SECTION 01570

TRAFFIC REGULATION

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Construction parking control.

B. Flagmen.

C. Flares and lights.

D. Haul routes.

E. Removal.

1.02 RELATED SECTIONS

A. Section 00710 - General Conditions

B. Section 01530 - Barriers

PART 2 - PRODUCTS

2.01 SIGNS AND DEVICES

A. Traffic Cones and Drums, Flares and Lights: as approved by federal, state, and local jurisdictions, and as required by 3.02 Traffic Control in this section.

B. Flagman Equipment: as required by federal, state, and local jurisdictions, and as required by 3.02 Traffic Control in this section.

PART 3 - EXECUTION

3.01 CONSTRUCTION PARKING CONTROL

A. Control vehicular parking to prevent interference with public traffic and parking, access by emergency vehicles and Owner's operations.

B. Monitor parking of construction personnel's vehicles in existing facilities. Maintain vehicular access to and through parking areas.

C. Prevent parking on or adjacent to access roads or in non-designated areas.

3.02 TRAFFIC CONTROL

A. The temporary construction access entrance from U.S. 42 has limited sight distance. The Contractor shall provide a Certified Traffic Control Plan to be submitted and approved by District 5 of the Kentucky Transportation Cabinet. This plan must be prepared by a Certified Traffic Control Planner, and it will include all necessary signage and safety equipment. The presence of radio-coordinated Certified Traffic Control Technicians shall be mandatory during all entrances from, and all exits to, U.S. 42.

B. Whenever and wherever, in the Engineer's opinion, traffic is sufficiently congested or public safety is endangered, Contractor shall furnish uniformed officers to direct traffic and to keep traffic off the highway area affected by construction operations.

B. Contractor shall abide by all county and state regulations governing utility construction Work.

C. Traffic control shall be provided according to the Kentucky Department of Highways Manual on Uniform Traffic Control Devices for Streets and Highways.

3.03 FLAGMEN

Radio-coordinated Certified Traffic Control Technicians will be mandatory, and no use of the temporary access for entrance to or exit from the site will be allowed otherwise.

3.04 FLARES AND LIGHTS

Use flares and lights during hours of low visibility to delineate traffic lanes and to guide traffic.

3.05 HAUL ROUTES

A. Consult with authorities, establish public thoroughfares to be used for haul routes and site access.

B. Confine construction traffic to designated haul routes.

C. Provide traffic control at critical areas of haul routes to regulate traffic and minimize interference with public traffic.

3.06 REMOVAL

Remove equipment and devices when no longer required.

- END OF SECTION -

SECTION 01580

PROJECT IDENTIFICATION AND SIGNS

PART 1 - GENERAL

1.01 SCOPE OF WORK

The Contractor shall provide signs near the site of the Work. The sign shall set forth the description of the Work and the names of the Owner, Engineer, and Contractor.

1.02 RELATED SECTIONS

Section 00710 - General Conditions.

PART 2 - PRODUCTS

2.01 IDENTIFICATION SIGN (4' x 8')

A. Basic design shall be as required by the Engineer per the attached Drawing.

B. Colors shall be as selected by the Engineer.

C. Number Required: three (3)

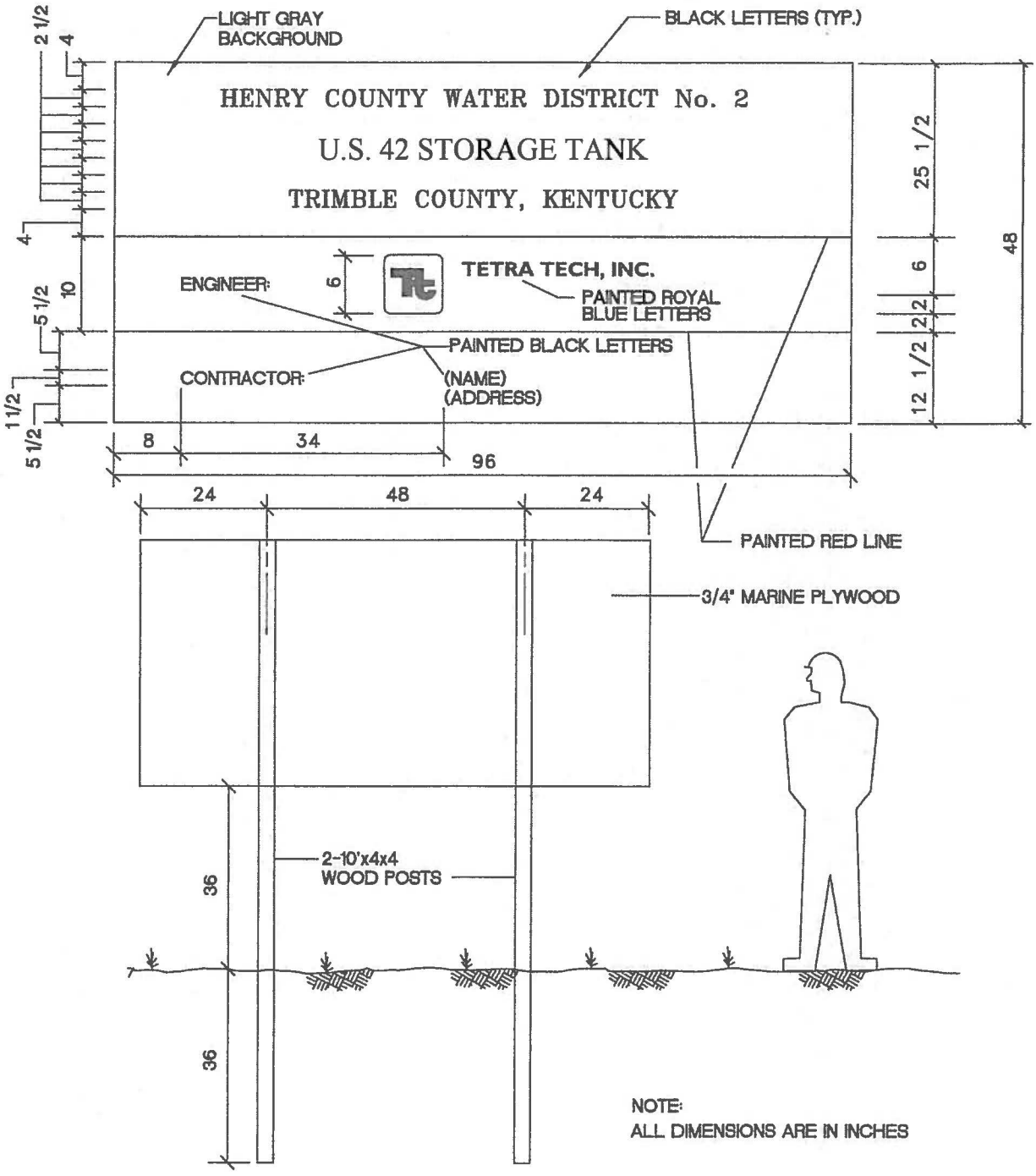
PART 3 - EXECUTION

3.01 INSTALLATIONS

Signs shall be installed at locations specified by the Engineer.

3.02 MAINTENANCE

The signs shall be maintained in good condition until the completion of the project.



CONSTRUCTION SIGN DETAIL

NOT TO SCALE

- END OF SECTION -

SECTION 01590

FIELD OFFICES AND SHEDS

PART 1 - GENERAL

1.01 CONTRACTOR'S FIELD OFFICE

Contractor shall establish and maintain a field office on this project and have available at the office a responsible representative who can officially receive communications from the Engineer. The Contractor shall have one (1) complete, up-to-date set of Drawings, Specifications, and Contract Documents (including all Addenda and Change Orders) in this office at all times, available for reference at any time. The office shall be provided with telephone service, toilet facilities, light, air conditioning, and heat; the cost of which shall be borne by the Contractor. Notices, instructions, orders, directions, or other communications from the Engineer, left at this office, shall be considered as received by the Contractor. Contractor shall pay for all permits that may be required. Contractor shall remove field office and storage facilities upon Final Completion, unless otherwise directed by Owner or Engineer.

1.02 RESIDENT REPRESENTATIVE'S FIELD OFFICE

A. Contractor shall establish and maintain a separate field office trailer (400 square feet of floor space minimum) for the resident representative on this project. The office shall be provided with telephone service, toilet facilities, light, air conditioning, and heat; the cost of which shall be borne by the Contractor. The Contractor shall provide:

1. One (1) plan table approximately 3' x 5' with smooth top and appropriate swivel chair.
2. Two (2) additional chairs.
3. Electric lights and outlets as directed.
4. One (1) desk for general office use with appropriate chair.
5. One (1) plan rack.
6. Two (2) four-drawer letter-size metal filing cabinets with a lock.
7. One (1) trash can (25 gallon).
8. One (1) OSHA approved first aid kit.
9. Fire extinguishers and smoke detectors as required by the State and Local building code.
10. Provide connection to internet service provider with monthly fee paid by Contractor. Internet service shall be via broadband (including DSL) if available in area.

11. Twelve (12) folding chairs and a folding table capable of seating eight (8) people comfortably.

B. Contractor shall broom and mop field office at least once per week.

C. Contractor shall provide continuous maintenance of office and services. Maintenance shall be for the duration of the Contract.

D. Contractor shall remove office upon Final Completion, unless otherwise directed by Owner or Engineer.

E. Contractor shall pay for all permits that may be required.

- END OF SECTION -

SECTION 01600

MATERIAL AND EQUIPMENT

PART 1 - GENERAL

1.01 STORAGE OF MATERIALS AND EQUIPMENT

All excavated materials and equipment to be incorporated in the Work shall be placed so as not to injure any part of the Work or existing facilities and so that free access can be had at all times to all parts of the Work and to all public utility installations in the vicinity of the Work. Materials and equipment shall be kept neatly piled and compactly stored in such locations as will cause a minimum of inconvenience to public travel and adjoining owners, tenants, and occupants.

1.02 HANDLING AND DISTRIBUTION

A. The Contractor shall handle, haul, and distribute all materials and all surplus materials on the different portions of the Work, as necessary or required; shall provide suitable and adequate storage room for materials and equipment during the progress of the Work, and be responsible for the protection, loss of, or damage to materials and equipment furnished by him, until the final completion and acceptance of the Work.

B. Storage and demurrage charges by transportation companies and vendors shall be borne by the Contractor.

1.03 MATERIALS, SAMPLES, INSPECTION

A. Unless otherwise expressly provided on the Drawings or in any of the other Contract Documents, only new materials and equipment shall be incorporated in the Work. All materials and equipment furnished by the Contractor to be incorporated in the Work shall be subject to the inspection of the Engineer. No material shall be processed or fabricated for the Work or delivered to the Work site without prior concurrence of the Engineer.

B. As soon as possible after execution of the Agreement, the Contractor shall submit to the Engineer the names and addresses of the manufacturers and suppliers of all materials and equipment he proposes to incorporate into the Work. When shop and working Drawings are required as specified below, the Contractor shall submit prior to the submission of such Drawings, data in sufficient detail to enable the Engineer to determine whether the manufacturer and/or the supplier have the ability to furnish a product meeting the Specification. As requested, the Contractor shall also submit data relating to the materials and equipment he proposes to incorporate into the Work in sufficient detail to enable the Engineer to identify and evaluate the particular product and to determine whether it conforms to the Contract requirements. Such data shall be submitted in a manner similar to that specified for submission of shop and working Drawings.

C. Facilities and labor for the storage, handling, and inspection of all materials and equipment shall be furnished by the Contractor. Defective materials and equipment shall be removed immediately from the site of the Work.

D. If the Engineer so requires, either prior to or after commencement of the Work, the Contractor shall submit samples of materials for such special tests as the Engineer deems necessary to demonstrate that they conform to the Specifications. Such samples, including concrete test cylinders, shall be furnished, taken, stored, packed, and shipped by the Contractor as directed. The Contractor shall furnish suitable molds for making concrete test cylinders. Except as otherwise expressly specified, the Owner shall make arrangements for, and pay for, the tests.

E. All samples shall be packed so as to reach their destination in good condition, and shall be labeled to indicate the material represented, the name of the building or work and location for which the material is intended, and the name of the Contractor submitting the sample. To ensure consideration of samples, the Contractor shall notify the Engineer by letter that the samples have been shipped and shall properly describe the samples in the letter. The letter of notification shall be sent separate from and should not be enclosed with the samples.

F. The Contractor shall submit data and samples, or place his orders, sufficiently early to permit consideration, inspection, and testing before the materials and equipment are needed for incorporation in the Work. The consequences of his failure to do so shall be the Contractor's sole responsibility.

G. When required, the Contractor shall furnish to the Engineer triplicate sworn copies of manufacturer's shop or mill tests (or reports from independent testing laboratories) relative to materials, equipment performance ratings, and concrete data.

H. After review of the samples, data, etc., the materials and equipment used on the Work shall in all respects conform therewith.

- END OF SECTION -

SECTION 01615

STORAGE

PART 1 - GENERAL

1.01 REQUIREMENTS INCLUDED

A. General Storage

B. Enclosed Storage

C. Exterior Storage

D. Maintenance of Storage

1.02 RELATED REQUIREMENTS

Division 1 - General Requirements

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.01 GENERAL STORAGE

A. Store products, immediately on delivery, in accordance with manufacturer's instructions, with seals and labels intact. Protect until installed.

B. Arrange storage in a manner to provide access for maintenance of stored items and for inspection.

3.02 ENCLOSED STORAGE

A. Store products, subject to damage by the elements, in substantial weather-tight enclosures.

B. Maintain temperature and humidity within ranges stated in manufacturer's instructions.

C. Provide humidity control and ventilation for sensitive products as required by manufacturer's instructions.

D. Store unpacked and loose products on shelves, in bins, or in neat groups of like items.

3.03 EXTERIOR STORAGE

A. Provide substantial platforms, blocking, or skids, to support fabricated products above ground; slope to provide drainage. Protect products from soiling and staining.

B. For products subject to discoloration or deterioration from exposure to the elements, cover with impervious sheet material. Provide ventilation to avoid condensation.

C. Store loose granular materials on clean, solid surfaces such as pavement, or on rigid sheet materials, to prevent erosion and ponding of water.

D. Provide surface drainage to prevent erosion and ponding of water.

E. Prevent mixing of refuse or chemically injurious materials.

3.04 MAINTENANCE OF STORAGE

A. Regularly inspect stored products on a scheduled basis. Maintain a log of inspections, make available to Engineer on request.

B. Verify that storage facilities comply with manufacturer's product storage requirements.

C. Verify that manufacturer required environmental conditions are maintained continually.

D. Verify that surfaces of products exposed to the elements are not adversely affected; that any weathering of finishes is acceptable under requirements of Contract Documents.

3.05 MAINTENANCE OF EQUIPMENT STORAGE

A. For mechanical and electrical equipment in long-term storage, provide manufacturer's service instructions to accompany each item, with notice of enclosed instructions shown on exterior of package.

B. Service equipment on a regularly scheduled basis, in accordance with the manufacturer's recommendations, maintaining a log of services; submit as a record document.

- END OF SECTION -

SECTION 01700

CONTRACT CLOSEOUT

PART 1 - GENERAL

1.01 RELATED REQUIREMENTS

A. Section 01710 – Cleaning/Final Cleaning

B. Section 01720 - Project Record Documents

1.02 SUBSTANTIAL COMPLETION

A. Contractor shall submit written certification to Engineer that project is substantially complete and includes a list of major items to be completed or corrected.

B. Engineer will make an inspection within fourteen (14) days after receipt of certification, together with the Owner's representative.

C. Should Engineer consider that work is substantially complete:

1. Engineer will prepare and issue a certificate of substantial completion, containing:

   a. Date of substantial completion.

   b. Contractor's list of items to be completed or corrected, verified, and amended by Engineer.

   c. The time within which Contractor shall complete or correct work of listed items.

2. Contractor shall complete work listed for completion or correction, within designated time.

D. Should Engineer consider that work is <u>not</u> substantially complete:

1. He shall immediately notify Contractor, in writing, stating reasons.

2. Contractor shall complete work, and send second written notice to Engineer, certifying that project, or designated portion of project is substantially complete.

3. Engineer will re-review work.

1.03 FINAL INSPECTION

A. Contractor shall submit written certification that:

1. Contract Documents have been reviewed.

2. Project has been inspected for compliance with Contract Documents.

3. Work has been completed in accordance with Contract Documents.

4. Equipment and systems have been tested in presence of Owner's representative and are operational.

5. Project is completed and ready for final inspection.

B. Engineer will make final on-site observation/review within fourteen (14) days after receipt of certification.

C. Should Engineer consider that work is finally complete in accordance with requirements of Contract Documents, he shall request Contractor to make Contract closeout submittals.

D. Should Engineer consider that work is <u>not</u> finally complete:

1. He shall notify Contractor, in writing, stating reasons.

2. Contractor shall take immediate steps to remedy the stated deficiencies, and send second written notice to Engineer certifying that work is complete.

3. Engineer will re-review the work.

1.04 FINAL CLEANING UP

The work will not be considered as completed and final payment made until all final cleaning up has been done by the Contractor in a manner satisfactory to the Engineer. See Section 01710 for detailed requirements.

1.05 CLOSEOUT SUBMITTALS

A. Project Record Documents: in accordance with Section 01720.

B. Operation and Maintenance Data: in accordance with particular technical specifications and Section 01730.

C. Guarantees, Warranties, and Bonds: in accordance with particular technical specifications and Section 01740.

1.06 INSTRUCTION

Instruct Owner's personnel in operation of all systems, mechanical, electrical, and other equipment.

1.07 FINAL APPLICATION FOR PAYMENT

Contractor shall submit final applications in accordance with requirements of general conditions.

1.08 FINAL CERTIFICATE FOR PAYMENT

A. Engineer will issue final certificate in accordance with provisions of general conditions.

B. Should final completion be materially delayed through no fault of Contractor, Engineer may issue a semi-final certificate for payment.

- END OF SECTION -

SECTION 01710

CLEANING/FINAL CLEANING

PART 1 - GENERAL

1.01 WORK INCLUDED

A. On a continuous basis, maintain premises free from accumulations of waste, debris, and rubbish, caused by operations.

B. At completion of work, remove waste materials, rubbish, tools, equipment, machinery, and surplus materials, and clean all sight-exposed surfaces; leave project clean and ready for occupancy.

1.02 RELATED REQUIREMENTS

A. Section 01700 - Contract Closeout

B. Cleaning for Specific Products or Work: Specification section for that work.

1.03 SAFETY REQUIREMENTS

A. Hazards Control

1. Store volatile wastes in covered metal containers, and remove from premises daily.

2. Prevent accumulation of wastes which create hazardous conditions.

3. Provide adequate ventilation during use of volatile or noxious substances.

B. Conduct cleaning and disposal operations to comply with local ordinances and anti-pollution laws.

1. Do not burn or bury rubbish and waste materials on project site without written permission from the Owner.

2. Do not dispose of volatile wastes such as mineral spirits, oil, or paint thinner in storm or sanitary drains.

3. Do not dispose of wastes into streams or waterways.

PART 2 - PRODUCTS

2.01 MATERIALS

Use only cleaning materials recommended by manufacturer of surface to be cleaned.

PART 3 - EXECUTION

3.01 DURING CONSTRUCTION

A. Execute cleaning to ensure that building, grounds, and public properties are maintained free from accumulations of waste materials and rubbish.

B. Maintain public roads and all paved surfaces free from mud, dirt or other debris. Contractor shall have on-site mechanical broom to keep these areas cleaned daily (minimum) or as needed.

C. Wet down dry materials and rubbish to allay dust and prevent blowing dust.

D. At reasonable intervals during progress of work, clean site and public properties, and dispose of waste materials, debris, and rubbish.

E. Provide on-site containers for collection of waste materials, debris, and rubbish.

F. Remove waste materials, debris, and rubbish from site and legally dispose of at public or private dumping areas off Owner's property.

G. Handle materials in a controlled manner with as few handlings as possible; do not drop or throw materials from heights.

H. The Contractor shall thoroughly clean all materials and equipment installed.

3.02 FINAL CLEANING

A. This work consists of the final site clean-up prior to Contractor demobilization. Subsequent to completion of the work, the Contractor shall clean up the entire site to remove all loose trash, debris, and vestiges of his work. The Contractor shall clean up all areas he has worked or used for staging and/or storage. A site walkover shall be conducted by the Engineer and Contractor. All trash, debris, and other materials shall be removed so to leave the site in a better condition than existing prior to commencement of the work.

B. Employ experienced workmen, or professional cleaners as needed, for final cleaning.

C. In preparation for substantial completion, conduct final inspection of sight-exposed interior and exterior surface, and of concealed spaces.

D. Repair, patch, and touch up marred surfaces to specified finish, to match adjacent surfaces.

E. Broom clean paved surfaces; rake clean other surfaces of grounds.

F. Maintain cleaning until project, or portion thereof, is occupied by Owner.

G. The Contractor shall restore or replace existing property or structures as promptly and practicable as work progresses.

- END OF SECTION -

SECTION 01720

PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.01 RELATED SECTIONS

A. General Conditions

B. Section 01050 – Surveying

B. Section 01300 – Submittals

1.02 MAINTENANCE OF DOCUMENTS

A. Maintain at job site, one copy of:

1. Contract Drawings;
2. Specifications;
3. Addenda;
4. Reviewed Shop Drawings;
5. Change Orders; and
6. Other modifications to Contract.

B. Store documents in approved location, apart from documents used for construction.

C. Provide files and racks for storage of documents.

D. Maintain documents in clean, dry, legible condition.

E. Do not use record documents for construction purposes.

F. Make documents available at all times for inspection by Engineer and Owner.

1.03 MARKING DEVICES

Provide colored pencil or felt-tip marking pen for all marking.

1.04 RECORDING

A. Label each document "PROJECT RECORD" in 2-inch high printed letters.

B. Keep record documents current.

C. Do not permanently conceal any work until required information has been recorded.

D. Contract Drawings: legibly mark to record actual construction:

1. Horizontal and vertical location of underground utilities and appurtenances referenced to permanent surface improvements.

2. Location of internal utilities and appurtenances concealed in construction referenced to visible and accessible features of structure.

3. Field changes of dimension and detail.

4. Changes made by Change Order or field order.

5. Details not on original Contract Drawings.

E. Specifications and Addenda: legibly mark up each section to record:

1. Manufacturer, trade name, catalog number, and supplier of each product and item of equipment actually installed.

2. Changes made by Change Order or field order.

3. Other matters not originally specified.

F. Shop Drawings: Maintain as record documents; legibly annotate Shop Drawings to record changes made after review.

1.05 SUBMITTAL

A. At completion of project, deliver record documents to Engineer.

B. Accompany submittal with transmittal letter, in duplicate, containing:

1. Date;

2. Project title and Contract number;

3. Contractor's name and address;

4. Title and sheet number of each record document;

5. Certification that each document as submitted is complete and accurate;

6. Signature of Contractor or his authorized representative.

- END OF SECTION -

SECTION 01730

OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Compile product data and related information appropriate for Owner's maintenance and operation of equipment furnished under the Contract. Prepare operation and maintenance data as specified.

B. Instruct Owner's personnel in the maintenance and operation of equipment and systems.

C. In addition to maintenance and operations data, the manufacturer's printed recommended installation practice shall also be included. If not part of the operations and maintenance manual, separate written installation instructions shall be provided, serving to assist the Contractor in equipment installation.

1.02 RELATED REQUIREMENTS

A. Section 01300 - Submittals

B. General Conditions

1.03 OPERATION AND MAINTENANCE MANUAL

A. Every piece of equipment furnished and installed shall be provided with complete operation and maintenance manual. These shall be detailed in instructions to the Owner's personnel. They shall be attractively bound for the Owner's records.

B. The manuals shall be submitted to the Engineer for review as to adequacy and completeness. Provide six (6) copies each.

1.04 FORM OF SUBMITTALS

A. Prepare data in the form of an instructional manual for use by Owner's personnel.

B. Format

1. Paper Size: 8½" x 11"
2. Data: Manufacturer's printed data, or neatly typewritten.

3. Drawings:

(a) Provide reinforced punched binder tab, bind with text.

(b) Fold large drawings to the size of the data pages where feasible.

(c) For flow or piping diagrams that cannot be detailed on the standard size drawings, a larger, appropriate size drawing may be submitted.

4. Provide tab sheet for each separate product, or each piece of operating equipment.

(a) Provide typed description of product, and major component parts of equipment.

(b) Provide indexed tabs.

5. Cover: Identify each volume with types or printed title "OPERATION AND MAINTENANCE MANUAL". List:

(a) Title of project.

(b) Identity separate equipment as applicable.

(c) Identify general subject matter covered in the manual.

C. Binders

1. Commercial quality, durable and cleanable, 3-hole, 3-inch or 4-inch post type binders with oil and moisture resistant hard covers.

2. When multiple binders are used, correlate the data into related consistent grouping.

3. Labeled on the front cover and side of each binder shall be the name of the Plant, the Contractor Number and Volume Number.

1.05 CONTENT OF MANUAL

A. Neatly typewritten table of contents for each volume, arranged in systematic order.

1. Contractor, name of responsible principal, address and telephone number.

2. A list of each equipment required to be included, indexed to the content of the volume.

3. List, with each equipment, the name, address and telephone number of:

(a) Supplier of equipment.

(b) Subcontractor or installer.

(c) Maintenance contractor, as appropriate.

(d) Identify the area of responsibility of each.

(e) Local source of supply for parts and replacement.

4. Identify each product by product name and other identifying symbols as set forth in Contract Documents.

B. Equipment Data

1. Include only those sheets which are pertinent to the specific equipment. References to other sizes and type or models of similar equipment shall be deleted or lined out.

2. Annotate each sheet to:

(a) Clearly identify the specific equipment or part installed.

(b) Clearly identify the data applicable to the installation.

(c) Provide a parts list for all new equipment items, with catalog numbers and other data necessary for ordering replacement parts.

(d) Delete references to inapplicable information.

3. Clear and concise instructions for the operation, adjustment, lubrication, and other maintenance of the equipment, including a lubrication chart.

C. Drawings

1. Supplement equipment data with drawings as necessary to clearly illustrate:

(a) Relations of component parts of equipment and systems.

(b) Control and flow diagrams.

2. Coordinate drawings with information in project record documents to assure correct illustration of completed installation.

3. Do not use project record documents as maintenance drawings.

D. Written text, as required to supplement equipment data for the particular installation:

1. Organize in a consistent format under separate headings for different procedures.

2. Provide a logical sequence of instructions for each procedure.

E. Copy of each warranty, bond, and service contract issued: Provide information sheet for Owner's personnel.

1. Proper procedures in the event of failure.

2. Instances which might affect the validity of warranties or bonds.

F. These manuals shall be delivered to the Engineer at the same time that the equipment to which it pertains is delivered at the site. The manuals must be approved by the Engineer before final payment on the equipment is made.

1.06 MAINTENANCE AND LUBRICATION SCHEDULES

The Contractor's attention is directed to the general conditions and Section 01300 for all requirements relative to the submission of shop drawings for the mechanical equipment. For all mechanical and electrical equipment furnished, the Contractor shall provide a list including the equipment name, and address and telephone number of the manufacturer's representative and service company so that service and/or spare parts can be readily obtained. In addition, a maintenance and lubrication schedule for each piece of equipment shall be submitted along with shop drawings. Submission shall be in six (6) copies. The lubrication schedule shall include the types of lubricant required for each schedule item.

- END OF SECTION -

SECTION 01740

WARRANTIES AND BONDS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Compile specified warranties and bonds.

B. Compile specified service and maintenance contracts.

C. Co-execute submittals when required.

D. Review submittals to verify compliance with Contract Documents.

1.02 RELATED REQUIREMENTS

A. Bid Bond

B. Performance and Payment Bonds

C. Guaranty

D. General Warranty of Construction

E. Warranties and bonds required for specific products: as listed in other Specification sections.

1.03 EXECUTION OF BONDS

A. Performance and Payment Bonds shall be executed and in full effect at the same time as the Agreements are executed.

B. Warranty Bond shall be issued with final application for payment and effective the date of Substantial Completion.

1.04 WARRANTY BONDS OR CORPORATE GUARANTEES IN LIEU OF EXPERIENCE RECORD

A. When specifically requested in the products and installation general provisions of a Specification section for a particular piece of equipment or product, a record of five (5) years of successful full-scale operation shall be required from the equipment manufacturer. This record of full-scale operation shall be from existing facilities utilizing the equipment or product specified, in an application similar to the application intended for this project.

B. The manufacturer shall certify in writing to the Contractor that it has the required record of successful full-scale operation. This certification shall be submitted by the Contractor with his construction materials and/or equipment data list. In the event the manufacturer cannot provide the five (5) year certification of experience to the Contractor, the Contractor shall furnish within thirty (30) days after the notice of award, a warranty bond of corporation guarantee from the equipment manufacturer written in the name of the Contractor and acceptable to the Owner. The warranty bond or corporate guarantee shall be kept in force for five (5) years from the date of substantial completion of the Contract, less the number of years of experience the manufacturer may be able to certify to the Engineer. As a minimum, the bond or guarantee shall be in force for one (1) year after the date of substantial completion of the Contract. The warranty bond shall be written in an amount equivalent to the manufacturer's quotation, the Contractor's installation cost plus 100 percent (100%). The warranty bond or corporate guarantee will assure the Owner that, if in the judgement of the Engineer, the equipment does not perform its specified function, the Contractor shall remove the equipment and install equipment that will perform the specified function and the work by the Contractor shall be paid for by the warranty bond or corporate guarantee.

1.05 SUBMITTALS REQUIREMENTS

A. Assemble warranties, bonds, and service and maintenance contracts, executed by each of the respective manufacturers, suppliers, and subcontractors.

B. Furnish two (2) original signed copies.

C. Table of Contents: neatly typed, in orderly sequence. Provide complete information for each item:

1. Product, equipment, or Work item.
2. Manufacturer name, address, and telephone number.
3. Supplier name, address, and telephone number.
4. Contractor name, address, and telephone number.
5. Scope.
6. Date of beginning of warranty, bond, or service and maintenance contract.
7. Duration of warranty, bond, or service and maintenance contract.
8. Provide information for Owner's personnel:
    a. Proper procedure in case of failure.
    b. Instances that might affect the validity of warranty or bond.

1.06 FORM OF SUBMITTALS

A. Prepare in duplicate packets.

B. Format

1. Size 8½" x 11", punch sheets for 3-ring binder; fold larger sheets to fit into binders.

2. Cover: identify each packet with typed or printed title "WARRANTIES AND BONDS". List:

a. Title of project.

b. Date of project.

c. Contractor name, address, and telephone number.

C. Binders: commercial quality, 3-ring, with durable and cleanable plastic covers.

1.07 TIME OF SUBMITTALS

A. For equipment or component parts of equipment put into service during progress of construction: submit documents within ten (10) days after inspection and acceptance.

B. Otherwise, make submittals within ten (10) days after date of substantial completion, prior to final request for payment.

C. For items of work, where acceptance is delayed materially beyond the date of substantial completion, provide updated submittal within ten (10) days after acceptance, listing the date of acceptance as the start of the warranty period.

1.08 SUBMITTALS REQUIRED

Submit warranties, bonds, and service and maintenance contracts as specified in the respective sections of the Specifications. Additionally, the Contractor shall warrant the entire Contract, including all concrete, paving, building, plumbing, HVAC, mechanical and electrical equipment to be free from defects in design and installation for one (1) year from the date of startup. In the event a component fails to perform as specified or is proven defective in service during the warranty period, the Contractor shall repair the defect without cost to the Owner.

- END OF SECTION -

SECTION 01750

SPARE PARTS AND MAINTENANCE MATERIALS

PART 1 - GENERAL

1.01 GENERAL

A. Contractor shall furnish spare parts and maintenance materials as specified in the individual Sections.

B. Parts and materials shall be furnished in manufacturers' unopened cartons, boxes, crates, or other protective covering suitable for preventing corrosion or deterioration for the maximum length of storage which may be normally anticipated. They shall be clearly marked and identified as to contents and storage instructions.

C. During construction, store parts in buildings or trailers with floor, roof, and closed sides, and in accordance with manufacturers' recommendations. Protect from weather, condensation, and humidity.

D. Parts and materials shall be delivered to the Owner upon completion of the work or when the Owner assumes occupancy. Contractor shall then place them in permanent storage rooms or areas approved by the Owner.

E. Provide a letter of transmittal including the following:

1. Date of letter and transfer of parts and material,
2. Contract title and number,
3. Contractor's name and address,
4. A complete inventory of the parts and material, listing the applicable Specification Section for each, and
5. A place for the Owner to sign and signify receipt of the parts and materials.

F. Contractor shall be fully responsible for loss or damage to parts and materials until they are transmitted to the Owner.

- END OF SECTION -

DIVISION 2

SITE WORK

SECTION 02110

SITE CLEARING

PART 1 - GENERAL

1.01 SUMMARY

A. Clear site within construction limits of plant life and grass.

B. Remove root system of trees and shrubs.

C. Remove surface debris.

D. Consult with KIPDA and U.S. Fish and Wildlife Service regarding tree removal and preservation of the endangered Indiana Bat.

1.02 REGULATORY COMPLIANCE

Conform to applicable local codes and ordinances for disposal of debris.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 REMOVAL OF EXISTING TREES AND OTHER VEGETATION

A. Reasonable care shall be taken during construction to avoid damage to vegetation. Ornamental shrubbery and tree branches shall be temporarily tied back, where appropriate, to minimize damage. Trees that receive damage to branches shall be trimmed of those branches to improve the appearance of the tree. Tree trunks receiving damage from equipment shall be treated with a tree dressing. The Contractor shall not cut or injure any trees or other vegetation outside right-of-way or easement line and outside areas to be cleared, as indicated on the drawings, without written permission from the Engineer. The Contractor shall be responsible for all damages done outside these lines.

B. The Engineer shall designate which trees are to be removed within permanent and temporary easement lines or right-of-way lines.

3.02 CLEARING

A. From areas to be cleared, the Contractor shall cut or otherwise remove all trees, brush, and other vegetable matter such as snags, bark, and refuse. The ground shall be cleared to the width of the permanent easement or right-of-way unless otherwise directed by the Engineer.

B. Except where clearing is done by uprooting with machinery, trees, stumps, and stubs to be cleared shall be cut as close to the ground surface as practicable, but no more than six (6) inches above the ground surface for small trees and 12 inches for larger trees.

C. Elm bark shall be either buried at least one (1) foot deep or burned in suitable incinerators off site with satisfactory antipollution controls and fire prevention controls, to prevent the spread of Dutch Elm disease and as required by applicable laws.

3.03 GRUBBING

From areas to be grubbed, the Contractor shall remove completely all stumps, remove to a depth of 12 inches all roots larger than 3-inch diameter, and remove to a depth of six (6) inches all roots larger than 1/2-inch diameter. Such depths shall be measured from the existing ground surface or the proposed finished grade, whichever is lower.

3.04 STRIPPING OF TOPSOIL

Prior to starting general excavation, strip topsoil to a depth of six (6) inches or to depths required by the Engineer. Do not strip topsoil in a muddy condition and avoid mixture of subsoil. Stockpile the stripped topsoil within easement or right-of-way lines for use in finish grading and site restoration. Topsoil stockpiled shall be free from trash, brush, stones over two (2) inches in diameter and other extraneous material.

3.05 PROTECTION

A. Protect plant growth and features remaining as final landscaping.

B. Protect bench marks and existing work from damage or displacement.

C. Maintain designated site access for vehicle and pedestrian traffic.

3.06 OPEN BURNING OR CLEARING DEBRIS

A. Natural growth from land clearing may be burned in accordance with the open burning regulations administered by the Kentucky Division for Air Quality and any local regulations. The Kentucky Division for Air Quality regulations may be found at 41 KAR 63:005 and stipulate that extraneous material, such as tires or heavy oil, which tends to produce dense smoke, may not be used to cause ignition or aid combustion. In addition, burning must be done on sunny days with mild winds. Finally, the Contractor must take all necessary precautions to ensure that surrounding areas or structures are not ignited and to follow all fire bulletins issued by the Kentucky Division of Forestry.

B. Burning clearing debris shall be conducted at locations agreed upon by the Owner and Engineer.

C. At a minimum all burning shall be a minimum of 100 feet from the remaining tree line or adjacent structures. The Contractor shall confirm the location for the burning with the Owner and Engineer prior to commencement of the activity.

D. No burning shall occur or will be allowed over the weekend periods.

E. The Contractor shall have personnel on-site continuously monitoring the burn area during burning activities. The Contractor shall have on-site and ready to use appropriate fire suppression equipment.

3.07 DISPOSAL

A. All materials resulting from clearing and grubbing and not scheduled for reuse shall become the property of the Contractor and shall be suitably disposed of off-site, unless otherwise directed by the Engineer, in accordance with all applicable laws, ordinances, rules, and regulations.

B. Such disposal shall be performed as soon as possible after removal of the material and shall not be left until the final period of cleaning up.

- END OF SECTION -

SECTION 02150

SHORING AND UNDERPINNING

PART 1 - GENERAL

1.01 SUMMARY

A. Shore and brace sidewalls in deep excavations with steel sheet, soldier piles or timber lagging as required to protect existing buildings, utilities, roadways, and improvements. Prevent cave-ins, loss of ground, or damage to people and property.

B. Maintain shoring and bracing during construction activities, and remove shoring and bracing if practical when construction and filling is complete.

C. The Contractor is solely responsible for any determination necessary for the proper sizing of shoring and bracing.

1.02 SAFETY

Comply with all federal, state, and local codes and regulations regarding safety. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Sheet Steel: Heavy-gauge steel sheet suitable for service.

B. Soldier Piles: Steel H-beams in serviceable condition.

C. Timber Lagging: Heavy timber pressure treated with wood preservative.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in proper relation with adjacent construction. Coordinate with work of other sections.

B. Locate shoring and bracing to avoid permanent construction. Anchor and brace to prevent collapse.

- END OF SECTION -

SECTION 02211

ROUGH CLEANUP

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Rough (preliminary) Clean-up

On a daily basis, maintain the work area free from accumulations of waste, debris, excess rock and excavated material, downed trees and brush resulting from line installation operations. Repair fences directly following backfilling of trench. Generally restore contours as directed by Engineer.

B. Final Clean-up

Fully restore contours, seed or sod, fertilize, and straw mulch as directed by Engineer. Restore property to original condition. Refer to Section 01710.

1.02 RELATED SECTIONS

A. Section 01710 – Cleaning/Final Cleaning

B. Section 02221 - Rock Removal

C. Section 02222 - Excavation

D. Section 02225 - Excavating, Backfilling, and Compacting for Utilities

1.03 PROTECTION

A. Protect trees and other features remaining as portion of final landscaping.

B. Protect bench marks, existing structures, fences, roads, sidewalks, and other features not designated for demolition.

C. Protect above or below grade utilities which are to remain.

D. Contractor shall be responsible for repairing any damage to those items not designated for demolition or removal in a manner satisfactory to the Owner at no additional cost to the Owner.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Topsoil

Topsoil shall be fertile, natural soil, typical of the locality, free from large stones, roots, sticks, peat, weeds, and sod, and obtained from naturally well-drained areas. It shall not be excessively acid or alkaline nor contain other toxic material harmful to plant growth. Topsoil stockpiled under other sections or divisions may be used, but the Contractor shall furnish additional topsoil at his own expense, if required.

B. Subsoil

Subsoil shall be excavated material, graded free of lumps larger than 12 inches, rocks larger than 12 inches, and debris.

PART 3 - EXECUTION

3.01 PREPARATION

A. Identify required lines, levels, contours, and datum.

B. Identify known below grade utilities. Stake and flag locations.

C. Identify and flag above grade utilities.

D. Maintain and protect existing utilities remaining which pass through work area.

E. Upon discovery of unknown utility or concealed conditions, discontinue affected work; notify Engineer.

3.02 TOPSOIL EXCAVATION

A. Excavate topsoil from areas to be further excavated, and stockpile in area designated on site by the Engineer.

B. Do not excavate wet topsoil.

C. Stockpile topsoil to depth not exceeding eight (8) feet.

3.03 SUBSOIL EXCAVATION

A. Excavate subsoil from indicated areas and stockpile in area designated on site. Excess subsoil may be reused according to Section 02225, Excavating, Backfilling, and Compacting for Utilities.

B. Do not excavate wet topsoil.

C. Stockpile topsoil to depth not exceeding eight (8) feet.

D. When excavation through roots is necessary, perform work by hand and cut roots with a sharp axe.

- END OF SECTION -

SECTION 02221

ROCK REMOVAL

PART 1 - GENERAL

1.01 SUMMARY

A. The Contractor shall excavate rock, if encountered, as required to perform the required work, and shall dispose of the excavated material, and shall furnish acceptable material for backfill in place of the excavated rock.

B. In general, rock in pipe trenches shall be excavated so as to be not less than six (6) inches from the pipe after it has been laid.

C. Use of explosives for rock removal shall not be permitted. Rock shall be excavated by means of rock trencher, or by hoe ram in areas field-approved by the Owner.

1.02 SAFETY

A. Conform to all federal, state, and local codes and regulations regarding safety.

1.03 RELATED SECTIONS

A. Section 02222 – Excavation

B. Section 02225 – Excavating, Backfilling, and Compacting for Utilities

PART 2 - PRODUCTS

2.01 MATERIALS

A. Rock Definition

Solid mineral material that cannot be removed with a power shovel.

PART 3 - EXECUTION

3.01 EXECUTION - RESERVED

- END OF SECTION -

SECTION 02222

EXCAVATION

PART 1 - GENERAL

1.01 SUMMARY

A. Structure Excavation

B. Shoring Excavation

C. Trench Excavation

D. Lagoon Excavation

E. Boring Pit and Receiving Pit Excavation

1.02 RELATED SECTIONS

A. Section 02221 - Rock Removal

B. Section 02225 - Excavating, Backfilling, and Compacting for Utilities

1.03 SAFETY

A. Conform to all federal, state, and local codes and regulations regarding safety.

B. Protect excavations by shoring, bracing, sheet piling, underpinning, or other methods required to prevent cave-in or loose soil from falling into excavation.

C. Underpin adjacent structures which may be damaged by excavation work, including service utilities and pipe chases.

D. Notify Engineer of unexpected subsurface conditions and discontinue affected work in area until notified to resume work.

E. Protect bottom of excavations and soil adjacent to and beneath foundations from frost.

F. Grade excavation top perimeter to prevent surface water run-off into excavation.

G. Contractor shall provide ample means and devices with which to intercept any water entering the excavation area.

1.04 ROCK EXCAVATION

Rock removal should be in accordance with Section 02221.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Subsoil

Excavated material, graded free of lumps larger than 12 inches, rocks larger than 12 inches, and debris.

B. Pea Gravel

Mineral aggregate graded 1/4 inch to 5/8 inch, free of soil, subsoil, clay, shale, or foreign matter.

PART 3 - EXECUTION

3.01 CLASSIFICATION

A. Without regard to the materials encountered, all trenching, roadway and drainage excavation is unclassified and the Owner will consider it Unclassified Excavation. Any reference to rock, earth, or any other material on the Drawings or cross sections, whether in numbers, words, letters, or lines, is solely for the owner's information and is not an indication of classified excavation or the quantity of either rock, earth, or any other material involved. The Bidder must draw his own conclusions as to the conditions to be encountered. The Owner does not give any guarantee as to the accuracy of the data and will not consider any claim for additional compensation when the materials encountered are not in accord with the classification shown.

3.02 PREPARATION

Identify required lines, levels, contours, and datum.

3.03 EXCAVATION

A. All unclassified excavation shall be done in accordance with Section 204 – Roadway and Drainage Excavation in the Kentucky Transportation Cabinet's *Standard Specifications for Road and Bridge Construction*, Latest Edition.

B. Reasonable care shall be taken during construction to avoid damage to vegetation. Ornamental shrubbery and tree branches shall be temporarily tied back, where appropriate, to minimize damage. Trees that receive damage to branches shall be trimmed of those branches to improve the appearance of the tree. Tree trunks receiving damage from equipment shall be treated with a tree dressing.

C. Before excavation and grading is commenced for buildings, structures, roads, parking areas, or other work described hereinafter or before material is removed from borrow pits, the topsoil shall be removed from areas affected and stockpiled.

D. Excavate subsoil required for construction operations and other work.

E. Contractor is responsible to adequately brace open cuts and protect workmen and equipment from cave-in, in accordance with all federal, state, and local regulations.

F. Remove lumped subsoil, boulders, and rock up to 1/3 cu. yd., measured by volume.

G. Correct unauthorized excavation at no cost to Owner.

H. Fill over-excavated areas under structure bearing surfaces in accordance with Section 02225 – Excavating, Backfilling, and Compacting for Utilities or as directed by Engineer.

I. Stockpile excavated material in area designated on site.

3.03 DEWATERING

A. The Contractor, at his own expense, shall provide adequate facilities for promptly and continuously removing water from all excavation. Additionally, no additional payment will be made for dewatering associated with leakage from any existing facilities during the construction.

B. To ensure proper conditions at all times during construction, the Contractor shall provide and maintain ample means and devices (including spare units kept ready for immediate use in case of breakdowns) with which to remove promptly and dispose properly of all water entering trenches and other excavations. Such excavation shall be kept dry until the structures, pipes, and appurtenances to be built therein have been completed to such extent that they will not be floated or otherwise damaged.

C. All water pumped or drained from the work shall be disposed of in a suitable manner without undue interference with other work, damage to pavements, other surfaces, or property. Suitable temporary pipes, flumes, or channels shall be provided for water that may flow along or across the site of the work.

D. If necessary, the Contractor shall dewater the excavations by means of an efficient drainage wellpoint system which will drain the soil and prevent saturated soil from flowing into the excavation. The wellpoints shall be designed especially for this type of service. The pumping unit shall be designed for use with the wellpoints, and shall be capable of maintaining a high vacuum and of handling large volumes of air and water at the same time.

E. The installation of the wellpoints and pump shall be done under the supervision of a competent representative of the manufacturer. The Contractor shall do all special work such as surrounding the wellpoints with sand or gravel or other work which is necessary for the wellpoint system to operate for the successful dewatering of the excavation.

3.05 UNAUTHORIZED EXCAVATION

If the bottom of any excavation is taken out beyond the limits indicated or prescribed, the resulting void shall be backfilled at the Contractor's expense with thoroughly compacted crushed stone in accordance with Section 02225, or with 4000 psi concrete, if the excavation was for a structure.

3.06 EXCAVATION / DISPOSAL OF UNSUITABLE MATERIAL

A. If material unsuitable for foundation (in the opinion of the Engineer) is found at or below the grade to which excavation would normally be carried in accordance with the drawings and/or specifications, the Contractor shall remove such material to the required width and depth and replace it with thoroughly compacted, screened gravel, select bank-run gravel, fine aggregate, or concrete as directed.

B. No excavated materials shall be removed from the site of the work or disposed of by the Contractor except as directed or permitted.

C. Surplus excavated materials suitable for backfill shall be used to backfill normal excavations in rock or to replace other materials unacceptable for use as backfill; shall be neatly deposited and graded so as to make or widen fills, flatten side slopes, or fill depressions. All work shall be as directed or permitted and without additional compensation.

D. Surplus excavated materials not needed as specified above shall be hauled away and dumped by the Contractor, at his expense, at appropriate locations, and in accordance with arrangements made by him.

3.07 EXCESS MATERIAL

Disposal of excess material shall be the responsibility of the Contractor. The Contractor shall determine the best method and area for disposal and obtain all permits and required permission. Disposal on site will not be permitted unless specifically indicated on the Drawings.

3.08 EXISTING UTILITIES AND OTHER OBSTRUCTIONS

Prior to the commencement of construction on the project, the Contractor shall contact the Owner and utility companies whose lines, above and below ground, may be affected during construction and verify the locations of the utilities as shown on the drawings. The Contractor shall ascertain from said parties if he will be allowed to displace or alter, by necessity, those lines encountered or replace those lines disturbed by accident during construction, or if the parties themselves are only permitted by policy to perform such work. If the Contractor is permitted to perform such work, he shall leave the lines in as good condition as were originally encountered and complete the work as quickly as possible. All such lines or underground structures damaged or molested in the construction shall be replaced at the Contractor's expense, unless in the opinion of the Engineer, such damage was caused through no fault of the Contractor.

- END OF SECTION -

SECTION 02225

EXCAVATING, BACKFILLING, AND COMPACTING FOR UTILITIES

PART 1 - GENERAL

1.01 SUMMARY

A. Excavation of Trenches

B. Bedding of Pipe

C. Backfilling Trenches

D. Installing Identification Tape

1.02 RELATED SECTIONS

A. Section 02150 - Shoring and Underpinning

B. Section 02221 - Rock Removal

C. Section 02610 - Pipe and Fittings

PART 2 - PRODUCTS

2.01 BEDDING AND BACKFILLING STONE

A. Crushed Stone material shall conform to the Kentucky Bureau of Highways Standard Specifications.

B. Bedding Stone: No. 9 Crushed Stone.

C. Backfill Stone: No. 9 Crushed Stone.

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. Trenching may be accomplished by means of a backhoe, trenching machine or by hand depending on the construction area. Blasting of rock for the trench will not be permitted. At the Contractor's option, trenching by a trenching machine or by backhoe is acceptable except as noted below:

1. Where the pipeline parallels a state highway and is being installed within the limits of the shoulder, a trenching machine must be used whenever practicable.

2. Where the pipe line is being constructed close to other utilities, structures, building, or large trees, and it is reasonable to anticipate possible damage from the use of a backhoe, then trenching shall be made by hand methods.

B. Clearing

All trees, stumps, bushes, shrubbery, and abandoned concrete or masonry structures within the limits of the trench shall be removed by the Contractor and disposed of in a manner satisfactory to the land owner and in accordance with federal, state, and local regulations. All clearing work shall be considered as incidental to the cost of laying pipe.

C. Bracing and Sheeting

In areas of unstable soils, bracing and sheeting shall be provided to adequately protect the workers during pipeline installation.

1. All requirements of the Occupational Safety and Health Act (OSHA) shall be met during trenching and backfill operations.

2. When sheeting and bracing are required, the trench width shall not be less than specified herein. As backfill is placed, the sheeting shall be withdrawn in increments not exceeding one (1) foot and the void left by the withdrawn sheeting shall be filled and compacted.

3. The Engineer will not be responsible for determining requirements for bracing or sheeting.

D. Excavated materials shall be piled in a manner that will not endanger the Work and will avoid obstructing driveways and sidewalks. Gutters shall be kept clear or other satisfactory provisions made for street and roadway drainage.

E. The maximum amount of a continuous open/exposed trench that shall be allowed prior to installing the pipe and backfilling is 500 linear feet. No excavation shall remain open for more than four (4) calendar days.

3.02 TRENCHING

A. General

1. The Contractor shall perform all excavation of every description and of whatever substances encountered, including clearing over the pipe line route. All excavations for the pipeline shall be open-cut except at paved city and county roads, state and federal highways, and railroads which shall be bored unless otherwise approved by Engineer. Banks of excavations shall be kept as nearly vertical as possible.

2. Trench widths at the top of the pipe shall not be less than or greater than that given in the following table:

ALLOWABLE TRENCH WIDTHS		
Pipe Diameter (inches)	**Minimum Width (inches)**	**Maximum Width (inches)**
4 & less	16	28
6	18	30
8	20	32
10	22	34
12	24	36
14	26	38
16	28	40
18	30	42
20	32	44

B. Trench Depth

1. The trench shall be excavated to a depth sufficient to provide 30 inches of cover over the pipe in non-traffic areas and 36 inches in traffic areas. In addition, excavation shall be carried to a minimum of six (6) inches below pipe grade in rock.

2. When it is necessary to install a pipeline below a roadway ditch, it shall be provided with 48 inches of cover unless otherwise approved by Engineer.

C. All excavation will be classified as unclassified. Unclassified excavation shall include all material encountered during excavation of trench to proper depth and width. It includes the removal of all slate, hardpan, soil, pavements, loess and solid rock and any other material which may be encountered in the trench.

D. Blasting for excavation will not be permitted.

3.03 WATER PIPE BEDDING

A. The trench shall be excavated to a depth to allow a minimum of 30 inches cover over the top of the pipe.

B. Bedding material, in earth excavation areas, shall be soil free from rocks, debris, or other foreign material.

C. Bedding material, in rock excavation or vehicular traffic (including driveways) areas, shall be No. 9 Crushed Stone. The trench shall be over-excavated six (6) inches and filled with No. 9 Crushed Stone prior to laying pipe. In no case shall pipe be laid on solid or blasted rock.

D. Bedding material shall be placed from bottom of pipe in earth excavation, and from six (6) inches below bottom of pipe in rock excavation, to the centerline (springline) of the pipe. Bedding shall be compacted in layers not to exceed six (6) inches.

E. When the subgrade is found to be unstable or to include ashes, cinders, refuse, organic material, or other unsuitable material, such material shall be removed to the depth ordered by the Engineer and replaced under the directions of the Engineer with clean, stable backfill material. When the bottom of the trench or the subgrade is found to consist of material that is unstable to such a degree that, in the judgement of the Engineer it cannot be removed, a foundation for the pipe and/or appurtenance shall be constructed using piling, timber, concrete, or other materials at the direction of the Engineer.

3.04 WATER PIPE BACKFILLING

A. Initial Backfill

1. Initial backfill is defined as the material placed from the centerline (springline) of the pipe to 12 inches above the top of the pipe.

2. Initial backfill, in earth excavation areas, shall be soil material free from rocks, debris, or other foreign materials.

3. Initial backfill, in rock excavation or vehicular traffic (including driveways) areas shall be No. 9 Crushed Stone.

B. Final Backfill

1. Final backfill is defined as the material placed from a point 12 inches above the top of the pipe to the original surface.

2. Final backfill, in earth excavation areas, shall be soil material free from rocks, debris, or other foreign materials.

3. Final backfill, in rock excavation shall be No. 9 Crushed Stone. Top six (6) inches shall be topsoil or earth material suitable for revegetation.

4. Final backfill, in vehicular traffic (including driveways) areas shall be No. 9 Crushed Stone up to the subgrade of vehicular traffic surface courses. See Sections 02507, 02510, or 02520 for specifications of surface courses.

3.05 CHANNEL LINING, CLASS III

In areas indicated on plans Class III Channel Lining shall be used as a protective covering. This material and its method of installation shall comply with the Kentucky Department of Highways 2012 Standard Specifications, Section 703 and Section 805.

- END OF SECTION -

SECTION 02275

SEDIMENT CONTROL

PART 1 - GENERAL

1.01 SUMMARY

The Contractor shall furnish all labor, equipment, materials, and routine maintenance for the construction of temporary erosion and sediment control measures in accordance with the Drawings and Specifications, or as otherwise directed by the Engineer.

1.02 SUBMITTALS

There are no submittals required for this section.

PART 2 - PRODUCTS

2.01 SILT FENCE

A. Silt fences shall be installed as shown on the Drawings, or as directed by the Engineer.

B. Material: Silt Fence filter fabric shall be specifically recommended for this purpose by the manufacturer and shall meet or exceed the following criteria:

Property	Conformance	Specification
Bursting Strength	ASTM D 751	150 psi
Grab Strength	ASTM D 1682	100 psi
Permeability		0.02 - 0.03 cm/sec

C. The silt fence shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0°F to 120°F.

D. Posts for the silt fence shall be either 2-inch diameter wood or 1.33 pounds per linear foot steel with a minimum length of 5 feet. The posts shall be set to sufficient depth to provide a sound anchor for the filter fabric. Steel posts shall have projectiles for fastening the silt fence.

PART 3 - EXECUTION

3.01 GENERAL

A. All sediment and erosion control devices shall be installed prior to the initiation of site clearing and grubbing and/or excavation/construction to prevent sediment generated by the operation from escaping downstream of the work site.

B. The Contractor shall monitor and maintain all sediment and erosion control devices throughout the construction period.

3.02 SILT FENCE INSTALLATION

A. The silt fence posts shall be installed 6 to 10 feet apart on a slight angle toward the anticipated run-off source.

B. A trench 4 to 6 inches deep shall be dug along the uphill side of the fence line.

C. The silt fence shall then be attached to the posts with a maximum height of 3 feet.

D. The lower 4 to 6 inches of the silt fence shall be laid in the trench and curled toward the erosion source.

E. The trench shall then be backfilled with any available soil.

3.03 MAINTENANCE

All sediment and erosion control devices shall be maintained in a sound condition during the period of construction. Accumulations of silt, which may threaten their effectiveness, shall be removed. The sediment and erosion control devices shall be inspected after each storm event. Any required repairs shall be made promptly to insure the devices continue to function properly.

- END OF SECTION -

SECTION 02507

CRUSHED STONE PAVING

PART 1 - GENERAL

1.01 SUMMARY

Crushed stone paving course, compacted.

1.02 REFERENCES

ASTM C33 - Aggregate for Concrete.

1.03 TESTS

Gradation of stone material will be performed in accordance with ASTM C33.

PART 2 - PRODUCTS

2.01 MATERIALS

Crushed stone shall conform to ASTM C33, Type Dense Grade Aggregate (DGA), Type No. 57, Type No.2, and No. 610.

PART 3 - EXECUTION

3.01 FIELD QUALITY CONTROL

A. Verify compacted subgrade.

B. Verify gradients and elevations of base are correct.

C. Beginning of installation means acceptance of existing conditions.

3.02 PLACING AND COMPACTING STONE PAVING

A. Spread stone material over prepared base to a total compacted thickness of 12 inches.

B. Stone shall be placed in four 3-inch layers. Each layer shall have three (3) inches of No. 2 stone placed and then DGA worked into the No. 2 stone. Each layer shall be compacted after placement.

C. Level surfaces to elevations and gradients indicated.

D. Add small quantities of sand to stone mix as appropriate to assist compaction.

E. Adequately compact placed stone materials.

F. Add water to assist compaction. With an excess water condition, rework topping and aerate to reduce moisture content.

- END OF SECTION -

SECTION 02610

PIPE AND FITTINGS

PART 1 - GENERAL

1.01 SUMMARY

A. The Contractor shall furnish all labor, material, and equipment necessary to install water piping and appurtenances as shown on the drawings and specified herein.

B. This section describes several types of pipe which may or may not apply to the current project. Selected pipe materials will be identified either on the drawings or the bid form.

1.02 RELATED SECTIONS

A. Section 02222 - Excavation

B. Section 02225 - Excavating, Backfilling, and Compacting for Utilities

C. Section 02642 - Water Valves and Accessories

D. Section 02630 - Casing Pipe

E. Section 02675 - Disinfection of Water Distribution Systems

F. Section 13210 – Composite Elevated Water Storage Tank

1.03 DELIVERY, STORAGE, AND HANDLING

A. Pipe and accessories shall be unloaded at the point of delivery, hauled to, and distributed at the site of the project by Contractor in such a manner to avoid damage to the materials. Whether moved by hand, skidways, or hoists, materials shall not be dropped or bumped against pipe or accessories already on the ground or against any other object.

B. In distributing material at the construction site, each piece shall be unloaded as near the installation point as possible.

C. Pipe shall be handled in such a manner as to avoid damage to the ends. When such damaged pipe cannot be repaired to the Engineer's satisfaction, it shall be replaced at the Contractor's expense. The interior of all pipe and accessories shall be kept free from dirt and foreign matter at all times. The interior of all pipe and accessories shall be checked for dirt and debris and, if necessary, thoroughly cleaned before use in the project.

PART 2 - PRODUCTS

2.01 DUCTILE IRON PIPE AND FITTINGS

A. Scope

This article covers the design and manufacture of ductile iron centrifugally cast in metal molds and ductile iron fittings.

B. Specific Requirements

Ductile iron pipe shall be furnished cement lined unless otherwise noted on the drawings or in other sections of these specifications. Ductile iron pipe shall be furnished with rubber gasket push-on joints except as may otherwise be noted on the drawings or in difficult working areas and approval of the Engineer.

1. Pressure class shall be 350 psi for pipe sizes 14 inches or smaller and pressure class 250 psi for pipe sizes larger than 14 inches for mechanical and push-on joint pipe.

2. Thickness design of ductile iron shall conform in all aspects to the requirements of ANSI/AWWA C150/A 21.50 latest revision.

3. Manufacture and testing of ductile iron pipe shall conform in all aspects to the requirements of ANSI/AWWA C151/A 21.51 latest revisions .

4. Cement mortar lining with bituminous seal coat shall conform to the requirements of ANSI/AWWA C104/A 21.4, latest revision for cement-mortar lining for ductile iron pipe, gray iron pipe, and fittings for water. Bituminous outside coating shall be in accordance with ANSI/AWWA C151/A 21.51 for pipe and ANSI/AWWA C110/A 21.10 for fittings.

5. Fittings and gaskets for mechanical and push-on joint ductile and cast iron pipe shall conform to the latest revisions of ANSI/AWWA C110/A 21.10 for mechanical and push-on joint fittings, ANSI/AWWA C111/A 21.11 for gaskets, and ANSI/AWWA C153/A 21.53 for mechanical and push-on joint compact fittings. Mechanical and push-on joint fittings shall have pressure class rating of 350 psi for sizes 14 inches and smaller and 250 psi for sizes larger than 14 inches.

6. All ductile and cast iron fittings shall be ductile iron grade 80-60-03 in accordance with ASTM A536.

7. Flanged ductile iron pipe shall conform to the latest revisions of ANSI/AWWA C115/A 21.15. Bolt pattern of flange shall be in accordance with ANSI/AWWA C115/A 21.15 (which is equivalent to ASME/ANSI B16.1, Class 125 flange bolt pattern). Pipe shall have pressure class 250 rating. Gaskets shall be synthetic rubber ring gaskets with a thickness of 1/8 inch. Nuts and bolts shall be in accordance with ASME/ANSI B18.2.1, ASME/ANSI B18.2.2, ASME/ANSI B1.1, and ASTM A307.

8. Flanged fittings shall conform to the latest revisions of ANSI/AWWA C110/A 21.10 or ANSI/AWWA C153/A 21.53 (compact fittings). Gaskets shall be in accordance with ANSI/AWWA C111/A 21.11. Fittings shall have pressure class rating of 250 psi. Bolt pattern of flange shall be in accordance with ANSI/AWWA C115/A 21.15 (which is equivalent to ASME/ANSI B16.1, class 125 flange bolt pattern).

9. Restrained joint pipe and fittings using restraining gaskets shall be a boltless system equal to "Field-Lok" restraining gaskets as manufactured by U.S. Pipe & Foundry Company or approved equal.

10. Restrained joint pipe and fittings using a locking ring system shall be American Flex-Ring, U.S. Pipe TRFLEX, or Clow Tyton/Fastite shop or field systems.

11. Restrained joint pipe and fittings using a grip ring system shall be equal to Romac Grip Rings or Mega Lugs.

12. Mechanical joint ductile iron anchor pipes shall be included as required. Anchor pipes shall be Clow Corporation F1211 mechanical joint, Tyler swivel by solid adapter 5-198 mechanical joint, or approved equal.

13. Ball and socket restrained joint pipe and fittings shall be a boltless system equal to USIFLEX manufactured by U.S. Pipe & Foundry Company or FLEX-LOK manufactured by American Pipe Company. Pipe shall have a working pressure rating of 250 psi and have a maximum joint deflection of 15°. Nominal laying lengths shall be in range of 18 feet 6 inches to 20 feet 6 inches.

14. Manufacturers: Pipe shall be as manufactured by U.S. Pipe & Foundry Company, Clow, American Cast Iron Pipe Company, or equal.

15. Marking: Pipe or fitting shall have the ANSI/AWWA standard, pressure (or thickness) class, diameter, DI or ductile noted, manufacturer, and country and year where cast on the outside of the body.

16. A separate pay item has been established for fittings. Payment for both mechanical joint fittings and restrained joint fittings will be made under the same pay item per unit pound.

17. No separate pay item will be made for a push-on or restrained joint bell – they are considered equal in price. Locking rings or restraining gasket/grip rings will be paid for per pound as fittings.

18. Restrained joints shall be used at all fittings, in all casing pipes, and under all driveways and roads.

19. Polyethylene tubing (Polywrap, or approved equal) when required, shall be eight (8) millimeters thick and comply with AWWA C105.

2.02 PVC (POLYVINYL CHLORIDE) PIPE

A. Scope

This article covers the design and manufacture of PVC 1120 manufactured of CLASS 12454-B or CLASS 12454-C (cell classification) resin material with a hydrostatic-design-basis (HDB) rating of 4,000 psi at 73.4° F (23° C).

B. Specific Requirements

PVC pressure pipe shall be furnished, constructed of materials and to the specifications of this section. The types of PVC pipe permitted for use on the project will be as noted on the drawings or bid form. The selected pipe will be designated either as PVC (ASTM) or PVC (AWWA) followed by an appropriate pressure rating or dimension ratio (DR or SDR).

1. PVC (ASTM) Pipe

   a. PVC (ASTM) pipe shall be designed, manufactured, and tested to conform with the latest revision of ASTM D-2241, ASTM D-1784, and ASTM D-2672.

   b. Rubber gasketed joints shall conform to ASTM D-3139. The gaskets for the PVC pipe joint shall conform to ASTM F-477 and D-1869. Gaskets shall be twin gasket joints or integral bell joints with rubber O-ring seals.

   c. PVC (ASTM) pipe shall be furnished as SDR 17 for Class 250 psi.

2. PVC (AWWA) Pipe

   a. PVC (AWWA) pipe shall be designed, manufactured, and tested to conform with the latest revision of AWWA C900 for pipes sizes 12 inches and smaller and AWWA C905 for pipes sizes 14 inches and larger.

   b. Pipe shall have cast iron pipe equivalent ODs.

   c. Rubber gasketed joints shall conform to ASTM D-3139. The gaskets for the PVC pipe joint shall conform to ASTM F-477 and D-1869.

   d. PVC (AWWA) pipe shall be furnished as DR 14 for Class 200 psi,

C. Rubber gasket joints shall provide adequate expansion to allow for a 50° change in temperature on one length of pipe. Lubrication for rubber connected couplings shall be water soluble, non-toxic, be non-objectionable in taste and odor and have no deteriorating affect on the PVC or rubber gaskets and shall be as supplied by the pipe manufacturer.

D. Standard laying lengths shall be 20 feet ± for all sizes. At least 85 percent of the total footage of pipe of any class and size shall be furnished in standard lengths, the remaining 15 percent in random lengths. Random lengths shall not be less than 10 feet long. Each standard and random length of pipe shall be tested to four times the class pressure of the pipe for a minimum of five (5) seconds. The integral bell shall be tested with the pipe.

E. PVC Pipe shall be NSF approved for potable water service.

F. All pipe and couplings shall bear identification markings that will remain legible during normal handling, storage, and installation, which have been applied in a manner what will not reduce the strength of the pipe or the coupling or otherwise damage them. Pipe and coupling markings shall include the nominal size and OD base, material code designation, dimension ratio number, ASTM or AWWA Pressure Class, ASTM or AWWA designation number for this standard, manufacturer's name or trademark seal (mark) of the testing agency that verified the suitability of the pipe material for potable-water service. Each marking shall be applied at intervals of not more than five (5) feet for the pipe and shall be marked on each coupling.

G. Fittings shall be ductile iron in accordance with Article 2.01 of this section.

2.03 Stainless Steel Pipe and Fittings

A. Scope

This article covers the design and manufacture of Stainless Steel (SS) pipe and Stainless Steel fittings. See also Section 01321 – Composite Elevated Water Storage Tank.

B. Specific Requirements

SS pressure pipe shall be furnished according to the specifications of this section and constructed of materials meeting the specifications of this section.

1. SS Pipe and fittings shall be Type 304L unless otherwise noted on the drawings or in other sections of these specifications.

2. All SS piping and fittings shall be fabricated from materials meeting the requirements of ASTM A240.

3. Pipe, fittings, and flange thicknesses shall be in accordance with the manufacturers' certified pressure rating for the applicable service pressures. The design pressure rating shall be 125 psi minimum for any piping located within closed or valved sections.

4. Pipe, fittings, and welds shall be cleaned and passivated.

5. Pipe shall be milled. It shall be designed, manufactured, and tested to conform with the latest revision of ASTM A312 and AWWA C220.

C. Pipe Ends

1. Pipe ends, whether plain, beveled, belled, fitted with butt straps, prepared for mechanical coupling, or other, shall be prepared in accordance with AWWA C220.

D. Welding

1. Field welding of joints and fittings shall be performed in accordance with AWWA C206.

E. Fabrication, Inspection, Testing, Marking, and Certification

1. Fabrication, inspection, testing, marking and certification of pipe and fittings shall be in acordance with ASTM A778 and A774, respectively.

F. Fittings

1. Fittings shall conform to ASTM A774 and AWWA C226.

G. Flanges

1. Flanges shall conform to AWWA C228.

2.04 COUPLINGS AND ADAPTERS

A. Flexible couplings shall be of the sleeve type with a middle ring, two round-wedge shaped rubber gaskets at each end, two following rings together, and compress the gasket against the pipe. Flexible couplings shall be steel with minimum wall thickness of the middle ring or sleeve installed on pipe being 5/16-inch for pipe smaller than 10 inches, 3/8-inch pipe for 10 inches or larger. The minimum length of the middle ring shall be 5 inches for pipe sizes up to 10 inches and 7 inches for pipe 10 inches to 30 inches. The pipe stop shall be removed. Gaskets shall be suitable for 250 psi pressure rating or at rated working pressure of the connecting pipe. Couplings shall be harnessed and be designed for 250 psi.

B. Flanged adapters shall have one end suitable for bolting to a pipe flange and the other end of flexible coupling similar to that described hereinbefore. The adapters shall be furnished with bolts of an approved corrosion resistant steel alloy, extending to the adjacent pipe flanges. Flanges on flanged adapter (unless otherwise indicated or required) shall be faced and drilled ANSI B16.1 Class 125. Locking pins shall be provided.

C. Flexible couplings and flanged adapters shall be as manufactured by Dresser, Rockwell, or equal, per the following, unless otherwise specified and/or noted on the Drawings.

1. Steel couplings for joining same size, plain-end, steel, cast iron, and PVC plastic pipe shall be Dresser style 38, Rockwell 411, or equal.

2. Transition couplings for joining pipe of different outside diameters:

Dresser	Rockwell
Style 162 (4" – 12")	413 steel (2" – 24")
Style 62 (2" – 24")	415 steel (6" – 48")
	433 cast (2" – 16")
	435 cast (2" – 12")

3. Flanged adapters for joining plain-end pipe to flanged pipe, fittings, valves, and equipment:

Style 127 cast (3" – 12")	912 cast (3" – 12")
Style 128 steel (3" – 48" C.I. pipe)	913 steel (3" and larger)
Style 128 steel (2" – 96" steel pipe)	

2.04 WALL PIPE AND SLEEVES

A. All wall pipe shall be furnished with cast or welded collar water stops in the positions shown on the Drawings. Welding of water stop collars on pipe shall be accomplished by the wall pipe manufacturer in their shop. All centrifugally cast wall pipe shall be ductile iron meeting the requirements of AWWA C151 for the pipe barrel, conforming to the pressure rating of the pipeline in which installed, and in no case be lighter than Class 53. All statically cast wall pipe shall be ductile iron meeting the requirements of AWWA C110 for fittings. Mechanical joint end and cast-on flange end wall pipe shall conform to AWWA C110, and threaded flange wall pipe shall conform to AWWA C115. Where flanged or mechanical joint bell ends are flush with the wall, they shall be drilled and tapped for stud bolts which are to be of 300 Series stainless steel. The length of all wall pipe shall be not less than the thickness of the wall in which installed. Wall pipe shall have the same pressure rating as connecting pipe. All wall pipe shall be cement-mortar lined per AWWA C104. The outside of wall pipes shall be left uncoated and shall be field primed for painting on the portion exposed, uncoated where embedded, and field coated with standard bituminous coated where buried.

B. Contractor may have the option to install wall pipe flush face-face of wall, in lieu of the dimensioned length wall pipe shown on the Drawings, in order to eliminate form penetrations. This option will be subject to Engineer's review at each wall pipe location and covers both flanged and mechanical-joint bell-end wall pipe. Embedded flanged and M.J. bell-end bolt holes shall be tapped for stud bolts; tapped bolt holes in embedded flanges shall be plugged for protection during concrete pouring.

C. All pipe wall sleeves shall be plain end galvanized steel pipe of diameter noted on Drawings and length to fit flush face-to-face of wall.

PART 3 - EXECUTION

3.01 LAYING DEPTHS

Water pipe shall be laid with a minimum cover of 30 inches unless otherwise noted on Drawings.

3.02 THRUST BLOCKING

A. Concrete

Concrete thrust blocking (3500 psi) shall be installed as shown on drawings.

B. Hydrants

The bowl of each hydrant shall be well braced against a sufficient area of unexcavated earth at the end of the trench with stone slabs, concrete blocking, or it shall be tied to the pipe as shown on drawings.

1. Tie rods, clamps, or other components of dissimilar metal shall be protected against corrosion by hand application of a bituminous coating or by encasement of the entire assembly with eight (8) millimeter thick, loose polyethylene film in accordance with AWWA C105.

2. Thrust restraint design pressure shall be equal to the test pressure.

C. Fittings

All plugs, caps, tees, and bends, unless otherwise specified, shall be provided with thrust blocking. Substituting other restraint materials such as metal rods, clamps, or restrained joints must be specifically authorized by Engineer in writing.

D. Restraint Materials

1. Thrust Blocking

Vertical and horizontal thrust blocking shall be made of concrete having a compressive strength of not less than 3,500 psi after 28 days. Blocking shall be placed between solid ground and the fitting to be anchored; the area of bearing on the pipe and on the ground in each instance shall be that shown or directed by the Engineer. The blocking shall, unless otherwise shown or directed, be so located as to contain the resultant thrust force and so that the pipe and fitting joints will be accessible for repair.

2. Restrained Joints

Restrained push-on joints, mechanical joints utilizing set-screw retainer glands or metal harness of tie-rods, or clamps may only be used instead of concrete blocking if specifically authorized by Engineer. Tie rods, clamps,

or other components of dissimilar metal shall be protected against corrosion by hand application of a bituminous coating or by encasement of the entire assembly with eight (8) millimeter thick, loose polyethylene film in accordance with AWWA C105.

3.03 PIPE INSTALLATION

A. Proper implements, tools, and facilities shall be provided and used for the safe and convenient performance of the work. All pipe, fittings, valves, and hydrants shall be lowered carefully into the trench by means of a derrick, ropes, or other suitable tools or equipment, in such a manner as to prevent damage to water line materials and protective coatings and linings. Under no circumstances shall water line materials be dropped or dumped into the trench. The trench should be dewatered prior to installation of the pipe.

B. The Contractor shall secure from the manufacturer an installation guide for the pipe being used. The Contractor shall in all cases adhere to the recommended installation procedures of the manufacturer except where those given herein are more stringent. The more stringent requirements shall be met.

1. Examination of Material

   All pipe fittings, valves, hydrants, and other appurtenances shall be examined carefully for damage and other defects immediately before installation. Defective materials shall be marked and held for inspection by the Engineer who may prescribe corrective repairs or reject the materials.

2. Pipe Ends

   All lumps, blisters, and excess coating shall be removed from the socket and plain ends of each pipe, and the outside of the plain end and the inside of the bell shall be wiped clean and dry and be free from dirt, sand, grit, or any foreign material before the pipe is laid.

3. Pipe Cleanliness

   Foreign material shall be prevented from entering the pipe while it is being placed in the trench. During laying operations, no debris, tools, clothing, or other materials shall be placed in the pipe.

4. Pipe Placement

   As each length of pipe is placed in the trench, the joint shall be assembled and the pipe brought to correct line and grade. The pipe shall be secured in place with approved backfill material.

5. Pipe Plugs

At times when pipe laying is not in progress, the open ends of pipe shall be closed by a water tight plug or other means approved by the Engineer. The plug shall remain in place until the trench is pumped completely dry. Care must be taken to prevent pipe floatation should the trench fill with water.

3.04 JOINT ASSEMBLY

A. Push-On Joints

Push-on joints are to be assembled as follows:

1. Thoroughly clean the groove and bell socket and insert the gasket, making sure that it faces the proper direction and that it is correctly seated.

2. After cleaning dirt or foreign material from the plain end, apply lubricant in accordance with the pipe manufacturer's recommendations. The lubricant is supplied in sterile cans and every effort should be made to keep it sterile.

3. Be sure that the plain end is beveled; square or sharp edges may damage or dislodge the gasket and cause a leak. When pipe is cut in the field, bevel the plain end with a heavy file or grinder to remove all sharp edges. Push the plain end into the bell of the pipe. Keep the joint straight while pushing. Make deflection after the joint is assembled.

4. Small pipe can be pushed into the bell socket with a long bar. Large pipe requires additional power, such as a jack, lever puller, or backhoe. The supplier may provide a jack or lever pullers on a rental basis. A timber header should be used between the pipe and jack or backhoe bucket to avoid damage to the pipe.

B. Mechanical Joints

Mechanical joints are to be assembled as follows:

1. Wipe clean the socket and plain end. The plain end, socket, and gasket should be washed with a soap solution to improve gasket seating.

2. Place the gland on the plain end with the lip extension toward the plain end, followed by the gasket with the narrow edge of the gasket toward the plain end of the pipe.

3. Insert the pipe into the socket and press the gasket firmly and evenly into the gasket recess. Keep the joint straight during assembly.

4. Push the gland toward the bell and center it around the pipe with the gland lip against the gasket.

5. Align bolt holes and insert bolts with bolt heads behind the bell flange, and tighten opposite nuts to keep the gland square with the socket. Make deflection after joint assembly but before tightening the bolts.

6. Tighten the nuts in accordance with the following table:

MECHANICAL JOINTS - BOLT TORQUES	
Bolt Diameter (inches)	**Torque (feet - pound)**
5/8	45 - 60
3/4	75 - 90
1	86 - 100
1¼	105 - 120

3.05 PIPE CUTTING

Cutting of pipe for the insertion of valves, fittings or closure pieces shall be done in a neat workmanlike manner without creating damage to the pipe, linings, or coatings and in strict accordance to manufacturer's recommendation.

3.06 TESTING

A. After the pipe has been laid, all newly laid pipe or any valved section thereof shall be subjected to a hydrostatic pressure test of at least 1.5 times the working pressure of the pipe at the point of testing, but in no case less than that required by other sections herein. In addition, a leakage test shall be conducted concurrently with the pressure test.

B. Pressure Test – Ductile Iron and PVC Piping

1. Test Pressure Shall:

a. Not be less than 1.25 times the working pressure at the highest point along the test section.

b. Not to exceed pipe or thrust restraint design pressures at the lowest point along the test section.

c. Be of at least two (2) hour duration.

d. Not vary by more than plus or minus 5 psi.

e. Not exceed twice the rated pressure of the valves or hydrants when the pressure of the test section includes closed gate valves or hydrants.

f. Not to exceed the rated pressure of resilient seat butterfly valves when used.

2 Each valved section of pipe shall be filled with water slowly and the specified test pressure, based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe in a manner satisfactory to the Engineer.

3. Before applying the specified test pressure, air shall be expelled completely from the pipe, valves, and hydrants. If permanent air vents are not located at all high points, the Contractor shall install corporation cocks at such points so that the air can be expelled as the line is filled with water. After all the air has been expelled, the corporation cocks shall be closed and the test pressure applied. At the conclusion of the pressure test, the corporation cocks shall be removed and plugged, or left in place at the discretion of the Engineer.

4. All exposed pipe, fittings, valves, hydrants, and joints shall be examined carefully during the test. Any damage or defective pipe, fittings, valves, or hydrants that are discovered following the pressure test shall be repaired or replaced with sound material and the test shall be repeated until it is satisfactory to the Engineer.

C. Pressure Test – Stainless Steel Piping

1. Pressure tests shall be conducted in accordance with AWWA's C220 Hydrostatic Test, and with the requirements described as follows:

a. Each length of pipe shall be tested to a hydrostatic pressure not less than that determined by the following formula:

$$p = 2St / D$$

Where:

p = minimum hydrostatic test pressure, in pounds per square inch (Mpa)
S = stress in pipe wall during hydrostatic test, in psi (kPa), which shall be 0.75 times the specified minimum yield strenght of the material used
t = nominal wall thickness as specified, in inches (mm)
D = outside diameter, in inches (mm)

The test pressure shall be held for a duration of at least 2 hours.

b. Each valved section of pipe shall be filled with water slowly and the specified test pressure, based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe in a manner satisfactory to the Engineer.

c. Before applying the specified test pressure, air shall be expelled completely from the pipe, valves, and hydrants. If permanent air vents are not located at all high points, the Contractor shall install corporation cocks at such points so that the air can be expelled as the line is filled with water. After all the air has been expelled, the corporation cocks shall be closed and the test pressure applied. At the conclusion of the pressure test, the corporation cocks shall be removed and plugged, or left in place at the discretion of the Engineer.

d. All exposed pipe, fittings, valves, hydrants, and joints shall be examined carefully during the test. Any damage or defective pipe, fittings, valves, or hydrants that are discovered following the pressure test shall be repaired or replaced with sound material and the test shall be repeated until it is satisfactory to the Engineer.

D. Leakage Test

1. Leakage shall be defined as the quantity of water that must be supplied into the newly laid pipe, or any valved section thereof, to maintain pressure within 5 psi of the specified test pressure after the air in the pipeline has been expelled and the pipe has been filled with water.

2. The pipe shall be tested in accordance with AWWA C600 concurrently with the pressure test. No pipe installation will be accepted if the leakage is greater than that allowed in the following formula:

$$L = (S \times D \times (P)^{1/2}) \div 133{,}200$$

Where:

L = the allowable leakage (gallons per hour)
S = length of pipe tested, in feet
D = nominal diameter of the pipe (inches)
P = test pressure (psig)

a. When hydrants are in the test section, the test shall be made against the closed hydrant.

3. Acceptance shall be determined on the basis of allowable leakage. If any pipe has leakage greater than allowed, the Contractor shall, at his own expense, locate and repair the defective material until the leakage is within the specified allowance.

a. All visible leaks are to be repaired regardless of the amount of leakage.

- END OF SECTION -

SECTION 02630

CASING PIPE

PART 1 - GENERAL

1.01 GENERAL

Contractor shall provide all labor, materials, and equipment to construct, complete and in place, the casing pipe at the locations shown on the drawings.

1.02 RELATED SECTIONS

A. Section 02222 - Excavation

B. Section 02225 - Excavating, Backfilling, and Compacting for Utilities

C. Section 02610 - Pipe and Fittings

PART 2 - PRODUCTS

2.01 STEEL CASING PIPE

A. Casing pipe shall be steel (unless otherwise shown on the drawings), plain end, conforming to AWWA Specification C-200, latest revision. Steel for casing pipe shall have a minimum yield strength of 35,000 psi. Casing pipe shall neither be coated or wrapped. The inside diameter of the casing pipe shall be a minimum of four (4) inches greater than the outside diameter of the carrier pipe joint or coupling.

B. The minimum wall thickness shall be as shown on Drawings, or in accordance with the following table:

STEEL CASING PIPE WALL THICKNESS		
Casing Diameter (inches)	Minimum Wall Thickness Under Railroads (inches)	Minimum Wall Thickness All Other Uses (inches)
16 and under	0.250	0.250
18	0.281	0.250
20 and 22	0.312	0.281
24	0.344	0.312
26	0.375	0.344
28	0.406	0.375
30	0.438	0.406
32	0.469	0.438

STEEL CASING PIPE WALL THICKNESS		
Casing Diameter (inches)	Minimum Wall Thickness Under Railroads (inches)	Minimum Wall Thickness All Other Uses (inches)
34 and 36	0.500	0.469
38	0.531	0.500
40	0.563	0.531
42	0.594	0.563
44 and 46	0.625	0.594
48	0.656	0.625
50	0.688	0.656
52	0.719	0.688
54	0.750	0.719
56 and 58	0.781	0.750
60	0.813	0.781
62	0.844	0.813
64	0.875	0.844
66 and 68	0.906	0.875
70	0.938	0.906
72	0.938	0.938

2.02 PIPELINE SPACERS

A. Pipeline spacers and accessories such as nuts and bolts shall be constructed of polyethylene and/or stainless steel. Other materials will not be accepted.

B. Carrier pipes installed inside casing pipes shall be centered throughout the length of casing pipe. Centering shall be accomplished by the installation of polyethylene pipeline spacers attached to the carrier pipe in such a manner as to prevent the dislodgement of the spacers as the carrier pipe is pulled or pushed through the casing pipe. Spacers shall be of such dimensions to provide: full supportive load capacity of the pipe and contents; of such thickness to allow installation and/or removal of the pipe; and to allow no greater than 1/2 inch movement of the carrier pipe within the cover pipe after carrier pipe is installed.

C. Spacers shall be located immediately behind each bell and at a maximum spacing distance as follow:

Carrier Pipe Diameter (inches)	Maximum Spacing (feet)
2 – 2½	4
3 – 8	7
10 – 26	10
28	9
30	8
32	7
34	6
36 - 38	5.5
40 - 44	5
46 - 48	4

D. The materials and spacing to be used shall be accepted by the Engineer prior to installation. The polyethylene pipeline spacers shall be manufactured by Pipeline Seal and Insulator, Inc. (PSI), Raci Spacers, Inc., Advanced Products & Systems, Inc., or approved equal. Installation shall be in accordance with manufacturer's recommendations.

2.03 SEALING

After installation of the carrier pipe within the casing pipe, the ends of the casing shall be sealed using a 1/8" thick 60 durometer synthetic neoprene rubber, end seal, seamless, with vulcanized edges. The seal shall be securely bound to the casing and the carrier pipe barrel with ½" wide stainless steel bandings with nonmagnetic worm gear mechanisms. The seal shall be APS Advance Standard Model AC Pull-On casing end seals, or an approved equal.

PART 3 - EXECUTION

3.01 BORE AND JACK

A. Where designated on the drawings, crossings beneath state maintained roads, railroads, or other surfaces shall not be disturbed and are to be installed by boring and jacking of steel casing pipe followed by installation of the carrier pipe within the casing pipe. The Contractor shall provide a jacking pit, bore through the earth, and/or rock, jack the casing pipe into proper line and grade and then install the carrier pipe within the casing pipe.

B. The approach trench shall be large enough to accommodate one section of casing pipe, the jacks and blocking. The Contractor shall furnish and use adequate equipment to maintain the line and grade.

3.02 OPEN CUT

Where designated on drawings, the Contractor shall open the trench under the direction of the Engineer and install the casing pipe and complete the bedding, backfilling, and paved surface restoration as specified elsewhere herein.

3.03 DAMAGE

The cost of repairing damage which is caused by boring or open cutting the trench under a highway or railroad shall be borne by the Contractor.

- END OF SECTION -

SECTION 02642

WATER VALVES AND ACCESSORIES

PART 1 – GENERAL

1.01 SUMMARY

The Contractor shall furnish all labor, material, and equipment necessary to install valves together with all appurtenances as shown and detailed on the drawings and specified herein.

1.02 RELATED SECTIONS

A. Section 02225 - Excavating, Backfilling, and Compacting for Utilities

B. Section 02610 - Pipe and Fittings

1.03 SUBMITTALS

A. Complete shop drawings of all valves and appurtenances shall be submitted to the Engineer in accordance with the requirements of Section 01300.

B. The manufacturer shall furnish the Engineer two (2) copies of an affidavit stating that the valve and all materials used in its construction conform to the applicable requirements of the latest revision of the applicable AWWA Standard, and that all tests specified therein have been performed and that all test requirements have been met.

C. The Engineer shall be furnished two (2) copies of affidavit that the "Valve Protection Testing" has been done and that all test requirements have been met.

D. The Engineer shall be furnished with two (2) copies of affidavit that inspection, testing, and rejection are in accordance with the latest revision of the applicable AWWA Standard.

E. The Engineer shall be furnished with two (2) copies of an affidavit stating that valves are constructed with NSF 61 approved materials (drinking water service).

1.04 VALVE COATINGS

See paragraph 3.02 in this Section.

PART 2 - PRODUCTS

2.01 MATERIALS

A. All valves and appurtenances shall be of the size shown on the Drawings and, as far as possible, all equipment of the same type shall be from one manufacturer.

B. All valves and appurtenances shall have the name of the maker, flow-directional arrows, and the design working pressure cast in raised letters on some appropriate part of the body.

C. Except as otherwise shown on the Drawings or specified herein, all valves with operators located seven (7) feet or more above the operating floor shall be provided with chain wheel operators complete with chain guides and galvanized steel chain.

D. All buried valves shall open left (counter-clockwise). Insofar as possible, all valves shall open counter-clockwise.

E. All valves must be provided with suitable operating devices and adapted for operation in the position in which they are shown on the Drawings.

F. All bolts and nuts for valves that are under water or in unheated vaults shall be of stainless steel. They shall be of the size recommended for the pipe and fittings they are to be used on and shall be in the recommended quantity.

G. Buried valve operators shall be lubricated for the life of the valve and suitable for operation submerged in groundwater.

2.02 GATE VALVES

A. All gate valves shall be of the resilient seat type in accordance with the latest revision of AWWA C509 Standard. The valve body, bonnet, and gate castings shall be ductile iron or cast iron. The valve shall have a non-rising stem (NRS), fully bronze or stainless steel mounted with o-ring seals. Valve body and bonnet, inside and out, shall be fully coated with fusion bonded epoxy coating in accordance with AWWA C550 Standard. Valves shall have a rated working pressure of 200 psi. Valves 14 inches and larger shall be provided with gearing.

B. Gate valves for buried service shall be furnished with mechanical joint end connections unless otherwise shown on the drawings or specified herein. The end connection shall be suitable to receive ductile iron or PVC pipe.

C. All gate valves shall have the name or monogram of the manufacturer, the year the valve casting was made, the size of the valve, and the working pressure cast on the body of the valve.

D. Buried service gate valves shall be provided with a 2-inch square operating nut and shall be opened by turning to the left (counterclockwise)

E. Buried service gate valves shall be installed in a vertical position with valve box as detailed on the drawings. They shall be set vertically and properly adjusted so that the cover will be in the same plane as the finished surface of the ground or street.

F. Valves shall be those manufactured by Mueller, M & H Valve Company, American, American AVK, or approved equal.

2.03 BUTTERFLY VALVES (Buried)

A. Valves 14-inch through 24-inch

The butterfly valve shall be DeZurik or M&H Valve Company AWWA C504 series (or approvable equal), mechanical joint, resilient seat, cast iron body and disk, stainless steel shaft and seating edge (ring), neoprene seat, Class 150B or Class 250B as noted on Drawings, cast iron housing with 2-inch operator nut in vertical position for use with a valve box. The valve shall be fully coated, inside and out, with fusion bonded epoxy in accordance with the latest revision of AWWA C550 Standard. Valves shall be rated for 150 psi or 250 psi working pressure as noted on Drawings and/or Bid Schedule.

2.04 VALVE BOXES

A. Each buried stop and valve shall be provided with a suitable valve box top. Tops shall be aluminum "tophat" type as manufactured by Castings, Inc. or approved equal.

B. The valve box top shall be adjusted to proper ground height by installing an appropriate length of 6-inch SDR 17 PVC from the valve to the box top.

C. Covers for valves shall be close fitting and substantially dirt-tight and marked "WATER."

D. The top of the cover shall be flush with the top of the box rim. An arrow and the word OPEN to indicate the direction of turning to open the valve shall be cast in the top of the valve covers.

2.05 COMBINATION AIR RELEASE AND AIR/VACUUM VALVES

A. The combination air/vacuum valves shall be the size noted on the Drawings and equal to A.R.I., D-052, Val-Matic 202c.2, or Engineer approved equal.

B. The valves shall be in accordance with ANSI/AWWA C512.

C. The valves shall be of the type that automatically exhausts large quantities of air during the filling of a system and allows air to re-enter during draining or when a vacuum occurs. The overall height, less backwash accessories, shall not exceed 18 inches. Valves shall be constructed of standard cast iron body with a baked polyester coating and all operating parts shall be made of specially selected corrosion-resistant materials.

D. The valve shall have a rolling seal mechanism that limits the possibility of obstruction by debris, discharges high air flow rates up to 200 yd^3/hr, have a self-cleaning mechanism, and a one size orifice with a wide pressure range.

E. The valve shall be non-slamming with a working pressure range of 0.3 to 230 psi.

F. The discharge orifice shall be fitted with a double-acting throttle device to regulate and restrict air venting.

G. All parts of the valves and the operating mechanisms shall be made of non-corrodible materials.

2.06 TAPPING SLEEVES

A. Tapping sleeves shall be cast iron and capable of containing pressure within the full volume of the sleeve. Sleeve shall be mechanical joint suitable for use with ductile iron or PVC pipe.

B. Sleeve shall be rated at 200 psi working pressure except at wellfield, where sleeve shall be rated for 250 psi working pressure.

C. Flanged throat section of mechanical joint sleeves through 12-inch size shall conform to MSS SP60 Standard. For throat sections larger than 12 inches, flanged section shall mate valves of same manufacture as sleeves.

D. All cast iron shall conform to ASTM A-126, Class B. Castings shall be cleaned and sound without defects that will impair their service. No plugging or welding of such defects will be allowed. Bolts, nuts, and gaskets shall be in accordance with mechanical joint requirements of AWWA C111.

E. Tapping sleeves shall be capable of withstanding their rated pressure without leakage past the side gaskets and end gaskets of the sleeve. Sleeves shall be supplied with split end gaskets and two-piece glands. Side flange rubber gaskets shall butt against the rubber end gaskets to make a watertight seal. Side and end bolts shall be of a T-head design. The throat flange shall be designed to center the tapping valve to the sleeve. Tapping sleeve shall be equipped with a test plug.

F. Tapping sleeves shall be fully coated with fusion bonded epoxy coating in accordance with AWWA C550 Standard.

G. Sleeves shall be marked with the name of the manufacturer and size (run x branch).

H. Tapping sleeve shall be manufactured by Mueller, M & H Valve Company, or approved equal.

2.07 TAPPING VALVES

A. All tapping valves shall be of the resilient seat, gate valve type in accordance with the latest revision of AWWA C509 Standard. The valve body, bonnet, and gate

castings shall be cast iron. The valve shall have a non-rising stem (NRS), fully bronze mounted with o-ring seals. Valve body and bonnet, inside and out, shall be fully coated with fusion bonded epoxy coating in accordance with AWWA C550 Standard. Valves shall have a rated working pressure of 200 psi.

B. Valve shall be furnished with ANSI B16.1 flanged end with centering ring on tapping side. Outlet side shall be mechanical joint. All valves through 12 inches shall mate all sleeves through 12-inch outlet regardless of manufacturer.

C. All cast iron shall conform to ASTM A-126, Class B. Castings shall be clean and sound without defects that will impair their service. No plugging or welding of such defects will be allowed. Bolts shall be electric-zinc plated steel with hex heads and hex nuts in accordance with ASTM A-307 and A-563.

D. Stems shall be manganese bronze having a minimum tensile strength of 60,000 psi, a minimum yield of 20,000 psi. NRS stem collars shall be cast integral with them and machined to size. The housing for the valve stem collar shall be machined. All thrust bearing shall be incorporated, as required, to optimize operating torques. NRS valves shall be furnished with two (2) o-ring stem seals located above the thrust collar and one (1) below. O-rings shall be set in grooves in the stem. The o-ring grooves shall not be less than the root diameter of the stem threads.

Gates for valve shall be totally encapsulated in rubber, be field replaceable, and provide a dual seal on the mating body seat. Valve shall be capable of installation in any position with rated sealing in both directions. Rubber sets of specially compounded SBR materials shall be utilized and be capable of sealing even under conditions of normal wear. The valve body shall have integral guide engaging lugs in the gate in a tongue-and-groove manner, supporting the gate throughout the entire open/close travel.

E. Tapping valves shall be capable of making taps by using any cutter not less than 1/4 inch smaller than nominal pipe size.

F. All tapping valves shall have the name or monogram of the manufacturer, the year the valve casting was made, the size of the valve, and the working pressure cast on the body of the valve.

G. Tapping valves shall be provided with a 2-inch square operating nut and shall be opened by turning to the left counterclockwise.

H. Tapping valves shall be installed in a vertical position with valve box as detailed on the drawings. They shall be set vertically and properly adjusted so that the cover will be in the same plane as the finished surface of the ground or street.

I. Valves shall be those manufactured by Mueller, M & H Valve Company, American, or approved equal.

2.08 COUPLING ADAPTER

A. The pipe couplings shall be of a gasketed, sleeve-type with diameter to properly fit the pipe. Each coupling shall consist of one (1) steel middle ring of thickness and length specified, two (2) steel followers, two (2) rubber-compounded wedge section gaskets and sufficient track-head steel bolts to properly compress the gaskets. Field joints shall be made with this type of coupling. The middle ring and followers of the coupling shall be true circular sections free from irregularities, flat spots, or surface defects. They shall be formed from mill sections with the follower-ring section of such design as to provide confinement of the gasket. After welding, they shall be tested by cold expanding a minimum of one (1) percent beyond the yield point. The coupling bolts shall be of the elliptic-neck, track-head design with rolled threads. The manufacturer shall supply information as to the recommended torque to which the bolts shall be tightened. All bolt holes in the followers shall be oval for greater strength. The coupling shall have longitudinal restraint accomplished by locking pins. The gaskets of the coupling shall be composed of a crude or synthetic rubber base compounded with other products to produce a material which will not deteriorate from age, from heat, or exposure to air under normal storage conditions. It shall also possess the quality of resilience and ability to resist cold flow of the material so that the joint will remain sealed and tight indefinitely when subjected to shock, vibration, pulsation, and temperature or other adjustments of the pipeline. The couplings shall be assembled on the job in a manner to ensure permanently tight joints under all reasonable conditions of expansion, contraction, shifting and settlement, unavoidable variations in trench gradient, etc.

B. Nuts and bolts shall be in accordance with AWWA C111.

C. Couplings shall be shop primed and field painted in accordance with Division 9 (or one coat of coal tar epoxy if not specified in Division 9).

D. Compression couplings shall be equal to Style 38 manufactured by Dresser. Flanged couplings shall have flanges in accordance with AWWA C207 and be equal to Style 127 manufactured by Dresser.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Valves shall be installed as nearly as possible in the positions indicated on the drawings consistent with conveniences of operating the handwheel or wrench. All valves shall be carefully erected and supported in their respective positions free from all distortion and strain on appurtenances during handling and installation.

B. All material shall be carefully inspected for defects in workmanship and material, all debris and foreign material cleaned out of valve openings and seats, all operating mechanisms operated to check their proper functioning, and all nuts and bolts checked for tightness.

C. Valves and other equipment which do not operate easily or are otherwise defective shall be repaired or replaced at the Contractor's expense.

D. Valves shall be provided with extension stems where required for convenience of operation. Extension stems shall be provided for valves installed underground and elsewhere so that the operating wrench does not exceed six (6) feet in length.

3.02 PAINTING

A. Valves shall be factory primed and fully coated, inside and out, with fusion bonded epoxy in accordance with the latest revision of AWWA C550 Standard, if valve is available in this coating.

- END OF SECTION -

SECTION 02675

DISINFECTION OF WATER SYSTEMS

PART 1 - GENERAL

1.01 STERILIZATION

A. General

It is the intent of this section to present essential procedures for disinfecting new and repaired water mains. The section is patterned after AWWA C651. The basic procedure comprises:

1. Preventing contaminating materials from entering the water mains during construction or repair and removing by flushing materials that may have entered the water main.

2. Disinfecting any residual contamination that may remain.

3. Determining the bacteriologic quality by laboratory test after disinfection.

B. Preventive Measures During Construction

1. Precautions shall be taken to protect pipe interiors, fittings, and valves against contamination. Pipe delivered for construction shall be strung so as to minimize entrance of foreign material. When pipe laying is not in progress, as for example, at the close of the day's work, all openings in the pipeline shall be closed by watertight plugs. Joints of all pipe in the trench shall be completed before work is stopped. If water accumulates in the trench, the plugs shall remain in place until the trench is dry.

   If dirt, that, in the opinion of the Engineer, will not be removed by the flushing operation (Article 1.01-C.) enters the pipe, the interior of the pipe shall be cleaned and swabbed as necessary, with a five percent (5%) hypochlorite disinfecting solution.

2. Packing Materials and Joints

   No contaminated material or any material capable of supporting prolific growth of micro-organisms shall be used for sealing joints. Packing material shall be handled in such a manner as to avoid contamination. Where applicable, packing materials must conform to AWWA standards. Packing material for cast iron pipe must conform to AWWA C600. Yarning or packing material shall consist of molded or tubular rubber rings, or treated paper. Materials such as jute or hemp shall not be used. The lubricant used in the installation of sealing gaskets shall be suitable for use in potable water. It shall be delivered to the job in enclosed containers and shall be kept clean.

C. Preliminary Flushing

No site for flushing should be chosen unless it has been determined that drainage is adequate at the site. The main shall be flushed prior to disinfection, except when the tablet or granular methods are used (Articles 1.01-E.3. and 1.01-E.4.). It is recommended that the flushing velocity be not less than 2.5 ft/sec. The rate of flow required to produce this velocity in various diameters is shown in the following table:

REQUIRED OPENINGS TO FLUSH PIPELINES (40-psi Residual Pressure)				
Flow Required to Produce 2.5 ft./sec.		Minimum Outlet Size		
		Flushing Pipe Size (in)	Hydrant Nozzle	
Pipe Size (in)	Flow Rate (gpm)		Number	Size (in)
4	100	1	1	2½
6	220	1½	1	2½
8	390	2	1	2½
10	610	3	1	2½
12	880	3	2	2 ½
14	1,200	4	2	2½
16	1,565	4	2	2½
18	1,980	6	2	2½

D. Form of Chlorine for Disinfection

The most common forms of chlorine used in the disinfecting solutions are liquid chlorine (gas at atmospheric pressure), calcium hypochlorite tablets, calcium hypochlorite granules, and sodium hypochlorite solutions.

1. Liquid Chlorine Use

Liquid chlorine shall be used only when suitable equipment is available and only under the direct supervision of a person familiar with the physiological, chemical, and physical properties of this element and who is properly trained and equipped to handle any emergency that may arise. Introduction of chlorine gas directly from the supply cylinder is unsafe and shall not be permitted.

Note: The preferred equipment consists of a solution fed chlorinator in combination with a booster pump for injecting the chlorine gas water mixture into the main to be disinfected. Direct feed chlorinators are not recommended because their use is limited to situations where the water pressure is lower than the chlorine cylinder pressure.

2. Hypochlorites

a. Calcium Hypochlorite - Calcium hypochlorite contains sixty-five percent (65%) available chlorine by weight. It is either tabular or granular in form. The tablets, 6-8 to the ounce, are designed to dissolve slowly in water. Calcium hypochlorite is packaged in containers of various types and sizes ranging from small plastic bottles to 100-pound drums.

A chlorine-water solution is prepared by dissolving the granules in water in the proportion requisite for the desired concentration.

b. Sodium Hypochlorite - Sodium hypochlorite is supplied in strengths from five and one-quarter percent (5.25%) to sixteen percent (16%) available chlorine. It is packaged in liquid form in glass, rubber, or plastic containers ranging in size from one (1) quart bottles to five (5) gallon carboys. It may also be purchased in bulk for delivery by tank truck.

The chlorine water solution is prepared by adding hypochlorite to water. Product deterioration must be reckoned with in computing the quantity of sodium hypochlorite required for the desired concentration.

E. Methods of Chlorine Application

1. Continuous Feed Method - This method is suitable for general application.

a. Water from the existing distribution system or other approved sources of supply shall be made to flow at a constant, measured rate into the newly laid pipeline. The water shall receive a dose of chlorine, also fed at a constant, measured rate. The two rates shall be proportioned so that the chorine concentration in the water in the pipe is maintained at a minimum of 50 mg/L available chlorine. To assure that this concentration is maintained, the chlorine residual should be measured at regular intervals in accordance with the procedures described in the current edition of Standard Methods and AWWA M12--Simplified Procedures for Water Examination.

Note: In the absence of a meter, the rate may be determined either by placing a pitot gauge at the discharge or by measuring the time to fill a container of known volume.

Solutions of one percent (1%) chlorine may be prepared with sodium hypochlorite or calcium hypochlorite. The latter solution requires approximately one (1) pound of calcium hypochlorite in eight and five-tenths (8.5) gallons of water. The following table

gives the amount of chlorine residual required for each 100 feet of pipe of various diameters:

CHLORINE REQUIRED TO PRODUCE 50 mg/L CONCENTRATION IN 100 FT. OF PIPE (By Diameter)		
Pipe Size (in)	**100 Percent Chlorine (lb)**	**1 Percent Chlorine Solutions (gal)**
4	0.027	0.33
6	0.061	0.73
8	0.108	1.3
10	0.170	2.04
12	0.240	2.88

b. During the application of the chlorine, valves shall be manipulated to prevent the treatment dosage from flowing back into the line supplying the water. Chlorine application shall not cease until the entire main is filled with the chlorine solution. The chlorinated water shall be retained in the main for at least twenty-four (24) hours during which time all valves and hydrants in the section treated shall be operated in order to disinfect the appurtenances. At the end of this 24-hour period, the treated water shall contain no less than 25 mg/L chlorine throughout the length of the main.

2. Slug Method

This method is suitable for use with mains of large diameter for which, because of the volumes of water involved, the continuous feed method is not practical.

a. Water from the existing distribution system or other approved source of supply shall be made to flow at a constant, measured rate (see Article 1.01-E.1.a.) into the newly laid pipeline. The water shall receive a dose of chlorine also fed at a constant, measured rate. The two rates shall be proportioned so that the concentration in the water entering the pipeline is maintained at no less than 300 mg/L. The chlorine shall be applied continuously and for a sufficient period to develop a solid column or "slug" of chlorinated water that will, as it passes along the line, expose all interior surfaces to a concentration of at least 300 mg/L for at least three (3) hours. The application shall be checked at a tap near the upstream end of the line by chlorine residual measurements.

b. As the chlorinated water flows past tees and crosses, related valves and hydrants shall be operated as to disinfect appurtenances.

3. Tablet Method

Tablet disinfection is best suited to short extension (up to 2,500 feet) and smaller diameter mains (up to 12 inches). Because the preliminary flushing step must be eliminated, this method shall be used only when scrupulous cleanliness has been exercised. It shall not be used if trench water or foreign material has entered the main or if the water is below 5 degrees C (41 degrees Fahrenheit).

a. Placement of Tablets - Tablets are placed in each section of pipe and also in hydrants, hydrant branches, and other appurtenances. They shall be attached by an adhesive, except for the tablets placed in hydrants and in the joints between the pipe sections. All the tablets within the main must be at the top of the main. If the tablets are fastened before the pipe section is placed in the trench, their position should be marked on the section to assure that there will be no rotation. When placing tables in joints, they are either crushed and placed on the inside annular space, or, if the type of assembly does not permit, they are rubbed like chalk on the butt ends of the sections to coat them with calcium hypochlorite.

The adhesive may be Permatex No. 1 or any alternative approved by the Engineer of the purchaser. There shall be no adhesive on the tablet except on the broad side next to the surface to which the tablet is attached. The following table gives the number of hypochlorite tablets required for various pipe diameters and lengths:

NUMBER OF 5G HYPOCHLORITE TABLES REQUIRED FOR DOSE OF 50 mg/L

Length of Pipe (ft)	Pipe Diameter					
	2	4	6	8	10	12
13 or less	1	1	2	2	3	5
18	1	1	2	3	5	6
20	1	1	2	3	5	7
30	1	2	3	5	7	10
40	1	2	4	6	9	14

b. Filling and Contact - When installation has been completed, the main shall be filled with water at a velocity of less than one (1) foot per second. This water shall remain in the pipe for at least twenty-four (24) hours.

Valves shall be manipulated so that the strong chlorine solution in the line being treated will not flow back into the line supplying the water.

4. Granule Method

Granular disinfection should only be used in the same instances when tabular disinfection can be used; that is, it may be used if the pipes and appurtenances are kept clean and dry during construction.

a. Placement of Granules - Granules of calcium hypochlorite shall be placed during construction at the upstream end of the first section of pipe, at the upstream end of each branch main, and at 500-ft intervals.

Note: These granules cannot be used on solvent-welded plastic or on screwed-joint pipe because of the danger of fire or explosion from the reaction of the joint compounds with the calcium hypochlorite.

The following table gives the ounces of hypochlorite granules required for various pipe diameters:

OUNCES OF CALCIUM HYPOCHLORITE GRANULES TO BE PLACED AT BEGINNINGS OF MAIN AND AT 500-ft INTERVALS	
Pipe Diameter (in.)	**Calcium Hypochlorite Granules (oz.)**
4	0.5
6	1.0
8	2.0
12	4.0
16 and larger	8.0

b. Filling and Contact - When installation has been completed, the main shall be filled with water at a velocity of less than one (1) foot per second. This water shall remain in the pipe for at least twenty-four (24) hours. If the water temperature is less than 41°F (5 °C), the water shall remain in the pipe for at least forty-eight (48) hours.

Valves shall be manipulated so that the strong chlorine solution in the line being treated will not flow back into the line supplying the water.

F. Final Flushing

After the applicable retention period, the heavily chlorinated water shall be flushed from the main until the chlorine concentration in the water leaving the main is no higher than that generally prevailing in the system, or less than 1 mg/L. Chlorine residual determination shall be made to ascertain that the heavily chlorinated water has been removed from the pipeline.

G. Bacteriologic Tests

1. After final flushing, and before the water main is placed in service, a sample or samples shall be collected from the end of the line and tested for bacteriologic quality and shall show the absence of coliform organisms. If the number and frequency of samples is not prescribed by the public health authority having jurisdiction, at least one sample shall be collected from chlorinated supplies where a chlorine residual is maintained throughout the new main. From unchlorinated supplies at least two samples shall be collected at least twenty-four (24) hours apart.

2. Samples for bacteriologic analysis shall be collected in sterile bottles treated with sodium thiosulphate. No hose or fire hydrant shall be used in collection of samples. A suggested sampling tap consists of a standard corporation cock installed in the main with a copper tube gooseneck assembly. After samples have been collected, the gooseneck assembly may be removed, and retained for future use.

H. Repetition of Procedure

If the initial disinfection fails to produce satisfactory samples, disinfection shall be repeated until satisfactory samples have been obtained. The tablet method cannot be used in these subsequent disinfections. When the sample tests indicate that disinfection has been effective, the main may be placed in service.

I. Procedure After Cutting Into or Repairing Existing Mains

The procedures outlined in the Article apply primarily when mains are wholly or partially dewatered. Leaks or breaks that are repaired with clamping devices while the mains remain full of water under pressure present little danger of contamination and require no disinfection.

1. Trench "Treatment"

When an old line is opened, either by accident or by design, the excavation will likely be wet and may be badly contaminated from nearby sewers. Liberal quantities of hypochlorite applied to open trench areas will lessen the danger from such pollution. Tablets have the advantage in such a situation because they dissolve slowly and continue to release hypochlorite as water is pumped from the excavation.

2. Main Disinfection

The following procedure is considered as a minimum that may be used.

a. Swabbing with Hypochlorite Solution - The interior of all pipe and fittings used in making the repair (particularly couplings and tapping sleeves) shall be swabbed with five percent (5%) hypochlorite solution before they are installed.

b. Flushing - Thorough flushing is the most practical means of removing contamination introduced during repairs. If valving and hydrant locations permit, flushing from both directions is recommended. Flushing shall be started as soon as the repairs are completed and continued until discolored water is eliminated.

c. Slug Method - Where practicable, in addition to the above procedures, a section main in which the break is located shall be isolated, all service connections shut off, and the section flushed and chlorinated as described in Article 2.5.2, except that the dose may be increased to as much as 500 mg/L, and the contact time reduced to as little as one-half (1/2) hour. After chlorination, flushing shall be resumed and continued until discolored water is eliminated.

3. Sampling

Bacteriologic samples shall be taken after repairs to provide a record by which the effectiveness of the procedures used can be determined. If the direction of flow is unknown, samples shall be taken on each side of the main break.

1.02 DISINFECTION OF WATER PLANT PROCESS BASINS AND CONNECTING PIPING

All water treatment plant basins and connecting piping downstream of the filter influent shall be disinfected to the same specification as given for the disinfection and bacteriological testing of mains. The Contractor shall take all necessary precautions to assure that there is no damage due to chlorine fumes during or after the disinfection process.

1.03 ALTERNATIVE METHOD FOR DISINFECTION OF LARGE TANKS

Fill tank with enough water (containing a free chlorine concentration of at least 250 mg/L) to spray all inside tank surfaces with the chlorinated water. Repeat the spraying again at no less than 60 minutes from the end of the first spraying. Drain the tank at no less than 30 minutes from the end of the second spraying before filling for use.

1.04 DECHLORINATION

All water discharged to the environment that could reach streams or ponds shall be properly dechlorinated prior to discharge.

- END OF SECTION -

SECTION 02835

CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.01 SUMMARY

A. The Contractor shall furnish and erect the chain link fence and gates as indicated on the drawings and as herein specified.

B. The chain link fence shall have a top rail and bottom tension wire, and three (3) strands of barbed wire projecting outward at the top.

C. The chain link fence materials and installation shall meet or exceed the standards of the Chain Link Fence Manufacturers Institute, New York, NY, except as otherwise specified in this Section. Fence materials shall meet or exceed Federal Specification RR-F-191H/GEN for fencing, wire, and post metal (gates, chain link fence fabric, and accessories), and shall conform to the ASTM Standard Specifications hereinafter noted.

D. Fence framework, fabric, and accessories.

E. Excavation for post bases.

F. Concrete anchorage for posts and center drop for gates.

G. Manual gates and related hardware.

1.02 RELATED SECTIONS

Section 03300 - Cast-in-Place Concrete

1.03 REFERENCES

A. ANSI/ASTM A123: Zinc (hot galvanized) coating of products fabricated from rolled, pressed, and forged steel shapes, plates, bars, and strips.

B. ANSI/ASTM F567: Installation of chain link fence.

C. ASTM A120: Pipe, steel, black and hot-dipped zinc-coated (galvanized) welded and seamless, for ordinary uses.

D. ASTM C94: Ready-mix concrete.

E. FS RR-F-191: Fencing, wire, post, and metal.

1.04 QUALITY ASSURANCE

A. Manufacturer: Company specializing in commercial quality chain link fencing with two (2) years of experience.

B. Installation: ANSI/ASTM F567.

1.05 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 01300.

B. Include plan layout, grid, spacing of components, gates, accessories, fittings, hardware, anchorages, and schedule of components.

C. Submit manufacturer's installation instructions under provisions of Section 01300.

PART 2 - PRODUCTS

2.01 MATERIALS

A. All ferrous metal fittings, posts, fence, and gate framework, and all accessories shall be galvanized with a heavy coating of 2.0 ounces pure zinc spelter per square foot of surface area to be coated using the hot-dip process. Thinner zinc coatings and electro-galvanizing will not be used as a substitute for the specified hot-dip galvanized finish.

B. All fabrication and welding shall be done before hot-dip galvanizing. All welding shall conform to the American Welding Society standards.

C. The chain link fence fabric shall be galvanized steel chain link fabric conforming to ASTM Standard Specification for zinc-coated steel chain link fence fabric, Designation A392-74, with Class 2 zinc coating (2.0 ounces of zinc per square foot of uncoated wire surface). The fabric shall be woven in 2-inch mesh from No. 9 gage wire in a 7-foot width with barbed salvages top and bottom.

D. The barbed wire shall be galvanized steel barbed wire consisting of two (2) strands of twisted No. 12 1/2-gage wires with 4-point barbs spaced three (3) inches apart and conforming to ASTM Standard Specification of zinc-coated (galvanized) steel barbed wire, Designation A121-77, with Class 3 zinc coating (minimum of 0.80 ounces of zinc per square foot of uncoated wire surface for No. 12 1/2-gage wire).

E. The tension wire shall be No. 7 gage coil spring steel wire with galvanized finish having minimum of 0.80 ounces of zinc coating per square foot of uncoated wire surface.

F. Tie wires for fastening fence fabric to line posts and rails shall be not less than No. 6 gage aluminum wire.

G. Line posts shall be $2^3/_8$ inches outside diameter steel pipe weighing not less than 3.65 pounds per foot, or $1^7/_8$ inches high carbon steel H-beams weighing not less than 2.70 pounds per foot.

H. End, corner, and pull posts shall be $2^7/_8$ inches outside diameter steel pipe weighing not less than 5.79 pounds per foot, or 2½ inches square steel tube weighing not less than 5.14 pounds per foot, or 3½ inches roll-formed, steel corner section weighing not less than 5.14 pounds per foot.

I. Gate posts for gate leaves up to and including 6-foot wide, shall be $2^7/_8$ inches outside diameter steel pipe weighing not less than 5.79 pounds per foot or 3½ inches by 3½ inches roll-formed, steel corner section weighing not less than 5.14 pounds per foot.

J. Gate posts for gate leaves over six (6) feet wide, including 13 feet wide, shall be four (4) inches outside diameter steel pipe weighing not less than 9.10 pounds, outside diameter steel pipe weighing not less than 9.10 pounds per foot.

K. Top railings and railing for top, middle, and bottom braces between terminal posts and adjacent line posts shall be $1^5/_8$ inch outside diameter steel pipe weighing not less than 2.27 pounds per foot, or $1^5/_8$ inches by 1¼ inches, 14 gage roll-form section.

L. Diagonal truss braces between terminal and adjacent line posts and for gate framework shall be 3/8-inch diameter steel rod.

M. Barbed wire support arms shall project outward from the top of the posts at 45 degrees and shall be capable of withstanding a 200-pound downward pull on the outermost end of arm, without failure. The arms shall have provision for the attachment of three (3) strands of evenly spaced barbed wire. Arms shall be integral with post top weather caps having holes for the passage of the top rail at intermediate posts.

N. Fittings shall be heavy duty malleable iron or pressed steel of suitable size to produce strong construction.

O. Stretcher bars for attaching fabric to terminal posts such as end, corner, pull, or gate posts and gate frames shall be flat bars with minimum cross-section dimensions of not less than 1/4-inch by 3/4-inch. The stretcher bars shall be the full height of the fabric and shall be secured with bar bands of not less than 11 gage sheet steel, spaced approximately 15 inches on centers and bolted with 3/8-inch diameter bolts.

P. Gate framework shall be $1^7/_8$ inches outside diameter steel pipe weighing not less than 2.72 pounds per foot.

Q. If bolted or riveted corner fittings are not used, the gate frame shall be hot-dip galvanized after welding.

R. Gate hinges shall be of heavy pattern of adequate strength for the gate size, with large bearing surfaces for clamping or bolting in position.

S. The gates shall be provided with a suitable latch accessible from both sides and with provision for padlocking.

T. Double leaf swing gates shall have a center bolt, center stop, and automatic backstops to hold leaves in open position.

U. Gate padlocks shall have solid brass cases, hardened steel shackles, removable core cylinders, and stainless steel chains attached to the shackle by a clevis. Padlocks shall be manufactured by Eaton Corporation Lock & Hardware Division, of Emhart Corporation, Berlin, CT; Best Universal Lock Company, Inc., Indianapolis, IN; or approved equal. The padlocks shall be furnished with two (2) keys each and keyed on the project master key system.

2.02 CONCRETE MIX

Concrete shall be in accordance with Division 3.

2.03 FINISHES

A. Galvanized: ANSI/ASTM A123; 1.8 ounce per square foot coating.

B. Accessories: Same finishing as framing and fabric.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The fence and gates shall be erected by skilled mechanics.

B. Post spacing shall be uniform with maximum spacing of 10 feet in fences erected along straight lines. All posts shall be placed plumb and centered in the concrete foundation.

C. Post foundations in earth shall be concrete cylinders with a minimum diameter of 12 inches, crowned at grade to shed water, and shall not be less than 36 inches deep in the ground. Posts shall be set in the full depth of the foundations except for three (3) inches of concrete under the posts.

D. If foundation holes are excavated in peat or other unstable soil, the Engineer shall be notified for determination of suitable construction precautions.

E. If solid ledge is encountered without overburden of soil, posts shall be set into the rock a minimum depth of 12 inches for line posts and 18 inches for terminal posts. Post holes shall be at least one (1) inch greater in diameter than the post, and the grout shall be thoroughly worked into the hole so as not to leave voids, and shall be

crowned at the top to shed water. Where solid rock is covered by an overburden, the total setting depths shall not exceed the depths required for setting in earth, and the posts shall be grouted into the rock as described.

F. Any change in direction of the fence line of 20 degrees or more shall be considered corners. Pull posts shall be used at any abrupt change in grade.

G. Maximum area of unbraced fence shall not exceed 1,500 square feet.

H. Terminal posts shall be braced to adjacent posts with horizontal brace rails and diagonal truss rods brought to proper tension so that posts are plumb.

I. There shall be no loose connections or sloppy fits in the fence framework. The fence framework shall withstand all wind and other forces due to the weather.

J. Fabric shall be stretched taut and tied to posts, rails, and tension wires with the bottom edge following the finished grade not more than two (2) inches above the grade. The fabric shall be installed on the security side of the fence and shall be anchored to the framework so that the fabric remains in tension after pulling force is released. The fabric shall be attached to line posts with ties spaced at not more than 15-inch intervals and to rails and braces at no more than 24-inch intervals. The fabric shall be attached to the tension wire with hog ring ties on 24-inch centers.

K. Three (3) strands of barbed wire shall be installed on each extension arm of the line fence at the top of each gate. The wires shall be pulled taut and fastened at each support.

L. Gates shall be installed plumb, level, and secure for the full width of the opening and the hardware adjusted for smooth operation. Provide concrete center drip to foundation depth and drop rod retainers at center of double gate openings.

- END OF SECTION -

SECTION 02935

SEEDING AND SODDING

PART 1 - GENERAL

1.01 GENERAL

The Contractor shall furnish all labor, materials, and equipment to regrade construction areas to original contours or regrade contours shown on drawings, fertilize and lime, seed or sod, and return all disturbed areas to their original or regrade contour and condition.

PART 2 - PRODUCTS

2.01 LIME AND FERTILIZER

Four (4) tons of agricultural limestone per acre and 1,000 pounds per acre of fertilizer with a 10-10-10 analysis shall be uniformly applied.

2.02 SEED

A mixture of fifty percent (50%) Falcon Fescue, twenty-five percent (25%) Creeping Red Fescue (Festuca rubra), ten percent (10%) Redtop (Agrostis alba), five percent (5%) White Dutch Clover (Trifolium repens), and ten percent (10%) Ryegrass, perennial (Colium perenne) shall be sowed at the rate of 100 pounds per acre (2.3 pounds per 1000 square feet). The seed shall have a minimum of eighty percent (80%) germination and a maximum of one percent (1%) weeds.

2.03 SOD

Sod shall be thirty percent (30%) to fifty percent (50%) bluegrass and fifty percent (50%) to seventy percent (70%) Falcon Fescue.

2.04 TOPSOIL

Topsoil shall be fertile, natural soil, typical of the locality, free from large stones, roots, sticks, peat, weeds, and sod, and obtained from naturally well-drained areas. It shall not be excessively acid or alkaline nor contain other toxic material harmful to plant growth. Topsoil stockpiled under other Sections or Divisions may be used, but the Contractor shall furnish additional topsoil at his own expense, if required.

2.05 MULCH

Mulch shall be clean small-grain straw.

PART 3 - EXECUTION

3.01 GRADING

A. Upon completion of backfill, the construction area shall be regraded roughly to original or regrade contours. The top four (4) inches of the regrade must be free from rocks and other deleterious material. All rock shall be picked up and disposed of at a designated place approved by Owner.

B. Any and all settled areas must be brought to grade and restored to as near original conditions as possible prior to final acceptance of the project by the Owner.

3.02 TOPSOIL APPLICATION

Topsoil shall be spread and lightly compacted to finished grade. Compacted topsoil shall not be less than the depth specified. No topsoil shall be spread in water or while frozen or muddy.

3.03 SEEDING AND SODDING

A. Preparation of Seed Bed

Where the area to be seeded is not sufficiently pulverized to provide a good seedbed, the seedbed will be prepared by pulverizing the soil to a depth of four (4) inches with a disk harrow, drag harrow, spike toothed harrow or similar tool immediately prior to seeding. Lime and fertilizer shall be applied prior to preparing seedbed.

B. Seeding

The seed shall be raked into the ground to a depth of approximately ¼ inch.

C. Mulching

All seeded areas shall be mulched with clean small-grain straw at a rate of 1½ to 2 tons per acre. Asphalt emulsion shall be applied uniformly at a rate of 300 gallons per acre to tack the mulch, unless otherwise shown on the Drawings. Mechanical tacking will be considered on a case-by-case basis as approved by the Engineer .

D. Sodding

The sod bed shall be prepared, fertilized and limed similar to those areas to be seeded. Then the sod shall be placed in accordance with Section 528.3.4 of the Standard Specifications for Road and Bridge Construction of the Kentucky Department of Transportation.

E. Watering

The Contractor shall keep all seeded and sodded areas watered and in good condition, reseeding if, and when, necessary, until a good, healthy, uniform growth is established over the entire area seeded, and shall maintain these areas in good condition until final acceptance of the Contract.

F. Washouts

On slopes, the Contractor shall provide against washouts by an approved method. Any washout which occurs shall be regraded and reseeded at the Contractor's expense until good sod is established.

G. Maintenance

The Contractor shall maintain the areas in grass in a neat manner by watering, mowing, and raking clippings and leaves until the project is completed.

- END OF SECTION -

DIVISION 3

CONCRETE

SECTION 03100

CONCRETE FORMWORK

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Formwork for cast-in-place concrete, with shoring, bracing, and anchorage.

B. Openings for other affected work.

C. Form accessories.

D. Stripping forms.

1.02 RELATED WORK

A. Section 03210 - Reinforcing Steel

B. Section 03310 - Structural Concrete

C. Section 13210 – Composite Elevated water Storage Tank

1.03 REFERENCES

A. ACI 301 - Specifications for Structural Concrete for Buildings.

B. ACI 347 - Recommended Practice for Concrete Formwork.

C. PS 1 - Construction and Industrial Plywood.

D. ACI 318 - Building Code Requirements for Reinforced Concrete.

E. Field Reference Manual, ACI Publication SP-15.

F. ACI 117 B Standard Specifications for Tolerances for Concrete Construction and Materials.

1.04 SYSTEM DESCRIPTION

Design, engineer and construct formwork, shoring, bracing to meet design and code requirements, so that resultant concrete conforms to required shapes, lines, dimensions and tolerances. See also Section 13210 for concrete specific to tank.

1.05 QUALITY ASSURANCE

Construct and erect concrete formwork in accordance with ACI 301 and 347, latest revisions. Contractor shall maintain a copy of these standards, or Publication SP-15 in the field at all times.

PART 2 - PRODUCTS

2.01 FORM MATERIALS

A. Plywood; APA Plyform, Class 1; sound, undamaged sheets with straight edges.

B. Forms shall be sufficiently rigid to prevent displacement or sagging between supports, and so constructed that the concrete will not be damaged by their removal. The Contractor shall be entirely responsible for their adequacy.

C. For surfaces to be given rubbed finish, the form in contact with the concrete shall be made of plywood, metal, metal framed plywood faced, or other acceptable panel-type materials, to provide continuous straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize the number of joints. Forms shall not be pieced out by use of material different from those in the adjacent form or in such manner as will detract from the uniformity of the finished surface.

D. For surfaces other than those to be given rubbed finish forms shall be made of wood, metal, or other acceptable material. Wooden forms shall be constructed of sound lumber or plywood of suitable dimensions, free from knotholes and loose knots. Plywood shall be in reasonably good, condition. Metal forms shall be of an acceptable type for the work involved.

2.02 FORMWORK ACCESSORIES

A. Form ties to be encased in concrete shall not be made of through bolts or common wire, but shall be of a well established type, so made and installed as to embody the following features:

1. After removal of the protruding part of the tie, there shall be no metal nearer than 1½ inch to the face of the concrete.

2. That part of the tie which is to be removed shall be at least 1/2 inch in diameter, or if smaller, it shall be provided with a wood, metal, or plastic cone one (1) inch long placed against the inside of the forms. Cones shall be carefully removed from the concrete after the forms have been stripped.

3. Ties which pass through walls of liquid retaining basins and all below grade structures which are to remain dry shall be provided with acceptable water stop, securely fastened to the ties.

B. Form Release Agent: Colorless material which will not stain concrete, absorb moisture or impair natural bonding or color characteristics of coating intended for use on concrete. Acceptable products include Nox-Crete Form Coating Release Agent, Debond Form Coating by L&M Construction Chemicals Inc., or approved equal.

C. Fillets for Chamfered Corners: Wood strip type to the size and shape as shown on the Drawings.

D. Nails, spikes, lag bolts, through bolts, anchorages: Sized as required of strength and character to maintain formwork in place while placing concrete.

PART 3 - EXECUTION

3.01 INSPECTION

Verify lines, levels and measurements before proceeding with formwork.

3.02 PREPARATION

Earth or rock forms for vertical surfaces are not permitted. The vertical surface of all footings shall be formed.

3.03 ERECTION

A. Provide bracing to ensure stability of formwork. Strengthen formwork liable to be overstressed by construction loads.

B. Camber slabs and beams to achieve ACI 301 tolerances.

C. Forms for walls shall have removable panels at bottom for cleaning, and inspection. Forms for thin sections (such as walls) of considerable height shall be arranged with suitable openings so that the concrete can be placed in a manner that will prevent segregation and accumulations of hardened concrete on the forms or reinforcement above the fresh concrete, unless special spouts are used to place concrete, and so that construction joints can be properly keyed and treated.

D. Forms for exposed surfaces shall be built with 3/4-inch chamfer strips attached to produce smooth, straight chamfers at all sharp edges of concrete.

E. Before form material is reused, all surfaces that are in contact with the concrete shall be thoroughly cleaned, all damaged places repaired, and all projecting nails withdrawn.

3.04 TOLERANCES

ACI 117 shall be followed for forming tolerance limits.

3.05 APPLICATION OF RELEASE AGENT

Apply form release agent on formwork in accordance with manufacturer's instructions. Apply prior to placing reinforcing steel, anchoring devices, and embedded items.

3.06 INSERTS, EMBEDDED PARTS, AND OPENINGS

A. Provide formed openings where required for work embedded in or passing through concrete.

B. Coordinate work of other sections in forming and setting openings, and other inserts.

C. Install accessories in accordance with manufacturer's instructions, level and plumb. Ensure items are not disturbed during concrete placement.

3.07 FORM REMOVAL

A. Do not remove forms and bracing until concrete has sufficient strength to support its own weight, construction and design loads which may be imposed upon it. Remove load supporting forms when concrete has attained 75 percent of required 28-day compressive strength, provided construction is reshored immediately, and the shoring remains until the concrete attains its 28-day compressive strength.

B. Reshore structural members due to design requirements or construction conditions to permit successive construction.

C. Remove formwork progressively so that unbalanced loads are not imposed on structure.

D. Do not damage concrete surfaces during form removal.

3.08 CLEANING

A. Clean forms to remove foreign matter as erection proceeds.

B. Ensure that water and debris drain to exterior through clean out ports.

C. During cold weather, remove ice and snow from forms. Do not use deicing salts. Do not use water to clean out completed forms, unless formwork and construction proceed within heated enclosure. Use compressed air to remove foreign matter.

- END OF SECTION -

SECTION 03210

REINFORCING STEEL

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Reinforcing steel.

B. Shop Drawings.

1.02 RELATED WORK

A. Section 03100 - Concrete Formwork

B. Section 03310 - Structural Concrete

C. Section 13210 – Composite Elevated Water Storage Tank

1.03 REFERENCES

A. ASTM A-615 - Deformed and Plain Billet - Steel Bars for Concrete Reinforcement.

B. ASTM A-616 - Rail Steel Deformed and Plain Bars for Concrete Reinforcement.

C. ASTM A-617 - Axle Steel Deformed and Plain Bars for Concrete Reinforcement.

D. ACI 315 - Details and Detailing of Concrete Reinforcement.

E. ACI 315R - Manual of Engineering and Placing Drawings for Reinforced Concrete Structures.

F. ASTM A-185 - Welded Steel Wire Fabric For Concrete Reinforcement.

G. ACI 301-96 - Standard Specifications For Structural Concrete.

H. ACI 117-90 - Standard Specifications for Tolerances for Concrete Construction and Materials.

1.04 SUBMITTALS

Shop Drawings: The Contractor shall submit a complete set of shop drawings including schedules and bending drawings for all reinforcement used in the work in accordance with

ACI 315, and ACI 315R. Review of drawings by the Contractor and the Engineer is required before shipment can be made.

PART 2 - PRODUCTS

2.01 MATERIALS

A. The minimum yield strength of the reinforcement shall be 60,000 pounds per square inch. Bar reinforcement shall conform to the requirements of ASTM A-615, A-616, or A-617. All bar reinforcement shall be deformed.

B. Smooth dowels shall be plain steel bars conforming to ASTM A-615, Grade 40.

C. Reinforcement supports and other accessories in contact with the forms for members which will be exposed to view in the finished work shall have approved high density polyethylene tips so that the metal portion shall be at least one quarter of an inch from the form or surface. Supports for reinforcement, when in contact with the ground or stone fill, shall be precast stone concrete blocks.

2.02 FABRICATION

A. Reinforcement shall be bent cold. It shall be bent accurately to the dimensions and shapes shown on the plans and to within tolerances specified in the CRSI Manual of Standard Practice.

B. Reinforcement shall be shipped with bars of the same size and shape, fastened securely with wire and with metal identification tags using size and mark.

PART 3 - EXECUTION

3.01 PLACING AND FASTENING

A. Before being placed in position, reinforcement shall be cleaned of loose mill and rust scale, dirt and other coatings that will interfere with development of proper bond.

B. Reinforcement shall be accurately placed in positions shown on the drawings and firmly held in place during placement and hardening of concrete by using annealed wire ties. Bars shall be tied as required to prevent displacement under foot traffic and during casting operations, and shall be placed within tolerances allowed in ACI 117.

C. Distance from the forms shall be maintained by means of stays, blocks, ties, hangers or other approved supports. (See paragraph 2.01 D) If fabric reinforcement is shipped in rolls, it shall be straightened into flat sheets before being placed.

D. Before any concrete is placed, the Engineer shall have inspected the placing of the steel reinforcement and given permission to deposit the concrete. Concrete placed in violation of this provision will be rejected and thereupon shall be removed.

E. Unless otherwise specified, reinforcement shall be furnished in the full lengths indicated on the plans. Splicing of bars, except where shown on the plans, will not be permitted without the approval of the Engineer. Where splices are made, they shall be staggered insofar as possible.

F. Wire mesh reinforcement shall be continuous between expansion joints. Laps shall be at least one full mesh plus two (2) inches, staggered to avoid continuous lap in either direction and securely wired or clipped.

G. Dowels shall be installed at right angles to construction joints and expansion joints. Dowels shall be accurately aligned parallel to the finished surface, and shall be rigidly held in place and supported during placing of the concrete. One end of dowels shall be oiled or greased or dowels shall be coated with high density polyethylene with a minimum thickness of 14 mils.

- END OF SECTION -

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. See also Section 13210 – Composite Elevated Water Storage Tank for concrete specific to tank.

B. Provide all labor, material, equipment, and services to complete all cast-in-place concrete work stipulated by the project, shown on the Drawings, or as herein specified. Generally, the work is to include, but not limited to, the following:

1. Entire concrete work shown on the contract Drawings.
2. Steel reinforcement including welded wire fabric.
3. Exterior concrete pavements, walks, and concrete curbs.
4. Concrete accessories.
5. Openings, pockets, chases, blockouts required, or as shown on the Drawings.
6. Forming, finishing, curing, and patching.
7. Construction, control, and expansion joints.
8. Granular base course under floors and all exterior pavements as indicated.
9. Moisture barrier under floor slab as specified.
10. Sealing of construction joints, exterior concrete pavements, and walks.
11. Non-shrink grout, grout, and patching mortar.
12. Waterstops.

C. All work shall be performed to provide homogeneous concrete having required strength, durability, weather resistance, and watertight basins without any structural defects such as, but not limited to, planes of weakness, pronounced honeycombs, voids, and air pockets.

1.02 RELATED SECTIONS

Section 03410 – Plant Precast Structural Concrete
Section 13210 – Composite Elevated Water Storage Tank

1.03 REFERENCES (Latest Editions)

A. ACI 211.1- Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete

B. ACI 301 – Standard Specifications for Structural Concrete

C. ACI 302 – Guide for Concrete Floor and Slab Construction

D. ACI 304 – Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete

E. ACI 305R – Hot Weather Concreting

F. ACI 306R – Cold Weather Concreting

G. ACI 308 – Standard Practice for Curing Concrete

H. ACI 311 – Recommended Practice for Concrete Inspection

I. ACI 315 – Details and Detailing of Concrete Reinforcement

J. ACI 318 – Building Code Requirements for Reinforced Concrete

K. ACI 350R – Environmental Engineering Concrete Structures

L. ASTM C33 – Concrete Aggregates

A. ASTM C94 - Ready-Mixed Concrete

B. ASTM C150 - Portland Cement

C. ASTM C260 - Air Entraining Admixtures for Concrete

D. ASTM C494 - Chemical Admixtures for Concrete

E. ASTM C618 - Fly Ash and Raw or Calcinated Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete

F. ASTM C948 - Test Method for Dry and Wet Bulk Density, Water Absorption and Apparent Porosity of Thin Sections of Glass-Fiber-Reinforced Concrete

G. ASTM D994 - Preformed Expansion Joint Filler for Concrete (Bituminous Type)

H. ASTM D1190 - Concrete Joint Sealer, Hot-Poured Elastic Type

I. ASTM D1751 - Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)

J. ASTM D1752 - Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

K. ASTM E1155 – Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers

1.04 SUBMITTALS

A. Product Data

For each manufactured material and product utilized under this section including, but not limited to, aggregates, admixtures, method of adding admixtures, materials and method of curing, method of developing bond at joints, joint materials, waterstops, and vapor barriers.

B. Design Mixes

For each concrete mix indicated.

C. Shop Drawings

Include details of steel reinforcement placement including material, grade, bar schedules, stirrup spacing, bent bar diagrams, arrangement, and supports. Shop drawings to include the proposed construction and control joint locations.

D. Material Certificates

E. Testing agency to perform service required in ACI 301.

F. Laboratory tests on concrete.

G. If ready-mixed concrete is used, provide the following:

1. Physical capacity of mixing plant.

2. Trucking facilities available.

3. Estimated average amount which can be produced and delivered to the site during a normal 8-hour day excluding the output to other customers.

4. Delivery Tickets: Furnish to Engineer copies of all delivery tickets for each load of concrete delivered to the site. Provide items of information as specified in ASTM C 94.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications

A firm experienced in manufacturing ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.

B. Comply with ACI 301, "Specifications for Structural Concrete", including the following unless modified by the requirements of the Contract Documents.

1. General requirements including submittals, quality assurance, acceptance of structure, and protection of in-place concrete.

2. Formwork and form accessories.

3. Steel reinforcement and supports.

4. Concrete mixtures.

5. Handling, placing, and constructing concrete.

C. Conform to ACI 305R when concreting during hot weather.

D. Conform to ACI 306R when concreting during cold weather.

E. Acquire cement and aggregate from same source for all work.

F. Preinstallation Conference

Conduct conference at project site.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Formwork

Furnish formwork and form accessories according to ACI 301.

B. Steel Reinforcement

1. Reinforcing Bars: ASTM A 615, Grade 60, deformed.

2. Plain-Steel Tie Wire: ASTM A 82, as drawn.

3. Plain-Steel Welded Wire Fabric: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.

4. Supports for Reinforcement

Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place. Use wire-bar-type supports complying with CRSI specifications.

a. For slabs-on-grade, use supports with sand plates or horizontal runners where base material will not support chair legs.

b. For exposed-to-view concrete surfaces where legs of support are in contact with forms, provide supports with legs that are protected by plastic (CRSI, Class 1) or stainless steel (CRSI, Class 2).

C. Concrete Materials

1. Portland Cement

ASTM C 150, Type I or II. Air-entrained Portland cements shall not be utilized.

2. Normal-Weight Aggregate

ASTM C 33, uniformly graded, not exceeding 1½-inch nominal size for foundation mats, and not exceeding 3/4-inch for others.

3. Water: Complying with ASTM C 94.

D. Admixtures

1. Air-Entraining Admixture: ASTM C 260.

2. Water-Reducing Admixture: ASTM C 494, Type A.

3. High-Range, Water-Reducing Admixture (Superplasticizers): ASTM C 494, Type F.

4. Water-Reducing and Accelerating Admixture: ASTM C 494, Type E.

5. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.

6. Fly Ash: ASTM C 618, Type F.

7. General

a. Submit method of adding mixtures.

b. All admixtures shall be approved by the cement manufacturer.

c. Use water-reducing admixture or high-range water-reducing admixture (superplasticizers), (ASTM C 494, type F) in concrete, as required, for placement and workability.

d. Use accelerating admixture in concrete slabs placed at ambient temperatures below 50°F.

e. Use high-range water-reducing admixture in pumped concrete, architectural concrete, concrete required to be watertight, and concrete with water-cement ratios below 0.50.

f. Use air-entraining admixture in exterior exposed concrete unless otherwise indicated. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having total air content with a tolerance of plus or minimum 1½ percent within the following limits:

(1) Concrete structures and slabs exposed to freezing and thawing; deicers, chemicals, or hydraulic pressure:

(1a) 4.5 percent (moderate exposure); 5.5 percent (severe exposure) for 1½-inch maximum aggregate.

(1b) 4.5 percent (moderate exposure); 6.0 percent (severe exposure) for 1-inch maximum aggregate.

(1c) 5.0 percent (moderate exposure); 6.0 percent (severe exposure) for ¾-inch maximum aggregate.

(1d) 5.5 percent (moderate exposure); 7.0 percent (severe exposure) for ½-inch maximum aggregate.

(2) Other concrete not exposed to freezing, thawing, or hydraulic pressure, or to receive a surface hardener: 2 to 4 percent.

(3) Air content of trowel-finished interior concrete floor shall not exceed 3.0 percent.

g. Use admixtures for water reduction and set accelerating or retarding in strict compliance with manufacturer's directions.

E. Form Materials

1. Forms for Exposed Finish Concrete

Plywood, metal, metal framed plywood faced, or other acceptable panel-type materials, to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on Drawings.

2. Forms for Unexposed Finish Concrete

Plywood, lumber, metal, or other acceptable material. Provide lumber dressed on at least two edges and one side for tight fit.

3. Form Coatings

Provide commercial formulation form-coating compounds with a maximum VOC of 350 mg/L that will not bond with, stain, or adversely affect concrete surfaces, and will not impair subsequent treatments of concrete surfaces.

4. Form Ties

Factory-fabricated, adjustable length, removable, or snap-off metal form ties, designed to prevent form deflection and to prevent spalling concrete upon removal. Provide units that will leave no metal closer than 1½ inches to exposed surface.

F. Vapor Retarder

1. Multi-ply reinforced polyethylene sheet, ASTM E 1745, Class C, not less than 7.8 mils thick.

2. Fine-Graded Granular Material

Clean mixture of crushed stone, crushed gravel, and manufactured or natural sand; ASTM D 448, Size 10, with 100 percent passing a No. 4 sieve and 10 to 30 percent passing a No. 100 sieve; complying with deleterious substance limits of ASTM C 33 for fine aggregates.

G. Joint Filler Strip

1. ASTM D 1752; closed cell polyvinyl chloride or molded vinyl foam, resiliency recovery of 95 percent if not compressed more than 50 percent of original thickness. Asphalt impregnated fiberboard (ASTM D 1751) may be used with Engineer's approval.

H. Curing Materials

General curing and sealing compounds shall be clear such that the finished work maintain the concrete gray color without any noticeable discoloring.

1. Evaporation Retarder

Waterborne, monomolecular film forming, manufactured for application to fresh concrete.

2. Absorptive Cover

ASHTO M 182, Class 2, burlap cloth made from jute or kenaf.

3. Moisture-Retaining Cover

ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

4. Clear, Waterborne, Membrane-Forming Curing Compound

ASTM C 209, Type 1, Class B, manufactured by Sonneborn, W.R. Meadow, The Euclid Chemical Company, or equal.

5. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound (Non-Yellowing):

ASTM C 1315, Type 1, Class A, for concrete floors manufactured by Sonneborn, W.R. Meadow, The Euclid Chemical Company, or equal.

I. Concrete Construction Joint Sealants

Two-component, non-sag, polyurethane base, elastomeric sealants shall be utilized at all construction joints. Sealants shall perform properly under water submersion with no adverse chemical reactions. Joint sealants shall be Sikaflex-2C NS, manufactured by Sika Corporation, or equal. Primer shall be utilized where the joints are subjected to water submersion after cure, and other locations as instructed by the manufacturer. Installation shall be per manufacturer's instructions.

J. Self-Leveling Floor, Deck, and Sidewalk Joint sealant

1. One-part self-leveling polyurethane sealant for concrete floors, decks, sidewalks, and other horizontal contraction and expansion joints shall be Sonolastic SL1, complying with Federal Specification TT-S-0023oC, Type 1, Class A and ASTM C 920. Sealant shall be manufactured by Sonneborn or W.R. Grace Company or equal.

2. Sealant color shall be limestone or gray as selected by the Engineer unless otherwise required.

K. Joint Sealants and Backing for Sealant

1. For sealing vertical exposed faces of joint fillers, use Sonneborn-Contech Sonolastic NP1 or NP2 (one or two component urethane) or equivalent W.R. Grace Co. products, or equal. For water immersion, prime with Sonneborn-Contech Primer No.733 for concrete and masonry or Primer No. 758 for glass and metals or as required by manufacturers of equivalent acceptable sealants.

2. For sealing horizontal exposed faces of joint fillers, use Sonneborn-Contech Sonolastic SL1, one-part, self-leveling, polyurethane sealant with Primer No. 733 or equivalent W.R. Grace Co. products, or equal.

3. Where additional sealant backing is needed to control the depth of sealant in relation to joint width, use Sonneborn-Contech Sonoflex F foam expansion joint filler or Sonofoam Backer Rod (closed cell polyethylene foam) or equivalent W.R. Grace Co. products or equal.

L. Epoxy Bonding Agent

1. Provide an epoxy-resin bonding agent, two component, polysulfide type.

2. Product and Manufacturer - provide one of the following:

   a. Sikadur Hi-Mod LPL by Sika Corporation.

   b. Eucopoxy LPL by the Euclid Chemical Company, or equal.

M. Patching Mortar

Use free flowing, polymer modified cementitious mortar, "Euco Thin Coat, Concrete Coat" (horizontal repairs), "verticoat" (vertical and overhead repairs) by the Euclid Chemical Company or "Sikatop 121 or 122" (horizontal repairs), "Sikatop 123" (vertical and overhead repairs) by Sika Corp.

N. Waterstop for Construction and Control Joints

1. Unless otherwise shown, waterstops shall be four (4) inches wide, 3/16-inch minimum thickness, virgin polyvinyl chloride, in accordance with Corps of Engineers Specifications CRD-C-572, latest revision, as manufactured by Greenstreak, Inc., or equal. Where joint movements are desired, as shown on the Drawings, ribbed with center bulb shall be utilized.

2. Waterstops shall be furnished in maximum lengths available to reduce the number of joints to the minimum.

3. Provide factory fabrications for all intersections, transitions, and changes of direction, leaving only straight butt joint splices for the field.

O. Construction Joint Devices

Integral galvanized steel, formed to tongue and groove profile, with removable top strip exposing sealant trough, knockout holes spaced at six (6) inches, ribbed steel spikes with tongue to fit top screed edge.

P. Non-Shrink Grout

Premixed compound consisting of non-metallic aggregate, cement, water-reducing and plasticizing agents; capable of developing minimum compressive strength of 2,400 psi in 48 hours and 7,000 psi in 28 days.

Q. Chemical Adhesive and Expansion Anchors

Chemical adhesive and expansion anchors shall be manufactures by Hilt, Corporation, and installed per manufacturer's instructions.

2.02 CONCRETE PROPORTIONING AND DESIGNING MIXES

A. Comply with ACI 301 requirements for concrete mixtures unless otherwise specified herein.

B. Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301. For the trial batch method, use an independent testing agency acceptable to Engineer for preparing and reporting proposed mix design.

1. Do not use the same testing agency for field quality control testing.

2. Limit use of fly ash to not exceed 20 percent of cement content by weight.

C. Submit written reports to Engineer of each proposed mix for each class of concrete at least 15 days prior to start of work. Do not begin concrete production until proposed mix designs have been reviewed by Engineer.

D. Design mixes to provide normal weight concrete with the following properties as indicated on drawings and schedules:

1. 4000 psi, 28-day compressive strength; water-cement ratio, 0.44 maximum (non air-entrained), 0.35 maximum (air-entrained).

2. 3500 psi, 28-day compressive strength; water-cement ratio, 0.58 maximum (non air-entrained), 0.46 maximum (air-entrained).

3. 2500 psi, (lean concrete, if used) 28-day compressive strength; water-cement ratio, 0.67 maximum

E. Water-Cement Ratio

Provide concrete for following conditions with maximum water-cement (W/C) ratios as follows:

1. Subjected to freezing and thawing: W/C 0.45.

2. Subjected to de-icers/watertight: W/C 0.40.

3. Subjected to brackish water, salt spray, or de-icers: W/C 0.40.

F. Slump Limits

Proportion and design mixes to result in concrete slump at point of placement as follows:

1. Ramps, slabs, and sloping surfaces: Not more than three (3) inches.

2. Reinforced foundation system: Not less than one (1) inch and not more than three (3) inches.

3. Concrete containing high-range water-reducing admixture (superplasticizer): Not more than eight (8) inches after adding admixture to site-verified 2- to 3-inch clump concrete.

4. Other concrete: Not more than four (4) inches.

G. Adjustment to Concrete Mixes

Mix design adjustments may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant, as accepted by Engineer. Laboratory test data for revised mix design and strength results must be submitted to and accepted by Engineer before using in work.

H. Ready-Mixed Concrete (Comply with ASTM C 94)

When air temperature is between 85 and 95°F, reducing mixing and delivery time from 1½ hours to 75 minutes; when air temperature is above 90°F, reduce mixing and delivery time to 60 minutes.

I. Provide batch ticket for each batch discharged and used in the work, indicating project identification name and number, date, mix type, mix time, quantity, and amount of water added. Record approximate location of final deposit in structure.

PART 3 – EXECUTION

3.01 INSTALLATION, GENERAL

A. Examination

1. Verify site conditions.

2. Verify requirements for concrete cover over reinforcement. Where not shown, use minimum as specified in ACI 318 and ACI 35 or whichever is deeper.

3. Verify that anchors, plates, reinforcements, and other items to be cast into concrete are accurately placed, positioned securely, and will not cause hardship in placing concrete.

B. Formwork

Design, construct, erect, shore, brace, and maintain formwork according to ACI 301.

C. Vapor Retarder

1. Install, protect, and repair vapor retarder sheets according to ASTM E 1643. Place sheets in position with longest dimensional parallel with direction of pour.

2. Lap joints six (6) inches and seal with manufacturer's recommended tape.

3. Cover vapor retarder with fine-graded granular material, moisten, and compact with mechanical equipment to elevation tolerances of plus 0 inch or minimum 3/4 inch.

D. Steel Reinforcement

1. Comply with ACI 315 and CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

2. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

E. Joints

1. Construct joints true to line with faces perpendicular to surface plane of concrete.

2. Construction Joints

Locate and install so as not to impair strength or appearance of concrete at locations indicated on the reviewed shop drawings. Any deviation from the shop drawings shall be approved by Engineer.

3. Isolation Joints

Install joint-filler strips at junctions with slabs-on-grade and vertical surfaces such as column pedestals, foundation walls, and other locations as indicated.

a. Extend joint fillers full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated or where joint sealants are specified. Keep top of joint filler ½ inch lower than with finished concrete surface.

4. Contraction Joints in Slabs-on-Grade

Form weakened-plane contraction joints, sectioning concrete into areas as indicated unless otherwise is shown. Construct contraction joints, where shown, for a depth equal to at least one-fourth of the concrete thickness, as follows:

a. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with groover tool to a radium of 1/8 inch. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover marks on concrete surfaces.

b. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch wide joints into 1/4-inch depth of slab thickness when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

F. Tolerances

Comply with ACI 117, "Specifications for Tolerances for Concrete Construction and Materials".

G. Preparation

1. Prepare previously placed concrete by cleaning with steel brush and applying epoxy bonding agent in accordance with manufacturer's instructions.

2. Coordinate the placement of joint devices with erection of concrete formwork and placement of form accessories.

3.02 CONCRETE PLACEMENT

A. Comply with recommendations in ACI 304 R for measuring, mixing, transporting, and placing concrete.

B. Do not add water to concrete during delivery at project site or during placement.

C. Consolidate concrete with mechanical vibrating equipment.

D. Notify Engineer a minimum of 24 hours prior to commencement of operations.

E. Ensure reinforcement, inserts, embedded parts, and formed construction and contraction joints are not disturbed during concrete placement.

F. Separate slabs on grade from vertical surface with 1/4 to 3/8-inch joint filler unless otherwise indicated.

G. Extend joint filler from bottom of slab to within about 1/2 inch of finished slab surface. Conform to Section 07900 for finish joint sealer requirements.

H. Install preformed metal tongue and groove joint devices, if used, in accordance with manufacturer's instructions.

I. Apply sealants in joint devices in accordance with Section 07900.

J. Maintain records of concrete placement. Record date, location, quantity, air temperature, and test samples taken.

K. Place concrete continuously between predetermined expansion, control, and construction joints.

L. Do not interrupt successive placement; do not permit cold joints to occur.

M. Provide 3/4-inch chamfers as exposed edges of concrete.

N. Allow a minimum of three (3) days before placing concrete against a slab or wall already in place.

O. All embedded aluminum materials in concrete shall be coated as specified.

P. Screed floors in accordance to ASTM E 1155 with slab-on-grade floor utilizing flatness (F_F), SOV = 25, MLV = 17, and floor levelness (F_L), SOV = 20, MLV = 15. For elevated floor utilizing flatness (F_F), SOV = 30, MLV = 24, and floor levelness (F_L), SOV = 20, MLV = 15. Measuring the levelness of elevated floors shall be while the shoring are in place. ACI 302.1R includes a construction guide on how to achieve these flatness and levelness values.

3.03 FINISHING FORMED SURFACES

A. Rough-Formed Finish

1. As-cast concrete texture imparted by form-facing material with tie holes and defective areas repaired and patched, and fins and other projections exceeding 1/4- inch in height rubbed down or chipped off.

2. Apply to concrete surfaces not exposed to public view.

B. Smooth-Formed Finish

1. As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defective areas. Completely remove fins and other projections.

2. Apply to concrete surfaces exposed to public view or to be covered with a coating or covering material applied directly to concrete, such as waterproofing, dampproofing, veneer plaster, or painting. "Concrete surfaces exposed to public view" shall include inside walls and floors of water holding basins except for covered clearwells and covered pump station wet wells.

3. Apply smooth-rubbed finish, defined in ACI 301, to smooth-formed finished concrete.

C. Related Unformed Surfaces

At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

3.04 FINISHING UNFORMED SURFACES

A. General

Comply with ACI 302.1R for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.

B. Screed surfaces with a straight-edge and strike off. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane before excess moisture or bleedwater appears on the surface.

1. Do not further disturb surfaces before starting finishing operations.

C. Scratch Finish

Apply scratch finish to surfaces to receive concrete floor topping or mortar setting beds for ceramic or quarry tile, portland cement terrazzo, and other bonded cementitious floor finish unless other indicated.

D. Float Finish

Apply float finish to surfaces to receive trowel finish and to floor and slab surfaces to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing, or sand-bed terrazzo, or any other surfaces not specified.

E. Trowel Finish

Apply a hard trowel finish to floor and slab surfaces exposed to view or to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin film-finish coating system.

F. Trowel and Fine-Broom Finish

Apply a partial trowel finish, stopping after second troweling, to surfaces indicated and to surfaces where ceramic or quarry tile is to be installed by either thickset or thin-set methods. Immediately after second troweling, and when concrete is still plastic, slightly scarify surface with a fine broom.

G. Nonslip Broom Finish

Apply a nonslip broom finish to exterior concrete platforms, steps, sidewalks, and ramps. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route.

H. Floor Drains

In areas with floor drains, maintain floor elevations at walls; slope surfaces uniformly to drains at 1:100 minimum, but not less than shown on the Drawings.

3.05 CONCRETE PROTECTION AND CURING

A. General

Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection, and follow recommendations in ACI 305R for hot-weather protection during curing.

B. Evaporation Retarder

Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions occur before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

C. Begin curing after finishing concrete, but not before free water has disappeared from concrete surface.

D. Cure formed and unformed concrete in accordance with ACI 301 and ACI 308, and for at least seven (7) days as follows:

1. Moisture-Retaining Cover Curing

Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

2. Curing Compound

Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three (3) hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.06 FIELD QUALITY CONTROL

A. See Section 01400 – Quality Assurance: Field Inspection and Testing.

B. Testing Agency

Contractor shall engage a qualified independent testing and inspecting agency, acceptable to the Owner, to sample materials, perform tests, and submit test reports during concrete placement. All testing costs shall be borne by the Contractor. Tests will be performed according to ACI 301 except as modified herein. Contractor shall provide testing services for qualification of proposed materials and establishment of design mixture.

C. Provide free access to work and cooperate with appointed testing agency.

D. Submit proposed mix design of each class of concrete to testing firm and Engineer for review prior to commencement of work.

E. Tests of cement and aggregates may be performed to ensure conformance with specified requirements.

F. Contractor shall have a minimum of four (4) concrete cylinders taken for every 25 c.y. of concrete or discreet concrete delivery should the amount be less than 25 c.y. even though placement may be at multiple locations. Cylinders shall be submitted to independent laboratory for testing of strength by breaking at 7 days, 14 days, and 28 days by the testing agency. Additional cylinders may be taken as deemed necessary by the Engineer and all costs shall be borne by Contractor. Cylinders shall be cured on-site in same condition as poured concrete.

G. One additional test cylinder will be taken during cold weather concreting, cured on job site under same conditions as concrete it represents.

H. One slump test will be taken for each set of test cylinders taken.

I. All concrete for liquid retaining structures, and all concrete in contact with earth, water, or exposed directly to the elements shall be watertight and shall be tested for leakage in accordance with ACI 3350R.

3.07 PATCHING

A. Allow Engineer to inspect concrete surfaces immediately upon removal of forms.

B. Excessive honeycomb or embedded debris in concrete is not acceptable. Notify Engineer upon discovery.

C. Patch imperfections in accordance with ACI 301.

3.08 DEFECTIVE CONCRETE

A. Defective Concrete

Concrete not conforming to required lines, details, dimensions, tolerances, or specified requirements.

B. Repair or replacement of defective concrete will be determined by the Engineer.

C. Do not patch, fill, touch-up, repair, or replace exposed concrete except upon express direction of Engineer for each individual area.

3.09 SCHEDULE – CONCRETE TYPES

A. Below grade footings: 4000 psi.

B. Thrust blocks: 3500 psi.

C. All other concrete: 4000 psi.

- END OF SECTION -

SECTION 03310

STRUCTURAL CONCRETE

PART 1 - GENERAL

1.01 WORK INCLUDED

The work in this section shall include all formwork, shoring, bracing, anchorage, concrete reinforcement and accessories for cast-in-place concrete.

1.02 GENERAL REQUIREMENT

All concrete construction shall conform to all applicable requirements of ACI 301, Specifications for Structural Concrete for Buildings, except as modified by the supplemental requirements specified herein. For concrete specific to tank, see also Section 13210 – Composite Elevated Water Storage Tank.

1.03 RELATED WORK

A. Section 02200 - Earthwork

B. Section 03100 - Concrete Formwork

C. Section 03210 - Reinforcing Steel

D. Section 03251 - Expansion and Contraction Joints

E. Section 05520 - Metal Fabrications

F. Section 13210 – Composite Elevated Water Storage Tank

1.04 REFERENCES

A. The Contractor shall obtain and have available in the field office at all times the latest edition of the following references:

1. Specifications for Structural Concrete for Building ACI 301-96.
2. Specifications for Structural Concrete for Buildings ACI Sp-15.
3. Manual of Standard Practice - CRSI (latest revision).
4. Placing Reinforcing Bars - CRSI (latest revisions).
5. Building Code Requirements for Reinforced Concrete ACI 318.

6. Standard Specification for Tolerances for Concrete Construction and Materials ACI 117-90.

B. The following standard shall also apply to this work:

1. ASTM C-143 Test Method for Slump of Hydraulic Cement Concrete
2. ASTM C-150 Specification for Portland Cement
3. ASTM C-33 Specification for Concrete Aggregates
4. ASTM C-260 Specification for Air Entraining Admixtures for Concrete
5. ASTM C-494 Specification for Chemical Admixtures for Concrete
6. ASTM A-615 Specification for Deformed and Plain Billet Steel Bars for Concrete Reinforcement
7. ASTM C-94 Specification for Ready-Mixed Concrete
8. ASTM C-31 Practice for Making and Curing Concrete Test Specimens in the Field
9. ASTM C-39 Test Method for Compressive Strength of Cylindrical Concrete Specimens
10. ASTM C-42 Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

1.05 SUBMITTALS

A. The Contractor shall submit the following data established per Section 4.2.3 of ACI 301.

1. Concrete mix designs, test results and curves plotted to establish water cement ratio if paragraph 4.2.3.4b of ACI 301 is used.
2. Proposed mix designs and all necessary substantiating data used to establish proposed mix designs if paragraph 4.2.3.1 of ACI 301 is used.
3. Mix designs for all mixes proposed or required to be used, including all mixes containing admixtures.
4. A certified copy of the control records of the proposed production facility establishing the standard deviation as defined in paragraph 4.2.3.2 of ACI 301.

B. Certification attesting that admixtures equal or exceeds the physical requirements of ASTM C-494 for Type A (water reducing) Type D (water reducing and retarding), and Type E (water reducing and accelerating) admixtures.

C. Drawings showing locations of all proposed construction joints.

D. Certification that the concrete aggregates comply with the provisions of ASTM C-33.

E. Certification that the air-entraining admixture complies with ASTM C-260.

1.06 QUALITY ASSURANCE

A. Consistency: Concrete shall be of such consistency that it can be worked readily into all parts of the forms and around embedded work, without permitting the materials to segregate, or free water to collect on the surface.

B. Compression Tests

1. During the progress of the work, at least one set of three compression test cylinders shall be made for each 50 cubic yards of structural concrete or major fraction thereof, and not less than one such set for each type of concrete for each days pouring. Cylinders made in the field shall be made and cured in accordance with the ASTM C-31 Standard Method of Making and Curing Concrete Test Specimens in the Field, except that wherever possible molds shall be left on cylinders until they reach the laboratory.

2. One cylinder of each set shall be broken in accordance with ASTM C-39 at seven days and the other two at twenty-eight days. Two copies of these test results shall be submitted to the Engineer on the same day of the tests.

3. Additional tests of the in-place concrete shall be made when test results indicate specified concrete strengths and other characteristics have not been attained in the structure. Cored cylinders used to test concrete adequacy shall comply with ASTM C-42. All test procedures and results shall be subject to the review and approval of the Engineer. The Contractor shall pay for such tests when unacceptable concrete is verified. On evidence of these tests, any concrete that fails to meet the specified strength requirements shall be strengthened or replaced as directed by the Engineer at the Contractor's expense.

C. Inserts in Concrete Other Trades

1. All trades shall be notified, at the proper time, to install items to be embedded in concrete.

2. All castings, inserts, conduits, and other metalwork shall be accurately built into or encased in the concrete by the Contractor as directed and all necessary precautions shall be taken to prevent the metalwork from being displaced or deformed. The installation shall be inspected before concrete is placed.

3. Anchor bolts shall be set by means of substantial templates.

D. Testing:

1. The necessary testing service of this section shall be performed by a testing agency approved by the Owner, and paid by the Contractor.

2. The testing agency shall perform the following tests on the sampled concrete:

   a. Slump

   b. Air Content

   c. Concrete Temperature

   d. Compression test of cylinders made under paragraph B.

3. If, in the opinion of the Engineer, there is reasonable doubt that the concrete aggregates comply with ASTM C-33. The testing agency shall, test the fine aggregate and course aggregate for compliance with these specifications.

4. Written reports shall be submitted to the Engineer as soon after completion as feasible.

E. Hot Weather Requirements: Placing of concrete under conditions of high temperatures, low humidity or wind shall be done in accordance with the American Concrete Institute "Hot Weather Concreting" (ACI 305R-latest edition).

F. Cold Weather Requirements: Cold weather concreting procedures and precautions shall conform with American Concrete Institute "Cold Weather Concreting" (ACI 306 R-latest edition).

PART 2 - PRODUCTS

2.01 CONCRETE MIX

A. Structural concrete of the various classes required shall be proportioned by Section 4.2.3 of ACI 301 to produce the following 28-day compressive strengths:

B. Selection of Proportions for Class A Concrete:

1. 4,000 psi compressive for strength at 28 days.
2. Type I cement plus water reducing dispersing agent and air.
3. Maximum (water)/(cement and water reducing dispersing agent) ratio = 0.45.
4. Minimum cement content = 564 lbs. (6.0 bags)/cu. yd. concrete.
5. Nominal maximum size coarse aggregate = No. 67 (3/4" maximum).
6. Air content = 6% plus or minus 1% by volume.
7. Slump = 2" - 3" in accordance with ASTM C-143.

2.02 OPTIONAL CONCRETE MIX USING FLY ASH

Selection of Proportions for Class A Concrete:

A. 4,000 psi compressive for strength at 28 days.

B. Type I cement plus water reducing dispersing agent and air.

C. Maximum (water)/(cement plus water reducing dispersing agent) ratio - 0.45.

D. Minimum cement content - 517 lbs. (5.5 bags)/cu. yd. concrete.

E. Minimum Fly Ash content-47lbs./cu. yd.

F. Maximum Fly Ash Content - 71 lbs./cu. yd.

G. Nominal maximum size coarse aggregate - No. 57 (1" maximum).

H. Air content - 6% plus or minus 2% by volume.

I. Slump = 2" - 3" in accordance with ASTM C-143.

2.03 GROUT

A. Provide the following grout mixture at locations noted on the plans to be grouted, such as fillets, tank, and trough bottoms:

1. Less than 2" in depth:

Material	Volume
Cement	1 part
Sand	2 part

Water = 5 gals./200 lbs cement

2. From 2" to 12" in depth:

Material	Volume
Cement	1 part
Pea Gravel	2.5 parts
Sand	2 parts

Water = 5 gals. /100 lbs cement

3. Greater than 12" in depth:

Material
Concrete as specified in paragraph 2.01 or 2.02.

B. The mixtures in part A are not to be used in areas that are to receive non-shrink grout.

C. Grout fill which is formed in place by using rotating equipment as a screed, such as for clarifiers, shall be mixed in proportions and consistencies as required by the manufacturer or supplier of the equipment.

2.04 FLY ASH CONCRETE

A. In the absence of a verified and acceptable history of fly ash concrete mixes, the following procedure is required to establish the quality of the concrete mix.

B. Trial batches must be made starting 30 days ahead of initial concrete pour. Three (3) mixes shall be designed and produced at no cost to the Owner or the Engineer as follows:

1. Mix using Type I cement with water reducing admixture for normal temperatures (Class A).

2. Mix using Type I cement with water reducing admixture for cold weather temperatures (Class A).

3. Mix using Type I cement with water reducing admixture for hot temperatures (Class A).

C. Four (4) test cylinders shall be cast for each of the (3) mixes. Two (2) cylinders shall be broken at 7 days, and two (2) cylinders shall be broken at 28 days, for each of the (3) mixes. The trial batch design report shall include strength breaks at 7-days and 28-days, air content, slump and mix proportions.

D. The water-reducing, cement dispersing admixture used in fly ash concrete, shall be a normal, accelerated, or retarded hardening admixture. The admixture shall be used at optimum dosage to offset the slow strength development and setting characteristics of the fly ash. Only those brands of admixture that can provide readily available field

service on short notice to provide field services, inspection, and assistance, will be acceptable.

E. Prior to the use of fly ash concrete, recent mill reports shall be submitted on a regular basis during the project. Maximum loss on ignition (LOI) shall be 6%.

F. Tests for air content shall be made twice a day at the job site prior to pouring, for all mixes containing fly ash.

2.05 ADMIXTURES

A. An air entraining admixture shall be used on all concrete and shall be the Master Builders MB-VR, or MicroAir, Euclid Chemical Company AIR-MIX, W. R. Graces Darex, or equal. The admixture shall meet the requirements of ASTM C-260. Certification attesting to the percent of effective solids and compliance of the material with ASTM C-260 shall be furnished.

B. A water-reducing, admixture for concrete shall conform to ASTM C-494 for type A (water-reducing and normal setting admixtures) and shall be Master Builders Pozzolith 344N, Nox-Crete Plastiflow, or Plastocrete 161 by Sika, or an approved equal.

C. The water-reducing, set retarding admixture for concrete shall conform to ASTM C-494 for Type D (water reducing and retarding admixtures) and shall be Master Builders, Pozzolith 100-XR, Daratard-17 by W. R. Grace, or an approved equal.

D. Certification shall be furnished attesting that the admixture exceeds the physical requirements of ASTM C-494, Type A, water reducing and normal setting admixture, and when required, for ASTM C-494, Type D, water reducing and retarding admixture when used with local materials with which the subject concrete is composed.

E. The admixture manufacturer shall provide a qualified concrete technician employed by the manufacturer to assist in proportioning concrete for optimum use. He also will be available to advise on proper addition of the admixture to the concrete and on adjustment of the concrete mix proportions to meet changing job conditions.

F. Where the Contractor finds it impractical to employ fully the recommended procedures for hot weather concreting, the Engineer may at his discretion require the use of a set retardant admixture for mass concrete 2.5 feet or more thick and for all concrete whenever the temperature at the time concrete is cast exceeds 80° F. The admixture shall be selected by the Contractor subject to the review of the Engineer. The admixture and concrete containing the admixture shall meet all the requirements of these specifications. Preliminary tests of this concrete shall be required at the Contractor's expense.

G. When more than one admixture is used, all admixtures shall be compatible. They should preferably be by the same manufacturer.

H. Calcium chloride will not be permitted as an admixture in any concrete.

I. Water-reducing, non chloride, accelerators shall conform to ASTM C494 Type E and shall be Accelquard 80 by the Euclid Chemical Company or an approved equal.

2.06 WATER

The water for concrete shall be clean, fresh, and free from injurious amounts of oil, acid, alkali, organic matter, or other deleterious substances.

2.07 AGGREGATES

A. Fine aggregates shall be natural and having clean, hard, uncoated grains, and shall be free from injurious amounts of clay, dust, organic matter or other deleterious substances, and shall conform to ASTM C-33. Sand shall be graded as follows:

	Percent
Passing 3/8 Inch Sieve	100
Passing No. 4 Sieve	90 - 100
Passing No. 16 Sieve	45 - 80
Passing No. 50 Sieve	5 - 25
Passing No. 100 Sieve	0 - 8

B. Coarse aggregate shall be crushed stone having clean, hard, uncoated particles, and shall be free from injurious amounts of soft, friable, thin, elongated or laminated pieces. Coarse aggregates shall conform to ASTM C-33 and shall be graded in accordance with the following:

	Percent by Weight No. 67
Passing 1-Inch Square Sieve	100
Passing 3/4-Inch Square Sieve	90 - 100
Passing 3/8-Inch Square Sieve	20 - 55
Passing No. 4 Square Sieve	0 - 10
Passing No. 8 Square Sieve	0 - 5

2.08 AGGREGATES AND DETERMINING PROPORTIONS

A. No concrete shall be used in the work until the materials and mix designs have been tested by the testing laboratory and accepted by the Engineer.

B. The Engineer shall have the right to order changes as may be necessary to meet the specified requirements.

C. If concrete of the required characteristics is not being produced as the work progresses, the Engineer may order such changes in proportions or materials, or both, as may be necessary to secure concrete of the specified quality. The Contractor shall make such changes at his own expense and no extra compensation will be allowed because of such changes.

2.09 MIXING

All central plant and rolling stock equipment and methods shall conform to the Truck Mixer and Agitator Standards of the Truck Mixer Manufacturers' Bureau of the National Ready Mixed Concrete Assn., as well as the ACI Standards for Measuring, Mixing, Transporting, and Placing Concrete ACI 304R-89, and with the ASTM specification for Ready Mixed Concrete, Designation C-94.

PART 3 - EXECUTION

3.01 PLACING AND COMPACTING CONCRETE

A. At least 24 hours before the Contractor proposes to make any placement of concrete, he shall notify the Engineer of his intention and planned procedure. Unless otherwise planned, the work shall be so executed that a section begun on any day shall be completed during daylight of the same day.

B. Ready mixed concrete shall be transported to the site in watertight agitator or mixer trucks. The quantity of concrete to be mixed or delivered in any one batch shall not exceed the rated capacity of the mixer or agitator for the respective conditions as stated on the nameplates.

C. Information necessary to calculate the total mixing water shall be recorded on the delivery slip for the Engineer's information. Total mixing water includes free water on the aggregates, water and ice batched at the plant, and water added by the truck operator. The Contractor must request permission to add water at the job site from the ready mix plant and the engineer. When the addition of water is permitted, the quantity added shall be the responsibility of the Contractor and in no case shall the total water per bag of cement exceed that determined by the designed mix. Mixing and discharge time shall be as recommended in ACI-304R.

D. Concrete which has become compacted or segregated during transportation to or on the site of the work shall be satisfactorily remixed just prior to being placed in the forms.

E. Partially hardened concrete shall not be deposited in the forms. The retempering of concrete which has partially hardened (that is, the remixing of concrete with or without additional cement, aggregate, or water) will not be permitted.

F. The concrete shall be mixed only in the quantity required for immediate use. Concrete that has developed an initial set shall not be used. The Contractor shall have sufficient plant capacity and transporting apparatus to insure continuous delivery at the rate required.

G. The temperature of the concrete mixture immediately before placement shall be between 50° F and 90° F.

H. Concrete that is truck mixed or transported in truck mixers or truck agitators shall be delivered to the site of the work and discharge completed in the forms within 1½ hours or before the drum has revolved 300 revolutions whichever comes first after the introduction of the mixing water to the cement and aggregates, or the introduction of the cement to the aggregates. When the concrete temperature exceeds 85° F, the time shall be reduced to 45 minutes. Concrete shall be placed in the forms within 15 minutes after discharge from the mixer at the job site.

I. If concrete is placed by pumping, no aluminum shall be used in any parts of the pumping system which contact or might contaminate the concrete. Aluminum chutes and conveyors shall not be used.

J. No concrete shall be placed on frozen subgrade or in water, or until the subgrade, forms, and preliminary work have been accepted. No concrete shall be placed until all materials to be built into the concrete have been set and have been accepted by the various trades and by the Engineer. All such materials shall be thoroughly clean and free from rust, scale, oil, or any other foreign matter.

K. Forms and excavations shall be free from water and all dirt, debris, and foreign matter when concrete is placed. Except as otherwise directed, wood forms and embedded wood called for or allowed shall be thoroughly wetted just prior to placement of concrete.

L. Chutes for conveying concrete shall be metal or metal lined and of such size, design and slope as to ensure a continuous flow of concrete without segregation. The slope of chutes shall have approximately the same slope. The discharge end of the chute shall be provided with a baffle, or if required, a spout and the end of the chute or spout shall be kept as close as practicable to, but in no event more than five (5) feet above the surface of the fresh concrete. When the operation is intermittent, the chute shall discharge into a hopper.

M. In thin sections of considerable height (such as walls and columns), concrete shall be placed in such manner as will prevent segregation and accumulations of hardened concrete on the forms or reinforcement above the mass of concrete being placed. To

achieve this end, suitable hoppers spouts with restricted outlets, etc., shall be used as required or permitted unless the forms are provided with suitable openings.

N. Chutes, hoppers, spouts, etc. shall be thoroughly cleaned before and after each run and the water and debris shall not be discharged inside the form.

O. For any one placement, concrete shall be deposited continuously in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause the formation of seams and planes of weakness within the section, and so as to maintain until the completion of the unit, an approximately horizontal plastic surface.

P. No wooden spreaders shall be left in the concrete.

Q. During and immediately after being deposited, concrete shall be thoroughly compacted by means of suitable tools and methods, such as internal type mechanical vibrators operating at not less than 5,000 rpm. or other tool spading to produce the required density and quality of finish. Vibration shall be done only by experienced operators under close supervision and shall be carried in such manner and only long to produce homogeneity and optimum consolidation without permitting segregation of the solid constituents, "pumping" of air, or other objectionable results. All vibrators shall be supplemented by proper spade puddling approximately two (2) to three (3) inches away from forms to remove included bubbles and honeycomb. Excessive spading against the forms, causing the deposition of weak mortar at the surface shall be avoided.

R. The concrete shall be thoroughly rodded and tamped about embedded materials so as to secure perfect adhesion and prevent leakage. Care shall be taken to prevent the displacement of such materials during concreting.

3.02 BONDING CONCRETE AT CONSTRUCTION JOINTS

A. In order to secure full bond at construction joints, the surface of the concrete previously placed (including vertical, inclined, and substantially horizontal areas) shall be thoroughly cleaned at foreign materials and laitance, if any.

B. The previously placed concrete at the joint shall be damp but free of standing water. The surface shall be prepared as per ACI 301. The referenced cement grout shall be between one (1) and two (2) inches thick on all wall pours.

3.03 CURING AND PROTECTION

A. All concrete, particularly slabs and including finished surfaces, shall be treated immediately after concreting or cement finishing is completed, to provide continuous moist curing for at least seven (7) days, regardless of the adjacent air temperature. Walls and vertical surfaces may be covered with continuously saturated burlap, or

kept moist by other acceptable means. Horizontal surfaces, slabs, etc., shall be ponded to a depth of 1/2 inch wherever practicable, or kept continuously wet by the use of lawn sprinklers, a complete covering of continuously saturated burlap, or by other acceptable means.

B. For at least seven (7) days after having been placed, all concrete shall be so protected that the temperature at the surface will not fall below 45° F. The methods of protecting the concrete shall be as specified in that section of the General Specifications titled "Precautions During Adverse Weather" and shall be subject to the review of the Engineer.

C. No manure, salt, or other chemicals shall be used for protection.

D. The above-mentioned 7-day periods may be reduced if compression tests, in accordance with ASTM C-39, on field cured cylinders indicate that expected 7-day strength gain has been achieved, and approval is granted by the Engineer.

E. Wherever practicable, finished slabs shall be protected from the direct rays of the sun to prevent checking and crazing.

3.04 TRIMMING AND REPAIR OF SURFACE DEFECTS

A. The Contractor shall use suitable forms, mixture of concrete, and workmanship so that concrete surfaces, when exposed, will require no patching. Concrete which, in the opinion of the Engineer has excessive honeycomb, aggregate pockets, or depressions will be rejected and the Contractor shall, at his own expense remove the entire section containing such defects and replace it with acceptable concrete.

B. As soon as the forms have been stripped and the concrete surfaces exposed, fins and other projections shall be removed, recesses left by the removal of form ties shall be filled and surface defects which do not impair structural strength shall be repaired.

C. Defective concrete shall be cut perpendicular to the surface until sound concrete is reached, but not less than one (1) inch deep. The remaining concrete shall be thoroughly roughed and cleaned. Concrete in an area at least six (6) inches wide surrounding the area to be patched shall be dampened. A bonding grout shall be prepared using a mix of approximately 1 part cement to 1 part fine passing a No. 30 mesh sieve, mixed to the consistency of thick cream, and then well brushed into the surface.

D. The patching mixture shall be made of the same materials and approximately the same proportions as used for the concrete except that the coarse aggregate shall be omitted and the mortar shall consist of not more than 1 part cement to 2½ parts sand by damp loose volume. White portland cement shall be substituted for a portion of the gray portland cement on exposed concrete in order to produce a color matching the color of the surrounding concrete. The quantity of mixing water shall be no more

than necessary for handling and placing. The patching mortar shall be mixed in advance and allowed to stand with frequent manipulation with a trowel, without addition of water, until it has reached the stiffest consistency that will permit placing.

E. After surface water has evaporated from the area to be patched, the bond coat shall be well brushed into the surface. When the bond coat begins to lose the water sheen, the premixed patching mortar shall be applied. The mortar shall be thoroughly consolidated into place and struck off so as to leave the patch slightly higher than the surrounding surface. To permit initial shrinkage, it shall be left undisturbed for at least 1 hour before being finally finished. The patched area shall be kept damp for seven (7) days. Metal tools shall not be used in finishing a patch in a formed wall which will be exposed.

F. After being cleaned and thoroughly dampened, the tie holes shall be filled solid with patching mortar.

G. The use of mortar patching as above specified shall be confined to the repair of small defects in relatively green concrete. If substantial repairs are required, the defective portions shall be cut out to sound concrete and the defective concrete replaced by means of gunite, or the structure shall be taken down and rebuilt, all as the Engineer may decide or direct.

3.05 FINISHES

A. Exposed to View Concrete Surfaces

1. All concrete exposed to view in the completed structures shall be produced using materials and workmanship to such quality that only nominal finishing will be required. The provisions of paragraph 5.3.3.3b of ACI 301 (Smooth Form Finish) shall apply to all exterior exposed to view concrete surfaces.

2. All formed, exterior, exposed to view, concrete shall be prepared as paragraph 3.04 B, then rubbed. Exterior vertical surfaces shall be rubbed to one (1) foot below grade.

B. All smooth form concrete vertical surfaces shall be true plane within 1/4 inch in 10 feet as determined by a 10-foot straight edge placed anywhere on the surface, in any direction. Abrupt irregularities shall not exceed 1/8 inch.

3.06 WATERTIGHTNESS

A. Pipes shall not be poured or solidly grouted in concrete walls or floors unless fixations are indicated on the Project Drawings, for example as anchorage to resist pipe thrusts, unless otherwise required or permitted.

B. At wall and slab penetrations, openings shall be formed approximately 1 inch greater than the OD of the pipe. For openings 10 inches and less in diameter, openings may be cored if permitted by the Engineer before pouring wall or slab so that extra reinforcing steel can be accurately located and referenced to avoid the subsequent core hole, unless otherwise required or permitted. After pipe placement and alignment adjustment, the annular space between opening and outside of pipe shall be packed with dry braided hemp (or unbraided where pipe does not center in openings) to within two (2) inches of the wall or slab surface. The 2-inch deep annular spaces shall be packed with non-shrink grout or caulked as required or permitted with materials specified in Division 7 of these Specifications and in strict accordance with the material manufacturers' instructions.

C. Where openings larger than 10 inches in diameter are required for pipe penetrations in existing walls and slabs, the opening shall be made approximately two (2) inches to four (4) inches larger in diameter than the pipe OD. The pipe shall be wrapped with 1/2-inch braided hemp and positioned in the opening. The space between the hemp and the opening shall be solidly packed with non-shrink grout previously described, after application of a bonding adhesive to the opening surfaces. The grout shall be finished flush with wall and floor surfaces. After the grout has hardened sufficiently, hemp shall be removed to 2-inch depths on each side of walls and slabs and the resulting annular spaces shall be packed with non-shrink grout or caulked as required or permitted, as previously described.

D. All joints around pipe shall be watertight unless otherwise required or permitted.

3.07 EQUIPMENT PADS

Unless otherwise shown or directed, all pumps, other equipment, and items such as motor control centers and the like, shall be installed on concrete bases. The bases shall be constructed to the dimensions shown on the plans or as required to meet plan elevations. Where no specific footprint or elevation are required, the bases shall be six (6) inches thick and shall extend six (6) inches outside the metal equipment base. In general, the concrete bases shall be placed up to one (1) inch below the metal base. The equipment shall then be properly shimmed to grade and the 1-inch void filled with nonshrink grout. Prior to the final set of the grout, it shall be cut back and the edge plastered with 1:2 cement mortar.

- END OF SECTION -

DIVISION 9

FINISHES

SECTION 09870

PAINTING AND SANDBLASTING OF WATER TANK

PART 1 - GENERAL

1.01 WORK INCLUDED

Surface Preparation and Painting of the New Water Tank:

A. Surface preparation shall consist of near white blast cleaning in accordance with SSPC-SP 10 in all wetted areas of the interior of the tank, and for the exterior of the tank including bracings, catwalks, ladders and other attachments and repairs of all pitting.

B. Painting shall consist of applying a minimum of three coats of paint to the interior and three (3) coats to the exterior surfaces to achieve the required finish covering.

1.02 REQUIREMENTS

The Contractor shall furnish all materials, labor, equipment and appliances and shall do all tank surface preparation and field painting as directed on the Drawings and as specified herein.

1.03 RELATED WORK

Division 5 - Metals

1.04 REFERENCES

A. Kentucky State Board of Health.

B. Current AWWA D102 Standards.

C. U.S. Environmental Protection Agency.

D. KY Natural Resources and Environmental Protection Cabinet.

E. National Sanitation Foundation (NSF) Standard #61 (for interior tank coating).

1.05 SUBMITTALS, DELIVERY AND STORAGE

A. Submittals shall include: color selection charts, color chips of finish coatings, a copy of manufactures technical information for coatings used on project, performance data for substitute products if used, shipping list with batch numbers for all coatings and thinners as well as shelf life delivered to site. MSDS sheets for all products on site shall be on site at all times.

B. Deliver all materials to job site in original, new and unopened containers bearing the manufactures name and label.

1. Name of material
2. Manufactures Stock number and date of manufacture
3. Manufactures name
4. Contents by volume
5. Thinning instructions
6. Application instructions
7. Color name and number

C. Storage of materials:

1. Store only acceptable project materials on project site
2. Store according to manufactures recommendation
3. Comply with all State and Federal health and fire hazard regulations.
4. MSDS sheets shall be in a bound set on job-site at all times, available to emergency personnel if required.

1.06 QUALITY CONTROL

A. The Contractor shall do a complete painting job throughout the work in accordance with these Specifications, the paint manufacturer's current surface preparation and application instructions, and with generally accepted practices for work of high quality.

B. All paints and painting materials not specifically specified shall be products of nationally known manufacturers of established good reputation, and shall be suitable for the intended use. Materials listed in the painting schedule without reference to a specification number, or materials not further described hereinafter, shall be products that have had a minimum of two years' satisfactory field service.

C. All paint shall be applied under favorable conditions by skilled painters to produce smooth, even, pinhole-free coatings of all interior and exterior surfaces.

D. Contractor to complete Holiday Detection, for interior wetted surfaces, in accordance with NACE International RPO188. Three copies of the results, noting any deficiencies, shall be transmitted to the Engineer.

PART 2 - PRODUCTS

2.01 MATERIALS

A. The paints to be used in the work shall be products of Rust-Oleum Industrial, Vernon Hills, IL, Tnemec Company, Inc., Kansas City, MO, or acceptable equivalent products. The types of paint products to be used in the work shall be identified by the

manufacturer's name and/or number and brought to the job site in the original sealed containers of the manufacturer. All paints and paint products used on the project shall be from the same manufacturer.

B. The products of the manufacturers other than those herein named, which are acceptable equivalents to the products specified, may be substituted, except that, insofar as possible, all paints applied to a surface shall be products of one manufacturer. Data showing equivalent performance of each paint product to be substituted for the ones specified shall be submitted for review at least 30 calendar days before the painting is to begin, and no painting shall proceed until the substituted products have been accepted.

C. All paints and painting materials not particularly specified shall be products of nationally known manufacturers of established good reputation, and shall be merchantable and suitable for the intended use. Materials listed in the painting schedule without reference to a specification number, and not further described hereinafter, shall be products that have had a minimum of two years' satisfactory field service.

D. All paints shall comply with the latest EPA regulations concerning volatile organic compounds (VOC).

2.02 COLORS AND FINISHES

A. The colors of finish coatings shall be selected by the Engineer from color chips submitted by the Contractor for review. The color selection shall be in the form of a color schedule indicating the colors to be used on the various surfaces. The colors used in the final work shall be in accordance with the color schedule and shall match the selected color chips.

B. In order to provide contrast between successive coats, each coat shall be of such tint as will distinguish it from preceding coats.

2.03 STORING AND MIXING

All painting materials shall be stored and mixed in a single place. Owner shall designate an area where all coatings shall be stored and mixed only. All mixing shall be done over a double tarped area. Any and all spills shall be reported to the Owner immediately at the time of incidence. Contractor shall bear responsibility, as well as all costs associated with cleanup and removal of any contaminated area(s). The Contractor shall not use any plumbing fixture or pipe for mixing or for disposal of any refuse material. He shall carry to his mixing area all water necessary, and shall dump all waste outside of the structure into a suitable receptacle so as not to create hazards or damage. The Contractor will be held responsible for all damage due to his failure to observe these provisions.

PART 3 - EXECUTION

3.01 SURFACE PREPARATION

A. General: Shop Surface Preparation: Prior to surface preparation, all surfaces shall be cleaned of all oil and grease in accordance with SSPC-SP 1 Solvent Cleaning. Before any surface is painted, it shall be cleaned carefully of all dust, dirt, grease, loose rust, mill scale, weathered paint, efflorescence, oil, moisture, or other foreign matter and conditions detrimental to coating bond and life. Where required, imperfections and holes in surfaces to be painted shall be filled in an acceptable manner. Surface profile shall be 1.5 - 2.5 mils.

B. All interior wetted metal surfaces shall be abrasive blast cleaned to near white condition corresponding to SSPC-SP10 prior to applying any paint to the surfaces. Abrasive blasted surfaces shall be painted prior to the formation of rust and not allowed to remain unpainted until the next working day. The primer shall be applied in accordance with the recommendations of the manufacturer and not more than eight hours after surface preparation. If the primer has exceeded its recoat time, 100% of the existing primer will be swept blasted to create a profile for the subsequent coats. Prepared surfaces shall be verified in accordance with SSPC-VIS1. Surfaces not meeting these requirements shall be re-blasted at no expense to the Owner.

C. All interior and exterior surfaces shall be sand blasted to remove all dust, rust and scale, as well as all other foreign matter and shall result in a surface preparation equal to that of SSPC-SP 10 Near White Blast Cleaned Surface.

D. All sandblasting work to be conducted on areas not previously sandblasted which are adjacent to areas that have previously been sandblasted and painted shall be done in a manner so that a minimum of six (6) inches of the painted surface is removed and will receive a fresh coat of paint at the same time as the newly blasted surface. This method shall be used for all interior and exterior surfaces.

E. Coordination: Surface preparation and painting shall be so programmed that dust and other contaminates from the cleaning process will not fall on wet, newly painted surfaces.

F. After erection and prior to painting, all interior and exterior surfaces shall be cleaned of all grease, oil, dirt, dust, rust, chalk residue, weld flux and spatter, and all other foreign matter or contaminants. All field welded edges and joints, as well as all abraded areas, shall be Near White Blasted in accordance with SSPC-SP 10. All surface preparation work shall comply with all state and local EPA regulations governing lead based paint removal and the levels of lead and silica to which the public can be exposed.

G. Dust from cleaning operations shall be properly removed by dry methods such as vacuuming or dry air blast, while not reducing the quality of the cleaned surface. Contractor shall have on the job at all times at least one (1) copy of the latest SSPC pictorial standards, which shall be followed. For ferrous metals, surface preparation shall consist of on or more of the methods contained in the methods supplied. Abrasives utilized for blasting operations shall contain less than 0.01% free silica during and following blasting operations. Contractor is responsible for all cleanup and removal of blasting media following operations, as well as total removal from

Owner's site. Media shall be profiled and documentation submitted to Consultant prior to media leaving site. Abrasive shall be of the correct size to create the desired profile from the coatings manufactures data sheet.

3.02 APPLICATION

A. Paint shall be used and applied as recommended by the manufacturer without being extended or modified, and with particular attention to the correct preparation and condition of surfaces to be painted. Only those solvents appearing as approved on the manufacturers product data pages shall be on the jobsite and used in the coating.

B. Surfaces which have been cleaned, pretreated, or otherwise prepared for painting shall be painted with the first field coat as soon as practicable after such preparation has been completed, but prior to any deterioration of the prepared surface. A prepared surface, which becomes corroded or contaminated, shall be re-prepared before painting at no additional cost to the Owner.

C. After the tank is completely erected, any abraded spots and all field-welded areas shall be cleaned as specified in the paragraph above. Field application of the coatings to a field sandblasted area shall be done the same day that the cleaning operation is carried out. Surfaces not coated the same day as surface preparation operations shall be re-blasted prior to application of the prime coat. All field-sandblasted areas shall be primed and the entire interior and exterior of the tank shall be finish painted as hereinafter specified. Unless otherwise specified, stainless steel surfaces throughout the work shall not be painted.

D. Hardware accessories, machine surfaces, plates, lighting fixtures, and similar items in place prior to surface preparation and painting, and not intended to be painted, shall be removed during painting operations and repositioned upon completion of each area or shall otherwise be protected. Existing antennas and communications facilities are to remain in service during repaint and repairs.

E. Paints or other finish shall not be applied to wet or damp surfaces, or when the relative humidity exceeds 85% except in accordance with the instructions of the manufacturer. Exterior painting shall not be done during cold, rainy, or frosty weather, or when ambient temperature or painting surface temperature is likely to drop to 50° F or below 5° above the dew point. Temperature requirements of paint manufacturer are to be observed when minimum is greater than 50° F. Painting of surfaces while they are exposed to the sun shall be avoided.

F. All paint shall be applied under favorable conditions by skilled painters and shall be brushed or rolled out carefully to a smooth, even coating without runs or sags. All coatings related work shall be performed only by competent blasters and painters. If workmen exhibit lack of experience they may not be allowed to work on project. Consultant has final determination on workmen & foreman assigned to project. SSPC or NACE surface preparation standards shall be on-site clearly visible to all workmen. A copy of project specifications shall be on job site at all times for workmen. Welds shall be stripe coated by brush or roller for additional corrosion

protection. Each coat of paint shall be allowed to dry thoroughly, not only on the surface but throughout the thickness of the paint film before the next coat is applied.

G. Finish surfaces shall be uniform in finish and color, and free from flash spots and brush marks. In all cases, the paint film produced shall be satisfactory in all respects to the Engineer.

H. Spraying with adequate apparatus may be substituted for brush application of those paints and in those locations for which spraying is suitable.

I. The Contractor shall not only protect his work at all times, but shall also protect all adjacent work and materials. Upon completion of the work, he shall clean up all paint spots, oil, and stains from floors, glass, hardware, and similar finished items.

J. Shop priming of any accessories to be added to the existing tank shall be allowed by the Contractor. The preparation of all metal surfaces prior to applying any paint shall be conducted in accordance with the specification herein.

K. If the accessories are shop primed, the Contractor shall pay for all costs and expenses for the Engineer to inspect the tank while being shop primed. Once the accessories have been installed in the field, all welds, scratches, and other areas which were damaged during installation shall be sandblasted and primed as per the specification herein.

L. Ventilation is essential to remove vapors during application and curing of coatings. Ventilation shall be exhausted from lowest portion of tank with top openings kept clear. During coating applications the capacity of the ventilating fans shall be at least 400 cfm per gallon of coating applied per hour. The ventilation requirements are to ensure proper curing of the applied coatings and are not to be taken as requirements to insure worker safety. Following the application of the final interior coating the tank shall be force ventilated by mechanical means from the lowest possible point for a minimum of 48 hours, ventilation shall be such that it creates a total turn over on the interior of the tank a least once per hour.

M. Quality assurance shall be coordinated with manufacturers:

1.	Rust-Oleum Industrial	Mark Sholtes	502-451-2226
2.	Tnemec	Jerry Petro	877-348-8427

Alternate products may be considered, Contractor shall submit in writing detailed explanation for requesting product change, along with pricing of product. If product is accepted any and all savings shall revert back to owner. Contractor shall bear any and all costs associated with evaluation of product by consultant, which may include but not limited too research, and testing by independent laboratories for product performance, and equality of those specified.

N. Only approved thinners from coatings manufacture shall be used at all times. Any and all spills shall be reported to the Owner immediately at the time of incidence.

Contractor shall bear responsibility, as well as all costs associated with cleanup and removal of any contaminated area (s).

O. Apply paints only when temperature of surfaces to be painted and surrounding air temps are between 55 and 90 degrees Fahrenheit unless otherwise permitted by paint manufactures printed instructions. Application of coatings will not be permitted in snow, rain, fog, mist or when the relative humidity exceeds 85%; or when the surface temp of substrate is less than 5 degrees Fahrenheit above the dew point; or to damp or wet surfaces. Painting will not be allowed during periods of inclement weather. The Contractor at all times shall provide adequate illumination in areas where painting operations are in progress. Lighting shall be OSHA approved and explosion proof.

P. All coatings-related work shall be performed only by competent blasters and painters. If workmen exhibit lack of experience they may not be allowed to work on project. Engineer has final determination on workmen & foreman assigned to project

3.03 RATES OF APPLICATION

A. Paint shall be applied so as to obtain the coverage per gallon and the dry film thickness recommended by the manufacturer or as specified herein. The Contractor shall record, in a manner satisfactory to the Engineer, the quantities of paint used for successive coats on the various parts of the work.

B. If paints are thinned for spraying, the film thickness after application shall be of the same as for unthinned paint applied by brush. Thinning of paint for spraying shall be in accordance with the paint manufacturer's recommendations. Deficiencies in film thickness shall be corrected by the application of another coat of paint. Excessive application rates will not be allowed. The Contractor shall submit to the Engineer, immediately upon completion of the job, certification from the paint manufacturer indicating that the quantity of each coating purchased was sufficient to properly coat all surfaces. Such certification shall make reference to the square footage figures provided to the manufacturer and the Engineer by the Contractor.

C. The paint applicator shall have available on the project site a paint film thickness measuring device capable of measuring 0-59 mils with accuracy of □ 2% + 0.1 mil, operating temperature range 5° C to 50° C and meet ASTM B499 and ISO 2178 specifications.

3.04 PAINT TYPES AND SCHEDULE

The following types of paints shall be used throughout the work on items and surfaces indicated. All paints and painting schedules shall be in accordance with current EPA regulations and NSF Standards.

A. External Painting: The Contractor shall furnish all materials and labor to paint the external surface of the tank, center riser, support legs, bracing, catwalk, ladder, and

any and all exterior metal surfaces on or related to the tank. There shall be no paint applied until the sandblasting is complete and approved by the Owner prior to applying new paint. The painting shall conform to the following:

1. Rust-Oleum Industrial

First Coat: Rust-Oleum 9380 to a DFT of 3-5 mils
Gray
Second Coat: Rust-Oleum 9370 to a DFT of 3-5 mils
Buff
Third Coat: Rust-Oleum 9400 to a DFT of 2-3 mils
White

Minimum DFT shall not be less than 10 mils

2. Tnemec Co

First Coat: Tnemec Series 69 to a D.F.T. of 3.0-5.0 mils
Red
Second Coat: Tnemec Series 69 to a D.F.T. of 3.0-5.0 mils
Beige
Third Coat: Tnemec Series 73/74 to a D.F.T. of 3.0-5.0 mils
White
Minimum DFT of the exterior 9 mils

The DFT specified shall be obtained and additional coats shall be applied at the contractor's expense, to achieve the specified DFT.

B. Interior Painting: The Contractor shall furnish all materials and labor to paint the interior of the tank and center riser. There shall be no paint applied until the abrasive blasting is complete and approved by the Owner prior to applying new paint. The painting shall conform to the following:

1. Rust-Oleum Industrial

First Coat: Rust-Oleum W 9200 Primer to a DFT of 5.0-8.0 mils
Red
Second Coat: Rust-Oleum W 9293 Total DFT 5.0-8.0 mils
Marlin Blue
Finish coat: Rust-Oleum W 9293 Total DFT 5.0-8.0 mils
White

All weld seams shall receive an additional roll coat to a DFT of 5.0-8.0 mils Prior to finish application Red

Total DFT shall not be less than 15 mils not including the weld seams which shall be a minimum of 5 mils greater.

2. Tnemec Co

First Coat: 1 coat of Tnemec Series 20-1255 to a DFT of 3.0-5.0 mils
Red
Second Coat: 1 coat of Tnemec Series 20-1255 to a DFT of 3.0-5.0 mils
Beige
Third Coat: 1 Coat of Tnemec Series WH02 to a DFT of 4.0-6.0 mils
Tank White

All weld seams shall receive an additional roll coat to a DFT of 5.0 mils Prior to finish application Red

Total DFT shall not be less than 10 mils not including the weld seams which shall be a minimum of 5 mils greater.

The DFT specified shall be obtained and additional coats shall be applied at the contractor's expense, to achieve the specified DFT.

3.05 PAINT CURING

A. A combination of forced and natural ventilation should be continued after coating application is completed to ensure complete curing and solvent removal. Coating life may be shortened if there is inadequate ventilation during the curing period and residual coatings solvent may contribute to taste and odor problems in stored water. Lower temperature or higher humidity may extend the time that ventilation is necessary.

B. Should force curing become necessary during cold weather or for other reasons, the contractor and paint manufacturer shall submit a minimum of three copies of a plan the Engineer and Owner for approval.

C. Force curing is recommended during cold weather, for enclosed tanks or when coated surface is to be immersed before the 7 day room temperature curing can take place.

D. Approximate final cure of material is indicated when the surface is hard and cannot be marked by the fingernail and exhibits only slight softening after 120 minutes exposure to MIBK.

E. Rinse potable water tanks with fresh water before filling to remove any traces of solvent thus assuring the coating will impart taste or odor to the water for distribution.

3.06 DISINFECTION AND STERILIZATION

A. Disinfection and sterilization of the interior of the tank(s) shall not take place until the interior paint has sufficiently cured. This time shall not be less than seven (7)

days. Force curing may be conducted in accordance with the paint manufacturer; however, the Engineer shall be notified of the forced curing of the interior paint.

B. After curing at least the minimum number of days required by the paint manufacture, the Contractor shall wash the Head tank interior with an adequate volume of water to thoroughly wet all the interior surfaces including those above the high water level. All water will be removed and disposed of in accordance with approved regulations.

C. The Contractor shall sterilize the tower in accordance with current AWWA C652 Standard for disinfection and Kentucky Regulations 401 KAR 6-015. It is the Contractor's responsibility after washing and curing to completely disinfect the interior portion of the tank, AWWA C652 Method 2 ONLY if acceptable to KY Division of Water. If not acceptable then method 1 or 3 shall be used at no additional expense to owner. The Owner shall take and send water samples to the laboratory, but shall assume no responsibility for the sampling technique or the care of the samples. The stored tank water shall comply with Current STATE, USEPA, and AWWA standards for organic, inorganic, and biological contaminants as influenced by the operations of the Contractor. The Tank Contractor is to drain and clean all facilities after sterilization. The Owner reserves the right to delay testing and sterilization until the water is adequate for such major usage.

D. The tank(s) may be sterilized during preloading provided that no leaks are found which would require re-work and re-sterilization. Otherwise the spray method of sterilization as approved by the Kentucky Division of Water will be required.

E. Bacteriological testing of the water shall be conducted by the State Department of Health. The tank(s) shall not be placed in service until the sample is approved by the Health Department. All results are to be mailed to the Engineer. All costs of sampling, testing, and postage shall be borne by the Contractor.

3.07 WARRANTY

The Contractor, in signing his bid proposal, guarantees to repair any and all defects due to workmanship, i.e. sags, drips, cracks, separation or unsuitable material which may appear in the structures during the period of two years after the date of acceptance. A Third Party firm shall conduct warranty inspection. Any deficiencies shall be corrected at no cost to the owner; all costs for repair shall be incurred by the contractor and shall include the use of outside inspection personnel to verify to owner that repair work has been completed as needed. The owner may at their discretion elect to hold a 5% retainage until after the warranty inspection and any repair work has been completed, or alternatively, to accept a maintenance bond.

3.08 CLEAN UP

All construction material and debris shall be removed from the site upon completion of work

- END OF SECTION -

DIVISION 11

EQUIPMENT

SECTION 11268

HYDRODYNAMIC MIXING SYSTEM

PART 1 – GENERAL

1.01 The hydrodynamic mixing system (HMS) shall passively utilize the energy provided by the inlet water supply and generate sufficient inlet momentum to achieve a complete homogeneous blending of the water volume within the reservoir. Determination of complete blending shall be defined by the modeling requirements and supporting hydraulic analysis as conducted by the individual manufacturer. System submittals not providing this validation shall not be accepted.

1.02 The HMS shall consist of a bi-directional flow manifold equipped with variable orifice duckbill inlet nozzles and outlet flow check valves that are NSF61 certified. The HMS manufacturer shall be responsible for designing the system in accordance with the hydrodynamic criteria defined within these specifications and submit design calculations verifying compliance in accordance with the submittal requirements. All modeling and hydraulic and mixing calculations pertaining to the HMS shall be performed and certified by the duckbill valve manufacturer.

1.03 The complete hydrodynamic mixing system shall be supplied by the variable orifice nozzle manufacturer to maintain single source responsibility for the system. The complete system shall be defined as all piping and appurtenances within the tank reservoir downstream of the tank penetration. Appurtenances include pipe, fittings, horizontal and vertical pipe supports, expansion joints, variable orifice duckbill check valves, and any other equipment specified within this section of the specifications. HMS manufacturer shall be Tideflex Technologies, or approved equal.

PART 2 – REFERENCED STANDARDS

2.01 American National Standards Institute (ANSI)

B16.1 – Cast Iron Pipe Flanges and Flanged Fittings
B16.5 – Pipe Flanges and Flanged Fittings
B36.10 – American National Standard Weights and Dimensions of Welded and Seamless Wrought Steel Pipe

2.02 American Society for Testing and Materials (ASTM)

A53 – Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
A234 – Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
A240 – Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
A351 – Standard Specification for Castings, Austenitic, Austenitic-Ferritic (Duplex), for Pressure-Containing Parts
A536 – Standard Specification for Ductile Iron Castings

C110 – Ductile Iron and Gray-Iron Fittings, 3 In. through 48 In. for Water
D1330 – Standard Specification for Rubber-Sheet Gaskets
D1784 – PVC/CPVC Pipe Compounds
D1785 – PVC Pipe, Schedules 40, 80 & 120
D2466 – PVC Solvent Cement
D2855 – PVC Solvent Joints
D3261 – Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Fittings
D3915 – PVC Pipe Fitting Compounds

2.03 American Iron and Steel Institute (AISI)

AISI 304 – 304 Stainless Steel Plate
AISI 316 – 316 Stainless Steel Plate
AISI 1040 – Carbon Steel Plate

2.04 American Water Works Association (AWWA)

C104 – Cement-Mortar Lining of Ductile Iron Pipe and fittings for Water
C110 – Ductile-Iron and Gray-Iron Fittings, 3 In. through 48 In. for Water
C115 – Flange Ductile Iron Pipe with Ductile Iron or Gray Iron Threaded Flanges
C200 - AWWA Standard for Steel Water Pipe 6" and Larger
C207 – Standard for Steel Pipe Flanges for Waterworks Service – Size 4 In. to 144 In.
C220 – AWWA Standard for Stainless Steel Pipe, 4" and Larger
C900 – AWWA Standard for Polyvinyl Chloride (PVC) Pressure Pipe, 4 In. Through 12 In. for Water Distribution
C905 – AWWA Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In Through 48 In. for Water Transmission and Distribution
C906 – AWWA Standard for Polyethylene (PE) Pressure Pipe and Fittings, 4 In. Through 63 In. for Water Distribution

2.05 American Water Works Association Research Foundation (AwwaRF)

Project No. E20-J08 – Physical Modeling of Mixing in Water Storage Tanks (Forthcoming)

2.06 National Sanitation Foundation (NSF)

NSF Standard 14 – Plastic Piping System Components and Related Materials
NSF Standard 61 – Drinking Water System Components – Health Effects

PART 3 –PRODUCTS

3.01 Variable Orifice Duckbill Inlet Nozzles

A. Inlet ports/nozzles shall be duckbill-style check valves that allow fluid to enter the reservoir during fill cycles and prevent flow in the reverse direction through the nozzle during draw periods. Inlet ports/nozzles may not be fixed-diameter ports or pipes. The duckbill valves shall be NSF61 Certified. NSF61 approved/Certified materials will not be accepted in lieu of valve certification.

B. Inlet ports/nozzles shall have a variable diameter vs. flow hydraulic profile that provides a non-linear jet velocity vs. flow characteristic and a linear headloss vs. flow characteristic. The inlet ports/nozzles shall discharge an elliptically shaped jet. The nozzle must have been modeled by an independent laboratory.

C. Manufacturer shall have conducted independent hydraulic testing to determine headloss and jet velocity characteristics of duckbill valves. The testing must include multiple constructions (stiffness) and must have been conducted for free discharge (discharge to atmosphere) and submerged conditions. This testing shall include the flow distribution characteristics of duckbill valves installed on multiport manifolds.

D. Manufacturer shall have tested duckbill valves to determine deflection, stress, and strain characteristics under various load conditions. Modeling must have been done for flowing conditions (positive differential pressure) and reverse differential pressure.

E. Manufacturer shall have at least ten (10) years experience in the manufacturing of "duckbill" style elastomeric valves, and have duckbill valves installed on manifold piping systems in at least 50 distribution system reservoirs.

F. The duckbill style nozzles shall be one-piece elastomer matrix with internal fabric reinforcing designed to produce the required discharge velocity and minimum headloss requirements as stipulated in Part 11 - Submittals. The flange portion shall be an integral portion of the nozzle with fabric reinforcing spanning across the joint between the flange and nozzle body.

G. The elastomer used in construction of the duckbill valves must have been tested by an accredited independent laboratory that confirmed there is no degradation in the elastomer when exposed to chlorine and chloramine per ASTM D471-98. The manufacturer's name, plant location, serial number and product part number which designates nozzle size, material and construction specifications shall be bonded onto the surface of the nozzle.

3.02 Outlet Check Valves

A. The outlet flow valves shall be perforated disc type with elastomeric membrane, and shall be NSF61 Certified. NSF61 approved/Certified materials will not be accepted in lieu of valve certification.

B. The perforated disc shall be fabricated of stainless steel plate with welded support gussets. The disc shall be flanged and drilled to mate with ANSI B16.1, Class 125/ANSI B16.5 Class 150 flanges. The disc shall have three (3) tapped holes used for fastening the membrane and support rod to the disc with stainless steel bolts, nuts, and lock washers. The top of the disc shall be tapped and supplied with lifting eyebolt for installation.

C. The membrane shall be circular, one piece rubber construction with fabric reinforcement. The diameter of the membrane shall allow adequate clearance between the membrane O.D. and the pipe I.D. The membrane shall be vulcanized

with a specified convex radius to produce a compression set to allow the membrane to seal against the perforated disc at low reverse differential pressure.

D. The support rod shall be stainless steel and drilled with three (3) longitudinal holes to allow fastening of rod to membrane and perforated disc. When line pressure inside the valve exceeds the backpressure outside the valve, the line pressure shall force the membrane to open, allowing flow to pass through the perforations in the disc. When backpressure exceeds the line pressure, the membrane shall seat on the perforated disc preventing backflow. The valve shall allow flow out of the reservoir during draw cycles and prevent flow into the reservoir through the outlet check valve during fill cycles.

E. The elastomer used in construction of the membrane must have been tested by an accredited independent laboratory that confirmed there is no degradation in the elastomer when exposed to chlorine and chloramine per ASTM D471-98. The manufacturer's name, plant location, serial number and product part number which designates membrane size, material and construction specifications shall be bonded onto the surface of the membrane.

3.03 Stainless Steel Pipe and Fittings

A. Stainless steel pipe and fittings shall conform to the associated standards listed in Section 3.0: Reference Standards. Dimensions for stainless steel fittings shall conform to AWWA C110, unless otherwise specified. Piping shall be Schedule 10s stainless steel 304L fabricated from material per ASTM-A240.

B. All flanges shall be plate ring flanges. Flange drilling pattern shall be in accordance with ANSI B16.1/B16.5 standards. Ring flanges shall be continuously welded on both sides.

C. All shop welds shall be manually scrubbed or brushed with non-metallic pads or stainless steel wire brushes to remove weld discoloration. Welds to be chemically passivated with nitric or citric acid. Field welding of stainless steel pipe and fittings will not be allowed unless approved by the Engineer.

3.04 Flange Gaskets

A. Flange gaskets shall be full-faced and shall be in accordance with ASTM D1330. Drilling pattern shall conform to ANSI B16.1/B16.5.

B. Flange gaskets shall be 1/8" thick. Gasket material shall be EPDM.

3.05 Fasteners

A. Hex head bolts and nuts shall be stainless steel 304 conforming to ANSI/ASME B18.2.1 and ANSI/ASME B18.2.2.

B. Plastic insulating sleeve/washers shall be utilized to isolate dissimilar bolt and flange metals where required.

3.06 Pipe Supports

A. All components of the bracket assembly shall be stainless steel 304 in accordance with the associated standards.

B. The bracket assemblies shall consist of four components:

1. A base plate (when required). For concrete tanks, the base plate will have four thru holes for expansion anchors.
2. A top-works weldment that consists of structural channel and angle iron. The TMS piping shall rest on the angle iron. The angle iron has predrilled holes for the U-bolt.
3. U-bolt with four hex nuts.
4. A 1/8" thick EPDM strip with a length equivalent to the circumference of the pipe. The strip shall be placed between the pipe and the angle iron and U-bolt.

C. The channel of the top-works weldment shall be field fit and modified to the required length. The channel shall then be field welded to the base plate. For steel tanks, the base plate shall be field welded to the tank floor or shell. The location of the base plate shall avoid welded joints in the floor/shell plates. For concrete tanks, the support shall be anchored to the concrete floor with stud type expansion anchors, the pull-out rating of the combined anchors shall be a minimum of 10 times greater than the static weight of the vertical pipe section.

D. Plastic insulating sleeve/washers shall be utilized to isolate dissimilar metals where required.

3.07 Coatings

A. Following installation of the manifold system, all carbon steel and ductile iron pipe, fittings, bolted connections, pipe supports, and appurtenances shall be coated according to the interior tank paint specification as specified by the Engineer. (See Section 09870)

B. Valves shall not be coated. The valves shall either be masked or be mounted after coating of the tank and piping. Contractor to ensure masking materials are removed after coating.

3.08 Delivery, Storage, and Material Handling

A. Individual nozzles and outlet valves shall be packaged separately from the piping equipment. All flanges shall be protected by using plastic inserts or plank wood, pipe sections are to be fully supported to prevent pipe deflection or damage to fittings or connections. All equipment shall be shipped on pallets capable of fully supporting the pipe sections across their entire length. Pallets should be

accessible for fork lift transport or strap and hoist means without causing any load to the pipe equipment.

B. All stainless steel components shall be stored separately away from any carbon steel components or other materials that could stain or deface the stainless steel finish from run-off of oxidized ferrous materials. All pipe equipment should be covered and stored in areas free from contact with construction site sediment erosion to prevent accumulation of materials within the pipe and fittings.

C. Duckbill nozzles should be protected from contact with rigid objects during handling and storage. The contractor shall be responsible for replacing any duckbill nozzles or elastomeric components that are damaged after arrival on the site through installation and start-up of the system.

PART 4 – SUBMITTALS

4.01 Independent Validation

A. The mixing system designer/supplier must supply data or report from at least one project where an independent company conducted fluid dynamics modeling on their mixing system design which confirmed the HMS design achieved complete mixing.

B. The mixing system designer/supplier must supply data or report from at least one project where a full scale tracer study using calcium chloride was conducted on an elevated tank and the tracer study results verified the mixing system design achieved complete mixing.

4.02 Inlet Nozzle and Outlet Valve Testing and Validation

A. The duckbill valve manufacturer shall provide summary documentation of modeling and/or independent testing to determine:

1. Headloss and jet velocity characteristics on a minimum of eight (8) sizes of duckbill valves ranging from 2" through 48". The testing must include multiple constructions (stiffness) within each size and must have been conducted for free discharge (discharge to atmosphere) and submerged conditions.

2. Headloss characteristics of the duckbill valve and to prove the repeatability and consistency of the manufacturing process to produce the same hydraulic characteristics.

3. Deflection, stress and strain characteristics under various load conditions. Modeling must have been done for flowing conditions (positive differential pressure) and reverse differential pressure.

4. Headloss characteristics of perforated disc/elastomeric membrane check valves, with and without the membrane installed.

5. Performance of a perforated disc/elastomeric membrane check valve to determine stress and deflection characteristics under reverse differential pressure.

6. No degradation in the elastomer when exposed to chlorine and chloramine per the ASTM D471-98 "Standard Test Method for Rubber Property – Effect of Liquids."

B. The mixing system designer/supplier must submit at least one inspection report showing proper operation of, and no deterioration of, the duckbill valves after being in service in a water storage tank mixing application for a minimum of 10 years.

C. The mixing system designer/supplier shall submit the NSF61 Certified listing for the valves used in the Hydraulic Mixing System (HMS) and the valves themselves must be NSF61 certified, not just the elastomer used in construction of the valves. NSF61 approved/certified materials will not be accepted in lieu of valve certification. The NSF61 Certification for the valves must be for a minimum volume of 2,000 gallons. Valves with NSF61 Certification for minimum volume of greater than 2,000 gallons are not acceptable.

D. The duckbill valve manufacturer shall submit engineering installation drawings of the complete manifold piping system as supplied by the manufacturer. These drawings shall include plan view piping arrangement, sections and elevations as required, support bracket installation details, duckbill nozzle orientation details, and all dimensions required for locating the system within the specified dimensions of the tank. Six (6) sets of plans shall be submitted for review and approval. Two (2) sets of final fabrication and installation drawings shall be included with the shipment of the manifold piping equipment.

E. All Design Calculations, curves, and reference information listed below must originate and be submitted by the duckbill valve manufacturer. Calculations, curves, and reference information provided by contractors relating to the HMS are not acceptable. The duckbill valve manufacturer must include within the submittal package the following design calculations, curves, and reference information:

1. Calculations showing the fill time required, under isothermal conditions, for the HMS system to achieve complete mix of the reservoir volume at minimum, average and peak fill rates. Complete mixing defined as 95% homogenous solution. The theory and equations used in calculating the mixing times must be from a published AWWA reference manual or paper. The reference document(s) must be submitted with the equations and calculations.

2. Calculations showing the water level drawdown required to achieve complete mixing on the fill cycles at minimum, average, and peak flow rates.

3. Calculations of average storage tank water age for both fill-then-draw, and simultaneous fill and draw scenarios. Theory used in calculating water age must be submitted with the calculations.

4. A representative fluid dynamics model evaluation of the proposed HMS system configuration applied within a reservoir of similar geometry. Model output documentation shall include all design variables applied for the simulation, plot of the 3-D geometry showing the mesh definition, velocity magnitude vector and contour plots at different cross-sections throughout the water volume, simulated tracer animations showing the spatial and temporal distribution of inlet water in real time during the fill cycle.

5. Hydraulic calculations showing the resulting jet velocities of each inlet nozzle at minimum, average, and peak fill rates.

6. Hydraulic calculations showing the flow distribution among all inlet ports at minimum, average, and peak fill rates.

7. Manifold hydraulic calculations showing the total headloss of the HMS at minimum, average, and peak fill and draw rates. Headloss shall include all minor losses and headloss of nozzles and outlet check valves.

8. Hydraulic curves showing thrust vs. flow for the inlet nozzles.

9. Hydraulic curves for each outlet check valves showing headloss vs. flow.

10. Calculations showing the terminal rise height of the jets that discharge at an angle above horizontal. The terminal rise height shall be calculated assuming 10°F and 20°F colder inlet water and calculated at minimum, average and peak fill rates. The theory and equations used to calculate the terminal rise height shall be included.

11. Hydraulic curves for each inlet nozzle of Densimetric Froude number vs. flow.

F. Within 30 days of final approval of the installation drawings, by the Engineer, the HMS valve manufacturer shall submit four (4) sets of the installation portion of the Installation, Operation and Maintenance (IOM) Manuals for the applicable system. Within 30 days of final approval, by the Engineer, of the installed system the manufacturer shall provide six (6) copies of the complete Installation, Operation and Maintenance (IOM) Manual for final review and approval. The manuals shall include the listed required information as a minimum:

1. Copy of design calculations for the manifold system as defined in the previous section.

2. Copy of complete set of the installation plans.

3. Copy of NSF61 Certified Listing for the valves

4. Parts and equipment list with specification numbers for ordering of replacement parts.

5. Product specification sheets for nozzles, outlet valves, expansion joints, concrete anchors, and any other specialized items supplied with the system.

6. Installation guidelines for the HMS manifold system.

7. Operational procedures for the HMS manifold system.

8. Guidelines for repair of system components.

9. Schedule for suggested periodic maintenance of the manifold system.

PART 5 – INSTALLATION, INSPECTION, START-UP, AND WARRANTY

Installation of the manifold system shall be in accordance with the installation plans and guidelines provided by the HMS manufacturer and as specified in the installation section of the IOM manual. Refer to Part II - Submittals for quantities and delivery schedules of the documents. The HMS manufacturer's authorized representative shall provide one (1) day inspection to verify that the system has been installed in accordance with the design specifications and installation drawings, and shall perform.

A. Start-Up Flow Testing:

1. Following installation of the complete manifold piping system, the contractor shall open the upstream isolation valve to allow flow into the tank through the manifold system. The isolation valve must be opened slowly to prevent surge or over-pressurization of the manifold system. The isolation valve must be fully opened to inspect the flow characteristics of the manifold system.

2. The contractor and factory representative shall visually inspect the entire piping system for leakage.

3. The contractor and factory representative shall visually inspect all of the inlet nozzles to ensure flow is being discharged into the tank through all nozzles.

B. Warranty shall include the following:

1. The complete manifold piping system shall be supplied by the HMS manufacturer to maintain single source responsibility for the system. The complete system shall be defined as all piping and appurtenances within the tank downstream of the tank penetration. Appurtenances include pipe, fittings, horizontal and vertical pipe supports, expansion joints, duckbill valves, and any other equipment specified within this section of the specifications.

2. All piping, pipe support brackets, joint connections, expansion joints, and anchors shall be warranted by the HMS manufacturer against failure under

design conditions for a period of one (1) year from the date of final installation approval by the Engineer.

3. Inlet nozzles and outlet valves shall be warranted by the manufacturer against failure under design operating conditions for a period of one (1) year from the date of final installation approval by the Engineer. Elastomer components damaged as a result of maintenance activities, foreign debris, or excessive exposure to direct ultraviolet and thermal radiation shall be excluded warranted coverage.

- END OF SECTION -

DIVISION 13

SPECIAL CONSTRUCTION

SECTION 13210

COMPOSITE ELEVATED WATER STORAGE TANK

PART 1 – GENERAL

1.01 SUMMARY

A. Work Included

This Section includes the design, construction, testing, disinfection, and commissioning of a composite elevated tank and related work including foundation, painting, electrical and appurtenances.

B. Related Documents

Drawings and the general provisions of this document, including General Conditions, Supplementary Conditions, KIA Supplemental Conditions, and other Sections apply to work in this Section.

1.02 REFERENCES

The following Specifications, Codes and Standards may be referenced in this Section. All references are to the latest published edition.

A. American Concrete Institute (ACI)

117-10	Standard Tolerances for Concrete Construction and Materials
228.1R-03	In-Place Methods to Estimate Concrete Strength
301-05	Specification for Structural Concrete
304-00	Guide for Measuring, Mixing, Transporting and Placing Concrete
305-10	Hot Weather Concreting
306-10	Cold Weather Concreting
318-08	Building Code Requirements for Structural Concrete
347-04	Guide to Formwork for Concrete
371R-08	Guide for the Analysis, Design and Construction of Elevated Concrete and Composite Steel-Concrete Water Storage Tanks

B. American Institute of Steel Construction (AISC)

S335 Specification for Structural Steel Buildings

C. American National Standards Institute (ANSI)

B16.5 Pipe Flanges and Flanged Fittings

D. American Society of Civil Engineers (ASCE)

ASCE 7 Minimum Design Loads for Buildings and Other Structures

E. American Society for Testing Materials (ASTM)

A 123	Zinc Coatings on Iron and Steel Products
A 240	Stainless Steel Plate, Sheet and Strip for Pressure Vessels
A 285	Pressure Vessel Plates, Carbon Steel
A 774	Welded Stainless Steel Fittings
A 778	Welded Stainless Steel Tubular Products

F. American Water Works Association (AWWA)

C652-02	Disinfection of Water-Storage Facilities
D100-11	Welded Steel Tanks for Water Storage
D102-11	Coating Steel Water Storage Tanks
D107-10	Composite Elevated Tanks for Water Storage

G. Federal Aviation Administration (FAA)

70/7460-1H	Obstruction Marking and Lighting

H. National Association of Corrosion Engineers (NACE)

RP0178	Recommended Practice - Fabrication Details, Surface Finish Requirements and Proper Design Considerations for Tanks and Vessels to be lined for Immersion Service

I. National Fire Protection Association (NFPA)

NEC	National Electric Code
780	Standard for the Installation of Lightning Protection Systems

J. National Sanitation Foundation (NSF)

61	Standard for Drinking Water System Components

K. Occupational Safety and Health Administration (OSHA)

29 CFR Part 1926	Safety and Health Regulations for Construction

L. Steel Structures Painting Council (SSPC)

VIS-89 Visual Standard for Abrasive Blast Cleaned Steel

1.03 SYSTEM DESCRIPTION

A. Elevated Tank

The composite elevated tank shall consist of the following: foundation, reinforced concrete support structure, and a welded steel water tank. The support tower shall extend vertically from the foundation as a circular concrete support structure/wall. A structural concrete dome shall be provided as structural support for the contained water within the perimeter of the wall. A reinforced concrete ring beam shall be provided to connect the welded steel water tank, concrete dome and concrete support wall. The composite elevated tank shall be in accordance with the shape, dimensions and details required by these Specifications and Drawings. Dimensions may be slightly adjusted to suit the composite elevated tank Manufacturer's standard welded steel water tank shape.

B. Operating Parameters

Minimum capacity within operating range		1,000,000 gallons
Maximum operating range		35 ft.
Elevation	- overflow/top capacity	1,140 ft.
	- grade slab	948 ft.
	- final grade	946 ft.

C. General Design

The structural design of the composite elevated water storage tank shall conform to AWWA D107 and the following design standards. In case of conflict between the Standard and the criteria listed below, the more stringent requirement shall apply.

Reinforced Concrete Foundation – ACI 318
Concrete Support Structure – AWWA D107 and ACI 318
Welded Steel Water Tank – AWWA D107

D. Design Loads

Design loads shall be in accordance with ASCE 7 for Category IV (essential facility) structure.

1. Dead load shall be the estimated weight of all permanent construction.

2. Water load shall be the weight of water when the tank is filled to overflow.

3. Roof live load in addition to snow load: none.

4. Roof snow load shall be the larger of 25 psf. or the snow load determined in accordance with ASCE 7. Ground snow load shall be determined from Figure 7-1 in ASCE 7.

5. Wind loads shall be in accordance with ASCE 7 for wind exposure category C, and basic wind speed of 90 mph. (see Figure 6-1 in ASCE 7)

6. Horizontal and vertical seismic loads shall be in accordance with ASCE 7 and the Site Class as determined in the soil investigation report.
Importance factor I = 1.50.
Response Modification Coefficient R = 3.0 in accordance with ASCE 7

E. Foundation Design – AWWA D107

The foundation shall be designed by the composite elevated water storage tank Contractor to safely support the structure based on the foundation recommendations within the Contractor's Final Geotechnical Report. Foundations shall be sized in accordance with load combinations defined by AWWA D-107, Sec. 4.3

F. A Preliminary Geotechnical Report by Consulting Services Incorporated is provided as Appendix A of the Specifications for information purposes only. The tank foundation design shall be the tank contractor's responsibility. Obtaining and evaluating all necessary additional subsurface information for the foundation design shall also be the Contractor's responsibility. Copies of the Contractor Final Geotechnical Report reports shall be submitted with foundation design to the Engineer for review.

1.04 SUBMITTALS

A. Proposal (Submit the following with the proposal):

1. Experience List – A completed contracts summary shall demonstrate a minimum of ten years experience in the design and construction of composite elevated tanks. Contractor shall list a minimum of five completed composite elevated tanks of similar capacity. Provide the location, capacity, Owner's name and contact information, Engineer's name and contact information and year completed. Failure to provide this information shall be cause for rejection of the bid (See also 1.05 A 1).

2. Tank Drawing – A preliminary section view drawing of the composite elevated tank proposed for this project. The drawing shall include sufficient detail to illustrate tank geometry, materials of construction, primary dimensions, the high water level elevation, concrete support structure wall thickness and other information required to show compliance with this Specification. If the proposed design does not comply with this Specification, the bid shall be cause for rejection of the bid.

3. Foundation Drawing – A drawing of the preliminary design of the foundation for the composite elevated tank proposed for this project. The drawing shall include sufficient detail to illustrate foundation geometry, materials of construction, preliminary dimensions and approximate quantities of concrete and reinforcing steel. Failure to provide this information shall be cause for rejection of the bid.

B. Construction Drawings

1. Provide elevation, plan and sectional view drawings of the foundation, concrete support structure, welded steel water tank and all appurtenant equipment and accessories. Show the location, dimensions, material, specifications and finish requirements. The submission shall be sealed by a professional engineer registered in the Commonwealth of Kentucky.

2. Reinforced concrete details shall include construction joints, openings and inserts. Reinforcement shall be clearly indicated on the structural drawings and identified by mark numbers that are used on the fabrication schedule. Location, spacing and splice dimensions shall also be shown. Placement and fabrication details shall conform to ACI 318.

3. Steel tank details shall include weld joints and a layout showing all primary and secondary shop and field welds.

C. Construction Procedures

1. Provide design, detail drawings and procedures for the support structure forming system. Details shall include location of form and construction joints, rustications and any form ties. The criteria and minimum elapsed time for adjacent concrete placement shall also be clearly stated in the construction procedures. Procedures shall yield a minimum of twenty-four (24) hours of cure time before form removal.

2. Provide shop and field weld procedures for all structural joints on the steel tank.

D. Design Data

1. Provide a table showing capacity of the tank in gallons at all levels in one ft. increments.

2. Provide a summary of the design for the foundation, concrete support structure, welded steel water tank and other components. Include the design basis, the loads and load combinations and the results.

E. Product Data

1. Provide separate concrete mix designs for each specified concrete compressive strength indicated on the drawings.

2. Provide technical data and manufacturer's standard color chart of all coating products to be used.

3. Provide manufacturer's descriptive information for appurtenant equipment and accessories that are not detailed on the construction drawings.

F. Reports/Certification

7. Provide documentation of all tests, inspections and certifications required by this Section.

8. Provide general qualifications of all welders.

G. Operation/Maintenance

Provide operating instructions and maintenance procedures for the composite elevated tank and applicable appurtenant equipment, mechanical components and miscellaneous accessories.

1.05 QUALITY ASSURANCE

A. Qualification of Manufacturer

1. A composite elevated tank manufacturer/contractor shall perform the work described in this Section. No part of the design or construction of the concrete support structure or welded steel water tank shall be subcontracted. The Contractor shall have designed, constructed and placed in service a minimum of five (5) composite elevated tanks of similar capacity in the past ten (10) years.

2. The Contractor shall employ a full-time Professional Engineer with a minimum five (5) years cumulative experience in the design and construction of composite elevated tanks. The engineer shall be registered in accordance with these Specifications and shall be in responsible charge of the work.

3. The Contractor shall own and maintain all equipment necessary for the turnkey construction of the composite elevated tank as specified herein. This includes the formwork for the concrete support structure construction as well as the fabrication and erection equipment required for the welded steel water tank construction. Neither the concrete support structure construction or the welded steel water tank fabrication and erection shall be subcontracted.

4. Acceptable manufacturers meeting these qualifications are Caldwell Tanks, Inc., Phoenix Fabricators and Erectors, Inc., CB&I Constructors, Inc. and Landmark Structures, Inc.

B. Regulatory Requirements

1. The Specifications, Codes and Standards referenced in Article 1.02 shall govern the work with regard to materials, design, construction, inspection and testing to the extent specified.

2. The composite elevated tank shall be designed and constructed in compliance with applicable federal, state and local regulations.

3. Personnel safety equipment shall be provided in accordance with OSHA requirements and the manufacturers' documentation.

1.06 DELIVERY, STORAGE, & HANDLING

A. Handling and Shipping

The Contractor shall handle materials and fabricated components in a manner that will protect them from damage. Allow painted materials adequate cure time prior to stacking or shipping.

B. Storage and Protection

Protect delivered materials and equipment from damage. Store in well drained areas and provide blocking to minimize contact with the ground.

1.07 PROJECT CONDITIONS

A. Permits and Easements

1. Airspace authority approval, Division of Water approval, site access easements, and highway access permits, shall be secured and paid for by the Owner prior to the start of construction.

2. All other licenses or permits shall be the responsibility of the Contractor.

B. Existing Conditions

G. A Preliminary Geotechnical Report by Consulting Services Incorporated is provided as Appendix A of the Specifications for information purposes only. The tank foundation design shall be the tank contractor's responsibility. The Contractor shall be responsible for securing all final geotechnical information required beyond the preliminary report, and shall retain the services of a geotechnical engineer to verify the capacity and adequacy of the bearing stratum. Obtaining and evaluating all necessary additional subsurface information for the foundation design shall also be the Contractor's responsibility. Copies of the Contractor Final Geotechnical Report reports shall be submitted with foundation design to the Engineer for review.

C. Access

The Owner shall provide an access easement and highway permit from U.S. 42 to the construction site. The Contractor shall provide traffic control in compliance with notes on the plans. The temporary construction access entrance from U.S. 42 has poor sight distance and high potential for accidents. The Contractor shall provide a Certified Traffic Control Plan to be submitted and approved by District 5 of the Kentucky Transportation Cabinet. This plan must be prepared by a Certified Traffic Control Planner, and it will include all necessary signage and

safety equipment. The presence of radio-coordinated Certified Traffic Control technicians will be mandatory during all entrances from, and exits to U.S. 42.

D. Working Conditions

1. Safety and Health - The Contractor shall comply with safe working practices and all health and safety regulations of OSHA, state and local health regulatory agencies and Material Safety Data Sheets (MSDS). Provide protective and lifesaving equipment for persons working at the site.

2. Times for Work - Times for work shall comply with local, state and federal regulations and laws.

1.08 SEQUENCING AND SCHEDULING

A. Schedule

The Contractor shall provide an anticipated schedule for design, submittals, site work and the major components of construction including foundation, concrete support structure and welded steel water tank, tank painting, electrical installation and other significant activities. Update the schedule as required.

B. Notification

The Contractor shall provide notification of the intent to start work at least seven days prior to commencing each major phase of work.

C. Certifications

1. Provide certification that the composite elevated tank has been completely designed in accordance with the requirements of the Specification.

2. Provide certification that field testing and inspection requirements of item 3.4 have been performed and the results comply with the requirements of the specification.

1.09 GUARANTEES

A. The Contractor shall guarantee the structure, appurtenant equipment and accessories provided under this Section against defective design, workmanship, or materials for a period of one year from the date of substantial completion. If notified within this period, the Contractor shall repair any defects caused by faulty design, workmanship, or material furnished under these Specifications at no cost to the Owner. If Contractor is not advised of any defects within 30 days of the end of the guarantee period, then this guarantee shall be considered fulfilled and complete. Defects caused by damaging service conditions, such as electrolytic, chemical, or abrasive, are not covered by this guarantee.

B. All guarantees from any manufacturer or installer of paint, materials, equipment and accessories not manufactured by the composite elevated tank manufacturer

and that are provided under this Section, shall be obtained by the Contractor and submitted to the Owner.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Reinforced Concrete

Concrete materials and reinforcement shall comply with ACI 318 and AWWA D107, except as modified in this Section.

B. Steel Tank

Welded steel water tank components, including steel plates, sheets, structural shapes, and filler metals shall be in accordance with AWWA D107.

2.02 CONCRETE FOUNDATION

The concrete foundation shall be designed in accordance with ACI 318. Minimum specified compressive strength shall be as, required by final design but not less than 4000 psi at 28 days. Reinforcing steel shall be ASTM A615 Grade 60. The service load reinforcement tension stress shall not exceed 30,000 psi under dead plus water load unless flexural cracking is otherwise controlled in accordance with ACI 318.

2.03 CONCRETE SUPPORT STRUCTURE

The concrete support structure shall be designed in accordance with ACI 318. The specified compressive strength of concrete shall be as required by design, but not less than 4000 psi at 28 days. The maximum specified compressive strength of concrete for the wall and dome shall be 6000 and 5000 psi respectively.

A. Support Wall

The support wall shall be reinforced concrete with a minimum thickness of 8 in. exclusive of any architectural relief. Wall thickness shall be provided such that the average compressive stress due to the weight of the structure and stored water is limited to 25% of specified compressive strength, but not greater than 1000 psi. A minimum total wall reinforcement of 0.15% vertically and 0.20% horizontally shall be distributed approximately equally to each face. A minimum of 0.75% vertical reinforcement shall be provided in the top 6 ft. of the wall extending into the concrete ring beam. Minimum concrete cover for interior/exterior faces shall be 1 in. and 1-1/2 in. respectively.

B. Tank Floor

The tank floor shall be a reinforced concrete dome not less than 8 in. thick. The average compressive stress due to the weight of the structure and stored water shall not exceed 15% of the specified compressive strength, nor greater than 600 psi. Minimum total reinforcement in orthogonal directions shall be 0.40% distributed approximately equally to each face. Additional reinforcement shall be provided for stress caused by edge restraint effects.

C. Openings

1. The effects of openings in the wall shall be considered in the design. Not less than 60% of the interrupted reinforcement in each direction shall be placed each side of the opening. Reinforcement shall extend past the opening not less than half the transverse opening dimension.

2. Openings 8 ft. 0 in. or wider used for vehicle access shall be strengthened against vehicle impact and local buckling by means of an internal buttress located on each side of the opening. The buttress shall consist of a thickened, reinforced concrete wall section that is integrally formed and placed with the concrete support structure.

2.04 CONCRETE SUPPORT STRUCTURE/STEEL TANK INTERFACE

A. Interface Region

1. The interface region includes those portions of the concrete support structure and steel tank affected by the transfer of forces from the tank cone and the tank floor to the concrete support structure. This includes a ring beam and connection details. The Contractor shall provide evidence that a thorough review of the interface region has been performed. Finite element and finite difference analyses are the required methods for examining such local stresses in detail.

2. The geometry of the interface shall provide for positive drainage and not allow either condensate or precipitation to accumulate at the top of the concrete wall or ring beam.

B. Ring Beam

1. The ring beam shall be reinforced concrete with a nominal width and height of at least two times the concrete support structure wall thickness. Minimum radial and circumferential reinforcement shall be 0.25%. For direct tension, reinforcement shall be provided such that the average service load stress in tension reinforcement due to the weight of the structure and stored water does not exceed 12,750 psi.

2. Ring beam design shall consider unbalanced forces from the welded steel tank cone and concrete dome, load conditions varying with water level,

eccentricity of loads resulting from design geometry and allowance for variations due to construction imperfection and tolerance.

2.05 WELDED STEEL TANK

A. General

The steel tank shall be all welded construction and shall be designed, fabricated and erected in accordance with applicable sections of AWWA D107. The required capacity and dimensions of the tank are noted on the drawings and in this Section of the Specifications. All exposed lap joints shall be fully seal welded on both sides.

B. Plate Thickness

All members shall be designed to safely withstand the maximum stress to which they may be subjected during erection and normal operation. The minimum thickness of any steel plate in contact with water shall be 1/4 in. The minimum thickness of any steel plate not in contact with water shall be 3/16 in.

C. Roof Support

All structural members supporting the roof of the steel tank shall be flat bar or sealed square tubular sections. I-beams or other sections with horizontal projections may be used if the nominal depth is 10 in. or greater. Support beams shall be seal welded to the underside of the roof plate along the entire length of the beam.

D. Cone

1. Conical sections of the tank shall be designed using one of the 3 methods described in AWWA D107, Section 5.3.5. Inspections and reports shall be provided to the extent required by AWWA D107.

E. Bottom Liner

Liner plates shall be shop fabricated to conform to the shape of the concrete dome. They may be placed directly on the concrete. All liner plate seams shall be lap welded on the topside only with continuous fillet welds or continuous butt welds with backup bars. The minimum thickness for liner plates shall be 1/4 in.

2.06 APPURTENANCES AND ACCESSORIES

A. General

Accessories shall comply with the minimum requirements of the Specifications, Codes and Standards listed in paragraph 1.2, current applicable safety regulations and the operating requirements of the structure.

B. Ladder Access

1. Ladders shall be provided from the slab on grade inside the base of the concrete support structure to the upper walkway platform located below the tank floor. The tank floor manhole shall be provided with ladder access from the upper platform. A ladder shall extend from the upper platform, through the access tube interior to the roof. A ladder mounted on the access tube exterior shall be provided for access to the tank interior, extending from the roof manhole to the tank floor.

2. Ladders that terminate at platforms or landings shall extend 48 in. above the platform elevations. A removable extension kit (Bilco Ladder-Up Safety Post or equal) shall be added to the fall protection system for all ladders not extending 48 in. above the platform elevations.

3. Ladders located in the concrete support structure shall be galvanized steel. Tank interior and access tube ladders shall be coated in accordance with the tank interior coating system.

4. Ladder side rails shall be a minimum 3/8 in. by 2 in. with a 16 in. clear spacing. Rungs shall be minimum 3/4 in. diameter, spaced at 12 in. centers and plug welded into holes drilled in the side rails. The surface of the rungs shall be knurled, dimpled, or otherwise treated to minimize slipping.

5. Ladders shall be secured to the adjacent structure by brackets located at intervals not exceeding 10 ft. Brackets shall be of sufficient length to provide a minimum distance of 7 in. from the center of the rung to the nearest permanent object behind the ladder. Ladder brackets located on the access tube exterior shall be reinforced at the access tube shell so that potential ice damage is confined to the ladder and bracket; and not the access tube shell.

C. Safe Climbing Device/Safety Equipment

OSHA compliant safe climbing system shall be provided on all ladders. Two sleeves with snap hooks shall be provided that are designed to be operated with the system. Two harnesses with shock resistant lanyards shall be provided with the system. A caution sign shall be provided at the lowest point of access to the ladder requiring safe climbing devices. The sign shall read "CAUTION – Safety Equipment Required When Climbing Ladder ". The sign shall be secured to the wall.

D. Rest Platforms

Rest platforms shall be provided at maximum 50 ft. intervals along the interior concrete support structure ladder. The platforms shall be nominal 5 ft. x 5 ft. and platform floor shall be grating, with handrails, mid rails and toe plates in accordance with OSHA requirements. Openings shall be provided in the landings to accommodate the ladder that shall have a straight-run its full height. All

platform components shall be galvanized steel and attachment hardware shall be zinc plated.

E. Platforms

A 4 ft. wide upper walkway platform shall be located at the top of the concrete support structure to provide access from the concrete support structure ladder to the roof access ladder located on the interior of the access tube. Platforms shall be provided with handrails, midrails and toe plates in accordance with OSHA requirements. Grating shall be used for the walking surface. All components shall be galvanized steel and attachment hardware shall be zinc plated.

F. Concrete Support Structure Doors

1. Personnel Door - Door frames shall be 16-gauge with concealed reinforcement at hardware locations. Expansion type anchors for existing openings shall be installed near the top, bottom and intermediate point of each jamb to rigidly secure the frame. Doors shall be 1-3/4 in. thick insulated, reinforced, full, flush type with 18-gauge face sheets and concealed reinforcement at hardware locations. All edges shall be finished flush with watertight seams. Shop applied finish for the frame and door shall be baked on rust inhibitive primer. Field finish shall be compatible with the tank exterior. Standard hardware shall be stainless steel and include three 4-1/2 in. by 4-1/2 in. hinges, industrial duty closer and lockset. Quantity, location and size of personnel door(s) shall be as shown on the Project Drawings.

2. Overhead Vehicle Door - Provide a manually operated 10 ft. x 10 ft. overhead steel rolling door located in the base of the tower. The door frame shall be fabricated of galvanized steel plate, fastened and reinforced on the interior face of the concrete support structure. The curtain shall be formed of 22-gauge steel interlocking slats designed for a wind loading of 20 psf. A 24-gauge steel hood shall be provided with a weather seal to protect the assembly. The curtain, bottom bar, brackets, guides, hood, pipe and chain shall be galvanized. Size and location of the overhead door shall be as indicated on the project drawings.

G. Tank Openings

1. Floor - Provide a 30 in. diameter manhole through the tank floor. The manhole shall be operable from a ladder located on the upper platform and shall be designed to withstand the pressure of the tank contents without leakage. The manhole assembly shall include a stainless steel hand wheel operator and threaded components.

2. Roof - Provide one 30 in. diameter weatherproof access hatch on the roof of the tank. The hatch will allow access from the roof to the interior tank ladder. The hatch opening shall have a minimum 4 in. curb. Hatch cover to be

constructed of aluminum and shall have a 2 in. downward edge, stainless steel hardware and locking mechanism.

3. Roof – Provide one 24 in. diameter exhaust hatch located adjacent to the roof hatch. The exhaust hatch will be flanged with a bolted removable cover and designed such that an exhaust fan may be connected for ventilation during painting. The opening shall have a minimum 4 in. curb.

H. Access Tube

1. Provide a 48 in. diameter centrally located access tube through the welded steel water tank to provide access to the tank roof from the upper walkway platform. A 30 in. diameter access hatch shall allow egress from the access tube to the roof. The openings shall have a minimum 4 in. curb. Hatch cover to be constructed of aluminum and shall have a 2 in. downward edge, stainless steel hardware and locking mechanism.

2. The area under the access tube shall be provided with a galvanized drip pan to prevent condensation from dripping onto the concrete floor slab below. The drip pan shall extend 3 in. beyond the drip line of the access tube. A 3/4 in. PVC drain pipe shall be provided to drain condensate to the overflow.

I. Roof Railing

A 42 in. high roof handrail shall be provided to enclose all centrally located roof accessories. The roof railing shall be a minimum of 15 ft. diameter.

J. Rigging Access

A removable access panel shall be located at the top of the concrete support structure accessible from a platform and shall provide access to the exterior rigging rails located near the welded steel tank/concrete support structure interface. This access panel shall be stainless steel or aluminum and have a minimum size of 24 in. by 36 in.

K. Utility Rails

Provide permanently installed utility rails suitable for rolling trolleys on the interior of the welded steel tank at the wall/roof and access tube/roof connections. Provide an exterior utility rail at the base of the welded steel tank adjacent to the concrete support structure. Provide an interior concrete support structure utility rail at the top of the concrete support structure in order to assure access for maintenance of piping.

L. Piping

1. Inlet/Outlet Pipe - Provide a 16 in. diameter inlet/outlet pipe that extends from the base of the concrete support structure thru the floor elevation of the welded steel tank. Provide a minimum of 6 in. high removable silt stop where the inlet/outlet pipe enters the tank. The bottom capacity level of the

tank's operating range shall be at or above the elevation of the top of the silt stop. Pipe material within the concrete support structure shall be minimum 10-gauge 304L stainless steel.

The inlet/outlet pipe shall be designed to support all related static and dynamic loads. Suitable galvanized brackets, guides and hangers shall be provided on the wall of the concrete support structure and welded steel water tank floor at intervals not exceeding 20 ft.

The inlet/outlet pipe shall be designed and constructed to accommodate any differential movement caused by settlement and by thermal expansion and contraction over the range of extreme temperature differences expected for the concrete support structure and pipe. The required flexibility shall be provided by an expansion joint located in the vertical section of pipe. The inlet/outlet pipe shall incorporate a unidirectional outlet valve at minimum water level. The inlet/outlet pipe shall discharge upward when filling the tank through a hydrodynamic mixing system as specified in Section 11.

2. Overflow Pipe - Provide a hydraulic analysis to determine optimum diameter overflow pipe. The top of the overflow shall be located within the welded steel water tank at the overflow elevation. The overflow pipe extend downward inside the concrete support structure. A base elbow shall direct the overflow through the wall of the concrete support structure, where the pipe shall turn and discharge downward through an elastomeric valve. Pipe material within the support structure shall be minimum 10-gauge 304L stainless steel.

   The entrance to the overflow pipe shall be designed for the maximum inlet flow rate. The design shall be based on the water level cresting within 6 in. above the overflow elevation. A weir shall be provided if the entrance capacity of the overflow pipe diameter is not adequate. The Contractor's standard vortex prevention device shall also be used.

   The overflow shall be designed to support all related static and dynamic loads. Suitable galvanized brackets, guides and hangers shall be provided on the wall of the concrete support structure and welded steel water tank floor at intervals not exceeding 20 ft. The overflow and weir section within the tank shall be coated carbon steel and supported by the central access tube.

   The overflow pipe shall be designed and constructed to accommodate any differential movement caused by settlement and by thermal expansion and contraction over the range of extreme temperature differences expected for the concrete support structure and pipe. The required flexibility shall be provided by an expansion joint located in the vertical section of pipe.

3. Stainless Steel Requirements - Pipe and fittings shall be Type 304L stainless steel fabricated from material meeting the requirements of ASTM A240.

Fabrication, inspection, testing, marking and certification of pipe and fittings shall be in accordance with ASTM A778 and A774, respectively. Backing flanges shall be in accordance with ASTM A285-C drilled to ANSI B16.5 Class 150.

Pipe, fittings and flange thickness shall be in accordance with the manufacturers certified pressure rating for the applicable service pressures.

M. Ventilation

1. Tank Ventilation - A tank vent shall be provided, located near the center on the tank roof above the maximum weir crest elevation. It shall consist of a support frame, screened area and cap. The support shall be fastened to a flanged opening in the tank roof. The vent cap shall be provided with sufficient overhang to prevent the entrance of wind driven debris and precipitation. A minimum of 4 in. shall be provided between the roof surface and the vent cap.

   The tank vent shall have an intake and relief capacity sized to prevent excessive pressure differential during the maximum flow rate of water, either entering or leaving the tank. The overflow pipe will not be considered as a vent. The maximum flow rate of water exiting the tank shall be calculated assuming a break in the inlet/outlet at grade when the tank is full. The vent shall be provided with an insect screen. Vent capacity shall be determined based on open area provided by the screen.

2. Support Structure Ventilation - As a minimum, one louvered vent shall be provided at the top of the concrete support structure. This vent shall be accessible from the upper platform and may also be designed to provide access to the exterior rigging rails located at the welded steel tank/concrete support structure intersection. Vents shall be galvanized steel with stainless steel or aluminum insect screen.

N. Interior Floors

Slab on Grade - Provide a 6 in. thick, 4000 psi concrete floor slab in the base of the concrete support structure. The slab shall be supported on compacted granular fill and shall be reinforced with #5 reinforcing steel bars at 12 in. centers each way. Provide 1/2 in. expansion joint between floor slab and concrete support structure and at pipes and supports that extend through the floor. Place cap strip and sealant over the expansion joint. The slab shall be sloped at 0.5% toward the overhead door for drainage.

O. Lightning Protection

1. Provide a lightning protection system for the composite elevated tank and any roof mounted equipment that may be damaged by lightning. Install the

system in accordance with NFPA 780 with materials that meet UL96 and UL96a. (See also Section 16670)

2. Minimum requirements include two 28 strand by 14-gauge copper conductors bonded to the steel tank 180 degrees apart. The conductors shall be fastened to the interior concrete support structure at 3 ft. minimum spacing and shall terminate with buried 5/8 in. diameter by 8 ft. long copper clad ground rods.

3. Lightning protection for obstruction lights shall consist of an air terminal mounted on the support and formed to fit around the fixture. The 1/2 inch diameter copper air terminal shall extend a minimum of 10 inches above the light fixture and shall connect to a copper conductor that terminates in a bonding plate secured to the tank roof.

P. Identification Plate

1. A tank identification plate shall be mounted near the personnel door. The identification plate shall be corrosion resistant and contain the following information:
Tank Contractor
Contractor's project or file number
Tank capacity
Height to high water level
Date erected

2.07 ELECTRICAL AND LIGHTING

A. Electrical and Lighting shall be provided in accordance with Division 16 and the Contract Drawings.

1. One exterior light fixture shall be provided above the personnel access door and one above the overhead vehicular door. The lights shall be controlled by a switch located 42 in. above the floor slab on the interior pedestal, adjacent to the open side of the access door. The fixtures shall also be provided with a photo-cell for auto-control.

2. Provide additional exterior, motion sensor lighting as indicated in Division 16 and the Contract Drawings.

3. Interior lighting shall fully illuminate all areas of the base floor and all ladders and access manways.

B. All work shall be performed and all materials shall be provided in accordance with National Electric Code and governing electrical, safety and inspection codes, regulations and ordinances.

C. Obstruction lighting shall be provided in accordance with FAA standards. The obstruction light shall be centrally located on the roof of the tank above all permanent installations. It shall incorporate the fixture type required by the FAA, and shall be a steady burning, dual fixture type with a lamp-out relay switch. The fixture shall be weather sealed, corrosion resistant, with aluminum base and housing. A pilot light located near the electrical panel shall be provided to indicate when an obstruction bulb has failed.

2.08 STEEL TANK PAINTING

Refer to Division 9 of the Project Specifications.

2.09 SOURCE QUALITY CONTROL

A. Tests

Review mill test certifications of all steel plate, structural components and reinforcement to ensure compliance with specification requirements.

B. Quality Assurance

Provide quality assurance of shop fabricated components in accordance with AWWA D100.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Foundation Excavation

The foundation bearing surface and excavation shall be inspected and verified by a geotechnical engineer retained by the Contractor prior to construction of the foundation (See also 1.7.2).

B. Environmental Conditions

Prior to performing any work, verify the expected temperature, humidity and weather conditions are within the specified limitations for executing the work.

C. Elevated Tank Components

After completion of each major component and prior to proceeding with the next stage of construction, verify that tolerance inspections and material quality control tests conform to this specification.

3.02 REINFORCED CONCRETE CONSTRUCTION

A. Reinforcement

1. Fabrication, placement, development and splicing of reinforcement shall be in accordance with ACI 318 and ACI 117.

2. Concrete support structure reinforcement shall be installed with plastic supports. Maximum spacing of supports for welded wire fabric shall be 5 ft. centers, horizontal and vertically.

B. Architectural Concrete Construction (concrete support structure or pedestal shaft)

1. The exposed exterior surface of the concrete support structure is designated as architectural concrete. The concrete and formwork requirements of this Section shall be strictly enforced to ensure concrete of the highest practicable structural and architectural standard. Concrete proportioning, placing and finishing shall be in accordance with the ACI 301, Chapter 18, except as modified by this Section. Formwork design, installation and removal shall comply with the minimum requirements of ACI 318 and ACI 117 and with the applicable requirements of ACI 347 and ACI 371R, except as modified by this Section.

2. Attention shall be given to ensure the same concrete design mix is used throughout the concrete support structure. The proportion, type and source of cement and aggregates shall not be changed. Uniform moisture content and placing consistency shall be maintained.

3. Drop chutes shall be used in all wall concreting operations where concrete placement is 5 ft. and greater in drop height. Concrete shall be placed directly between reinforcement layers to prevent aggregate segregation and form splatter with the resulting finish variations.

4. Forming systems not designed for lateral pressures associated with full height plastic concrete head shall be designed with the provision of ties and bracing such that concrete components conform to the correct dimensions, shape, alignment and elevation without leakage of mortar. Formwork systems shall be designed to safely support all loading conditions. Embedded items shall be properly positioned and secured. Form surfaces shall be cleaned of foreign materials and coated with a release agent prior to placing reinforcement. Do not allow excessive release agent to accumulate on the form. Steel forms shall be coated with non-staining, rust preventative form oil or otherwise protected.

5. The forming system for the concrete support structure wall shall be fully engineered and detailed with procedures to meet the increased demands of architectural concrete. The concrete support structure shall be constructed with a jump form process using form segments prefabricated to match the

wall curvature. Concrete pour height shall be a minimum of 4 ft. and a maximum of 12 ft. Form panels shall extend the full height of the concrete pour using only vertical panel joints. Form systems that are designed to lap the previous wall pour shall be sealed to prevent grout leakage. Form system shall incorporate a positive means of adjustment to maintain dimensional tolerances specified herein. Panels shall be designed for lateral pressures associated with full height plastic concrete head; support and bracing shall be provided for construction related impact loads and wind loads. Working platforms that allow safe access for inspection and concrete placement shall be provided. Form facing material shall be metal, or plywood faced with plastic or fiberglass.

6. The form system shall incorporate a uniform pattern of vertical and horizontal rustications to provide architectural relief to the exterior wall surface. Rustication strips shall be attached to the form face to minimize potential grout leakage that results in broken corners, color variations and rock pockets. All construction joints and panel joints shall be located in rustications. Vertical panel joints shall be sealed using closures that combine with the form pattern to prevent grout leakage and panel joint lines. All joints shall be grout tight in order to prevent leakage during concrete placement. The vertical and horizontal rustications shall be proportioned and combined to impart a symmetrical architectural pattern to the completed structure. No architectural form treatment is required on the interior surface.

7. Support structure concreting shall be capable of segmented placement procedures only when required. Temporary vertical bulkheads shall divide the wall pour into segments corresponding to a single batch (truckload) of concrete. The bulkheads shall be located at rustications; braced rigid and tight to maintain vertical alignment under concrete load without grout leakage. Wall segment concrete shall be placed continuously to full form height from a single load. Placement from multiple batches is not permitted. Temporary bulkheads shall not be removed until adjacent concrete is placed.

8. Wall forms shall not be disturbed or removed for a minimum period of twenty four (24) hours after concrete placement. Additionally, in no instance shall the forms be removed before the concrete has attained sufficient strength to prevent forming operations or environmental loads from causing surface damage or excessive stress. Form removal shall be based on early age concrete strength testing. The minimum concrete strength shall be established by the Contractor, based on an analysis of stress at critical stages throughout the forming and concrete operations. Early age concrete testing shall be in accordance with ACI 228.1R-03.

9. The formwork system for the domed structural floor shall be designed to support all construction loads. Adequate shoring and bracing shall be provided to transfer loads without appreciable movements. Form surfaces shall be steel, plastic, or fiberglass coated material. Shoring and forms for the

structural dome slab shall remain in place until the concrete has gained sufficient strength to carry the floor weight without damaging deflections.

C. Concrete

Concrete proportioning, production, placement, quality control and curing procedures shall comply with ACI 318 and ACI 117. Concrete shall satisfy the specific structural, durability and architectural requirements of the completed components.

1. Proportioning - The proportions of materials for concrete shall be established to provide adequate workability and proper consistency to permit concrete to be worked readily into the forms and around reinforcement without excessive segregation or bleeding. If high range water reducer is used, concrete slump prior to addition shall be 3 to 4 in. The slump, after addition of high range water reducer, shall be a maximum of 9 in. Air shall be entrained to provide concrete with 3.5% to 6.5% air content.

2. Production - Concrete that arrives at the project with slump below that suitable for placing may have water added within the limits of the maximum permissible water-cement ratio. Maximum slump shall not be exceeded. The water shall be incorporated by additional mixing equal to at least half of the total mixing time required. For concrete with site-administered high range water reducer, the preplasticized minimum slump requirement shall be attained as permissible by addition of water and mixing prior to the addition of the water reducer.

3. Placement - Prior to concrete placement, all snow, ice, water, or other foreign material shall be removed from the spaces that the concrete will occupy. Concrete shall be deposited in its final position in accordance with ACI 318 or the applicable building code. Drop chutes or tremies shall be used in walls and columns to prevent free-fall of the concrete over 5 ft. and to allow the concrete to be placed through the cage of reinforcing steel. These shall be moved at short intervals to prevent stacking of concrete.

4. Vibration - All concrete shall be consolidated by vibration so that the concrete is thoroughly worked into the corners of forms and around the reinforcement and embedded items to eliminate all air or stone pockets which may cause honeycombing. Internal vibrators shall be the largest practical size that can be used in the work and shall be operated by competent workmen.

5. Wall Finish - Provide a smooth form finish for the interior and exterior concrete support structure. Tie holes shall be plugged using grout on the interior and manufactured plugs on the exterior that match the color of the cured concrete as closely as possible. Provide a light sandblast to the exposed exterior concrete support structure surface.

6. Dome Finish - Provide a smooth form finish for the interior dome slab. The unformed surface shall have a floated finish.

D. Weather

1. Concrete shall not be placed during precipitation or extreme temperatures unless protection is provided.

2. During cold weather the recommendations of ACI 306 shall be followed.

3. During hot weather the recommendations of ACI 305 shall be followed.

E. Concrete Support Structure Dimensional Tolerances

Support structure concrete construction shall conform to the following:

1. Variation in thickness

Wall	-3.0% to +5.0%
Dome	-6.0% to +10.0%

2. Concrete support structure variation from plumb:

in any 10 ft. of height	1 in.
in any 50 ft. of height	2 in.
maximum in total height	3 in.

3. Concrete support structure diameter variation - 0.4% (not to exceed 3 in.)

4. Dome floor radius variation 1.0%

5. Level alignment variation:

from specified elevation	1 in.
from horizontal plane	1/2 in.

6. The offset between adjacent pieces of formwork facing material shall not exceed the following:

Exterior exposed surfaces	1/8 in.
Interior exposed surfaces	1/4 in.
Unexposed surfaces	1/2 in.

3.03 FOUNDATION

The foundation shall be constructed in conformance with the design certified by Contractor's structural engineer and in compliance with the recommendations of Contractor's Final Geotechnical Report. A Preliminary Geotechnical Report by Consulting Services Incorporated is provided as Appendix A to the Specifications for information purposes only. The tank foundation design shall be the Contractor's responsibility, and obtaining and evaluating all necessary additional subsurface information for the foundation design shall also be the Contractor's responsibility. A

copy of the Contractor's Final Geotechnical Report shall be submitted with the foundation design to the Engineer for review.

3.04 FIELD QUALITY CONTROL

A. Concrete Testing and Inspection

1. The evaluation and acceptance of concrete shall be in accordance with Section 5.6 of ACI 318 and ACI 117, except as modified in this Section.

2. Three cylinders shall be made from each sample required. A 7-day compressive strength test shall be used to supplement the 28 day tests.

3. Slump, air, temperature and compressive cylinder testing shall be performed by an independent laboratory. The Contractor shall retain the independent laboratory and provide the Contractor with copies of all test results.

4. The concrete support structure radius, plumbness and thickness shall be verified for each concrete lift at 45 degree intervals. An inspection report by the Contractor shall be provided to the Owner at project completion.

B. Welded Steel Water Tank Testing & Inspection

1. Inspection procedures for the welded steel tank shall be as required by AWWA D107, Section 9, "Inspection and Testing". Radiographic inspection of full penetration butt-welded joints shall be made by an independent inspection company retained by the Contractor.

2. Conical sections of the welded steel water tank designed using Method 2 or Method 3 of AWWA D107 shall be inspected in accordance with Section 9.4 of AWWA D107.

3. Weld joints of plate over the structural concrete floor shall be tested for leaks by vacuum box/soap solution testing, or equivalent method.

- END OF SECTION –

SECTION 13325

SCADA

PART 1 – GENERAL

1.01 PROJECT DESCRIPTION

A. Description of Work

The work to be accomplished under this section shall consist of furnishing the equipment necessary for a complete automatic control and monitoring system to function as specified herein and as shown on the drawings. The system integrator shall furnish a completely integrated all solid-state radio telemetry base Supervisory Control and Data Acquisition (SCADA) system. It shall be the system integrator's responsibility to supply a system that is compatible with existing Micro-Comm Thermopolis SCADA equipment, new equipment supplied by others as part of this contract, and equipment supplied in other contracts. The complete system shall be designed, fabricated, programmed, tested, started up, and warranted by a single supplier to insure a single source of responsibility.

B. Scope of Work

This section covers a radio telemetry based SCADA and Instrumentation System to include:

1. Highway 42 Tank-II Remote Unit.

C. General/Electrical Contractor Shall Supply

1. All equipment required in other sections of the specifications.
2. All labor for installation of the system.
3. Access and easements as needed for all sites.
4. 120VAC power at the RTU sites.
5. Pressure sensing taps for all sensing points (transducers) in the system.

D. System Integrator Shall Supply:

1. Engineering submittal and shop drawings prior to installation.
2. All the paper work and fees necessary to obtain a FCC radio license in the name of the Owner.
3. All user licenses and fees for software supplied in this system with licenses in the name of the owner.
4. Spare parts and maintenance tools, as detailed in this section.
5. Operation and maintenance manuals, as detailed in this section.

6. All start-up labor and services, as required for equipment specified in this section.

7. Operator training as detailed in this section.

1.02 QUALITY ASSURANCE

A. Manufacturer's Qualifications

The system specified herein shall be the product of a manufacturer who can demonstrate at least ten (10) years of satisfactory experience in furnishing and installing comparable radio based telemetry/control systems for water and wastewater installations. The manufacturer of this system shall maintain a 24-hour available inventory of all replaceable modules to assure the Owner of prompt maintenance service and a single source of responsibility. The manufacture and shall certify this to the Engineer in writing at the time of bidder pre-qualification.

B. Pre-bid Approval

The Base Bid approved systems integrator for this project is:

Micro-Comm, Inc.	Local Representative:
15895 S. Plfumm Rd	Brian Gatewood; Delaney and Associates
Olathe, KS 66066	Tel: 859-342-4944

Other integrators desiring to bid this project as "alternate" integrators must seek pre-bid approval by providing a submittal (14) days prior to the bid date. Submissions that fail to include a complete submittal as detailed shall be deemed unresponsive. The Consulting Engineer and the Owner shall be the sole judge as to whether the alternate equipment is considered an approved equal. Approval of an alternate system by the Engineer will not relieve the alternate system of strict adherence to these specifications. The pre-bid submittal shall include the following:

1. An installation list with the names and phone numbers of both the Owner and Consulting Engineer for at least ten projects of similar size and complexity.

2. A "statement of compliance" detailing paragraph by paragraph the bidders compliance to these specifications.

3. Block diagrams for the various sites in the proposed system showing the selected pieces of hardware equipment to be used.

4. Sample electrical drawings for typical sites proposed in this contract.

5. A product performance data sheet shall be included for each hardware component in the system (i.e. antennas, radios, coaxial cables & arrestors, programmable controllers, power supplies, time delays and relays, and the various sensors required) and each software component (programming & configuration software and operator display console software).

6. Radio path study for each radio path in the system. Bidders shall satisfy themselves that the necessary radio frequency(s) can be obtained. The radio path study provided by each bidder shall utilize either:

   a. Computer generated techniques utilizing a USGS 3 second terrain database to plot the path profiles for each radio path with elevation samples at not more than 200 foot increments.

   b. Actual field measurements to showing the necessary antenna heights, transmitter power, and antenna gains required to insure a 20db fade margin as detailed in Section 2.02 of these specifications. The physical path analysis shall be made using temporary equipment installations and a radio communications analyzer to measure actual path margins. The bidder shall include in his bid, all the calculations used to extrapolate the measured data. The bidder is expected to obtain the necessary temporary FCC license for the study.

7. Communications diagram for the entire system showing normal CTU-RTU communications paths and Peer-to-Peer back-up communications paths.

C. Approval Agencies

The control system and its components shall comply will all applicable requirements of the following:

1. Electrical Code Compliance (National & Local)
2. UL 508A
3. NEMA Compliance
4. IEEE Compliance
5. EIA Compliance
6. FCC Compliance

1.03 SUBMITTALS

A. Complete submittal shall be provided to the engineer for approval prior to equipment fabrication. The submittal data shall include the following:

1. Product Data - Provide product data sheets for each instrument and component supplied in the system. The data sheets shall show the component name as used on reference drawings, manufacturer's model number or other product designator, input and output characteristics, scale or ranges selected, electrical or mechanical requirements, and materials compatibility.

2. Shop Drawings - Provide drawings for each panel showing the wiring diagrams for control circuits and interconnections of all components. The drawings shall include wiring diagrams for all remote devices connected to the panel.

3. Panel Layout Drawings - A front panel and sub-panel layout shall be included as part of each control panel drawing. Components shall be clearly labeled on the drawing.

4. Installation Drawings - Typical installation drawings applicable to each site in the system shall be included.

5. Operator Interface Software - The submittal shall include a generic but detailed technical description of the Operator's Interface Software as proposed for this system including:

   a. Sample text screens and menus

   b. Sample graphics screens

   c. Sample report logs and printed graphs

1.04 MAINTENANCE INFORMATION

A. Maintenance Data Manuals

Submit maintenance manuals and "as built" drawings on all items supplied with the system. The manuals and drawings are to be bound into one or more books as needed. In addition to "as built" engineering submittal data and drawings, the manual shall include trouble shooting guides and maintenance and calibration data for all adjustable items.

1.05 JOB CONDITIONS

A. All instruments and equipment shall be designed to operate under the environmental conditions where they are to perform their service. The equipment shall be designed to handle lightning and transient voltages as normal environmental hazards. The environmental conditions are as follows:

1. Outdoor - The equipment will be exposed to direct sunlight, dust, rain, snow, ambient temperatures from -20 to +120 degrees F, relative humidity of 10 to 100 percent, and other natural outdoor conditions. The installations shall be hardened to with stand normal vandalism.

2. Indoor - The equipment will be capable of operating in ambient temperatures of +32 to +130 degrees F and relative humidity of 20 to 100 percent.

1.06 DELIVERY, STORAGE, AND HANDLING

A. All items shall be stored in a dry sheltered place, not exposed to the outside elements, until ready for installation. All items shall be handled with appropriate care to avoid damage during transport and installation.

1.07 SEQUENCING & SCHEDULING

A. Coordination

The Systems Integrator shall coordinate with other electrical and mechanical work including wires/cables, raceways, electrical boxes and fittings, controls supplied by others, and existing controls, to properly interface installation and commissioning of the control system.

B. Sequence

Sequence installation and start-up work with other trades to minimize downtime and to minimize the possibility of damage and soiling during the remainder of the construction period.

1.08 DISTRIBUTED CONTROL OPERATION

A. General

The control system shall use "Programmable Logic Controllers" (PLCs) at all locations in the system as detailed later in these specifications. Each site in the system shall have a unique digital address. The Central Processing Units (CPUs) and Input/Output (I/O) cards used in each of the PLCs shall all be identical, fully interchangeable without reprogramming by the operator. The PLCs shall be "self-initializing" and "self-restoring" so that operator intervention is not required after power interruptions, transients from lightning storms, or component changes.

The system shall be composed of a Central Terminal Unit (CTU) that monitors and or controls the operation of multiple Remote Terminal Units (RTUs). The CTU shall be composed of a PLC (as described above) and one or more Operator Display Consoles (ODCs) with Human-Machine-Interface (HMI) software to display, alarm, record, all data received and for operator input for changes to the system.

The control system shall be capable of implementing multiple modes of communications in a single system to include: radio, leased phone-line, dial-up phone-line, high speed data highway, fiber optic, and Ethernet communications as details in these specifications. The individual sites in the system shall simultaneously support both Master-Slave and Peer-to-Peer communications as needed implement the distributed control features listed in these specifications.

B. Distributed Control Software Features

The system shall be a "distributed control" type system that simultaneously provides for the features of both "supervisory control" (ie centralize control of RTUs from the CTU) and "distributed control" (ie RTU self-initiated control using local inputs and peer-to-peer communications with other RTUs) in to a single unified control system. The control system shall simultaneously support both Master-Slave (ie CTU to RTU) and Peer-to-Peer (i.e. RTU to RTU) communications to provide completely automatic control with no single point of system wide failure in either the PLC system or the communications system. The systems integrator shall implement redundant communications paths between RTUs to maintain automatic control in the event of CTU or system wide communications failure.

The control algorithms shall have the ability to integrate both hardware and software operator inputs (ie ODC setpoints and selector switch inputs) along with hardware inputs at the remote sites (ie remote Hand/Off/Auto selector switches, etc.) in to a unified cohesive automatic control system. As data is received, changes, or lost (i.e. a loss of signal from a RTU or CTU), the Central Unit control logic shall automatically adjust the controlling algorithm to the new situation.

In general the RTUs shall receive and store control parameter commands as inputted by the operator from either the CTU or the RTU. These inputs shall be displayed at both the CTU and RTU. Distributed control shall provide for fully automatic by the RTU based on the pre-programmed control algorithm, operator inputs received from the CTU, operator inputs received from the RTU front panel display, data received from other RTUs, and local inputs monitored at the RTU. For example, the RTU shall be based on operator inputs automatically control the operation of pumps or valves based on level data received from other RTUs and local pressure, flow, and discrete inputs monitored at the RTU. Pump call/run/fail status shall be reported to the CTU for centralize display, alarming, and recording. The RTU distributed control algorithm shall handle the daily pump call/run/fail, automatic alternation, automatic transfer on fail, high discharge cut-off, low suction cut-off, low & high flow cut-ff and basic tank fill or demand supply operations at the pump station for RTUs as detailed for each RTU.

Supervisory control shall automatically or manually provide for the CTU to be able to override or modify the automatic operation of RTUs based on a pre-programmed control algorithm. For example, the CTU shall be able to automatically turn on or off pumps at RTUs or change RTU operational parameters as needed to satisfy "system" wide requirements such as peak load shedding for power or water distribution management during peak demand periods. The control system shall provide for multiple levels of control such that a single point of failure shall not render the control system in-operative:

1. In the event of an ODC failure, the PLC at shall continue to poll all of the RTUs to collect data and provide supervisory control.

2. In the event of PLC failure at the CTU, the individual RTUs shall continue to provide fully automatic control using last stored operator inputs and peer-to-peer communications with other RTUs for control data as needed.

3. In the event of peer-to-peer communications failure between RTUs, the controlling RTUs (ie sites with pumps, valves, etc) shall continue to provide automatic control based on locally sensed pressures and flows.

4. In the event of complete failure of local RTU at a booster station (or similar site), the failure shall cause a "system normal" lamp and relay to be de-energized to automatically re-engage any existing back-up control system (such as pressure switches, float switches, etc.) to maintain automatic control.

The system shall automatically revert to the next higher level of control as communications or equipment failures are repaired.

C. Standard Control Software Features

The supplied software shall not be a one-of-a-kind system, but rather a comprehensively designed software platform that provides a number of built in features that monitor local & remote inputs combined with standard software algorithms to provide an integrated system as follows:

1. Monitor local Hand/Off/Automatic (HOA) selector switch positions (ie on existing pump control panels) and integrate the switch position in to the control logic such that a HOA in HAND or OFF shall be considered by the control system as 'un-available".

2. Provide for High Discharge Cut-off and Low Suction Cut-off control of pumps from locally entered setpoints at RTUs equipped with suction and discharge pressure transmitters and/or from existing pressure switches.

3. Provide automatic Pressure/Flow pump staging operation of pumps of different sizes (including variable speed pumps) from local discharge pressure and discharge flow inputs in a closed-loop system. The pumps shall be up-staged on decreasing discharge pressure and down-staged on decreasing flow rate. The control shall include PID (Proportional Integral Derivative) loop control of variable speed pumps mixed with constant speed pumps for the various stages required.

4. Provide "Compound Loop" PID control of final devices (ie chemical feeders) from multiple inputs (ie flow rate and a chemical process analyzer, such as chlorine residual).

1.09 RADIO CHANNEL DATA OPERATION

A. General

The control system shall be specifically designed for radio channel data communications. The core of the system shall be over FCC licensed radio frequency spectrum intended for SCADA and remote control purposes. The systems integrator shall be responsible of obtaining the necessary FCC licenses for one or more frequencies as needed to establish both supervisory and distributed control.

All of the equipment required for operation of the system shall be directly owned by the Owner and included as part of this contract. Systems using third party repeaters, trunking masters, or leased equipment will not be allowed. The Systems Integrator shall select radio equipment as detailed below to insure reliable operation and be able to implement all software features listed in this specification whether currently required or described as a "shall be capable" feature.

The overall system design and operation shall provide a 20db pad over the minimum required for operation on all primary data paths (primary paths may include data relays) to insure a 98% reliability of communications. Remote site communications for distributed peer-to-peer communications shall provide 30db of pad to insure operation under all weather conditions and provide a 99.9% communications reliability. The 20db and 30db pad requirements and FCC rule compliance shall be demonstrated (at no additional cost) to the Engineer at his request. The testing shall be accomplished using an IFR AM/FM 1000S communications analyzer or equal equipment.

B. Communications

The CTU-RTU supervisory communications and RTU-RTU distributed control communications system shall operate in a half-duplex mode over a single "licensed" radio frequency using "point-to-point" communication techniques. The RTUs shall monitor for the channel to avoid data collisions with other RTUs during peer-to-peer communications. The system shall be capable of sharing the radio channel with other radio telemetry system.

To facilitate system layout and future expansion all RTUs shall under the direction of the CTU be able to implement store-and-forward communications to relay data and commands to and from other RTUs as required to establish the desired path. Should the assigned relay site for a distant remote be inoperative, the Central Unit shall automatically choose another remote site to access the distant remote. Any RTU shall be able to provide automatic antenna switching as part of their relaying operations.

All data transmitted shall be in digital word form using FSK (frequency shift keying) transmission. All transmissions shall include the address of the sender and the receiver, and be subject to check sum, parity, and framing error checks, to insure a minimum data reliability of 1 error in 1,000,000,000 bits. Any transmissions that fail the data checking will be retried until correct. No data correction methods will be allowed. A plug-in RS232C data port shall be provided at all locations in the system to allow the use of a standard data terminal to view data exchanges between the sites and to provide a means of extensive de-bugging.

The system shall provide a complete data update at least once every (2) minutes with some functions updating faster as required by local system conditions.

C. Radio Channel Operation

The system shall be capable of operation on the narrow band splinter frequencies of the Private Land Mobile Radio Services within the Federal Communications Commissions (FCC) rules and regulations regarding these telemetry channels. The manufacture shall guarantee operation under co-channel conditions with other radio systems without interference to this system. FSK tones, data baud rates, transmitter output power, transmitter deviation, antenna gain, and antenna height shall be chosen to comply with the FCC requirements Part 90 - Subpart 90.35 and 90.238 for the Industrial/Business frequency pools. The radio system shall specifically meet the

operating requirement that the sum of the highest FSK frequency and the amount of deviation shall not exceed 1.7 kHz for 3F2 emission (or 2.8 kHz for 6F2 emission) as detailed by the FCC for the specific frequency assigned.

CTUs and RTUs shall be capable of automatically switching antennas and/or radios (including radios on different frequencies) during CTU-RTU, RTU-RTU, and store & forward communications. The antenna/radio switching at remote units shall automatically default back to RTU-CTU paths if communications are lost with the CTU.

D. FCC Licensing

The system manufacturer/supplier shall be responsible for collecting all information, generating all paper work, and paying all fees required obtaining a license on behalf of the Owner.

PART 2 – PRODUCTS

2.01 PROGRAMMABLE LOGIC CONTROLLERS & LOCAL I/O EQUIPMENT

A. General

Industrial Programmable Logic Controllers (PLCs) shall be used at all locations. The PLCs shall have an operational range of 0-60degC and 5-95% relative humidity. The PLCs shall all be from the same family of controllers, scalable from very small to very large applications, and programmed from identical programming software used for all processors. The PLCs shall be Allen-Bradley CompactLogix or Micro-Comm M1550 Series controllers.

The software at all locations shall be stored in a user removable non-volatile CompactFlash or similar type ROM memory that can be exchanged under power, used to upgrade sites in the field, and store historical data (local trends, accumulators, etc) for retrieval locally or by the central unit. The memory modules shall store all site-specific logic and configurations including communication parameters, control algorithms, analog input/output scaling, PID control parameters. The module shall be programmed via the CPU and without the use of external adapters. The PLCs shall include "watch-dog" circuitry and be "self-initializing" without operator intervention. In the event that the program or configuration data is corrupted, the CPU shall reload the program and configuration data from the EEPROM memory module.

The PLCs shall be fully online programmable while the PLC continues to communicate with the rest of the system and performs its assigned control tasks. The PLCs shall support "fill-in-the-blank" type configuration for basic operation and to set-up common features such as COM port set-up, peer-to-peer data collections, local back-up control set points, input and output setup, output on/off time delay settings, front panel display setup, etc. The PLC shall also support a process script language

or ladder logic type programming for site-specific customizations including special input and output manipulations, local sequential control, math functions, and PID control as follows:

1)	Relay (Bit) Type	- Examine if ON, Examine if OFF
2)	Timer & Counter	- Timer ON, Timer OFF, Timer DONE
3)	Compare Functions	- Equal, Not Equal, Greater Than, Less Than, etc
4)	Math Functions	- Add, Subtract, Multiply, Divide, Square Root
5)	Scaling Functions	- Scale & Scale with Parameters
6)	Logical Functions	- AND, OR, & NOT
7)	Program Control	- Jump & Skip Next functions
8)	PID	- PID with compound loop input

The PLC programming software shall be written for the 32 bit interface of Windows XP. The supplier shall provide a licensed copy of the PLC configuration and programming software along with the necessary communications cables to the owner. Training on the use of the software shall be provided as part of the system training.

B. Construction

The PLC shall use modular construction. The base unit shall be composed of the power supply, CPU, communications modules, and basic inputs and outputs (I/O). The unit shall have expandable inputs and outputs using a "rack-less" DIN rail mount design and capable of supporting local I/O (via an integrated high-performance serial I/O bus) and remote I/O via an industrial serial bus. All terminations shall use removable, NEMA-style "finger-safe" terminal blocks so that individual modules may be removed without disturbing adjacent modules.

The PLC shall be capable of being powered from AC, DC, or solar sources. DC and solar powered PLCs shall have an integral battery charging circuit that protects the external battery from over and under voltage conditions and provides automatic charging of the battery after power failures. The back-up power supply shall be either 12VDC with 24VDC DC/DC converter or 24VDC with a 12VDC DC/DC converter to run the 12VDC radio and 24VDC to power external sensors from a single battery source. Series tapped 24VDC batteries for 12VDC will not be allowed. Back-up batteries shall be rechargeable sealed lead-acid type batteries as manufactured by PowerSonic or equal. The back-up battery shall provide for 24 hours of back-up operation at water tower remote units and 3 hours at all other sites.

The PLC shall have a minimum of two (2) communications ports. The first shall be used primarily for CTU-RTU and RTU-RTU communications. It shall support baud rates of 110-19,200 baud and have a plug-in standard 25pin or 9pin sub-D connector that provides a full RS232 interface and radio modem interface. The second communications port shall provide programming, operator front panel interface, multiple PLC interconnect and other local communications. It shall support baud rates of 110-19,200 baud and have a 9-pin sub-D interface. The communications ports shall include LED's to show the status of all control lines. The PLC shall also optionally support Ethernet communications as detailed in the specifications.

The PLC shall utilize a rack-less design and provide for sufficient installed and configured spare inputs and outputs (I/O) to meet the site requirements as detailed and provide for 25% spares of each type. The unit shall have a minimum of (4) discrete (relay) outputs, (8) discrete inputs (DI), (4) analog inputs (AI), and (2) analog outputs (AO). The analog inputs shall provide for sensor excitation with separate fuses for each input. The fuses may be the self-resetting type. All input and output connections to the PLC shall be via Nema "finger-safe" plug-in terminal blocks.

The PLC shall support both local and remote I/O. Input/Output cards shall be mounted on a DIN rail channel. The PLC inputs, outputs, and operator interface shall be as follows:

1. DISCRETE OUTPUTS - The discrete outputs shall be isolated relay outputs rated at 5.0A continuous @ 240VAC. LEDs on the front of the PLC base unit or expansion module shall indicate the status of each output point. Interposing relays shall be provided if the voltage or current of the external load on a contact exceed the 5.0A 240VAC ratings. Each output shall be provided with operator settable software ON and OFF time delays.

2. DISCRETE INPUTS - The discrete inputs shall be optically isolated and provide for 24VDC excitation to remote sensors and switches. Each input shall be separately fused or current limited such that accidental grounding shall not render the other inputs non-functional. LEDs on the front of the input module shall indicate the status of each input point.

3. ANALOG INPUTS - The analog inputs shall provide filtered and scalable analog to digital conversion of input signals. The analog inputs shall be switch selectable from 0-5VDC to 0-20mADC and provide a minimum of 0.3% resolution and 0.5% accuracy over the temperature range of 0-70degrees C. The PLC shall provide separately fused 24VDC excitations to the remote sensors.

4. ANALOG OUTPUTS - The analog outputs shall provide a 4-20mA isolated signal to other panels and devices as specified.

5.PULSE INPUTS - The high-speed counter/pulse inputs shall provide for pulse rates up to 1KHz direct from flow meter transmitter heads without interposing equipment. The pulse input shall include fused 12VDC excitation to the meter transmitter.

6. POWER SUPPLY - Each PLC assembly shall include an integral power supply. Power supplies shall be designed for 12VDC or 24VDC input power and suitable for use in battery back-up operations. DC/DC converters shall be required to insure that both the 12VDC and 24VDC are regulated separately from the common source.

7. KEYPAD & DISPLAY UNIT - The optional keypad & display unit shall have a 4x20 back-lighted LCD display to display the status of all local inputs and the tank level of the associated control water tower level. The 5x5 keypad shall provide for operator input of set points and timer settings. The operator interface shall be menu driven and provide for dedicated keys for cursor position and input functions. The operator interface shall provide for up to 50 screens of data display. The keypad & display unit shall be supplied and mounted on the front of the PLC enclosure if detailed in the specific PLC I/O requirement list. The keypad & display unit shall maintain the Nema 4 rating of the PLC enclosure.

C. Enclosures

The remote unit enclosures for indoor mounting shall meet all the requirements for NEMA Type 12 enclosures. The enclosure body shall be made of a minimum 14 gauge steel with continuously welded seems and be furnished with external mounting feet. The enclosure door shall be made of a minimum 16 gauge steel with have a 14 gauge steel hinge. Enclosures larger than 16x14 shall have a rolled lip on 3 sides of the door for added strength. The door opening shall have a rolled edge on 4 sides to protect the door gasket. The door gasket shall be heavy neoprene and attached to the door with oil resistant adhesive. Sub-panels shall be 14-gauge steel for 16x14 enclosures and 12 gauge for larger enclosures. The enclosure finish shall be gray polyester powder coating inside and out over phosphatized surfaces. The subpanels shall be finished in white. Nema 12 enclosures shall be Hoffman "CH" or "CONCEPT" wall mount enclosures.

Remote site installations requiring equipment to be mounted outside shall be a lockable NEMA 3R enclosure. The NEMA 3R enclosure shall be constructed of 14 gauge galvanized steel, with a drip shield top and seems free sides front and back, and a stainless steel hinge pin. The enclosure finish shall be gray polyester powder coating inside and out over phosphatized surfaces. The NEMA 3R enclosure shall be Hoffman Bulletin A-3.

The remote unit enclosures mounted in damp corrosive areas (such as concrete meter vaults) shall be NEMA Type 4X rated enclosures. The enclosures shall be made of molded fiberglass polyester and be furnished with external mounting feet. The door shall have a seamless foam-in-place gasket and corrosion-resistant hinge pin and bails. Sub-panels shall be 14-gauge steel for 16x14 enclosures and 12 gauge for larger enclosures. The enclosure finish shall be a light gray inside and out. The subpanels shall be finished in white. Nema type 4X enclosures shall be Hoffman "Fiberglass Hinged Cover".

Refer to Appendix for specific enclosure requirements.

D. Front Panel Hardware Displays

As detailed in the appendix, the PLC units may include front panel displays of the specified inputs and outputs. The indicator lamps, pushbuttons, and selector switches used in the system shall be IP65 oiltight/waterproof/corrosion resistant rated. The

indicators use slide or bayonet based colored LED light sources. The lenses shall be acrylic and color matched to the LED color. The lamps shall have translucent marking plates for legends and be constructed such that the acrylic lens covers the legends for dust and water protection. The pushbutton and selector switch operators shall be Nema 600V rated with contacts rated for 6A @ 120VAC inductive. The contact blocks shall be stackable and snap-fit with screw terminals for termination.

Refer to Appendix for specific front panel display requirements.

E. Local Control Functions

In general the PLC shall be programmed to provide generic control functions as detailed earlier and to work in concert with the CTU. The integrator shall be responsible to meet with the owner and the engineer to develop the automatic control strategy required for the system.

Refer to Appendix for special input and output control requirements.

2.02 RADIO TRANSCEIVERS & ACCESSORIES

A. General

The radio transceivers shall be standard "un-modified" radios that can be tuned, aligned, and repaired at any two-way radio shop. Interface to external data modems shall be through the front panel microphone jack. The radios shall be synthesized and fully field programmable and include a built-in time-out timer to disable the transmitter after 0-60seconds. The units shall be tuned to FCC specifications for the specific frequency assigned. The radio equipment shall be FCC type approved and the system capable of operation on the 3KHz to 6KHz narrow band splinter frequencies (154 or 173MHz) in the Industrial/Business radio service.

B. VHF Radio Transceiver (154Mhz or 173Mhz)

The system manufacturer shall supply a 25-watt VHF radio transceiver to insure a high level of quality and reliability. The radios shall be adjustable to 4 watts output power as may be required by the FCC for ERP (Effective Radiated Power) restrictions. All connections to the radio shall be plug-in. The VHF radio transceiver shall have the following specifications:

Transmitter:

RF output power	25 watts minimum (adjustable to 4)
Spurs & Harmonics	16 dBm (25uW) (or -50dBc)
Frequency stability	±0.00025% (-30 to +60 degrees C)
Emission	6F2 (2.5kHz DEV max) or 3F2 (1.2kHz DEV max)
FM hum and noise	-40 dB

Receiver:

Sensitivity	0.35uV @ 12 dB SINAD (.5uV @ 20db quieting)
Selectivity	-65 dB
Spurious image rejection	-50 dB
Inter-modulation	-65 dB
Frequency stability	±0.00025% (-30 to +60 degrees C)
Receive bandwidth	*6kHz (or 3kHz) as required to match the transmitter

* The receiver bandwidth shall be reduced to match the transmit bandwidth of the transmitter and provide a minimum adjacent channel rejection of -50db.

The radio transceivers shall be a Motorola Radius CM200 or a Microwave Data Systems 1710.

C. UHF Radio Transceiver (450Mhz)

If the system supplier can demonstrate to the satisfaction of the Engineer that no VHF (154-173 MHz) frequency can be obtained, an UHF (450-470 MHz) frequency may be used. The UHF shall operate under Part 90.35 and 90.238 for secondary fixed operations. The system will still be required to operate with point-to-point operation within the FCC rules and regulations and provide the same RF path margins as detailed in these specifications.

The UHF radios must meet or exceed the requirements set forth in these specifications for VHF radios, except that the radio output power must be adjustable to 2 watts as needed to meet FCC requirements. The radios shall be tuned to operate in 6KHz of bandwith to meet the proposed FCC standards for 2005. Antennas shall provide a minimum 10db of gain.

The radio transceivers shall be Motorola Radius CM200 or Microwave Data Systems 4710. No changes to the contract amount will be made for a change to UHF operation.

D. Antenna & Coaxial Cable

The radio antennas at all locations shall be a five element Yagi, constructed with 3/8" diameter solid aluminum rod elements and 1-1/16" diameter aluminum pipe element support with a type N coaxial connector. The antenna shall have a minimum 8.0db forward gain with a 20.0db front-to-back ratio. The antenna shall be wind rated for a 100-MPH wind speed. The VHF antennas shall be MC-Yagi, Decibel Products DB292, or Celwave PD390S. The UHF antennas shall be MC-Yagi or Celwave PD688S.

Antennas shall be cabled to the transmitter enclosure connection by a RG/8U type low loss (less than 1.8db per 100ft @ 100MHz) coaxial cable with cellular polyethylene (foam) dielectric. The coaxial cable shall have a braided copper shield coverage of 97% and a long life weather resistant polyvinyl chloride jacket. The

antenna coaxial cable connection shall be a constant impedance weatherproof Type N connector, taped with a weather resistant electrical tape to insure a lifetime watertight assembly. The coaxial cable shall be Belden 8214 or 9913 cable.

E. Antenna Lightning Protection

Coaxial connection to remote and central unit enclosures shall be by means of a coaxial type bulkhead lightning arrestor. The units shall be rated at 1 kilowatt with a minimum 500V and maximum 2000V-breakdown voltage. Coaxial lightning arrestors shall be a PD-593 or PolyPhaser IS-B50LN-C1.

F. Antenna Mounting Systems

Antennas shall be mounted at a height above ground that is consistent with FCC rules and regulations and provides adequate signal fade margin as described earlier. Antennas must be a minimum of 15 feet above ground and mounted as follows:

1. Water Towers: The antenna shall be mounted on the ladder or the water tower catwalk railing at a height consistent with FCC requirements. The coaxial cable shall be secured to the ladder or obstruction lighting conduit. A 3/4" rigid conduit with a weather-head shall be provided from the transmitter to the ladder on the tower.

2. Above Ground Structures: The antenna shall be mounted on a 10' long X 1-1/2" diameter galvanized mast with top mounted weather-head. The mast assembly shall be secured to the side of the structure with Uni-strut clamps. The coaxial cable shall feed through the mast assembly to the interior of the building.

3. Below Ground Structures: The antenna shall be mounted on a 20' high Class II power pole with a 10' long X 1-1/2" galvanized mast secured to the side of the pole and extending 5' above the pole or a 20' high free-standing antenna tower. A 3/4" rigid conduit with a weather-head shall be provided from the below ground vault to a location 10 feet up the power pole for the coaxial cable.

4. Antenna Towers (>20feet): A bracketed antenna tower shall be supplied where specifically noted on the plans or in the RTU & CTU site descriptions. The tower shall be assembled from 10 sections built on a 12-1/2" (or 18" for ROHN 45G) equilateral triangle design. Tower sections shall be constructed of 1-1/4" steel tubing with continuous solid steel rod "zigzag" cross bracing electrically welded to the tubing. The entire 10' sections shall be Hot-Dip Galvanized after fabrication for long life. The antenna towers shall be ROHN Model 25G (for unsupported heights of up to 33 feet) or ROHN Model 45G (for unsupported heights less than 45 feet).

2.03 INSTRUMENTATION & ACCESSORIES

A. General

All items in the control system (electronic cards, power supplies, radios, time delays, relays, etc.) shall be of plug- in construction, make use of a plug-in wiring harness,

use plug-in terminal blocks, and be interchangeable without recalibration. To insure field repair-ability by non-technical personnel, equipment that must be un-wired for replacement will not be accepted.

The following instrumentation devices and techniques shall be used as specifically called for in the RTU and CTU input/output sections of this specification.

B. Power Supplies

The DC power supplies shall provide ±0.1% line and load regulation with ±10% input variations. They shall have a temperature coefficient of ±0.02% per degree C. The input/output isolation shall be 100 Mohms DC (900Volts AC) with output transient response of 50 microseconds maximum. The power supplies shall be sized to operate the remote unit equipment with or without the back-up battery in place. Power Supplies shall be a Power One Series MAP130, Sola SLS, or approved equal.

C. Battery Back-up Operation

The remote units indicated shall be supplied with battery back-up operation. The rechargeable batteries shall be the sealed solid gelled electrolyte types, designed for float or standby service. Unless noted otherwise in the RTU descriptions, batteries shall be sized to maintain 24-hour service at water tower remotes and 8-hour service at pump stations and other remotes. The remote shall include a charging module to recharge the battery when power is resumed, maintain the charge between outages, and provide a low voltage cut-off to protect the battery from excessive discharge during prolonged outages. All discrete, analog, and pulse inputs (i.e. switch closures, pressure, level, flows, etc.) shall continue to function on battery backup. Batteries shall be Globe Gel/Cell or approved equal.

D. Single Phase 120VAC Power Line Lightning Protection

Every site in the system shall be equipped with AC line filtering and lightning protection. The equipment shall provide 2-stage lighting/transient protection including inductive and capacitive filtering and MOV over-voltage protection.

E. Pressure Transducers

Tank water level/pressure transducers shall be of the all solid-state two-wire transmitter type with a 4-20mA output from a 10.5-24VDC excitation. The units shall be powered from the RTU power supply. The transducers shall have a combined error (linearity and hysteresis) of ±0.25% full scale and be temperature compensated to ±2.5% per 100 degrees Fahrenheit. Zero and span adjustments shall be standardized so that transducers are interchangeable without recalibration. All exposed or wetted parts shall be series 316 stainless steel, PVC, or Buna-N. The units shall be capable of a three times full scale over pressure without damage or change of calibration.

The (suction and discharge) pressure transducers shall be mounted at the sensing point and wired to the enclosure. The transducers shall have a 1/4" or 1/2" NPT process pressure connection. Transducers for above ground mounting shall have a 1/2" conduit connection for cable entry. Transducers at water towers (and other outside locations) shall be mounted below grade and below frost line to prevent freezing. Below grade mounted units shall have factory signal cabling and be suitable for a minimum of 100' submerged duty.

The water tank level transducer shall be suspended in the fiberglass tank and supplied with sufficient factory installed cable to access a "clean/dry area" junction box (as shown on the plan sheet). The suspension cable shall have a polyethylene jacket and internal venting to provide for atmospheric sensing of the non-process side of the diaphragm. The sensors shall have a multi-ported pressure-sensing end that protects the diaphragm while sensing the level of viscous liquids or slurries. The cable connection in wet-well applications shall have a non-fouling guard to prevent buildup of foreign materials.

Pressure/Level transducers shall be Micro-Comm L5N series, Consolidated A300 Model 221GEE, or Ametek Model 57S.

PART 3 – EXECUTION

3.01 EQUIPMENT EXAMINATION

A. The control system shall be completely tested prior to shipment. The entire control system shall be "Burned In" at the factory for a period of at least 20 days. The component equipment shall be computer tested and temperature cycled at zero degrees and at fifty degrees centigrade.

3.02 SYSTEM START-UP

A. The manufacturer shall supply "Factory" personnel for start-up service as needed to insure satisfactory operation. Subsequent trips to the job site to correct defects shall be made at no charge to the Owner during the warranty period.

3.03 SUBSTANTIAL COMPLETION

A. The Engineer will grant substantial completion only after completion of the start-up and initial training phase of the project. The Engineer shall make an inspection of the system to determine the status of completion. Substantial completion will be awarded only when the system is providing usable service to the Owner. If the system is commissioned in phases, the Contractor may request substantial completion for the completed phases.

3.04 WARRANTY/SUPPORT PROGRAM

A. The control system manufacturer shall supply a FIVE (5) year parts and labor warranty and comprehensive support program for all items and software supplied under this section (except as noted below). Power surges and lightning damage shall be included as part of the warranty.

B. The warranty shall begin from the time of "substantial completion" as issued by the engineer. The manufacturer shall provide a 24-hour response to calls from the Owner. The manufacturer, at his discretion, may dispatch replacement parts to the Owner by next-day delivery service for field replacement by the Owner. Any damage to the control system caused by the actions of the Owner in attempting these field replacements shall be the sole responsibility of the manufacturer. If, during the warranty period, satisfactory field repair cannot be attained by field replacement of parts by the Owner, the manufacturer shall dispatch "factory" personnel to the job site to complete repairs at no cost to the Owner.

C. The support program shall begin from the time of "substantial completion" as issued by the engineer. The support program shall include free updating of all software as needed and providing free phone support from the integrator throughout the warranty period.

PART 4 – APPENDIX: DETAILED EQUIPMENT DESCRIPTION

4.01 HIGHWAY 42 TANK II REMOTE UNIT REQUIREMENTS:

A. Installation Requirements:

The Tank RTU shall be mounted inside lockable NEMA 3R enclosure. The RTU enclosure shall be installed on a uni-strut equipment rack. Two 6" aluminum/concrete mounting poles shall support the rack. A 10' long X 1-1/2" rigid conduit antenna mast shall be fastened to equipment rack/mounting pole. The installation shall be detailed in the submittal process.

The level transducer shall be a two-wire transmitter suitable for below ground mounting. The level transducer shall be installed at a point below freezing in the altitude vault. The pressure connection shall be equipped with a corporation stop providing a 1/4" NPT female connection for the transducer. The Electrical Contractor shall run 3/4" rigid conduit from the vault or meter box to the transceiver enclosure for the transducer signal cable.

B. Front Panel Display Requirements:

1. Keypad LCD Display

C. Discrete Outputs:

1. Reserved for Altitude Valve Control
2. spare
3. spare
4. spare

D. Discrete Inputs:

1. Power Failure
2. Reserved for Altitude Valve Open/Closed signal
3. spare
4. spare
5. spare
6. spare
7. spare
8. spare

E. Analog Inputs:

1. Tank Water Level (from new pressure transducer)
2. spare
3. spare
4. spare

4.02 CENTRAL UNIT MODIFICATION REQUIREMENTS:

A. The proposed RTU Information will be added to the existing Central Unit:

The new RTU site information shall be displayed, monitored, and controlled via the existing SCADAview software program.

- END OF SECTION -

DIVISION 16

ELECTRICAL

SECTION 16010

GENERAL ELECTRICAL REQUIREMENTS

PART 1 – GENERAL

1.01 All electrical work shall be performed in accordance with the requirements of the latest revision of the National Electrical Code (NFPA 70), National Safety Code, and Kentucky Building Code. All electrical equipment where applicable shall conform to NEMA, ANSI, and be UL listed where a listing for such equipment exists. Whenever and wherever the design or state and local regulations require higher standards than the above codes, then these codes shall be followed.

The Contractor shall contact a licensed and recognized electrical inspector in the area to inspect the project. All costs incidental to Electrical Inspection shall be borne by the Contractor. A certificate of compliance shall be furnished to the Owner with a copy to the Engineer. All electrical equipment shall be marked with voltage indicators and appropriate signage.

Shop drawings shall be furnished in accordance with Section 01300 to the Engineer for review and acceptance prior to ordering equipment for the following equipment: Conductors, Conduit, and Hangers,

PART 2 – PRODUCTS

2.01 CONDUCTORS

Conductors shall be new, UL listed, 600-Volt, THWN/THHN insulation, copper stranded. Minimum conductor size is #12 AWG. Instrumentation cable shall be one pair #16 shielded and twisted full shield, UL listed, 600-Volt insulation.

2.02 RACEWAYS

Raceways for this project shall be rigid, galvanized inside and out, using threaded couplings, UL listed, with appropriate fittings. All hangers shall be UL listed for electrical raceway use. Underground conduit shall be painted with UL listed mastic with appropriate pre-treatment. Schedule 40 conduit may be used for underground conduits that are not service entrance. Schedule 80 conduit may be used for service entrance conduits. All conduit shall be UL listed. No PVC conduit will be allowed above grade.

2.03 COMPRESSION CONNECTORS

Only UL listed compression connectors shall be used. Absolutely no wire trimming or multiple conductors under one screw, etc., will be allowed.

2.04 TESTING AND COMPLETION

A. The system shall be left fully calibrated and operational. Provide Owner training as required to satisfy their requirements.

B. See Section 11215, Article 34 for other training.

2.05 OUTLET BOXES

A. Standard Boxes

1. NEMA 250, Type 1, minimum two (2) inches deep, unless shallower required by structural conditions.

B. Large Galvanized Steel Boxes

1. NEMA 250, Type 4.
2. 14-gauge, with full access screw covers mounted with corrosion resistant machine screws.

C. Large Cast Metal Boxes

1. NEMA 150, Type 4, cast malleable iron.
2. Neoprene casket, watertight, with cast metal covers, stainless steel screws, and drilled and tapped conduit entrances.

2.06 SERVICE ENTRANCE

Meet requirements of local electric utility.

2.07 CONDUIT SUPPORTS

A. Provide pipe straps, wall brackets, conduit clamps, conduit hangers, thread C clamps with retainers, or ceiling trapeze.

B. Securely and rigidly fasten in place.

C. Maximum interval: 10 feet.

2.08 COVER PLATES

A. Metal

1. Material: Specification grade, one-piece, stainless steel.
2. Thickness: Minimum 0.40-inch nominal.
3. Finish: No. 302/304 satin.
4. Mounting Screws: Oval head, stainless steel, to match plate.

B. Cast Metal

1. Material: Malleable ferrous, with gaskets.

2. Mounting Screws: Oval head, stainless steel.

C. Weatherproof Device Plates

1. Material: Cast metal, gasketed, weatherproof, with individual cap over each opening held with stainless steel springs.

2. Finish: Stainless steel or fiberglass reinforced plastic.

3. Mounted Screws: Stainless steel.

2.09 GROUNDING

A. The resistance value of the main grounding conductor measured between the main disconnect and a good earth ground shall not exceed five (5) ohms.

B. Ground Rods

Ground rods shall be the copper clad steel type and shall be a minimum of 10 feet in length, 3/4 inch in diameter. Ground rods shall be equal to those as manufactured by Copperweld Steel Company.

C. Grounding electrode conductors shall be bare copper. Equipment grounding conductor shall be copper, THW insulated, green (or green with yellow tracer) in color, and rated at 600 volts.

-END OF SECTION-

SECTION 16050

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 – GENERAL

1.01 CONTRACTOR'S UNDERSTANDING

A. Contractors bidding work under this Contract shall read and understand Division 0 and Division 1 - General Requirements. If any discrepancies are discovered between the Basic Electrical Materials and Methods and General Requirements, the above-mentioned documents shall overrule this section. The Basic Electrical Materials and Methods are intended as a supplement to the above-mentioned documents.

B. The Contractor shall bid as outlined in the above-mentioned Specifications and shall be governed by any alternates or unit prices called for in the form of proposal.

C. Each contractor bidding on the work included in these Specifications shall view the building site and carefully examine the Contract Drawings and Specifications so that he/she may fully understand what is to be done, and to document existing conditions.

1.02 SCOPE OF WORK

A. Work include in this section of the Specifications includes the furnishing of all labor, material, tools, approvals, utility connection fees, excavation, backfill, and other equipment necessary to install the electrical system as shown on the Contract Drawings and as specified herein.

B. It also includes installation and connection of all electrical utilization equipment included in this Contract but furnished by other contractors or suppliers.

C. The Contractor shall furnish and install all conduit, wire, disconnect switches, and miscellaneous material to make all electrical connections to all items of utilization equipment or wiring devices except as otherwise specified.

D. Equipment connections shall be made with flexible or rigid conduit as required.

E. Where wiring diagrams are not shown on the Contract Drawings, they are to be provided by the supplier of the equipment served and such diagrams shall be adhered to except as herein modified.

F. The following is a list of items that may not be defined clearly on the Contract Drawings or in other parts of these Specifications. The list is meant to be an aid to the Contractor and is not necessarily a complete list of all work to be performed under this Contract:

1. Connect all accessories furnished by equipment suppliers.

2. Furnish, install, and connect indoor and outdoor lighting, including FAA signal.

3. Furnish, install, and connect power and signal lines to all telemetry equipment, and accessories.

4. Furnish, install, and connect all electrical conduit, duct, and cables.

5. Furnish, install, and connect all power distribution equipment.

1.03 SHOP DRAWINGS, DESCRIPTIVE LITERATURE, INSTALLATION, OPERATION, AND MAINTENANCE INFORMATION

A. Shop drawings including descriptive literature and/or installation, operation, and maintenance instructions shall be submitted in the amount of four (4) copies for this division.

B. Shop drawings shall be submitted on the following materials specified in this division:

1. Conduit - all types and sizes, including liquid-tight flexible.

2. Boxes - all types and sizes.

3. Coal tar epoxy paint.

4. Conduit fittings, expansion joints, support hardware.

5. Power distribution equipment - including individually mounted items.

6. Wire - all types and sizes.

7. Light fixtures, including FAA signal.

8. Wire markers, signs, and labels.

9. Lightning/transient suppressors.

1.04 SYMBOLS AND ABBREVIATIONS

The symbols and abbreviations generally follow standard electrical and architectural practice; however, exceptions to this shall be as shown on the Contract Drawings.

1.05 COORDINATION WITH OTHER TRADES

The Contractor shall coordinate the electrical work with that of other trades to ensure proper final location of all electrical equipment and/or connections. The Contractor shall verify door swings to see that light switches are located properly.

1.06 CODES

A. The minimum standard for all work shall be the latest revision of the Kentucky Building Code (KBC) and the National Electrical Code (NEC). Whenever and wherever state and/or local laws or ordinances and/or regulations and/or the Engineer's design require a higher standard than the current NEC or KBC, then these laws and/or regulations and/or the design shall be followed.

B. Following is a list of other applicable Standards or Codes:

1. Kentucky Building Code.....KBC
2. National Electrical Code.....NEC
3. National Electrical Safety Code.....NESC
4. Underwriters Laboratories, Inc. .....UL
5. Factory Mutual System .....FM
6. National Fire Protection Association.....NFPA
7. National Electrical Manufacturers Association .....NEMA
8. Occupational Safety and Health Administration .....OSHA
9. Insulated Cable Engineers Association, Inc.....ICEA
10. Illuminating Engineering Society of North America.....IES
11. Instrument Society of America .....ISA
12. Institute of Electrical and Electronic Engineers, Inc.....IEEE
13. Certified Ballast Manufacturers Association.....CBM
14. American National Standards Institute, Inc. .....ANSI
16. Joint Industry Council.....JIC
19. American Society for Testing and Materials .....ASTM
20. Federal Aviation Administration .....FAA
21. Rural Electrification Association .....REA

1.07 INSPECTIONS AND PERMITS

A. Inspection of the electrical system is required. If the local government has appointed a state-licensed inspector, the Contractor shall be required to use that person to perform the inspections. If a locally mandated inspector does not exist, the Contractor shall select and hire a state licensed inspector who has jurisdiction before any work is concealed. The Contractor shall notify the electrical inspector in writing immediately upon notice to proceed, and a copy of the notice shall be submitted to the Engineer.

B. At the time of completion of the project, there shall be furnished to the Owner a certificate of compliance from the agency having jurisdiction pursuant to all electrical work performed. The Engineer shall also receive a photostatic copy.

C. All costs incurred by the Contractor to execute the above-mentioned requirements shall be paid by the Contractor at no extra cost to the Owner.

D. All permits necessary for the complete electrical system shall be obtained by the Contractor from the authorities governing such work. For further information, see Division 1.

1.08 STORAGE

A. All work, equipment, and materials shall be protected against dirt, water, or other injury during the period of construction.

B. Sensitive electrical equipment, such as light fixtures shall be protected against injury or corrosion due to atmospheric conditions or physical damage by other means. Protection is interpreted to mean that equipment shall be stored under roof, in a structure properly heated in cold weather and ventilated in hot weather. Provision shall be made to control the humidity in the storage area to 50 percent relative. The stored equipment shall be inspected periodically, and if it is found that the protection is inadequate, further protective measures shall be employed.

1.09 MATERIALS

A. All materials used shall be new and at least meet the minimum standards as established by the NEC and/or National Electrical Manufacturers Association (NEMA). All materials shall be UL listed for the application, where a listing exists. Additional requirements are found in Division 1. All equipment shall meet applicable FCC requirements and restrictions.

B. The material and equipment described herein has been specified according to a particular trade name or make to set quality standards. However, each contractor has the right to substitute other material and equipment in lieu of that specified, other than those specifically mentioned at matching or for standardization, providing such material and equipment meets all of the requirements of those specified and is accepted in writing by the Engineer.

C. The reuse of salvaged electrical equipment and/or wiring will not be permitted unless specified herein or indicated on the Contract Drawings.

D. All salvaged or abandoned electrical materials shall become the property of the Contractor and shall be removed from the job site upon completion of the project, unless otherwise noted on the Contract Drawings or specified herein.

1.10 ERRORS, CORRECTIONS, AND/OR OMISSIONS

A. Should a piece of utilization equipment be supplied of a different size or horsepower than shown on the Contract Drawings, the Contractor shall be responsible for installing the proper size wiring, conduit, starters, circuit breakers, etc., for proper operation of that unit and the complete electrical system at no extra cost to the Owner.

B. It is the intent of these Specifications to provide for an electrical system installation complete in every respect, to operate in the manner and under conditions as shown in these Specifications and on the Contract Drawings. The Contractor shall notify the Engineer, in writing, of any omission or error at least 10 days prior to opening of bids. In the event of the Contractor's failure to give such notice, he/she may be required to correct work and/or furnish items omitted without additional cost. Further requirements on this subject may be found in the General Requirements, Division 1.

C. Necessary changes or revisions in electrical work to meet any code or power company requirement shall be made by the Contractor without additional charge.

1.11 GUARANTEES AND WARRANTIES

A. The Contractor shall guarantee all work including equipment, materials, and workmanship. This guarantee shall be against all defects of any of the above and shall run for a period of one (1) year from the date of acceptance of the work, concurrent with the one-year guarantee period designated for the general construction contract under which electrical work is performed. Date of acceptance shall be considered to be the date on which all "punch list" items are completed ("punch list" is defined to be the written listing of work that is incomplete or deficient that must be finished or replaced/repaired before the Contractor receives final payment).

B. Repair and maintenance for the guarantee period is the responsibility of the Contractor and shall include all repairs and maintenance other than that which is considered as routine. (That is oiling, greasing, etc.) The Engineer shall be the judge of what shall be considered as routine maintenance.

C. Lamps shall bear the manufacturer's warranty.

1.12 TESTING

A. After the wiring system is complete, and at such time as the Engineer may direct, the Contractor shall conduct an operating test for acceptance. The equipment shall be demonstrated to operate in accordance with the requirements of these Specifications and the Contract Drawings. The test shall be performed in the presence of the Engineer or his authorized representative. The Contractor shall furnish all instruments and personnel required for the tests as well as the necessary electrical power.

B. Before energizing the system, the Contractor shall check all connections and set all relays and instruments for proper operation. He shall obtain all necessary clearances, approvals, and instructions from the serving utility company and/or equipment manufacturers prior to placing power on the equipment.

C. Tests may be performed by the Engineer to determine integrity of insulation on wiring circuits selected by the Engineer at random.

D. Cost of utilities for testing done prior to beneficial occupancy by the Owner shall be borne by the Contractor.

1.13 CLEANUP

A. Cleanup shall be completed as soon as possible after the electrical installation is complete. All electrical equipment shall be free of shipping tags, stickers, etc. All painted equipment shall be left free of scratches or other blemishes such as splattered or blistered paint, etc. All light fixture diffusers shall be clean and the interior of all motor controls, etc., shall be free of dust, dirt, wire strippings, etc. Surplus material, rubbish, and equipment resulting from the work shall be removed from the job site by the Contractor upon completion of the work.

B. During construction, cover all Owner equipment and furnishings subject to mechanical damage or contamination in any way.

1.14 CUTTING AND PATCHING

Cutting and patching shall be held to an absolute minimum and such work shall be done only under the direction of the Engineer or Owner. The Contractor shall be responsible for and shall pay for all openings that may be required in the floors or walls, and he shall be responsible for putting said surfaces back in their original condition. Every attempt shall be made to avoid cutting reinforcing steel bars when an opening is required in a reinforced concrete wall or floor slab.

1.15 EXCAVATION AND BACKFILL

A. Excavation

Excavation for conduits shall be of sufficient width to allow for proper jointing and alignment of the type conduit used. Conduit shall be bedded on original ground. Where conduit is in solid rock, a 6-inch earth cushion must be provided. Conduit shall be laid in straight lines between pull boxes and/or structures unless otherwise noted on the Contract Drawings. The cost of solid rock excavation shall be included in the lump sum bid with no extra pay allowed (unclassified).

B. Backfill

Backfill shall be hand placed, loose granular earth for a height of six (6) inches above the top of the largest conduit. This material shall be free of rocks over two (2) inches in diameter. Above this, large rocks may be included but must be mixed with sufficient earth to fill all voids.

1.16 SLEEVES, CHASES, AND OPENINGS

A. Sleeves shall be required at all points where exposed conduits pass through new concrete walls, slabs, or masonry walls. Sleeves that must be installed below grade or where subject to high water conditions, must be installed watertight.

B. Wiring chases shall be provided where shown on the Contract Drawings. The Contractor shall have the option of installing chases below surface mounted panelboards provided all structural requirements are met.

C. It is the Contractor's responsibility to leave openings to allow installation of the complete, operational electrical system. Openings required, but not left, shall be cut as outlined under cutting and patching. The Contractor shall coordinate all holes and other openings with necessary diameters for proper firestopping.

1.17 POWER COMPANY COORDINATION

A. The Contractor is responsible for coordinating all activities on-site by the power company.

B. Any special provisions required by the serving electrical utility shall be as outlined on the Contract Drawings or as advised by the utility at the time of construction, and work required by these special provisions shall be executed with no extra cost to the Owner.

1.18 OVER-CURRENT PROTECTION

Circuit breakers or fused switches shall be the size and type as written herein and shown on the Contract Drawings. Any additional over-current protection required to maintain an equipment listing by an authority having jurisdiction shall be installed by the Contractor at no extra cost to the Owner.

1.19 AS-BUILT DRAWINGS

The Contractor shall maintain one (1) set of the Contract Drawings on the job in good condition for examination at all times. The Contractor's qualified representative shall enter upon these drawings, from day to day, the actual "as-built" record of construction and/or alteration progress. Entries and notes shall be made in a neat and legible manner and these drawings delivered to the Engineer after completion of the construction, for use in preparation of Record Drawings.

1.20 MAINTAINING CONTINUOUS ELECTRICAL SYSTEM AND SERVICE

A. Existing service(s) continuity shall be maintained at all times. In no way shall the installation and/or alteration of the electrical work interfere with or stop the normal operation of the existing facilities, except where prior arrangements have been made.

B. When additions and taps to existing service(s) require electrical outages of duration in excess of a few minutes, arrangements shall b made in advance for such outages. All outages shall be held to an acceptable minimum with none exceeding eight (8) hours continuous duration. If necessary, cuts shall be performed on premium time. If performed at night, requiring a general outage, the Contractor shall furnish an auxiliary source of light and power as required. Under no circumstances shall an electrical outage of any duration be initiated until the Owner and Engineer have concurred, and as far as possible in advance.

1.21 GROUNDING AND BONDING

All metallic conduit, cabinets, equipment, and service shall be grounded in accordance with the latest issue of the National Electrical Code. All supporting framework and other metal or metal clad equipment or materials which are in contact with electrical conduit, cable and/or enclosures, shall be properly grounded to meet the code requirements.

1.22 RELATED SPECIFICATION DIVISIONS

The following divisions contain specifications on utilization equipment, equipment accessories, and procedures related to execution of the electrical work, and are included here for the Contractor's information. Bids shall still be based on complete Contract Documents.

A. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract

B. Division 1 - General Requirements

C. Division 11 – Equipment

D. Division 13 - Special Construction

1.23 SERVICE ENTRANCE

A. Conductors and terminations for service entrances shall be furnished and installed by the Contractor. Voltage, phase, and number of wires shall be as shown on the Drawings. Clearances for overhead entrance wires shall be per power company, NEC, and NESC requirements.

B. Any details not shown on the Drawings or written in the Specifications pertaining to the service entrance shall be per power company requirements. It is the Contractor's responsibility to contact the utility prior to bidding and obtain any special requirements or costs they will be imposing. Those costs shall be included in the bid.

1.24 CONTRACTOR LICENSING

The Contractor performing the electrical work on this project shall be locally licensed if required by local law or ordinance. If the Contractor has passed the State test, it may not be necessary to meet local testing requirements. It shall be the Contractor's responsibility to investigate these requirements and comply with same.

1.25 ANCHOR / MOUNTING

A. Electrical conduits and/or equipment shall be rigidly supported. Anchors used shall be metallic expansion type, or if appropriate to prevent spalling concrete, epoxy set type. Plastic or explosive type anchors are prohibited.

B. Contractor shall be sure that all supports are consistent with the KBC seismic zone requirements.

PART 2 – PRODUCTS

Not Applicable.

PART 3 – EXECUTION

Not Applicable.

- END OF SECTION -

SECTION 16120

CONDUCTORS AND CABLES

PART 1 – GENERAL

1.01 SCOPE OF WORK

A. All wire and cable shall conform to the latest requirements of the NEC and shall meet all ASTM/UL specifications. Wire and cable shall be new; shall have size, grade of insulation, voltage rating and manufacturer's name permanently marked on the outer covering at regular intervals. Complete descriptive literature shall be submitted to the Engineer for review and acceptance prior to installation.

B. Building wire #12 - #1 shall be applied based on a 60° C temperature rise. Building wire larger than #1 may be applied at its 75° C temperature rise.

1.02 DELIVERY, STORAGE AND HANDLING

Wire and cable shall be suitably protected from weather and damage during storage and handling and shall be in first class condition when installed.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Building Wire (types "THWN" and "THW"-cu.) – "Collyer," "Rome," "American," "Carol," or equal.

B. Control Cables (Shielded or unshielded) 600V max. – "Belden," "Rome," "Eaton-Dekoron," "Okonite," or equal.

C. Instrumentation Cables (Shielded) 600V max. – "Eaton-Dekoron," "Manhatton," "Rome," "American," "Belden," "Okonite," or equal.

2.02 MATERIALS

A. General

1. In general, all conductors shall be 98 percent conductive, annealed copper unless otherwise noted on the Contract Drawings.

2. Conductors shall be type THW or THWN insulation. Conductor size shall be AWG (American Wire Gauge) Standard. Minimum conductor size shall be AWG number 12 except branch circuits in excess of 75 feet from panel to first outlet not smaller than No. 10 AWG. Minimum voltage rating shall be

600 volts. Conductors for small power may be solid (i.e. lighting, receptacles), but conductors for control work shall be stranded.

3. Conductors with high temperature rated insulations and special construction shall be used where required in connecting to light fixtures or appliances that have special requirements.

PART 3 – EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. General

1. Conductors shall be continuous from outlet to outlet and no splices shall be made except accessible in junction or outlet boxes. Wire connectors of insulating material or solderless pressure connectors, properly taped, shall be used for all splices in wiring, wherever possible.

2. Conductors shall be color coded in accordance with the standard schedule.

3. Conductors shall be pulled into raceways in strict accordance with manufacturer's recommendations.

4. Ample slack conductors shall be allowed at each terminal point, and pull or junction box, to permit installation with ease and without crowding.

5. All conductors terminating at terminal blocks shall be identified with numbers and/or letters identical to circuit or control identification.

6. No conductors shall be drawn into conduits until all work which may cause wire or cable damage is completed. Wire pulling shall be accomplished utilizing machinery and accessories intended for the purpose.

7. All connections and splices shall be made in accordance with conductor manufacturer's recommendations, and as written herein.

- END OF SECTION -

SECTION 16130

RACEWAYS

PART 1 – GENERAL

1.01 SCOPE OF WORK

A. This section of the Technical Specifications includes all raceways for accommodation of electrical conductors, communications conductors, sleeves for underground electrical installations, conduit stubs for future installations, fittings therefore and accessories.

B. All raceways shall be marked with the manufacturer's name or trademark as well as type of raceway and size. This marking shall appear at least once every 10 feet and shall be of sufficient durability to withstand the environment involved. All raceways shall be furnished and installed as outlined under Part 3 of this Specification.

C. All raceways and fittings shall be painted to match existing or surrounding surfaces except in mechanical spaces.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Tubular Raceways

1. Steel, Galvanized, Rigid, Heavy-Wall, Threaded – "Wheatland Tube Co.," "Triangle," "Allied Tube & Conduit Corp.," or equal.
2. Plastic (PVC); Type A (Thin Wall); Type 40 (or Schedule 40); Type 80 (or Schedule 80) (Heavy -Wall) – "Robin-Tech," "Carlon," or equal.
3. Liquidtight Flexible Metal Conduit – "Carol Cable Co., Inc.," "Superflex," "OZ Gedney," or equal.

D. Raceway Fittings

1. Conduit fittings – "Crouse-Hinds," "Appleton," "OZ Gedney," or equal.
2. Non-metallic conduit fittings – "Robin-Tech," "Carlon," "Scepter," or equal.
3. Flexible conduit fittings – "Raco," "T & B," "OZ Gedney," or equal.

2.02 MATERIALS

A. Rigid Steel Conduit

Rigid steel conduit and fittings shall be of mild steel piping, galvanized inside and out, and shall conform to UL standards. The conduit and fittings hall be listed and labeled by UL as well. The galvanized coating of zinc shall be of uniform thickness applied by the hot-dipped process, and shall be applied also to the threads. It shall be further dipped in a chromic acid bath so as to chemically form a corrosion resistant protective coating of zinc chromate which has a characteristic yellow-green color. Each piece of conduit shall be straight, free from blisters and other defects, cut square, and taper reamed. It shall be delivered with plastic protectors on the threads.

B. Polyvinylchloride (PVC) Conduit

PVC conduit and fittings shall be Schedule 40, 80 heavy wall, or thinwall, as indicated in these Specifications manufactured to conform to UL standards. It shall be listed and labeled by UL. It shall have at least the same temperature rating as the conductor insulation. Expansion joints shall be used as recommended by the manufacturer in published literature. PVC systems shall be 90 degrees Celsius minimum UL rated, have a tensile strength of 7,000 psi @ 73.4 degrees Fahrenheit, flexural strength of 11,000 psi and compressive strength of 8,000 psi.

C. Flexible Conduit

Flexible metallic conduit shall be constructed from flexibly or spirally wound electro-galvanized steel. Connections shall be by means of galvanized malleable iron squeeze type fittings, or tomic twist-in type in sizes not exceeding 3/4 inch. Liquidtight conduit shall be light gray in color and have sealtight fittings, type UA.

D. Conduit Fittings

1. Rigid Steel Conduit Fittings

a. Standard threaded couplings, locknuts, bushings, and elbows made only of steel or malleable iron are acceptable. Integral retractable type IMC couplings are acceptable also.

b. Locknuts: Bonding type with sharp edges for digging into the metal wall of an enclosure.

c. Bushings: Metallic insulating type, consisting of an insulating insert molded or locked into the metallic body of the fitting. Bushings made entirely of metal or nonmetallic material are not permitted.

d. Erickson (union-type) and set screw type couplings: Approved for use in concrete are permitted or use to complete a conduit run where conduit is installed in concrete. Use set screws of case hardened steel with hex head and cup point to firmly seat in conduit wall for positive ground. Tightening of set screws with pliers is prohibited.

e. Sealing Fittings: Threaded cast iron type. Use continuous drain type sealing fittings to prevent passage of water vapor. In concealed work,

installed fittings in flush steel boxes with blank coverplates having the same finishes as that of other electrical plates in the room.

f. Fittings for PVC coated rigid conduit shall be manufactured by the maker of the conduit.

2. Expansion and Deflection Couplings

a. Accommodate 1.9 cm (0.75 inch) deflection, expansion, or contraction in any direction, and allow 30 degree angular deflections.

b. Include internal flexible metal braid sized to guarantee conduit ground continuity and fault currents in accordance with UL, and the NEC code tables for ground conductors.

c. Watertight, seismically qualified, corrosion-resistant, threaded for and compatible with rigid or intermediate metal conduit.

d. Jacket: Flexible, corrosion-resistant, watertight, moisture and heat resistant molded rubber material and stainless steel jacket clamps.

PART 3 - EXECUTION

3.01 PREPARATION

Exterior underground metallic conduits shall be degreased, pretreated, and coated with two (2) coats of Carboline 888 epoxy, or equal. Other finishes may be acceptable upon the Engineer's review.

3.02 INSTALLATION

A. Conduit

1. All conduit shall be installed in a first class workmanship manner. It shall be installed in horizontal and vertical runs in such a manner as to ensure against trouble from the collection of trapped condensation and shall be arranged so as to be devoid of traps wherever possible. Special care shall be used in assuring that exposed conduit runs are parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings. No open wiring is allowed.

2. Fittings or symmetrical bends shall be required wherever right angle turns are made in exposed work. Bends and offsets shall be avoided wherever possible, but where necessary, they shall be made with an approved conduit bending machine. All conduit joints shall be cut square, reamed smooth and drawn up tight, using couplings intended for the purpose.

3. Conduits shall be securely fastened to all sheet metal outlets, junction and pull boxes with double galvanized locknuts and insulating-grounding bushings as required by the NEC. Conduit crossings in insulating roof fill will require both conduits to be secured to the roof deck, and these crossings can only be made where the insulating fill is a minimum of three (3) inches deep. Runs of exposed conduit shall be supported in accordance with the NEC using cast aluminum or malleable iron one hole pipe straps with spacers to provide an air space behind the conduit. Stainless steel minerallaac, one-piece conduit clamps shall be acceptable where located such that building occupants are not in danger of inadvertent contact, since this type fitting has several sharp edges. In general terms, they may be considered in areas such as on or above ceilings, or high on walls. All conduit in walls and slabs shall be securely braced, capped (wooden plugs are prohibited), and fastened to the forms to prevent dislodgement during vibration and pouring of concrete.

4. During construction, all conduit work shall be protected to prevent lodgement of dirt, plaster or trash in conduits, fittings or boxes. Conduits which have been plugged shall be entirely freed of accumulations or be replaced. All conduits in floors or below grade shall be swabbed free of debris and moisture before wires are pulled. Crushed or deformed conduit shall not be permitted.

5. Where GRS conduit penetrates a floor slab the conduit shall be painted with two (2) coats of Koppers Bitumastic 300-M or equal to a point six (6) inches above the penetration.

6. The final section of conduit connecting each motor or piece of utilization equipment subject to vibration shall be of the flexible type. Type "UA" shall be used in all process areas and in outdoor or wet locations. Flexible conduit to space heaters shall be long enough to allow swivel action.

7. All underground conduits entering a building shall be sealed against water/condensate entering around the conductors. Sealant may be silicone rubber based caulk.

8. In certain situations, conduit expansion joints shall be required to ensure against conduit and/or cable damage due to settling or thermal expansion and contraction. These expansion joints shall be required where required by the manufacturer or the Contract Drawings and shall be installed per manufacturer's instructions.

9. PVC conduit installed underground for low voltage application shall be schedule 80 without encasement. Where PVC conduit is installed, transition shall be made to GRS conduit at bends where wire pulling could cut conduit.

10. Conduit stubs, for future use, extended through outside walls shall be capped with threaded pipe caps and coated to prevent corrosion. Stubs shall extend five (5) feet beyond the walls from which they are stubbed unless otherwise indicated on the Contract Drawings.

11. All metal raceway systems shall be grounding conductive, solidly bonded throughout and grounded in accordance with NEC requirements and/or as noted on the Contract Drawings. In addition, all raceway systems shall be provided with separate grounding conductors.

12. Minimum conduit size shall be 3/4 inch. The following table shows the minimum burial depth required for all exterior conduit or cable:

Rigid Metal Conduit	18 inches
Schedule 80 PVC	30 inches

13. Wire pulling shall be facilitated by the use of a UL approved pulling compound in pulls over 30 feet in length or where there are two or more 90 degree bends. Only polypropylene, nylon, or manila pulling ropes will be permitted. Standard industry recognized wire pulling equipment shall be used.

14. Underground raceways (conduit) shall be provided with steel sleeves where they pass over or under obstructions such as sidewalks, roadways, piping, etc.

15. All conduit shall have an insulated ground wire pulled to all equipment and receptacles.

16. All raceway runs are shown diagrammatically to outline the general routing of the raceway. The installation shall be made to avoid interference with pipes, ducts, structural members or other equipment. Should structural or other interference prevent the installation of the raceways, or setting of boxes, cabinets, or the electrical equipment, as indicated in the Drawings, deviations must be approved by the Owner, and after approval, shall be made without additional charges and shown on the Record Drawings.

17. Conduit may be run inside concrete slabs as long as the slab is at least six (6) inches thick and conduit will have at least one to two inches of cover on both sides.

18. Flexible conduit shall be liquid tight.

19. Runs of exposed flexible conduit shall be limited to five (5) feet. All runs of flexible conduit shall be supported in accordance with NEC requirements.

- END OF SECTION -

SECTION 16131

BOXES

PART 1 – GENERAL

1.01 SCOPE OF WORK

Outlet and junction boxes shall be furnished and installed where indicated on the Contract Drawings, and\or as required by the work in accordance with the NEC.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

Boxes – "Queen," "Wiegmann," "Appleton," "Raco," "Bauers," "Crouse-Hinds," "Hoffman," "Robroy Industries," "Cloud Concrete Products," "Spring City," "Carlon," "Sedco," or equal.

2.02 GENERAL

A. Junction and/or pull boxes for wet or damp locations shall be cast metal, rust and corrosion resistant (NEMA 4X), with at least five (5) 2-full threads for each (bossed) conduit opening, and shall be suitable for flush or surface mounting as required with drilled external, cast mounting extensions (bossed to provide at least 1/8-inch between back of box and mounting surface for drainage). Box covers shall be hinged or cap screw retained as required, of the same material as the box and provided with stainless steel (rustproof) hardware.

B. Junction boxes for out-of-doors use, not mounted in concrete may be sheet metal (NEMA 4X), waterproof, rustproof, rain and sleetproof, with hinged covers and latches and provided means of locking by means of keyed locks, tamper-resistant screws or padlocking as required and with clamping cap-screws top and bottom door edges to provide firm contact with gasketing. All gaskets shall be molded (unbroken) neoprene or butyl rubber.

C. NEMA 4X junction and/or pull boxes may be stainless steel, if called for on the Contract Drawings; or non-metallic or cast aluminum.

PART 3 – EXECUTION

3.01 INSTALLATION, APPLICATION, AND ERECTION

A. Exposed Work

1. Outlet or junction boxes for use with exposed steel conduit shall be cast steel.

2. Outlet or junction boxes for use with exposed aluminum conduit shall be copper free, cast aluminum type.

3. Outlet or junction boxes for use with exposed PVC conduit shall be PVC.

B. Openings in Electrical Boxes

All openings in electrical equipment, enclosures, cabinets, outlet and junction boxes shall be by means of welded bosses, standard knockouts, or shall be sawed, drilled, or punched with tools specially made for the purpose. The use of a cutting torch is prohibited. Unused openings shall be plugged per the NEC.

- END OF SECTION -

SECTION 16150

WIRE CONNECTIONS AND CONNECTING DEVICES

PART 1 – GENERAL

1.01 SCOPE OF WORK

Wire connection and connecting devices shall be as herein specified.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Connectors, Lugs, etc. – "T & B", "Anderson", "Burndy", or equal.

B. Termination and splice connectors – "3M Scotchlok", "Anderson", "T & B", "Burndy", or equal.

2.02 MATERIALS

A. Wire Splicing and Terminations (600 Volts and Below)

1. Electrical Terminal and Splice Connectors (#22 - #4 AWG)

a. Terminals and splice connectors from #22 - #4 AWG shall be compression types with barrels to provide maximum conductor contact and tensile strength. Performance, construction, and materials shall be in conformance with UL standards for wire connectors and rated for 600 volts and 105° C.

b. Connectors shall be manufactured from high conductivity copper and entirely tin plated. Terminal barrels shall be serrated on the inside surface and have a chamfered conductor entry. Terminals shall have funnel entry construction to prevent strand fold-back. All barrels shall be brazed seam or seamless construction.

c. Spade type terminals shall be sized for the appropriate stud and shall be locking type that snap firmly onto studs with a close fit for maximum retention. Spade type terminals shall be insulated with an insulation suitable for maintaining a high dielectric strength when crimped and be made form nylon, PVC, or equal.

2. Electrical Lugs and Connectors (#6 AWG - 1000 Kcmil)

a. Lugs and splice connectors from #6 AWG - 1000 Kcmil shall be compression types with barrels to provide maximum conductor contact and tensile strength. They shall be manufactured from high conductivity copper and entirely tin plated. They shall be crimped with standard industry tooling. The lugs and connectors must have a current carrying capacity equal to the conductors for which they are rated and must also meet all UL requirements. All lugs above 4/0 AWG shall be 2-hole lugs with NEMA spacing. The lugs shall be rated for operation through 35 KV. The lugs shall be of closed end construction to exclude moisture migration into the cable conductor.

3. Twist-on Wire Connectors (#22 AWG - #10 AWG)

a. All twist-on wire connectors must have a corrosion resistant spring that is free to expand within a steel jacket. The steel jacket must be insulated with a flexible vinyl jacket capable of withstanding 105° C ambient temperatures and of sufficient length to cover wires that are inadvertently overstripped.

b. Each connector size must be listed by UL for the intended purpose and color coded to assure that the proper size is used on the wire combinations to be spliced. The connectors must be compatible with all common rubber and thermoplastic wire insulations.

4. Solderless/re-usable lugs shall be used only when furnished with equipment such as control panels, furnished by others, where specification of compression type lugs is beyond the Contractor's control. In the event their use is necessary, the Contractor shall be responsible for assuring that they are manufactured to NEMA standards, with proper number and spacing of holes and set screws.

PART 3 – EXECUTION

3.01 INSTALLATION, APPLICATION, AND ERECTION

A. Insulation of Splices and Connections

1. Connections/splices with a smooth even contour shall be insulated with a conformable 7-mil thick vinyl plastic insulating tape which can be applied under all weather conditions and is designed to perform in a continuous temperature environment up to 105° C. The tape shall have excellent resistance to abrasion, moisture, alkalies, acids, corrosion, and varying weather conditions (including sunlight). The tape shall be equal to Scotch 33+ and shall be applied in conformance with manufacturer's recommendations. In addition, it shall be applied in successive half-lapped layers with sufficient tension to reduce its width to 5/8 of its original width. The last inch of the wrap shall not be stretched.

2. Connections/splices with irregular shapes or sharp edges protruding shall be first wrapped with 30 mil rubber tape to smooth the contour of the joint before being insulated with 33+ insulating tape specified in the previous paragraph. The rubber tape shall be high voltage (69 KV) corona-resistant based on self-fusing ethylene propylene rubber and be capable of operation at 130° C under emergency conditions. The tape must be capable of being applied in either the stretched or unstretched condition without any loss in either physical or electrical properties. The tape must not split, crack, slip, or flag when exposed to various environments. The tape must be compatible with all synthetic cable insulations. The tape must have a dissipation factor of less than five percent (5%) at 130° C, be non-vulcanizing, and have a shelf life of a least five (5) years. The rubber tape shall be applied in successive, half-lapped wound layers and shall be highly elongated to eliminate voids. Other manufacturer's recommendations on installation shall be adhered to. The rubber tape shall be equal to Scotch 23 or 130C electrical splicing tape.

3. Splices made in wet or damp locations shall be made submersible and watertight with special kits made for the application and compatible with type of cables employed.

B. Connection Make-up

1. Connections of lugs to bus bars, etc., shall be made up with corrosion resistant steel bolts having non-magnetic properties with matching nuts, and shall utilize a Belleville spring washer (stainless steel) to maintain connection integrity. Connections shall be torqued to the proper limits. Prior to bolting up the connection, electrical joint compound shall be brushed on the contact faces of the electrical joint.

2. All motor lead connections shall be made up to match the type of lead furnished on the motor. If the lead is not lugged, then twist-on wire connectors may be used. To prevent possible vibration problems, twist-on connectors shall be taped after installation.

3. All lugged motor lead connections (excluding motors over 200 horsepower) shall be made up using ring tongue compression lugs with proper size stainless steel nuts and bolts. Belleville type spring shall be used to maintain tension on the connections. The connections shall then be insulated using the procedure described for irregular shapes, utilizing rubber tape in conjunction with vinyl electrical tape.

4. At the time of final inspection, the Engineer may request the Contractor to disassemble three (3) randomly selected motor lead connections in the Engineer's presence, to assure conformance with these Specifications.

5. The Contractor shall include all necessary tools, materials, and labor in his bid for disassembly of the connections and for remaking them with new insulating materials after inspection.

- END OF SECTION -

SECTION 16670

LIGHTNING PROTECTION SYSTEM

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. The lightning protection system shall be furnished, installed, and connected as detailed on the Contract Drawings and as specified herein to provide a complete and functional system of lightning protection for the U.S. 42 Storage Tank. Installation and equipment construction shall comply with Lightning Protection Institute Installation Code, UL Master Label Code 96A, and NFPA 780.

B. All equipment shall be of the same manufacturer, insofar as possible.

1.02 SUBMITTALS

A. Submit shop drawings of proposed installation and cutsheets on proposed equipment. Also submit installer qualifications. Shop drawings shall be approved before installation and procurement.

B. Submit O&M manuals including cutsheets, as-built drawings, and operation/maintenance information.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. "Thompson Lightning Protection, Inc.," "Independent Protection Co., Inc.," "National Lightning Protection, Inc." or equal.

2.02 EQUIPMENT

A. All equipment used in this installation shall be UL approved and labeled in accordance with UL procedures.

B. All equipment shall be new, and of design and construction to suit the application where it is used in accordance with accepted industry standards and LPI and UL code requirements and as per manufacturers recommendations.

C. Air terminals shall be solid, round aluminum bar of ½" minimum diameter, and shall project above the object to be protected as indicated on the Drawings.

D. Air terminal bases shall be securely mounted with stainless steel screws or bolts.

E. E. Ground rods shall be a minimum of 3/4" in diameter and 10'-0" long. They shall be connected to the system using exothermic welds, Cadweld, or equal.

F. F. Cable fasteners shall be substantial in construction, electrolytically compatible with the conductor and mounting surface and shall be spaced according to LPI and UL code requirements.

G. G. Bonding devices, cable splicers and miscellaneous connectors shall be of copper with bolted pressure connections to cable, or exothermic welds. Cast or stamped crimp fittings are not acceptable. All miscellaneous bolts, nuts, and screws shall be stainless steel.

PART 3 - EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. The installation shall be accomplished by an experienced installer listed with Underwriters' Laboratories as qualified and who is also a Certified Master Installer of the LPI or working under the direct supervision of an LPI manufacturer as listed above or his authorized LPI Certified Master Installer representative.

B. All equipment shall be installed in a neat workmanlike manner in the most inconspicuous manner possible.

C. The lightning protection installer will work with other trades to ensure a correct, neat, and unobtrusive installation.

D. It shall be the responsibility of the lightning protection installer to assure a sound bond to the structure grounding electrode system.

E. The lightning protection installer shall secure and deliver a UL Master Label and LPI System Certification to the Engineer for the Owner upon completion of the installation.

F. A permanent plate shall be affixed to the protected structure in a prominent location, indicating its UL approval.

END OF SECTION

APPENDIX A

PRELIMINARY GEOTECHNICAL REPORT

Preliminary Geotechnical Report

for

U.S. 42 Water Tank

Trimble County, Kentucky

November 25, 2015
Revised December 4, 2015

Prepared for

Tetra Tech
Infrastructure Group
Lexington, Kentucky

CSI Project Number CN150066

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November 25, 2015
Revised December 4, 2015

Mr. Tom Green
Tetra Tech Infrastructure Group
424 Lewis Hargett Circle, Suite 100
Lexington, KY 40503

Subject: **Preliminary Geotechnical Report**
Trimble County Water Tank
Pendleton, Trimble County, Kentucky
CSI Project Number CN150066

Dear Mr. Green:

Consulting Services Incorporated of Kentucky (CSI) is pleased to present our report for the geotechnical services completed on the subject project. We provided our services in general accordance with the CSI Proposal Number 3319, dated July 31, 2014.

Our report represents information provided to us, readily available published data relevant to the site and site area, our observations and subsurface conditions encountered and our opinion of primary geotechnical conditions (discussion and recommendations) affecting design, construction and performance of the proposed earth-supported portions of the project.

We appreciate the opportunity to provide our geotechnical services to you and the design team. Please do not hesitate to contact us for questions or comments about the information contained herein.

Sincerely,

Graham T. Duncan, E.I.T.
Staff Engineer

Joseph S. Burkhardt, P.E.
Principal Geotechnical Engineer
Registered Kentucky 24743

STATE OF KENTUCKY
JOSEPH S. BURKHARDT
24743
LICENSED PROFESSIONAL ENGINEER

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INTRODUCTION

1 SCOPE OF THE GEOTECHNICAL EXPLORATION

As we proposed, CSI conducted a preliminary geotechnical exploration for the proposed water tank, which is summarized in the following report. Our services included a review of the project information provided, conducting a subsurface exploration that utilized soil borings to obtain samples for modeling the soil conditions at the subject site, an analysis of the data and information obtained and providing recommendations for foundations associated with the proposed structure along with recommendations for the site development.

Our geotechnical services provided, while yielding design recommendations, are general in terms of the amount of information provided to us and the level of exploration performed. Due to the foundations being in the preliminary design phase, a geotechnical engineer should be retained review final design details and modify this report as necessary if needed.

2 SITE AND PROJECT INFORMATION

Project information was provided by you during the proposal and design phases of the project. In preparing for this report, CSI has been provided with the following:

- An untitled aerial image outlining the general location of the proposed water tower;
- An untitled topographic drawing of the immediate area; and
- Preliminary structure and load data dated, July 6, 2015

Based upon our understanding, the project will consist of constructing a new 1,000,000 gallon water storage tank adjacent to the existing water tank at the site. Preliminary details indicate the tank will be a composite structure with a height of about 200 feet and a diameter at the base of about 38 feet. The diameter at the top of the structure will be approximately 75 feet. Preliminary structural information indicates the total weight will approach 12,000 kips with transient loads due to wind and earthquake loading on the order of 11,000 kip-feet (wind), 70,000 kip-feet (earthquake) and 500 kips of shear. It is our understanding, that the above design information is of a typical tank of this type and may change.

The current water tower structure occupies the adjacent site and is accessed by a gravel roadway located approximately 530’ west of the intersection of US 42 and Stauffer Road. At the time of drilling, the proposed tank location (west of the existing tank) had been cleared (150’x150’ area) to allow for drilling and construction equipment to access the area. Slopes within the cleared area are relatively gentle, experiencing approximately 10 feet of grade change from east to west across the cleared area. Slopes along the perimeter of the site are more severe, experiencing as much as 20 feet of grade change.

If any of the aforementioned information is in error or if the information changes during any time of the project, please contact our office so we can evaluate the new information with respect to our findings and recommendations.

3 PUBLISHED SITE INFORMATION

3A AREA TOPOGRAPHY/PHYSIOGRAPHY

The site is located on the border of the Outer Bluegrass area of North-Western Kentucky. This area is characterized by deep valleys, with little flat land due to the bedrock being comprised of interbedded Ordovician limestones and shales that erodes more easily as compared to the Inner Blue Grass Region where the land is more flat with gently rolling hills. Published mapping reviewed indicates the elevations in the site vicinity range from about 950 feet near the existing water tank to 920 feet along the perimeter of the site. Below is a figure of the location of the site with respect to the regional physiography.

Figure 1: Kentucky Physiographic Map (site vicinity shown with star)

3B SITE GEOLOGY

A review of the *Geologic Map of the Bedford Quadrangle, North-Central Kentucky,* dated 1977 indicates the project site is underlain by Glacial Drift (Qd) consisting of red-brown clays and various amounts of chert, as well as Silurian age dolomite (Sl, Laurel Dolomite Formation), and Silurian age shale (Sob, Osgood and Brassfield Formations). As with many areas in the Blue Grass Region, the development of Karst is a concern. Review of available information indicates the Laurel Dolomite formation is at a medium risk of developing karst features, while the Glacial Drift and Shale formations are non-karst.

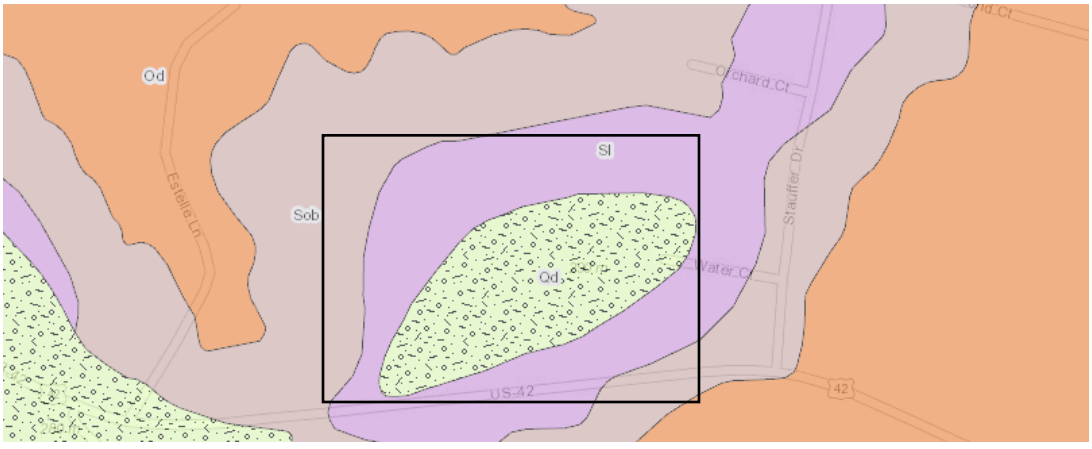


Figure 2: Site Surficial Geology (Geologic Map of the Bedford Quadrangle, North-Central Kentucky)

3C COUNTY SOIL SURVEY

Review of the USDA Soil Survey of Trimble County (NRCS website), the soils underlying the site consist of the following series:

- Beasley Silty Clay Loam (BeC2), 6 to 12% slopes - Accounts for approximately 98% of site
    - These well drained soils are comprised of silty clay residuum. Depth to restrictive features reported to be more than 40 to 56 inches with the depth to water table to be greater than 80 inches.
- Urban (BsE2), 20 to 40% slopes - Accounts for approximately 2% of site
    - These well drained soils are comprised of silty clay. Depth to restrictive features reported to be more than 20 to 40 inches with the depth to water table to be greater than 80 inches.

Figure 3: USDA Soil Survey Map of Project Site

3D AERIAL PHOTOGRAPHS (Google Earth)

Review of the historical aerial photos over the past 25 years indicates the immediate site has seen little to no development. To the east of the site a residential street and homes were constructed between 1998 and 2003. A small residential structure to the south of the site along US 42 was constructed between 2004 and 2006.

Figure 4: Google Earth Aerial Site Photo Dated 4/5/1998

Figure 5: Google Earth Aerial Site Photo Dated 11/7/2013

FINDINGS

4 SUBSURFACE CONDITIONS

A total of 3 soil test borings were performed to explore the subsurface conditions at the site. Refusal depths are shown in the table below. Groundwater was not encountered in any borings.

Table 1: Boring Information Summary

Boring Number	Depth to Refusal (ft)
B-1	33.0
B-2	33.0
B-3	33.0

4A STRATA INFORMATION

The subsurface conditions encountered at the boring locations are shown on the Test Boring Records in Appendix A. These Test Boring Records represent our interpretation of the subsurface conditions based on the field logs, visual examination of field samples by an engineer, and tests of the samples collected. The letters in parentheses following the soil descriptions are the soil classifications in accordance with the Unified Soil Classification System. It should be noted that the stratification lines shown on the soil boring logs represent approximate transitions between material types. In-situ stratum changes could occur gradually or at slightly different depths. Water level reading represent water levels directly after drilling was complete.

SURFICIAL SOILS

As indicated, at the time of drilling the site was cleared of trees and vegetation. Loess (windblown) material was encountered in all borings at the surface to a depth of about 8 inches. The soils sampled were described primarily as red-brown lean clays with some silt, trace roots, and trace black oxide nodules/staining. These soils tend to be more silty and can be sensitive to changes in moisture content.

RESIDUUM

Residual soils were encountered in all borings underlying the loess stratum. The soils were described primarily as dark red-brown lean to fat clays with various amounts of silt, chert fragments, and trace black oxide nodules/staining. SPT N-Values ranged from 8 to 28 bpf indicating a firm to very stiff consistency. In general, SPT N-Values decreased with depth. Laboratory index testing on representative samples indicates Liquid Limits (LL) of 47 and 52 percent and a Plasticity Indices (PI) of 22 and 28 percent, respectively. Natural moisture contents ranged from 18 to 37 percent, and in general moisture contents increased with depth.

SHALE/DOLOMITE

Bedrock samples were recovered in Borings B-1 and B-3 at depths of 33 to 43 feet below grade. Bedrock encountered consisted of interbedded shale (70%) and dolomite (30%) layers with occasional thin clay seams, which is typical of the area. Rock Quality Designations (RQD) of the cores ranged from 33 to 43 percent indicating rock of poor engineering quality. All borings encountered auger refusal at depths of 33 feet.

For details of subsurface conditions encountered at a particular boring location please refer to the boring logs contained in Appendix A. It should be noted that our borings were drilled and sampled according to the procedures presented in the appendix. All borings were located by in the field by the geotechnical engineer. The boring locations shown in the appendix should be considered accurate only to the degree implied by the method used.

4B GROUND WATER CONDITIONS

Free groundwater was not encountered in any borings. Water level readings were performed immediately after completion of the borings. In the immediate site area, water conditions that usually affect construction and performance of projects consist of trapped/perched water zones which occur in variable areas in the soil mass that are typically present at the soil/bedrock interface and/or due to sand layers and seams. Perched water sources are often not linked to the more continuous relatively stable ground water table that typically occurs at greater depths. Site excavation activities or ground disturbance can expose these features and the resulting seepage can vary greatly. Groundwater issues

are also dependent upon recent rainfall activity and surface and subsurface drainage patterns in the area that may change depending on climatic conditions.

5 LABORATORY TESTING

Laboratory tests were performed on selected recovered samples from our borings. Details for the test methods and results are shown in the appendix. The tests include obtaining data for estimating soil shear strengths, and compressibility, and to provide data for earthworks. Detailed descriptions of these tests and the results of our testing are included in the appendix. Tests performed included:

- 14 Natural moisture content tests
    - Moisture contents ranged from 18 to 37 percent.
- 3 Atterberg limits tests
    - Liquid Limits ranged from 47 to 52 percent with Plasticity Indices ranged from 22 to 28 percent.

GEOTECHNICAL DISCUSSION AND RECOMMENDATIONS

6 DISCUSSION-GEOTECHNICAL ISSUES

Based on our experience with similar projects and the conditions observed during our subsurface exploration, we believe the site is suitable for the proposed development. The primary geotechnical concerns are

- SILTY SURFICIAL SOILS
- HIGH PLASTICITY (FAT) CLAYS
- CLEARING AND GRUBBING

We recommend that a geotechnical engineer review all final design information related to the earthwork portion of the project and observe the cut and fill operations for compliance with this report.

6A SILTY SURFICIAL SOILS

Based on the samples obtained from the borings, as well as the published site geology, indicate more silty soils are present at the surface. Silty soils are prone to degradation and become unstable during wet periods of the year and/or under heavy construction traffic. Care must be taken and exercised during earthwork and in areas where construction traffic is expected to minimize repetitive traffic over the site soils. The repetitive traffic will cause the soils to become unstable; therefore, filling operations should only use enough compactive effort to achieve stability and job site requirements for compaction. During wet periods of weather, undercutting should be expected. Construction excavations or earthwork operations should be avoided during wetter seasons of the year. *Given the relatively shallow depth at which the silty soils extended to in the borings, it is anticipated that this concern will be minor.* Please refer to the Earthwork section of the report for recommendations.

6B HIGH PLASTICITY (FAT) CLAYS

Atterberg limits testing was performed on 3 representative samples taken from the boring samples. Although only one of the samples indicated high plasticity clay, the other samples were borderline and it is expected that high plasticity clay comprises a majority of the site given our experience in the area. The Atterberg limits testing on the representative samples indicated a maximum Plasticity Index (PI) of 28 percent; however, the residual soils will most likely have a higher PI. Soils with a PI above 30

percent can have a tendency to shrink/swell with changes in moisture content. Soils with a PI greater than 50 are generally highly susceptible to volume change. Soils with a PI between these limits have moderate volume change potential.

Shrinking and swelling of foundation and bearing soils are generally not as severe in North-Western Kentucky as in other areas because long periods of excessively wet or dry weather do not normally occur. However, if site grading takes place during the dry summer or fall months, significant drying of the exposed subgrade soils may occur. If these soils re-saturate after completion of construction, structural distress may be experienced. Also, moisture content loss typically results in settlement of soil supported structures. Where the soil moisture fluctuates, movement may be ongoing throughout the structure's life, resulting in deterioration and building distress.

Methods to control the adverse effects of these soils include soil modification methods (i.e.- undercut/ replace, lime stabilization, etc.), providing efficient drainage around the structure, installation of foundation components at depths below levels where moisture contents are subject to significant fluctuation, implementing more stringent moisture control specifications for new fill placement, and using higher plasticity clay soils in deeper areas of fill placement. *Given the size of the structure and the need to control overturning, it is anticipated that the foundation of the tank will be extended to a depth such that moisture fluctuation will be a minimal concern.*

6C CLEARING AND GRUBBING

At the time of drilling, the site had been recently cleared of numerous large mature trees with supposed deep root masses. Although the site had been cleared large root masses may still be present below grade. Clearing and grubbing operations within the previously wooded area may produce large depressions along with loose soils. We recommend these depressions be backfilled with a properly compacted engineered fill as recommended in Section 7 of this report. Large depressions from rootball removal should be laid back or benched to allow access for earthwork equipment to properly compact these areas. The geotechnical engineer should observe clearing operations to verify proper compaction procedures are performed.

7 EARTHWORK

Historically, more change orders (in orders and costs) occur during the earthwork portion of construction than in almost any other part of the project. Further, the site preparation phase of construction always affects the future performance of project structures and pavements. Add into this, the fact that earthwork is the portion of work most influenced by wet weather and unknown conditions and time-wise, this section of the report could be the most important to prevent and minimize delays and costs during construction and for the life of the project.

Please review the geotechnical concerns listed in Section 6 prior to reading the following recommendations. If problems occur that the recommendations do not address or do not adequately remedy, please contact CSI as soon as possible.

7A EXCAVATION

Normal earth excavation equipment should be suitable for necessary grading and fill operations that are associated with the overburden soils. All below-grade excavations should be in compliance with OSHA guidelines and evaluated by a competent individual.

7B SITE PREPARATION (WORK PRIOR TO FILLING)

- Areas ready to receive new fill should be proofrolled with a heavily loaded dump truck or similar equipment judged acceptable by the geotechnical engineer;
- The level of proofroll should be determined by the geotechnical engineer on a case-by-case basis;
- Perform the proofrolling after a suitable period of dry weather to avoid degrading the subgrade;
- Areas which pump, rut, or wave during proofrolling may require undercutting, depending on the location of the area and the use of the area, so the geotechnical engineer should be contacted for guidance.
- Backfill of undercut areas should be done in accordance with sections 7C and 7D;
- Deleterious materials such as topsoil, roots, wood or other materials that will decay should be removed from the site;
- Retain a geotechnical engineer to observe the proofrolling operations and make recommendations for any unstable or unsuitable conditions encountered---this can save time on the construction schedule and save unnecessary undercutting;

We recommend that site grading should take place between about late April to early November. Earthwork taking place outside this time period will likely encounter wet conditions and weather conditions that will provide little to no assistance with drying the soils.

7C NEW FILL OPERATIONS (MASS EARTHWORK)

Before new fill construction, representative samples should be obtained of the proposed fill material to determine the moisture-density, classification of the material, and whether the material is suitable to be used as structural fill. After the subgrade has been approved to receive new fill, the fill may commence with the following procedures and guidelines recommended:

- Place cohesive fill (clay) in maximum 8-inch thick loose lifts. Granular soils may be placed in maximum 12 inch loose lifts provided properly sized equipment is used in the compaction process;
- Fill lifts should be compacted to at least 98 percent of the soil's maximum dry density (ASTM D 698) beneath the structure;
- Non-structural areas (i.e. grassed and/or landscape areas) can utilize a lower compaction requirement of 95 percent. Non-structural areas should be considered 5 feet beyond the limits of structural entities (i.e. building, pavements, sidewalks, etc);
- Maintain the moisture content of compacted fill at plus 2 percent and minus 2 percent of optimum moisture;
- Soils with a plasticity index (PI) of greater than 35 should not be used in the upper 4 feet of new fill;
- If soils with a PI of greater than 35 are used in any portion of the fill, the geotechnical engineer should be contacted for specific guidelines for that material usage;
- Maximum particle size of the soil should be limited to the lift thickness;

- Density testing should be performed as a means to verify percent compaction and moisture content of the material as it is being placed and compacted;
- Observation of fill "stability" is also critical, so it is recommended to observe the operation of the filling equipment traversing over the new fill to document movement (similar to proof rolling);
- Density testing should be performed at a rate of at least one per 10,000 square feet per lift with a minimum of 3 tests per lift;
- Soils should not be "over compacted" and construction traffic should be kept to minimum to assure compaction is achieved and that the soil is not allowed to "break down";
- Retain a representative of the geotechnical engineer to observe and document fill placement and compaction operations.

7D BACKFILL OPERATIONS (FOUNDATION WALLS, UTILITIES, ETC.)

These materials are placed in more confined areas than mass earthwork materials and therefore cannot be placed in full compliance with sections 7B or 7C. The following are general recommendations for backfill areas:

- Fill lift thicknesses will vary dependent on compaction equipment available and material types, but in no case should exceed 8 inches for clay and 12 inches for granular soils;
- For crushed stone/aggregate backfills in trenches or elsewhere when using smaller compaction equipment the lift thickness should be based on the type of aggregate and equipment. For well-graded granular soils such as KYTC Dense Grade Aggregate, a thickness of 4 to 6 inches is typically required. If open-graded stone such as KYTC No. 57 is used, the lift thickness may be able to be increased. This should be evaluated by the geotechnical engineer;
- Compaction/moisture percentages and density testing frequency should be the same as in section 7C;
- A geotechnical engineer should be retained to provide addition recommendations for backfill.

7E GENERAL NOTES

- For all earthwork operations, positive surface drainage is prudent to keep water from ponding on the surface and to assist in maintaining surface stability;
- The surface should be sealed prior to expected wet weather. This can usually be accomplished with rubber-tired construction equipment or a steel-drum roller;
- If any soil placement problems occur, a geotechnical engineer should be retained to provide additional recommendations, as needed.

8 SITE DRAINAGE

During construction, water should not be allowed to pond in excavations or undercutting will likely be required. During the life of the project, slope the subgrade and other site features so that surface water flows away from the site structures.

For excavations during construction, most free water from the subsurface conditions could likely be removed via sump pumps and open channel flow (ditches) at or near the source of seepage. However, if normal dewatering measures prove insufficient, CSI should be retained to provide recommendations on the issue.

9 FOUNDATIONS

Based on the information provided and and the bearing pressures expected, the use of a ground-supported foundation will not be possible due to over-stressing the soil. To support the structure, CSI is recommending two alternative foundation systems. It is our opinion the most economical foundation options would include using Rammed Aggregate Piers extended to a depth of about 25 feet or using Drilled Piers socketed into bedrock.

Due to the foundation being in the initial design phase, CSI should evaluate the final foundation design with respect to the recommendations outlined below. If CSI is not contracted to evaluate the foundation design, a separate analysis should performed by a qualified geotechnical engineer of which their recommendations should be provided in lieu of what is provided in this report.

9A RAMMED AGGREGATE PIERS

Compared to the deep foundations, Geopiers may provide a more economical alternative to support the structure using a soil supported foundation option. Geopier has performed an initial review of the site and limited project information and has determined Geopiers would be appropriate to support the structure using a ring or raft-type foundation. The Geopier evaluation letter dated November 18, 2015 is included in the Appendix of this report.

Geopiers elements are installed by advancing 20 to 30 inch diameter holes and ramming thin lifts of well-graded aggregate within the holes to form very stiff, high-density aggregate piers. The stone is placed is successive lifts and compacted using direct vertical ramming energy. The result is a pre-stressing of the existing soil around the “piers” and a partial transfer of foundation loads to a deeper, more competent stratum effectively reducing foundation settlement. These elements effectively increase the bearing capacity and reduce the settlement potential when compared to the supporting the structure on the native soils.

The preliminary evaluation for this project indicates that foundation bearing on “improved” subgrade soils can be designed for net allowable soil bearing pressures of 7 kips per square foot (ksf) for the stattic condition and 9.1 ksf for transient conditions. Rammed aggregate pier lengths should be drilled to approximately 25 feet below footings. Geopier is, at this time, not recommending the use of uplift anchors and is assuming that the foundation will be sized to resist uplift forces.

9B DRILLED PIERS

Drilled piers may also be used to support the structure. We recommend the drilled piers bear a minimum of one pier diameter or 5 feet, whichever is greater, into the underlying interbedded shale and dolomite. Drilled piers bearing on this material can be sized using a maximum bearing capacity of 40 ksf. If additional capacity is needed either through bearing or uplift, a rock and concrete adhesion value of 10 ksf may be used for the portion of the piers extended below rock socket (defined above). In addition, the following are recommended:

- Clean the base of the pier excavation of any loose debris and/or disturbed material.

- Install a temporary protective steel casing to prevent side wall collapse, prevent excessive mud and water intrusion if necessary.

- Make provisions for ground water removal from the drilled shaft excavation. Ground water conditions at this site may require the use of special procedures to achieve a satisfactory foundation installation. Less than 2 inches of standing water should be in the bottom of the excavation at the time of concrete placement.

- The protective steel casing may be extracted as the concrete is placed provided a sufficient head of concrete is maintained inside the steel casing to prevent soil or water intrusion into the newly placed concrete;

- Direct the concrete placement into the drilled hole through a tremie pipe to reduce side flow and/or segregation.

10 SEISMIC SITE ANALYSIS

The Kentucky Building Code (KYBC), as updated was reviewed to determine the Site Seismic Classification. Based on our review of geologic data, our experience, and subsurface conditions encountered, we recommend a Seismic Site Class "D" for the site.

11 NOTES ON THE REPORT AND RECOMMENDATIONS

This report is based on the provided project information, the subsurface conditions observed at the time of the report, and our experience with similar conditions. As such, it cannot be applied to other project sites, types, or combinations thereof. If the project information section in this report contains incorrect information or if additional information is available, you should convey the correct or additional information to us and retain us to review our recommendations. Our recommendations may then require modification. *If CSI is not contracted to evaluate the foundation design with respect to our recommendations, this report should not be used for design purposes and a separate exploration and design should be provided by a qualified geotechnical engineer.*

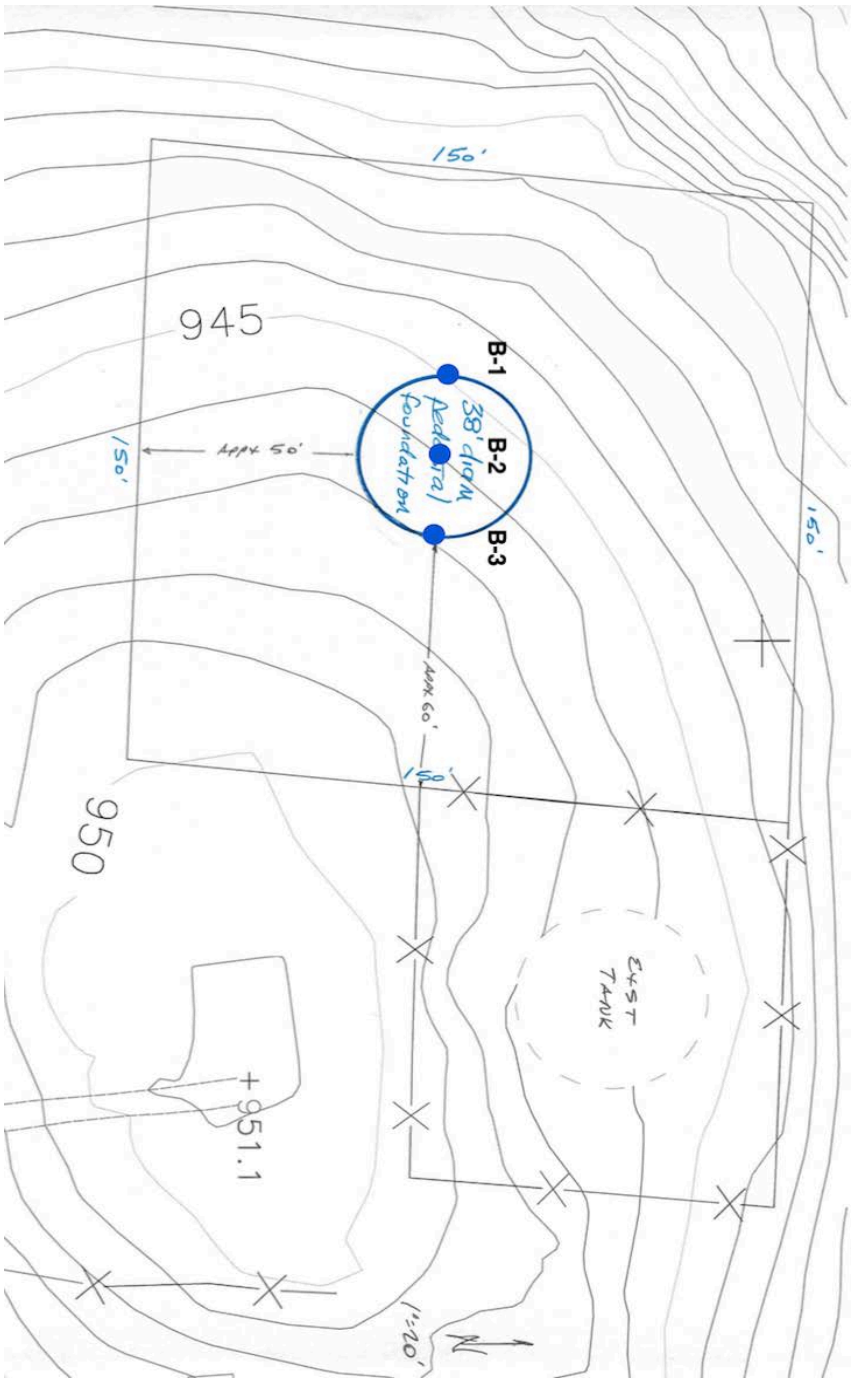
A geotechnical exploration, such as the one we performed, uses widely spaced borings to attempt to model the subsurface conditions at the site. Because no exploration contains complete data or a complete model, there is always a possibility that conditions between borings will be different from those at specific boring locations and that conditions will not be as anticipated by the project team. Also, it has been our experience that the construction process often disturbs soil conditions and this process, no matter how much experience we use to anticipate construction methodology, is not completely predictable. Therefore, changes or modifications to our recommendations are likely needed due to these possible variances. Experienced geotechnical personnel should be used to observe and document the construction procedures and the conditions encountered. Unanticipated conditions and inadequate procedures should be reported to the design team along with timely recommendations to solve the problems created. We recommend that the owner retain CSI to provide this service based upon our familiarity with the project, the subsurface conditions and the intent of the recommendations.

No section or portion of this report (including appendix information) can be used as a stand alone article to make distinct changes or assumptions. The entire report and appendices should be used together as one resource. We recommend that this complete report be provided to the various design team members, the contractors and the project owner. Potential contractors should be informed of this report in the "instructions to bidders" section of the bid documents.

We wish to remind you that our exploration services include storing the samples collected and making them available for inspection for 30 days. The samples are then discarded unless you request otherwise.

APPENDIX

Boring Location Plan
Key to Symbols and Descriptions
Test Boring Records/Photos
Field Testing Procedures
Summary of Laboratory Test Results
Laboratory Testing Procedures



Adapated from site plan provided to CSI

LEGEND

B-XX BORING LOCATIONS

FOR ILLUSTRATION PURPOSES ONLY

Consulting Services Incorporated of Ohio
11162 Luschek Drive
Cincinnati, Ohio 45241
513.252.2059 Office|888.792.3121 Fax
www.csiohio.com

TITLE: BORING LOCATION PLAN		Project No: CN150066	Drawn By: GD
PROJECT: Trimble County Watertank		Date: 11-25-15	Checked By: JC
		Scale: Not To Scale	Drawing No: 1 of 1

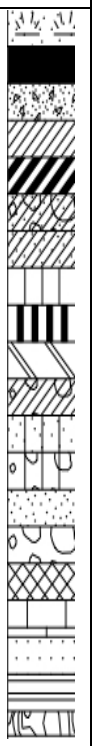
Consulting Services Incorporated
LEXINGTON | LOUISVILLE | CINCINNATI

Geotechnical Boring Information Sheet

Sample Type Symbols

Splitspoon (SPT)
Shelby Tube
Grab
Rock Core
Auger Cuttings

Surface Symbols



Topsoil
Asphalt
Concrete
Lean Clay
Fat Clay
Glacial Till
Sandy Clay
Silt
Elastic Silt
Lean Clay to Fat Clay
Gravelly Clay
Sandy Silt
Gravelly Silt
Sand
Gravel
Fill
Limestone
Sandstone
Shale/Siltstone
Weathered Rock

Samples Strength Descriptors

Cohesive Soils:	**N**
Very Soft	0-1
Soft	2-4
Firm	5-8
Stiff	9-15
Very Stiff	16-30
Hard	31+
Non-cohesive Soils:	
Very Loose	0-4
Loose	5-10
Firm	11-20
Very Firm	21-30
Dense	30-50
Very Dense	51+

Definitions

SPT-"Splitspoon" or standard penetration test. Blow counts are number of drops required for a 140 lb hammer dropping 30 inches to drive the sampler 6 inches.

N-value is the addition of the last two intervals of the 18-inch sample.

Shelby tubes are often called "undisturbed samples". They are directly pushed into the ground, twisted, allowed to rest for a small period of time and then pulled out of the ground. Tops and bottoms are cleaned and then sealed.

Sample classification is done in general accordance with ASTM D2487 and 2488 using the Unified Soil Classification System (USCS) as a general guide.

Soil moisture descriptions are based on the recovered sample observations. The descriptors are dry, slightly moist, moist, very moist and wet. These are typically based on relative estimates of the moisture condition of a visual estimation of the soils optimum moisture content (EOMC). Dry is almost in a "dusty" condition usually 6 or more percent below EOMC. Slightly moist is from about 6 to 2 percent below EOMC at a point at which the soil color does not readily change with the addition of water. Moist is usually 2 percent below to 2 percent above EOMC and the point at which the soil will tend to begin forming "balls" under some pressure in the hand. Very moist is usually from about 2 percent to 6 percent above EOMC and also the point at which it's often considered "muddy". Wet soil is usually 6 or more percent above EOMC and often contains free water or the soil is in a saturated state.

Silt or Clay is defined at material finer than a standard #200 US sieve (<0.075mm) Sand is defined as material between the size of #200 sieve up to #4 sieve. Gravel is from #4 size sieve material to 3". Cobbles are from 3" to 12". Boulders are over 12".

Rock hardness is classified as follows:

Very Soft:	Easily broken by hand pressure
Soft:	Ends can be broken by hand pressure; easily broken with hammer
Medium:	Ends easily broken with hammer; middle requires moderate blow
Hard:	Ends require moderate hammer blow; middle requires several blows
Very Hard:	Many blows with a hammer required to break core

Rock Quality Designation (RQD) is defined as total combined length of 4" or longer pieces of core divided by the total core run length; defined in percentage.

Water or cave-in observed in borings is at completion of drilling each boring unless otherwise noted.

Strata lengths shown on borings represents a rough estimate. Transition may be more abrupt or gradual. Soil borings are representative of that estimated location at that time and are based on recovered samples. Conditions may be different between borings and between sample intervals. Boring information is not to be considered stand alone but should be taken in context with comments and information in the geotechnical report and the means by which the borings are logged, sampled and drilled.

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TEST BORING LOG

CLIENT **Tetra Tech**
PROJECT NAME **Trimble County Water Tank**
PROJECT LOCATION **Pendleton, KY**

BORING # **B-1**
JOB # **CN150066**
LOGGED BY **GD**
APPROVED BY **JB**

DRILLING and SAMPLING INFORMATION

Date Started **10/12/15** Contractor **Hoosier**
Date Completed **10/12/15** Boring Size **3.25** in.
Drill Rig **CME-750** Boring Method **HSA**
Weather **Sunny 60's** Hammer Type **Deitrich**

TEST DATA

Depth Scale	SOIL CLASSIFICATION / SURFACE ELEVATION	Sample No.	Sample Type	Sample Graphics	Groundwater	Standard Penetration Test Blows per 6" [*N-Value*] *blows/foot*	Pocket Penetrometer (tsf)	Moisture Content %	Liquid Limit (LL)	Plastic Limit (PL)	Percent Passing #200 Sieve	Remarks
2	Light Brown silty clay (8 in) [Loess] - dry Red-brown FAT CLAY (CH) with some silt and trace black oxide nodules [Residuum] - moist, very stiff	1	SS			5-9-11 [*20*]	4.5					
4		2	SS			6-7-9 [*16*]	4.5	17.6	52	24		
6	Red-brown to dark red brown FAT CLAY (CH) with little to some silt, trace black oxide nodules, and various amounts of chert fragments [Residuum] - moist, stiff to very stiff	3	SS			7-8-13 [*21*]	4.0					
8		4	SS			9-8-11 [*19*]	4.5	20.1				
10												
12												
14		5	SS			6-10-16 [*26*]	4.5	21.7				
16												
18												
20		6	SS			5-7-8 [*15*]	3.0					
22												
24	Red-brown FAT CLAY (CH) with trace chert fragments and trace black oxide nodules [Residuum] - moist, very stiff	7	SS			7-11-10 [*21*]	2.8	24.1				

Depth to Groundwater

- Noted on Drilling Tools _____ ft.
- At Completion (in augers) _____ ft.
- At Completion (open hole) _____ ft.
- After _____ hours _____ ft.
- After _____ hours _____ ft.
- Cave Depth _____ ft.

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TEST BORING LOG

CLIENT **Tetra Tech**
PROJECT NAME **Trimble County Water Tank**
PROJECT LOCATION **Pendleton, KY**

BORING # **B-1**
JOB # **CN150066**
LOGGED BY **GD**
APPROVED BY **JB**

DRILLING and SAMPLING INFORMATION

Date Started **10/12/15** Contractor **Hoosier**
Date Completed **10/12/15** Boring Size **3.25** in.
Drill Rig **CME-750** Boring Method **HSA**
Weather **Sunny 60's** Hammer Type **Deitrich**

TEST DATA

Depth Scale	SOIL CLASSIFICATION (continued)	Sample No.	Sample Type	Sample Graphics	Groundwater	Standard Penetration Test Blows per 6" [*N-Value*] *blows/foot*	Pocket Penetrometer (tsf)	Moisture Content %	Liquid Limit (LL)	Plastic Limit (PL)	Percent Passing #200 Sieve	Remarks
26	Red-brown FAT CLAY (CH) with trace chert fragments and trace black oxide nodules [Residuum] - moist, very stiff											
28		8	SS			4-6-13 [*19*]	2.5	29.2				
30												
32												
34	Gray weathered SILTSTONE, moderately hard	9	RC									RQD: 42.5% REC: 84.2%
36												
38												
40												
42												
44	Boring Terminated at 43 feet											
46												
48												

Depth to Groundwater

- Noted on Drilling Tools _____ ft.
- At Completion (in augers) _____ ft.
- At Completion (open hole) _____ ft.
- After _____ hours _____ ft.
- After _____ hours _____ ft.
- Cave Depth _____ ft.

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TEST BORING LOG

CLIENT **Tetra Tech**
PROJECT NAME **Trimble County Water Tank**
PROJECT LOCATION **Pendleton, KY**

BORING # **B-2**
JOB # **CN150066**
LOGGED BY **GD**
APPROVED BY **JB**

DRILLING and SAMPLING INFORMATION

Date Started **10/12/15** Contractor **Hoosier**
Date Completed **10/12/15** Boring Size **3.25** in.
Drill Rig **CME-750** Boring Method **HSA**
Weather **Sunny 60's** Hammer Type **Deitrich**

TEST DATA

Depth Scale	SOIL CLASSIFICATION / SURFACE ELEVATION	Sample No.	Sample Type	Sample Graphics	Groundwater	Standard Penetration Test Blows per 6" [*N-Value*] *blows/foot*	Pocket Penetrometer (tsf)	Moisture Content %	Liquid Limit (LL)	Plastic Limit (PL)	Percent Passing #200 Sieve	Remarks
2	Light Brown silty clay (8 in) [Loess] - dry	1	SS			6-9-11 [*20*]	4.5	19.0	47	25		
	Light brown LEAN CLAY (CL) with some silt and trace roots [Residuum] - moist, very stiff											
4	Red-brown LEAN CLAY (CL) with little to some silt and trace black oxide nodules [Residuum] - moist, very stiff	2	SS			9-9-11 [*20*]	4.5					
6		3	SS			10-10-14 [*24*]	4.5	19.5	49	27		
8		4	SS			6-8-11 [*19*]	4.5					
10												
12												
14		5	SS			7-9-12 [*21*]	4.5	22.6				
16												
18	Dark red-brown FAT CLAY (CH) with little silt, trace black oxide nodules, and trace chert [Residuum] - moist, stiff to very stiff	6	SS			4-7-12 [*19*]	4.3					
20												
22												
24		7	SS			7-7-9 [*16*]	3.5	22.9				

Depth to Groundwater
- Noted on Drilling Tools _____ ft.
- At Completion (in augers) _____ ft.
- At Completion (open hole) _____ ft.
- After _____ hours _____ ft.
- After _____ hours _____ ft.
- Cave Depth _____ ft.

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TEST BORING LOG

CLIENT **Tetra Tech**
PROJECT NAME **Trimble County Water Tank**
PROJECT LOCATION **Pendleton, KY**

BORING # **B-2**
JOB # **CN150066**
LOGGED BY **GD**
APPROVED BY **JB**

DRILLING and SAMPLING INFORMATION

Date Started **10/12/15** Contractor **Hoosier**
Date Completed **10/12/15** Boring Size **3.25** in.
Drill Rig **CME-750** Boring Method **HSA**
Weather **Sunny 60's** Hammer Type **Deitrich**

TEST DATA

Depth Scale	SOIL CLASSIFICATION (continued)	Sample No.	Sample Type	Sample Graphics	Groundwater	Standard Penetration Test Blows per 6" [*N-Value*] *blows/foot*	Pocket Penetrometer (tsf)	Moisture Content %	Liquid Limit (LL)	Plastic Limit (PL)	Percent Passing #200 Sieve	Remarks
26	Dark red-brown FAT CLAY (CH) with little silt, trace black oxide nodules, and trace chert [Residuum] - moist, stiff to very stiff											
28		8	SS			5-6-8 [*14*]	2.8					
30												
32												
34	Boring Terminated at 33 feet; No Refusal											
36												
38												
40												
42												
44												
46												
48												

Depth to Groundwater

- Noted on Drilling Tools _____ ft.
- At Completion (in augers) _____ ft.
- At Completion (open hole) _____ ft.
- After _____ hours _____ ft.
- After _____ hours _____ ft.
- Cave Depth _____ ft.

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TEST BORING LOG

CLIENT **Tetra Tech**
PROJECT NAME **Trimble County Water Tank**
PROJECT LOCATION **Pendleton, KY**

BORING # **B-3**
JOB # **CN150066**
LOGGED BY **GD**
APPROVED BY **JB**

DRILLING and SAMPLING INFORMATION

Date Started **10/12/15** Contractor **Hoosier**
Date Completed **10/12/15** Boring Size **3.25** in.
Drill Rig **CME-750** Boring Method **HSA**
Weather **Sunny 60's** Hammer Type **Deitrich**

TEST DATA

Depth Scale	SOIL CLASSIFICATION / SURFACE ELEVATION	Sample No.	Sample Type	Sample Graphics	Groundwater	Standard Penetration Test Blows per 6" [*N-Value*] *blows/foot*	Pocket Penetrometer (tsf)	Moisture Content %	Liquid Limit (LL)	Plastic Limit (PL)	Percent Passing #200 Sieve	Remarks
2	Light Brown silty clay (8 in) [Loess] - dry	1	SS			5-7-9 [*16*]	4.5					
	Light brown FAT CLAY (CH) with some silt [Residuum] - moist, very stiff											
4	Red brown FAT CLAY (CH) with trace black oxide nodules and chert [Residuum] - moist, very stiff	2	SS			11-11-11 [*22*]	2.8					
6		3	SS			6-9-14 [*23*]	4.5	21.3				
8		4	SS			7-11-15 [*26*]	4.5	21.3				
10												
12												
14		5	SS			5-8-12 [*20*]	4.5					
16												
18												
20		6	SS			8-14-14 [*28*]	3.0					
22												
24		7	SS			7-8-10 [*18*]		20.6				

Depth to Groundwater
- Noted on Drilling Tools _____ ft.
- At Completion (in augers) _____ ft.
- At Completion (open hole) _____ ft.
- After _____ hours _____ ft.
- After _____ hours _____ ft.
- Cave Depth _____ ft.

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TEST BORING LOG

CLIENT **Tetra Tech**
PROJECT NAME **Trimble County Water Tank**
PROJECT LOCATION **Pendleton, KY**

BORING # **B-3**
JOB # **CN150066**
LOGGED BY **GD**
APPROVED BY **JB**

DRILLING and SAMPLING INFORMATION

Date Started **10/12/15** Contractor **Hoosier**
Date Completed **10/12/15** Boring Size **3.25** in.
Drill Rig **CME-750** Boring Method **HSA**
Weather **Sunny 60's** Hammer Type **Deitrich**

TEST DATA

Depth Scale	SOIL CLASSIFICATION (continued)	Sample No.	Sample Type	Sample Graphics	Groundwater	Standard Penetration Test Blows per 6" [*N-Value*] *blows/foot*	Pocket Penetrometer (tsf)	Moisture Content %	Liquid Limit (LL)	Plastic Limit (PL)	Percent Passing #200 Sieve	Remarks
26												
28	Light brown FAT CLAY (CH) with trace silt [Residuum] - moist, firm	8	SS			4-4-4 [*8*]	2.50	36.7				
30												
32												
34	Gray interbedded moderately weathered SILTSTONE and LIMESTONE with thin clay seams, moderately hard to hard	9	RC									RQD: 32.9% REC: 85%
36												
38												
40												
42												
44	Boring Terminated at 43 feet											
46												
48												

Depth to Groundwater

- Noted on Drilling Tools _____ ft.
- At Completion (in augers) _____ ft.
- At Completion (open hole) _____ ft.
- After _____ hours _____ ft.
- After _____ hours _____ ft.
- Cave Depth _____ ft.

FIELD TESTING PROCEDURES

Field Operations: The general field procedures employed by CSI are summarized in ASTM D 420 which is entitled "Investigating and Sampling Soils and Rocks for Engineering Purposes." This recommended practice lists recognized methods for determining soil and rock distribution and ground water conditions. These methods include geophysical and in situ methods as well as borings.

Borings are drilled to obtain subsurface samples using one of several alternate techniques depending upon the subsurface conditions. These techniques are:

a. Continuous 2-1/2 or 3-1/4 inch I.D. hollow stem augers;

b. Wash borings using roller cone or drag bits (mud or water);

c. Continuous flight augers (ASTM D 1425).

These drilling methods are not capable of penetrating through material designated as "refusal materials." Refusal, thus indicated, may result from hard cemented soil, soft weathered rock, coarse gravel or boulders, thin rock seams, or the upper surface of sound continuous rock. Core drilling procedures are required to determine the character and continuity of refusal materials.

The subsurface conditions encountered during drilling are reported on a field test boring record by the chief driller. The record contains information concerning the boring method, samples attempted and recovered, indications of the presence of various materials such as coarse gravel, cobbles, etc., and observations between samples. Therefore, these boring records contain both factual and interpretive information. The field boring records are on file in our office.

The soil and rock samples plus the field boring records are reviewed by a geotechnical engineer. The engineer classifies the soils in general accordance with the procedures outlined in ASTM D 2488 and prepares the final boring records which are the basis for all evaluations and recommendations.

The final boring records represent our interpretation of the contents of the field records based on the results of the engineering examinations and tests of the field samples. These records depict subsurface conditions at the specific locations and at the particular time when drilled. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the subsurface soil and ground water conditions at these boring locations. The lines designating the interface between soil or refusal materials on the records and on profiles represent approximate boundaries. The transition between materials may be gradual. The final boring records are included with this report.

The detailed data collection methods using during this study are discussed on the following pages.

Soil Test Borings: Soil test borings were made at the site at locations shown on the attached Boring Plan. Soil sampling and penetration testing were performed in accordance with ASTM D 1586.

The borings were made by mechanically twisting a hollow stem steel auger into the soil. At regular intervals, the drilling tools were removed and soil samples obtained with a standard 1.4 inch I.D., 2 inch O.D., split tube sampler. The sampler was first seated 6 inches to penetrate any loose cuttings, then driven an additional foot with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final foot was recorded and is designated the "penetration resistance". The penetration resistance, when properly evaluated, is an index to the soil strength and foundation supporting capability.

Representative portions of the soil samples, thus obtained, were placed in glass jars and transported to the laboratory. In the laboratory, the samples were examined to verify the driller's field classifications. Test Boring Records are attached which graphically show the soil descriptions and penetration resistances.

Core Drilling: Refusal materials are materials that cannot be penetrated with the soil drilling methods employed. Refusal, thus indicated, may result from hard cemented soil, soft weathered rock, coarse gravel or boulders, thin rock seams or the upper surface of sound continuous rock. Core drilling procedures are required to determine the character and continuity of refusal materials.

Prior to coring, casing is set in the drilled hole through the overburden soils, if necessary, to keep the hole from caving. Refusal materials are then cored according to ASTM D 2113 using a diamond-studded bit fastened to the

end of a hollow double tube core barrel. This device is rotated at high speeds, and the cuttings are brought to the surface by circulating water. Core samples of the material penetrated are protected and retained in the swivel-mounted inner tube. Upon completion of each drill run, the core barrel is brought to the surface, the core recovered is measured, the samples are removed and the core is placed in boxes for storage.

The core samples are returned to our laboratory where the refusal material is identified and the percent core recovery and rock quality designation is determined by a soils engineer or geologist. The percent core recovery is the ratio of the sample length obtained to the depth drilled, expressed as a percent. The rock quality designation (RQD) is obtained by summing up the length of core recovered, including only the pieces of core which are four inches or longer, and dividing by the total length drilled. The percent core recovery and RQD are related to soundness and continuity of the refusal material. Refusal material descriptions, recoveries, and RQDs are shown on the "Test Boring Records".

Hand Auger Borings and Dynamic Cone Penetration Testing: Hand auger borings are performed manually by CSI field personnel. This consists of manually twisting hand auger tools into the subsurface and extracting “grab” or baggie samples at intervals determined by the project engineer. At the sample intervals, dynamic cone penetration (DCP) testing is performed. This testing involves the manual raising and dropping of a 20 pound hammer, 18 inches. This “driver” head drives a solid-1¾ inch diameter cone into the ground. DCP “counts” are the number of drops it takes for the hammer to drive three 1¾ inch increments, recorded as X-Y-Z values.

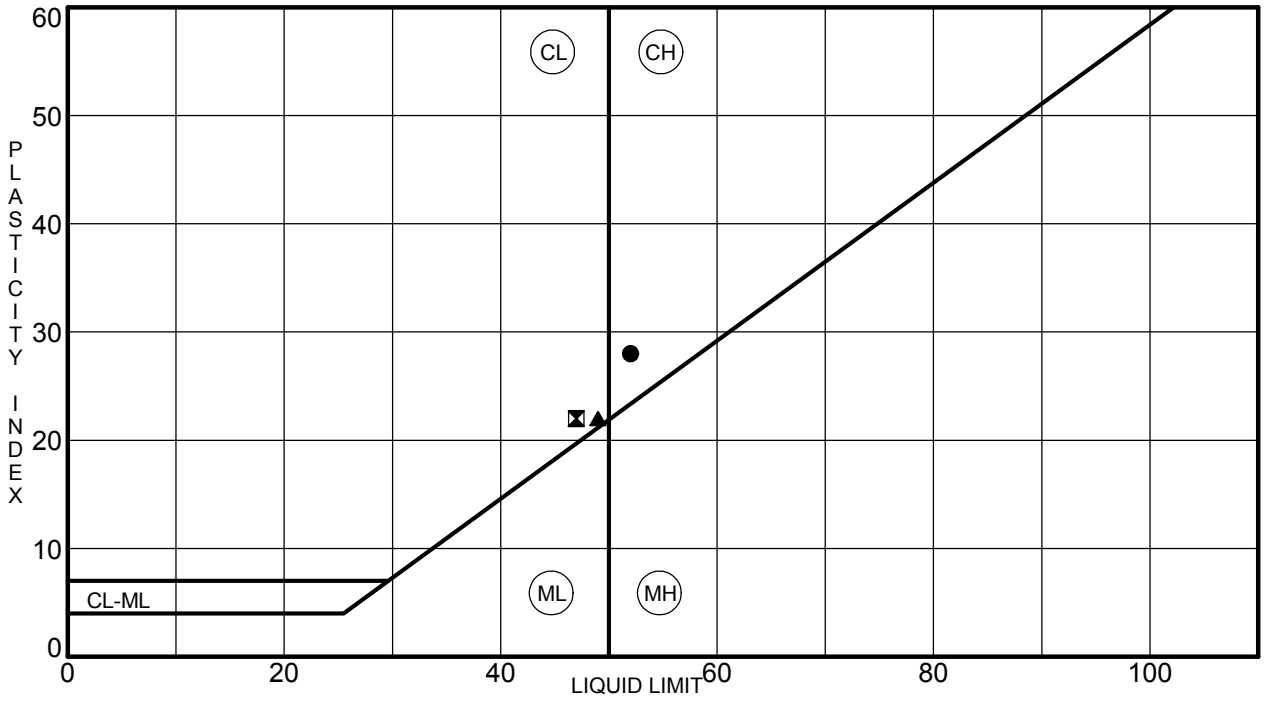
Test Pits: Test pits are excavated by the equipment available, often a backhoe or trackhoe. The dimensions of the test pits are based on the equipment used and the power capacity of the equipment. Samples are taken from the spoils of typical buckets of the excavator and sealed in jars or “Ziplock” baggies. Dynamic Cone Penetration or hand probe testing is often performed in the upper few feet as OSHA standards allow. Refusal is deemed as the lack of advancement of the equipment with reasonable to full machine effort.

Water Level Readings: Water table readings are normally taken in conjunction with borings and are recorded on the "Test Boring Records". These readings indicate the approximate location of the hydrostatic water table at the time of our field investigation. Where impervious soils are encountered (clayey soils) the amount of water seepage into the boring is small, and it is generally not possible to establish the location of the hydrostatic water table through water level readings. The ground water table may also be dependent upon the amount of precipitation at the site during a particular period of time. Fluctuations in the water table should be expected with variations in precipitation, surface run-off, evaporation and other factors.

The time of boring water level reported on the boring records is determined by field crews as the drilling tools are advanced. The time of boring water level is detected by changes in the drilling rate, soil samples obtained, etc. Additional water table readings are generally obtained at least 24 hours after the borings are completed. The time lag of at least 24 hours is used to permit stabilization of the ground water table which has been disrupted by the drilling operations. The readings are taken by dropping a weighted line down the boring or using an electrical probe to detect the water level surface.

Occasionally the borings will cave-in, preventing water level readings from being obtained or trapping drilling water above the caved-in zone. The cave-in depth is also measured and recorded on the boring records.

Liquid and Plastic Limits Test Report



	Sample	Depth	LL	PL	PI	Water Content	% < #40	% < #200	USCS	Description
●	**B-1**	**3.5**	**52**	**24**	**28**	**17.6**			**CH**	**Red Brown Fat Clay**
⊠	**B-2**	**1.0**	**47**	**25**	**22**	**19.0**			**CL**	**Light Brown Lean Clay**
▲	**B-2**	**6.0**	**49**	**27**	**22**	**19.5**			**CL**	**Red Brown Lean Clay**

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PROJECT INFORMATION

Client: Tetra Tech
Project Name: Trimble County Water Tank
Project Number: CN150066
Project Location: Pendleton, KY

LABORATORY TESTING PROCEDURES

Soil Classification: Soil classifications provide a general guide to the engineering properties of various soil types and enable the engineer to apply past experience to current problems. In our investigations, samples obtained during drilling operations are examined in our laboratory and visually classified by an engineer. The soils are classified according to consistency (based on number of blows from standard penetration tests), color and texture. These classification descriptions are included on our "Test Boring Records."

The classification system discussed above is primarily qualitative and for detailed soil classification two laboratory tests are necessary: grain size tests and plasticity tests. Using these test results the soil can be classified according to the AASHTO or Unified Classification Systems (ASTM D 2487). Each of these classification systems and the in-place physical soil properties provides an index for estimating the soil's behavior. The soil classification and physical properties obtained are presented in this report.

Rock Classification: Rock classifications provide a general guide to the engineering properties of various rock types and enable the engineer to apply past experience to current situations. In our explorations, rock core samples obtained during drilling operations are examined in our laboratory and visually classified by an engineer. The rock cores are classified according to relative hardness and RQD (see Guide to Rock Classification Terminology), color, and texture. These classification descriptions are included on our Test Boring Records.

Atterberg Limits: Portions of the samples are taken for Atterberg Limits testing to determine the plasticity characteristics of the soil. The plasticity index (PI) is the range of moisture content over which the soil deforms as a plastic material. It is bracketed by the liquid limit (LL) and the plastic limit (PL). The liquid limit is the moisture content at which the soil becomes sufficiently "wet" to flow as a heavy viscous fluid. The plastic limit is the lowest moisture content at which the soil is sufficiently plastic to be manually rolled into tiny threads. The liquid limit and plastic limit are determined in accordance with ASTM D 4318.

Moisture Content: The Moisture Content is determined according to ASTM D 2216.

Percent Finer Than 200 Sieve: Selected samples of soils are washed through a number 200 sieve to determine the percentage of material less than 0.074 mm in diameter.

Rock Strength Tests: To obtain strength data for rock materials encountered, unconfined compression tests are performed on selected samples. In the unconfined compression test, a cylindrical portion of the rock core is subjected to increasing axial load until it fails. The pressure required to produce failure is recorded, corrected for the length to diameter ratio of the core and reported.

Compaction Tests: Compaction tests are run on representative soil samples to determine the dry density obtained by a uniform compactive effort at varying moisture contents. The results of the test are used to determine the moisture content and unit weight desired in the field for similar soils. Proper field compaction is necessary to decrease future settlements, increase the shear strength of the soil and decrease the permeability of the soil.

The two most commonly used compaction tests are the Standard Proctor test and the Modified Proctor test. They are performed in accordance with ASTM D 698 and D 1557, respectively. Generally, the Standard Proctor compaction test is run on samples from building or parking areas where small compaction equipment is anticipated. The Modified compaction test is generally performed for heavy structures, highways, and other areas where large compaction equipment is expected. In both tests a representative soil sample is placed in a mold and compacted with a compaction hammer. Both tests have three alternate methods.

Test	Method	Hammer Wt./Fall	Mold Diam.	Run on Material Finer Than	No. of Layers	No. of Blows/ Layer
Standard	A	5.5 lb./12"	4"	No. 4 sieve	3	25
D 698	B	5.5 lb./12"	4"	3/8" sieve	3	25
	C	5.5 lb./12"	6"	3/4" sieve	3	56

Test	Method	Hammer Wt./Fall	Mold Diam.	Run on Material Finer Than	No. of Layers	No. of Blows/ Layer
Modified	A	10 lb./18"	4"	No. 4 sieve	5	25
D 1557	B	10 lb./18"	4"	3/8" sieve	5	25
	C	10 lb./18"	6"	3/4" sieve	5	56

The moisture content and unit weight of each compacted sample is determined. Usually 4 to 5 such tests are run at different moisture contents. Test results are presented in the form of a dry unit weight versus moisture content curve. The compaction method used and any deviations from the recommended procedures are noted in this report.

Laboratory California Bearing Ratio Tests: The California Bearing Ratio, generally abbreviated to CBR, is a punching shear test and is a comparative measure of the shearing resistance of a soil. It provides data that is a semi-empirical index of the strength and deflection characteristics of a soil. The CBR is used with empirical curves to design pavement structures.

A laboratory CBR test is performed according to ASTM D 1883. The results of the compaction tests are utilized in compacting the test sample to the desired density and moisture content for the laboratory California Bearing Ratio test. A representative sample is compacted to a specified density at a specified moisture content. The test is performed on a 6-inch diameter, 4.58-inch-thick disc of compacted soil that is confined in a cylindrical steel mold. The sample is compacted in accordance with Method C of ASTM D 698 or D 1557.

CBR tests may be run on the compacted samples in either soaked or unsoaked conditions. During testing, a piston approximately 2 inches in diameter is forced into the soil sample at the rate of 0.05 inch per minute to a depth of 0.5 inch to determine the resistance to penetration. The CBR is the percentage of the load it takes to penetrate the soil to a 0.1 inch depth compared to the load it takes to penetrate a standard crushed stone to the same depth. Test results are typically shown graphically.

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November 18, 2015

Joe Burkhardt, PE
Principal
Consulting Services Incorporated
11162 Luschek Drive
Cincinnati, Ohio 45241

Subject: **Geopier® Foundation Recommendations**
Proposed Trimble County Water Tank, Pendleton, Kentucky
P15PGL01955

INTRODUCTION

It is our understanding that a new 1.0 MG Elevated Water Storage Tank is planned in Pendleton, Kentucky. At your request we have reviewed the available soil boring logs performed by Consulting Services Incorporated and the potential for soil improvement using Geopier Soil Reinforcement.

Based on our review, this appears to be a good site for the use of *Geopier®* technology to improve the existing soil conditions for support of the proposed new construction. As discussed with you we can improve the subgrade soils at the site, increasing the bearing capacity of the soil in order to support the structure on a ring or raft-type mat foundation.

PROJECT DESCRIPTION

Based on information provided, we understand that the proposed construction consists of a new 1.0 MG Elevated Water Storage Tank is planned in Pendleton, Kentucky. The new elevated water storage tank will measure approximately 200 feet in height with a pedestal diameter on the order of 32 feet. It is assumed the mat foundation will bear at a depth of approximately 8 feet below the current site grades. Based upon the preliminary information provided, static loads will be on the order of 12,050 kips and transient loads will be on the order of 81,000 k-ft. We have used this data to prepare a preliminary design for the project. If any of the above information is incorrect, or changes during design, we must be notified in order to revisit the preliminary design recommendations.

EXISTING SUBSURFACE CONDITIONS

Subsurface soil data was provided to us as a series of soil borings performed as part of the geotechnical investigation report. In general, the soil conditions below existing grade consist of 33 feet of stiff to very stiff fat clay over weathered siltstone/limestone (rock cores) extending to the maximum depth explored, 43 feet. Groundwater was not encountered.

TYPICAL GEOPIER DESIGN AND CONSTRUCTION PROCESS

Geopier® elements are installed by advancing 20 to 30-inch diameter holes and ramming thin lifts of well-graded aggregate within the holes to form very stiff, high-density aggregate piers. The drilled holes typically extend from 10 to 30 feet below grade and 7 to 30 feet below footing bottoms. The first lift of aggregate forms a bulb below the bottoms of the piers, thereby pre-stressing and pre-straining the soils to a depth equal to at least one element diameter below drill depths. Subsequent lifts are typically about 12 inches in thickness. Ramming takes place with a high-energy beveled tamper that both densifies the aggregate and forces the aggregate laterally into the sidewalls of the hole. This action increases the lateral stress in surrounding soil; thereby further stiffening the stabilized composite soil mass. The result of Geopier® installation is a significant strengthening and stiffening of subsurface soils that then support footings and floor slab loads.

Geopier® designs are based on a two-layer settlement analysis as described by Lawton et al. (1994) and in our Geopier® Reference Manual, available upon request. Settlements within the "upper zone" (zone of soil that is reinforced with Geopier® elements) are computed using a weighted modulus method that accounts for the stiffness of the Geopier® elements, the stiffness of the matrix soil, and the area coverage of Geopier® elements below supported footings. Settlements within the "lower zone" (zone of soils beneath the upper zone which receives lower intensity footing stresses) are computed using conventional geotechnical settlement methods.

EXPERIENCE

Geopier® elements have been used to support structures since 1989. We have developed a database of modulus load tests that confirm our design parameter values. We have recently completed installations or received contracts for the following facilities, which have similar characteristics to the referenced project.

- **Laurel Grocery Products Warehouse Addition, London, Kentucky** – Soft, organic clay soil was stabilized with Geopier Soil Reinforcement for this large, high bay warehouse addition. Geopier elements were installed beneath the new column and wall foundations as well as the floor slab.

- **Flex Film Manufacturing Plant, Elizabethtown, Kentucky** – Support of "grass roots" manufacturing plant with assembly line supported on large mat foundation. In addition, site was a balanced cut site and new fill was placed and supported on RAP elements.

- **Consolidated Grain and Barge, Uniontown, Kentucky** – Support of two – 105 foot diameter grain bins.

- **Riverview Coal Preparation Plant, Uniontown, Kentucky** – Support of coal preparation plant and surge tank for coal mining facility.

- **Newport Daycare and Housing (Northern Kentucky Residence and Scholar House), Newport, Kentucky** –support of four new, 3 - story, residential buildings, and an addition to the existing community center with maximum loads on the order of 3 to 4 kips per lineal foot. The subsurface conditions beneath existing grade generally consist of up to 15 feet of silty clay, sandy silt, sand fill with traces of cinders, brick fragments, topsoil and other materials. The fill is underlain by soft to stiff silt and clay and loose to medium dense sand to the depths of 73 to 78 feet where rock was encountered.

- **The Grove at Louisville (Campus Crest), Louisville, Kentucky** – Support of 4-story multi-family residential structures over urban fill. Project included multi-level parking garage in between the housing units with column loads on the order of 900 kips.

- **Lexington Road Apartments, Louisville, Kentucky** – Support of multi-level apartments with a first floor parking deck over up to 18 feet of clay fill soils.

- **RiverPark Place, Louisville, Kentucky** – Support of new, multi - story, apartment structure with first floor parking supported on column and strip foundations with loads on the order of 200 to 400 kips and 5 kips per lineal foot, respectively. Project was constructed near the Ohio River.

- **Angliana Avenue Student Housing, Lexington, Kentucky** – Support of 6 individual, 3-story apartment buildings over old clay fill and natural fat clay soils, including support of foundations and floor slab.

PRELIMINARY DESIGN RECOMMENDATIONS

Geopier® Rammed Aggregate Pier (RAPs) elements are a positive alternate to reduce settlement potential for the project and provide an increased bearing capacity.

Based on the design loading and subsurface conditions, GFC recommends the following:

- RAP elements can be used to reinforce the fat clay soils beneath the structure to support the mat foundation loaded to an allowable bearing pressure of up to 7 ksf for static conditions and 9.1 ksf for transient conditions.
- Our preliminary design indicates that RAP element shaft lengths should be drilled to depths of approximately 25 feet below footing bottoms. Our preliminary design indicates that use of Geopier® Soil Reinforcement will control total and differential settlements to less than 2 inch and 1 inch, respectively.

- We have assumed the three borings were performed within the footprint of the proposed water tank. Please let us know if this is not the case.
- We have assumed proposed grades will be at or near (+/- 1 ft) existing grades. Fill should be placed in accordance with the geotechnical engineer's recommendations.
- We have assumed the foundation will be sized and embedded to prevent a net uplift/tension force on the footing during application of the transient moment. Please let us know if this is not the case.
- Of particular importance when considering this proposal is that RAP element construction should significantly reduce the time necessary for placement of spread footings at this site. Typical construction rates average 30 to 50 RAP elements installed per day. Spread foundations can be placed directly on the RAP reinforced soil mass immediately after installation of the RAP elements. Since the RAP system is a soil reinforcement system, there is no "set-up" time for the RAP elements.
- The high stress concentration on RAP elements and high coefficient of friction between piers and footing bottoms provide significant resistance to sliding resulting from dynamic lateral loads. RAP element supported footings typically provide lateral resistance equal to 50% of the supported column dead load.

- Quality Control - The licensed RAP element installer's internal QC program is designed to verify that each element is installed correctly. This is achieved by:
    - Coordinating footing layout, elevation and grading with the General Contractor,
    - Observing soils encountered during drilling,
    - Measuring drill depths and top elevation of RAP elements,
    - Controlling moisture content of the aggregate within acceptable limits,
    - Controlling and recording type and number of lifts of aggregate
    - Performing qualitative tests on RAP elements, including but not limited to "bottom stabilization tests" and down-hole dynamic cone tests of the aggregate,
    - Reporting construction activities to the owner's representative.

The above recommendations should be considered preliminary. Once detailed grading and structural loading information is available, we request that they be forwarded to this office so that we may perform a detailed analysis to aid the design team in examining the feasibility of Geopier® foundations for the new structure.

BUDGET ESTIMATE AND SCHEDULE

In order for us to provide a fixed price for Geopier® installation, it will be necessary to provide us with:

- Final Foundation Plan with final loading information, and
- Final Geotechnical Report,
- Confirmation of the aforementioned design criteria, working pad elevations, locations, and approach.

Please note that it will be necessary for survey/layout and spoil removal be provided by others.

This appears to be a good site for Rammed Aggregate Pier® soil improvement using the Geopier® system. A Geopier® solution should offer great economy and schedule savings to this project while providing proven performance. If you have any questions concerning this report, or if we can be of further assistance, please contact us at (937) 790-1084.

Sincerely,

Mark Salveter, PE
Region Engineer

James R. Bullard, PE
Lead Region Engineer