

Change Management in Large and Complex Civil Infrastructure Projects: District of Columbia Clean Rivers Project¹

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Abstract

Change management is essential for any organization designing and constructing complex multi-million dollar civil infrastructure projects. The District of Columbia Clean Rivers Project change management plan uses the Primavera Contract Management Version 14 (CM14) system to identify, track, and manage Design-Build and Construction contract changes. This process starts at the early design stage and continues through construction and system startup on a divisional contract basis. This paper describes the step by step approach used in the DC Clean Rivers Project to manage changes at different stages of the project (design and construction/startup) on multiple contracts delivered by either the Design-Build or Design-Bid-Build approach. It also describes how trend analysis is used for updating the cost to completion.

Keywords: change management, change order, work change directive, contingency, trend analysis, minor change.

Introduction

This paper describes the approach to change management for a large and complex civil infrastructure program, namely the District of Columbia Clean Rivers (DCCR) Project. It describes the scope and objectives of the change management effort, the methodologies and tools used throughout execution of the change management plan.

The key aspects of the project change management plan include:

- Change Management Approach,
- Change Log Updating and Management, and
- Program Change Analysis of Cost and Schedule Impacts.

For this study, the definition of change is taken from Page 229 of Total Cost Management Framework (2012), “Changes are alterations or variations to the scope of work and/or any other approved or baseline project control plan (e.g., schedule, budget, resource plans, etc.).”

¹ How to cite this paper: Lisse, S. D. (2019). Change Management in Large and Complex Civil Infrastructure Projects: District of Columbia Clean Rivers Project; *PM World Journal*, Vol. VIII, Issue II (February).

Background

The DCCR Project is comprised of a system of tunnels for the Anacostia River, Rock Creek, Piney Branch and the Potomac River that will capture combined sewer flows for treatment at Blue Plains. About one-third of the district sewer system is a combined system and annual discharges into local waterway are estimated at 2 billion gallons. The Anacostia River receives 1.3 billion gallons, the Potomac River receives 640 million gallons and Rock Creek 50 million gallons of overflow each year. The schedule for completing the Project is included in a Federal Court Consent Decree between the United States, the District Government and DC Water.

The Anacostia River Projects (ARP) include 12.8 miles (20.7 km) of deep tunnels with approximately 16 shafts, several pumping stations, and several river crossings. The Anacostia River Projects are broken into four main tunneling contracts. Geographically from south to north, these are the Blue Plains Tunnel (BPT), the Anacostia River Tunnel (ART), the Northeast Boundary Tunnel (NEBT), and the First Street Tunnel (FST).

Implementation of the ARP is divided into two phases. Phase 1 of the Program includes the BPT, ART, and several diversion structures and is required to be completed by March 2018. Phase 2 of the Program, consisting of the NEBT and FST, along with the Potomac River and Rock Creek projects, must be completed by March 2025.

Project Delivery Method

DC Water regulations allow DCCR contracts to be procured by either using the traditional Design-Bid-Build (DBB) or the Design-Build (DB) with early contractor involvement (ECI). In December 2013, a hybrid delivery method that combines the traditional DBB approach and DB with ECI was added to the mix. Having these different project delivery methods available allows flexibility in project management requirements.

The twenty contract divisions representing the Anacostia River, Rock Creek and Potomac River Projects applicable to the DCCR change management approach are listed in Table 1.

Table 1 — DCCR Contract Divisions

CONTRACT DIVISIONS		
Anacostia River Projects		
Division	Contract Description	Type
A	Blue Plains Tunnel	DB
B	Tingey Street Diversion Sewer	DB
C	CSO 019 Overflow and Diversion Structures	DBB
D	Joint Base Anacostia-Bolling Overflow and Diversion Structures	DB
E	M Street Diversion Sewer	DBB
G	CSO 007 Diversion Structure and Sewer	DBB

H	Anacostia River Tunnel	DB
I	Main Pumping Station Diversions	DB
J	Northeast Boundary Tunnel	DB
N	LID Retrofit at DC Water Facilities	DBB
P	First Street Tunnel	DB
S	Irving Street Green Infrastructure	DBB
U	Northeast Boundary Tunnel Utility Relocation	DBB
Z	Poplar Point Pumping Station Replacement	DBB
Rock Creek Projects		
Division	Contract Description	Type
RC-A	Green Infrastructure	DB
RC-B	Kennedy Street GI Streetscape	DB
RC-C	Piney Branch Diversion Structure	DB
Potomac River Projects		
Division	Contract Description	Type
PR-A	Green Infrastructure	DBB
PR-B	CSO 021 Diversion Facilities	DBB
PR-C	CSO 025, 026 Sewer Separation	DBB

Construction Change Management Approach

The DC Clean Rivers Project Change Management Plan (DCCR ChaMP) provides the guidelines for the management of changed work required for the District of Columbia Water and Sewer Authority (DC Water) DC Clean Rivers Project (DCCR, also known as the Long Term Control Plan (LTCP)).

Construction contracts are procured utilizing both the Design-Build (DB) and Design-Bid-Build (DBB) contract delivery methods. The terms and conditions contained within the Contract Documents differ significantly between each delivery method. In addition language within the Contract Documents for each of the delivery methods differs slightly from contract to contract.

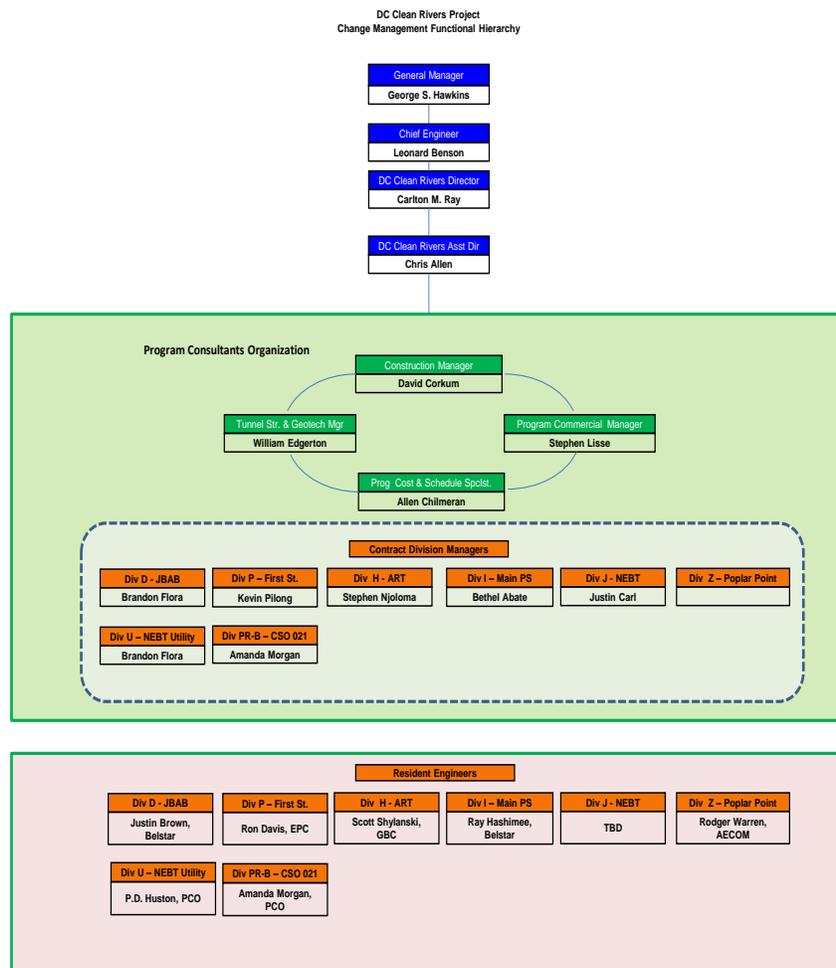
DC Water plans to issue separate Consultant Construction Manager (CCM) contracts for each portion of the DC Clean Rivers Project. An individual CCM will either manage a single Design-Build tunnel construction contract or Design-Bid-Build construction contract(s). In certain cases, several individual Design-Bid-Build contracts will be managed under a single CCM Procurement.

Each CCM will have specific construction contract(s) to be managed including the management of associated work change directives and change orders. The PCO Oversight Construction Manager will oversee the change management process assisted by the PCO Commercial Manager who will be the lead resource for developing, implementing, and maintaining the DC Clean Rivers change/dispute/claim procedures.

Organizational Structure

Figure 1 depicts the DC Clean Rivers Project Change Management Functional Hierarchy. The DC Clean Rivers Project change management organization is led by the DC Clean Rivers Project Director, with assistance from the DC Clean Rivers Assistant Director, and the Program Consultants Organization (PCO).

Figure 1 — DC Clean Rivers Project Change Management Functional Hierarchy



The roles and responsibilities of positions within the DC Clean Rivers Project organization as related to the DC Clean Rivers Project construction change management are summarized in the Responsibility Matrix provided in Table 2. Not all CCM positions will require full-time services on every project, and for some projects, depending on the proposed workload, positions may be

combined. If positions are combined, the appropriate qualifications for the combined functions must be provided.

Table 2. DC Clean Rivers Change Order Matrix

DCCR CHANGE MANAGEMENT RESPONSIBILITIES				
Position	Prepare	Review	Approve	Remarks
DC Water General Manager				Approves Contingency Changes \geq \$1M Approves Change Orders \leq \$500k Executes Change Orders $>$ \$500k after Board approval
DC Water Chief Engineer				Approves Contingency Changes \geq \$500k $<$ \$1M and \geq 30 days w/o impacting consent decree Recommends approval of Contingency Changes $>$ \$1M Recommends approval of all Change Orders
DC Clean Rivers Director				Approves Contingency Changes \leq \$500k \leq 30 days w/o impacting consent decree Recommends approval of Contingency Changes $>$ \$500k Reviews and recommends approval of all Change Orders
Assistant Director				Reviews and recommends approval of all Contingency Changes and Change Orders
PCO Construction Manager				Provides oversight of CCM change management activities
PCO Commercial Manager				Leads change/dispute/claim management activities
PCO Cost and Schedule Manager				Provides schedule/cost analysis for Changes as needed
Consultant Construction Manager				Estimates, negotiates, and recommends Changes and prepares documentation

Change Management Methodology

The DCCR ChaMP provides general guidelines and procedures for the various change management functions along with definition of the roles and responsibilities of the organizational structures. The DCCR ChaMP will provide a framework to be utilized by the individual project construction management teams. This ChaMP may be referenced by the CCM in their Construction Management Implementation Plans (CMIPs) and supplemented to incorporate special procedures, such as contingency allowances, structure mitigation allowances, unit prices or other project specific features. Consultant Construction Managers (CCMs) will manage all change orders for assigned construction and design-build projects for DC Water. CCMs shall adopt and incorporate the requirements of this DCCR ChaMP into the CMIPs for the management of specific contracts.

Section 1 provides general information regarding the DCCR ChaMP including the following:

- Purpose
- Scope
- Description of the DC Clean Rivers Project
- Change management approach

Section 2 contains the following:

- DC Clean Rivers Project organizational change management structure
- Roles and responsibilities of the functional positions identified in the DC Clean Rivers Project organizational structure

Section 3 contains the following:

- Overall construction change management approach
- Major change management functional elements

Section 4 contains referenced DC Water Standard Operating Procedures.

- Overall guidelines on change management procedures

Section 5 contains sample DCCR Contract Change Forms.

- DC Water forms modified for DCCR requirements

Section 6 is a list of abbreviations used in the DCCR ChaMP.

- Listing of abbreviations used in this Plan

The PCO Construction Manager will monitor and audit the CCM activities regarding contract changes and insure consistency among all CCMs and compliance with the DC Clean Rivers Project CM Plan, CMIP and SOPs. Figure 2 provides an overview of the Change Management Process.

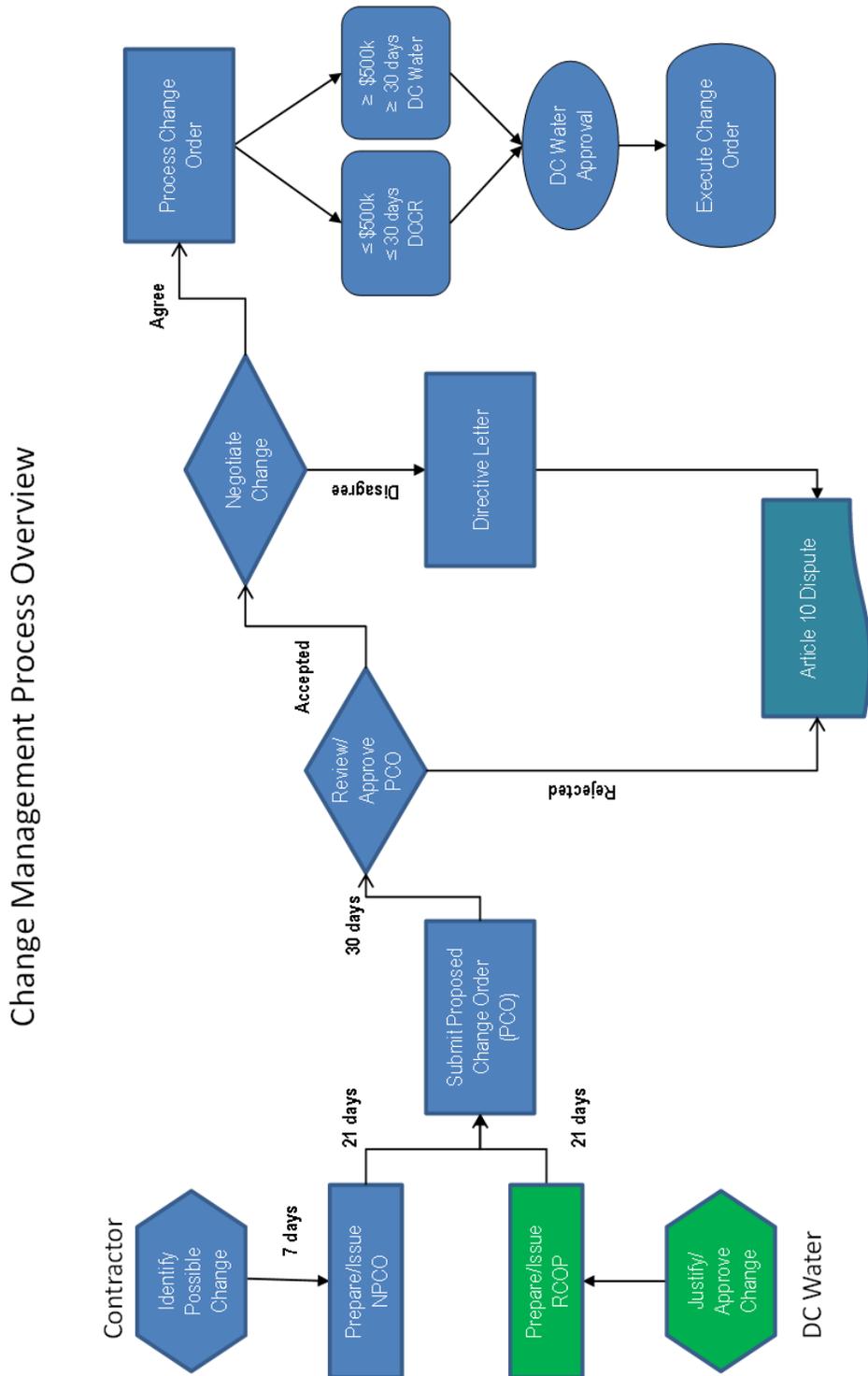


Figure 2 - Change Management Process Overview

Work Change Directive (WCD)

In cases where the Contractor is allowed payment under a Contract Allowance Item, within the Contingency, the CCM will manage and process such request as a Work Change Directive (WCD).

A Work Change Directive may be used to issue immediate direction to a Contractor for obvious required changed work that is on or near the critical path which may impact the project completion date. The issuance of such a WCD will minimize the impact on project completion time and cost. A WCD cannot extend the contract time; only by Change Order can the contract time be changed.

In the event that a Request for Change Order Proposal (RCOP) is issued to the Contractor, a WCD number will be assigned to the respective change. The Contractor will submit a cost proposal for the scope of change and CCM will prepare an independent cost estimate for the same scope of work. Shortly thereafter, negotiations are to be held between the Contractor and the CCM, with participation of the PCO Commercial Manager, to establish a lump sum, unit price, a combination of both, or a cost-not-to-exceed for the WCD.

The cost of any change negotiated under WCD is covered with the inclusion of an allowance in the contract. These WCDs could be for differing site conditions, design errors, owner preference, or other reasons. The CCM Resident Engineer executes WCDs with authorization from the change management approval levels shown in Table 2. When the CCM determines that a required change in the work can have an adverse impact on contract time or cost if timely direction is not given to the Contractor, the CCM immediately informs the PCO Commercial Manager and recommends a WCD.

The CCM will prepare the WCD Forms for approval by DC Water, and Figure 3 provides a Work Change Directive Checklist. The WCD package will contain:

1. DCCR Certification Sheet
2. Running Total of Contingency Allowance
3. Work Change Directive
4. Record of Negotiation
5. Contractor's Cost Proposal
6. CCM-Cost Estimate
7. Errors and Omissions Memo, if applicable

WORK CHANGE DIRECTIVE CHECKLIST

DC Water Contract No. _____

RCOP/NPCO No. _____

CO/WCD No. _____

ACTIONS/DOCUMENTS REQUIRED	COMPLETED ✓	INCLUDED ✓
Green Folder Inside Left		
DCCR Certification Sheet		
Running Total of Contingency Allowance		
Green Folder Inside Right		
Summary		
Work Change Directive		
Negotiation Synopsis		
Record of Negotiations		
Contractor Proposal		
Certification of Costs		
Engineer Estimate		
Pre-Negotiation Position		
Background Material		
E&O Memo, if applicable		

 CCM Resident Engineer or Preparer Date

Figure 3 – Work Change Directive Checklist

The WCD will be signed by the Contractor and CCM will log and submit the package to PCO Commercial Manager, who will review and send it forward to the Assistant Director. After the Assistant Director’s concurrence, it is forwarded to the Director for final approval. A copy of the approved WCD will be provided to CCM who will retain a copy and deliver the original to the Contractor for their record.

Upon issuance of the WCD, the Contractor may bill against the contract allowance up to the agreed upon cost or the cost-not-to-exceed amount. A WCD is closed as soon as the work is found to be acceptable by the CCM. Whenever it is determined that the allowance amount may become exhausted while the potential need for WCDs still exists, a Change Order shall be processed to appropriately replenish the allowance. CCM will prepare a memorandum identifying changes caused by "Errors and Omissions" in the contract documents and include an estimate of the change in cost and time resulting therefrom. All PCO summaries with responsibility indicating "Errors and Omissions" are attached with this memorandum, if applicable.

The PCO Construction Manager will monitor and audit the CCM activities regarding Potential Change processing and insure consistency among all CCMs and compliance with the DC Clean Rivers Project CM Plan, CMIP and SOPs.

Change Log

A log of all proposed changes will be maintained in Primavera Contract Manager (CM14). The format of the change log will include tracking of sufficient steps in the change process through final approval of a change order to ensure a record of the status of each proposed change at any point in time. This log will include both of the following:

- Change orders, which are proposed changes that have been approved (and the contract amount modified accordingly).
- Rejected (or closed) changes, which are proposed changes that have been rejected or otherwise withdrawn by the contractor.

Changes will be tracked as follows:

- Date NPCO received, date of NPCO resolution and resolution status by either rejection letter to contractor or issuance of resulting RCOP.
- Date when a potential RCOP was identified, date when DC Water was approved preparation of RCOP, and date when RCOP was issued to the contractor.
- Date when NPOC was received from contractor, status of COP review or negotiations, date of COP resolution, and resolution results in either issuance of Change Order or cancelation of the COP.

The change log must also include an estimated cost and/or time impact of the change or trend. Estimated costs and time impacts will be updated as changes are negotiated. Proposed changes will be documented by the Resident Engineer according to the following reason categories or types of changes:

- DCCR requests
- DCW DETS
- DCW Water Services
- DDOT

- DDOE
- Other agencies
- Differing site conditions
- Design errors or omissions
- Regulatory requirements
- Program schedule conflict
- Other
- Contract Interfaces

Reports derived from the change log will be used for the monthly forecast to complete, to monitor the status of each proposed change within the overall process and to highlight proposed changes that are not being processed in a timely manner. These reports are required to be submitted by the Resident Engineer monthly and will be monitored by the PCO Oversight Construction Manager to ensure consistency among all CCMs and compliance with DC Clean Rivers Project CM Plan, CMIP, and SOPs.

Time Adjustment Request

If a proposed change involves an impact to the approved construction schedule, the contractor will be required to include a time adjustment request with the proposed change. The Resident Engineer will review the time impacts and provide an alternate impact analysis if required to support negotiation of the change. The PCO will review the CCM's analysis. The PCO will coordinate with other CCMs and review the master program schedule to determine if the time adjustment will impact other projects. This is particularly important for impacts that affect planned system shutdowns.

This coordination is also necessary for DC Water requested changes. For DC Water requested changes, the PCO will prepare a time impact analysis prior to the request being submitted to the contractor for use by the Clean Rivers Assistant Director and the PCO Commercial Manager to determine if the change should be submitted to the contractor. After completion of this analysis, the PCO Project Control Specialist will make a recommendation for action by the Clean Rivers Assistant Director and the PCO Commercial Manager.

Change Order Cost Proposal

If a proposed change involves an impact to the contract cost, the Contractor will be required to include a detailed cost proposal with the proposed change for analysis. The CCM Resident Engineer will review the cost proposal and provide an assessment to support negotiation of the change. The CCM shall prepare a Fair Cost Estimate per the CM-Cost Estimate form.

The CCM's recommendation will be forwarded to the PCO Oversight Construction Manager and the PCO Commercial Manager for action as required. At the discretion of the PCO Commercial Manager, Pre-Negotiation Targets (Low and High) may be developed with the CCM and the PCO Project Control Specialist for complex and significant changed work. For DC Water requested

changes, the CCM will prepare a cost estimate analysis prior to the request being submitted to the Contractor for use by the DCCR Assistant Director to determine if the proposed change should be submitted to the Contractor.

The integrity of the DC Clean Rivers Change Management process must be maintained at all times. The pricing of the Fair Cost Estimate and any Pre-Negotiation Targets that may have been developed cannot be divulged to the Contractor. However, quantities and rates can be discussed among the parties during fact finding meetings to ensure all parties are considering the same scope in the changed work.

Contract Change Order Negotiation

The CCM shall proceed with contract change negotiations in accordance with DCW SOP 5400. The purpose of the negotiation is to evaluate the cost and time proposal submitted by the Contractor for a proposed change/modification to the contract and to come to an agreement on cost and/or time for the proposed change. Fact finding meetings between the CCM and Contractor to ascertain and confirm changed work scope any time after receipt of a NPCO or issuance of a RCOP may occur.

The CCM will establish a Pre-Negotiation Position (PNP) based upon evaluation of the pertinent change documentation, including but not limited to, the Contractor's Change Proposal and the Fair Cost Estimate. In many cases, due to the complexity of the changed work, a low-high range for cost and time may be needed to be established to assist with negotiations. The PNP will be forwarded to the DCCR Assistant Director and/or Director for approval prior to negotiations with the Contractor. A checklist for the PNP process is provided in Figure 4.

PRE-NEGOTIATION POSITION CHECKLIST

DC Water Contract No. _____

RCOP/NPCO No. _____

CO/WCD No. _____

ACTIONS/DOCUMENTS REQUIRED	COMPLETED ✓	INCLUDED ✓
<u>Change/Issue Identified and Evaluated for Merit</u>		
<u>Request for Change Order Proposal (RCOP), if applicable</u>		
<u>Contractor Notice of Proposed Change Order (NPCO), if applicable</u>		
<u>CCM Cost Estimate and Backup Material</u>		
<u>Contractor Change Proposal</u>		
<u>Pre-Negotiation Position Narrative/Spreadsheet</u>		
<u>PNP Meeting with Assistant Director/Director for approval</u>		
<u>Schedule Negotiation of Change Order/Work Change Directive</u>		

 CCM Resident Engineer or Preparer Date

Figure 4 – Pre-Negotiation Position Checklist

Within 30 days of receipt of the construction Contractor’s proposal, the CCM will schedule the change negotiation meeting. During this negotiation meeting, the CCM and the construction Contractor will discuss labor, materials, tools, equipment and insurance, and incidentals necessary to accomplish the additional work in accordance with the Contract Drawings and Specifications and any revisions to the contract with DC Water.

Once agreement is reached on cost and time, the CCM will prepare a Record of Negotiations Agreement that contains the settled upon amount and time extension (if agreed upon). The Record of Negotiations Agreement shall be first signed by the Contractor. Following signature by the Contractor, this document shall be returned to the CCM who will sign the negotiated settlement and include it within the Change Order Package.

If, after reasonable attempts, an agreement cannot be reached on the changed work and DC Water determines that the work is necessary for the completion of the Contract, it may at its discretion have the CCM issue a Change Directive.

Contract Change Order Processing

When DC Water and the contractor agree on the total scope and/or cost and/or time of a proposed change, the CCM shall prepare a Change Order Package for approval to the appropriate management levels within DC Water. When a change order is approved that affects the contractual design or specifications the contract documents will be revised to reflect the approved changes. The contractor is responsible for submitting an updated the Schedule of Values with the next monthly schedule update incorporating the approved change.

The PCO and DC Water will review and approve the Change Order Package. The purpose is to critically review the proposed change order and to formally amend the contract to adjust contract price and time and thus facilitate the completion of all the work required for a complete facility.

When the Change Order (CO) package is complete, the CCM will submit it to the PCO Project Control Specialist who will first review the CO package and inspect it for any cost and schedule discrepancies. Following initial review, the CO package shall be forwarded to the PCO Commercial Manager who will verify the accuracy and completeness of the package. The PCO Commercial Manager will send the package to the DCCR Assistant Director for review and necessary signature via the PCO Oversight Construction Manager.

The Change Order Instrument along with the Consent of Surety Form and the Subcontractor Participation Form will be sent out to the Contractor for their review and consent. The remaining package will be sent to the PCO Project Control Specialist where the CO package is verified for the availability of budget. After the verification, the package will be sent back to the CCM. The Contractor will return, after executing, the CO package to the CCM. The CCM will combine the CO package and send it to DC Water Procurement.

The Director, Procurement will review the package for compliance with the procurement policy and sign the Contract Action Report (CAR) and Change Order Instrument. The CO package will be presented to the Contracting Officer for execution.

Once the CO package is signed by DC Water, it will be sent back to Procurement for preparing a Purchase Order (PO). Depending on the amount of the CO, the PO is signed by the appropriate DC Water manager. Procurement will send the CO package to the CCM who will file one copy in the master file, send a copy of fully executed CO to the Contractor, one copy to PCO Project Control Specialist, and another copy to the PCO Commercial Manager. Figure 5 provides a checklist for DCCR change package preparation.

CHANGE PACKAGE PREPARATION CHECKLIST

DCW Contract No. _____

RCOP/NPCO No. _____

CO/WCD No. _____

ACTIONS/DOCUMENTS REQUIRED	COMPLETE ✓	INCLUDED ✓
Contract Action Report		
Change Order Summary Sheet		
CCM Memorandum to Director		
Board of Directors Resolution, if applicable		
Director Memorandum to Contracting Officer		
Contract Identification Sheet		
PCO Summary Sheet		
CCM Memorandum identifying Errors & Omissions, if applicable		
Change Order Instrument (5 copies)		
Letter to Contractor transmitting the Change Order Instrument		
CCM Cost Estimate		
Contractor Change Proposal		
Letter to Contractor transmitting Executed Change Order		
Summary Record of Negotiation, including Settlement Sheet		
Backup Material, including RFP and other applicable documents		

 CCM Resident Engineer or Preparer Date

Figure 5 – Checklist for Change Package Preparation

Dispute Procedures

The CCM and Contractor shall make good faith efforts to resolve any claim, dispute or controversy arising out of or relating to the contract.

The contract documents provide procedures for how the Contractor should address disputes with DC Water. The CCM is responsible to do all possible to minimize disputes and avoid claims within the framework of the contract. In the event disputes arise, the contract may provide for a Disputes Review Board. Other recourses within the contract may be a request for Contracting Officer's Final Decision, mediation, and arbitration.

The contract documents for DB projects may contain procedures of a Dispute Review Board (DRB). The CCM will facilitate the process of DRB selection, which is a joint process between DC Water and DB Contractor in selecting the panel members. Once the DRB has been selected and under agreement, the CCM will be responsible for arranging regular DRB site visits and preparing and making the presentations to the Board on behalf of DC Water.

In the event that the DRB hears a specific dispute, the CCM will work with the PCO Commercial Manager and DC Cleans Rivers staff to prepare materials and presentations.

Claims Management

A claim is a contractor's request for adjustment of the contract price or the contract times, or both, based on assertions that the work actually required to be performed is different from work described by the contract documents. The contract describes the process for addressing disagreements between DC Water and the contractor about differing work. Disagreements often lead to claims. The contract documents describe the process and the time required to file a claim and the form and content of a formal claim submittal.

The entire organization works together to prevent claims. A major part of this effort involves precluding and limiting contract changes. Claims management includes "prevention" that must start during the design phase and be continued through construction.

The principal means of preventing claims is development of properly conceived contractual terms that clearly assign risks to the parties best suited to manage them, and complete, coordinated design drawings and specifications detailing the technical and operational requirements of the contract documents. During contract document reviews, the construction management staff will focus on these issues to begin the claims prevention measures.

Management of the claims process by the CCM must be conducted in accordance with the provisions of the contract and in accordance with DCW SOP 5140, as applicable. The Resident Engineer is responsible for the initial management of claims for his/her project. The Resident Engineer reviews a notice of potential claim for conformance to the contract documents, for making all attempts to resolve the issue with the contractor so as to avoid a formal claim and to advise the Clean Rivers Assistant Director, PCO Oversight Construction Manager and the PCO Commercial Manager of the receipt of a notice of potential claim. The Resident Engineer shall log and track the notice, submittal and response process closely to insure conformance with contract time requirements.

Should a formal claim be submitted by the contractor, the CCM reviews the claim for conformance to the requirements of the contract documents, notifies the PCO Commercial Manager and the

PCO Oversight Construction Manager who coordinate initiating discussions with DCCR Assistant Director for response to the claim. Under the direction of the PCO Oversight Construction Manager, the PCO Commercial Manager, the Project Controls Specialist, CCM staff and Inspectors, Contract Division Manager, and A/E consultant will provide support in analyzing a claim and preparing a negotiations position. The formal claim, draft response and negotiations position, along with supporting documentation, is presented to the PCO Commercial Manager. Upon finalization of the negotiations position, the Resident Engineer and PCO Commercial Manager will meet with the contractor to discuss the claim.

The CCM Resident Engineer is responsible for documenting all claims negotiations and maintaining record files as part of the contracts files.

Program Change Analysis

On a bi-weekly basis, a Change Management Status Meeting is held by the PCO Commercial Manager with mandatory attendance of the Resident Engineers and associated DC Water Program Managers. Prior to this meeting, each Division verifies the CM14 change data and then summarizes the current change status. Also discussed are major change events and approaches which may be useful to the other Divisions facing similar situations. Additionally, the PCO Construction Oversight Manager and PCO Commercial Manager perform routine monitoring and audit of divisional CM-14 files to assure documentation quality and standardization are met.

Trend analyses is performed by the PCO Commercial Manager to further define the risks to a specific Division in terms of the cost and number of changes listed in CM14. This assists DC Water in evaluating and refining appropriate budget contingencies as the project progresses. Each analysis is continuously performed during the contract life from initial design to project closeout as reflected in ongoing project re-estimation. From CM14 data on change orders, work change directives and minor change directives, Table 3 lists the source summary of all DCCR contract changes (with exception of Division C whose completion pre-dates current change reporting). As indicated, the largest change source (both the number of changes and cost of changes) for the DCCR Project is most recently been the DCCR Request category.

Table 3 – Source Summary of DCCR Contract Changes

SOURCE SUMMARY OF DCCR CONTRACT CHANGES AS OF 10/25/2016 ⁽¹⁾														
Division	DCCR Request	DCW DETS	DCW Water Services	DDOT	DDOE	Other Agencies	Differing Site Conditions	Design Errors or Omissions	Regulatory Requirements	Program Schedule Conflict	Other	Contract Interfaces	Division Change Totals	
A	Number	26	4	0	4	1	2	6	8	3	0	18	29	101
	% Div Total	25.7%	4.0%	0.0%	4.0%	1.0%	2.0%	5.9%	7.9%	3.0%	0.0%	17.8%	28.7%	100%
	% DCCR Total	5.6%	0.9%	0.0%	0.9%	0.2%	0.4%	1.3%	1.7%	0.6%	0.0%	3.9%	6.2%	21.7%
	\$ Amount	\$ (2,045,861.00)	\$ 287,313.62	\$ -	\$ -	\$ 57,873.00	\$ -	\$ 299,170.92	\$ 125,000.00	\$ (208,175.52)	\$ -	\$ (5,395,453.10)	\$ 10,809,912.67	\$ 3,929,780.59
	\$ % Div Total	-52.1%	7.3%	0.0%	0.0%	1.5%	0.0%	7.6%	3.2%	-5.3%	0.0%	-137.3%	275.1%	100.0%
TOTALS	Number	172	10	7	20	3	14	90	40	10	2	52	45	465
	% DCCR Total	37.0%	2.2%	1.5%	4.3%	0.6%	3.0%	19.4%	8.6%	2.2%	0.4%	11.2%	9.7%	100.0%
	% DCCR Change	-0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.2%	0.0%	0.0%	0.2%	0.0%	0.0%
	Total \$	\$ 15,156,880.61	\$ 1,116,690.97	\$ 2,870,451.25	\$ 1,112,622.90	\$ 1,171,141.00	\$ 556,507.93	\$ 4,803,031.13	\$ 1,563,745.10	\$ 349,938.32	\$ 59,362.62	\$ 13,685,241.11	\$ 11,108,263.02	\$ 53,553,875.96
	% Total Cost	28.3%	2.1%	5.4%	2.1%	2.2%	1.0%	9.0%	2.9%	0.7%	0.1%	25.6%	20.7%	100%

Note: (1) Includes all changes (CO, WCD, MCD, etc.) listed in CM-14

For illustration, data for the initial Design-Build project Division A Blue Plains Tunnel as well as the totals for all DCCR Divisions is shown in the above table. The major change cost impacts to Division A were associated with the Contract Interfaces source category. It is also evident that the 101 changes logged in for Division A have so far been 21.72% of the total number of changes

for the DCCR Project. However, the value of these Division A changes actually amounted to \$3.93 million or 7.34% of the total value of DCCR divisional changes at that date of analysis.

The DCCR change data can also be charted for the respective Divisions of the DCCR Project as below in Figure 6 for number of changes and in Figure 7 for the dollar value of the changes.

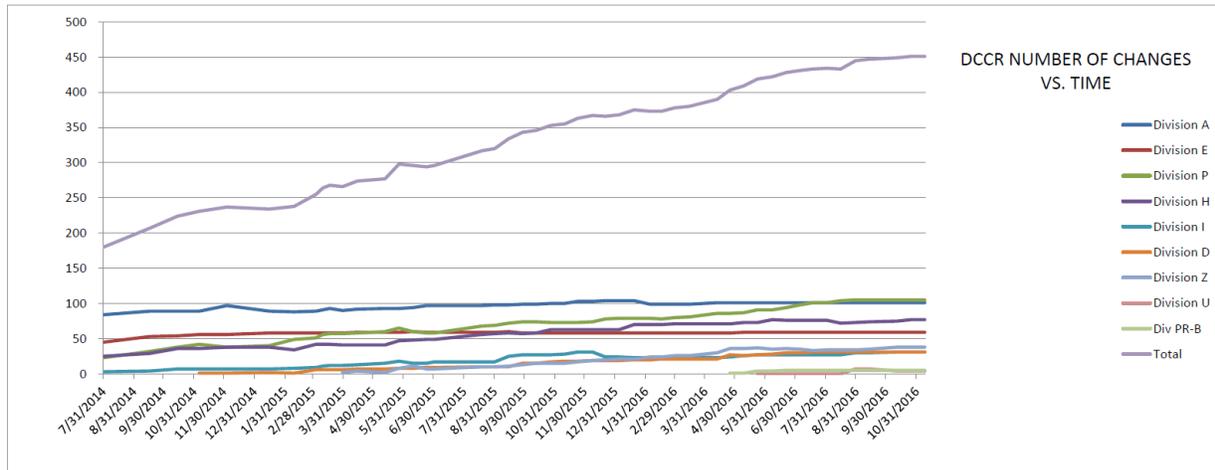


Figure 6 – Number of DCCR Contract Changes by Division

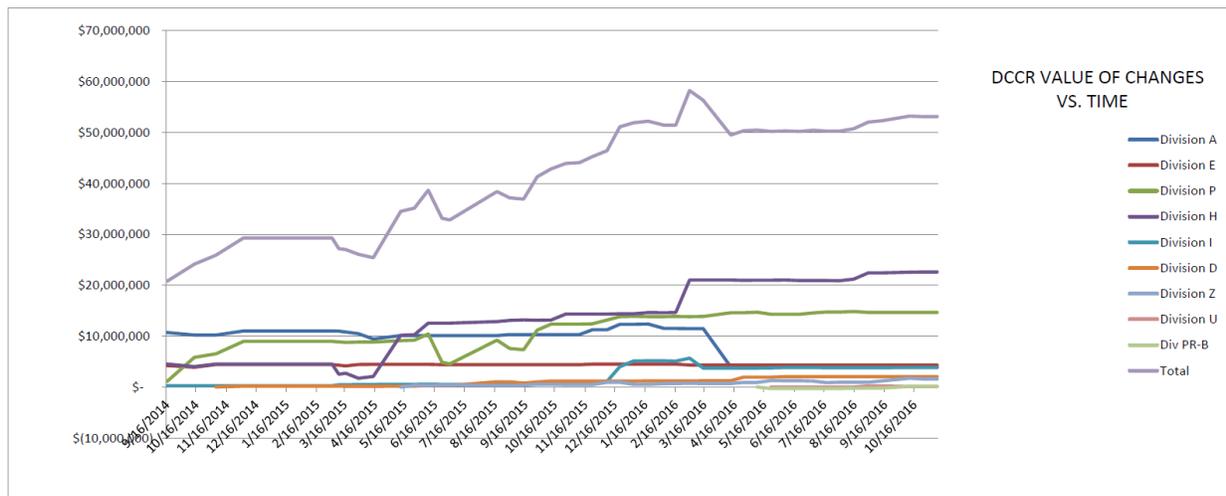


Figure 7 – Value of DCCR Contract Changes by Division

Using the above described methodology, DC Water has developed a change management process to readily monitor the Divisional change and contingency status through construction and startup. As discussed in Lisse (2016), if trending indicates the remaining contingency will be less than the minimum reserve amount, then augmentation of the project contingency may be initiated via the DCCR change order process.

Conclusion

The methodology described in this study results in an effective change management plan for large civil infrastructure projects that is:

- Built upon ongoing change processes,
- Requires continuous change status updates involving all project stakeholders,
- Uses trending to project numerical ranges of the potential current cost and schedule impacts, and
- Establishes projections of project cost to complete enabling a comparison to the current available project contingency.

Further, the DCCR Change Management Plan has demonstrated its utility as a Project Management tool that:

- Helps track changes to better manage contract interfaces and meet consent decree deadlines,
- Enables monitoring of current cost to completion position,
- Tracks and trends project contingency spending, and
- Updates program change analysis (costs and time impacts to other Divisions).

Acknowledgement

Many of the figures presented in this report were extracted from DC Clean Rivers Project Change Management Plan and the support of the DC Clean Rivers Project Office of DC Water is very much appreciated.

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