South Central Connecticut Regional Water District
90 Sargent Drive, New Haven, Connecticut 06511-5966 / 203-401-2515
http://www.rwater.com

NOTICE OF PUBLIC HEARING

The Representative Policy Board ("RPB") of the South Central Connecticut Regional Water District will hold a public hearing to consider the South Central Connecticut Regional Water Authority's Application for the approval of a project to construct improvements at the West River Water Treatment Plant located in Woodbridge, Connecticut.

The public hearing will be held on Thursday, February 18, 2021 at 7:00 p.m. In accordance with the Governor Lamont's, Executive Order No. 7B for the Protection of Public Health and Safety during COVID-19 Pandemic and Response, the public hearing will be held remotely. Members of the public may attend the hearing via conference call, videoconference or other technology. For information on attending the meeting via remote access, and to view hearing documents, please visit https://www.rwater.com/about-us/our-boards/board-meetings-minutes?year=2021&category=1435&meettype=1460&page=. The Public Hearing is being held pursuant to Sections 10 and 19 of Special Act 77-98, as amended.

All users of the public water supply system, residents of the Regional Water District, owners of property served or to be served, and other interested persons, shall have an opportunity to be heard concerning the matter under consideration. Questions may also be submitted in writing to the board office by emailing jslubowski@rwater.com or by calling (203) 401-2515.

Mario Ricozzi, Chairperson
REPRESENTATIVE POLICY BOARD
South Central Connecticut Regional Water District
90 Sargent Drive
New Haven, CT 06511

Topic: RPB Public Hearing – West River Water Treatment Plant Improvements Project

Time: Feb 18, 2021 07:00 PM Eastern Time (US and Canada)

Join Zoom Meeting (*via conference call*)

Dial by your location
+1 646 876 9923 US (New York)
+1 301 715 8592 US (Washington DC)
+1 312 626 6799 US (Chicago)
+1 669 900 6833 US (San Jose)
+1 253 215 8782 US (Tacoma)
+1 346 248 7799 US (Houston)
+1 408 638 0968 US (San Jose)

Meeting ID: 817 7955 4933
Passcode: 251042

Find your local number: https://us02web.zoom.us/u/kd2hWvdmgo

Application for Approval to the Representative Policy Board of a Project to Construct Improvements at the West River Water Treatment

South Central Connecticut Regional Water Authority
December 17, 2020

Application for Approval to the Representative Policy Board: West River Water Treatment Plant Improvements Project

Table of Contents

Appendix D: West River WTP DAF Summer Pilot Report, December 2015, prepared by Tighe & Bond - ANNEXED

Appendix E: West River WTP DAF Preliminary Design Report, November 2020, prepared by Tighe & Bond - ANNEXED

Appendix F: West River WTP DAF Business Case Evaluation, December 2020, prepared by RWA - ANNEXED

Appendix G: West River WTP Chlorination System Business Case Evaluation, November 2020, prepared by RWA and Tighe & Bond - ANNEXED

Appendix H: Engineer’s Opinion of Probable Cost for DAF System Upgrade

Appendix I: American Association of Cost Engineers (AACE) standards

1. Statement of Application

In accordance with Section 19 of Special Act 77-98, as amended, the South Central Connecticut Regional Water Authority (RWA) is pleased to present this application for West River Water Treatment Plant (WRWTP) improvements to the Representative Policy Board (RPB) for review and approval. Section 19 of Special Act 77-98, as amended, requires the RPB approval before the RWA commences any capital project that will cost more than $2 million. The proposed project cost is a not-to-exceed amount of $16.3 million. The proposed upgrades will improve treatment performance, provide consistent water quality, and strengthen the organization's present and future ability to serve our customers with high quality drinking water.

This application is a multi-project application consisting of three distinct projects as discussed below. The multi-project concept provides the RWA's management with a method to complete more than one project at a time at a water treatment plant or within a distribution system without returning to the RPB for separate project approvals. With an increasing number of planned projects expected to exceed the $2 million RPB application threshold, this multi-project method will increase the efficiency of conducting the RWA's capital program by reducing the time, expenses, and facility impacts associated with individual project applications. Importantly, this method will also increase capital efficiencies by achieving economies of scale for multiple project bids as a combined project.

Multi-project applications may include projects that are at the conceptual stage versus applications based on more complete designs. The sodium hypochlorite system replacement and electrical service replacement projects in this application are examples of projects at the conceptual stage. The design of these projects are at an early juncture and their cost estimates were developed without detailed engineering data and therefore their contingencies are relatively high at (+)30%. The inclusion of conceptual stage projects in multi-project applications will result in total project cost estimates that are in terms of a 'not-to-exceed' dollar amounts, as is the case with this application. The inclusion of conceptual stage projects in multi-project applications provides a method to incorporate evolving projects into applications that are anchored on a well-developed large project, and allows for the development of RPB applications to be completed sooner than if fully developed projects were included. This results in expediency in conducting the capital program and captures the associated efficiencies. The conceptual projects included in a multi-project application will be brought to full design after the project approval, if so granted by the RPB.

The WRWTP provides drinking water to the western part of the RWA's service area (New Haven, West Haven, Woodbridge, Seymour, Ansonia, and Derby). The WRWTP was initially constructed by the New Haven Water Company (NHWC) in 1980 to serve Woodbridge, New Haven, and interconnections with the Birmingham Utilities (BUI) and the Bridgeport Hydraulic Company (BHC). At that time, BUI served the towns of Ansonia, Seymour and Derby primarily through its Housatonic River well system. The RWA acquired BUI in 2008.

This comprehensive improvement project will allow the existing WRWTP to be operated at its design capacity under any conditions while improving water quality to customers. After thorough review of operating and capacity challenges associated with the legacy BUI wellfield system, the RWA is further recommending capital investment in the WRWTP to more efficiently serve customers in that area. The remaining interconnection with BHC, now Aquarion, would also be strengthened. The project's intent, summarized in this application, is to invest financial and human capital resources into facilities that will allow the organization to most effectively provide water to its northwestern service areas. Through improvements to the WRWTP's treatment process, disinfection system, and electrical equipment, the RWA achieves strategic goals of increasing resiliency and redundancy including water supply accessibility to the vast majority of its entire system. The WRWTP, located off Litchfield Turnpike in Woodbridge, CT, treats water from West River's surface water impoundments of Lake Glen, Lake Watrous, and Lake Dawson. Lake Bethany and Lake Chamberlain also feed into Lake Watrous and Lake Glen, respectively. The WRWTP is an in-line, direct filtration plant with a design capacity of 10.4 million gallons per day (MGD) and has a firm capacity of 7.8 MGD with one filter out of service.

Despite RWA's longstanding commitment to source water protection through aggressive land management practices, upgrades to the WRWTP are now necessary for the facility to run consistently greater than 8 MGD during summer months. The current treatment process that was state-of-the-art in the 1970s needs to be modified so that it can operate at its design capacity during times when raw water quality in the impoundments degrades from various environmental issues such as reservoir stratification, heavy precipitation events, and drought conditions, which are likely related to regional climate change. At times, the WRWTP can be reduced to operating at a maximum of only 5 MGD with available production limited to 3 MGD due to the high number of backwashes required.

.

This application outlines the components needed to address the issues described above, thus allowing full use of the existing facility's capacity. The projects in this application are:

1. Dissolved Air Floatation Unit Process Addition
2. Sodium Hypochlorite System Replacement
3. Electrical Service Upgrades

For each of the above components this application will provide: a description of the proposed work, an explanation of why it is necessary, a discussion of what alternatives were considered, and the estimated cost. The accuracy and completeness of this document are critical to the RPB's ability to make an informed decision on behalf of the RWA's customers and member communities. Tighe & Bond is providing design and construction administration services for the project.

2. Dissolved Air Floatation Unit Process Addition

2.1 Description of the Proposed Action

The existing WRWTP treatment process consists of caustic soda and potassium permanganate addition followed by two contact basins to oxidize manganese. Alum, polymer, and filter-aid polymer are added to the three-stage rapid-mix tanks. Following rapid mixing, the water is filtered using four dual-media filters [Granular Activated Carbon (GAC) and sand]. Sodium hypochlorite, fluoride, and caustic soda are applied to the filtered water before it flows into the two concrete filtered water reservoirs. A phosphate-based corrosion inhibitor and caustic soda, for pH adjustment, are added after the filtered water reservoirs, from which the treated water flows by gravity to the WRWTP service areas.

This project will include construction of three new Dissolved Air Floatation (DAF) basins within a new DAF building to the south of the existing filter building. Dissolved Air Flotation is a water treatment process often employed in drinking water supplies that are particularly vulnerable to unicellular algal blooms, as the WRWTP is. The DAF process clarifies previously coagulated water by the removal of suspended matter and solids. The removal is achieved by dissolving air in the water under pressure and then releasing the air at atmospheric pressure in a flotation tank basin. The released air forms tiny bubbles that attach to the algal floc created by coagulation, and mixing and floating it, which results in a floating mass of concentrated floc that is removed by a skimming device. The Lake Whitney WTP in Hamden employees DAF in its treatment train and has been found to be very effective in removal of algae.

To integrate the DAF system into the current WRWTP treatment process, the rapid mix tank effluent will be redirected to the new DAF basins, and the DAF effluent piping will be connected to the exiting rapid mix tank effluent piping. Coagulant and primary polymer will be injected in the existing rapid mix chamber, and filter-aid polymer will be moved to the DAF effluent channel upstream of the filters.

Appendix A contains the 50% design drawings for the Improvements Project.

Specifically, the DAF facility upgrades consist of:

- Site Work
    - Excavation for DAF basins, adjacent piping and associated paving
    - Access driveway extension and filtration building retaining wall
    - Site stairs and retaining wall along the south wall of the water treatment plant
    - Drainage infrastructure around the new building
    - Demolition of abandoned chlorine gas scrubber for access driveway extension
    - Relocation of the propane tank
- Existing Building Renovations
    - Core hole in the wall from rapid mix tank effluent chamber for 36-inch diameter pipe to new flocculation basins
    - Core hole in wall east of rapid mix tanks for 36-inch diameter pipe from DAF effluent
    - Cut existing 36-inch diameter pipe from the rapid mix tanks and replace with a tee and valve that allows for a potential DAF bypass
    - Remove existing filter media and replace with new media plus 12 inches of additional depth by using 36 inches of granular activated carbon (GAC) on top of 10 inches of sand.
    - Adsorption is the primary mechanism by which GAC works and the primary reason it is widely used to reduce undesirable taste, odor and color and to improve the safety of drinking water by also effectively removing common disinfection byproducts (THMs), organic contaminants like chlorinated solvents and other industrial pollutants, pesticides, and select heavy metals such as lead and mercury. By increasing the volume of GAC,12 inches, the Empty Bed Contact Time (EBCT) is increased 30%, enabling more effective removal of contaminants and cleaner water for RWA's customers
    - Replace the existing filter underdrains to allow for more efficient and effective filtration, by improving the plant's hydraulic profile, enabling the addition of more GAC and to replace the current underdrain system that is beyond its useful life and has allowed sand filter media to pass underneath
    - Replace windows and add a door for access from the existing building operation floor level to a new walkway to the new DAF building
    - Add a new online turbidimeter for DAF effluent monitoring
- New Building
    - Building housing three entirely new basins
    - Concrete including exterior walls, interior baffles, and floor
    - Masonry walls and a roof above the basins including heating and ventilation

    - Accommodations for a staircase, HVAC equipment, electrical equipment, and instrumentation and controls

    - Exterior stairs for roof access

    - Two bridges for access to existing building at main level and at roof level

- DAF System

    - Additional structural steel or concrete above the basins for walkways and mounting equipment

    - DAF System including flocculation mixers, adjustable weirs for hydraulically controlled wasting, collection systems, recycle pumps, saturation tanks, air compressors, and residual spray systems

- Piping
    - 36-inch diameter ductile iron (DI) header piping from the rapid mix tanks to the DAF basins

    - 24-inch diameter DI individual DAF train piping from header

    - 36-inch diameter DI header piping from DAF basins to the existing filter piping

    - DAF basin drain piping from DAF basins into residuals pipe

    - Residuals piping from residuals trough to existing lagoons

    - Filter aid polymer injection piping from rapid mix tanks to DAF effluent channel

- Electrical/Instrumentation

    - Variable frequency drives (VFD), starters and control panel for DAF equipment

    - New motor control center (MCC) cabinets within DAF building to house VFDs and starters

    - Power and control wiring for new DAF equipment and heating, ventilation, and air conditioning equipment

    - Lighting for new building

2.2 Need for the Proposed Action

The RWA operates four surface water treatment plants and seven wellfields with a combined total rated capacity of 138 MGD. However, due to operational issues at the various facilities including high algae at the surface water supplies in the summer months, the actual system capacity is currently 95 MGD. The maximum day system demand is approximately 90 MGD (103.5 MGD with a 15% safety margin), which means that the system capacity is lower than the maximum day demand when the safety margin is included.

The WRWTP has a capacity of 10.4 MGD with all 4 filters operating at 3 gpm/sf and has a firm capacity of 7.8 MGD with one filter out of service. However, due to algal impacts on the filters, the capacity of the WRWTP is reduced from 10.4 MGD to 8 MGD and the firm capacity is further reduced in the summer months. The WRWTP is an important source of supply for RWA’s water system. It is a source of supply for two consecutive water systems, a partial redundant source of supply for the New Haven Service Area and the Seymour and Derby service areas which allow the shutdown of other plants for maintenance. The addition of DAF and the additional media depth will improve the reliability of the WRWTP, especially in the summer enabling further system flexibility, reliability and reduction of risk.

Specifically, it has been determined that DAF is necessary based on the following reasons:

- DAF will treat seasonal algae blooms that cause algal toxins to negatively impact the finished water taste and odor. EPA issued a public National Health Advisory for these types of blooms on June 17, 2015.

- In the winter months, the filter runs typically range between 30-40 hours. In the summertime, when algae blooms occur, the filter runs can be 12 hours or lower. With DAF, RWA will be able maintain a firm capacity of 7.8 mgd and a maximum capacity of 11.7 mgd during all seasons with high quality water and a significant reduction in risk. Maintaining capacity is critical for all seasons but especially so for peak months during the summer.

- With DAF, the frequency of backwashing will be reduced. This will reduce electrical costs and the amount of spent filter backwash, and conserve significant amounts of process water.

- Currently, RWA's operational goal is that all sampling locations do not exceed 80% of the maximum contaminant levels (MCL's) for disinfection by-products (DBPs). Several locations in WRWTP's distribution system exceed the goal. To reduce the DBP precursors, RWA has installed GAC in its filters at the WRWTP but the GAC has to be replaced frequently at a considerable cost. With DAF, the RWA will be able to practice enhanced coagulation to reduce DBP precursors.

- Currently, WRWTP is the only source of water for the Woodbridge Pump Station and several customers along Route 69, which require a peak flow of 3.6 MGD. With DAF, the reliability of the WRWTP will be increased.

2.3 Analysis of the Alternatives to the Proposed Action

The evaluation of plant capacity began in November 2014 through a report titled *Phase 1 Report for the Conceptual Design for Regulatory Compliance for SCCRWA* (available in Appendix B) prepared by Tighe & Bond and CH2MHill. In that report, it was identified that installation of High Rate Dissolved Air Flotation (DAF) would be a viable alternative to increase the capacity of the WRWTP.

Tighe & Bond and subcontractor Blueleaf, Inc. further evaluated alternatives to increasing the capacity of the WRWTP in 2015 through jar testing and winter pilot testing. The *WRWTP DAF Winter Pilot Report* dated May 2015 (available in Appendix C) summarized DAF trials with various loading rates and filter media (sand and anthracite). The report recommended adding DAF for clarification and particulate removal and increasing the filter loading to 4.3 gpm/sf.

A subsequent report entitled *West River WTP DAF Summer Pilot Report* dated December 2015 (available in Appendix D) summarized how the same trials from the winter pilot test responded with the presence of high algae in the water during the summer months. The report recommended the following chemical dosages:

- Chemical Pretreatment
    - Polyaluminum chloride (PACl): 22 - 24 mg/L
    - Potassium Permanganate: 0.25 – 0.6 mg/L
    - Diallyldimethylammonium chloride (DADMAC) Polymer: 0-3 ppm

- Filter Chemicals
    - Filter Aid Polymer: 0.08-0.10 mg/L

To evaluate the different alternatives for optimizing system capacity and performance at the WRWTP, Tighe & Bond prepared the *West River WTP DAF Preliminary Design Report* dated November 2020 (available in Appendix E). Tighe & Bond evaluated several different DAF system alternatives. In addition, RWA identified other service area modification alternatives that conceptually could be implemented in lieu of a DAF system at the WRWTP.

1. **No Action Alternative –** Not completing any additions or upgrades to the existing WTP impacts the capacity and reliability of the facility. It also impacts the accessibility and quality of the water. Algae will continue to be an issue in the summer months, which reduces the plant's firm capacity and significantly impacts water quality thereby increasing the water's odor and taste issues, and organics loading which allows more precursors for disinfectant by-product production. West River has some of the highest DBPs leaving the finished water reservoirs out of the four surface water treatment plants operated by RWA.

2. **New Dissolved Air Flotation System –** This project includes the construction and operation of a new DAF system at the WRWTP. Also included in the construction of this project would be modifications to the existing media, improvements to filter underdrains, and modifications to the existing rapid mix basin to remove mixers made unnecessary by changes to the coagulation scheme. Operational costs for this alternative include cost of additional power to the DAF system; reductions in power due to the removal of mixers; additional raw water pumping; and reduction in power and water production increases due to the reduction in number of filter backwashes per year needed. This alternative fully addresses both the water quality and water quantity aspects of the project need. Below are four options that were considered for integrating a DAF system into the WRWTP. Ultimately, DAF Alternative 4 was chosen.

    DAF Alternative No. 1 - Two Extended Retrofit Basins: Retrofitting the existing potassium permanganate contact basins to house two retrofit DAF basins. This alternative would require extending the contact basins south into the existing pipe gallery. The alternative also required moving the potassium permanganate injection location to the access road and construction of a 280-foot long 96-inch diameter potassium permanganate contact pipe in the access driveway to obtain a 10 minute contact time at the proposed future flowrate prior to entering the new in-line mixer and adding coagulants.

    DAF Alternative No. 2 - Three Regular Retrofit Basins: Retrofitting the existing potassium permanganate contact basins to house two retrofit DAF basins, each sized for one third of the current plant design flow rate. A third matching DAF basin would be constructed in a building addition parallel to the first two basins, adjacent to the existing building on the east side. This alternative also required moving the potassium permanganate injection location to the access road and construction of a 280-foot long 96-inch diameter potassium permanganate contact pipe in the access driveway to obtain a 10 minute contact time at the proposed future flow rate prior to entering the new in-line mixer and adding coagulants.

    DAF Alternative No. 3 - Two New Basins/New Building: Construction of two entirely new 5.2 MGD DAF basins within a new building outside and to the south of the existing filter building. The existing potassium permanganate contact basins would continue to be used for potassium permanganate contact time. This alternative would also continue to use the rapid mix tanks. The rapid mix tank effluent would be redirected to the new DAF basins. Coagulant and DAF polymer would be injected in the existing rapid mix chamber. Filter aid polymer would be added into the DAF effluent channel upstream of the filters. 0.

    DAF Alternative No. 4 - Three New Basins/New Building: Construction of three entirely new 3.9 MGD DAF basins within a new building outside and to the south of the existing filter building.

The existing potassium permanganate contact basins would continue to be used for potassium permanganate contact time. This alternative would also continue to use the rapid mix tanks. The rapid mix tank effluent would be redirected to the new DAF basins. Coagulant and DAF polymer would be injected in the existing rapid mix chamber. Filter aid polymer would be added into the DAF effluent channel upstream of the filters. The principal advantage of DAF Alternative No. 4 over the other DAF alternatives is maintaining the firm capacity of 7.8 MGD with one DAF train out-of-service.

3. **New Haven Service Area: HDD Pipe to York Hill Service Area –** This project includes the construction and operation of a high-density directional drilled pipeline connecting the York Hill Service Area to mains on the Litchfield Turnpike. This involves the installation of a 20-inch diameter main of approximately 3,000 feet through the ridge of West Rock Park. The exact location would need to be determined after the completion of a geological report. A pump station will be necessary to supply the higher gradient. This alternative was first conceptualized in the New Haven Service Area Phase III Report (2014), and also provides the ability to send water to the southern and western areas of the system in the event of a shutdown at the West River or Gaillard WTPs. The additional source of supply in this scenario is provided by the Lake Whitney WTP. Operational costs for this alternative include the difference in production costs per MG for the Lake Whitney WTP vs. West River WTP (increases), and increases in operation, maintenance, and pumping costs by the addition of the new pumping facility. This alternative fully addresses the water quantity aspect of the project need but does not address the water quality aspect, with water quality anticipated to be comparable to existing conditions.

4. **Additional Wellfield/Source of Supply** – This project includes the construction and operation of a new groundwater source of supply and treatment facility located in the western area of the system. This involves the siting, permitting, and development of the wellfield and design and construction of the treatment systems. In addition to the chemical treatment processes typical for RWA groundwater facilities, a manganese treatment system would also be anticipated. The existing wellfields in the western area of the system do not have the required area for expansion to adequately address the quantity of water necessary to supplement the existing supply, therefore a new source of supply was considered in this alternative. Operational costs for this alternative include the difference in production costs per MG for the groundwater source (estimated to be similar to South Cheshire Wellfield) and West River WTP, and increases in maintenance costs associated with a new site and equipment. This alternative fully addresses the water quantity aspect of the project need, and addresses about 30% of the water quality aspect (due to the fact that water quality at West River, the primary source of water for the area, would not change).

A Business Case Evaluation (BCE) was performed by RWA to compare and evaluate the alternatives above and is included in Appendix F. To summarize the results, Alternative 2, DAF at WRWTP was found to have the least life cycle cost – annuitized cost stream, most effective risk reduction, and overall greatest cost benefit ratio.

Of the DAF options available the alternatives analysis concluded that DAF Alternative No. 4 is most favorable in terms of water quality, availability, and reliability. The three new basins and building alternative was selected for the following reasons:

- Constructability is improved because the stand-alone DAF building can be installed with minimal impact to water treatment operations during construction

- Three DAF trains maintain the design capacity of 10.4 MGD as well as firm capacity of 7.8 MGD during the summer months

- DAF was proven effective at the design loading rates and chemical doses during winter and summer pilot testing

- DAF most completely meets the RWA's project goals of improving water quality and increasing quantity of treated water available to the service area

2.4 Statement of the Cost to Be Incurred and/or Saved

2.4.1 Capital Cost

This project will result in a capital expenditure of $12.6 million a (+) 20% when contingency factor is included. The RWA has expended approximately $589,669 to conduct the preliminary pilot testing of the DAF process, develop the Preliminary Design Report, and develop design documents. A breakdown of the capital cost for this project is presented in Table 1 below, and a detailed breakdown of this cost estimate is contained in Appendix H of this application. The project costs presented are based on a 50% design level of completion prepared in November 2020.

TABLE 1
Estimated Project Capital Cost for DAF Facility Addition

Cost Description	Estimated Cost
Previous Expenditures (from 2015 through November 2020)	$589,669
Final Design Cost	$161,323
Estimated Construction Cost	$8,008,300
Escalation to Mid-point of Construction – 2.7% per year	$216,224
Construction Cost Subtotal	$8,224,524
Consultant cost During Construction	$991,748
RWA Costs During Construction	$648,650
Engineering and Construction Oversight Sub-total	$1,640,398
Construction Sub-total (w/o previous spend & final design)	$9,864,922
Total	**$10,615,914**
Rounded Total	**$10,616,000**
Minimum Anticipated Project Cost (-15%)	$9,136,176*
Maximum Anticipated Project Cost (+20%)	$12,588,898*

***** Minimum and Maximum project costs includes (-15%) to (+20%) American Association of Cost Engineers (AACE) accuracy factors respectively on construction subtotal.

In accordance with cost estimating principles, the project costs have been adjusted for inflation forward 12 months from the date of the cost estimate, November 2020, to the mid-point of construction, which is anticipated to be January 2022. An inflation factor of 2.7% per year has been used in the cost estimate. This factor was calculated by Tighe & Bond from the ENR Construction Cost Index from August 2015 through August 2020.

For the construction cost estimate, a 20% contingency is included in the maximum anticipated project cost. This is consistent with the (AACE) International Recommended Practices and Standards for a Class 2 estimate, which is included in Appendix I. In a Class 2 estimate, the design of the project is normally expected to be between 30% to 70% complete and accurate within -15% to +20%. This implies that there is a high probability that the final project cost will fall within the specified range. The AACE defines contingency as a specific provision for unforeseeable elements of cost within the defined project scope, particularly where experience has shown that unforeseeable costs are likely to occur. The percent contingency allowance is included at this design stage in anticipation of items that will be further defined in subsequent phases of the design process, as well as for uncertainty in future bid prices and as a means to reduce the risk of possible cost overruns.

2.4.2 Operation and Maintenance Cost

The DAF system includes the following mechanical equipment that will require routine maintenance:

- Recycle pumps
- Compressors
- Mechanical Weirs
- Mixers
- Unit Heaters
- Exhaust Fans
- Air Handling Units

Maintenance of equipment will vary depending upon the manufacturer. However, the following basic maintenance activities can be expected.

It is anticipated that routine maintenance of the recycle pumps includes periodic inspection of oil level in thrust pots and changing lubrication in the gear drive approximately every 2,000 hours of operation or once a year, whichever occurs more frequently. Re-greasing motor bearings will be required approximately every 2,000 operating hours. In addition, systematic inspections of the pump and its components should be made at regular intervals.

Anticipated routine maintenance of the air compressors is dependent upon frequency of operation. After 8 hours of operation, the oil level should be checked and filled if needed. Operators should also observe if the unit loads and unloads properly, and check the discharge pressure and temperature. After 125 hours of operation, operators should check for dirt accumulation on oil/aftercooler core faces and the cooling fan. After 1,000 hours of operation, the oil filter element should be changed. After 4,000 hours of operation, the compressor lubricant should be changed. Once a year the relief valve should be checked for proper operation, and the oil separator should be changed.

The mechanical weirs have a mechanical actuator. The lubrication should be changed at a minimum of once a year.

Recommended maintenance for the mixers includes replacing the oil after the first 1,500 hours of operation and every 5,000 hours of operation after that. The level of lubricant should be monitored and filled as needed.

The HVAC exhaust fans should be initially checked after the first month and then every three months if there are no issues during the first check. Twice a year, operators should inspect the bolts and setscrews, belts, bearings, and fan cleanliness.

The filters in the dehumidifier should be checked after the first month and every three months if there are no issues during the first check.

In general, air handling units do not require special maintenance other than routine cleaning and maintenance work. Once a week, the air filters should be checked. Once a month, the fan belt tension, spray nozzle condition, drain condition, and the access door hinge condition should be checked. Twice a year, the condition of the motor running current, function controls, fan and motor bearings, electric heater battery elements, circulation pump and motor, inlet strainers, and chilled/hot water should be checked. In addition, the drain line should be flushed twice a year. Once a year, the operation of the dampers, condition of filter frame, access doors, controls, coils and fin condition, insulation, motor and fan lubrication, and wiring, controls, isolation devices, and terminal connections should be checked. Once a year, the belts on the air handling unit should be replaced.

It is anticipated that the maintenance of the DAF system equipment will require approximately 6 hours per month.

3. Sodium Hypochlorite System Replacement

3.1 Description of the Proposed Action

The West River Water Treatment Plant Improvements Project includes replacement of the existing sodium hypochlorite system. The existing hypochlorite system will be replaced with an on-site hypochlorite generation system with a brine or salt silo, day tank, metering pumps, and two on-site sodium hypochlorite generators. The equipment will be installed in the existing sodium hypochlorite room where the chemical resistant floor coating will be removed and replaced. A temporary sodium hypochlorite system will be furnished, installed, and operated by the RWA in the northeast corner of the Filter Building.

Specifically, the work consists of:

- General Work
  - Demolition of the existing sodium hypochlorite storage room
  - Installation of a temporary sodium hypochlorite system
- Existing Building Renovations
  - Removal and replacement of the chemical resistant floor coating
  - Elevated concrete pad for the day tank to ensure flooded suction to the metering pumps
  - Concrete pads for the brine silo and the metering pumps
- On-Site Sodium Hypochlorite Generation System
  - 1 brine or salt storage silo
  - 2 on-site chlorine generators
  - 1 water filter, 1 brine filter
  - 2 brine boost pumps
  - 2 water heaters
  - 1 water softener

  - 2 day tanks
  - 4 chemical metering pumps
- Piping
  - Piping and valves inside sodium hypochlorite room to be replaced; piping outside room to remain in service
- Electrical/Instrumentation
  - As necessary to support new sodium hypochlorite generation system
  - Lights and miscellaneous electrical devices are being replaced under a different RWA project.

The proposed improvements will replace the existing sodium hypochlorite system with a new on-site sodium hypochlorite generation system. These improvements will increase reliability of the system, reduce the risk of DBPs, reduce off-gassing odors, and meet the design requirement of 300 lbs. Cl_2/day.

3.2 Need for the Proposed Action

The existing sodium hypochlorite system was installed 15 years ago, at the time replacing a chlorine gas system, and is rated for 200 lbs. Cl_2/day. Installation of a new DAF system and upgrades to the filter underdrains and media will cause both the hydraulic capacity and chlorine demand to increase.

When all three DAF trains are in service, the projected maximum capacity of the plant could increase from 10.4 MGD to 11.7 MGD if the RWA elects to increase the filter loading rate in the future. The design criteria of 300 lbs./day will allow for a dose of approximately 3.07 mg/L at the projected future capacity, or a dose of 3.46 mg/L at the current plant capacity of 10.4 MGD. This design criteria was selected based on WTP data, including usage at the plant from 2017-2019.

Specifically, the existing sodium hypochlorite system requires a replacement based on the following reasons:

- At 15 years old, and with the use of the highly corrosive sodium hypochlorite, the existing tanks and associated piping have reached their useful life and are scheduled for replacement.
- RWA is interested in replacing the existing vacuum feeders with gear metering pumps. Vacuum feeders require excessive water use, can be maintenance intensive and gear metering pumps are preferred by the RWA.
- The design criteria will increase from 200 lbs./day to 300 lbs./day once filter improvements and the DAF system have been completed. The current system is not rated for this increased capacity.
- RWA needs to minimize their risk of DBPs being produced (chlorate and chlorite) through degradation resulting from long-term sodium hypochlorite storage.

3.3 Analysis of the Alternatives to the Proposed Action

To evaluate the different alternatives for replacing the existing chlorine system at the WRWTP, Tighe & Bond prepared a *West River WTP Chlorination System Business Case Evaluation Memorandum* dated November 2020 (available in Appendix G). Tighe & Bond evaluated several different alternatives, including one replacement in-kind option, one on-site generation option, and one option using a no action approach as follows:

Alternative 1 - Replace Sodium Hypochlorite System: This alternative includes replacement of the existing sodium hypochlorite system with two new bulks tanks, one new day tank, two new transfer pumps, and new gear metering pumps. These metering pumps would take the place of existing vacuum feeders. Piping and valves within the sodium hypochlorite room would be replaced, while piping outside of this room would remain in service. The chemical resistant floor coating also requires replacement due to its failing condition. An elevated concrete pad would be constructed for the new day tank to ensure flooded suction to the metering pumps.

While this alternative offers lower upfront costs and operation/maintenance consistent with RWA's current routine, the 12.5% hypochlorite solution presents safety hazards and storage concerns. In addition to off-gassing tendencies, this highly concentrated solution carries a higher risk of forming disinfection byproducts (DBPs) such as chlorate and chlorite during the degradation process. The corrosive fumes may cause premature failure of building elements, and the solution is often aggressive to piping systems, thus increasing the maintenance demand of operation staff.

Alternative 2 - On-Site Chlorine Generation: This alternative includes replacement of the existing sodium hypochlorite system with an on-site sodium hypochlorite generation system that uses a brine solution and electricity to create a 0.8% hypochlorite solution. This alternative would consist of a brine or salt storage silo, a water filter and softener, two water heaters, two electrolytic cell on-site generators (OSG), two day tanks, two boost pumps, and four metering pumps. The same piping and valve replacement, chemical resistant floor coating replacement, and elevated concrete pad addition would occur as stated in Alternative 1. As indicated by the DPH, RWA would not need to conduct a pilot test, provided that only sodium hypochlorite is generated and injected in the WTP.

This alternative does not require long-term storage of concentrated sodium hypochlorite, therefore reducing the risk of DBP production. The 0.8% hypochlorite solution has some of the same safety concerns as the 12.5% solution, but a dilute solution is more stable and inherently safer. The use of an on-site generation system would also result in less maintenance as new OSG cells are self-cleaning and report essentially no maintenance, while the water softener requires minimal maintenance. A less concentrated solution is also less of a challenge for operators to work with, including reduction of hypochlorite off-gassing fumes. The disadvantages of this alternative are the higher upfront and electrical costs, as well as the risks associated with using a lesser-known technology.

Alternative 3 - No Action: The existing vacuum feeders remain in service, and the replacement of existing chemical tanks and piping is deferred. At 15 years old, the existing chemical tanks and piping have reached the end of their anticipated life. Experience with similar vacuum feeder systems at our other treatment facilities, confirms that risk of failure significantly increases after approximately 15 years. The current feed systems have experienced numerous vacuum leaks due to degraded seals and PVC glue joints, interrupting continuous chemical feed. WRWTP is the last treatment facility that is using this type of feeder system, and the electronics are no longer supported by the manufacturer. Any electronic failure will mean a temporary sodium hypochlorite feed system will need to be installed to maintain operations.

This alternative has the lowest cost, but also presents no solution to the aging tanks and piping. The vacuum feeders require excessive water use and the existing vacuum chlorinators are not sufficiently rated for the capacity that will be necessary once the DAF system and filter upgrades have been completed.

Alternate 2 is the most favorable in terms of DBP reduction, non-cost advantages, and long-term benefits. On-site generation was selected for the following reasons:

- Reduction of chlorite and chlorate; as soon as sodium hypochlorite is manufactured, it begins to dissociate into disinfection byproducts including chlorate and chlorite. The process of dissociation increases due to increasing temperature, available light and time all of which occur during product storage. A study conducted by the RWA found significant increases in these DBPs well above the CTDPH Health Reference Level, especially during warmer months. Chlorite is currently regulated and chlorate is expected to be soon.

- Gear metering pumps are preferred by RWA and will take the place of vacuum feeders which use an excessive volume of water and are maintenance intensive.

- Off-gassing odors will be reduced.

- The 0.8% hypochlorite solution is more dilute and therefore safer, although safety precautions will likely remain the same.

- Table salt is less likely to be subject to market cost fluctuations and is also more stable, therefore it can be delivered less frequently. This also makes the plant more resilient in the event that natural disasters, weather, other issues impact deliveries or the plant itself.

- The OSGs and water softener require minimal maintenance.

3.4 Statement of the Cost to Be Incurred and/or Saved

3.4.1 Capital Cost

This project will result in a capital expenditure of $1.4 million when a (+) 30% contingency factor is included. A breakdown of the capital cost for this project is presented in Table 2 below, and a detailed breakdown of this cost estimate is contained in Appendix G of this application. The project costs presented are based on unit costs provided by De Nora, the manufacturer of an on-site hypochlorite generation system, which are available in Appendix G.

TABLE 2

Estimated Project Capital Cost for On-Site Generation of Sodium Hypochlorite – Including Escalation and Construction Phase Engineering

Cost Description	Estimated Cost
Consultant Design Cost	$55,000
RWA Design Cost	$10,000
Estimated Construction Cost	$752,000
Escalation to Mid-point of Construction – 2.7% per year	$20,304
Construction Total with Inflation	$772,304
Consultant cost During Construction	$93,128
RWA Costs During Construction (Includes temporary system)	$180,000
Engineering and Construction Oversight Sub-total	$273,128
Construction Sub-total (w/o final design)	$1,045,432
Total	**$1,110,432**
Rounded Total	**$1,110,000**
Minimum Anticipated Project Cost (-15%)	$953,617*
Maximum Anticipated Project Cost (+30%)	$1,424,062*

***** Minimum and Maximum project costs include (-15%) or (+30%) American Association of Cost Engineers (AACE) accuracy factors, respectively, on the Construction Subtotal.

In accordance with cost estimating principles, the project costs have been adjusted for inflation forward 12 months from the date of the cost estimate, November 2020, to the mid-point of construction, which is anticipated to be February 2022. An inflation factor of 2.7% per year has been used in the cost estimate. This factor was calculated by Tighe & Bond from the ENR Construction Cost Index from August 2015 through August 2020.

For the construction cost estimate, a 30% contingency is included in the maximum anticipated project cost. This is consistent with the American Association of Cost Engineers (AACE) International Recommended Practices and Standards for a Class 4 estimate, which is included in Appendix I. The cost estimates were developed without detailed engineering data and are considered approximate. A Class 4 estimate is prepared for budget authorization, appropriation, and/or funding. In a Class 4 estimate, the design of the project is normally expected to be accurate within -15% to +30%. This implies that there is a high probability that the final project cost will fall within the specified range. The AACE defines contingency as a specific provision for unforeseeable elements of cost within the defined project scope, particularly where experience has shown that unforeseeable costs are likely to occur. The 30% contingency allowance is included at the beginning of the detailed design stage in anticipation of items that will be further defined in subsequent phases of the design process, as well as for uncertainty in future bid prices and as a means to reduce the risk of possible cost overruns.

3.4.2 Operation and Maintenance Cost

The chlorination system includes the following mechanical equipment that will require routine maintenance:

- Chemical metering pumps
- On-site generators (OSG)
- Water softener
- Water heaters
- Water and brine filters
- Brine boost pumps

Maintenance of equipment will vary depending upon the manufacturer. However, the following basic maintenance activities can be expected.

- Anticipated routine maintenance of the on-site generators is minimal. The newer OSG cells are self-cleaning and reportedly require essentially no maintenance. Two OSG units are estimated to be installed for redundancy, but only one unit will be expected to operate at a time.
- The water softener requires minimal maintenance.
- The water heater will keep the raw water within range for the OSG to work properly, which is between 50-80ºF. This means that the heater only needs to operate during very cold periods (De Nora estimates 121 days/year).

- Maintaining an appropriate amount of salt on-site is also an important factor to consider. The plant averages about 31,177 lbs. Cl_2 each year, which translates into 62,354 lbs. salt/year. This amount will be delivered in predetermined quantities throughout the year.

- Electrolytic cells in the OSGs are expected to last approximately 10 years. Metering pumps should be replaced every 15 years.

4. Electric Service Improvements

4.1 Description of the Proposed Action

The existing electric system will also be upgraded as a part of the West River Water Treatment Plant Improvements Project. These upgrades are necessary in order to replace aged-out equipment and increase the emergency generator capacity to include the entire electrical system and provide capacity for the new DAF building.

This work includes:

- Site Work
    - Excavation required to locate generator, switchgear, automatic transfer switch (ATS) and transformer and associated electrical ductbank to distribute power to the existing buildings and new DAF building

- Electrical
    - New utility service
    - New transformer (furnished by UI)
    - New exterior switchgear and automatic transfer switch with walk-in enclosure
    - New generator
    - Connection box (cam-lock style) for connection of a portable generator as a backup to the facility generator

The proposed improvements will provide the buildings with updated equipment and a correctly sized generator capable of powering the entire facility, as well as a new transformer, switchgear and automatic transfer switch for improved reliability and safety.

4.2 Need for the Proposed Action

Currently, the existing electric system uses an outdoor 500KW diesel generator. The system is designed to shut down various equipment when running on generator power as the entire facility requires more power than the generator can provide. The addition of a DAF system and building would require even more power from an already deficient system. Electric system improvements such as the new transformer, automatic transfer switch (ATS) and switchgear are crucial to maintain a reliable power supply to the entire WRWTP.

The existing electrical equipment is obsolete and is beyond its rated life-expectancy. Most of the equipment is original to the plant and therefore well surpassing the typical 30-year life for this type of equipment. Finding replacement parts for this equipment is becoming more difficult and time consuming. Additionally, RWA would like one system that is able to power both the existing building and proposed DAF building.

Specifically, the existing electrical system requires a replacement based on the following reasons:

- Safety is compromised when working with the existing electrical equipment as it is aging and needs to be replaced.

- Time spent locating replacement parts would be reduced if the electrical equipment was newer and more widely used.

- A larger generator would sufficiently power the existing and proposed buildings without needing to design a system to strategically shutdown specific equipment when generator power is required.

4.3 Analysis of the Alternatives to the Proposed Action

In determining the best course of action to address the issue of upgrading aged electrical equipment to meet the increased electricity demand, several different alternatives were evaluated. The alternatives evaluated include the addition of a smaller generator to the DAF building, replacement of the existing generator with one that is correctly sized to provide power to the entire facility, motor control center (MCC) replacement, and a no action approach.

Alternative 1 – Addition of a Smaller Generator: Install a smaller, 300 KW generator to provide backup power for the new DAF building. This would include a new utility service, utility transformer, 1600A, 480V outdoor main switchgear with automatic transfer switch and walk-in enclosure, and new equipment to replace MCC-1, MCC-2, MCC-3, and panelboards.

While this is a less expensive alternative, it does not address the issue that the existing generator is already too small to handle existing loads. It also would add complexity, electrical coordination issues, and safety issues to operate two generators on this site.

Alternative 2 - Larger Replacement Generator: The replacement of the existing generator with a larger generator that is sized to power the entire facility would provide the existing buildings and proposed DAF building with a more reliable electric system. This would include the same upgrades noted in Alternative 1, but instead of adding a smaller generator, the existing generator would be removed and re-purposed at a RWA facility, and a larger generator would be installed in its place. In addition to the cost savings associated with locating the new ATS in the exterior switchgear, there are constructability benefits as well. Providing a new ATS in the new switchgear allows the contractor to fully install and wire the new switchgear, ATS and generator while the existing switchgear, ATS and generator serve the treatment plant during construction, eliminating the need for electrical tie-ins to the existing ATS if it were reused.

This alternative addresses the safety concerns operators may have when working near aging equipment, while also providing a solution to insufficient generator power for the facility.

Alternative 3 - No Action: Keep the electric system in service without additional generators or completing any upgrades. The existing electrical equipment is old, obsolete, and passed its rated life. The equipment is no longer reliable and finding replacement parts is increasingly more difficult and time consuming. This alternative is not feasible to ensure reliable operation of the WTP. The current generator is already undersized for the facility, and will not support the power requirement of both the DAF and on-site sodium hypochlorite generation. This alternative will result in continued excessive operation and maintenance expenditures to find replacement parts and deal with any potential equipment failures.

The most cost-effective approach to meeting the operational reliability needs of the RWA, to avoid losses resulting from unplanned equipment failure, and to supply the power required by the WRWTP, is to install a new transformer, new exterior switchgear and automatic transfer switch, and replace the existing generator with a larger generator (Alternative No. 2).

This alternative was selected for the following major reasons:

- Significantly increases reliability of the entire WRWTP.
- Provides sufficient generator power for the entire facility.
- Reduces the risk of possible failure of electrical equipment
- Increases the safety of operators working within the facility.
- Constructability benefits and cost savings to fully install and wire the new switchgear, ATS and generator.

4.4 Statement of the Cost to Be Incurred and/or Saved

4.4.1 Capital Cost

This project will result in a capital expenditure of approximately $2.3 million when a (+) 30% contingency factor is included. A breakdown of the capital cost for this project is presented in Table 3 below.

TABLE 3
Estimated Project Capital Cost for Electric Service Improvements

Cost Description	Estimated Cost
Consultant Design Cost	$65,000
RWA Design Cost	$10,000
Estimated Construction Cost	$1,370,000
Escalation to Mid-point of Construction – 2.7% per year	$36,990
Construction total with Inflation	$1,406,990
Consultant cost During Construction	$169,667
RWA Costs during Construction	$128,562
Engineering and Construction Oversight Sub-total	$298,229
Construction Sub-total (w/o final design)	$1,705,219
Total	**$1,780,219**
Rounded Total	**$1,780,000**
Minimum Anticipated Project Cost (-15%)	$1,524,436*
Maximum Anticipated Project Cost (+30%)	$2,291,785*

***** Minimum and Maximum project costs includes (-15%) or (+30%) American Association of Cost Engineers (AACE) accuracy factors, respectively, on the Construction Subtotal.

In accordance with cost estimating principles, the project costs have been adjusted for inflation forward 12 months from the date of the cost estimate, November 2020, to the mid-point of construction, which is anticipated to be February 2022. An inflation factor of 2.7% per year has been used in the cost estimate. This factor was calculated by Tighe & Bond from the ENR Construction Cost Index from August 2015 through August 2020.

For the construction cost estimate, a 30% contingency is included in the maximum anticipated project cost. This is consistent with the American Association of Cost Engineers (AACE) International Recommended Practices and Standards for a Class 4 estimate, which is included in Appendix I. The cost estimates were developed without detailed engineering data and are considered approximate. A Class 4 estimate is prepared for budget authorization, appropriation, and/or funding. In a Class 4 estimate, the design of the project is normally expected to be accurate within -15% to +30%. This implies that there is a high probability that the final project cost will fall within the specified range. The AACE defines contingency as a specific provision for unforeseeable elements of cost within the defined project scope, particularly where experience has shown that unforeseeable costs are likely to occur. The 30% contingency allowance is included at the beginning of the detailed design stage in anticipation of items that will be further defined in subsequent phases of the design process, as well as for uncertainty in future bid prices and as a means to reduce the risk of possible cost overruns.

4.4.2 Operation and Maintenance Cost

The electrical service equipment includes the following mechanical equipment that will require routine maintenance:

- Switchgear
- Automatic Transfer Switch
- Generator

5. Summary of Combined Project Costs

5.1 Cost Summary

The following table summarizes the combined opinion of probable construction costs for the DAF facility addition, sodium hypochlorite system replacement, and electrical service improvements.

TABLE 4

Summary of Combined Project Costs and Variability

Project	*AACE Cost Accuracy*	*Minimum Cost*	*Maximum Cost*	*Calculated Cost*
DAF Facility Addition	-15% to 20%	$9,136,176	$12,588,898	$10,616,000
Sodium Hypochlorite System Replacement	-15% to +30%	$953,617	$1,424,062	$1,110,000
Electric System Improvements	-15% to +30%	$1,524,436	$2,291,785	$1,780,000
TOTAL		$11,614,224	$16,304,738	$13,506,000

The requested approval amount is not-to-exceed $16.3 million and is based upon the higher range of the AACE cost accuracy factors

5.2 Bonds or Other Obligations the RWA Intends to Issue

The annual cost of this project to a typical residential customer, assuming a conservative financing assumption of RWA Bonds, would be approximately $5.55, based on the project cost of $16.3 million.

However, we expect this project to be funded by a combination of funding sources. This project has the potential for funding under the Connecticut Department of Public Health's (CTDPH) Drinking Water State Revolving Fund (DWSRF). By utilizing this funding source, the total financing costs associated with this project are lower than RWA issued bonds. Internally generated funds are also expected to be used. RWA has submitted an Eligibility Application with the State of Connecticut – Department of Public Health (DPH) Drinking Water State Revolving Fund (DWSRF). Since the time of the application, the project scope has become more comprehensive. As a result, RWA is currently working with the DPH to review the project scope, schedule and funding opportunities, and a revised Eligibility Application.

6. Preliminary Project Schedule and Permitting

6.1 Schedule

The project schedule presented below includes typical agency and local approvals from the State of Connecticut Department of Public Health and the municipal Planning and Zoning Commission.

1.	RPB Application	Submitted December 2020
2.	Assuming RPB approval, Final Design, Permitting and Bidding	April to May 2020
3.	Construction	June 2021 to July 2022
4.	Start-up, Optimization and Punch List	July to September 2022

6.2 Permitting

Permitting/agency considerations for construction of the DAF system, sodium hypochlorite system, and electrical service are as follows:

- State of Connecticut Department of Public Health (CTDPH) Nnotification - The RWA will submit a CTDPH Public Water System General Application for Approval or Permit, Chemical Changes Permit, and Surface Water Treatment Plant Permit, and a CTDPH Water Company Owned Land Permit Application and DWSRF Construction Contract Approval for the project.

- State of Connecticut Department of Energy and Environmental Protection Approval - The RWA will submit an Environmental Review Request form to the Connecticut Natural Diversity Database.

- CT Department of Economic and Community Development – The Office of Culture and Tourism will be contacted in order to request information regarding the potential presence of significant historic and archeological resources at or near the proposed project area.

- Town of Woodbridge Permits – The RWA will submit a Site Plan and Zoning Permit Application to the Woodbridge Planning and Zoning Commission.

7. Statement of the Facts on Which the Board Is Expected to Rely in Granting the Authorization Sought

- The existing plant capacity, 10.4 MGD, is reduced to 8 MGD and even 4 MGD during the summer months due to algae. With DAF, an additional 12-inches of filter media and filter underdrain replacement, the design capacity can be restored to 10.4 MGD and the firm capacity can be restored to 7.8 MGD.

- The filter run times are reduced from 30-40 to 12-24 hours due to increased algae during summer months. With DAF the filter runs will be up to 30-40 hours even with algae.

- Decreasing filter run time leads to increased backwashing frequency and backwash water use, increasing power and residual disposal costs.

- The WRWTP currently treats by installing granular activated carbon (GAC) in the filters. With high rate DAF, RWA can practice enhanced coagulation to reduce DBP precursors and may be able to switch from GAC to anthracite in the filters to further reduce costs in the future.

- With DAF, the filters will not have to be backwashed as often, thereby reducing power costs.

- The reliability of the WRWTP will be increased with the installation of DAF, replacement of the existing sodium hypochlorite system, and improvements to the existing electrical system. Currently, WRWTP is the only source of water for the Woodbridge Pump Station and several customers along Route 69.

- Sodium Hypochlorite is the RWA's most important chemical as it is critical to the reliability of treatment and safety of our drinking water to our customers. Eliminating bulk storage of the highly concentrated 12.5% sodium hypochlorite solution will reduce the risk of DBP production (chlorate and chlorite) and corrosive off-gassing odors.

- Replacing the sodium hypochlorite system will allow for the new design requirement of 300 lbs. Cl_2/day to be met. The current vacuum feeders are only rated at 200 lbs./day

- While a dilute 0.8% sodium hypochlorite solution still presents safety concerns, this solution is inherently safer than the 12.5% solution that is currently stored on-site.

- Table salt is stable in a brine silo, therefore reducing the frequency of deliveries that need to be made for the chlorination system. Salt is also less likely to be subject to market fluctuations.

- Installing a new, larger generator that is sized to power the entire facility will ensure that no parts of the facility need to shut down in the event that generator power is required.

- Upgrading the transformer and replacing the switchgear will improve electric service reliability and safety for personnel.

- United Illuminating wants to replace the outdated 4-bay trans-closure transformer with a newer reliable transformer. This facility is a critical facility and has one of the older model transformer in the UI inventory.

8. Explanation of Unusual Circumstances Involved in the Application

There were no unusual circumstances involved in this application.

9. Conclusion

The WRWTP provides service to over 44,000 customers or approximately 9.6% of the RWA demand when the plant is running at capacity and is an important source of supply for RWA's water system. It is a source of supply for two consecutive water systems a partial redundant source of supply for the New Haven Service Area, as well as for the Seymour and Derby service areas. The plant is frequently only able to operate at 8 MGD, or 77% of its design capacity, during seasonal peak demands which contributes to system strain to match water demand. WRWTP is important for the redundancy of RWA's water treatment systems. The addition of DAF and the additional media depth will improve the reliability of the WRWTP.

Based on the studies completed from November 2014 through November 2020, at $16.3 million, the selected project maximizes the cost and non-cost benefits for the RWA. As such, the RWA has concluded that the proposed action is consistent with and advances the policies and goals of the South Central Connecticut Regional Water Authority. .

Appendix H

Engineer’s Opinion of Probable Cost for DAF System Upgrade

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST Tighe&Bond

Project: **West River Water Treatment Plant Dissolved Air Flotation Upgrade Project**
Location: **Woodbridge, CT**

Estimate Type:
- [ ] Conceptual
- [ ] Preliminary Design
- [x] Design Development
- [ ] Construction
- [ ] Change Order

50 % Complete

Prepared By: Tighe & Bond
Date Prepared: 11/25/2020
T&B Project No.: S-1889-30

Spec. Section	Item No.	Description	Qty	Units	Material/Installed Cost $/Unit	Material/Installed Cost Total	Installation Total	Total
DIVISION 1 - GENERAL CONDITIONS			(Costs included in unit prices in other Divisions)					
	1	15% of Construction Subtotal	1	LS	$1,044,564	$1,044,564		$1,044,564
SUBTOTAL - DIVISION 1								**$1,044,564**
DIVISION 2 - SITE WORK								
02075	1	Geosynthetics	1	LS	$11,000	$11,000		$11,000
02200	2	Site Preparation						
	a	Haybales & Silt Fence	150	LF	$10	$1,500		$1,500
	b	Silt Sac	1	EA	$90	$90		$90
02210	3	Subsurface Investigations	1	LS	$11,000	$11,000		$11,000
02225	4	Selective Demolition						
	a	Exterior Drain Piping and Headwall	1	LS	$550	$550		$550
	b	Trees	3	EA	$1,100	$3,300		$3,300
	c	Chain Link Fence Remove and Reset	200	LF	$45	$9,000		$9,000
	d	Clearing and Grubbing	5,800	SF	$2	$11,600		$11,600
	e	Demolish 36" elbow and pipe	2,100	LB	$2	$4,200		$4,200
	f	Demolish and Relocate Sample Tap	1	LS	$500	$500		$500
	g	Demolish 4" chlorine booster pipe bend	1	LS	$500	$500		$500
	h	Core Hole for 42" DI Influent Pipe	1	LS	$5,000	$5,000		$5,000
	i	Core (3) Holes for polymer, water, and sump piping	1	LS	$5,000	$5,000		$5,000
	j	Core Hole for 36" DI Effluent Pipe	1	LS	$5,000	$5,000		$5,000
	k	Demolish Windows and Wall at New Door Location	1	LS	$5,000	$5,000		$5,000
	l	Raise filter surface wash pipes	4	EA	$3,000	$12,000		$12,000
	m	Demolish Scrubber	1	LS	$11,000	$11,000		$11,000
	n	Scrubber Media Disposal	21	TON	$200	$4,200		$4,200
	o	Filter Underdrain Demolition	2,400	SF	$80	$192,000		$192,000
02315	5	Excavation/Backfill/Compaction						
	a	Building foundation, walls, and Retaining Walls	1,200	CY	$80	$96,000		$96,000
	b	36" and 42" Pipe	52	CY	$80	$4,166		$4,166
	c	Drop Inlets	40	CY	$80	$3,200		$3,200
	d	18" Sanitary Drain	83	CY	$80	$6,667		$6,667
	e	Plant Water, Polymer, and Sump Pump Lines	4	CY	$80	$296		$296
02317	6	Underground Warning Tape	1,000	LF	$2	$2,000		$2,000
02320	7	Borrow Materials						
	a	Crushed stone - Below Slab	188	TON	$40	$7,524		$7,524
	b	Crushed Stone - Under Drains	19	TON	$40	$760		$760
	c	Process Trap Rock	130	TON	$40	$5,200		$5,200
02503	8	Sanitary Sewer and Storm Drain Systems Testing	1	LS	$1,000	$1,000		$1,000

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST Tighe&Bond

Project: **West River Water Treatment Plant Dissolved Air Flotation Upgrade Project**
Location: **Woodbridge, CT**

Estimate Type:
- ☐ Conceptual
- ☐ Preliminary Design
- ☑ Design Development
- ☐ Construction
- ☐ Change Order
- 50 % Complete

Prepared By: Tighe & Bond
Date Prepared: 11/25/2020
T&B Project No.: S-1889-30

Spec. Section	Item No.	Description	Qty	Units	Material/Installed Cost $/Unit	Material/Installed Cost Total	Installation Total	Total
02515	9	Polyvinyl Chloride (PVC) Pipe and Fittings						
	a	6" Perf PVC Pipe	280	LF	$110	$30,800		$30,800
	b	4" Perf PVC Pipe	335	LF	$100	$33,500		$33,500
	c	12" Roof Leader Piping	150	LF	$130	$19,500		$19,500
02516	10	HDPE						
	a	18" HDPE	185	LF	$110	$20,350		$20,350
02530	11	Manholes & Catchbasins						
	a	Drop Inlets	3	EA	$4,000	$12,000		$12,000
	b	Manholes	1	EA	$10,500	$10,500		$10,500
02740	12	Bituminous Concrete Pavement						
	a	Paving and Repair- Driveway	600	SY	$30	$18,000		$18,000
02775	13	Portland Cement Sidewalks	2	CY	$1,500	$3,000		$3,000
02820	14	Chain Link Fences						
	a	Retaining Wall Fence	65	LF	$40	$2,600		$2,600
02922	15	Hydroseeding						
	a	Loam	450	CY	$50	$22,500		$22,500
	b	Hydroseeding	1	LS	$1,000	$1,000		$1,000
SUBTOTAL - DIVISION 2								$593,003
DIVISION 3 - CONCRETE								
03300	1	Cast in Place Concrete						
	a	Building base mat	270	CY	$1,200	$324,000		$324,000
	b	Foundation and tank separation and baffle walls	480	CY	$1,500	$720,000		$720,000
	c	Elevated slabs and beams	80	CY	$1,500	$120,000		$120,000
	d	Exterior concrete apron @ East entrance door	3	CY	$100	$300		$300
	e	Retaining walls	50	CY	$1,500	$75,000		$75,000
	f	Housekeeping pads	1	LS	$5,000	$5,000		$5,000
	g	Concrete site stairs	5	CY	$1,500	$7,500		$7,500
	h	Pier at bottom of exterior aluminum stair	2	CY	$1,000	$2,000		$2,000
	i	Pier at bottom of room aluminum stair	2	CY	$1,000	$2,000		$2,000
	j	Concrete at pipe penetration into existing rapid mix tank	2	CY	$2,000	$4,000		$4,000
	k	Concrete infill at existing building brick removal	5	CY	$1,200	$6,000		$6,000
	l	Concrete fillets	9	LS	$1,000	$9,000		$9,000
	m	Concrete fillets and fill	15	LS	$800	$12,000		$12,000
	n	Raise Overflow Weirs in Contact Tanks	1	CY	$1,200	$1,200	$3,200	$4,400
03410	2	Precast Structural Concrete						
	a	Double tee roof planks	3,355	SF	$160	$536,800		$536,800
SUBTOTAL - DIVISION 3								$1,828,000

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST Tighe&Bond

Project: West River Water Treatment Plant Dissolved Air Flotation Upgrade Project

Location: Woodbridge, CT

Estimate Type:
- ☐ Conceptual
- ☐ Preliminary Design
- ☑ Design Development
- ☐ Construction
- ☐ Change Order
- 50 % Complete

Prepared By: Tighe & Bond
Date Prepared: 11/25/2020
T&B Project No.: S-1889-30

Spec. Section	Item No.	Description	Qty	Units	Material/Installed Cost $/Unit	Material/Installed Cost Total	Installation Total	Total
DIVISION 4 - MASONRY								
04810	1	Unit Masonry Assembly						
	a	8" Glazed CMU & 4" Brick exterior wall	2,445	SF	$90	$220,050		$220,050
	b	8" CMU & 4" Brick Exterior Wall @ Electrical Room & Parapets	830	SF	$75	$62,250		$62,250
	c	8" CMU Interior Walls	600	SF	$35	$21,000		$21,000
	d	Brick Cavity Wall at Pipe Gallery	1,030	SF	$60	$61,800		$61,800
	e	Brick removal on existing Filter Building	250	SF	$25	$6,250		$6,250
	f	Brick removal and reinstallation to install flashing on existing Filter Building	50	SF	$55	$2,750		$2,750
	g	Miscellaneous masonry repairs at new door opening in existing Filter Building	1	LS	$1,500	$1,500		$1,500
SUBTOTAL - DIVISION 4								$375,600
DIVISION 5 - METALS								
05500	1	Miscellaneous Metals						
	a	Aluminum Grating	700	SF	$45	$31,500		$31,500
	b	Exterior Stair Risers	17	EA	$300	$5,100		$5,100
	c	Interior Stair Risers	30	EA	$300	$9,000		$9,000
	d	Exterior Roof Stair Risers	29	EA	$300	$8,700		$8,700
	e	Aluminum Guardrail - Exterior Lower Bridge & Stairs	120	LF	$115	$13,800		$13,800
	f	Aluminum Guardrail and Gates - Floc Tank and DAF Basins	250	LF	$115	$28,750		$28,750
	g	Aluminum Guardrail - Pipe Gallery Stairs	65	LF	$115	$7,475		$7,475
	h	Aluminum Guardrail - Roof Perimeter	220	LF	$115	$25,300		$25,300
	i	Aluminum Guardrail - Roof on Filter Building	50	LF	$115	$5,750		$5,750
	j	Aluminum Guardrail - Roof Bridge	40	LF	$115	$4,600		$4,600
	k	Aluminum Guardrail - Roof Access Stairs	36	LF	$115	$4,140		$4,140
	l	Aluminum Structural Framing - Exterior Walkway & Stairs	1,350	LB	$20	$27,000		$27,000
	m	Aluminum Structural Framing - Interior Grating and Pump Support	600	LB	$20	$12,000		$12,000
	n	Aluminum Structural Framing - Exterior Roof Stairs and Walkway	1,200	LB	$20	$24,000		$24,000
	o	Aluminum Structural Framing - Interior Pipe Gallery Stair	1,250	LB	$20	$25,000		$25,000
	p	Galvanized Steel Lintels	2,566	LB	$10	$25,660		$25,660
	q	Galvanized Steel Lateral Support Angles at Top of Interior CMU Walls	120	LB	$10	$1,200		$1,200
	r	Stainless Steel Weir Plates & Angles	3,200	LB	$25	$80,000		$80,000
	s	Aluminum Gutters	132	FT	$40	$5,280		$5,280
SUBTOTAL - DIVISION 5								$344,255
DIVISION 6 - WOOD & PLASTICS								
06100	1	Rough Carpentry						
	a	Rough Carpentry	1	LS	$5,000	$5,000		$5,000
	b	Miscellaneous Items	1	LS	$5,000	$5,000		$5,000
SUBTOTAL - DIVISION 6								$10,000

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST Tighe&Bond

Project: **West River Water Treatment Plant Dissolved Air Flotation Upgrade Project**
Location: **Woodbridge, CT**

Estimate Type:
- ☐ Conceptual
- ☐ Preliminary Design
- ☑ Design Development
- ☐ Construction
- ☐ Change Order
- 50 % Complete

Prepared By: Tighe & Bond
Date Prepared: 11/25/2020
T&B Project No.: S-1889-30

Spec. Section	Item No.	Description	Qty	Units	Material/Installed Cost $/Unit	Material/Installed Cost Total	Installation Total	Total
DIVISION 7 - THERMAL & MOISTURE PROTECTION								
07110	1	Dampproofing behind retaining walls	600	SF	$3	$1,800		$1,800
07170	2	Bentonite Waterproofing - Under Slab and Foundation Walls	6,538	SF	$10	$65,379		$65,379
07210	3	Building Insulation						
	a	Foundation Insulation	1,120	SF	$3	$3,360		$3,360
	b	Building Insulation	4,550	SF	$3	$13,650		$13,650
	c	Roofing Insulation	3,355	SF	$3	$10,065		$10,065
07541	4	Thermoplastic Membrane Roofing System	3,355	SF	$25	$83,875		$83,875
07620	5	Sheet Metal Flashing and Trim						
	a	Painted Metal Trim, Gutters & Downspouts	260	LF	$50	$13,000		$13,000
	b	Painted Metal Coping	101	LF	$75	$7,575		$7,575
07920	7	Joint Sealants	1	LS	$15,000	$15,000		$15,000
SUBTOTAL - DIVISION 7								$213,704
DIVISION 8 - DOORS & WINDOWS								
08110	1	Steel Doors & Frames						
	a	Exterior Insulated Double Door	1	EA	$5,000	$5,000		$5,000
	b	Electrical Room Double Door	1	EA	$5,000	$5,000		$5,000
08410	2	Aluminum Framed Storefront Door & Windows						
	a	Exterior Door In DAF Building	1	EA	$4,000	$4,000		$4,000
	b	New Exterior Door in Existing Filter Building	1	EA	$4,000	$4,000		$4,000
	c	Windows in DAF Building	7	EA	$3,000	$21,000		$21,000
	d	New Windows in Existing Filter Building	3	EA	$3,000	$9,000		$9,000
SUBTOTAL - DIVISION 8								$48,000
DIVISION 9 - FINISHES								
09900	1	Painting						
	a	Walls	1,200	SF	$6	$7,200		$7,200
	b	Piping (36" Influent, 36" Effluent, and Drain Piping)	500	SF	$10	$5,000		$5,000
	c	Doors	80	SF	$10	$800		$800
	d	Miscellaneous (Equipment to be Painted)	1	LS	$5,000	$5,000		$5,000
SUBTOTAL - DIVISION 9								$18,000
DIVISION 10 - SPECIALTIES								
10440	1	Signage	1	LS	$5,000	$5,000		$5,000
10522	2	Fire Extinguishers and Accessories	1	LS	$525	$525		$525
SUBTOTAL - DIVISION 10								$5,525

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST Tighe&Bond

Project: **West River Water Treatment Plant Dissolved Air Flotation Upgrade Project**
Location: **Woodbridge, CT**

Estimate Type:
- ☐ Conceptual
- ☐ Preliminary Design
- ☑ Design Development
- ☐ Construction
- ☐ Change Order
- 50 % Complete

Prepared By: Tighe & Bond
Date Prepared: 11/25/2020
T&B Project No.: S-1889-30

Spec. Section	Item No.	Description	Qty	Units	Material/Installed Cost $/Unit	Material/Installed Cost Total	Installation Total	Total
DIVISION 11 - EQUIPMENT								
11210	1	Pumping Equipment						
	a	Sump Pump	1	EA	$1,500	$1,500		$1,500
11228	2	Packaged Dissolved Air Flotation System	1	LS	$900,000	$900,000	$360,000	$1,260,000
	a	Recycle Pumps (including standby)	3	EA	Included			
	b	Saturation Tank & Accessories	2	EA	Included			
	c	Air Compressors	2	EA	Included			
	d	Mechanical Weir	2	EA	Included			
	e	Mixers	4	EA	Included			
	f	Influent Weir	2	EA	Included			
	g	Air Header Manifold	2	Sets	Included			
	h	Collection System	2	Sets	Included			
	I	Wash Water System & Valves	2	Sets	Included			
	j	Control Panel	2	EA	Included			
SUBTOTAL - DIVISION 11								$1,261,500
DIVISION 13 - SPECIAL CONSTRUCTION								
	1	PCB Abatement	1	LS	$10,000	$10,000		$10,000
13220	2	Filter Underdrain	2,400	SF	$200	$480,000	$192,000	$672,000
13222	3	Removal of Existing Filter Media	250	CY	$325	$81,250		$81,250
13223	4	Filter Media						
	a	10" Sand	75	CY	$160	$12,000	$20,000	$32,000
	b	36" Anthracite	284	CY	$370	$104,895	$70,000	$174,895
13420	5	Instrumentation						
	a	Level Transmitter	2	EA	$4,000	$8,000		$8,000
	b	Turbidimeter	1	EA	$4,000	$4,000		$4,000
	c	Miscellaneous	1	LS	$5,000	$5,000		$5,000
13850	6	Fire Alarm System	1	LS	$5,000	$5,000		$5,000
13860	7	Intrusion Detection Systems	1	LS	$5,000	$5,000		$5,000
SUBTOTAL - DIVISION 13								$997,145

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST Tighe&Bond

Project: **West River Water Treatment Plant Dissolved Air Flotation Upgrade Project**
Location: **Woodbridge, CT**

Estimate Type: ☐ Conceptual ☐ Preliminary Design ☑ Design Development ☐ Construction ☐ Change Order 50 % Complete

Prepared By: Tighe & Bond
Date Prepared: 11/25/2020
T&B Project No.: S-1889-30

Spec. Section	Item No.	Description	Qty	Units	Material/Installed Cost $/Unit	Material/Installed Cost Total	Installation Total	Total
DIVISION 15 - MECHANICAL								
15080	1	Mechanical Insulation						
	a	1-1/2 inch Water line	110	LF	$10	$1,100		$1,100
	b	1-1/2 inch Polymer Feed Line	90	LF	$10	$900		$900
	c	3" Plant Water Piping	150	LF	$15	$2,250		$2,250
15101	2	Ductile Iron Pipe and Fittings						
	a	DAF Effluent						
		42" Wall Pipe	1	EA	$3,000	$3,000		$3,000
		36" DI Pipe	20	LF	$310	$6,200		$6,200
		42" DI Pipe	20	LF	$330	$6,600		$6,600
		36" Tee	1	EA	$24,000	$24,000	$1,780	$25,780
		42" DI Elbow	1	EA	$12,000	$12,000	$1,780	$13,780
		36" 45 Degree Elbow	2	EA	$16,000	$32,000	$3,560	$35,560
		42" Romac RC400 Steel Coupling	1	EA	$4,000	$4,000	$1,780	$5,780
		Link seal 525-C	66	EA	$30	$1,980		$1,980
		36" FL x PE CL X 3-6	1	EA	$3,000	$3,000	$1,780	$4,780
		36" FL x FL CL x 2-0	1	EA	$4,000	$4,000	$1,780	$5,780
		36" Flange Full Face Gasket	14	EA	$260	$3,640		$3,640
	b	DAF Influent						
		42" DI Pipe	75	LF	$330	$24,750		$24,750
		42" 45 Degree Elbow	3	EA	$16,000	$48,000	$5,340	$53,340
		42" x 36" Tee	3	EA	$25,000	$75,000	$5,340	$80,340
		36" DI 90 Degree Elbow	3	EA	$20,000	$60,000	$5,340	$65,340
		36" Seal and Sleeve	3	EA	$3,000	$9,000	$2,670	$11,670
		42" MJ Cap	1	EA	$4,200	$4,200	$890	$5,090
		36" Influent Pipe	15	LF	$310	$4,650		$4,650
		42" Wall Pipe	1	EA	$1,400	$1,400		$1,400
		42" Romac RC400 Steel Coupling	1	EA	$4,000	$4,000		$4,000
		36" Romagrip Accessory Pack	3	EA	$2,500	$7,500		$7,500
		42" Romagrip Accessory Pack	9	EA	$4,000	$36,000		$36,000
		36" Fl x PE CL x 6-0	3	EA	$8,000	$24,000		$24,000
		Link seal 525-C	38	EA	$30	$1,140		$1,140
	c	Bolts	600	EA	$50	$30,000		$30,000
	d	Hex Nut	600	EA	$20	$12,000		$12,000
	e	18" DI Process Drain	75	LF	$150	$11,250		$11,250
	f	6" Floc Tank Drain Lines	60	LF	$110	$6,600		$6,600
	g	6" Recycle Pipe	140	LF	$110	$15,400		$15,400
	h	Rigid Insulation for 36"	10	LF	$7	$70		$70
	i	3" Plant Water Piping	150	LF	$85	$12,750		$12,750

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST Tighe&Bond

Project: **West River Water Treatment Plant Dissolved Air Flotation Upgrade Project**
Location: **Woodbridge, CT**

Estimate Type:
- [ ] Conceptual
- [ ] Preliminary Design
- [x] Design Development
- [ ] Construction
- [ ] Change Order
- 50 % Complete

Prepared By: Tighe & Bond
Date Prepared: 11/25/2020
T&B Project No.: S-1889-30

Spec. Section	Item No.		Description	Qty	Units	Material/Installed Cost $/Unit	Material/Installed Cost Total	Installation Total	Total
15102	3		Carbon Steel Piping for Propane						
		a	3/4" pipe	150	LF	$50	$7,500		$7,500
		b	Fittings	1	EA	$3,000	$3,000		$3,000
15103	4		Copper Pipe and Fittings						
		a	1-1/2" Cold Water Piping	110	LF	$85	$9,350		$9,350
		b	1-1/2" Process Water Piping	150	LF	$85	$12,750		$12,750
15104	5		Plastic Pipe and Fittings						
		a	1-1/2" Polymer Feed Piping	100	LF	$110	$11,000		$11,000
15110	6		Valves						
		a	Flap Valves	6	EA	$500	$3,000		$3,000
		b	36" Butterfly Valves (DAF Influent, Effluent)	4	EA	$25,000	$100,000	$16,000	$116,000
		c	6" Mud Valves	3	EA	$2,000	$6,000		$6,000
		d	3/4" Ball valves for Propane	5	EA	$200	$1,000		$1,000
15120	7		Piping Specialties						
		a	Hose bibbs	2	EA	$250	$500		$500
15150	8		Sanitary Waste and Vent Piping						
		a	1 1/2" Sump Pump Drain Pipe	100	LF	$110	$11,000		$11,000
15951	9		Fuel Fired Unit Heaters (Gas)						
		a	GUH	2	EA	$3,000	$6,000		$6,000
		b	Vent	2	EA	$1,500	$3,000		$3,000
15721	10		Air Handling Units	1	LS	$35,000	$35,000		$35,000
15733	11		Split System AC Unit	1	LS	$7,500	$7,500	$6,000	$13,500
15810	12		Ducts						
		a	14" Diameter Duct	20	LF	$135	$2,700		$2,700
		b	16" Diameter Duct	15	LF	$175	$2,625		$2,625
		c	20" Diameter Duct	15	LF	$240	$3,600		$3,600
		d	22" Diameter Duct	10	LF	$260	$2,600		$2,600
		e	27" Diameter Duct	10	LF	$350	$3,500		$3,500
		f	10" x 10" Duct	25	LF	$115	$2,875		$2,875
		g	8" x 8" Duct	30	LF	$115	$3,450		$3,450
15820	13		Ductwork Accessories						
		a	20" x 10" Supply Grille	4	EA	$110	$440		$440
		b	8" x 8" Supply Grille	2	EA	$80	$160		$160
		c	6" x 6" Supply Grille	1	EA	$70	$70		$70
		d	28" x 14" Return/Exhaust inlet Grille	3	EA	$130	$390		$390
		e	transitions as shown	1	LS	$9,000	$9,000		$9,000

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST Tighe&Bond

Project: **West River Water Treatment Plant Dissolved Air Flotation Upgrade Project**
Location: **Woodbridge, CT**

Estimate Type: ☐ Conceptual ☐ Preliminary Design ☑ Design Development ☐ Construction ☐ Change Order 50 % Complete

Prepared By: Tighe & Bond
Date Prepared: 11/25/2020
T&B Project No.: S-1889-30

Spec. Section	Item No.	Description	Qty	Units	Material/Installed Cost $/Unit	Material/Installed Cost Total	Installation Total	Total
15850	14	Air Outlets and Inlets						
	a	Louvers (L-1)	1	EA	$600	$600		$600
	c	Exhaust Fan (EF-1)	1	EA	$6,000	$6,000		$6,000
15935	15	HVAC Control System	1	LS	$20,000	$20,000		$20,000
15950	16	Testing, Adjusting, and Balancing	1	LS	$3,000	$3,000		$3,000
	18	Davit	2	EA	$5,000	$10,000		$10,000
SUBTOTAL - DIVISION 15								$834,030
DIVISION 16 - ELECTRICAL								
16091	1	Minor Electrical Demolition	1	LS	$20,000	$20,000		$20,000
16120	2	Conductors and Cable	1	LS	$30,000	$30,000		$30,000
16131	3	Conduit	1	LS	$75,000	$75,000		$75,000
16140	4	Wiring Devices	1	LS	$15,000	$15,000		$15,000
16410	5	Enclosed Switches and Circuit Breakers	1	LS	$15,000	$15,000		$15,000
16440	6	Panelboards	1	LS	$15,000	$15,000		$15,000
16445	7	Motor Control Centers	1	LS	$200,000	$200,000		$200,000
16460	8	Dry Type Transformers	1	LS	$15,000	$15,000		$15,000
16500	9	Luminaries	1	LS	$30,000	$30,000		$30,000
16520	10	Exterior Luminaries	1	LS	$5,000	$5,000		$5,000
	11	SCADA Integration	1	LS	$15,000	$15,000		$15,000
SUBTOTAL - DIVISION 16								$435,000
SUBTOTAL CONSTRUCTION COST						**$7,309,087**	**$699,240**	**$8,008,327**
Escalation (from Nov. 2020 to Mid-Point Construction Nov. 2021)								**$160,167**
TOTAL CONSTRUCTION COST								**$8,168,493**
CONSTRUCTION PHASE ENGINEERING			@	12%				**$980,219**
CONTINGENCY			@	15%				**$1,225,274**
TOTAL								**$10,373,986**
							SAY	***$10,400,000***

Appendix I

American Association of Cost Engineers (AACE) standards

aace International

AACE International Recommended Practice No. 18R-97

COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

TCM Framework: 7.3 – Cost Estimating and Budgeting

Acknowledgments:
Peter Christensen, CCE (Author)
Larry R. Dysert, CCC (Author)
Jennifer Bates, CCE
Dorothy J. Burton
Robert C. Creese, PE CCE
John K. Hollmann, PE CCE
Kenneth K. Humphreys, PE CCE
Donald F. McDonald, Jr. PE CCE
C. Arthur Miller
Bernard A. Pietlock, CCC
Wesley R. Querns, CCE
Don L. Short, II

COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

TCM Framework: 7.3 – Cost Estimating and Budgeting

February 2, 2005

PURPOSE

As a recommended practice of AACE International, the Cost Estimate Classification System provides guidelines for applying the general principles of estimate classification to project cost estimates (i.e., cost estimates that are used to evaluate, approve, and/or fund projects). The Cost Estimate Classification System maps the phases and stages of project cost estimating together with a generic maturity and quality matrix, which can be applied across a wide variety of industries.

This addendum to the generic recommended practice provides guidelines for applying the principles of estimate classification specifically to project estimates for engineering, procurement, and construction (EPC) work for the process industries. This addendum supplements the generic recommended practice (17R-97) by providing:

- a section that further defines classification concepts as they apply to the process industries;
- charts that compare existing estimate classification practices in the process industry; and
- a chart that maps the extent and maturity of estimate input information (project definition deliverables) against the class of estimate.

As with the generic standard, an intent of this addendum is to improve communications among all of the stakeholders involved with preparing, evaluating, and using project cost estimates specifically for the process industries.

It is understood that each enterprise may have its own project and estimating processes and terminology, and may classify estimates in particular ways. This guideline provides a generic and generally acceptable classification system for process industries that can be used as a basis to compare against. It is hoped that this addendum will allow each user to better assess, define, and communicate their own processes and standards in the light of generally-accepted cost engineering practice.

INTRODUCTION

For the purposes of this addendum, the term process industries is assumed to include firms involved with the manufacturing and production of chemicals, petrochemicals, and hydrocarbon processing. The common thread among these industries (for the purpose of estimate classification) is their reliance on process flow diagrams (PFDs) and piping and instrument diagrams (P&IDs) as primary scope defining documents. These documents are key deliverables in determining the level of project definition, and thus the extent and maturity of estimate input information.

Estimates for process facilities center on mechanical and chemical process equipment, and they have significant amounts of piping, instrumentation, and process controls involved. As such, this addendum may apply to portions of other industries, such as pharmaceutical, utility, metallurgical, converting, and similar industries. Specific addendums addressing these industries may be developed over time.

This addendum specifically does not address cost estimate classification in nonprocess industries such as commercial building construction, environmental remediation, transportation infrastructure, "dry" processes such as assembly and manufacturing, "soft asset" production such as software development, and similar industries. It also does not specifically address estimates for the exploration, production, or transportation of mining or hydrocarbon materials, although it may apply to some of the intermediate processing steps in these systems.

The cost estimates covered by this addendum are for engineering, procurement, and construction (EPC) work only. It does not cover estimates for the products manufactured by the process facilities, or for research and development work in support of the process industries. This guideline does not cover the significant building construction that may be a part of process plants. Building construction will be covered in a separate addendum.

This guideline reflects generally-accepted cost engineering practices. This addendum was based upon the practices of a wide range of companies in the process industries from around the world, as well as published references and standards. Company and public standards were solicited and reviewed by the AACE International Cost Estimating Committee. The practices were found to have significant commonalities that are conveyed in this addendum.

COST ESTIMATE CLASSIFICATION MATRIX FOR THE PROCESS INDUSTRIES

The five estimate classes are presented in figure 1 in relationship to the identified characteristics. Only the level of project definition determines the estimate class. The other four characteristics are secondary characteristics that are generally correlated with the level of project definition, as discussed in the generic standard. The characteristics are typical for the process industries but may vary from application to application.

This matrix and guideline provide an estimate classification system that is specific to the process industries. Refer to the generic standard for a general matrix that is non-industry specific, or to other addendums for guidelines that will provide more detailed information for application in other specific industries. These will typically provide additional information, such as input deliverable checklists to allow meaningful categorization in those particular industries.

	Primary Characteristic	***Secondary Characteristic***			
ESTIMATE CLASS	**LEVEL OF PROJECT DEFINITION** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a]	**PREPARATION EFFORT** Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Study or Feasibility	Equipment Factored or Parametric Models	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or Bid/ Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% to +15%	5 to 100

Notes: [a] The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

[b] If the range index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

Figure 1. – Cost Estimate Classification Matrix for Process Industries
CHARACTERISTICS OF THE ESTIMATE CLASSES

The following charts (figures 2a through 2e) provide detailed descriptions of the five estimate classifications as applied in the process industries. They are presented in the order of least-defined estimates to the most-defined estimates. These descriptions include brief discussions of each of the estimate characteristics that define an estimate class.

For each chart, the following information is provided:

- **Description:** a short description of the class of estimate, including a brief listing of the expected estimate inputs based on the level of project definition.
- **Level of Project Definition Required:** expressed as a percent of full definition. For the process industries, this correlates with the percent of engineering and design complete.
- **End Usage:** a short discussion of the possible end usage of this class of estimate.
- **Estimating Methods Used:** a listing of the possible estimating methods that may be employed to develop an estimate of this class.
- **Expected Accuracy Range:** typical variation in low and high ranges after the application of contingency (determined at a 50% level of confidence). Typically, this results in a 90% confidence that the actual cost will fall within the bounds of the low and high ranges.
- **Effort to Prepare:** this section provides a typical level of effort (in hours) to produce a complete estimate for a US$20,000,000 plant. Estimate preparation effort is highly dependent on project size, project complexity, estimator skills and knowledge, and on the availability of appropriate estimating cost data and tools.
- **ANSI Standard Reference (1989) Name:** this is a reference to the equivalent estimate class in the existing ANSI standards.
- **Alternate Estimate Names, Terms, Expressions, Synonyms:** this section provides other commonly used names that an estimate of this class might be known by. These alternate names are not endorsed by this Recommended Practice. The user is cautioned that an alternative name may not always be correlated with the class of estimate as identified in the chart.

<table>
<tr><th colspan="2">CLASS 5 ESTIMATE</th></tr>
<tr><td>Description:
Class 5 estimates are generally prepared based on very limited information, and subsequently have wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systemic manner. Class 5 estimates, due to the requirements of end use, may be prepared within a very limited amount of time and with little effort expended—sometimes requiring less than an hour to prepare. Often, little more than proposed plant type, location, and capacity are known at the time of estimate preparation.

Level of Project Definition Required:
0% to 2% of full project definition.

End Usage:
Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc.</td><td>Estimating Methods Used:
Class 5 estimates virtually always use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, and other parametric and modeling techniques.

Expected Accuracy Range:
Typical accuracy ranges for Class 5 estimates are - 20% to -50% on the low side, and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.

Effort to Prepare (for US$20MM project):
As little as 1 hour or less to perhaps more than 200 hours, depending on the project and the estimating methodology used.

ANSI Standard Reference Z94.2-1989 Name:
Order of magnitude estimate (typically -30% to +50%).

Alternate Estimate Names, Terms, Expressions, Synonyms:
Ratio, ballpark, blue sky, seat-of-pants, ROM, idea study, prospect estimate, concession license estimate, guesstimate, rule-of-thumb.</td></tr>
</table>

Figure 2a. – Class 5 Estimate

CLASS 4 ESTIMATE

Description:
Class 4 estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1% to 15% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems, and preliminary engineered process and utility equipment lists.

Level of Project Definition Required:
1% to 15% of full project definition.

End Usage:
Class 4 estimates are prepared for a number of purposes, such as but not limited to, detailed strategic planning, business development, project screening at more developed stages, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next stage.

Estimating Methods Used:
Class 4 estimates virtually always use stochastic estimating methods such as equipment factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, the Miller method, gross unit costs/ratios, and other parametric and modeling techniques.

Expected Accuracy Range:
Typical accuracy ranges for Class 4 estimates are -15% to -30% on the low side, and +20% to +50% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.

Effort to Prepare (for US$20MM project):
Typically, as little as 20 hours or less to perhaps more than 300 hours, depending on the project and the estimating methodology used.

ANSI Standard Reference Z94.2-1989 Name:
Budget estimate (typically -15% to + 30%).

Alternate Estimate Names, Terms, Expressions, Synonyms:
Screening, top-down, feasibility, authorization, factored, pre-design, pre-study.

Figure 2b. – Class 4 Estimate

CLASS 3 ESTIMATE

Description:
Class 3 estimates are generally prepared to form the basis for budget authorization, appropriation, and/or funding. As such, they typically form the initial control estimate against which all actual costs and resources will be monitored. Typically, engineering is from 10% to 40% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, preliminary piping and instrument diagrams, plot plan, developed layout drawings, and essentially complete engineered process and utility equipment lists.

Level of Project Definition Required:
10% to 40% of full project definition.

End Usage:
Class 3 estimates are typically prepared to support full project funding requests, and become the first of the project phase "control estimates" against which all actual costs and resources will be monitored for variations to the budget. They are used as the project budget until replaced by more detailed estimates. In many owner organizations, a Class 3 estimate may be the last estimate required and could well form the only basis for cost/schedule control.

Estimating Methods Used:
Class 3 estimates usually involve more deterministic estimating methods than stochastic methods. They usually involve a high degree of unit cost line items, although these may be at an assembly level of detail rather than individual components. Factoring and other stochastic methods may be used to estimate less-significant areas of the project.

Expected Accuracy Range:
Typical accuracy ranges for Class 3 estimates are -10% to -20% on the low side, and +10% to +30% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.

Effort to Prepare (for US$20MM project):
Typically, as little as 150 hours or less to perhaps more than 1,500 hours, depending on the project and the estimating methodology used.

ANSI Standard Reference Z94.2-1989 Name:
Budget estimate (typically -15% to + 30%).

Alternate Estimate Names, Terms, Expressions, Synonyms:
Budget, scope, sanction, semi-detailed, authorization, preliminary control, concept study, development, basic engineering phase estimate, target estimate.

Figure 2c. – Class 3 Estimate

CLASS 2 ESTIMATE	
Description: Class 2 estimates are generally prepared to form a detailed control baseline against which all project work is monitored in terms of cost and progress control. For contractors, this class of estimate is often used as the "bid" estimate to establish contract value. Typically, engineering is from 30% to 70% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, piping and instrument diagrams, heat and material balances, final plot plan, final layout drawings, complete engineered process and utility equipment lists, single line diagrams for electrical, electrical equipment and motor schedules, vendor quotations, detailed project execution plans, resourcing and work force plans, etc. **Level of Project Definition Required:** 30% to 70% of full project definition. **End Usage:** Class 2 estimates are typically prepared as the detailed control baseline against which all actual costs and resources will now be monitored for variations to the budget, and form a part of the change/variation control program.	**Estimating Methods Used:** Class 2 estimates always involve a high degree of deterministic estimating methods. Class 2 estimates are prepared in great detail, and often involve tens of thousands of unit cost line items. For those areas of the project still undefined, an assumed level of detail takeoff (forced detail) may be developed to use as line items in the estimate instead of relying on factoring methods. **Expected Accuracy Range:** Typical accuracy ranges for Class 2 estimates are -5% to -15% on the low side, and +5% to +20% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Typically, as little as 300 hours or less to perhaps more than 3,000 hours, depending on the project and the estimating methodology used. Bid estimates typically require more effort than estimates used for funding or control purposes. **ANSI Standard Reference Z94.2-1989 Name:** Definitive estimate (typically -5% to + 15%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Detailed control, forced detail, execution phase, master control, engineering, bid, tender, change order estimate.

Figure 2d. – Class 2 Estimate

CLASS 1 ESTIMATE	
Description: Class 1 estimates are generally prepared for discrete parts or sections of the total project rather than generating this level of detail for the entire project. The parts of the project estimated at this level of detail will typically be used by subcontractors for bids, or by owners for check estimates. The updated estimate is often referred to as the current control estimate and becomes the new baseline for cost/schedule control of the project. Class 1 estimates may be prepared for parts of the project to comprise a fair price estimate or bid check estimate to compare against a contractor's bid estimate, or to evaluate/dispute claims. Typically, engineering is from 50% to 100% complete, and would comprise virtually all engineering and design documentation of the project, and complete project execution and commissioning plans. **Level of Project Definition Required:** 50% to 100% of full project definition. **End Usage:** Class 1 estimates are typically prepared to form a current control estimate to be used as the final control baseline against which all actual costs and resources will now be monitored for variations to the budget, and form a part of the change/variation control program. They may be used to evaluate bid checking, to support vendor/contractor negotiations, or for claim evaluations and dispute resolution.	**Estimating Methods Used:** Class 1 estimates involve the highest degree of deterministic estimating methods, and require a great amount of effort. Class 1 estimates are prepared in great detail, and thus are usually performed on only the most important or critical areas of the project. All items in the estimate are usually unit cost line items based on actual design quantities. **Expected Accuracy Range:** Typical accuracy ranges for Class 1 estimates are -3% to -10% on the low side, and +3% to +15% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Class 1 estimates require the most effort to create, and as such are generally developed for only selected areas of the project, or for bidding purposes. A complete Class 1 estimate may involve as little as 600 hours or less, to perhaps more than 6,000 hours, depending on the project and the estimating methodology used. Bid estimates typically require more effort than estimates used for funding or control purposes. **ANSI Standard Reference Z94.2 Name:** Definitive estimate (typically -5% to + 15%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Full detail, release, fall-out, tender, firm price, bottoms-up, final, detailed control, forced detail, execution phase, master control, fair price, definitive, change order estimate.

Figure 2e. – Class 1 Estimate

COMPARISON OF CLASSIFICATION PRACTICES

Figures 3a through 3c provide a comparison of the estimate classification practices of various firms, organizations, and published sources against one another and against the guideline classifications. These tables permits users to benchmark their own classification practices.

INCREASING PROJECT DEFINITION

<table>
<tr><th>AACE Classification Standard</th><th>ANSI Standard Z94.0</th><th>AACE Pre-1972</th><th>Association of Cost Engineers (UK) ACostE</th><th>Norwegian Project Management Association (NFP)</th><th>American Society of Professional Estimators (ASPE)</th></tr>
<tr><td rowspan="3">Class 5</td><td rowspan="3">Order of Magnitude Estimate
-30/+50</td><td rowspan="3">Order of Magnitude Estimate</td><td rowspan="3">Order of Magnitude Estimate
Class IV -30/+30</td><td>Concession Estimate</td><td rowspan="4">Level 1</td></tr>
<tr><td>Exploration Estimate</td></tr>
<tr><td>Feasibility Estimate</td></tr>
<tr><td rowspan="2">Class 4</td><td rowspan="4">Budget Estimate
-15/+30</td><td rowspan="2">Study Estimate</td><td rowspan="3">Study Estimate
Class III -20/+20</td><td rowspan="2">Authorization Estimate</td></tr>
<tr><td rowspan="2">Level 2</td></tr>
<tr><td rowspan="2">Class 3</td><td rowspan="2">Preliminary Estimate</td><td rowspan="2">Master Control Estimate</td></tr>
<tr><td>Budget Estimate
Class II -10/+10</td><td>Level 3</td></tr>
<tr><td rowspan="2">Class 2</td><td rowspan="4">Definitive Estimate
-5/+15</td><td rowspan="2">Definitive Estimate</td><td rowspan="4">Definitive Estimate
Class I -5/+5</td><td rowspan="4">Current Control Estimate</td><td>Level 4</td></tr>
<tr><td rowspan="2">Level 5</td></tr>
<tr><td rowspan="2">Class 1</td><td rowspan="2">Detailed Estimate</td></tr>
<tr><td>Level 6</td></tr>
</table>

Figure 3a. – Comparison of Classification Practices

INCREASING PROJECT DEFINITION

<table>
<tr><th>AACE Classification Standard</th><th>Major Consumer Products Company (Confidential)</th><th>Major Oil Company (Confidential)</th><th>Major Oil Company (Confidential)</th><th>Major Oil Company (Confidential)</th></tr>
<tr><td rowspan="2">Class 5</td><td rowspan="2">Class S
Strategic Estimate</td><td rowspan="2">Class V
Order of Magnitude Estimate</td><td>Class A
Prospect Estimate</td><td rowspan="2">Class V</td></tr>
<tr><td>Class B
Evaluation Estimate</td></tr>
<tr><td rowspan="2">Class 4</td><td rowspan="2">Class 1
Conceptual Estimate</td><td rowspan="2">Class IV
Screening Estimate</td><td>Class C
Feasibility Estimate</td><td rowspan="2">Class IV</td></tr>
<tr><td rowspan="2">Class D
Development Estimate</td></tr>
<tr><td rowspan="3">Class 3</td><td rowspan="3">Class 2
Semi-Detailed Estimate</td><td rowspan="2">Class III
Primary Control Estimate</td><td rowspan="2">Class III</td></tr>
<tr><td rowspan="2">Class E
Preliminary Estimate</td></tr>
<tr><td rowspan="2">Class II
Master Control Estimate</td><td rowspan="2">Class II</td></tr>
<tr><td>Class 2</td><td rowspan="2">Class 3
Detailed Estimate</td><td>Class F
Master Control Estimate</td></tr>
<tr><td>Class 1</td><td>Class I
Current Control Estimate</td><td>Current Control Estimate</td><td>Class I</td></tr>
</table>

Figure 3b. – Comparison of Classification Practices

INCREASING PROJECT DEFINITION

<table>
<tr><th>AACE Classification Standard</th><th>J.R. Heizelman, 1988 AACE Transactions [1]</th><th>K.T. Yeo, The Cost Engineer, 1989 [2]</th><th>Stevens & Davis, 1988 AACE Transactions [3]</th><th>P. Behrenbruck, Journal of Petroleum Technology, 1993 [4]</th></tr>
<tr><td>Class 5</td><td>Class V</td><td>Class V
Order of Magnitude</td><td>Class III*</td><td>Order of Magnitude</td></tr>
<tr><td>Class 4</td><td>Class IV</td><td>Class IV
Factor Estimate</td><td rowspan="4">Class II</td><td rowspan="2">Study Estimate</td></tr>
<tr><td rowspan="2">Class 3</td><td rowspan="2">Class III</td><td rowspan="2">Class III
Office Estimate</td></tr>
<tr><td rowspan="2">Budget Estimate</td></tr>
<tr><td>Class 2</td><td>Class II</td><td>Class II
Definitive Estimate</td></tr>
<tr><td>Class 1</td><td>Class I</td><td>Class I
Final Estimate</td><td>Class I</td><td>Control Estimate</td></tr>
</table>

[1] John R. Heizelman, ARCO Oil & Gas Co., 1988 AACE Transactions, Paper V3.7
[2] K.T. Yeo, The Cost Engineer, Vol. 27, No. 6, 1989
[3] Stevens & Davis, BP International Ltd., 1988 AACE Transactions, Paper B4.1 (* Class III is inferred)
[4] Peter Behrenbruck, BHP Petroleum Pty., Ltd., article in Petroleum Technology, August 1993

Figure 3c. – Comparison of Classification Practices

ESTIMATE INPUT CHECKLIST AND MATURITY MATRIX

Figure 4 maps the extent and maturity of estimate input information (deliverables) against the five estimate classification levels. This is a checklist of basic deliverables found in common practice in the process industries. The maturity level is an approximation of the degree of completion of the deliverable. The degree of completion is indicated by the following letters.

- None (blank): development of the deliverable has not begun.
- Started (S): work on the deliverable has begun. Development is typically limited to sketches, rough outlines, or similar levels of early completion.
- Preliminary (P): work on the deliverable is advanced. Interim, cross-functional reviews have usually been conducted. Development may be near completion except for final reviews and approvals.
- Complete (C): the deliverable has been reviewed and approved as appropriate.

	ESTIMATE CLASSIFICATION				
General Project Data:	**CLASS 5**	**CLASS 4**	**CLASS 3**	**CLASS 2**	**CLASS 1**
Project Scope Description	General	Preliminary	Defined	Defined	Defined
Plant Production/Facility Capacity	Assumed	Preliminary	Defined	Defined	Defined
Plant Location	General	Approximate	Specific	Specific	Specific
Soils & Hydrology	None	Preliminary	Defined	Defined	Defined
Integrated Project Plan	None	Preliminary	Defined	Defined	Defined
Project Master Schedule	None	Preliminary	Defined	Defined	Defined
Escalation Strategy	None	Preliminary	Defined	Defined	Defined
Work Breakdown Structure	None	Preliminary	Defined	Defined	Defined
Project Code of Accounts	None	Preliminary	Defined	Defined	Defined
Contracting Strategy	Assumed	Assumed	Preliminary	Defined	Defined
Engineering Deliverables:					
Block Flow Diagrams	S/P	P/C	C	C	C
Plot Plans		S	P/C	C	C
Process Flow Diagrams (PFDs)		S/P	P/C	C	C
Utility Flow Diagrams (UFDs)		S/P	P/C	C	C
Piping & Instrument Diagrams (P&IDs)		S	P/C	C	C
Heat & Material Balances		S	P/C	C	C
Process Equipment List		S/P	P/C	C	C
Utility Equipment List		S/P	P/C	C	C
Electrical One-Line Drawings		S/P	P/C	C	C
Specifications & Datasheets		S	P/C	C	C
General Equipment Arrangement Drawings		S	P/C	C	C
Spare Parts Listings			S/P	P	C
Mechanical Discipline Drawings			S	P	P/C
Electrical Discipline Drawings			S	P	P/C
Instrumentation/Control System Discipline Drawings			S	P	P/C
Civil/Structural/Site Discipline Drawings			S	P	P/C

Figure 4. – Estimate Input Checklist and Maturity Matrix

REFERENCES

ANSI Standard Z94.2-1989. **Industrial Engineering Terminology: Cost Engineering**.
AACE International Recommended Practice No.17R-97, **Cost Estimate Classification System**.

CONTRIBUTORS

Peter Christensen, CCE (Author)
Larry R. Dysert, CCC (Author)
Jennifer Bates, CCE

Dorothy J. Burton
Robert C. Creese, PE CCE
John K. Hollmann, PE CCE
Kenneth K. Humphreys, PE CCE
Donald F. McDonald, Jr. PE CCE
C. Arthur Miller
Bernard A. Pietlock, CCC
Wesley R. Querns, CCE
Don L. Short, II

Recommended Practice No. 17R-97

Cost Estimate Classification System

August 12, 1997

PURPOSE

As a recommended practice of AACE International, the Cost Estimate Classification System provides guidelines for applying the general principles of estimate classification to asset project cost estimates. Asset project cost estimates typically involve estimates for capital investment, and exclude operating and life-cycle evaluations. The Cost Estimate Classification System maps the phases and stages of asset cost estimating together with a generic maturity and quality matrix that can be applied across a wide variety of industries.

This guideline and its addenda have been developed in a way that:

- provides common understanding of the concepts involved with classifying project cost estimates, regardless of the type of enterprise or industry the estimates relate to;
- fully defines and correlates the major characteristics used in classifying cost estimates so that enterprises may unambiguously determine how their practices compare to the guidelines;
- uses degree of project definition as the primary characteristic to categorize estimate classes; and
- reflects generally-accepted practices in the cost engineering profession.

An intent of the guidelines is to improve communication among all of the stakeholders involved with preparing, evaluating, and using project cost estimates. The various parties that use project cost estimates often misinterpret the quality and value of the information available to prepare cost estimates, the various methods employed during the estimating process, the accuracy level expected from estimates, and the level of risk associated with estimates.

This classification guideline is intended to help those involved with project estimates to avoid misinterpretation of the various classes of cost estimates and to avoid their misapplication and misrepresentation. Improving communications about estimate classifications reduces business costs and project cycle times by avoiding inappropriate business and financial decisions, actions, delays, or disputes caused by misunderstandings of cost estimates and what they are expected to represent.

This document is intended to provide a guideline, not a standard. It is understood that each enterprise may have its own project and estimating processes and terminology, and may classify estimates in particular ways. This guideline provides a generic and generally-acceptable classification system that can be used as a basis to compare against. If an enterprise or organization has not yet formally documented its own estimate classification scheme, then this guideline may provide an acceptable starting point.

INTRODUCTION

An AACE International guideline for cost estimate classification for the process industries was developed in the late 1960s or early 1970s, and a simplified version was adopted as an ANSI Standard Z94.0 in 1972. Those guidelines and standards enjoy reasonably broad acceptance within the engineering and construction communities and within the process industries. This recommended practice guide and its addenda improves upon these standards by:

1. providing a classification method applicable across all industries; and
2. unambiguously identifying, cross-referencing, benchmarking, and empirically evaluating the multiple characteristics related to the class of cost estimate.

This guideline is intended to provide a generic methodology for the classification of project cost estimates in any industry, and will be supplemented with addenda that will provide extensions and additional detail for specific industries.

CLASSIFICATION METHODOLOGY

There are numerous characteristics that can be used to categorize cost estimate types. The most significant of these are degree of project definition, end usage of the estimate, estimating methodology, and the effort and time needed to prepare the estimate. The "primary" characteristic used in this guideline to define the classification category is the degree of project definition. The other characteristics are "secondary."

Categorizing cost estimates by degree of project definition is in keeping with the AACE International philosophy of Total Cost Management, which is a quality-driven process applied during the entire project life cycle. The discrete levels of project definition used for classifying estimates correspond to the typical phases and gates of evaluation, authorization, and execution often used by project stakeholders during a project life cycle.

Five cost estimate classes have been established. While the level of project definition is a continuous spectrum, it was determined from benchmarking industry practices that three to five discrete categories are commonly used. Five categories are established in this guideline as it is easier to simplify by combining categories than it is to arbitrarily split a standard.

The estimate class designations are labeled Class 1, 2, 3, 4, and 5. A Class 5 estimate is based upon the lowest level of project definition, and a Class 1 estimate is closest to full project definition and maturity. This arbitrary "countdown" approach considers that estimating is a process whereby successive estimates are prepared until a final estimate closes the process.

	Primary Characteristic	Secondary Characteristic			
ESTIMATE CLASS	LEVEL OF PROJECT DEFINITION Expressed as % of complete definition	END USAGE Typical purpose of estimate	METHODOLOGY Typical estimating method	EXPECTED ACCURACY RANGE Typical +/- range relative to best index of 1 [a]	PREPARATION EFFORT Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Screening or Feasibility	Stochastic or Judgment	4 to 20	1
Class 4	1% to 15%	Concept Study or Feasibility	Primarily Stochastic	3 to 12	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	Mixed, but Primarily Stochastic	2 to 6	3 to 10
Class 2	30% to 70%	Control or Bid/ Tender	Primarily Deterministic	1 to 3	5 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Deterministic	1	10 to 100

Notes: [a] If the range index value of "1" represents +10/-5%, then an index value of 10 represents +100/-50%.
[b] If the cost index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%.

Figure 1 – Generic Cost Estimate Classification Matrix

DEFINITIONS OF COST ESTIMATE CHARACTERISTICS

The following are brief discussions of the various estimate characteristics used in the estimate classification matrix. For the secondary characteristics, the overall trend of how each characteristic varies with the degree of project definition (the primary characteristic) is provided.

Level of Project Definition (Primary Characteristic)

This characteristic is based upon percent complete of project definition (roughly corresponding to percent complete of engineering). The level of project definition defines maturity or the extent and types of input information available to the estimating process. Such inputs include project scope definition, requirements documents, specifications, project plans, drawings, calculations, learnings from past projects, reconnaissance data, and other information that must be developed to define the project. Each industry will have a typical set of deliverables that are used to support the type of estimates used in that industry. The set of deliverables becomes more definitive and complete as the level of project definition (i.e., project engineering) progresses.

End Usage (Secondary Characteristic)

The various classes (or phases) of cost estimates prepared for a project typically have different end uses or purposes. As the level of project definition increases, the end usage of an estimate typically progresses from strategic evaluation and feasibility studies to funding authorization and budgets to project control purposes.

Estimating Methodology (Secondary Characteristic)

Estimating methodologies fall into two broad categories: stochastic and deterministic. In stochastic methods, the independent variable(s) used in the cost estimating algorithms are generally something other than a direct measure of the units of the item being estimated. The cost estimating relationships used in stochastic methods often are somewhat subject to conjecture. With deterministic methods, the independent variable(s) are more or less a definitive measure of the item being estimated. A deterministic methodology is not subject to significant conjecture. As the level of project definition increases, the estimating methodology tends to progress from stochastic to deterministic methods.

Expected Accuracy Range (Secondary Characteristic)

Estimate accuracy range is in indication of the degree to which the final cost outcome for a given project will vary from the estimated cost. Accuracy is traditionally expressed as a +/- percentage range around the point estimate after application of contingency, with a stated level of confidence that the actual cost outcome would fall within this range (+/- measures are a useful simplification, given that actual cost outcomes have different frequency distributions for different types of projects). As the level of project definition increases, the expected accuracy of the estimate tends to improve, as indicated by a tighter +/- range.

Note that in figure 1, the values in the accuracy range column do not represent + or - percentages, but instead represent an index value relative to a best range index value of 1. If, for a particular industry, a Class 1 estimate has an accuracy range of +10/-5 percent, then a Class 5 estimate in that same industry may have an accuracy range of +100/-50 percent.

Effort to Prepare Estimate (Secondary Characteristic)

The level of effort needed to prepare a given estimate is an indication of the cost, time, and resources required. The cost measure of that effort is typically expressed as a percentage of the total project costs for a given project size. As the level of project definition increases, the amount of effort to prepare an estimate increases, as does its cost relative to the total project cost. The effort to develop the project deliverables is not included in the effort metrics; they only cover the cost to prepare the cost estimate itself.

RELATIONSHIPS AND VARIATIONS OF CHARACTERISTICS

There are a myriad of complex relationships that may be exhibited among the estimate characteristics within the estimate classifications. The overall trend of how the secondary characteristics vary with the level of project definition was provided above. This section explores those trends in more detail. Typically, there are commonalties in the secondary characteristics between one estimate and the next, but in any given situation there may be wide variations in usage, methodology, accuracy, and effort.

The level of project definition is the "driver" of the other characteristics. Typically, all of the secondary characteristics have the level of project definition as a primary determinant. While the other characteristics are important to categorization, they lack complete consensus. For example, one estimator's "bid" might be another's "budget." Characteristics such as "accuracy" and "methodology" can vary markedly from one industry to another, and even from estimator to estimator within a given industry.

Level of Project Definition

Each project (or industry grouping) will have a typical set of deliverables that are used to support a given class of estimate. The availability of these deliverables is directly related to the level of project definition achieved. The variations in the deliverables required for an estimate are too broad to cover in detail here; however, it is important to understand what drives the variations. Each industry group tends to focus on a defining project element that "drives" the estimate maturity level. For instance, chemical industry projects are "process equipment-centric"—i.e., the level of project definition and subsequent estimate maturity level is significantly determined by how well the equipment is defined. Architectural projects tend to be "structure-centric," software projects tend to be "function-centric," and so on. Understanding these drivers puts the differences that may appear in the more detailed industry addenda into perspective.

End Usage

While there are common end usages of an estimate among different stakeholders, usage is often relative to the stakeholder's identity. For instance, an owner company may use a given class of estimate to support project funding, while a contractor may use the same class of estimate to support a contract bid or tender. It is not at all uncommon to find stakeholders categorizing their estimates by usage-related headings such as "budget," "study," or "bid." Depending on the stakeholder's perspective and needs, it is important to understand that these may actually be all the same class of estimate (based on the primary characteristic of level of project definition achieved).

Estimating Methodology

As stated previously, estimating methodologies fall into two broad categories: stochastic and deterministic. These broad categories encompass scores of individual methodologies. Stochastic methods often involve simple or complex modeling based on inferred or statistical relationships between costs and programmatic and/or technical parameters. Deterministic methods tend to be straightforward counts or measures of units of items multiplied by known unit costs or factors. It is important to realize that any combination of methods may be found in any given class of estimate. For example, if a stochastic method is known to be suitably accurate, it may be used in place of a deterministic method even when there is sufficient input information based on the level of project definition to support a deterministic method. This may be due to the lower level of effort required to prepare an estimate using stochastic methods.

Expected Accuracy Range

The accuracy range of an estimate is dependent upon a number of characteristics of the estimate input information and the estimating process. The extent and the maturity of the input information as measured by percentage completion (and related to level of project definition) is a highly-important determinant of accuracy. However, there are factors besides the available input information that also greatly affect estimate accuracy measures. Primary among these are the state of technology in the project and the quality of reference cost estimating data.

State of technology—technology varies considerably between industries, and thus affects estimate accuracy. The state of technology used here refers primarily to the programmatic or technical uniqueness and complexity of the project. Procedurally, having "full extent and maturity" in the estimate basis deliverables is deceptive if the deliverables are based upon assumptions regarding uncertain technology. For a "first-of-a-kind" project there is a lower level of confidence that the execution of the project will be successful (all else being equal). There is generally a higher confidence for projects that repeat past practices. Projects for which research and development are still under way at the time that the estimate is prepared are particularly subject to low accuracy expectations. The state of technology may have an order of magnitude (10 to 1) effect on the accuracy range.

Quality of reference cost estimating data—accuracy is also dependent on the quality of reference cost data and history. It is possible to have a project with "common practice" in technology, but with little cost history available concerning projects using that technology. In addition, the estimating process typically employs a number of factors to adjust for market conditions, project location, environmental considerations, and other estimate-specific conditions that are often uncertain and difficult to assess. The accuracy of the estimate will be better when verified empirical data and statistics are employed as a basis for the estimating process, rather than assumptions.

In summary, estimate accuracy will generally be correlated with estimate classification (and therefore the level of project definition), all else being equal. However, specific accuracy ranges will typically vary by industry. Also, the accuracy of any given estimate is not fixed or determined by its classification category. Significant variations in accuracy from estimate to estimate are possible if any of the determinants of accuracy, such as technology, quality of reference cost data, quality of the estimating process, and skill and knowledge of the estimator vary. Accuracy is also not necessarily determined by the methodology used or the effort expended. Estimate accuracy must be evaluated on an estimate-by-estimate basis, usually in conjunction with some form of risk analysis process.

Effort to Prepare Estimate

The effort to prepare an estimate is usually determined by the extent of the input information available. The effort will normally increase as the number and complexity of the project definition deliverables that are produced and assessed increase. However, with an efficient estimating methodology on repetitive projects, this relationship may be less defined. For instance, there are combination design/estimating tools in the process industries that can often automate much of the design and estimating process. These tools can often generate Class 3 deliverables and estimates from the most basic input parameters for repetitive-type projects. There may be similar tools in other industry groupings.

It also should be noted that the estimate preparation costs as a percentage of total project costs will vary inversely with project size in a nonlinear fashion. For a given class of estimate, the preparation cost percentage will decrease as the total project costs increase. Also, at each class of estimate, the preparation costs in different industries will vary markedly. Metrics of estimate preparation costs normally exclude the effort to prepare the defining project deliverables.

ESTIMATE CLASSIFICATION MATRIX

The five estimate classes are presented in figure 1 in relationship to the identified characteristics. Only the level of project definition determines the estimate class. The other four characteristics are secondary characteristics that are generally correlated with the level of project definition, as discussed above.

This generic matrix and guideline provide a high-level estimate classification system that is nonindustry specific. Refer to subsequent addenda for further guidelines that will provide more detailed information for application in specific industries. These will provide additional information, such as input deliverable checklists, to allow meaningful categorization in that industry.

REFERENCES

ANSI Standard Z94.2-1989. **Industrial Engineering Terminology: Cost Engineering.**