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A Case Study in the Effective Use of Schedule Control Techniques - Recovery Schedules

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Abstract

This paper presents a case study in the use of innovative schedule control techniques on the Stage III Ammonia and Stage II Phosphorus Removal Project at the Metropolitan Syracuse Waste Water Treatment Plant (Metro). The paper focuses on the effective use of Recovery Schedules to guarantee that the project was completed by the Major Milestones established in the Federal Court Ordered Amended Consent Judgment.

The Project Owner is Onondaga County, NY; the Design Engineer of Record is Environmental Engineering Associates, Inc.; and the Construction Manager is Camp Dresser & McKee/C&S Engineers, AJV.

Project Background

The scope of the work on this project, and timeline for completion, both stem from a 1998 Amended Consent Judgment (ACJ) settling litigation between the State of New York, the Atlantic States Legal Foundation, and Onondaga County (the County), in connection with alleged violations of state and federal water pollution control laws. The improvements slated for Metro relate to significantly reducing the amount of ammonia and phosphorous discharged into Onondaga Lake. The ACJ established the following criteria for discharge of effluent into Onondaga Lake:

TABLE 1- ACJ CRITERIA

COMPLIANCE DATE	STAGE	AMMONIA (30 DAY AVERAGE)	PHOSPHORUS (12 MONTH AVERAGE)
May 1st, 2004	II	Summer – 2 mg/day Winter – 4 mg/day	NA
April 1st, 2006	II	NA	0.12 mg/l
Dec. 1st, 2012	III	Summer – 1.2 mg/l Winter – 2.4 mg/l	0.02 mg/l

The Metro upgrade consists of three separate facilities combined in one large complex: The Biological Aerated Filter Facility (BAF), the High-Rate Flocculated Settling Facility (HRFS), and the Ultraviolet Disinfection Facility (UV). These systems work collectively in an intricate series of processes specifically targeted to reduce ammonia and phosphorus concentrations in the waste flow and to disinfect the effluent prior to discharge into the Lake. Flow from Metro is conveyed to the complex through a new 130 mgd Secondary Effluent Pumping Station (SEPS).

Innovative process technologies are used at the new Metro facility to treat the waste flow. The treatment process starts in the BAF after wastewater has received secondary treatment and is pumped by the SEPS from the existing clarifiers through 18 concrete tanks, each 28' wide by 57' deep by 23' high. The tanks are filled with media (polystyrene beads) which are used to expand the surface area in the tank for the growth of specialized bacteria that nitrify the ammonia nitrogen contained in the secondary effluent. Effluent from the BAF then flows by gravity to the 4 HRFS units where coagulants are injected. The coagulants adhere to the phosphorus molecules causing them to form large flocs or clumps of particles. The effluent then flows through a second tank where micro-sand is added to further enlarge and weigh-down the formed flocs. A concentrated sludge is formed in a third tank where it is siphoned off. The sand is separated from the phosphorus-rich sludge and recycled; and the phosphorus sludge is pumped back to the solids handling facilities at the existing Plant. Effluent then flows from the HRFS to the UV, which is designed to destroy pathogens using high intensity ultraviolet lights submerged in the effluent before discharge into Onondaga Lake.

The Metro project also includes the construction of a new three story Plant Operations Center where the County will control the new facilities as well as all of the systems of the existing 50 acre, 240 mgd Plant. Contributing to the complexity of the Metro project is its location on a "brownfield" site that required remediation of contaminated soils and groundwater that were deposited from a manufactured gas plant (MGP) operation. Remediation of the 3.2 acre site by the previous owner, Niagara Mohawk Power Corp. (NiMo), was a condition of a separate New York State Department of Environmental Conservation (NYSDEC) Consent Order. Through a negotiated agreement with NiMo for acquisition of the land, the County is responsible for the clean up of the Metro site with partial reimbursement of the costs from NiMo.

The Metro complex is the biggest of its kind in North America, and the $128 Million project consisted of an impressive amount of construction work, including:

- 154,700 tons of MGP contaminated soils removal and 270 Mil gallons of contaminated ground water treatment.
- 1,108 H14x102 steel piles—each driven about 250 ft.

- 28,500 cubic yards of structural concrete.
- $13.8 Million in pre-procured process equipment.
- 795 lf of pile supported 72-inch PCCP force main and 367 lf of pile supported 84-inch PCCP effluent pipe.
- 5,000 lf of mechanical piping within the existing Plant.
- Replacement of the existing Plant's boilers.
- Expansion of the exiting Plant's electrical distribution and supply system.

New Metro Complex at the 90% Completion Point

Initial Project Timeline and Sequencing

The ACJ required the successful operation of a BAF pilot ammonia removal demonstration project by November 1st, 1999, followed by submittal of approvable engineering reports and plans for the BAF to the NYSDEC by December 1st, 2000. Although the ACJ milestone for submittal of approvable engineering reports and plans to the NYSDEC for the HRFS was not until June 1st, 2005, the County elected to pilot the HRFS technology for phosphorus removal during the BAF pilot program.

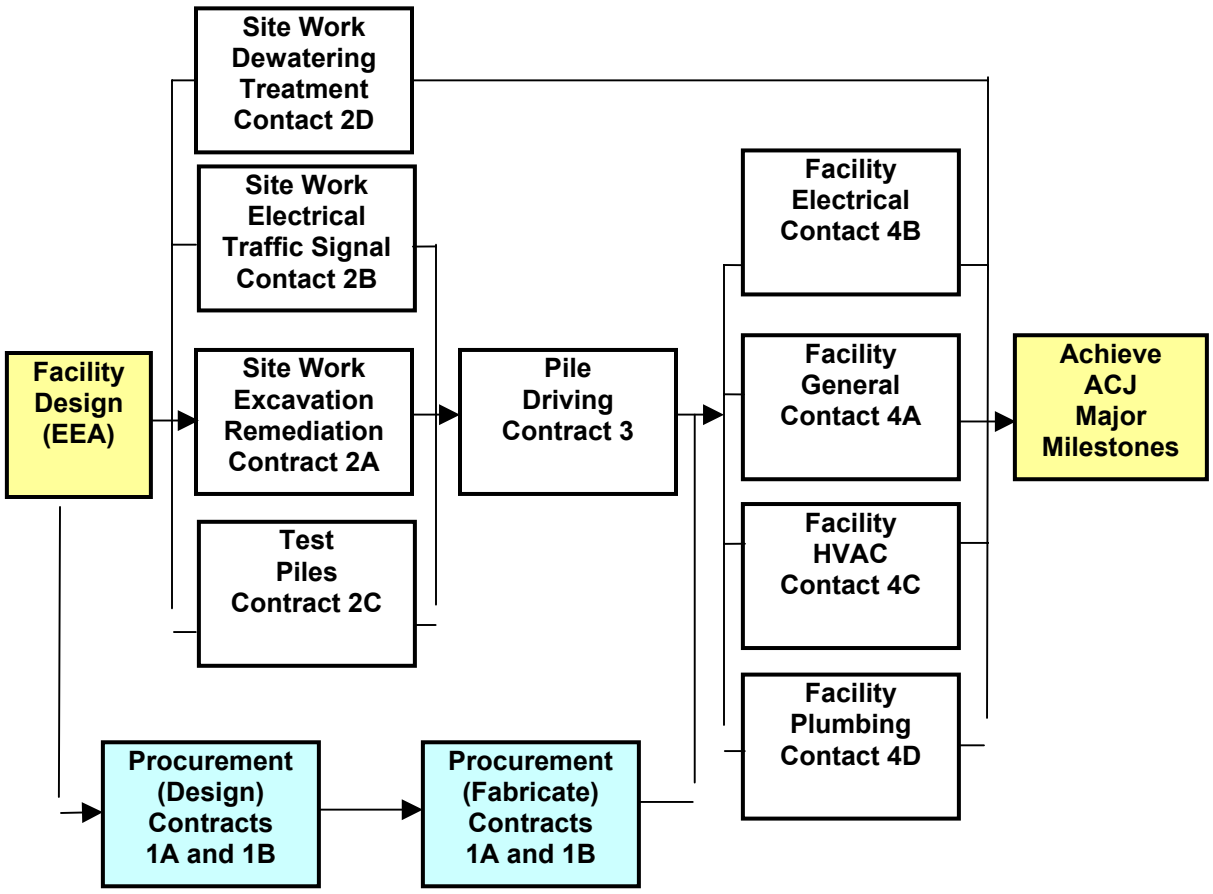
Fortunately, the pilot programs for both the BAF and HRFS successfully demonstrated the new technologies. Based on these positive results, the County choose to combine the HRFS and BAF into one project to simultaneously achieve the ACJ requirements for both phosphorus and ammonia removal. It was also determined during this time frame that a new UV facility would be added to replace the old liquid sodium hypochlorite disinfection system currently in use at the Plant. Combining the three facilities resulted in a significant reduction in

project costs and made it possible to achieve the ACJ goals for phosphorus removal almost 2 years ahead of schedule. This change, however, had the negative effect of adding an additional burden on the Engineer of Record to complete design of the combined Metro complex by the ACJ milestone date originally established for completion of the BAF design alone.

Engineering reports and plans for Metro were completed on schedule and the notice-to-proceed for the first construction contract for the Test Pile program was issued in June 2001. This allowed only 29 months for completion of the remaining bid documents, remediation activities, and construction and performance testing of the BAF, SEPS, and UV Facilities, and an additional 7 months for completion of construction and performance testing of the new Plant Operations Center and HRFS facility.

To achieve the aggressive construction schedule, the project was fast-tracked, which meant that when site remediation and other site-work activities were underway, the bidding documents for the general construction of the BAF, SEPS, HRFS and UV facilities were not yet complete. In fact, during this time frame several changes to the final design of Metro were made, including the addition of an 84" PCCP pile supported underground bypass system, which permitted operation of the BAF prior to completion of construction of the HRFS. Although the bypass system added significant upfront project cost, it added flexibility in the aggressive construction schedule by allowing the more critical BAF to go on-line first. The bypass system also increased flexibility during operation by allowing the County to completely divert flow to the HRFS for maintenance and other purposes. Ironically, even though the 84" bypass system added flexibility to the schedule, construction of it directly impacted and delayed the remediation, site work, and pile driving work because, due to hydraulic design considerations, it required the deepest excavation on site. In summary, the original sequence logic for execution of the 11 Prime Contracts was as follows:

FIGURE 1- ORIGINAL SEQUENCE LOGIC DIAGRAM



The 11 Prime Contracts were structured so that the site work contract, including the remediation of 154,700 tons of contaminated soil, was a prerequisite to the start of pile driving and all successor facility work. This was done due to the special requirements for handling of the contaminated materials including health and safety regulations. The idea here was to limit Owner risk by confining the remediation activities to one contract.

The remainder of the project was sequenced to coincide with the ACJ Major Milestones for the BAF and HRFS facilities. The ACJ included Major Milestones for both completion of construction and successful operation of both the BAF and HRFS facilities. Successful operation of the BAF and HRFS were defined by achievement of set limits for ammonia and phosphorus effluent. The BAF facility was required to meet the effluent limits much sooner than the HRSF, thus the BAF facility became the critical path of the project.

Delays to the Site Remediation Contractor

When the Site Remediation Contractor (Contract 2A) began work in July 2001, everyone associated with the project realized that the aggressive nature of the schedule meant that there was very little available float to allow for any delay in the start or execution of the work. Because of the direct relationship between the start of pile driving (Contract 3) and the finish of the site remediation activities, any slippage in the start, or execution, of the site remediation activities would result in a direct impact to the Major Milestones for completion of the BAF and HRFS. When scheduling the project, this was a noted concern given the general nature of remediation work and the high risk associated with the uncertainty of scope.

Unfortunately, these concerns were realized when a number of unforeseen site conditions severely impacted the progression of the remediation work. These included the discovery of several large, below grade, pile-supported concrete structures that obstructed installation of the support of excavation system. These concrete obstructions had to be removed, including extraction of the timber piles beneath them, prior to continuation of the work. Once excavation was underway, the poor consistency of the contaminated material made it very difficult for the Contractor in terms of handling and disposal, requiring the Contractor to "amend" the material with imported sand prior to disposal. Amending the soil with sand, and over-excavation for the removal of the concrete obstructions, resulted in the quantity for disposal at the landfill to be 95% greater than the estimated amount in the unit price bid item and the quantity of backfill to be over 200% greater than the estimated amount in the unit price bid item. Exacerbating the situation at the time was the fact that the project had already experienced a 60-day slippage in the start of activities due to the late development and approval of the Contractor's Health and Safety Plan and other contractual issues.

An analysis of the Updated Integrated Master CPM Schedule for the project showed that by November 2001, due to the additional impact of winter conditions, these cumulative delay events had impacted the critical path by 8 months.

Special Provisions for Recovery Schedules

Because the Major Milestones were court mandated and enforceable through significant fines for non-achievement, special provisions were included in the Prime Contracts to ensure compliance with the project's schedule goals. In New York State, public projects are subject to the provisions of the Wicks Act which requires that separate contracts be competitively bid and awarded to a minimum or 4 Prime Contractors: General, Electrical, HVAC, and the Plumbing

trades. The Wicks Act also stipulates that the public Owner, not the General Contractor, is responsible for coordination of the multiple Prime Contracts. Because of the requirements of the Wicks Act, many public Owners in New York State utilize a Construction Manager who acts as the Owner's agent to schedule and coordinate the work of the Multiple Prime Contractors. At Metro, the Construction Manager was responsible to develop an Integrated Master CPM Schedule for the project and the scheduling provisions focused on ensuring that the Prime Contractors provided detailed schedule information for their individual work activities. Each Prime Contractor was required to submit a comprehensive list of work activities which included submission and approval of all project deliverables, all required tasks for the procurement of equipment and materials, all construction work tasks, and project closeout tasks including punch list and testing activities. In addition to the list of activities, the Prime Contractors were also required to furnish a brief description of each activity, provide the activity duration, establish predecessor and/or successor activity(s) relationships, and discretely load each activity for revenue, equipment and manpower requirements. Based on the information provided, the Construction Manager prepared the Integrated Master CPM Schedule and it was used as the baseline to monitor schedule performance.

The types of contract requirements as outlined above for CPM scheduling are relatively commonplace on large/complex construction projects like Metro. What was unique on the Metro project was the effective use of special provisions regarding Recovery Schedules. This provision read in part:

> "…*if in the view of the Construction Manager, the Contractor is in jeopardy of not completing the Work on time, or not meeting any schedule project milestone, the Construction Manager may request the Contractor to submit a recovery schedule. The recovery schedule shall show, in such detail as is acceptable to the Construction Manager, the Contractor's plan to meet all schedule project milestones, and that the Work will be completed within the time frame stipulated in the Contract Documents*…"

Recovery Schedules were further defined as an adjustment to the Updated Integrated Master CPM Schedule, through either schedule logic revisions or duration acceleration, which eliminated any forecast delays to the Major Milestones. If a Recovery Schedule was requested by the Construction Manager, the affected Prime Contractor had to provide a narrative explaining the adjustments to their work plan that would be implemented to guarantee the project would be completed on time. Explanations could include items such as adding additional resources to accelerate activities on the critical path, working additional hours, working through holidays and weekends, change in means and methods, or revision of the overall sequence logic of the CPM to adjust the critical path. The specifications also stipulated that all payment to the Contractor would be withheld if an acceptable Recovery Schedule was not provided within 30 days of request.

The provision was careful to identify the Construction Manager, and not the Prime Contractors, as having the authority to request and implement a Recovery Schedule. This was done due to issues regarding cost vs. benefit of recovery, contractual requirements such as the effect on liquidated damages, the potential impact of recovery efforts on the other Prime Contractors, and the potential impact of recovery efforts on existing Plant operations. This special provision did not address the issue of reimbursement for the cost of implementing the Recovery Plan. Other contract provisions in the General Specifications, including "Changes" and "Time Provisions" addressed this issue. The idea here was to address the issue of payment through the contract modification process.

Implementation of Initial Recovery Efforts

As discussed above, the first major impact to the schedule occurred during the site remediation activities. Because of the uncertainty associated with this type of work the Construction Manager decided to implement only minor recovery efforts during this phase of the project. The most significant recovery effort involved reimbursing the Contractor to send the contaminated materials to the landfill as is, and to not amend the soils with sand prior to transport. Although this resulted in a surcharge of $27/Ton from the landfill, the excavation production rate on site nearly doubled which greatly reduced the impact of this delay. Not only did this save time, but the cost of the surcharge was more than offset by the reduced tonnage (i.e. no sand added) of material entering the landfill.

Once this recovery was implemented the focus for the Construction Manager became the acceleration of successor work, particularly the 50 miles of piles that had to be driven (Contract 3). It was important to accelerate this work because, without the piles in place, work on the process facilities (Contract 4) could not begin. After consideration of cost and risk factors, a Recovery Schedule was implemented as follows:

- The start of pile driving operations was allowed to overlap with the finish of the site remediation activities. This meant that the pile driving activities would commence before the remediation work was complete. As a result, the Pile Driving Contractor was issued a Change Order for $149,281 to implement a Health and Safety Plan to work on the contaminated site.

- The Prime Contractor agreed, at no cost, to increase the number of production pile driving rigs from three to five. This required that the Owner relax the rules which had stipulated the working distance between the pile driving rigs and other activities. Per contract, the pile driver had to maintain a minimum distance of 100' between the production rigs and other work activities. This requirement was relaxed to 50' to allow for the additional cranes and the overlap of work activities.

- The Prime Contractor agreed, at not cost, to alter the specified means and methods for pile driving. Although the specifications called for the use of an impact hammer, this was relaxed to allow for the more efficient method utilizing a vibratory hammer which greatly increased production.

Work on the pile driving contract commenced on February 2002 and was completed within the original Contract duration of 150 days. The recovery efforts ensured the original contract duration was maintained even though there were several modifications that directly impacted the work. These included encountering unforeseen buried concrete structures, issues regarding coordination of work with Contract 2, impact and stoppage of work due to health and safety precautions related to contaminated materials handling, and several changes in the design of the facility that resulted in the quantity of piles to increase 25,372 lf from the estimated amount in the unit price bid item. The Construction Manager estimates that had recovery efforts not been implemented, these impacts would have resulted in a minimum of 60-day extension of the 150-day contract duration.

Consideration of Formal Recovery for the General Contractor

Notice-to-Proceed for the Contract 4 Contracts was issued in January 2002, and the General Contractor immediately began preparation of a CPM schedule. In April 2002, based on the analysis from the CPM schedule, which included the impacts from the Contract 2 and 3 delays, the General Contractor submitted a request for a 13-month time extension.

Even with the great deal of effort expended to date to mitigate impacts to the schedule, in April 2002 the project still faced what first appeared to be an insurmountable task. Was it even possible to recover from a 13-month impact to a project with an overall duration of 29 months? Could the Construction Manager count on the Prime Contractors, Owner, and Engineer to buy into any proposed Recovery Plan? How much would recovery cost and who would pay for it? Could it be done and still maintain the quality standards established by the Project Team?

To answer these questions and to better communicate the issues to the Project Team, a very formal approach was taken by the Construction Manager. First the Construction Manager carefully performed a "what if" type of analysis of the Integrated Master CPM Schedule to determine if implementation of a Recovery Schedule was even feasible. If it was determined that recovery was feasible then a "benefit vs. cost" analysis would be performed to determine if it was the best course of action.

Following, in tabular form, are some of the issues addressed during this process. Table 2 includes the Feasibility Analysis and Table 3 the Cost vs. Benefit Analysis.

TABLE 2- FEASIBILITY OF RECOVERY

ISSUE	ANALYSIS
Can the Construction Manager demonstrate to the Owner that recovery is needed?	The state-of-the-art tool for this is the CPM scheduling technique with real-time controls for progress monitoring. At Metro, the Construction Manager utilized Primavera® CPM Scheduling Software integrated with the Primavera® Expedition Document Control System. The Construction Manager developed a detailed Integrated Baseline Master CPM Schedule and it was updated with real time (weekly) data provided by the active Prime Contractors. Each week, based on this information, the Construction Manager provided a forecast of the ACJ Major Milestones to the Owner. These forecast highlighted the specific areas where recovery was needed.
Can each of the Prime Contractors demonstrate and commit to a Recovery Schedule that they believed was achievable?	The strategy at Metro was to work most actively with the General Contractor to establish a Recovery Plan that was feasible to them and would not impact the other Prime Contractors. The General Contractor utilized the same state-of-the-art scheduling tools that the Construction Manager did and had demonstrated in the past that they were capable of planning and executing recovery efforts.
Can the Construction Manager demonstrate to the Owner that the Recovery Schedule is achievable?	The Construction Manager focused on key elements of the Recovery Schedule to demonstrate to the Owner that the plan was achievable. For instance, the Construction Manager outlined specific Intermediate Milestones such as "all BAF concrete work must be done by mid-December", "working through the winter will be required for the finish work", and the "BAF Gallery Ceiling must be done with prefabricated concrete beams".
Can the Recovery Schedule be "proved out" through development of a detailed Integrated CPM schedule?	It was easy to demonstrate "on paper" that the plan was achievable.
Can the Recovery Schedule be developed which	This was the most problematic issue. Almost any form of recovery will result in the adverse effect of limiting float time. Float time is valuable because is affords a

maintains an acceptable measure of float time to account for unforeseen conditions?	level of schedule contingency when unforeseen conditions arise. It is also hard to determine in advance what an acceptable level of float might be. At Metro, to be fair, the Recovery Schedule probably did not maintain an acceptable level of float time. The level of float in the Recovery Schedule, however, was not less than what was planned in the Original Master CPM.
Can the Recovery Schedule be developed which does not negatively impact the Owner's operations?	Because the Recovery Plan maintained the already established ACJ Major Milestones, this was not an issue.
Are there enough local resources (labor, materials, equipment) to implement all aspects of the Recovery Schedule?	During construction of Metro there was a planned $2.2 Billion development directly adjacent to the site. Had this project begun concurrently with ongoing work at Metro there was the potential for impact on the availability of materials, labor, and equipment. In the end it was decided that this actually favored implementation of the Recovery Schedule because without it the 13 month delay in the project would almost certainly cause an overlap with the development activities.
Can appropriate control mechanisms be established to monitor adherence to the Recovery Schedule?	Both the Construction Manager and each of the Prime Contractors had demonstrated real-time controls for schedule monitoring. The integrated Primavera® Software allowed for real time input of construction monitoring data and an accurate current forecast of both intermediate target dates and the ACJ Major Milestones.

TABLE 3 -- COST VS. BENEFIT OF RECOVERY

ISSUE	ANALYSIS
COST TO IMPLEMENT THE RECOVERY SCHEDULE	
Monetary cost for implementation of the Recovery Schedule	These cost included working extended shifts (overtime, weekend, and holiday work), labor inefficiencies (overlap of trades and fatigue), additional supervision, and working during winter conditions. Cost also included several "value engineering" suggestions to save schedule time, including revising the cast-in-place concrete to precast for the BAF gallery ceiling and using PVC instead of steel conduit for the embedded electrical items. The cost for implementation of the Recovery Schedule was negotiated with the General Contractor in two separate Change Orders. Total cost of Recovery for Contract 4A was $2.98 Million. The Change Orders were carefully written to include language which stipulated that all contract provisions, including the assessment of liquidated damages for late completion, were still applicable. In essence, the Owner through execution of the Change Orders "bought the completion dates" and the Contractor accepted all liability in event that the recovery effort was unable to mitigate the delays. The Change Orders also clearly stated that they fully reimbursed the Contractor for all schedule impacts that had occurred prior to the Recovery Schedule data date of July 31st, 2002.
Potential negative impact on quality	Sometimes a negative affect can result on the quality of the work during recovery efforts, especially if work is accelerated or allowed to proceed in adverse weather conditions.
BENEFIT OF IMPLEMENTING THE RECOVERY SCHEDULE	
Eliminating the monetary cost for delay	An analysis preformed by the Construction Manager showed that if the project were to be allowed to be delayed by 13 months (i.e. no recovery) the cost impact would be between $8 - $12 Million.

	These cost included extended overhead for the each Prime Contractor, Owner, Construction Manager and Engineer, ACJ Penalties for late completion, extension of time related unit price items such as dewatering and treatment of dewatering effluent, and escalation.
Good will associated with "getting done on time".	As a public project, there was a certain amount of "good will" in completing the project by the dates established in the ACJ. The project was designed to have a major influence on the quality of water in Onondaga Lake and the sooner these improvements could be realized the better.
Cost for recovery was reimbursable by the Funding Agencies.	The project was funded through various State and Federal Agencies. Cost to implement the Recovery Schedule was predetermined as fundable because it maintained the Major Milestones established in the ACJ.

The Successful "Time is Money" Argument

From April through July 2002 the Project Team debated what the best course of action would be based on the issues identified in Tables 2 and 3. During this debate, the most difficult concept for the Construction Manager to convey to the rest of the Project Team was that whichever choice was made, delay or recovery, there would be a significant impact to the project budget. The General Specifications contained a "No Cost for Delay" provision that some on the Project Team felt eliminated most of the potential cost for delay. This debate focused on whether the "No Cost for Delay" clause would completely preclude the Prime Contractors from recovering damages as a result of the schedule impacts from delay in the site work activities. Although much has been written about the enforceability of "No Cost for Delay" provisions, it was still a dividing issue and greatly impacted the decision making process. The Construction Manager argued that even if these cost savings were factored out, other costs savings, such as the elimination of extended project soft costs for the Owner, CM, and Engineer, extended time related unit price items, and the ACJ penalties, clearly favored recovery from strictly a project cost point of view.

Some on the Project Team were also not convinced that the proposed Recovery Schedule could be implemented without having a negative impact on the quality of the work. The Construction Manager agreed with this assessment if additional focus and procedures to ensure quality were not implemented during the recovery efforts. Ensuring a high level of quality during recovery, they argued, required that the Construction Manager, Inspection Team, and Contractors have added diligence in applying the established quality control and assurance procedures. It also required that additional procedures,

such as formal concrete placement and equipment start-up check lists be implemented.

In the end, the Construction Manager upheld its recommendation for the proactive choice of recovery because it could be shown to be the least expensive option and these costs could be reimbursed by the Funding Agencies. The "Time is Money" argument prevailed, and the Recovery Schedule was implemented in July, 2002. Although the Construction Manager's analysis clearly showed this was the best option it was by far the most difficult choice because it required the Project Team to take a proactive approach to the situation. This proactive approach required that Change Orders be issued to the General Contractor to pay for the planned recovery efforts. It also required that the Project Team feel confident that the General Contractor could achieve the recovery goals and not negatively impact project quality.

Results of the Recovery Efforts

In July 2002, prior to the start of the recovery efforts, the Updated Integrated CPM Schedule showed a delay in the Major Milestone for successful operation of the BAF Facility of 13 months. The schedule projected the achievement of the ammonia removal limits in June 2005 instead of the ACJ Major Milestone of May 2004. Through the implementation of the Recovery Schedule the actual date for achievement of the ammonia removal limits occurred in March 2004, 15 months earlier than originally forecast and 2 months ahead of schedule.

In addition to being built ahead of schedule, the project was built with a high level of quality which was evident in the successful functioning of the complex systems. The project's intended goal of achieving Stage III ammonia limits in the effluent discharged by Metro into Onondaga Lake within the time frames established in the ACJ was successfully achieved.

Completed BAF Facility - February 2004

Conclusions

The experience of the Metro project supports the use of the innovative schedule control technique of Recovery Schedules to effectively manage project time impacts in a proactive way. The successful implementation of the Recovery Schedule at Metro involved the following steps:

- The need for a Recovery Schedule was effectively established.
- The feasibility of the Recovery Schedule was effectively established.
- A "cost vs. benefit" analysis of implementing the Recovery Schedule was performed.
- The Project Team committed to the Recovery Schedule.
- The Recovery Schedule was effectively monitored utilizing real time controls to ensure conformance to the plan.

Lessons learned in implementation of the Recovery Schedule at Metro include:

- The proactive choice of recovery is often the most difficult to make.
- The entire Project Team (Contractors, Owner, CM, and Engineer) must commit to the recovery efforts.
- There is the potential for quality to be negatively affected by recovery efforts. Additional focus on the project quality goals is required during recovery efforts.
- Recovery can be an effective means to mitigate schedule impacts in a cost effective way.

About the Authors

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ranging to $330 Million. Mr. Delaney is an authority in the implementation and use of state-of-the-art project management software and is an expert CPM scheduler. Joe received his BS and Master's degree in Civil Engineering from the State University of New York at Buffalo and is a licensed Professional Engineer in New York and New Jersey.

Randy R. Ott, P.E. - Randy has more than 30 years experience working in the environmental field for the Onondaga County Department of Water Environment Protection. Randy received his BS degree in Civil and Environmental Engineering from Clarkson University and is a licensed Professional Engineer in New York. In his current position as Process Control Director, Randy is responsible for managing the operation and maintenance of six wastewater treatment plants and the department's biosolids management program and a staff of 200. He has played an integral part in developing the County's plans for improving water quality in Onondaga Lake. He is also currently serving as Project Manager for the design and construction of the $128 million ammonia and phosphorus removal project at the Metropolitan Syracuse WWTP and Project Manager for the $40 million design of the Wetzel Road WWTP/Sawmill Creek Pump Station expansion and upgrade.