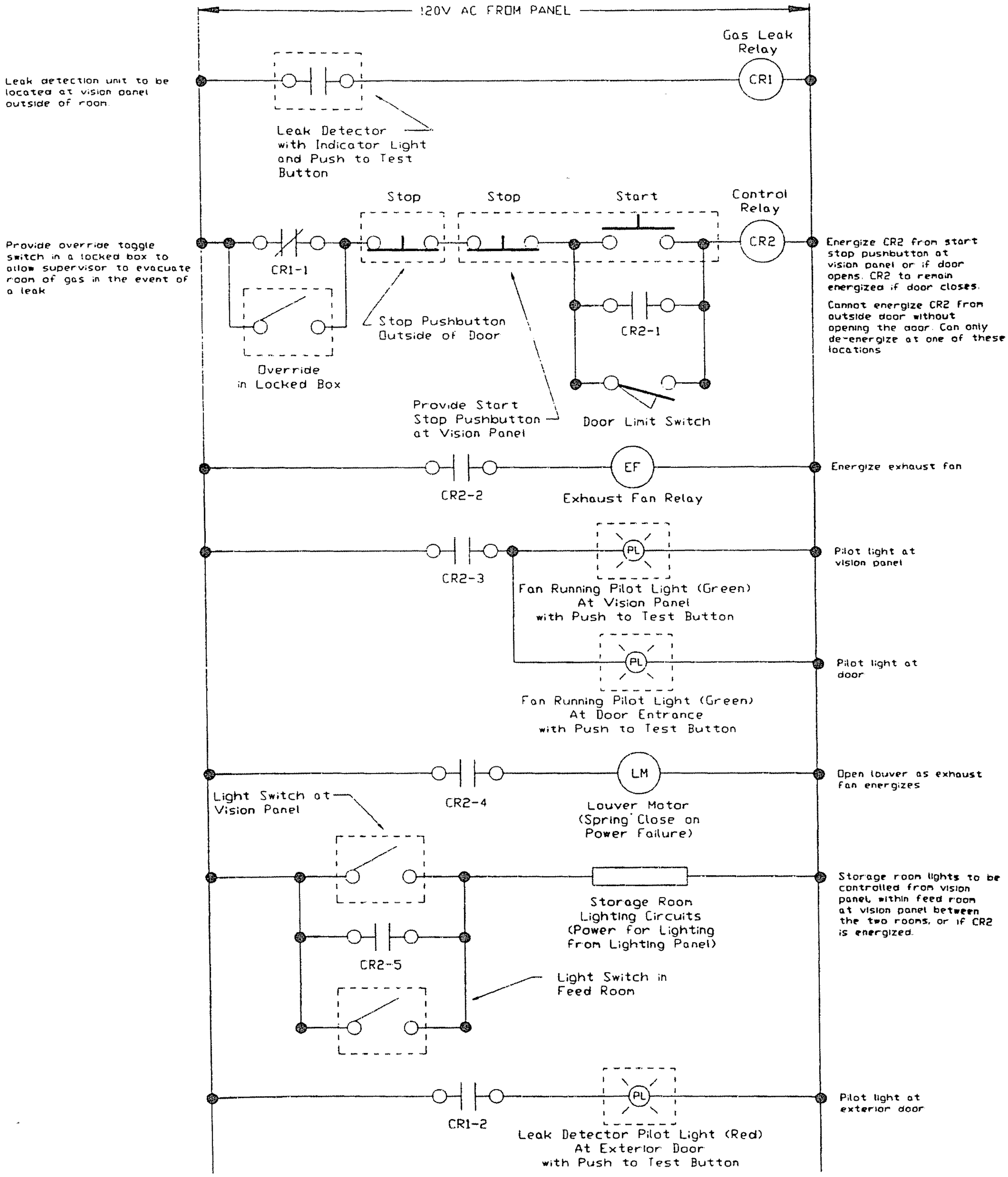


ATTACHMENT D

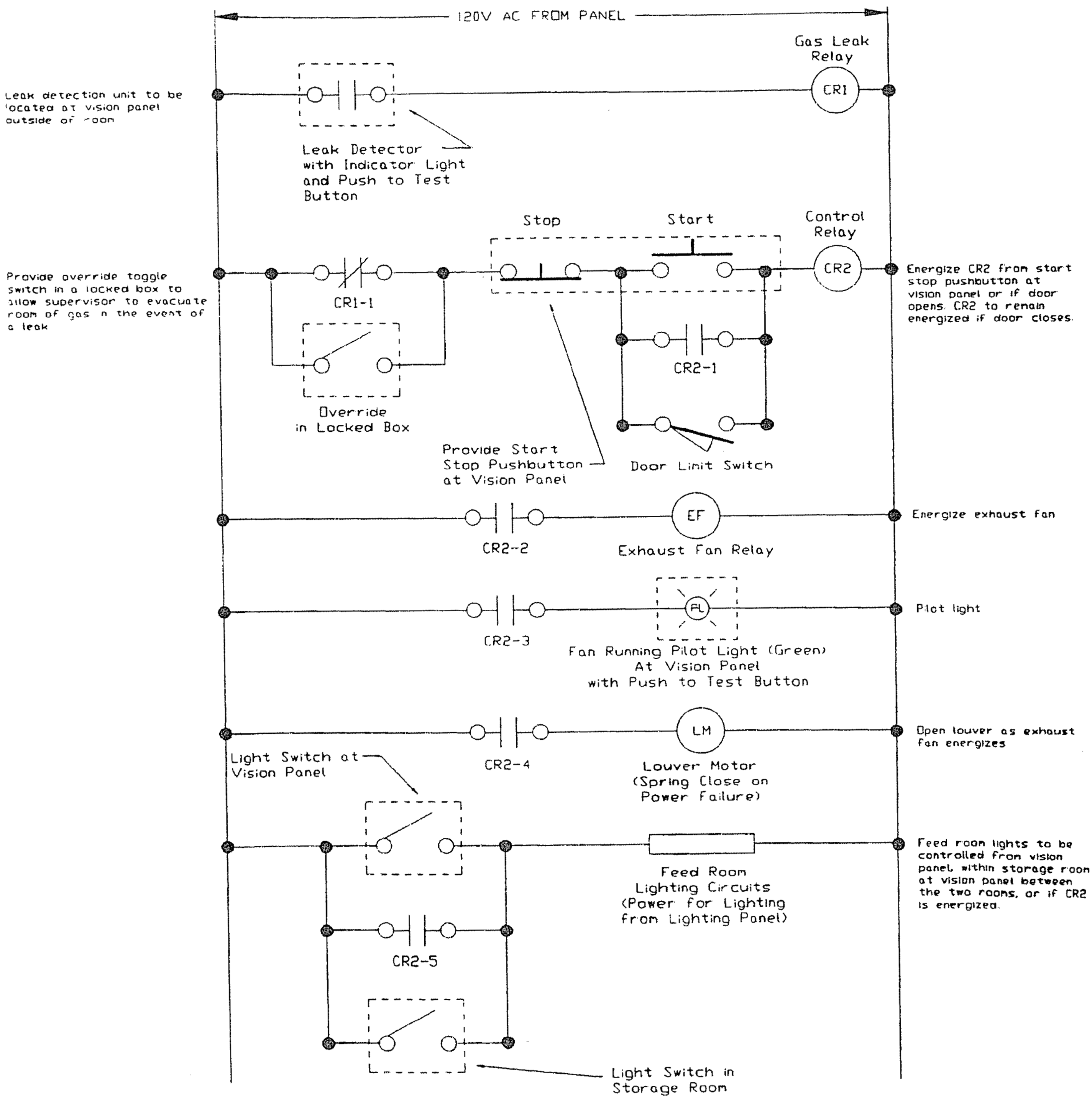
TYPICAL STORAGE FACILITY LAYOUT



ATTACHMENT E
STORAGE ROOM (WITH EXTERNAL DOOR) INSTRUMENTATION SCHEMATIC



ATTACHMENT F
FEED ROOM (WITH INTERNAL DOOR) INSTRUMENTATION SCHEMATIC



KENTUCKY-AMERICAN WATER COMPANY
BLUEGRASS WATER PROJECT

GENERIC CONTROL LOGIC

A. PUMPING OPERATIONS

Local Mode of Operation

a. Individual pumps are put in local mode at the pump location with no control capabilities from the operator workstation.

b. Monitoring of all pump operations shall continue to be available at the operator workstation. Clear indication of the pump status (local or remote mode) shall be provided at the operator workstation. A field shall also be provided on the display for an operator to provide the reason why an individual pump has been put in local mode.

Remote Manual Mode of Operation

a. Individual pumps are put in remote mode at the pump location, and the selection of remote manual (vs. remote automatic) mode is made at the operator workstation.

b. Once in remote manual mode, the operator has the capability to turn individual pumps on and off and control their speed from the workstation.

c. The allowable range of operation of the pump (in percentage of motor speed) shall be displayed on screen next to the field where the operator can change the speed, along with the actual speed of the pump. The range of operation shall be as follows:
   - The upper range of each pump will always be 100% of speed and limited from pump run out by the system head conditions.
   - The lower operating limit of each pump and its corresponding speed shall be specified by the engineer to prevent the pump from reaching a point on its curve where it will operate unstably or inefficiently as specified by the pump manufacturer.

d. Once a pump is started by the operator, it shall automatically ramp up to the speed which has been set. The change in system flow rate caused by the operation the pump shall be monitored by way of the input signal from the common meter.

e. Controlling the speed of the pump in terms of flow capacity (gpm or MGD) is not recommended since a centrifugal pump output at a particular speed will vary depending on the number of other pumps in operation.

B. LIQUID CHEMICAL FEED SYSTEMS

Assumed Typical Scenario

a. The chemical feed system is a bulk liquid system with a single bulk tank, single day tank, and redundant transfer pumps.
b. The system includes multiple metering pumps, some but not all of equal capacity.
c. The metering pumps have remote speed adjustment capabilities, manual stroke settings, and manual pulley settings.
d. The metering pumps are piped to multiple points of application. Changes in the points of application are made by manual valve changes.
e. An analyzer is present to allow for compound loop operation.

Local Mode of Operation

a. Individual metering pumps are put in local mode at the metering pump location with no control capabilities from the operator workstation.
b. Monitoring of all metering pump operations shall continue to be available at the operator workstation. Clear indication of the metering pump status (local or remote mode) shall be provided at the operator workstation. A field shall also be provided on the display for an operator to provide the reason why an individual metering pump has been put in local mode.

Remote Manual Mode of Operation

a. Individual metering pumps are put in remote mode at the pump location, and the selection of remote manual (vs. remote automatic) mode is made at the operator workstation.
b. Once in remote manual mode, the operator has the capability to turn individual metering pumps on and off and control their output (in units of gallons per hour, gph) by varying the speed of the metering pump from the workstation.
c. It is first necessary to define the operating capabilities of each metering pump based on their manual stroke and pulley settings. As the speed of the metering pump is varied, the output will be unique for a specific pulley setting and a specific stroke setting. This matrix of metering pump output capabilities needs to be fully defined on a limited access supervisory screen with the ability to update the information each time a metering pump is calibrated. The low end of the allowable speed shall consider the manufacturer's recommendations for metering pump turndown to ensure that the metering pump is still able to operate accurately at the minimum specified speed.
d. The specific pulley and stroke settings that each metering pump is manually set to must then be entered by the operator on the display from which the metering pumps are controlled. The control logic will then determine the output range (in gph) for each metering pump based on variations in speed, and display this information on screen such that the limits of operation for that specific metering pump are clear to the operator. The operator can then set the desired output of the pump (in gph). The actual speed of each metering pump shall be indicated on the display.
e. Controlling the output of the pump in terms of percentage is not recommended since metering pumps are not metered and a calculation would be required to determine the specific output in gph.

Remote Automatic Mode of Operation

a. Individual metering pumps are put in remote mode at the pump location, and the selection of remote automatic (vs. remote manual) mode is made at the operator workstation. Once in remote automatic mode, the operator must then select either "flow paced" remote automatic operation or "compound loop" remote automatic operation. The system then takes complete control of each metering pump that is in either of these two remote automatic modes.

b. It is first necessary to define the properties for each chemical on a limited access supervisory screen with the capability to update the information each time a shipment of the chemical is received. The necessary properties are "product density" in lbs/gal for all liquid chemicals, and product concentration (%) for those chemicals which are diluted in bulk either prior to or after the shipment is received.

c. In either flow paced or compound loop mode, it is then necessary for the operator to enter a desired dosage in mg/L. The specific chemical equations would then be as follows for a flow paced mode of operation for either a dry weight dosage entry (e.g. 48% alum), or a product dosage entry (e.g. polymers) respectively:

- [dry weight dosage (mg/L) x 8.34 x flow rate (MGD)] / [product density (lbs/gal)] / [product concentration (%) / 100] / [24 hrs/day] = gallons per hour (gph)
- [product dosage (mg/L) x 8.34 x flow rate (MGD)] / [product density (lbs/gal)] / [24 hrs/day] = gallons per hour (gph)

The specific "flow rate" to use in the equations is dependent on the point of application and could be a raw water, finished water, backwash water, or other rate of flow as specified by the engineer.

d. If the metering pump is in compound loop mode, the calculated dosages above would be adjusted (trimmed) as necessary based on the feedback from the respective analyzer (i.e. SCD, etc.). A operator adjustable field shall be provided on the display to allow for a feedback set point for each specific analyzer. This shall be displayed next to the actual reading from the specific analyzer.

e. When a point of application change is manually made and entered on the display, the system shall automatically determine which flow rate to use for flow pacing, and which analytical instrument to use for trimming (if applicable). It is the engineer's responsibility to provide this information to the systems integrator via the specifications.

f. Based on the previously entered information for each metering pump (pulley and stroke settings) the system shall select the appropriate metering pump or combination of metering pumps from those which are in remote automatic mode which can accommodate the calculated feed rate.

g. The operator shall have the ability to prioritize the selection of metering pumps such that the system will select the higher prioritized metering pump if more than one metering pump meets the required criteria. The metering pumps shall be prioritized 1, 2, 3, etc. regardless of capacity. If the system cannot find a single metering pump to meet the output requirements, it shall select more than one metering pump as necessary based on the prioritization. It should be noted that metering pumps will output a specific volume of the liquid chemical independent of head conditions or number of metering pumps in operation. Thus, the total output from more than one metering pumps is simply the summation of the output from each individual metering pump.

Common Control Features for All Modes of Operation

a. The control of the transfer pumps is a local operation only with no remote capabilities. Monitoring of the status of the transfer pumps (pump energized) shall be provided at the operator workstation.

Monitoring Requirements

a. It is necessary that the system calculate a daily chemical inventory and average dosage based on the level change in the day tank over a 24-hour period. The equations would be as follows for either a dry weight chemical (e.g. 48% alum), or a product weight chemical (e.g. polymers) respectively:
   - [tank level high (in) - tank level low (in)] x [incremental tank volume (gal/in)] x [product density (lbs/gal)] x [product concentration (%) / 100] = dry weight (lbs)
   - [dry weight pounds (calculated above)] / [total daily plant production (MG)] / 8.34 = dry weight average dosage (mg/L)
   - [tank level high (in) - tank level low (in)] x [incremental tank volume (gal/in)] x [product density (lbs/gal)] = product weight (lbs)
   - [product weight pounds (calculated above)] / [total daily plant production (MG)] / 8.34 = product weight average dosage (mg/L)

b. The system must recognize that the tank will be filled during the day, possibly more than once. This could be accomplished by monitoring the changes in level (rising or falling) and incorporating it into the logic.

Other Considerations

a. If a reliable means is provided to determine that an energized metering pump is actually producing flow (i.e. flow switch, etc.), this shall also be incorporated into the control logic to determine failure of a unit.

C. GASEOUS CHEMICAL FEED SYSTEMS

Assumed Typical Scenario

a. The chemical feed system is a vacuum operated system with automatic switchover capabilities withdrawing gas from multiple cylinders.

b. The system includes multiple gas dispensers, some but not all of equal capacity.

c. The gas dispensers have remote rotameter adjustment capabilities. It is also common for the size of the rotameter to be changed seasonally.

d. The gas is transported to the point of application by eduction. Changes in the points of application are made by manual valve changes.

e. An analyzer is present to allow for compound loop operation.

Local Mode of Operation

a. Individual gas dispensers are put in local mode at the gas dispensers location with no control capabilities from the operator workstation.

b. Monitoring of all gas dispensers operations shall continue to be available at the operator workstation. Clear indication of the gas dispenser status (local or remote mode) shall be provided at the operator workstation. A field shall also be provided on the display for an operator to provide the reason why an individual gas dispenser has been put in local mode.

Remote Manual Mode of Operation

a. Individual gas dispensers are put in remote mode at the gas dispenser location, and the selection of remote manual (vs. remote automatic) mode is made at the operator workstation.

b. Once in remote manual mode, the operator has the capability to control individual gas dispensers (in units of pounds per day, lbs/day) by varying the position of the rotameter from the workstation.

c. It is first necessary to define the operating capabilities of each gas dispenser based on the potential rotameter sizes. This matrix of gas dispenser output capabilities needs to be fully defined on a limited access supervisory screen. The low end of the rotameter setting shall consider the manufacturer's recommendations for gas dispenser turndown to ensure that the gas dispenser is still able to operate accurately at the minimum specified rotameter setting.

d. The specific rotameter that is installed in each gas dispenser must then be identified by the operator on the display from which the gas dispensers are controlled. The output range (in lbs/day) for each gas dispenser based on the installed rotameter shall be displayed on screen such that the limits of operation for that specific gas dispenser are clear to the operator. The operator can then set the desired output of the gas dispenser (in lbs/day).

e. Controlling the output of the gas dispensers in terms of percentage is not recommended since gas dispensers are not metered and a calculation would be required to determine the specific output in lbs/day.

Remote Automatic Mode of Operation

a. Individual gas dispensers are put in remote mode at the gas dispenser location, and the selection of remote automatic (vs. remote manual) mode is made at the operator workstation. Once in remote automatic mode, the operator must then select either "flow paced" remote automatic operation or "compound loop" remote automatic operation. The system then takes complete control of each gas dispenser that is in either of these two remote automatic modes.

b. In either flow paced or compound loop mode, it is then necessary for the operator to enter a desired dosage in mg/L. The specific chemical equation would then be as follows for a flow paced mode of operation:
   - [gas dosage (mg/L) x 8.34 x flow rate (MGD)] = pounds per day (lbs/day)

The specific "flow rate" to use in the equations is dependent on the point of application and could be a raw water, finished water, backwash water, or other rate of flow as specified by the engineer.

c. If the gas dispenser is in compound loop mode, the calculated dosages above would be adjusted (trimmed) as necessary based on the feedback from the respective analyzer (i.e. chlorine residual analyzer, etc.). A operator adjustable field shall be provided on the display to allow for a feedback set point for each specific analyzer. This shall be displayed next to the actual reading from the specific analyzer.

d. When a point of application change is manually made and entered on the display, the system shall automatically determine which flow rate to use for flow pacing, and which analytical instrument to use for trimming (if applicable). It is the engineer's responsibility to provide this information to the systems integrator via the specifications.

e. Based on the previously entered information for each gas dispenser (rotameter size) the system shall select the appropriate gas dispenser or combination of gas dispensers from those which are in remote automatic mode which can accommodate the calculated feed rate.

f. The operator shall have the ability to prioritize the selection of gas dispensers such that the system will select the higher prioritized gas dispensers if more than one gas dispenser meets the required criteria. The gas dispensers shall be prioritized 1, 2, 3, etc. regardless of capacity. If the system cannot find a single gas dispenser to meet the output requirements, it shall select more than one gas dispenser as necessary based on the prioritization.

Monitoring Requirements

a. It is necessary that the system calculate a daily chemical inventory and average dosage based on the weight reduction in the cylinder(s) over a 24-hour period. The total usage would be reported in pounds and the average dosage for the day would be calculated as follows:
   - [total weight reduction (lbs)] / [total daily plant production (MG)] / 8.34 = average dosage (mg/L)

b. The system must recognize that cylinders can be replaced during the day, possibly more than once, and on each side of the automatic switchover. This could be accomplished by monitoring the changes in weight (increasing or decreasing) and incorporating it into the logic.

Other Considerations

a. If a reliable means is provided to verify the flow of eduction water (i.e. flow switch, water meter, etc.), this shall also be incorporated into the control logic to determine failure of the system. This verification of flow shall be provided for each individual point of application.

D. ALARMS

Warning and Critical Alarms

a. In general, the capability for an operator to define two levels of alarms shall be provided for all variable inputs. This could be a direct analog input (e.g. from a chlorine residual analyzer) or a calculated value (e.g. clearwell CT).

b. The first alarm level is referred to as a "warning alarm" and would provide notification to an operator that a particular parameter is reaching an undesirable limit. The system would take no action for a warning alarm other than notification. This alarm set point would be defined on a separate supervisory display.

c. The second alarm level is referred to as a "critical alarm" and indicates that an undesirable limit has been reached. All non-variable alarms (ones which can't physically have a warning alarm such as a valve not reaching its open or closed limit) would also be classified as "critical alarms". When a critical alarm state is reached, action is required by the system in addition to providing notification. The type of action will be dependent on the specific alarm and would include, but not be limited to, the following:
   - Shutdown entire plant
   - Shutdown and isolate a specific process unit
   - Shutdown equipment
   - Shutdown primary equipment, start backup equipment (where possible)
   - Backwash filter

   The system shall not attempt to rectify a problem with actions that are not typical of the normal routine plant operations. For example, if the level in a filter rose too high, no attempt should be made to throttle inlet valves to force the level to drop.

d. The control logic must ensure that an action to correct a critical alarm cannot occur more than once (e.g. if a pump fails and the backup also fails, the system should not try to restart the first pump again). At this point, a secondary action would need to occur (e.g. shut down the entire plant).

e. The consultant is responsible for defining all initial alarm set points and actions in the specifications, preferably directly in the I/O list.

E. WORKSTATION DISPLAYS

Definition

a. The displays that are required for the specific project shall be defined in the specifications by the consultant. It is not acceptable to only specify the number of anticipated displays and defer the specific definition to the construction phase of the project. Each defined display shall include the following:
   - A title
   - A brief description of the purpose of the display
   - A listing of each point from the I/O list that shall be reflected on the display.

It is recommended that this be accomplished directly on the I/O list.

In lieu of the above, it is also acceptable for the consultant to provide actual screen displays which are created with the man-machine interface software specified for the project. The electronic files with the displays shall be made available to the successful systems integrator.

b. The following is a list of typical displays for a treatment plant. The consultant is responsible for modifying this list for the specific project.

- Title page with Water Company logo and listing of all available screens and reports
- Plant overview (possibly need two screens)
- Raw water intake and pump station overview
- Individual raw water pumps when multiple pump and motor parameters are being monitored (one display per pump)
- Each chemical feed system (one display per system)
- Chemical properties table
- Mixing, flocculation, clarification overview (very dependent on the specific process that is selected)
- Filter overview (including backwash pumps)
- Individual filters (one display per filter)
- Backwash setup
- Backwash sequence step display (text based)
- Plant service pumps
- Clearwell and distributive pump station overview
- Individual distributive pumps when multiple pump and motor parameters are being monitored (one display per pump)
- Residuals handling overview
- Individual residuals handling tanks and basins (one display per tank)
- Emergency power
- Security overview (intrusion, fire, smoke, entrance gates, etc.)
- Distribution system storage tanks (all on one display if possible)
- Alarm and set point setup (possibly multiple screens)
- RTU communications

c. Initial values for all alarms (warning and critical) and set points shall be defined by the consultant in the specifications.

Colors and Conventioning

a. The following color scheme is recommended unless the Water Company has a specific color scheme on which they have already standardized:

- Equipment that is not running should be grayed out.
- The process color should be displayed when equipment is running as follows:
  - raw water - blue/green
  - settled water - aqua

  - finished water - blue
  - waste water - brown
- Chemical process colors shall be in accordance with Ten State Standards or specific state standards if they exist.
- Equipment in transition (e.g. a modulating valve) should be shown in magenta.
- The background of all screens should be black.
- All text should be in a blue box with a white outline as follows:
  - Fixed text (titles) - white
  - Text that can be toggled or entered (such as set points) - yellow
  - Text which varies but is provided by the system (such as a flow rate) - green

b. Alarm conditions shall flash with the alarm words appearing on the screen (e.g. "Low Chlorine Residual") in red text. Once the alarm is acknowledged, it shall stop flashing but continue to be displayed in red text. The red text shall disappear once the alarm condition is rectified. Warning alarms shall be distinguished from critical alarms with the words "Warning" and "Critical". When an alarm occurs, it shall be displayed in an alarm block on the overview screen.

F. REPORTS

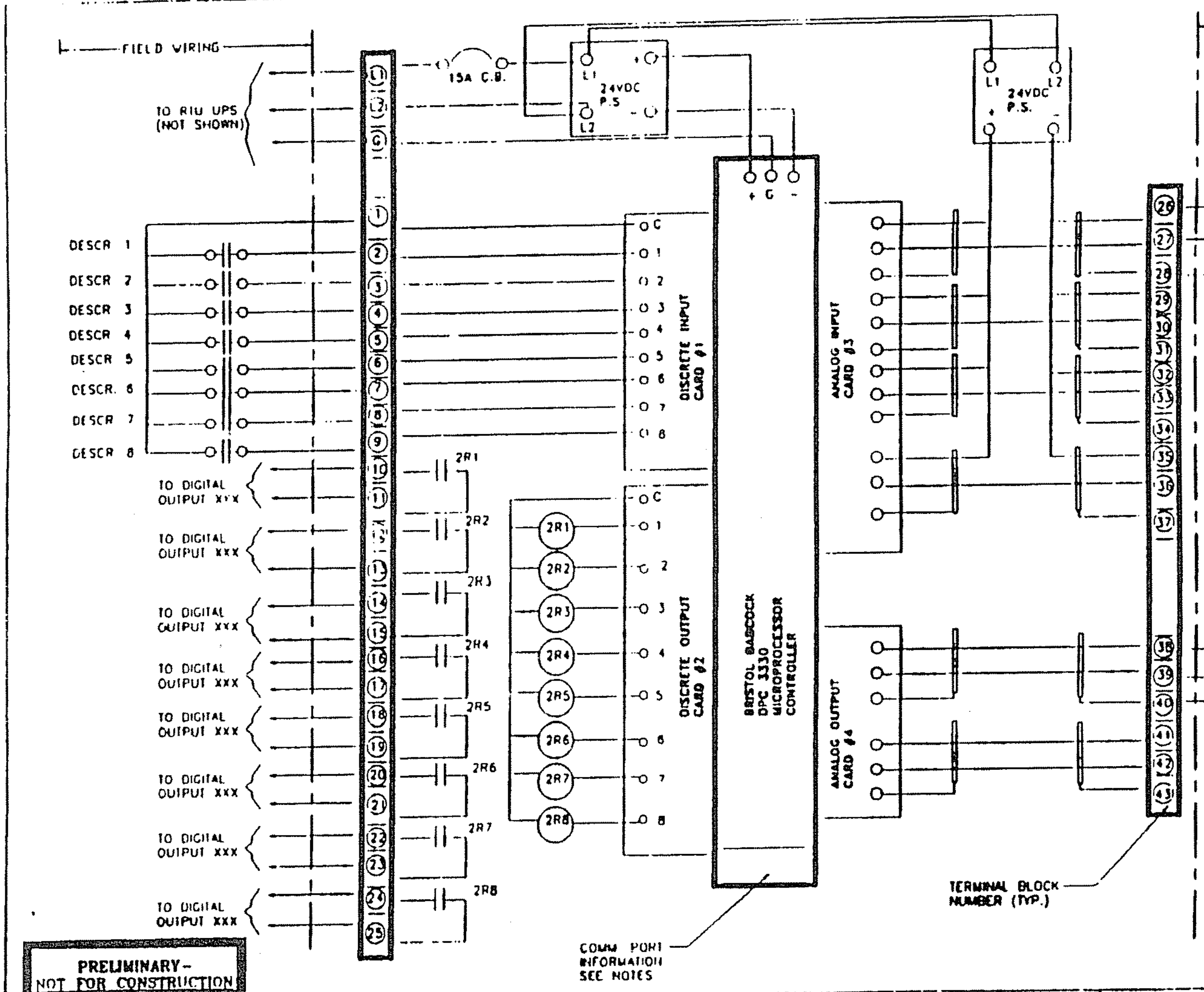
Definition

a. Examples of all reports that will need to be generated for the specific facility will be provided by the Water Company and shall be defined in the specifications by the consultant. The reports shall be created in Lotus 1-2-3 (or other spreadsheet software as specified by the Water Company) but integrated into the man-machine interface software such that the operator can launch each report directly from the title screen. It is <u>not</u> acceptable to only specify the number of anticipated reports and defer the specific definition to the construction phase of the project. Each defined report shall include the following:

- A title
- A brief description of the purpose of the report
- Identification of the I/O point that corresponds to each entry point on the report. If the entry point on the report involves a calculation, the specific calculation shall be provided by the consultant. If the entry point on the report requires a manual entry by an operator, it shall be defined as such. The operator shall have the ability to overwrite any information on any report that is generated by the system.

In lieu of the above, it is also acceptable for the consultant to provide actual electronic reports which are created with the spreadsheet software specified for the project. These electronic spreadsheets shall be made available to the successful systems integrator.

b. The systems integrator is responsible to ensure that the reports are archived properly at the end of each month (or at a time interval as defined by the Water Company) before initiating the next month's report.

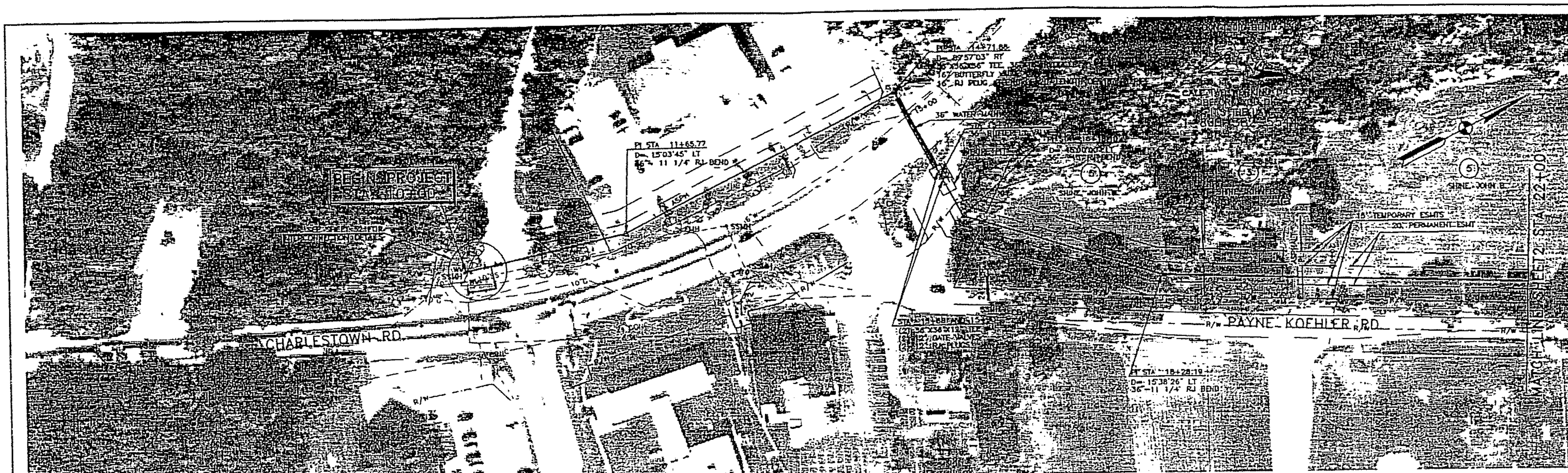


PRELIMINARY - NOT FOR CONSTRUCTION

NOTES

1 THE INTENT OF THIS DRAWING IS TO ILLUSTRATE THE MINIMUM LEVEL OF ACCEPTABLE DETAIL FOR I/O LOOP DRAWINGS. THIS DIAGRAM APPLIES TO THE INTERFACE BETWEEN NEW EQUIPMENT AS WELL AS EQUIPMENT TO BE RETAINED BUT CONDITIONED TO OPERATE AT 24VDC.
2 DURING DETAILED DESIGN, THE CONSULTANT SHALL PLACE I/O ON THE 4 TYPES OF I/O CARDS SHOWN ON THIS DRAWING
3 GROUNDING OF INSTRUMENT SHIELDS NOT SHOWN ON THIS DRAWING. CONSULTANT SHALL SHOW THIS ON I/O WIRING DIAGRAMS DURING DETAILED DESIGN.
4. THE NUMBER AND CONNECTION OF POWER SUPPLIES IS FOR ILLUSTRATIVE PURPOSES ONLY. THE CONSULTANT SHALL VERIFY THE SIZE OF THE SUPPLY REQUIRED BASED ON I/O AND MICROPROCESSOR REQUIREMENTS.
5. THE CONSULTANT SHALL VERIFY THE COMMUNICATIONS PORT TO BE USED ON THE DPC 3330. IF MULTIPLE RTU'S ARE REQUIRED INSIDE THE PLANT, ALL INPLANT RTU'S WILL BE CONNECTED VIA A FIBEROPTIC LINK.
6 THE UPS AND ITS ASSOCIATED CONNECTIONS ARE NOT SHOWN. IT IS THE INTENT OF THE DESIGN TO USE PATRIOT SERIES UPS INSIDE EACH CABINET TO PROVIDE ISOLATION AND SIGNAL CONDITIONING.
7. IF 4 WIRE INSTRUMENTS ARE USED, THE CONSULTANT SHALL SHOW THE 120VAC CONNECTIONS REQUIRED.
8 IT IS THE INTENT OF THIS DESIGN TO MAINTAIN 4 WIRE CONTROL I.E. ONE CONTACT FOR START AND ONE CONTACT FOR STOP (TYP ALL D.O.'S)
9 A COPY OF THIS TEMPLATE WILL BE TRANSMITTED TO THE CONSULTANT PRIOR TO THE BEGINNING OF DETAILED DESIGN.
10. SEPARATE CONTACT CLOSURES WILL BE USED TO INDICATE OPEN AND CLOSED STATUS ON ALL EQUIPMENT (SUCH AS VALVES).
11 INTERPOSING RELAYS ARE NOT SHOWN ON THIS DIAGRAM. CONSULTANT TO DEVELOP DETAILS FOR THE CONNECTION OF 24VDC CONTROL EQUIPMENT TO 230VAC CONTROL CIRCUITS FOUND THROUGHOUT THE PLANT.
12. THE DESIGN SHALL STANDARDIZE AROUND 12 SLOT DPC 3330'S (386 MICROPROCESSOR)

BP NO.			COMPANY	
DRAWN BY	MARRANO	DATE 11MAR96		
CHECKED BY			TITLE	TYPICAL RTU TEMPLATE LOOP DIAGRAM
DESIGNED BY	MARRANO	11MAR96	DWG NO. / FILE NAME	ICSK-
DESIGN ACTIVITY	AWWSC			
CUSTOMER	MO-AWC		SCALE NONE	DATE 11MAR96 — SHEET 1 of 1



GENERAL NOTES:

1. WATER MAIN SHALL BE INSTALLED WITH A MINIMUM OF 42" OF COVER, UNLESS OTHERWISE NOTED.

2. CONTRACTOR IS RESPONSIBLE FOR INVESTIGATION WORK TO DETERMINE IF DEFLECTION OF THE WATER MAIN WILL BE REQUIRED TO GUARANTEE AN 18" MINIMUM VERTICAL SEPARATION OR A 10' MINIMUM HORIZONTAL SEPARATION BETWEEN STORM SEWER LINES, SANITARY SEWER LINES AND THE PROPOSED WATER MAIN. PRIOR TO ANY COMPROMISE OF THESE REQUIREMENTS, WRITTEN APPROVAL SHALL BE OBTAINED FROM THE NAWC PROJECT MANAGER.

3. TO MINIMIZE STRESS TO TREE SPECIMENS IN THE AREA OF CONSTRUCTION, THE WATER MAIN TRENCH SHOULD BE OPEN FOR A MINIMUM AMOUNT OF TIME AND THE ROOTS ON THE TRENCH SIDE OF THE TREE SHALL BE SEVERED IN A CLEAN CUT MANNER.

4. EXISTING UTILITIES AND THEIR LOCATION SHOWN ON PLANS ARE APPROXIMATE. CONTRACTOR SHALL VERIFY ALL UTILITIES IN THE FIELD AND NOTIFY ALL UTILITY COMPANIES PRIOR TO INSTALLATION.

5. CONTRACTOR SHALL NOTIFY RESPECTIVE UTILITY COMPANIES AT LEAST 4 DAYS PRIOR TO INSTALLATION OF WATER MAIN IN LOCATIONS WHERE UTILITY POLE SUPPORT IS REQUIRED.

6. CONTRACTOR SHALL CLEAN STREETS OF CONSTRUCTION DEBRIS DAILY TO THE SATISFACTION OF THE JURISDICTION HAVING RESPONSIBILITY. OWNER AND ENGINEER. CONTRACTOR SHALL FURTHER ENSURE THAT AT LEAST ONE LANE OF TRAFFIC IS OPEN AT ALL TIMES DURING CONSTRUCTION ALONG ROADWAYS.

7. WATER MAIN & APPURTENANCES SHALL BE DISINFECTED PER SPECIFICATIONS. PRECAUTIONS SHALL BE TAKEN TO PROTECT THE INTERIORS OF PIPES, FITTINGS, AND VALVES AGAINST CONTAMINATION. ALL OPENINGS IN THE PIPELINE SHALL BE CLOSED WITH WATER TIGHT RINGS WHEN PIPELAYING IS STOPPED AT THE CLOSE OF EACH DAY'S WORK.

8. UTILITY CROSSING SUPPORTS MAY NOT BE REQUIRED AT ALL UTILITIES BEING CROSSED. CONTRACTOR SHALL NOTIFY THE ENGINEER FOR APPROVAL WHEN NOT CONSTRUCTING UTILITY CROSSING SUPPORTS FOR THOSE UTILITY CROSSINGS INDICATED ON PLANS. UTILITY CROSSINGS ARE DETAILED ON SHEET 30.

9. GRANULAR BACKFILL IS REQUIRED WHEN WATER MAIN TRENCH IS WITHIN 5 FT. OF THE EDGE OF ROADWAY PAVEMENT.

10. MAXIMUM ALLOWABLE DEFLECTION AT JOINTS FOR PUSH-ON PIPE SHALL NOT EXCEED MANUFACTURER'S RECOMMENDATIONS. WHERE DEFLECTIONS ARE TOO SHARP FOR THE ALLOWABLE DEFLECTION, SHORT LENGTHS OF PIPE OR EXPANDED LENGTH OF CURVE MAY BE USED UPON APPROVAL OF THE ENGINEER.

11. CONNECTION TO EXISTING SYSTEMS SHALL BE SCHEDULED IN ADVANCE TO ENSURE COORDINATION WITH THE WATER UTILITY AND ENGINEER.

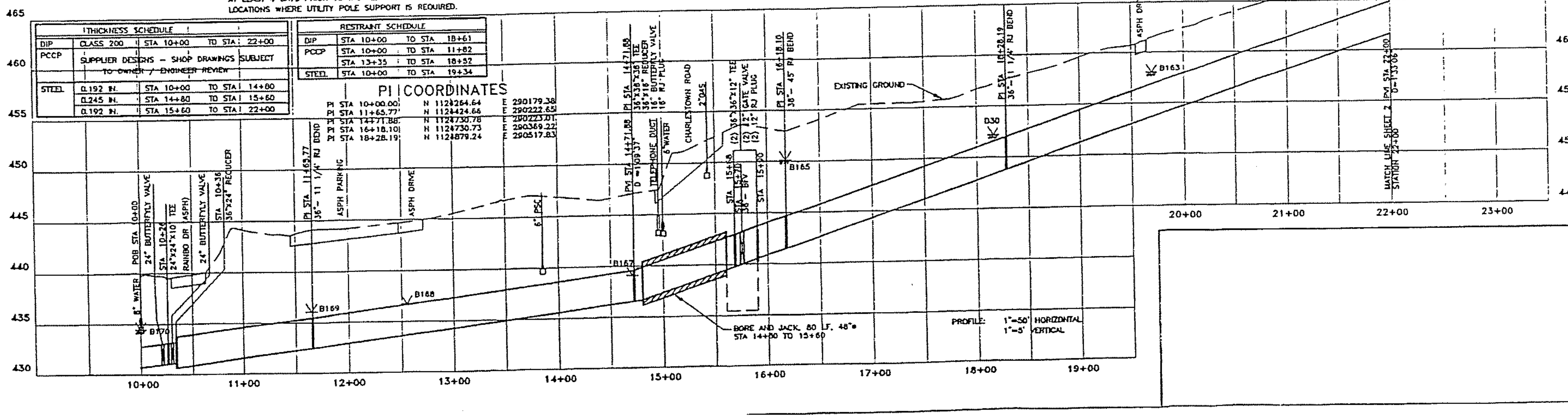
12. RESTRAINED JOINT PIPE IS USED FOR THRUST RESTRAINT. THRUST BLOCKING SHALL ONLY BE USED AT TIE-INS TO EXISTING PIPES AND AS APPROVED BY THE ENGINEER. RESTRAINED JOINTS SHALL USE A WELDED RETAINER RING OR RETAINING WELDMENT ON THE SPIGOT END AND DUCTILE IRON OR STEEL LOCKING SEGMENT OR RING THAT INSERTS INTO A SPECIAL BELL END JOINT EQUIVALENT TO U.S. PIPE'S TR-FLEX(TM) OR AMERICAN DUCTILE IRON PIPE'S LOK-RING(TM). THE USE OF FRICTION TYPE RESTRAINED JOINTS SUCH AS MEG-A-LUG(TM) OR UNI-FLANGE SERIES 1400 SHALL BE LIMITED TO FIELD CLOSURE PIECES AND EMERGENCY REPAIRS. THE USE OF FIELD INSTALLED RETAINING RINGS, SUCH AS GRIPPER RINGS(TM) AND FIELD LOCK GASKETS(TM) WILL NOT BE PERMITTED.

THICKNESS SCHEDULE			
DIP	CLASS 200	STA 10+00	TO STA 22+00
PCCP	SUPPLIER DESIGNS - SHOP DRAWINGS SUBJECT TO OWNER / ENGINEER REVIEW		
STEEL	0.192 IN.	STA 10+00	TO STA 14+80
	0.245 IN.	STA 14+80	TO STA 15+60
	0.192 IN.	STA 15+60	TO STA 22+00

RESTRAINT SCHEDULE		
DIP	STA 10+00	TO STA 18+61
PCCP	STA 10+00	TO STA 11+82
	STA 13+35	TO STA 18+52
STEEL	STA 10+00	TO STA 19+34

PI COORDINATES

PI STA 10+00.00	N 1124264.64	E 290179.38
PI STA 11+65.77	N 1124424.66	E 290222.65
PI STA 14+71.88	N 1124730.78	E 290223.01
PI STA 16+18.10	N 1124730.73	E 290369.22
PI STA 18+28.19	N 1124879.24	E 290517.83

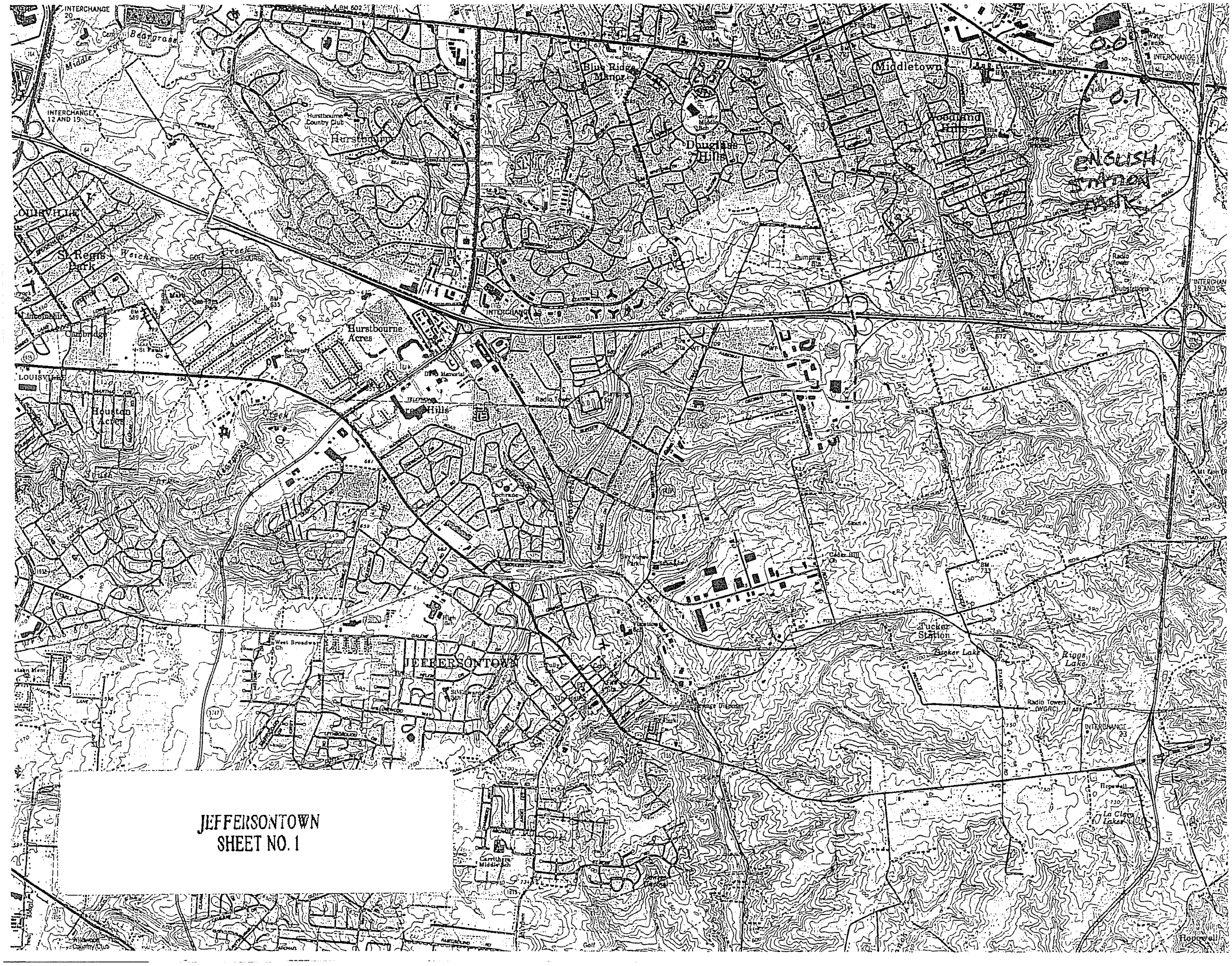


Revised per Addendum No. 1

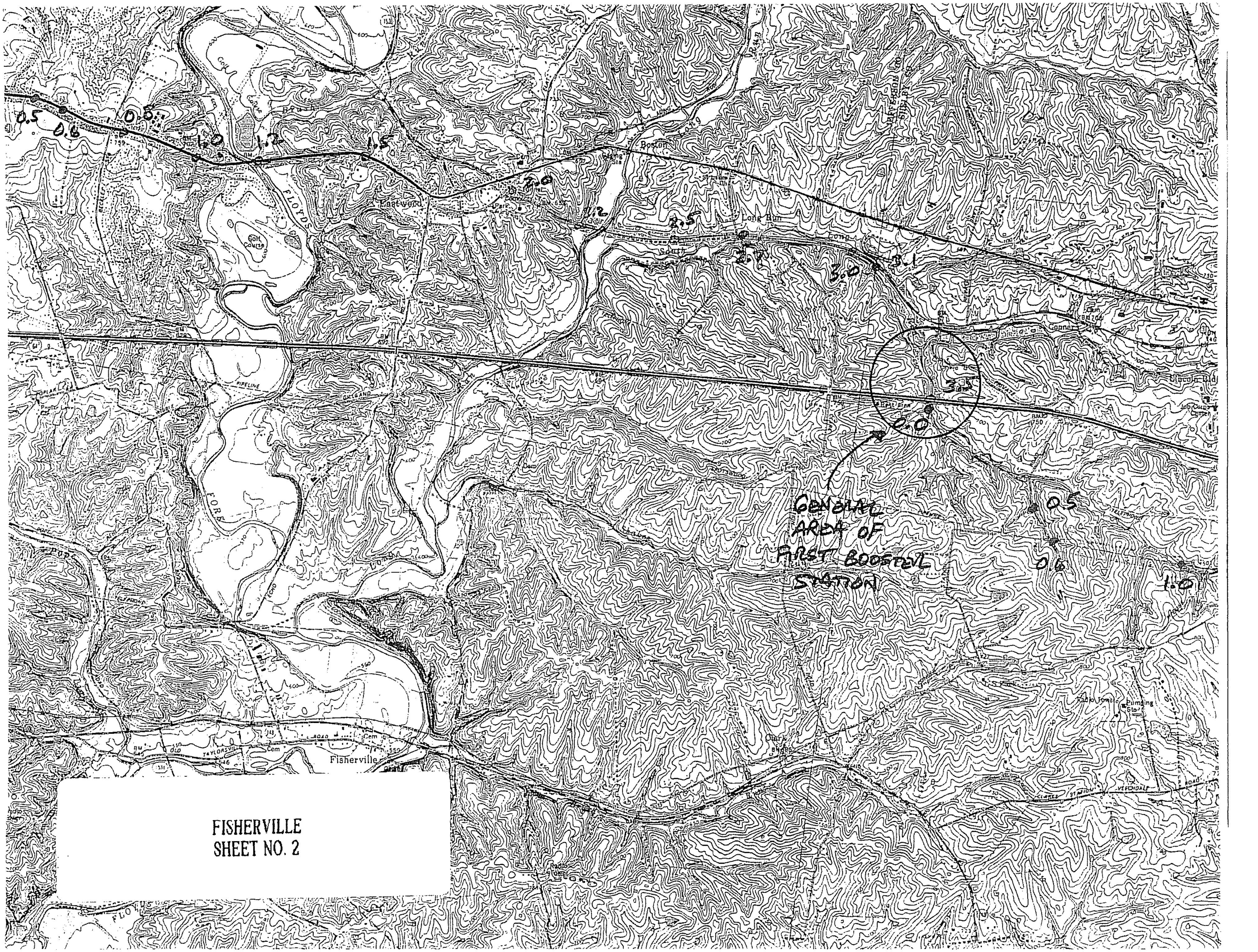
ATTACHMENT D

Miscellaneous Preliminary Project Information

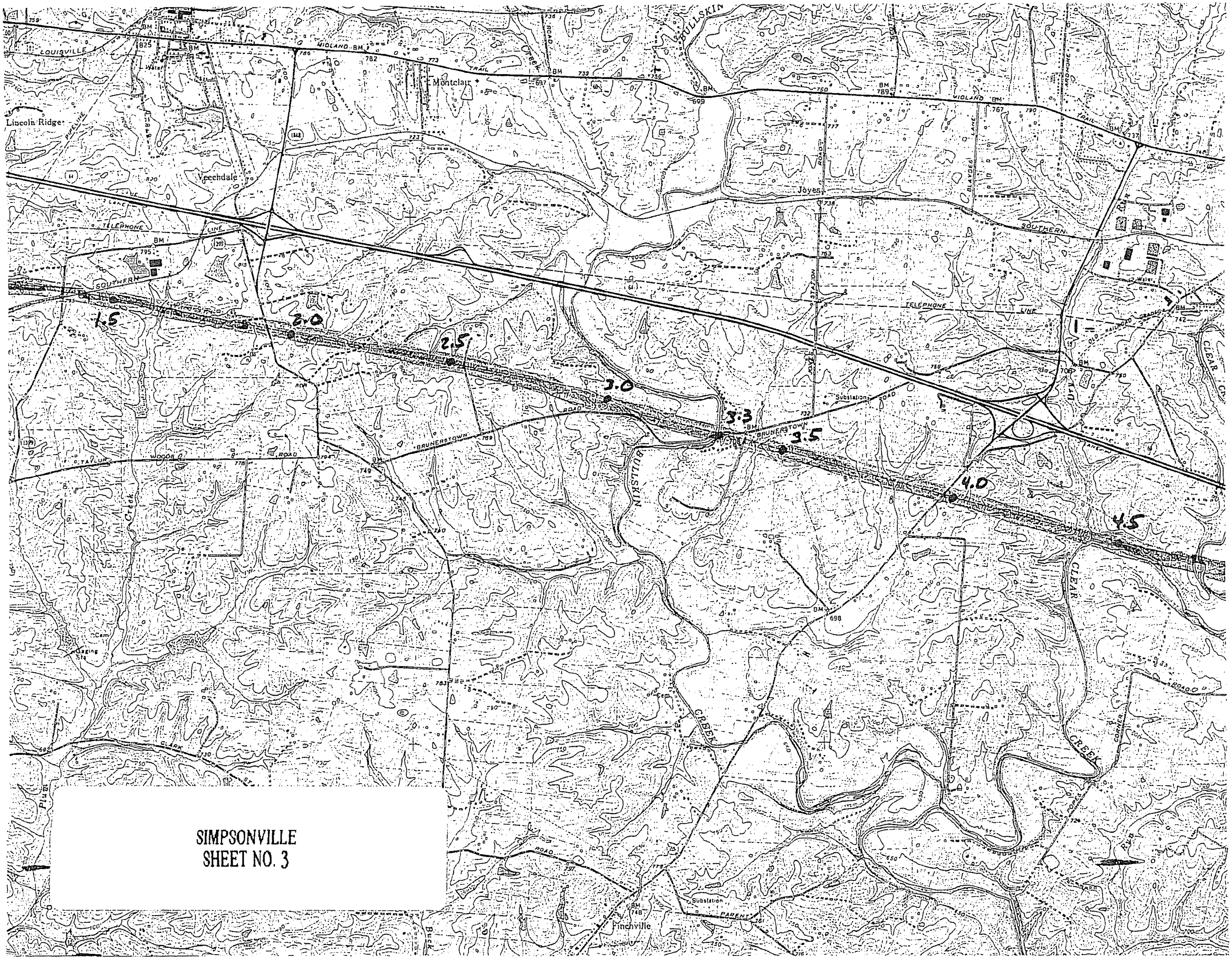
1. Pipeline Route (shown on twelve 8-1/2 x 11 USGS maps)
2. Tie-in Point at the KAWC Distribution System ~~*(PENDING)*~~
~~3. Booster Station No. 1 Site Tax Map *(PENDING)*~~
~~4. Booster Station No. 2 Site Tax Map *(PENDING)*~~
~~5. Retention Basin Site Tax Map *(PENDING)*~~
3~~6~~. LWC Pipeline Hydraulic Calculations (four spreadsheets)
4~~7~~. KAWC Pipeline Hydraulic Calculations (six spreadsheets)



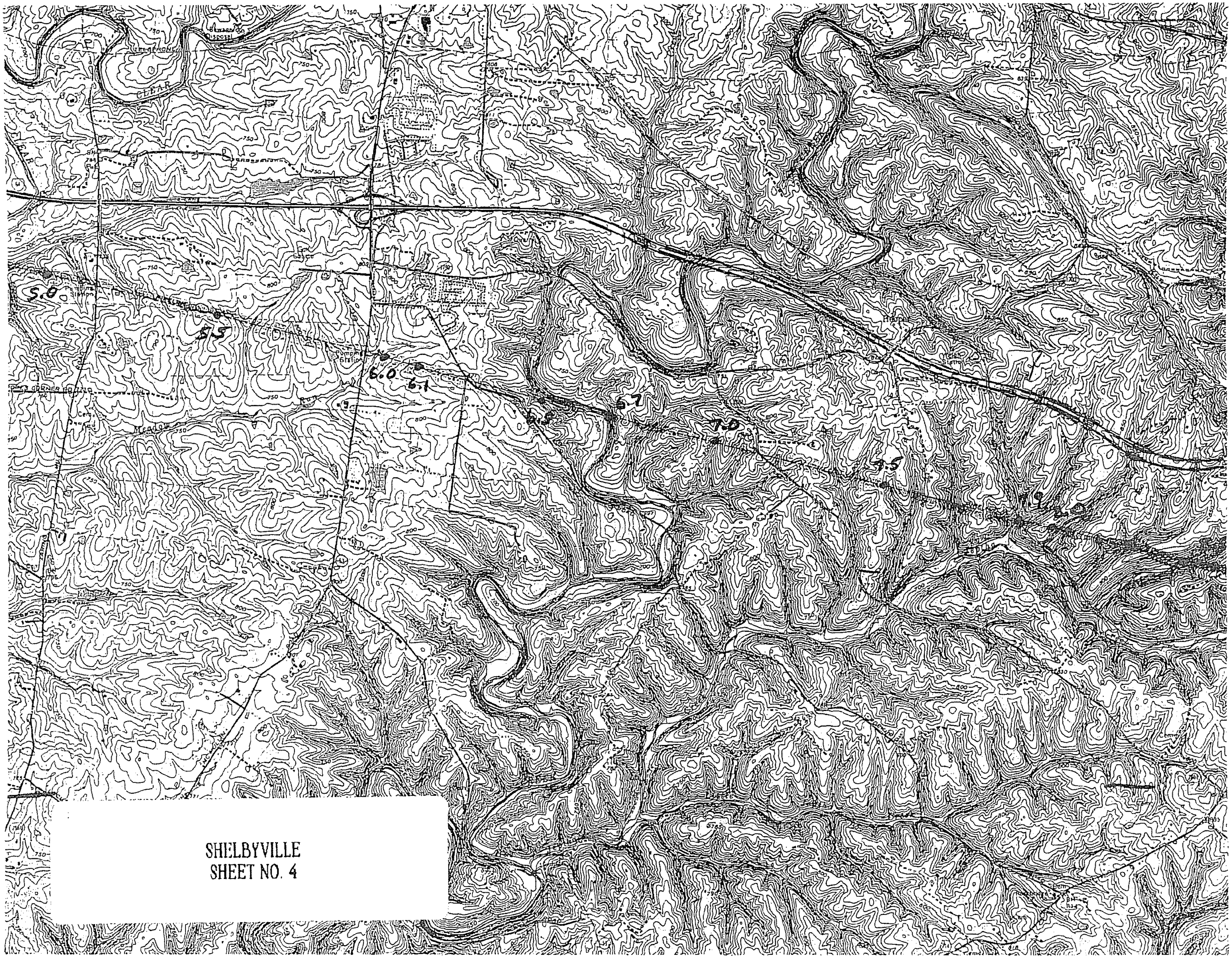
JEFFERSONTOWN
SHEET NO. 1
Middletown
Blue Ridge Manor
Douglass Hills
Hurstbourne
Hurstbourne Acres
Hurstbourne Country Club
St. Regis Park
Houston Acres
LOUISVILLE
JEFFERSONTOWN
Tucker Station
Tucker Lake
Riggs Lake
La Clara Lakes
Hopewell
Sky View Park
INTERCHANGE 20
INTERCHANGE 12 AND 19
INTERCHANGE 23
ENGLISH STATION PARK

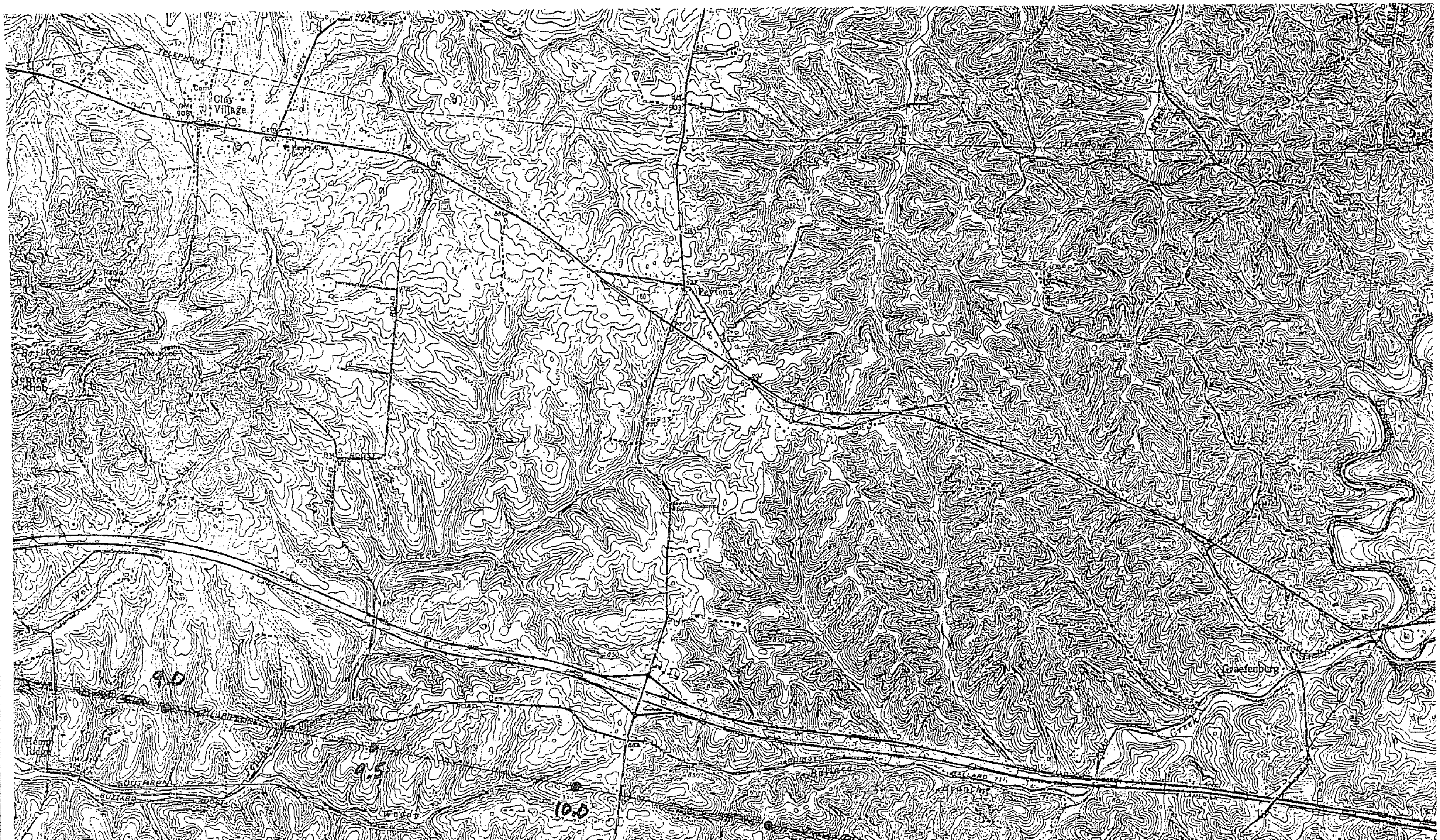


FISHERVILLE
SHEET NO. 2

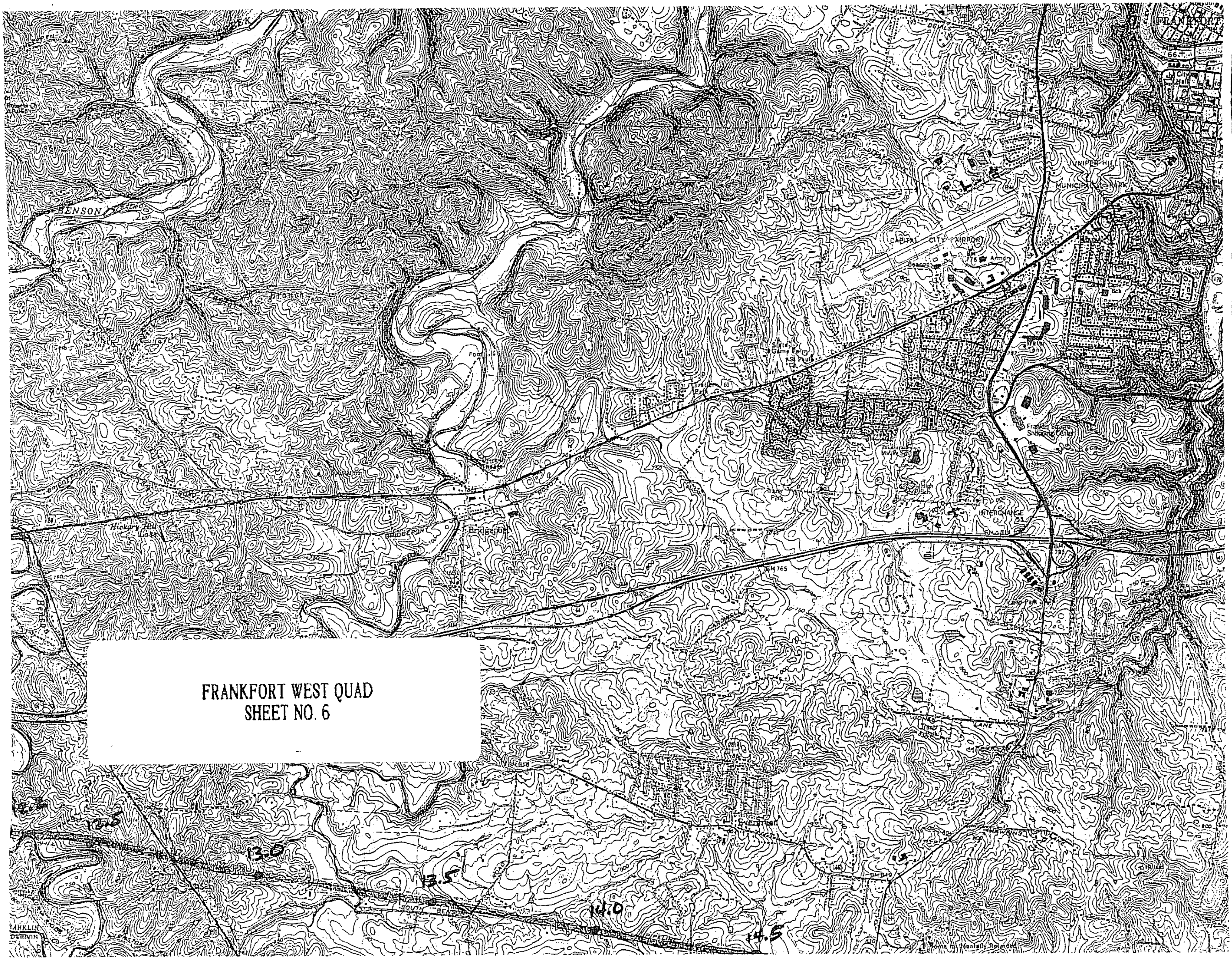


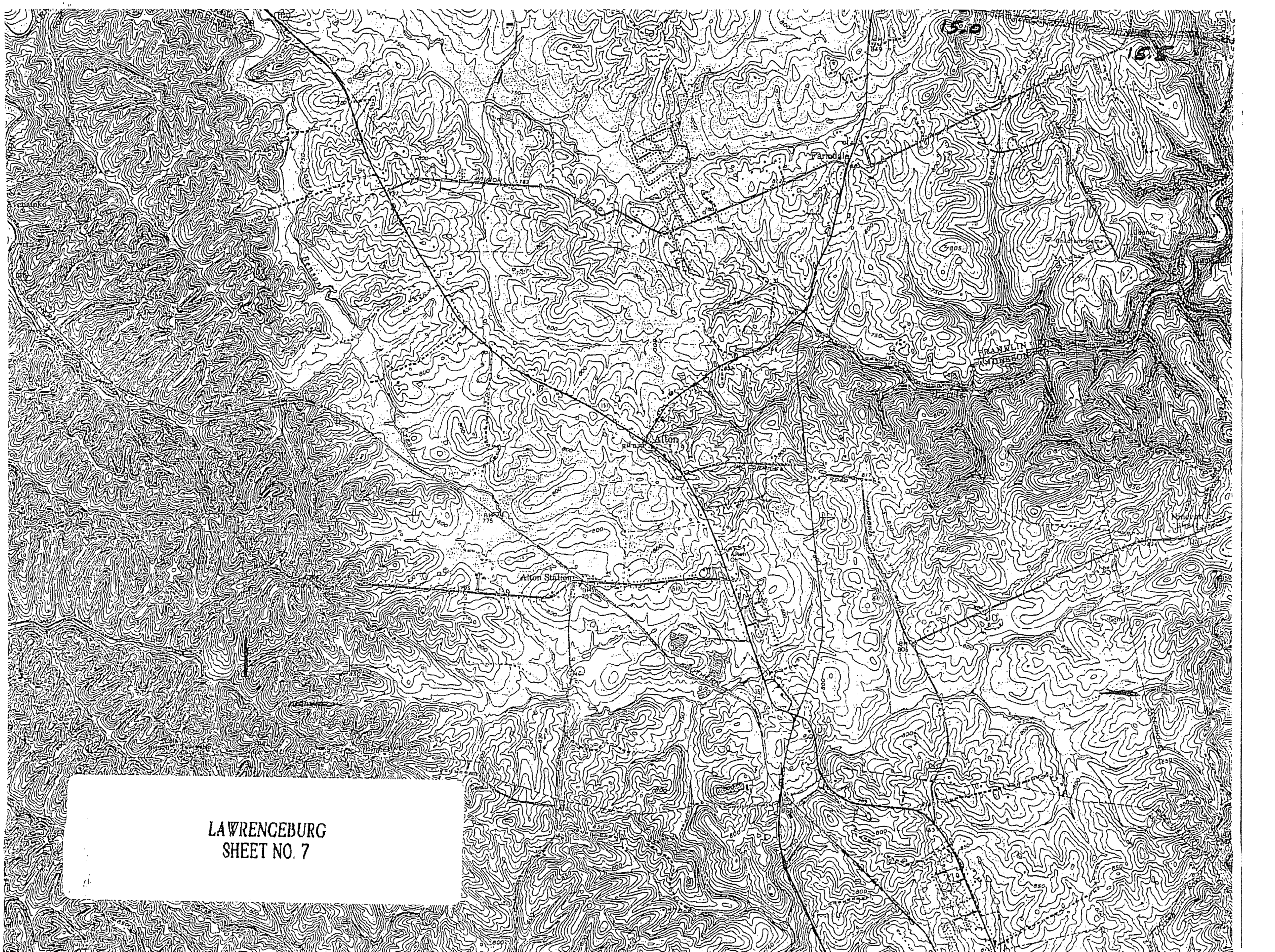
Lincoln Ridge
LOUISVILLE
MIDLAND TRAIL
Montclair
Vecchdale
Joyes
BULLSKIN
TELEPHONE LINE
SOUTHERN
STATION ROAD
Substation
BRUNERSTOWN ROAD
TAYLOR WOODS ROAD
CLEAR CREEK
CREEK
Finchville
Substation
PARENT
CLARK
1.5
2.0
2.5
3.0
3.3
3.5
4.0
4.5
SIMPSONVILLE
SHEET NO. 3


SHELBYVILLE
SHEET NO. 4

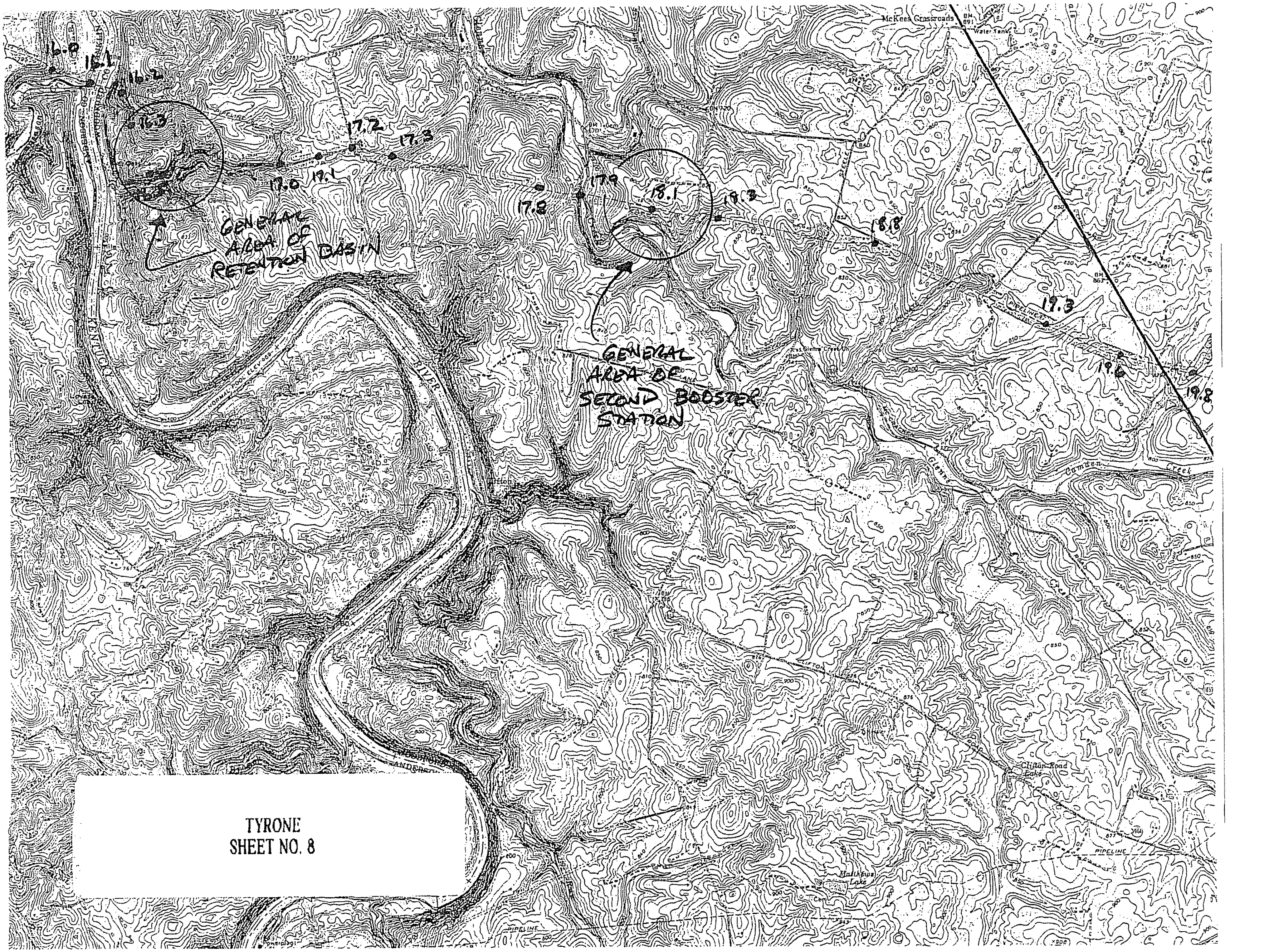


WADDY
SHEET NO. 5

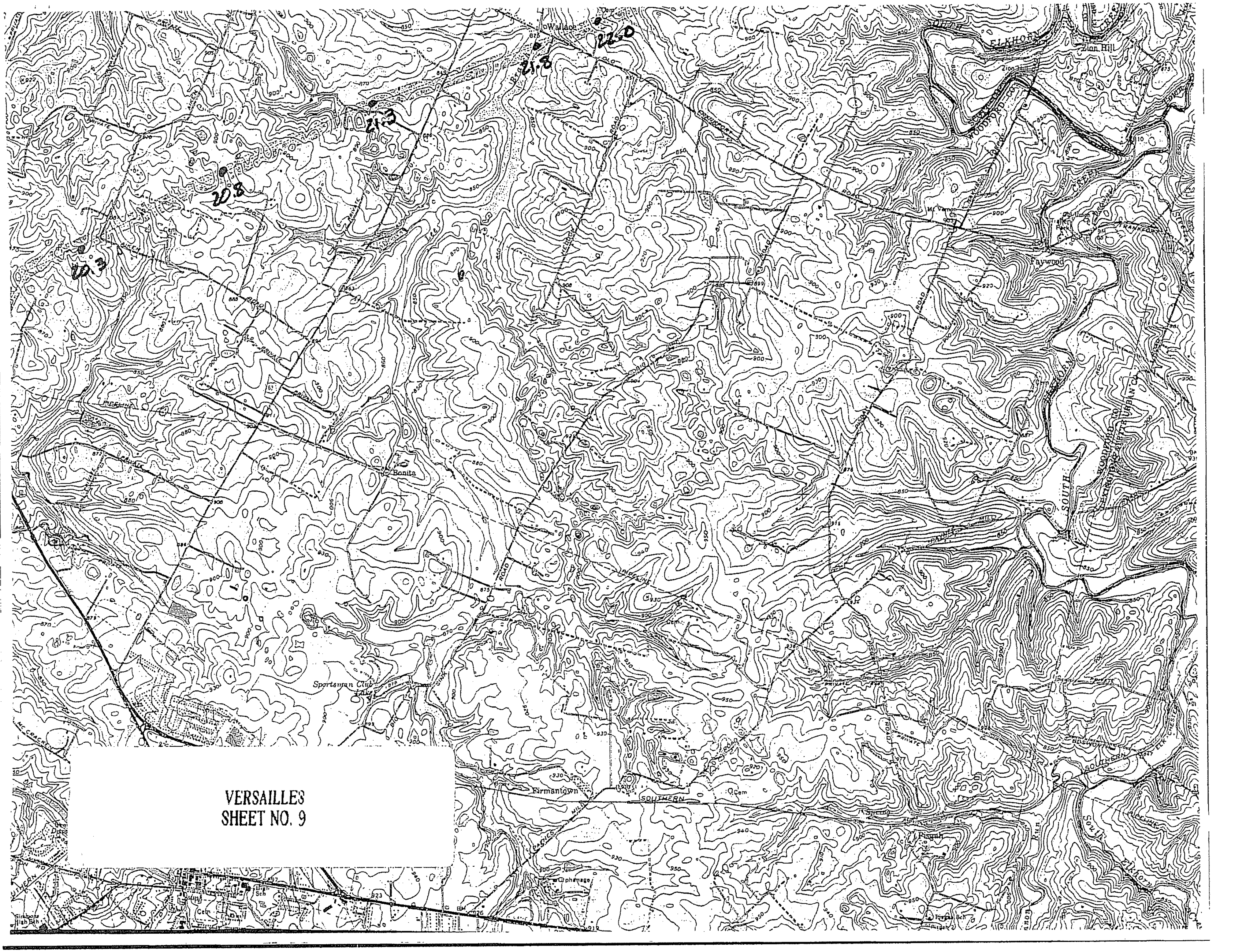

FRANKFORT WEST QUAD
SHEET NO. 6
CAPITAL CITY AIRPORT
JUNIPER HILL
BENSON
Hickory Hill Lake
Bridgeport
INTERCHANGE
12.5
13.0
13.5
14.0
14.5



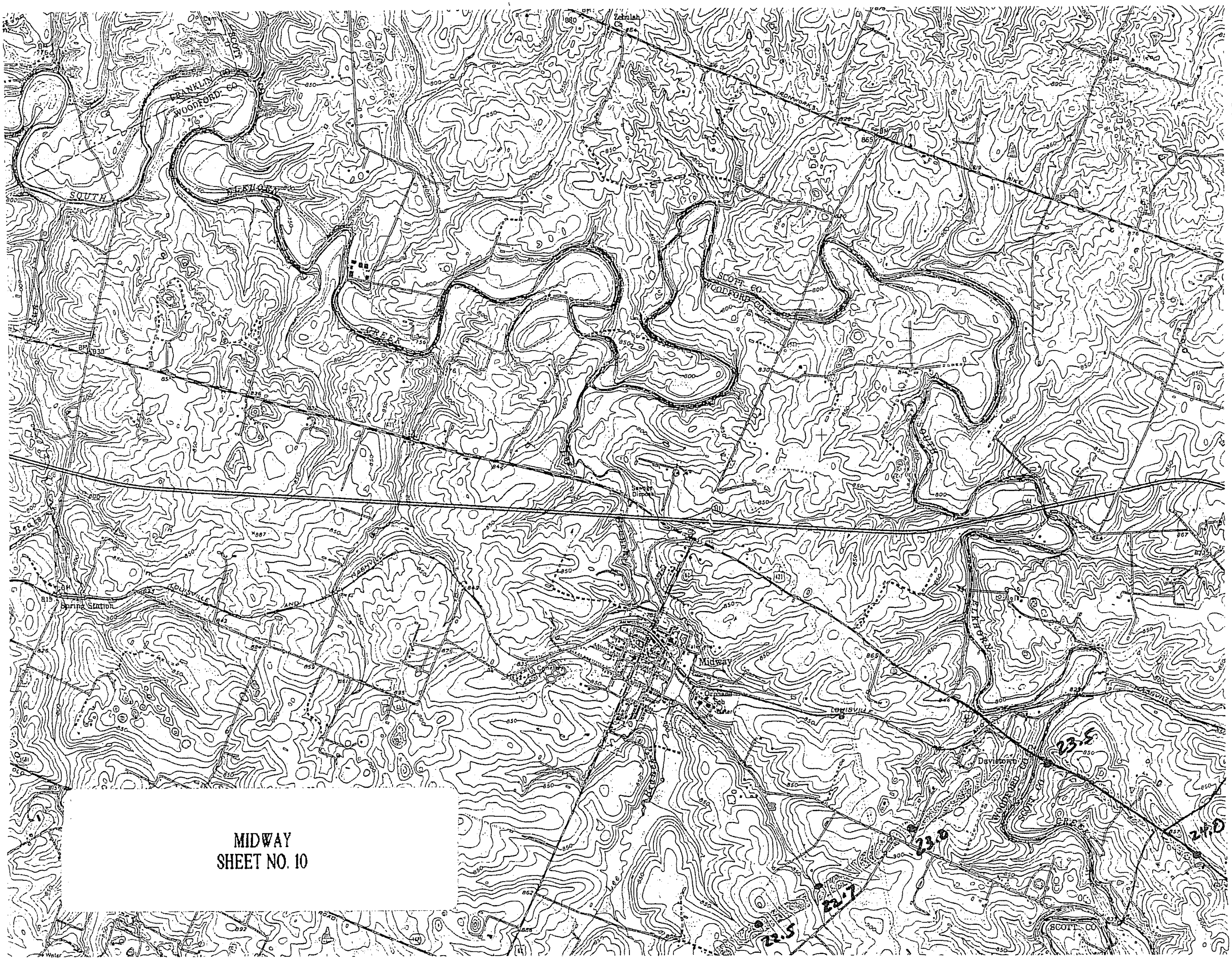
LAWRENCEBURG
SHEET NO. 7



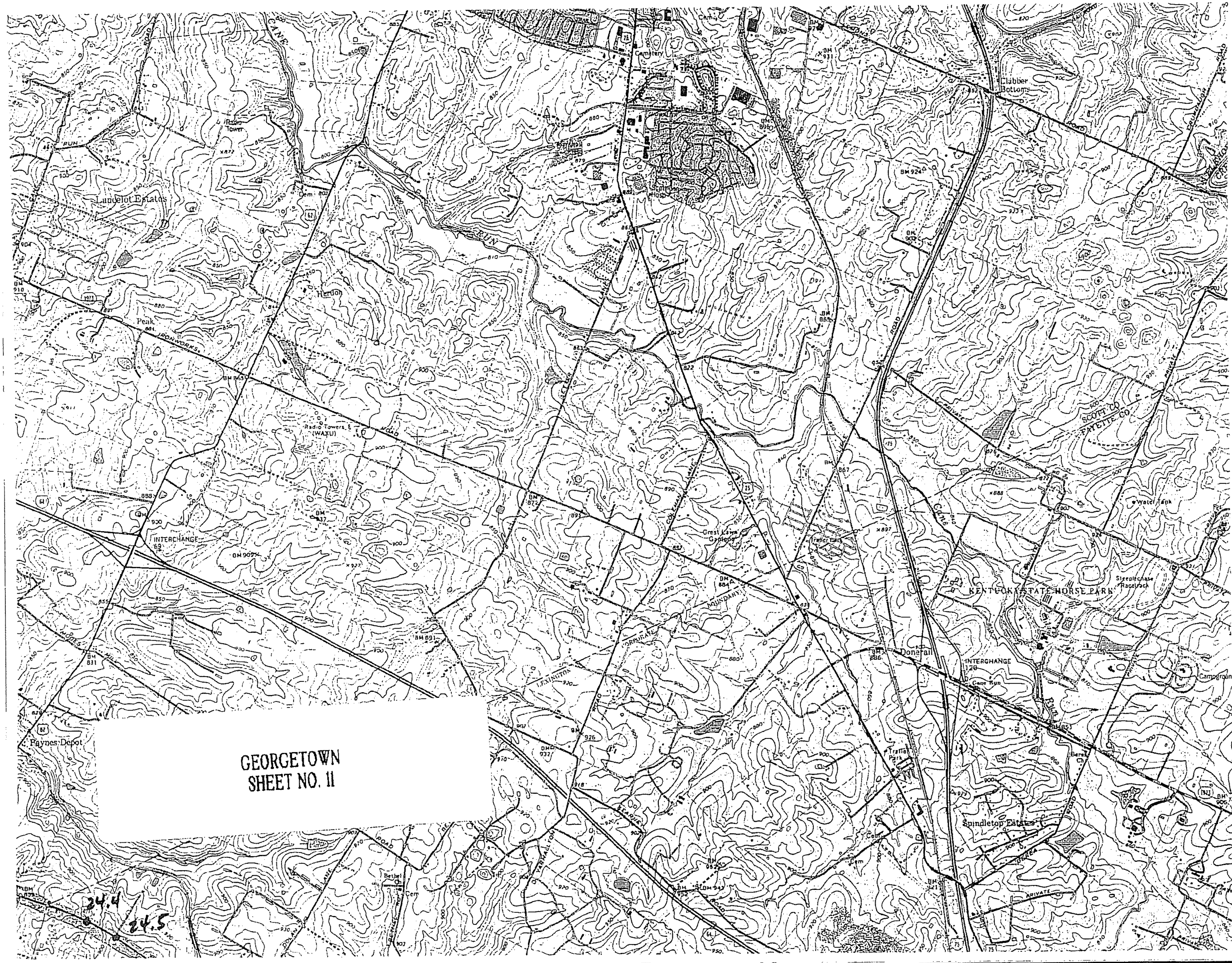
TYRONE
SHEET NO. 8



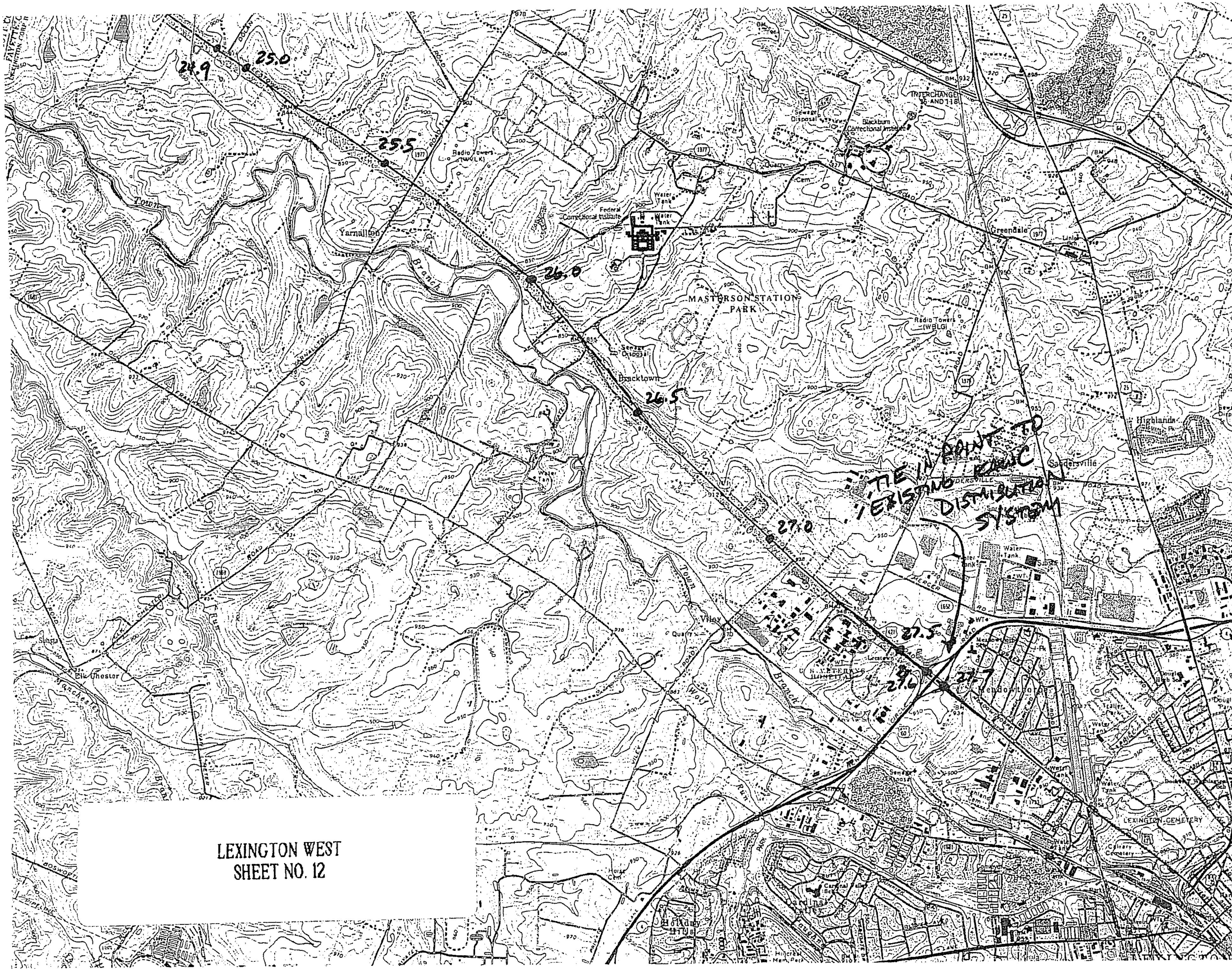
VERSAILLES
SHEET NO. 9



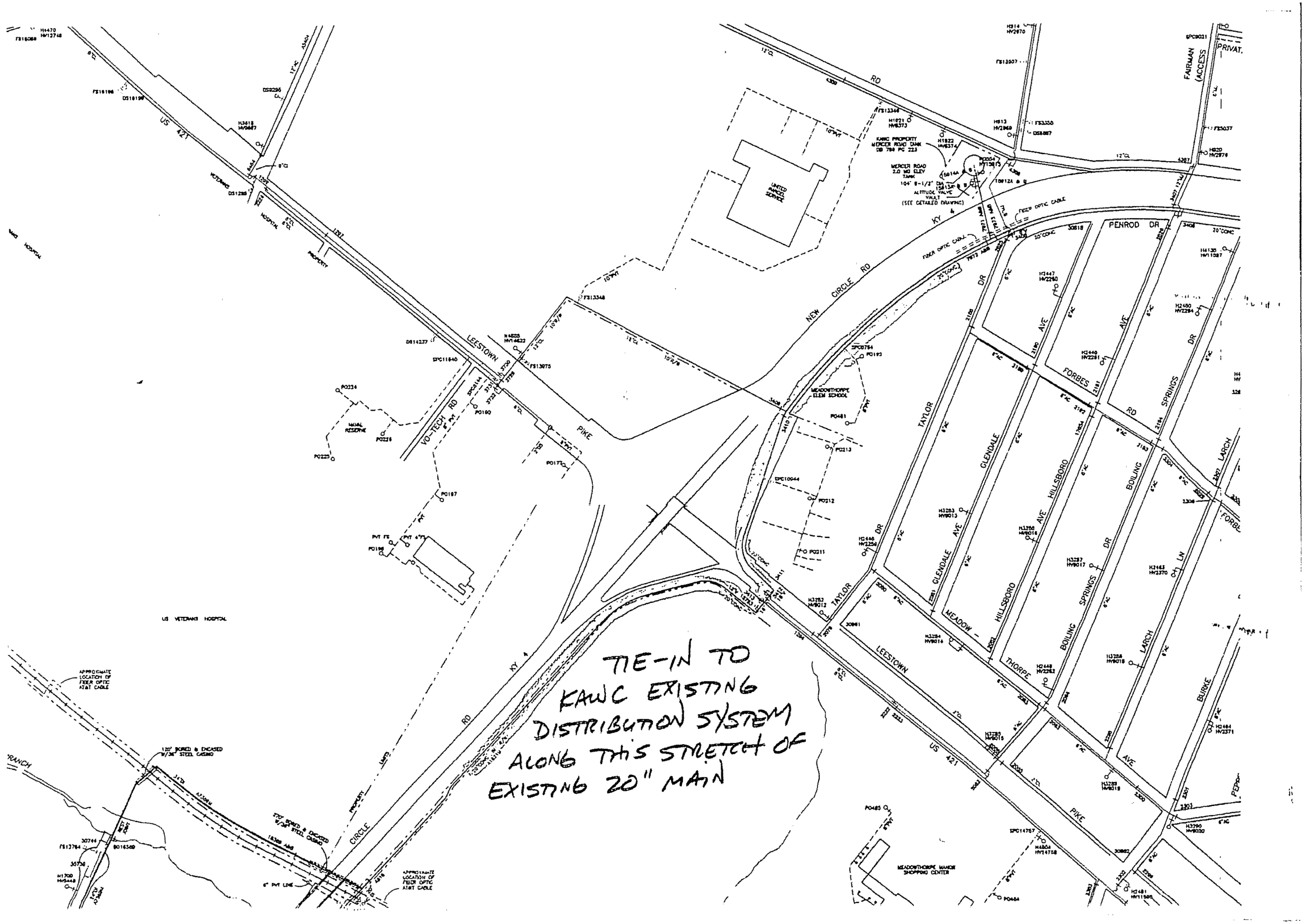
MIDWAY
SHEET NO. 10



GEORGETOWN
SHEET NO. 11



LEXINGTON WEST
SHEET NO. 12


TIE-IN TO
KAWC EXISTING
DISTRIBUTION SYSTEM
ALONG THIS STRETCH OF
EXISTING 20" MAIN
NEW CIRCLE RD
KY 4
LEESTOWN PIKE
US 421
VO-TECH RD
TAYLOR DR
GLENDALE AVE
HILLSBORO AVE
BOILING SPRINGS DR
LARCH LN
BURKE AVE
FORBES RD
PENROD DR
MEADOW THORPE
FAIRMAN (ACCESS
PRIVAT.
UNITED PARCEL SERVICE
MEADOWTHORPE ELEM SCHOOL
MEADOWTHORPE MANOR SHOPPING CENTER
US VETERANS HOSPITAL
KAWC PROPERTY MERCER ROAD TANK DB 798 PG 223
MERCER ROAD 2.0 MG ELEV TANK
CIRCLE
RD

Louisville Pipeline					C=	**130**	
February 17, 1998					Flow =	**23.0**	MGD
Flow from the English Station Tank to the Proposed First Booster					Diameter =	**36**	inches
		Elevation	**Distance**	**Head Loss**	**HGL**	**Pressure**	**Pressure**
Location	**Station**	**(feet)**	**(feet)**	**(feet)**	**(feet)**	**(feet)**	**(psi)**
English Station tank	0.0	764	0		830.0	66.0	28.6
	0.1	750	1,000	2.1	827.9	77.9	33.8
	0.5	750	4,000	8.2	819.7	69.7	30.2
Critical high point	0.6	770	1,000	2.1	817.7	47.7	20.7
	0.8	760	2,000	4.1	813.6	53.6	23.2
	1.0	680	2,000	4.1	809.5	129.5	56.1
	1.2	590	2,000	4.1	805.4	215.4	93.3
	1.5	700	3,000	6.2	799.2	99.2	43.0
	2.0	700	5,000	10.3	789.0	89.0	38.5
	2.2	600	2,000	4.1	784.9	184.9	80.1
	2.5	610	3,000	6.2	778.7	168.7	73.1
	2.7	630	2,000	4.1	774.6	144.6	62.6
	3.0	650	3,000	6.2	768.5	118.5	51.3
Jefferson/Shelby County Line	3.1	650	1,000	2.1	766.4	116.4	50.4
First booster station	3.5	650	4,000	8.2	758.2	108.2	46.9

Louisville Pipeline

February 17, 1998

Flow from the English Station Tank to the Proposed First Booster

C= **130**

Flow = **23.0** MGD

Diameter = **36** inches

Location	Station	Elevation (feet)	Distance (feet)	Head Loss (feet)	HGL (feet)	Pressure (feet)	Pressure (psi)
English Station tank	0.0	764	0		864.0	100.0	43.3
	0.1	750	1,000	2.1	861.9	111.9	48.5
	0.5	750	4,000	8.2	853.7	103.7	44.9
Critical high point	0.6	770	1,000	2.1	851.7	81.7	35.4
	0.8	760	2,000	4.1	847.6	87.6	37.9
	1.0	680	2,000	4.1	843.5	163.5	70.8
	1.2	590	2,000	4.1	839.4	249.4	108.0
	1.5	700	3,000	6.2	833.2	133.2	57.7
	2.0	700	5,000	10.3	823.0	123.0	53.3
	2.2	600	2,000	4.1	818.9	218.9	94.8
	2.5	610	3,000	6.2	812.7	202.7	87.8
	2.7	630	2,000	4.1	808.6	178.6	77.3
	3.0	650	3,000	6.2	802.5	152.5	66.0
Jefferson/Shelby County Line	3.1	650	1,000	2.1	800.4	150.4	65.1
First booster station	3.5	650	4,000	8.2	792.2	142.2	61.6

Louisville Pipeline

February 17, 1998

Flow from the English Station Tank to the Proposed First Booster

C= **130**

Flow = **1.6** MGD

Diameter = **36** inches

Location	Station	Elevation (feet)	Distance (feet)	Head Loss (feet)	HGL (feet)	Pressure (feet)	Pressure (psi)
English Station tank	0.0	764	0		830.0	66.0	28.6
	0.1	750	1,000	0.0	830.0	80.0	34.6
	0.5	750	4,000	0.1	829.9	79.9	34.6
Critical high point	0.6	770	1,000	0.0	829.9	59.9	25.9
	0.8	760	2,000	0.0	829.9	69.9	30.3
	1.0	680	2,000	0.0	829.9	149.9	64.9
	1.2	590	2,000	0.0	829.8	239.8	103.8
	1.5	700	3,000	0.0	829.8	129.8	56.2
	2.0	700	5,000	0.1	829.7	129.7	56.2
	2.2	600	2,000	0.0	829.7	229.7	99.4
	2.5	610	3,000	0.0	829.6	219.6	95.1
	2.7	630	2,000	0.0	829.6	199.6	86.4
	3.0	650	3,000	0.0	829.6	179.6	77.7
Jefferson/Shelby County Line	3.1	650	1,000	0.0	829.5	179.5	77.7
First booster station	3.5	650	4,000	0.1	829.5	179.5	77.7

Louisville Pipeline					C=	**130**	
February 17, 1998					Flow =	**1.6**	MGD
Flow from the English Station Tank to the Proposed First Booster					Diameter =	**36**	inches
		Elevation	**Distance**	**Head Loss**	**HGL**	**Pressure**	**Pressure**
Location	**Station**	**(feet)**	**(feet)**	**(feet)**	**(feet)**	**(feet)**	**(psi)**
English Station tank	0.0	764	0		864.0	100.0	43.3
	0.1	750	1,000	0.0	864.0	114.0	49.4
	0.5	750	4,000	0.1	863.9	113.9	49.3
Critical high point	0.6	770	1,000	0.0	863.9	93.9	40.7
	0.8	760	2,000	0.0	863.9	103.9	45.0
	1.0	680	2,000	0.0	863.9	183.9	79.6
	1.2	590	2,000	0.0	863.8	273.8	118.6
	1.5	700	3,000	0.0	863.8	163.8	70.9
	2.0	700	5,000	0.1	863.7	163.7	70.9
	2.2	600	2,000	0.0	863.7	263.7	114.2
	2.5	610	3,000	0.0	863.6	253.6	109.8
	2.7	630	2,000	0.0	863.6	233.6	101.1
	3.0	650	3,000	0.0	863.6	213.6	92.5
Jefferson/Shelby County Line	3.1	650	1,000	0.0	863.5	213.5	92.5
First booster station	3.5	650	4,000	0.1	863.5	213.5	92.4

Kentucky-American Pipeline

February 17, 1998

Pipeline operating at capacity with both booster stations

C= 130

Flow = 23.0 MGD

Diameter = 36 inches

Location	Station	Elevation (feet)	Distance (feet)	Head Loss (feet)	HGL (feet)	Pressure (feet)	Pressure (psi)	Pressure Class Req'd	Pressure Class to Use
First booster station at I-64	0.0	650	0	0.0	1288.2	638.2	276.3	300	350
	0.5	700	5,000	10.3	1277.9	577.9	250.2	300	350
	0.6	710	1,000	2.1	1277.9	567.9	245.9	250	300
	1.0	780	5,000	10.3	1267.7	487.7	211.2	250	300
	1.5	780	5,000	10.3	1257.4	477.4	206.7	250	300
	2.0	810	5,000	10.3	1247.2	437.2	189.3	200	250
	2.5	770	5,000	10.3	1236.9	466.9	202.2	250	300
	3.0	710	5,000	10.3	1226.6	516.6	223.7	250	300
	3.3	670	3,000	6.2	1220.5	550.5	238.4	250	300
	3.5	710	2,000	4.1	1216.4	506.4	219.3	250	300
	4.0	760	5,000	10.3	1206.1	446.1	193.2	200	250
	4.5	660	5,000	10.3	1195.9	535.9	232.0	250	300
	5.0	710	5,000	10.3	1185.6	475.6	205.9	250	300
	5.5	790	5,000	10.3	1175.4	385.4	166.9	200	250
	6.0	770	5,000	10.3	1165.1	395.1	171.1	200	250
	6.1	800	1,000	2.1	1163.1	363.1	157.2	200	250
	6.5	730	4,000	8.2	1154.9	424.9	184.0	200	250
	6.7	680	2,000	4.1	1150.8	470.8	203.8	250	300
	7.0	800	3,000	6.2	1144.6	344.6	149.2	150	200
	7.5	780	5,000	10.3	1134.4	354.4	153.4	200	250
	7.9	710	4,000	8.2	1126.2	416.2	180.2	200	250
	8.0	810	1,000	2.1	1124.1	314.1	136.0	150	200
	8.5	890	5,000	10.3	1113.9	223.9	96.9	100	150
	9.0	810	5,000	10.3	1103.6	293.6	127.1	150	200
	9.5	850	5,000	10.3	1093.4	243.4	105.4	150	200
	10.0	880	5,000	10.3	1083.1	203.1	87.9	100	150
	10.5	870	5,000	10.3	1072.8	202.8	87.8	100	150
	11.0	850	5,000	10.3	1062.6	212.6	92.1	100	150
	11.1	740	1,000	2.1	1060.5	320.5	138.8	150	200
	11.5	820	4,000	8.2	1052.3	232.3	100.6	150	200
	12.0	800	5,000	10.3	1042.1	242.1	104.8	150	200
	12.2	710	2,000	4.1	1038.0	328.0	142.0	150	200
	12.5	800	3,000	6.2	1031.8	231.8	100.4	150	200
	13.0	760	5,000	10.3	1021.6	261.6	113.3	150	200
	13.5	770	5,000	10.3	1011.3	241.3	104.5	150	200
	14.0	800	5,000	10.3	1001.1	201.1	87.1	100	150
	14.5	790	5,000	10.3	990.8	200.8	87.0	100	150
	15.0	830	5,000	10.3	980.6	150.6	65.2	100	150
	15.5	750	5,000	10.3	970.3	220.3	95.4	100	150
	16.0	650	5,000	10.3	960.1	310.1	134.3	150	200
Kentucky River crossing	16.1	460	1,000	2.1	958.0	498.0	215.6	250	300
	16.2	600	1,000	2.1	956.0	356.0	154.1	200	250
	16.3	700	1,000	2.1	953.9	253.9	109.9	150	200
	16.5	700	2,000	4.1	949.8	249.8	108.2	150	200
	17.0	700	5,000	10.3	939.6	239.6	103.7	150	200
	17.1	740	1,000	2.1	937.5	197.5	85.5	100	150
	17.2	760	1,000	2.1	935.5	175.5	76.0	100	150
	17.3	770	1,000	2.1	933.4	163.4	70.8	100	150
Critical high point	17.8	830	5,000	10.3	923.2	93.2	40.3	50	100
Glenns Creek crossing	17.9	660	1,000	2.1	921.1	261.1	113.1	150	200
Suction pressure slightly raised	18.1	810	2,000	4.1	917.0	107.0	46.3	50	100
Second booster station	18.1	810		0.0	1360.7	550.7	238.5	250	300
	18.3	800	2,000	4.1	1356.6	556.6	241.0	250	300
	18.8	850	5,000	10.3	1346.4	496.4	214.9	250	300
	19.3	850	5,000	10.3	1336.1	486.1	210.5	250	300
	19.6	870	3,000	6.2	1332.0	462.0	200.0	250	300
	19.8	860	2,000	4.1	1332.0	472.0	204.4	250	300
	20.3	910	5,000	10.3	1321.7	411.7	178.3	200	250
	20.8	890	5,000	10.3	1311.5	421.5	182.5	200	250
	21.3	890	5,000	10.3	1301.2	411.2	178.1	200	250
	21.8	830	5,000	10.3	1291.0	461.0	199.6	200	250
	22.0	850	2,000	4.1	1286.9	436.9	189.2	200	250
	22.5	890	5,000	10.3	1276.6	386.6	167.4	200	250
	22.7	850	2,000	4.1	1272.5	422.5	183.0	200	250
	23.0	900	3,000	6.2	1266.4	366.4	158.6	200	250
	23.5	770	5,000	10.3	1256.1	486.1	210.5	250	300
	24.0	850	5,000	10.3	1245.9	395.9	171.4	200	250
	24.4	910	4,000	8.2	1237.7	327.7	141.9	150	200
	24.5	880	1,000	2.1	1235.6	355.6	154.0	200	250
	24.9	900	4,000	8.2	1227.4	327.4	141.8	150	200
	25.0	890	1,000	2.1	1225.4	335.4	145.2	150	200
	25.5	940	5,000	10.3	1215.1	275.1	119.1	150	200
	26.0	850	5,000	10.3	1204.9	354.9	153.7	200	250
	26.5	900	5,000	10.3	1194.6	294.6	127.6	150	200
	27.0	940	5,000	10.3	1184.4	244.4	105.8	150	200
	27.5	950	5,000	10.3	1174.1	224.1	97.0	100	150
	27.6	950	1,000	2.1	1172.1	222.1	96.1	100	150
KAWC distribution system gradient	27.7	950	1,000	2.1	1170.0	220.0	95.3	100	150

Kentucky-American Pipeline							C=	130	
February 17, 1998							Flow =	19.0	MGD
Pipeline operating at capacity with both booster stations							Diameter =	36	inches
		Elevation	Distance	Head Loss	HGL	Pressure	Pressure	Pressure	Pressure
Location	Station	(feet)	(feet)	(feet)	(feet)	(feet)	(psi)	Class Req'd	Class to Use
First booster station at I-64	0.0	650	0	0.0	1177.7	527.7	228.5	250	300
	0.5	700	5,000	7.2	1170.5	470.5	203.7	250	300
	0.6	710	1,000	1.4	1170.5	460.5	199.4	200	250
	1.0	780	5,000	7.2	1163.3	383.3	165.9	200	250
	1.5	780	5,000	7.2	1156.1	376.1	162.8	200	250
	2.0	810	5,000	7.2	1148.9	338.9	146.7	150	200
	2.5	770	5,000	7.2	1141.7	371.7	160.9	200	250
	3.0	710	5,000	7.2	1134.5	424.5	183.8	200	250
	3.3	670	3,000	4.3	1130.1	460.1	199.2	200	250
	3.5	710	2,000	2.9	1127.3	417.3	180.7	200	250
	4.0	760	5,000	7.2	1120.1	360.1	155.9	200	250
	4.5	660	5,000	7.2	1112.9	452.9	196.1	200	250
	5.0	710	5,000	7.2	1105.7	395.7	171.3	200	250
	5.5	790	5,000	7.2	1098.5	308.5	133.6	150	200
	6.0	770	5,000	7.2	1091.3	321.3	139.1	150	200
	6.1	800	1,000	1.4	1089.8	289.8	125.5	150	200
	6.5	730	4,000	5.8	1084.0	354.0	153.3	200	250
	6.7	680	2,000	2.9	1081.2	401.2	173.7	200	250
	7.0	800	3,000	4.3	1076.8	276.8	119.9	150	200
	7.5	780	5,000	7.2	1069.6	289.6	125.4	150	200
	7.9	710	4,000	5.8	1063.9	353.9	153.2	200	250
	8.0	810	1,000	1.4	1062.4	252.4	109.3	150	200
	8.5	890	5,000	7.2	1055.2	165.2	71.6	100	150
	9.0	810	5,000	7.2	1048.0	238.0	103.1	150	200
	9.5	850	5,000	7.2	1040.8	190.8	82.6	100	150
	10.0	880	5,000	7.2	1033.6	153.6	66.5	100	150
	10.5	870	5,000	7.2	1026.4	156.4	67.7	100	150
	11.0	850	5,000	7.2	1019.2	169.2	73.3	100	150
	11.1	740	1,000	1.4	1017.8	277.8	120.3	150	200
	11.5	820	4,000	5.8	1012.0	192.0	83.2	100	150
	12.0	800	5,000	7.2	1004.8	204.8	88.7	100	150
	12.2	710	2,000	2.9	1002.0	292.0	126.4	150	200
	12.5	800	3,000	4.3	997.6	197.6	85.6	100	150
	13.0	760	5,000	7.2	990.4	230.4	99.8	100	150
	13.5	770	5,000	7.2	983.2	213.2	92.3	100	150
	14.0	800	5,000	7.2	976.0	176.0	76.2	100	150
	14.5	790	5,000	7.2	968.8	178.8	77.4	100	150
	15.0	830	5,000	7.2	961.6	131.6	57.0	100	150
	15.5	750	5,000	7.2	954.4	204.4	88.5	100	150
	16.0	650	5,000	7.2	947.2	297.2	128.7	150	200
Kentucky River crossing	16.1	460	1,000	1.4	945.8	485.8	210.4	250	300
	16.2	600	1,000	1.4	944.4	344.4	149.1	150	200
	16.3	700	1,000	1.4	942.9	242.9	105.2	150	200
	16.5	700	2,000	2.9	940.0	240.0	103.9	150	200
	17.0	700	5,000	7.2	932.8	232.8	100.8	150	200
	17.1	740	1,000	1.4	931.4	191.4	82.9	100	150
	17.2	760	1,000	1.4	930.0	170.0	73.6	100	150
	17.3	770	1,000	1.4	928.5	158.5	68.6	100	150
Critical high point	17.8	830	5,000	7.2	921.3	91.3	39.5	50	100
Glenns Creek crossing	17.9	660	1,000	1.4	919.9	259.9	112.5	150	200
Suction pressure slightly raised	18.1	810	2,000	2.9	917.0	107.0	46.3	50	100
Second booster station	18.1	810		0.0	1303.9	493.9	213.9	250	300
	18.3	800	2,000	2.9	1301.0	501.0	217.0	250	300
	18.8	850	5,000	7.2	1293.8	443.8	192.2	200	250
	19.3	850	5,000	7.2	1286.6	436.6	189.1	200	250
	19.6	870	3,000	4.3	1283.8	413.8	179.2	200	250
	19.8	860	2,000	2.9	1283.8	423.8	183.5	200	250
	20.3	910	5,000	7.2	1276.6	366.6	158.7	200	250
	20.8	890	5,000	7.2	1269.4	379.4	164.3	200	250
	21.3	890	5,000	7.2	1262.2	372.2	161.1	200	250
	21.8	830	5,000	7.2	1255.0	425.0	184.0	200	250
	22.0	850	2,000	2.9	1252.1	402.1	174.1	200	250
	22.5	890	5,000	7.2	1244.9	354.9	153.7	200	250
	22.7	850	2,000	2.9	1242.0	392.0	169.7	200	250
	23.0	900	3,000	4.3	1237.7	337.7	146.2	150	200
	23.5	770	5,000	7.2	1230.5	460.5	199.4	200	250
	24.0	850	5,000	7.2	1223.3	373.3	161.6	200	250
	24.4	910	4,000	5.8	1217.5	307.5	133.2	150	200
	24.5	880	1,000	1.4	1216.1	336.1	145.5	150	200
	24.9	900	4,000	5.8	1210.3	310.3	134.4	150	200
	25.0	890	1,000	1.4	1208.9	318.9	138.1	150	200
	25.5	940	5,000	7.2	1201.7	261.7	113.3	150	200
	26.0	850	5,000	7.2	1194.5	344.5	149.2	150	200
	26.5	900	5,000	7.2	1187.3	287.3	124.4	150	200
	27.0	940	5,000	7.2	1180.1	240.1	104.0	150	200
	27.5	950	5,000	7.2	1172.9	222.9	96.5	100	150
	27.6	950	1,000	1.4	1171.4	221.4	95.9	100	150
KAWC distribution system gradient	27.7	950	1,000	1.4	1170.0	220.0	95.3	100	150

Kentucky-American Pipeline

February 17, 1998

Pipeline operating at minimum flows with both booster stations

C= 130
Flow = 1.6 MGD
Diameter = 36 inches

Location	Station	Elevation (feet)	Distance (feet)	Head Loss (feet)	HGL (feet)	Pressure (feet)	Pressure (psi)	Pressure Class Req'd	Pressure Class to Use
First booster station	0.0	650	0	0.0	983.7	333.7	144.5	150	200
	0.5	700	5,000	0.1	983.6	283.6	122.8	150	200
	0.6	710	1,000	0.0	983.6	273.6	118.5	150	200
	1.0	780	5,000	0.1	983.5	203.5	88.1	100	150
	1.5	780	5,000	0.1	983.5	203.5	88.1	100	150
	2.0	810	5,000	0.1	983.4	173.4	75.1	100	150
	2.5	770	5,000	0.1	983.3	213.3	92.4	100	150
	3.0	710	5,000	0.1	983.2	273.2	118.3	150	200
	3.3	670	3,000	0.0	983.2	313.2	135.6	150	200
	3.5	710	2,000	0.0	983.2	273.2	118.3	150	200
	4.0	760	5,000	0.1	983.1	223.1	96.6	100	150
	4.5	660	5,000	0.1	983.0	323.0	139.9	150	200
	5.0	710	5,000	0.1	982.9	272.9	118.2	150	200
	5.5	790	5,000	0.1	982.9	192.9	83.5	100	150
	6.0	770	5,000	0.1	982.8	212.8	92.1	100	150
	6.1	800	1,000	0.0	982.8	182.8	79.1	100	150
	6.5	730	4,000	0.1	982.7	252.7	109.4	150	200
	6.7	680	2,000	0.0	982.7	302.7	131.1	150	200
	7.0	800	3,000	0.0	982.6	182.6	79.1	100	150
	7.5	780	5,000	0.1	982.6	202.6	87.7	100	150
	7.9	710	4,000	0.1	982.5	272.5	118.0	150	200
	8.0	810	1,000	0.0	982.5	172.5	74.7	100	150
Critical high point	8.5	890	5,000	0.1	982.4	92.4	40.0	50	100
	9.0	810	5,000	0.1	982.3	172.3	74.6	100	150
	9.5	850	5,000	0.1	982.3	132.3	57.3	100	150
	10.0	880	5,000	0.1	982.2	102.2	44.3	50	100
	10.5	870	5,000	0.1	982.1	112.1	48.6	50	100
	11.0	850	5,000	0.1	982.1	132.1	57.2	100	150
	11.1	740	1,000	0.0	982.0	242.0	104.8	150	200
	11.5	820	4,000	0.1	982.0	162.0	70.1	100	150
	12.0	800	5,000	0.1	981.9	181.9	78.8	100	150
	12.2	710	2,000	0.0	981.9	271.9	117.7	150	200
	12.5	800	3,000	0.0	981.8	181.8	78.7	100	150
	13.0	760	5,000	0.1	981.8	221.8	96.0	100	150
	13.5	770	5,000	0.1	981.7	211.7	91.7	100	150
	14.0	800	5,000	0.1	981.6	181.6	78.6	100	150
	14.5	790	5,000	0.1	981.5	191.5	82.9	100	150
	15.0	830	5,000	0.1	981.5	151.5	65.6	100	150
	15.5	750	5,000	0.1	981.4	231.4	100.2	150	200
	16.0	650	5,000	0.1	981.3	331.3	143.5	150	200
Kentucky River crossing	16.1	460	1,000	0.0	981.3	521.3	225.7	250	300
	16.2	600	1,000	0.0	981.3	381.3	165.1	200	250
	16.3	700	1,000	0.0	981.3	281.3	121.8	150	200
	16.5	700	2,000	0.0	981.2	281.2	121.8	150	200
	17.0	700	5,000	0.1	981.2	281.2	121.7	150	200
	17.1	740	1,000	0.0	981.1	241.1	104.4	150	200
	17.2	760	1,000	0.0	981.1	221.1	95.8	100	150
	17.3	770	1,000	0.0	981.1	211.1	91.4	100	150
	17.8	830	5,000	0.1	981.0	151.0	65.4	100	150
Glenns Creek crossing	17.9	660	1,000	0.0	981.0	321.0	139.0	150	200
Suction pressure significantly raised	18.1	810	2,000	0.0	981.0	171.0	74.0	100	150
Second booster station	18.1	810		0.0	1131.4	321.4	139.2	150	200
critical low point	18.3	800	2,000	0.0	1131.3	331.3	143.5	150	200
	18.8	850	5,000	0.1	1131.3	281.3	121.8	150	200
	19.3	850	5,000	0.1	1131.2	281.2	121.8	150	200
	19.6	870	3,000	0.0	1131.2	261.2	113.1	150	200
	19.8	860	2,000	0.0	1131.2	271.2	117.4	150	200
	20.3	910	5,000	0.1	1131.1	221.1	95.7	100	150
	20.8	890	5,000	0.1	1131.0	241.0	104.4	150	200
	21.3	890	5,000	0.1	1130.9	240.9	104.3	150	200
	21.8	830	5,000	0.1	1130.9	300.9	130.3	150	200
	22.0	850	2,000	0.0	1130.8	280.8	121.6	150	200
	22.5	890	5,000	0.1	1130.8	240.8	104.3	150	200
	22.7	850	2,000	0.0	1130.7	280.7	121.6	150	200
	23.0	900	3,000	0.0	1130.7	230.7	99.9	100	150
	23.5	770	5,000	0.1	1130.6	360.6	156.1	200	250
	24.0	850	5,000	0.1	1130.5	280.5	121.5	150	200
	24.4	910	4,000	0.1	1130.5	220.5	95.5	100	150
	24.5	880	1,000	0.0	1130.5	250.5	108.5	150	200
	24.9	900	4,000	0.1	1130.4	230.4	99.8	100	150
	25.0	890	1,000	0.0	1130.4	240.4	104.1	150	200
	25.5	940	5,000	0.1	1130.3	190.3	82.4	100	150
	26.0	850	5,000	0.1	1130.3	280.3	121.3	150	200
	26.5	900	5,000	0.1	1130.2	230.2	99.7	100	150
	27.0	940	5,000	0.1	1130.1	190.1	82.3	100	150
	27.5	950	5,000	0.1	1130.0	180.0	78.0	100	150
	27.6	950	1,000	0.0	1130.0	180.0	77.9	100	150
KAWC distribution system gradient	27.7	950	1,000	0.0	1130.0	180.0	77.9	100	150

Kentucky-American Pipeline

February 17, 1998

Pipeline operating at minimum flows with both booster stations

C= 130
Flow = 6.0 MGD
Diameter = 36 inches

Location	Station	Elevation (feet)	Distance (feet)	Head Loss (feet)	HGL (feet)	Pressure (feet)	Pressure (psi)	Pressure Class Req'd	Pressure Class to Use
First booster station	0.0	650	0	0.0	1011.9	361.9	156.7	200	250
	0.5	700	5,000	0.9	1011.0	311.0	134.7	150	200
	0.6	710	1,000	0.2	1011.0	301.0	130.4	150	200
	1.0	780	5,000	0.9	1010.2	230.2	99.7	100	150
	1.5	780	5,000	0.9	1009.3	229.3	99.3	100	150
	2.0	810	5,000	0.9	1008.5	198.5	85.9	100	150
	2.5	770	5,000	0.9	1007.6	237.6	102.9	150	200
	3.0	710	5,000	0.9	1006.8	296.8	128.5	150	200
	3.3	670	3,000	0.5	1006.3	336.3	145.6	150	200
	3.5	710	2,000	0.3	1005.9	295.9	128.1	150	200
	4.0	760	5,000	0.9	1005.1	245.1	106.1	150	200
	4.5	660	5,000	0.9	1004.2	344.2	149.0	150	200
	5.0	710	5,000	0.9	1003.4	293.4	127.0	150	200
	5.5	790	5,000	0.9	1002.5	212.5	92.0	100	150
	6.0	770	5,000	0.9	1001.7	231.7	100.3	150	200
	6.1	800	1,000	0.2	1001.5	201.5	87.2	100	150
	6.5	730	4,000	0.7	1000.8	270.8	117.3	150	200
	6.7	680	2,000	0.3	1000.5	320.5	138.8	150	200
	7.0	800	3,000	0.5	999.9	199.9	86.6	100	150
	7.5	780	5,000	0.9	999.1	219.1	94.9	100	150
	7.9	710	4,000	0.7	998.4	288.4	124.9	150	200
	8.0	810	1,000	0.2	998.2	188.2	81.5	100	150
Critical high point	8.5	890	5,000	0.9	997.4	107.4	46.5	50	100
	9.0	810	5,000	0.9	996.5	186.5	80.8	100	150
	9.5	850	5,000	0.9	995.7	145.7	63.1	100	150
	10.0	880	5,000	0.9	994.8	114.8	49.7	50	100
	10.5	870	5,000	0.9	994.0	124.0	53.7	100	150
	11.0	850	5,000	0.9	993.1	143.1	62.0	100	150
	11.1	740	1,000	0.2	993.0	253.0	109.5	150	200
	11.5	820	4,000	0.7	992.3	172.3	74.6	100	150
	12.0	800	5,000	0.9	991.4	191.4	82.9	100	150
	12.2	710	2,000	0.3	991.1	281.1	121.7	150	200
	12.5	800	3,000	0.5	990.6	190.6	82.5	100	150
	13.0	760	5,000	0.9	989.7	229.7	99.5	100	150
	13.5	770	5,000	0.9	988.9	218.9	94.8	100	150
	14.0	800	5,000	0.9	988.0	188.0	81.4	100	150
	14.5	790	5,000	0.9	987.1	197.1	85.4	100	150
	15.0	830	5,000	0.9	986.3	156.3	67.7	100	150
	15.5	750	5,000	0.9	985.4	235.4	101.9	150	200
	16.0	650	5,000	0.9	984.6	334.6	144.9	150	200
Kentucky River crossing	16.1	460	1,000	0.2	984.4	524.4	227.1	250	300
	16.2	600	1,000	0.2	984.2	384.2	166.4	200	250
	16.3	700	1,000	0.2	984.1	284.1	123.0	150	200
	16.5	700	2,000	0.3	983.7	283.7	122.9	150	200
	17.0	700	5,000	0.9	982.9	282.9	122.5	150	200
	17.1	740	1,000	0.2	982.7	242.7	105.1	150	200
	17.2	760	1,000	0.2	982.5	222.5	96.4	100	150
	17.3	770	1,000	0.2	982.4	212.4	92.0	100	150
	17.8	830	5,000	0.9	981.5	151.5	65.6	100	150
Glenns Creek crossing	17.9	660	1,000	0.2	981.3	321.3	139.1	150	200
Suction pressure significantly raised	18.1	810	2,000	0.3	981.0	171.0	74.0	100	150
Second booster station	18.1	810		0.0	1145.9	335.9	145.4	150	200
critical low point	18.3	800	2,000	0.3	1145.5	345.5	149.6	150	200
	18.8	850	5,000	0.9	1144.7	294.7	127.6	150	200
	19.3	850	5,000	0.9	1143.8	293.8	127.2	150	200
	19.6	870	3,000	0.5	1143.5	273.5	118.4	150	200
	19.8	860	2,000	0.3	1143.5	283.5	122.7	150	200
	20.3	910	5,000	0.9	1142.6	232.6	100.7	150	200
	20.8	890	5,000	0.9	1141.8	251.8	109.0	150	200
	21.3	890	5,000	0.9	1140.9	250.9	108.7	150	200
	21.8	830	5,000	0.9	1140.1	310.1	134.3	150	200
	22.0	850	2,000	0.3	1139.7	289.7	125.5	150	200
	22.5	890	5,000	0.9	1138.9	248.9	107.8	150	200
	22.7	850	2,000	0.3	1138.5	288.5	124.9	150	200
	23.0	900	3,000	0.5	1138.0	238.0	103.1	150	200
	23.5	770	5,000	0.9	1137.2	367.2	159.0	200	250
	24.0	850	5,000	0.9	1136.3	286.3	124.0	150	200
	24.4	910	4,000	0.7	1135.6	225.6	97.7	100	150
	24.5	880	1,000	0.2	1135.5	255.5	110.6	150	200
	24.9	900	4,000	0.7	1134.8	234.8	101.7	150	200
	25.0	890	1,000	0.2	1134.6	244.6	105.9	150	200
	25.5	940	5,000	0.9	1133.8	193.8	83.9	100	150
	26.0	850	5,000	0.9	1132.9	282.9	122.5	150	200
	26.5	900	5,000	0.9	1132.0	232.0	100.5	150	200
	27.0	940	5,000	0.9	1131.2	191.2	82.8	100	150
	27.5	950	5,000	0.9	1130.3	180.3	78.1	100	150
	27.6	950	1,000	0.2	1130.2	180.2	78.0	100	150
KAWC distribution system gradient	27.7	950	1,000	0.2	1130.0	180.0	77.9	100	150

Kentucky-American Pipeline								C=	130	
February 17, 1998								Flow =	6.0	MGD
Pipeline operating at minimum flows with one booster station								Diameter =	36	inches
		Elevation	Distance	Head Loss	HGL	Pressure	Pressure	Pressure	Pressure	
Location	**Station**	**(feet)**	**(feet)**	**(feet)**	**(feet)**	**(feet)**	**(psi)**	**Class Req'd**	**Class to Use**	
First booster station	0.0	650	0	0.0	1177.3	527.3	228.3	250	300	
	0.5	700	5,000	0.9	1176.4	476.4	206.3	250	300	
	0.6	710	1,000	0.2	1176.3	466.3	201.9	250	300	
	1.0	780	4,000	0.7	1175.6	395.6	171.3	200	250	
	1.5	780	5,000	0.9	1174.7	394.7	170.9	200	250	
	2.0	810	5,000	0.9	1173.9	363.9	157.6	200	250	
	2.5	770	5,000	0.9	1173.0	403.0	174.5	200	250	
	3.0	710	5,000	0.9	1172.2	462.2	200.1	250	300	
	3.3	670	3,000	0.5	1171.7	501.7	217.2	250	300	
	3.5	710	2,000	0.3	1171.3	461.3	199.7	200	250	
	4.0	760	5,000	0.9	1170.5	410.5	177.7	200	250	
	4.5	660	5,000	0.9	1169.6	509.6	220.7	250	300	
	5.0	710	5,000	0.9	1168.8	458.8	198.6	200	250	
	5.5	790	5,000	0.9	1167.9	377.9	163.6	200	250	
	6.0	770	5,000	0.9	1167.0	397.0	171.9	200	250	
	6.1	800	1,000	0.2	1166.9	366.9	158.9	200	250	
	6.5	730	4,000	0.7	1166.2	436.2	188.9	200	250	
	6.7	680	2,000	0.3	1165.9	485.9	210.4	250	300	
	7.0	800	3,000	0.5	1165.3	365.3	158.2	200	250	
	7.5	780	5,000	0.9	1164.5	384.5	166.5	200	250	
	7.9	710	4,000	0.7	1163.8	453.8	196.5	200	250	
	8.0	810	1,000	0.2	1163.6	353.6	153.1	200	250	
	8.5	890	5,000	0.9	1162.8	272.8	118.1	150	200	
	9.0	810	5,000	0.9	1161.9	351.9	152.4	200	250	
	9.5	850	5,000	0.9	1161.1	311.1	134.7	150	200	
	10.0	880	5,000	0.9	1160.2	280.2	121.3	150	200	
	10.5	870	5,000	0.9	1159.4	289.4	125.3	150	200	
	11.0	850	5,000	0.9	1158.5	308.5	133.6	150	200	
	11.1	740	1,000	0.2	1158.3	418.3	181.1	200	250	
	11.5	820	4,000	0.7	1157.7	337.7	146.2	150	200	
	12.0	800	5,000	0.9	1156.8	356.8	154.5	200	250	
	12.2	710	2,000	0.3	1156.5	446.5	193.3	200	250	
	12.5	800	3,000	0.5	1155.9	355.9	154.1	200	250	
	13.0	760	5,000	0.9	1155.1	395.1	171.1	200	250	
	13.5	770	5,000	0.9	1154.2	384.2	166.4	200	250	
	14.0	800	5,000	0.9	1153.4	353.4	153.0	200	250	
	14.5	790	5,000	0.9	1152.5	362.5	157.0	200	250	
	15.0	830	5,000	0.9	1151.7	321.7	139.3	150	200	
	15.5	750	5,000	0.9	1150.8	400.8	173.6	200	250	
	16.0	650	5,000	0.9	1150.0	500.0	216.5	250	300	
Kentucky River crossing	16.1	460	1,000	0.2	1149.8	689.8	298.7	300	350	
	16.2	600	1,000	0.2	1149.6	549.6	238.0	250	300	
	16.3	700	1,000	0.2	1149.5	449.5	194.6	200	250	
	16.5	700	2,000	0.3	1149.1	449.1	194.5	200	250	
	17.0	700	5,000	0.9	1148.3	448.3	194.1	200	250	
	17.1	740	1,000	0.2	1148.1	408.1	176.7	200	250	
	17.2	760	1,000	0.2	1147.9	387.9	168.0	200	250	
	17.3	770	1,000	0.2	1147.8	377.8	163.6	200	250	
	17.8	830	5,000	0.9	1146.9	316.9	137.2	150	200	
Glenns Creek crossing	17.9	660	1,000	0.2	1146.7	486.7	210.8	250	300	
	18.1	810	2,000	0.3	1146.4	336.4	145.7	150	200	
	18.3	800	2,000	0.3	1146.0	346.0	149.8	150	200	
	18.8	850	5,000	0.9	1145.2	295.2	127.8	150	200	
	19.3	850	5,000	0.9	1144.3	294.3	127.4	150	200	
	19.6	870	3,000	0.5	1143.8	273.8	118.6	150	200	
	19.8	860	2,000	0.3	1143.5	283.5	122.7	150	200	
	20.3	910	5,000	0.9	1142.6	232.6	100.7	150	200	
	20.8	890	5,000	0.9	1141.8	251.8	109.0	150	200	
	21.3	890	5,000	0.9	1140.9	250.9	108.7	150	200	
	21.8	830	5,000	0.9	1140.1	310.1	134.3	150	200	
	22.0	850	2,000	0.3	1139.7	289.7	125.5	150	200	
	22.5	890	5,000	0.9	1138.9	248.9	107.8	150	200	
	22.7	850	2,000	0.3	1138.5	288.5	124.9	150	200	
	23.0	900	3,000	0.5	1138.0	238.0	103.1	150	200	
	23.5	770	5,000	0.9	1137.2	367.2	159.0	200	250	
	24.0	850	5,000	0.9	1136.3	286.3	124.0	150	200	
	24.4	910	4,000	0.7	1135.6	225.6	97.7	100	150	
	24.5	880	1,000	0.2	1135.5	255.5	110.6	150	200	
	24.9	900	4,000	0.7	1134.8	234.8	101.7	150	200	
	25.0	890	1,000	0.2	1134.6	244.6	105.9	150	200	
	25.5	940	5,000	0.9	1133.8	193.8	83.9	100	150	
	26.0	850	5,000	0.9	1132.9	282.9	122.5	150	200	
	26.5	900	5,000	0.9	1132.0	232.0	100.5	150	200	
	27.0	940	5,000	0.9	1131.2	191.2	82.8	100	150	
	27.5	950	5,000	0.9	1130.3	180.3	78.1	100	150	
	27.6	950	1,000	0.2	1130.2	180.2	78.0	100	150	
KAWC distribution system gradient	27.7	950	1,000	0.2	1130.0	180.0	77.9	100	150	

Kentucky-American Pipeline

February 17, 1998

Pipeline operating at minimum flows with one booster station

							C=	130	
							Flow =	1.6	MGD
							Diameter =	36	inches

Location	Station	Elevation (feet)	Distance (feet)	Head Loss (feet)	HGL (feet)	Pressure (feet)	Pressure (psi)	Pressure Class Req'd	Pressure Class to Use
First booster station	0.0	650	0	0.0	1134.1	484.1	209.6	250	300
	0.5	700	5,000	0.1	1134.0	434.0	187.9	200	250
	0.6	710	1,000	0.0	1134.0	424.0	183.6	200	250
	1.0	780	4,000	0.1	1134.0	354.0	153.3	200	250
	1.5	780	5,000	0.1	1133.9	353.9	153.2	200	250
	2.0	810	5,000	0.1	1133.8	323.8	140.2	150	200
	2.5	770	5,000	0.1	1133.7	363.7	157.5	200	250
	3.0	710	5,000	0.1	1133.7	423.7	183.4	200	250
	3.3	670	3,000	0.0	1133.6	463.6	200.7	250	300
	3.5	710	2,000	0.0	1133.6	423.6	183.4	200	250
	4.0	760	5,000	0.1	1133.5	373.5	161.7	200	250
	4.5	660	5,000	0.1	1133.4	473.4	205.0	250	300
	5.0	710	5,000	0.1	1133.4	423.4	183.3	200	250
	5.5	790	5,000	0.1	1133.3	343.3	148.6	150	200
	6.0	770	5,000	0.1	1133.2	363.2	157.3	200	250
	6.1	800	1,000	0.0	1133.2	333.2	144.3	150	200
	6.5	730	4,000	0.1	1133.1	403.1	174.6	200	250
	6.7	680	2,000	0.0	1133.1	453.1	196.2	200	250
	7.0	800	3,000	0.0	1133.1	333.1	144.2	150	200
	7.5	780	5,000	0.1	1133.0	353.0	152.8	200	250
	7.9	710	4,000	0.1	1132.9	422.9	183.1	200	250
	8.0	810	1,000	0.0	1132.9	322.9	139.8	150	200
	8.5	890	5,000	0.1	1132.8	242.8	105.2	150	200
	9.0	810	5,000	0.1	1132.8	322.8	139.8	150	200
	9.5	850	5,000	0.1	1132.7	282.7	122.4	150	200
	10.0	880	5,000	0.1	1132.6	252.6	109.4	150	200
	10.5	870	5,000	0.1	1132.5	262.5	113.7	150	200
	11.0	850	5,000	0.1	1132.5	282.5	122.3	150	200
	11.1	740	1,000	0.0	1132.5	392.5	169.9	200	250
	11.5	820	4,000	0.1	1132.4	312.4	135.3	150	200
	12.0	800	5,000	0.1	1132.3	332.3	143.9	150	200
	12.2	710	2,000	0.0	1132.3	422.3	182.9	200	250
	12.5	800	3,000	0.0	1132.2	332.2	143.9	150	200
	13.0	760	5,000	0.1	1132.2	372.2	161.2	200	250
	13.5	770	5,000	0.1	1132.1	362.1	156.8	200	250
	14.0	800	5,000	0.1	1132.0	332.0	143.8	150	200
	14.5	790	5,000	0.1	1132.0	342.0	148.1	150	200
	15.0	830	5,000	0.1	1131.9	301.9	130.7	150	200
	15.5	750	5,000	0.1	1131.8	381.8	165.3	200	250
	16.0	650	5,000	0.1	1131.7	481.7	208.6	250	300
Kentucky River crossing	16.1	460	1,000	0.0	1131.7	671.7	290.9	300	350
	16.2	600	1,000	0.0	1131.7	531.7	230.2	250	300
	16.3	700	1,000	0.0	1131.7	431.7	186.9	200	250
	16.5	700	2,000	0.0	1131.7	431.7	186.9	200	250
	17.0	700	5,000	0.1	1131.6	431.6	186.9	200	250
	17.1	740	1,000	0.0	1131.6	391.6	169.5	200	250
	17.2	760	1,000	0.0	1131.6	371.6	160.9	200	250
	17.3	770	1,000	0.0	1131.5	361.5	156.5	200	250
	17.8	830	5,000	0.1	1131.5	301.5	130.5	150	200
Glenns Creek crossing	17.9	660	1,000	0.0	1131.5	471.5	204.1	250	300
	18.1	810	2,000	0.0	1131.4	321.4	139.2	150	200
	18.3	800	2,000	0.0	1131.4	331.4	143.5	150	200
	18.8	850	5,000	0.1	1131.3	281.3	121.8	150	200
	19.3	850	5,000	0.1	1131.2	281.2	121.8	150	200
	19.6	870	3,000	0.0	1131.2	261.2	113.1	150	200
	19.8	860	2,000	0.0	1131.2	271.2	117.4	150	200
	20.3	910	5,000	0.1	1131.1	221.1	95.7	100	150
	20.8	890	5,000	0.1	1131.0	241.0	104.4	150	200
	21.3	890	5,000	0.1	1130.9	240.9	104.3	150	200
	21.8	830	5,000	0.1	1130.9	300.9	130.3	150	200
	22.0	850	2,000	0.0	1130.8	280.8	121.6	150	200
	22.5	890	5,000	0.1	1130.8	240.8	104.3	150	200
	22.7	850	2,000	0.0	1130.7	280.7	121.6	150	200
	23.0	900	3,000	0.0	1130.7	230.7	99.9	100	150
	23.5	770	5,000	0.1	1130.6	360.6	156.1	200	250
	24.0	850	5,000	0.1	1130.5	280.5	121.5	150	200
	24.4	910	4,000	0.1	1130.5	220.5	95.5	100	150
	24.5	880	1,000	0.0	1130.5	250.5	108.5	150	200
	24.9	900	4,000	0.1	1130.4	230.4	99.8	100	150
	25.0	890	1,000	0.0	1130.4	240.4	104.1	150	200
	25.5	940	5,000	0.1	1130.3	190.3	82.4	100	150
	26.0	850	5,000	0.1	1130.3	280.3	121.3	150	200
	26.5	900	5,000	0.1	1130.2	230.2	99.7	100	150
	27.0	940	5,000	0.1	1130.1	190.1	82.3	100	150
	27.5	950	5,000	0.1	1130.0	180.0	78.0	100	150
	27.6	950	1,000	0.0	1130.0	180.0	77.9	100	150
KAWC distribution system gradient	27.7	950	1,000	0.0	1130.0	180.0	77.9	100	150

ATTACHMENT E

Drawing Standards

PLOTTING STANDARD FOR DESIGN DRAWINGS

PARAMETER	PLOTTER PEN NUMBER - AS ASSIGNED BY HP DESIGNJET 650C PALETTE A					
	1	2	3	4	5	6
PEN SIZE	0.18 mm	0.25 mm	0.35 mm	0.50 mm	0.65 mm	0.35 mm
SCREEN COLOR/NUMBER		yellow (2) white (7)	blue (5), red (1), green (3)	cyan (4)		magenta (6)
PLOTTER PEN INK COLOR	Black	Black	Black	Black	Black	Gray

Use this table to assign colors to new layers. If you want a layer to be plotted with a specific weight of pen, assign that layer the color listed under that pen size. You may use any other colors, (8 through 256) to create new layers and to control lie weight when plotting. Be sure to save pen assignments when plotting (creating a .pcp file) so that the next time a file needs to be plotted the pen assignments will already be available. Please provide the .pcp files on diskette with the drawing files so that the drawings may be reproduced in the event that a change occurs after project completion.

- All drawings should be submitted on reproducible media, either mylar, vellum or translucent bond paper. A diskette or tape copy of the drawings is also required in an AutoCAD R12 or R13 compatible format.

Layering Convention

All layer names shown are for proposed improvements. Any layers for existing structures and/or piping should have the suffix -EX attached to the end of the layer name. For example, to show an existing building on the site plan, the layer name would be **C-BLDG-EX**. All layers for existing objects will be color number 6 (magenta).

ARCHITECTURAL

NAME	DESCRIPTION	CLR	LINETYPE
0	Empty	7	Continuous
A-ACCESS	Access hatches	1	Continuous
A-ALUMINUM	Gutters, downspouts, alum. trim	2	Continuous
A-BLOCK	Block walls (incl. grout lines bet. blocks)	5	Continuous
A-BLOCKHATCH	Block hatching	6	Continuous
A-BRICK	Brick Face & Trim	14	Continuous
A-BRICKHATCH	Brick hatching	6	Continuous
A-COPING	Coping around parapet roof	1	Continuous
A-DOOR	Doors, door swings, door frames	2	Continuous
A-FRP	FRP (fiberglass) grating & members	7	Continuous
A-GRATING	Walkway, stair or containment grating	9	Continuous
A-GRTGHATCH	Grating Hatch pattern	7	Continuous
A-HANDRAIL	Handrails	8	Continuous
A-INSULATION	Roof Insulation, batt insulation, air gap	7	Continuous
A-LADDER	Ladders	8	Continuous
A-ROOFDECK	Roof decking (all types & associated pieces)	1	Continuous
A-SHINGLES	Roof Shingles	30	Continuous
A-WINDOW	Windows	2	Continuous

Layering Convention (cont'd)

PLUMBING

NAME	DESCRIPTION	CLR	LINETYPE
B-DRAIN	Drain lines & floor openings	1	Continuous
B-FIREPROT	Fire extinguishers, sprinklers	1	Continuous
B-SHOWER	Safety showers	1	Continuous
B-SUPPLY	Potable water supply (inside structure)	140	Continuous

CIVIL

NAME	DESCRIPTION	CLR	LINETYPE
C-BOLLARD	Pipe bollards in yard	4	Continuous
C-BOULDER	Rocks & boulders - Proposed	3	Continuous
C-CBASIN	Catch basins	1	Continuous
C-CONTOUR	Proposed contours	220	Continuous
C-CURB	Curb along edge of road	1	Continuous
C-FENCE	New fence along property	4	Continuous
C-GRADE	Finished grade	3	Continuous
C-HAY	Haybales for soil erosion/sediment control	2	Continuous
C-HYDRANT	Fire Hydrants	1	Continuous
C-LAGOON	Sludge/residuals lagoons	4	Continuous
C-MANHOLE	Manholes & covers	1	Continuous
C-PL	Property line	13	Continuous
C-RIVER	Lake, River or Stream edge	5	Continuous
C-ROAD	Roads, driveways, parking areas	7	Continuous
C-ROW	Right of way (as determined by survey)	7	Continuous
C-RR	Railroad tracks	2	Continuous

CIVIL (cont'd)

NAME	DESCRIPTION	CLR	LINETYPE
C-SANITARY	Sanitary Sewer lines	5	Continuous
C-SHORING	Temporary shoring	4	Continuous
C-SIDEWALK	Sidewalks	1	Continuous
C-SOILEROSION	Silt fence, stakes	1	Continuous
C-SPOTELEV	Spot Elevations	2	Continuous
C-STONE	Gravel subbase, rock driveways, filter fabric	9	Continuous
C-STORM	Storm Sewer catchbasins & lines	1	Continuous
C-TEXT	Contour text (elevations)	220	Continuous
C-TREE	Proposed individual tree	3	Continuous
C-TREELINE	Tree line (edge of clearing) – Proposed	3	Continuous
C-VALVEBOX	Valve boxes	1	Continuous
C-WETLANDS	Wetlands delineation line	5	Continuous

ELECTRICAL – SITE PLAN

NAME	DESCRIPTION	CLR	LINETYPE
E-CONCRETE	Concrete encased electrical lines	1	Continuous
E-EQUIP	RTU's, equipment boxes	4	Continuous
E-GROUND	Grounding rods	3	Center
E-PHONE	Telephone lines (label OH or UG), includ. conduits	2	Continuous
E-POLE	Utility poles	4	Continuous
E-POWER	Electrical power lines (label OH or UG), includ. conduits	4	Hidden

Layering Convention (cont'd)

ELECTRICAL – SINGLE LINES

NAME	DESCRIPTION	CLR	LINETYPE
E-SYMBOLS	Symbols for equipment	5	Continuous
E-TEXT	Text for proposed electrical items	2	Continuous
E-WIRES	Wires, lines	1	Continuous

GENERAL

NAME	DESCRIPTION	CLR	LINETYPE
G-BLDTEXT	Heavy text, i.e., titles, section marks, etc.	4	Continuous
G-BORDER	Border outline and cutlines	4	Continuous
G-DIMENSION	All horizontal, vertical and angular dimensions	2	Continuous
G-TEXT	All leaders, notes and other annotation	2	Continuous
G-VIEWPORT	Paper Space viewports	1	Continuous
G-XREF	Xref's	1	Continuous

HVAC

NAME	DESCRIPTION	CLR	LINETYPE
H-HVAC	Fans, Louvers, Ductwork, Heaters	1	Continuous

INSTRUMENTATION

NAME	DESCRIPTION	CLR	LINETYPE
I-DCS	DCS driven	11	Continuous
I-INST-AI	Analog Input Equipment	3	Continuous
I-INST-AO	Analog Output Equipment	2	Continuous
I-INST-DI	Digital Input Equipment	1	Continuous
I-INST-DO	Digital Output Equipment	5	Continuous
I-SOFTWARE	Software driven	8	Continuous

Layering Convention (cont'd)

MECHANICAL

NAME	DESCRIPTION	CLR	LINETYPE
M-AIR	Compressed air lines	7	Continuous
M-BACKWASH	Backwash water lines	20	Continuous
M-BWWASTE	Backwash waste lines	40	Continuous
M-CENTER	Pipe center line	7	Center
M-CLARIFIED	Clarified water line (clarifier or superpulsator)	132	Continuous
M-EQUIP	Pumps, air comp., blowers, etc.	3	Continuous
M-FILTERED	Filtered Water lines	130	Continuous
M-FTW	Filter to Waste lines	74	Continuous
M-OVERFLOW	Overflow lines	1	Continuous
M-PIPESUPPORT	Pipe support (other than concrete)	4	Continuous
M-RAW	Raw Water lines	94	Continuous
M-REMOVE	Items to be removed (mechanical only)	4	Continuous
M-SETTLED	Settled Water lines (from Sed. basins)	134	Continuous
M-SLEEVECL	Centerlines for wall sleeves	7	Continuous
M-SLUDGE	Sludge/residuals lines	30	Continuous
M-TANK	Tanks, daytanks, secondary containment	3	Continuous
M-TANKCL	Tank centerlines	7	Continuous
M-WALLSLEEVE	Wall sleeve (cast in place)	4	Continuous
M-WASH	Washwater lines	3	Continuous

PROCESS

NAME	DESCRIPTION	CLR	LINETYPE
P-ALUM	Alum lines	30	Continuous
P-AMMONIA	Ammonia lines	7	Continuous
P-CARBONSL	Carbon Slurry lines	14	Continuous
P-CAUSTIC	Caustic Soda lines	62	Continuous
P-CHLORINE	Chlorine lines (gas or liquid)	2	Continuous
P-COAGAID	Coagulant Aid Polymer lines	42	Continuous
P-COAGPRIMARY	Primary Coagulant lines	30	Continuous
P-CONDUIT	PVC conduit (carrier lines)	1	Continuous
P-FILTERAID	Filter Aid Polymer lines	200	Continuous
P-FLUORIDE	Fluoride lines	141	Continuous
P-LIMESL	Lime Slurry lines	70	Continuous
P-OZONE	Ozone lines	50	Continuous
P-POTASSIUM	Potassium Permanganate lines	201	Continuous
P-SLTHCKPOLY	Sludge Thickening Polymer lines	42	Continuous
P-SODAASH	Soda Ash lines	72	Continuous
P-SULFURICA	Sulfuric Acid lines	2	Continuous
P-SULFURDIO	Sulfur Dioxide lines	80	Continuous
P-ZINC	Zinc Orthophosphate lines	160	Continuous

Layering Convention (cont'd)

STRUCTURAL

NAME	DESCRIPTION	CLR	LINETYPE
S-BOLT	Miscellaneous bolts	9	Continuous
S-CONCSUPPORT	Pipe supports (concrete)	1	Continuous
S-FND	Foundation (ftgs only - elev. Views)	1	Continuous
S-FNDHATCH	Foundation hatch pattern	7	Continuous
S-FNDHIDDEN	Parts of foundation that need to be broken away in certain views	1	Continuous
S-FNDINNER	Inside footing line (for plan views)	1	Continuous
S-FNDOUTER	Outside footing line (for plan views)	1	Continuous
S-FNDWALL	Foundation walls (above ftgs – plans & elevations)	1	Continuous
S-FNDWALHATCH	Foundation wall hatch pattern	7	Continuous
S-LINKSEAL	Linkseal in wall	1	Continuous
S-LUMBER	All wood, Roof Trusses, Drywall, fascia, spacers	2	Continuous
S-OVERFLOWBOX	Overflow boxes - for tanks	1	Continuous
S-PAD	Concrete pads for all equipment (include filler material/sealant)	1	Continuous
S-PADHATCH	Hatching for concrete pads	7	Continuous
S-PLTFSTEEL	Platform steel members	8	Continuous
S-REBAR	Rebars, Ties	3	Continuous
S-REMOVE	Items to be removed (structural only)	4	Continuous
S-RETAINWALL	Retaining wall	5	Continuous
S-SLAB	Concrete floor slabs	1	Continuous
S-STAIRS	Stairs stringers & treads	8	Continuous

Layering Convention (cont'd)

STRUCTURAL (cont'd)

NAME	DESCRIPTION	CLR	LINETYPE
S-STEEL	Steel members, beams, baseplates, S.S. bolts, S.S. flashing	8	Continuous
S-STEELCL	Steel centerlines	7	Center
S-SUMP	Sump opening & center "x"	1	Continuous
S-SUMPFND	Sump foundation lines (hidden in plan view)	1	Continuous
S-SUPPORT	Pipe supports (steel)	4	Continuous
S-WALKWAY	Steel walkways	8	Continuous
S-WATERSTOP	Waterstops	3	Continuous

YARD PIPING

NAME	DESCRIPTION	CLR	LINETYPE
Y-AIR	Compressed air lines	7	Continuous
Y-CONCRETE	Concrete encasements (in yard)	1	Continuous
Y-DEADMAN	Deadman anchors	3	Continuous
Y-GAS	Gas supply (single line)	20	Continuous
Y-SUPPLY	Potable water supply (outside), hose bibbs	140	Continuous
Y-THRUSTBLOCK	Concrete thrust blocks for yard piping	1	Continuous

STANDARD ABBREVIATIONS

Abbreviation	Description
A.B.	Anchor Bolt
ADJ	Adjacent
ALUM.	Aluminum
ANSI	American National Standards Institute
APPROX.	Approximate
ARCH.	Architectural
AMP	Ampere
ASME	American Society of Mechanical Engineers
ASSY	Assembly
ASTM	American Society for Testing and Materials
AUTO.	Automatic
AUX.	Auxiliary
AVG	Average
BLDG	Building
B.O.M.	Bill of Material
B.O.C.	Bottom of concrete
B.O.S.	Bottom of steel
BR	Bronze
BRS	Brass
BTM	Bottom
C	Channel
°C	Centigrade, or Celsius
C to C	Center to Center
CFM	Cubic feet per minute
CHKD	Checked/Checkered (as in plate)
CI	Cast Iron pipe
℄	Centerline
CL.	Clearance
CM	Centimeter
COL.	Column
C.O.	Cleanout
CONC.	Concrete
CONSTR.	Construction
CONT.	Continued
CPLG	Coupling
CU.	Cubic
DEG(°)	Degrees
DIA.	Diameter
D.I.P.	Ductile Iron Pipe
DIM.	Dimension

Abbreviation	Description
DISCH.	Discharge
DN	Down
DPI	Differential Pressure Indicator
DWG	Drawing
E	East
EA.	Each
EA	Exhaust Air
E.F.	Each face
EL.	Elevation
ELL	Elbow
EQUIP.	Equipment
E.S.	Each Side
E.W.	Each way
EXIST.	Existing
EXPAN.	Expansion
F	Fan
°F	Fahrenheit
FD	Floor drain
FIG.	Figure
FL.	Floor
FLG	Flange
FLGD	Flanged
FPS	Feet per second
FS	Far side
FT(')	Foot or feet
FTG	Fitting
GAL.	Gallon(s)
GALV.	Galvanized
GPM	Gallons per minute
GND	Ground (as in electrical)
H	Height
HB	Hose Bibb
HEX	Hexagon(al)
HORIZ.	Horizontal
HP	Horsepower
HVAC	Heating, ventilation, and air conditioning
HZ	Hertz (frequency)
I.D.	Inside Diameter
IN.(")	Inches
INV.	Invert (inside bottom of pipe)
JT.	Joint
KG	Kilogram
KVA	Kilovolt amperes

Abbreviation	Description
KW	Kilowatts
L	Length
LBS	Pounds
LR	Long Radius (of elbow)
M	Meter
MATL	Material
MAX.	Maximum
MCC	Motor Control Center
MECH.	Mechanical
MFR.	Manufacturer
MH	Manhole
MJ	Mechanical Joint (Pipe)
MIN.	Minimum
MISC.	Miscellaneous
MM	Millimeter
MVA	Megavolt amperes
N	North
N/A	Not applicable
NC.	Normally Closed
N.O.	Normally Open
NO.	Number
NOM.	Nominal
NPS	National pipe size
NPT	National pipe thread
NS	Near Side
NTS	Not to scale
OA	Outside air
O.D.	Outside Diameter
OH	Overhead
OPN'G.	Opening
ORIG.	Original
O.S.D.	Open Site Drain
P&ID	Process & Instrumentation Diagram
PE	Plain End (Pipe, etc.)
PERP.	Perpendicular
PL	Plate
PRESS.	Pressure
PRV	Pressure reducing/regulating valve
PSI	Pound per square inch
PSIA	Pound per square inch absolute
PSIG	Pound per square inch gauge
PVC	Polyvinyl chloride
QTY	Quantity

Abbreviation	Description
QUAD.	Quadrant
RED.	Reducing/Reducer
REINF.	Reinforcing/Reinforcement
REQ'D.	Required
REV.	Revision
RPM	Revolutions per minute
S	South
SCH or SCHED.	Schedule
SHT	Sheet
SLV	Sleeve
SQ.	Square
SR	Short Radius (of elbow)
S.S.	Stainless Steel
STD	Standard
STRUCT.	Structure/Structural
SUCT.	Suction
TEMP.	Temperature
THRU	Through
T.O.C.	Top of concrete
T.O.P.	Top of pipe
T.O.S.	Top of steel
TYP.	Typical
UG	Underground
UH	Unit heater
V	Volts
VERT.	Vertical
W	Watts
W	West
W	Width

ATTACHMENT F

Agreement for Professional Engineering Services

AGREEMENT FOR
ENGINEERING SERVICES
BETWEEN KENTUCKY-AMERICAN WATER COMPANY
AND [SELECTED CONSULTANT]
FOR THE BLUEGRASS WATER PROJECT

THIS AGREEMENT, made and entered into this 1st of April 1998 by and between the KENTUCKY-AMERICAN WATER COMPANY, with its principal office at 2300 Richmond Road, Lexington, Kentucky 40502, hereinafter referred to as "OWNER", and [SELECTED CONSULTANT], providing professional engineering services with its office at [LOCATION] hereinafter referred to as "ENGINEER":

WHEREAS, KENTUCKY-AMERICAN WATER COMPANY, desires to receive the engineering services related to the design and bidding of the Bluegrass Water Project facilities with a scope generally defined by OWNER's Request for Proposal and Design Concept and ENGINEER'S proposal presented in Appendix A; and

WHEREAS, OWNER is desirous of engaging the services of said ENGINEER to perform or furnish said services.

WHEREAS, ENGINEER has available and offers to provide personnel and facilities necessary to accomplish said services in a timely manner.

NOW, THEREFORE, said OWNER and said ENGINEER, for the considerations hereinafter set forth, mutually agree as follows:

Article I - Professional Engagement

OWNER hereby engages (SELECTED CONSULTANT) as an independent contractor, to perform or furnish the services hereinafter more particularly described in Appendix A, commencing on the date of this Agreement.

ENGINEER hereby agrees to perform or furnish as an independent contractor professional engineering and related services as set forth herein. ENGINEER may retain qualified subconsultants to assist in the performance of professional services. OWNER shall be notified prior to ENGINEER sub-contracting such services and sufficient time shall be provided to allow OWNER to review the subconsultants qualification. Should OWNER, based upon reasonable cause, not accept any such subcontractor or subconsultant for use on the Project, OWNER shall so notify ENGINEER, within five (5) days following OWNER's receipt of such notice from ENGINEER, and ENGINEER shall not subcontract with any such subcontractor or subconsultant for the Project. OWNER shall have the right at any time to revoke its acceptance (whether given affirmatively or by its failure to object within said five day period) of any subcontractor or subconsultant on the basis of reasonable cause, in which case ENGINEER shall submit an acceptable substitute and a Task Order equitably adjusting ENGINEER's compensation will be issued. No acceptance of any subcontractor or subconsultant shall waive: (1) OWNER's right not to accept defective services performed or furnished for ENGINEER by said subcontractor or subconsultant; or (2) any other right or remedy OWNER has under this Agreement, including but not limited to its rights to suspend or terminate services under this Agreement.

ENGINEER is an independent contractor and is not and shall not be deemed to be an employee, agent, servant, partner or joint venturer of OWNER. ENGINEER shall have the exclusive supervision, direction and control of all employees, subconsultants, subcontractors, suppliers, materials, equipment and facilities employed, contract with or used by ENGINEER in performing or furnishing services under this Agreement.

Article II - Scope of Services

The scope of services performed or furnished by ENGINEER under the terms of this Agreement is defined in Appendix A and in the executed Task Orders pursuant hereto which will authorize ENGINEER to perform specific engineering services related to the project. Unless modified in writing by both parties through a Task Order, duties of ENGINEER shall not be construed to exceed those services specifically established in Appendix A. *(**NOTE**: ANY ADDITIONAL ENGINEERING FEES ASSOCIATED WITH SERVICES NOT INCLUDED IN APPENDIX A MUST BE DEFINED AND AGREED TO BY OWNER IN WRITING PRIOR TO INITIATION OF THESE SERVICES.)*

Article III - Cooperation by OWNER

OWNER shall, to the extent reasonable and practicable, cooperate with ENGINEER in the performance of ENGINEER's services hereunder. Such cooperation shall include, but not necessarily be limited to: providing right of access to work sites as required for ENGINEER to perform or furnish services under this Agreement; providing relevant material available from OWNER's files such as maps, drawings as available (whether or not as-built drawings), records, and operation and maintenance information; serving all notices; attending all hearings; payment of all permit and other required fees associated with the Project; and rendering assistance in determining the location of existing facilities and improvements which may be affected by the Project.

OWNER shall be responsible for providing legal services which it deems necessary for the Project including review of contract documents, public advertising and contract letting. OWNER shall pay fees for utility services to the Project.

OWNER shall appoint DAVID M. REVES, P.E. as OWNER'S REPRESENTATIVE with respect to the services to be performed under this Agreement. OWNER'S REPRESENTATIVE shall have complete authority to transmit instructions, receive information, and interpret and define OWNER's policies. ENGINEER shall be entitled to rely on representations made by OWNER'S REPRESENTATIVE unless otherwise specified in writing by OWNER.

Article IV - Schedule

A schedule for carrying out services performed by ENGINEER under the terms of this Agreement is set forth in Appendix A. ENGINEER will exert all reasonable efforts to perform or furnish all services under this Agreement in accordance with said schedule.

OWNER will be kept informed as to the progress of the services under this Agreement under the terms presented in Appendix A. Neither party shall hold the other responsible for damages caused by, arising out of or resulting from delays in performance caused by acts of God, strikes, lockouts or other events beyond the control of the other party.

Article V - Assignment of Agreement

ENGINEER shall not assign this Agreement or any portion of the services to be performed or furnished hereunder without prior written approval of OWNER.

Article VI - Litigation

The Agreement does not require ENGINEER to prepare for or appear as a witness in any litigation or alternative dispute resolution proceeding on behalf of OWNER, other than as specified in Appendix A, except in consideration of additional reasonable compensation negotiated as part of a Task Order specifically issued for such purpose. Notwithstanding the preceding, ENGINEER shall participate without additional compensation in any litigation or alternative dispute resolution proceeding in which ENGINEER is a party or in which a claim is made against OWNER based in whole or in part on ENGINEER's negligence, professional errors or omissions, breach of contract or deficiencies in ENGINEER's design or performance hereunder.

Article VII - Ownership of Document

Drawings, specifications, submittals and other work products of the ENGINEER for the Project, except working notes and internal documents, become the property of OWNER upon delivery thereof to OWNER and payment for the services which produced said documents in accordance with this Agreement. Reuse of any of these drawings, specifications, submittals or other work products of ENGINEER by OWNER for other than the specific project covered in this Agreement, or modification and use by OWNER of any documents connected with this Agreement, without the written permission of ENGINEER shall be at OWNER's risk and OWNER agrees to defend, indemnify, and hold harmless ENGINEER from all claims, damages and expenses including attorney's fees arising out of such unauthorized reuse of ENGINEER work product by OWNER or by others acting through OWNER. ENGINEER shall be entitled to a reproducible copy of all material furnished to OWNER, the costs of which is included in the compensation amounts specified in Appendix A and/or the Task Orders. Any incompleted work of ENGINEER delivered to OWNER due to cancellation of all or portions of the work or contract termination, which are utilized by OWNER in any way, shall have ENGINEER name removed, and OWNER agrees to defend, indemnify, and hold harmless ENGINEER from all claims, damages, and expenses including attorney's fees arising from any use by OWNER of such incompleted work Product.

Article VIII - Confidential Information

"Confidential Information" means all information about the OWNER or its affiliates furnished by OWNER or its affiliates, or their respective directors, officers, employees, agents or other representatives, whether furnished before or after the date hereof, or furnished orally or in writing or gathered by inspection, and regardless of whether specifically identified as "confidential", together with analyses, compilations, studies or other documents prepared by ENGINEER, or by ENGINEER's affiliates, subconsultants or subcontractors or their respective directors, officers, employees, (such affiliates, subconsultants, subcontractors or other persons collectively referred to herein as "ENGINEER's Representatives") which contain or otherwise reflect such information or ENGINEER's or ENGINEER's Representatives review of such information.

ENGINEER agrees not to use any of the Confidential Information for any purpose other than in performing the professional services contemplated under this Agreement (the "Permitted Use"). ENGINEER agrees that the Confidential Information will not be used by ENGINEER in any way detrimental to the OWNER and that the Confidential Information will be kept strictly confidential and, without the prior written consent of OWNER, neither ENGINEER nor ENGINEER's Representatives shall: (i) distribute or disclose to any person or entity any of the Confidential Information, or any facts related thereto (other than as permitted herein); (ii) permit any person or entity to have access to the Confidential Information (other than as permitted herein); or (iii) use the Confidential Information for any purpose other than the Permitted Use. Moreover, the ENGINEER agrees to transmit the Confidential Information only to the ENGINEER's Representatives who have a legitimate need to know the Confidential Information for the sole purpose of the Permitted Use and who shall (a) be advised by the ENGINEER of this

Article VIII and (b) agree with the ENGINEER to be bound by the provisions hereof. The ENGINEER shall be responsible for any breach of this Article VIII by the ENGINEER's Representatives (including employees of the ENGINEER or the ENGINEER's Representatives who, after the first date of disclosure of Confidential Information hereunder, become former employees). ENGINEER agrees, at its sole expense, to take all reasonable measures, including but not limited to court proceedings, to restrain the ENGINEER's Representatives (and former employees of the ENGINEER or the ENGINEER's Representatives) from unauthorized disclosure or use of the Confidential Information.

The ENGINEER hereby acknowledges that if any breach of this Article VIII occurs, the OWNER would be irreparably and immediately harmed and could not be made whole by monetary damages. Accordingly, in addition to any other remedy to which it may be entitled in law or equity, the OWNER shall be entitled to an injunction or injunctions to prevent breaches of this Article VIII and/or to compel specific performance of this Article VIII, and the ENGINEER shall not oppose the granting of such relief on the basis that monetary damages are adequate. The ENGINEER also agrees to reimburse the OWNER for all costs and expenses, including reasonable attorney's fees and expenses, incurred by it in enforcing the ENGINEER's or the ENGINEER's Representatives' obligations under this Article VIII.

Article IX - Payment

Payment for the engineering services set forth in Appendix A and specific executed Task Orders shall be made by OWNER to ENGINEER and shall be considered as full compensation for such services and all personnel, materials, supplies, and equipment used and costs incurred in carrying out such services.

A. Payment for services performed or furnished under terms of Appendix A and/or Task Orders in which a lump sum basis of compensation is specified shall be as described below:

1. Compensation to ENGINEER shall be a lump sum amount specified in Appendix A and Task Orders.

2. Payments shall be monthly, based on percent completion. As each payment is due, a statement describing the services which have been performed or furnished and listing the percent of completion and the total amount of prior payments paid by OWNER shall be submitted to OWNER. Payment shall be made for the balance due under such statement, without retention unless OWNER contests all or part of said billing in which event only that portion so contested will be retained by OWNER pending resolution of the dispute and any uncontested portion will be paid.

B. If a lump sum compensation is not agreed upon for a specific Task Order, payment for services performed or furnished under the terms of that Task Order in which a time and expense reimbursable basis of compensation is specified shall be as described below:

1. Compensation to ENGINEER shall be on a time and expense reimbursement basis in accordance with ENGINEER's Schedule of Charges. A current copy of the Schedule of Charges will be included with each Task Order.

2. Payments for services provided by ENGINEER on a time and expense basis shall be made monthly by OWNER based on an itemized invoice from ENGINEER which lists actual costs and expenses incurred on the Project in the immediate preceding month. Such payments shall be for the invoice amount, without retention unless OWNER contests all or part of said billing in which event only that portion so contested will be retained by OWNER pending resolution of the dispute and any uncontested portion will be paid.

3. A budget for compensation for services provided by ENGINEER on a time and expense basis will be established in the Compensation section of the Task Order. The budget established in the Task Order shall not be exceeded without OWNER's written authorization.

The budget may be increased by amendment to the Task Order if necessary to complete the scope of work. If appropriate, ENGINEER will advise OWNER of the anticipated expenditure over the budgeted amount at the fifty (50) percent completion point of the Task Order work and request additional budget authorization.

Task Orders using a time and expense reimbursement should be limited in scope. The product of these Task Orders should adequately define the specific scope and effort necessary to achieve the necessary addition/modification and develop a lump sum proposal for the required engineering services.

C. ENGINEER's final statement or invoice for any services which include construction, or the final statement or invoice for the Project, whichever occurs earlier in time, shall include properly completed and executed Releases of Liens and Claims (see Appendix C). Payment of any invoice not satisfying this requirements may be withheld until the requirements has been satisfied.

D. Payments are due upon receipt of a statement or invoice prepared in a manner acceptable to OWNER and approved by OWNER. Interest shall accrue and be paid on any unpaid approved statement or invoice amount at the legal rate of interest from the 45th day after receipt of such statement or invoice to the date of payment. Interest shall be payable at the same time that said statement or invoice amount is paid.

Article X - Suspension of Work

OWNER may, at OWNER'S discretion, suspend, in writing, all or a portion of the services under this Agreement. ENGINEER may suspend the services under this Agreement in the event OWNER does not make payment in accordance with the payment terms in Article VIII. The services under this Agreement will only be suspended for non-payment after written notice is received by OWNER from ENGINEER of its intention intending to suspend performance and a cure period of seven (7) days after receipt of this notification by OWNER. The time for completion of the services under this Agreement shall be extended by the number of days the services under this Agreement is suspended. If the period of suspension exceeds ninety (90) days, the terms of this Agreement are subject to renegotiation, and both parties shall have the option to terminate the services under this Agreement on the suspended portion of Project in accordance with Article X.

Article XI - Termination of Services

OWNER, by notifying ENGINEER in writing, may terminate any or all of the services covered by this Agreement. In the event of such termination, ENGINEER shall have the right to expend a reasonable amount of additional time to assemble work in progress for the purpose of proper filing and closing of the job. Such additional time shall not exceed five percent (5%) of the total time expended to the date of notice of termination or a designated total time agreed upon in a Task Order. All charges thus incurred, together with associated expenses reasonably incurred by ENGINEER and reasonable charges for any other commitments outstanding at the time of termination (such as for termination of subconsultants, rental agreements, orders for printing etc.), shall be payable by OWNER within thirty (30) days following submission of a final statement by ENGINEER. However, in the event that termination of said Agreement with ENGINEER occurs at the completion of a specific phase of the design, the aforesaid provision for the proper filing and closing will not apply unless agreed to by OWNER under a specific Task Order. The payment provided for under this Article X shall constitute full satisfaction of any obligation OWNER has, may have or could be found to have to pay for services performed or furnished and expenses or charges incurred by ENGINEER pursuant to this Agreement and any and all liabilities or damages arising out of or resulting from the termination of this Agreement.

Article XII - Indemnification

To the fullest extent permitted by law, ENGINEER shall indemnify, hold harmless and defend OWNER, its parent, subsidiaries, partners, officers, directors, employees and agents from and against any and all claim, damages, costs, losses and expenses (including but not limited to attorneys' fees) caused by, arising out of or related to the negligence (including but not limited to professional negligence, errors or omissions) of ENGINEER, its partners, officers, employees, agents, subconsultants and subcontractors in the performance or furnishing of services under this Agreement, provided however, that ENGINEER's liability to OWNER under this Article XI shall not exceed the percentage share of such claim, damages, cost, loss and expense that the negligence (including professional negligence, errors or omissions) of ENGINEER, its partners, officers, employees, agents, subconsultants and subcontractors bears to the total negligence of all negligent entities and individuals determined on the basis of comparative negligence principles.

Article XIII - Insurance

A. ENGINEER and its subcontractors shall maintain worker's compensation and employers' liability insurance in accordance with the amount(s) and coverage(s) in the attached Appendix B.

B. ENGINEER and its subcontractors shall maintain commercial general liability and automobile liability insurance protecting it against claims arising from bodily or personal injury or damage to property, including loss of use thereof, resulting from operations of ENGINEER pursuant to this Agreement or from the use of automobiles and equipment of or by ENGINEER. The amount(s) and coverage(s) shall be in accordance with Appendix B.

C. ENGINEER shall maintain a policy of professional liability insurance, protecting it against claims arising out of the negligent acts, errors, or omissions for which it is legally liable in the performance or furnishing of professional services pursuant to this Agreement. Such insurance shall be maintained for one (1) year after final completion of construction. The amount(s) and coverage(s) shall be in accordance with Appendix B.

D. ENGINEER is required to provide OWNER with Certificates of Insurance evidencing the afore-referenced coverages and, upon OWNER's written request, complete copies of such policies or certified evidence of coverage satisfactory to OWNER shall be provided to OWNER. Approval or acceptance of said insurance by OWNER shall not relieve or decrease the liability of ENGINEER hereunder.

E. OWNER agrees to endeavor to include a provision in OWNER's contract with the Construction Contractor engaged on the Project which requires that ENGINEER be listed as an additional insured on such Construction Contractor(s) liability insurance policy and property insurance (Builder's Risk) policy, if any.

Article XIV - Controlling Law

This AGREEMENT is to be governed by the law of the state in which OWNER's principal place of business is located.

IN WITNESS WHEREOF, this Agreement has been executed by the respective duly authorized agent of ENGINEER and OWNER , all as of the day and year first above written.

ENGINEER	OWNER
	Kentucky-American Water Company 2300 Richmond Road Lexington, Kentucky 40502

By ______________________________ By ________________________________

Title ____________________________ Title ______________________________

Appendix A

1. Reference American Water Works Service Company, Inc. Request for Proposal and Design Concept dated February 18, 1998.

2. Reference [CONSULTANT PROPOSAL] dated March [DATE], 1998.

Appendix B

Article XII, Insurance of the Agreement, is hereby supplemented to include the following agreement of the parties:

The limits of liability for the insurance required by Article XII are as follows:

XII	A. Worker's Compensation Employee's Liability	Statutory 100,000
	B. General Liability* General Aggregate Each Occurrence Products/Comp. Ops. Personal & Adv. Inj. Fire Damage (any one fire) Medical Expense (any one person) Automobile Liability Bodily Inj. & P.D. Combined Single Limit Each Accident	 2,000,000 2,000,000 2,000,000 2,000,000 50,000 5,000 2,000,000
	C. Professional Liability Limit Aggregate Deductible (if over 250,000)	 $3,000,000
	D. Excess Liability Occurrence Aggregate	 ** **

Additional Insured: OWNER will be added to the policies required in XII B as an additional insured.

**As needed to provide limits requested in XII B.

APPENDIX C INCLUDES:

Release of Liens and Claims (ENGINEER)
Release of Liens and Claims (Subconsultant & Subcontractor)

ENGINEER's RELEASE OF LIENS AND CLAIMS

WHEREAS, the undersigned, has installed or performed or furnished labor, services, materials and/or equipment for the installation of the Project entitled the Bluegrass Water Project, (the "Project"), installed pursuant to a written agreement dated April 1, 1998, between the undersigned, as "ENGINEER", and Kentucky-American Water Company, having an office at 2300 Richmond Road, Lexington, KY 40502, hereinafter called OWNER, at or on real estate owned by OWNER and described and located as follows:

Along the proposed pipeline route in Shelby, Franklin, Anderson, Woodford, and Lexington-Fayette Urban counties, at the proposed booster station site in Shelby County, and at the proposed booster station and retention basin sites in Woodford County

(the "Facilities"); and

WHEREAS, we, the undersigned, have agreed to release any and all claims and liens which the undersigned has, or might have, against OWNER, or said Facilities by reason of services, labor, materials and equipment performed or furnished by us in connection with the Project;

NOW THESE PRESENTS WITNESS that the undersigned, in consideration of the premises herein, and of the sum of One Dollar ($1.00) in hand paid by OWNER, at and before the sealing and delivery hereof, the receipt and sufficiency of which are hereby acknowledged, remises, releases and forever quitclaims, and by these presents does remise, release and forever quitclaim, unto OWNER, its successors and assigns, any and all manner of liens, claims and/or demands whatsoever which the undersigned now has, or might or could have, on or against the Facilities, or OWNER for work done, for services performed or furnished or for equipment or materials furnished in connection with the Project installation. It is the intent of this Release that OWNER, its successors and assigns, shall and may hold, have, use and enjoy the Facilities free and discharged from all liens and demands whatsoever which the undersigned now has, or might or could have, against the same if these presents had not been made.

IN WITNESS WHEREOF, the undersigned has hereunto set its hand and seal as of the _____ day of _______________, 19___ written.

(SEAL)

____
ENGINEER

Dated: ____________________________ By: ______________________________________

Title: ___________________________________

I, ____________________, duly authorized representative of _____________________, designated as ENGINEER in the above-referenced agreement, do hereby state that the parties whose names are signed to the attached releases, Documents 1 through _____, are all of the parties who have performed or furnished labor, services, materials, or equipment in connection with the construction of the Facilities mentioned above, excepting only such materials as may have been furnished by OWNER.

Dated: ____________________________ ____
Duly Authorized

Sworn to and subscribed before me, a Notary Public, this _____ day of _____________, 19___.

(SEAL)

____
Notary Public

SUBCONTRACTOR's OR SUBCONSULTANT's
RELEASE OF LIENS AND CLAIMS

WHEREAS, the undersigned, has installed or performed or furnished labor, services, materials and/or equipment for the installation of the Project entitled the Bluegrass Water Project, (the "Project"), installed pursuant to a written agreement dated April 1, 1998, between the undersigned, as "ENGINEER", and Kentucky-American Water Company, having an office at 2300 Richmond Road, Lexington, KY 40502, hereinafter called OWNER, at or on real estate owned by OWNER and described and located as follows:

Along the proposed pipeline route in Shelby, Franklin, Anderson, Woodford, and Lexington-Fayette Urban counties, at the proposed booster station site in Shelby County, and at the proposed booster station and retention basin sites in Woodford County

WHEREAS, the undersigned, has agreed to release any and all claims and liens which the undersigned has, or might have, against OWNER or Facilities by reason of the services, labor, materials and equipment performed or furnished by the undersigned in connection with the Project;

NOW THESE PRESENTS WITNESS that the undersigned, in consideration of the premises herein, and of the sum of One Dollar ($1.00) in hand paid by OWNER, at and before the sealing and delivery hereof, (the receipt and sufficiency of which are hereby acknowledged), have remises, releases and forever quitclaims, and by these presents do remise, release and forever quitclaim, unto OWNER, its successors and assigns, any and all manner of liens, claims and/or demands whatsoever which the undersigned now has, or might or could have, on or against the Facilities, or OWNER for work done, for services performed or furnished or for equipment or materials furnished in connection with the Project installation. It is the intent of this Release that OWNER, its successors and assigns shall and may hold, have, use and enjoy the Facilities free and discharged from all liens and demands whatsoever which the undersigned now has, or might or could have against the same if these presents had not been made.

IN WITNESS WHEREOF, the undersigned has hereunto set its hand and seal as of the ________ day of _______________, 19____ written.

(SEAL)

____
(Company Name)

Dated: [ ] By: _________________________________

Title: _________________________________

Sworn to and subscribed before me, a Notary Public, this ________ day of ______________________, 19___.

(SEAL)

____
Notary Public

2/6/98 Ky-Am Meeting

- Draft contract from 1992 being reworked and will be forwarded to us for review within a few weeks. Target for completion: April 1, 1998.
- Design Consultant
  - > RFP is only for their part.
  - > letter of understanding btw. John & Roy which will start the timeclock; will cover the intent of Ky-American and the understanding of financial responsibilities.

- LWC Players
  - > Legal & Financial → Bob Miller (LWCo)
  - > Engineering side → Greg & Karen (LWCo.)

- Ky-Am. Players
  - > Coleman Bush - Financial (Ky-Am.)

- Design Consultant
  - > Ky-Am. to put out RFP for their portion.
  - > LWCo. to either negotiate w/ Ky-Am. consultant or could do in-house, or select our own consultant

- Primary Goal: Most cost effective means of building the project.

Route

- U.S. 60 → Eastwood → R.R. → Shelby Co.

LWC is o.k. w/ general alignment; however there is a trade-off:

No pump: U.S. 60; commercial corridor / more easements

Pump: Pipeline; less development.

Hydraulics: 830 HGL — Primary Route: U.S. 60

Critical elev. 770 — Secondary Route: Pipeline

Tank

- Not feasible to build; would have to be approx. 200' tall at county line and U.S. 60.

- Buffer; intent of the tank was to act as a buffer btw. the 2 systems.

- Surge
  - > power failure scenario; surge tanks to be in pump station.
  - > Ky-Am to include surge analysis for ~~the~~ LWC side.

Consultant 2/17 out the door, 3/19 RFP back

1. general o.k. & review of RFP.
2. touch base in 1 wk. about hydraulic feasibility
3. Firm commitment 3/15.
4. Award contract 4/1

- Have 5 consultants selected, will fax page of consultants

Coordination of Design Work

- Provide status of design work to Ky-Am. & back to LWC.
- Ky-Am has a need to review scope changes from LWC prior to change occurs — GCH o.k.
-

Open records — use caution in what is kept.

Metering

- Prefer pumping, storage & metering to be at one location in a perfect world.
- Tentative location of pump station — along I-64 into Shelby Co. approx 2,000 ft.
- Objective of pump station
  - > maximize recovery through PSC
  - > BPS operations.
- LWC would prefer pumping & metering to be in same location
- LWC to own up to 1st booster telemetry
- Controls at Booster Station; full set-up back to ~~BER~~ English stn. Reservoir (Ky-Am.); telemetry then ~~[illegible]~~

LWC already sends back to BEP & CHFP.

Schedule of Completion

In RFP.

- > Ky-Am needs KDOW approval, design compl. 10/1/98.
- > File for certificate on Dec. 1st, 1998
- > bids rec'd April ~~March~~ 1, 1999 (advertise Jan. 15, 1999)
- > PSC hearing June 1, 1999.
- > LWC would not have to bid prior to Ky-Am bid; we will provide a NTE value
- > Construction start 9/1/99 - 12/99
- > In service March - June 2001

Water Quality

- > corrosion inhibitor; non-zinc based inhibitor
- > Ky-Am needs better info. on Cl_2 residual.
- * > Review table and fill in the blanks.
- > Contract language - guarantee; Meet or exceed all regulations by KDOW
- > Ky-Am wants 2 ppm at Lexington.
- > Free ammonia residual;

- > Ky-Am to give min./max. for any WQ ~~[illegible]~~ parameters.

Material Alternatives

- RFP references D.I., but contract to be 3 diff. materials: 1) steel, 2) PCCP & 3) DI.
- LWC takes care of our section, Ky-Am takes care of their section.

- Get back w/ Dave Reves.
  Send e-mail DReves@AmWater.com

absolute confirm. 3/15.

KW. call Sandy
Max. HG } ~~HSWD & NSWD~~
O.F. for tanks }

Cost Scenarios

#1 60" ES → 36" I64 to (Veechdale exit)

#2 60" ES → 36" I64 to Jeff Cty

+ P.S. #3 36" ES → U.S. 60 → R.R. → Clark Str → Co. line

+ 2 M. Tank #4. 36" ES → U.S. 60 → Veechdale → (I-64) Same endpt.

48" 50 MGD 175 psi Floyds Fork 1010 discharge 930 tank @ Simpsonville
42" 33 MGD

Flow curve for 48, 42, 36

Ky-American

1. Confirm easement consultant (GRW/Quest?)
   Get copy of proposal.

2. Assemble critical path for LWC (MS Project)
   - Have one month lag from this contract, and receive bids by April 1, 1999.
   - Easement acquis., design, construction
   - Critical dates; bid, in-service.

3. Future hydraulic model. (over next couple of months)

4. Power supply David Guy 627-3529
   - 4160 - 3 phase availability.
   - ✓ get w/ Kent about a contact for Shelby Co., Jeff. Co. near Middletown

~~5. Clean out file~~

Ky-Am 3/9/98.

1. determine what is meant by "design" on LWC's part

From: Greg Heitzman / THRD4
To: Karen Willis / THRD
Subject: Bluegrass Water Supply Project

===NOTE===============4/03/98==5:25pm==
I reviewed Alan's memo on the 36", 42", 48" supply. The attached profile graph didn't make much sense to me. It appeared to be data on the 36" main at 23 MGD.

Basically I need 3 profiles showing pressure, elevation, hyd grade, from English Station to Shelbyvill: one for 36", 42", 48".

See if Alan can assemble these profiles, then you, Alan and I meet next week, after WSWD/Clark Station mtg to discuss. From the graph I have it appears we need to draft a letter to K-A advising that our analysis indicates 23 MGD by gravity in 36" main from Engl Station 840 grade will cause pressure to drop below 40 psi along the route, and pumping in Jefferson County may be required to avoid impact on exising customers.

LOUISVILLE WATER COMPANY
MEMORANDUM

To: Karen Willis

From: Alan Arbuckle

Date: April 15, 1998

Re: Kentucky-American Water Company Service

The attached graphs are the hydraulic grade and static pressure profiles for the proposed Kentucky-American Water Company service. Assumptions were:

- English Station/US 60/Railroad/Conner Station/Natural Gas Pipeline route from the English Station Reservoir to the City of Shelbyville.
- Installation of a 36-inch, 42-inch or 48-inch transmission main along entire route.
- For the graph that does not include a pump station, the initial hydraulic grade is 840 feet at the English Station Reservoir.
- For the graph that does include a pump station, the initial hydraulic grade at the discharge of the proposed pumping facility is 940.67 feet (840.00 feet + 100.67 feet).
- Elevations were obtained from LOJIC data at 100-foot spacings within Jefferson County and from USGS maps for areas within Shelby County.
- Flow of 23.0 MGD in the transmission main.

The pumping facility head was determined by finding the lowest pressure that occurred without a pump station for the 48-inch transmission main (-3.58 psi) and calculating pressure needed to obtain 40 psi at that location (43.58 psi or 100.67 feet). On the graph with the pump station, the other two main sizes will have areas of pressure below 40 psi since higher pump station heads are required to obtain 40 psi. These head values are 117.26 feet for the 42-inch main and 204.76 feet for the 36-inch main. Discharge grade needed at the proposed pump station to obtain 40 psi is 957.26 feet for the 42-inch main and 1044.76 feet for the 36-inch main.

The charts appear busy. Each graph includes three pressure curves, three HGL curves and one elevation curve. The pressure and HGL curves for each main size are the same color to improve interpretation.

From: Karen Willis / THRD
To: Alan Arbuckle / THRD
Subject: fwd: KY-AM HGL

===NOTE===============4/17/98==2:41pm==
Received what you sent over - thank you very much for the extra effort on this. Hopefully GCH will like it too.

Ky-American is asking to see this profile, but I don't want to send them the entire thing. Can you modify the profile back to the very 1st one you did, where it only shows the 36-inch main, no ground elevation line or flow curves? The one that I had that you did originally I marked on, so I just really need another copy of it.

If you have any questions, leave me a voice mail message. I'll be out most of next week with the annual inspection. Thanks.

Fwd=by:=Alan=Arbuckle==================
Fwd to: Karen Willis / THRD

....
Yes, I will place in your in-box today. Your welcome, I enjoyed doing it.

04/20/98

KY-AM HGL/Ps Profiles, please let me know if you have q's.

Al

3609

LOUISVILLE WATER COMPANY

435 SOUTH THIRD STREET · LOUISVILLE, KENTUCKY 40202

TEL 502-569-3600 FAX 502-585-2806

JOHN L. HUBER
PRESIDENT

4/20/98

Ms. Linda Bridwell
Kentucky American Water Works Company
2300 Richmond Road
Lexington, KY 40502

Dear Ms. Bridwell:

Please find enclosed a graphic showing the estimated static pressure and hydraulic grade line for the proposed transmission main route. The route begins at the LWC's English Station Reservoir and ends at Veechdale, Kentucky. Please forward to Mr. Dave Reeves.

Sincerely,

Alan N. Arbuckle. P.E.
Long Range Planning and Capital Improvements
Enclosure (1)

ana
cc: Ms. Karen Willis