CLASSICAL RCM PILOT STUDY

PILOT No. 1 and 2

Main Pumping Station Screening System

Main Pumping Station Pumping System

June 21, 2018

Presenters:

Kenrick St. Louis and Gregory Stephens

Moderator: Gian Cossa

CWEA Plant O&M Committee

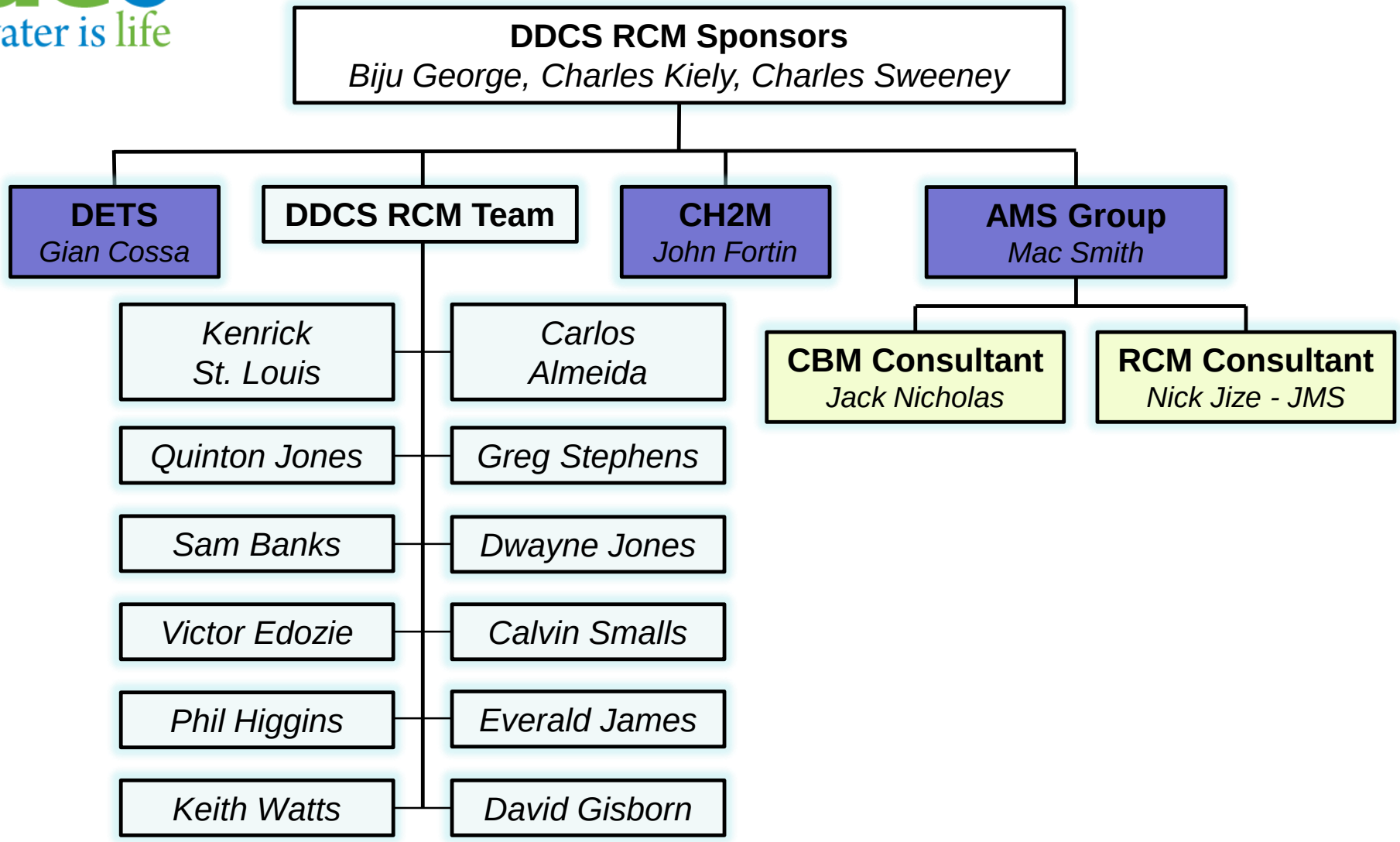
Safety Moment

- Doors across the facility
  - You can’t see when somebody is going to come barging through a door
  - Be mindful if you are standing on the swinging side of the door
  - Open doors slowly as a precaution

INTRODUCTION

- What is RCM?
  - RCM – Reliability Centered Maintenance – is a comprehensive, systematic, and structured approach to develop an efficient and effective maintenance plan to minimize the probability that our assets fail.
- Why RCM?
  - RCM is labor and time intensive – but it is considered the industry's best approach to maintenance.

RCM TEAM


DDCS RCM Sponsors
Biju George, Charles Kiely, Charles Sweeney
DETS
Gian Cossa
DDCS RCM Team
CH2M
John Fortin
AMS Group
Mac Smith
Kenrick St. Louis
Carlos Almeida
Quinton Jones
Greg Stephens
Sam Banks
Dwayne Jones
Victor Edozie
Calvin Smalls
Phil Higgins
Everald James
Keith Watts
David Gisborn
CBM Consultant
Jack Nicholas
RCM Consultant
Nick Jize - JMS

TEAM INTRODUCTION

- Victor Edozie – Maximo Administrator
- Calvin (CJ) Smalls – Lead Mechanic
- Everald James – Planner/Scheduler
- Keith Watts – Operations Foreman
- Charles Sweeney – Director, DDCS
- Gregory Stephens – Operations Foreman
- Nick Jize – RCM Facilitator
- Dwayne Jones – Acting Foreman, Electric Shop
- Carlos Almeida – Manager, Maintenance
- Jack Nicholas – CBM Expert
- Quinton Jones – Instrumentation Technician II
- Phil Higgins – Reliability Maintenance Supervisor
- Gian Cossa – Asset Manager, DETS
- David Gisborn – DDCS Operations
- Kenrick St. Louis – Manager, Operations
- John Fortin – CH2M
- Sam Banks – Planner/Scheduler
- Anthony “Mac” Smith – AMS Associates and “RCM Guru”

Enthusiastic team with great participation and commitment!

OBJECTIVES

- Establish a framework for DDCS to improve Maintenance efficiency and functional reliability of assets
  - Approach focus:
    - People
      - Training and Mentorship
      - Changing the cultural prospective
      - Increase cooperation and communication between Operations & Maintenance
    - Process
      - Reliability Centered Maintenance Approach
      - Computerized Maintenance Management System (CMMS)
      - Standard Operating Procedures (SOPs)
    - Equipment and technology
      - Condition Based Maintenance (CBM)
      - Predictive Maintenance (PdM)
      - Understand the complex interactions between assets.
- Alignment with Blue Horizon 2020 Strategic Goals
- Prevent the occurrence of catastrophic failures by developing and implementing a cost-effective maintenance program

DDCS & RCM

- How are we using RCM?
  - A core team has been meeting to apply the RCM process to Main Pumping Station.
  - The team consists of an Electrician, Mechanic, Instrumentation tech, Operator, Planners, Consultant, Scribe, and management support.
  - We will continue to apply RCM process to other stations.
- What do we get from RCM?
  - New PMs.
  - Changes to existing PMs.
  - Assets and tasks for Condition Based Maintenance.
  - A selection of assets we determined to Run to Fail.
  - Operator inspection items.
  - A more reliable station!!

RCM PROCESS

- What makes up a RCM Study?
  - Seven key questions:

1. What are the functions and associated desired standards of performance of the asset in its present operating context (**functions**)?
2. In what ways can the asset fail to fulfill its functions (**functional failures**)?
3. What causes each functional failure (**failure modes**)?
4. What happens when each failure occurs (**failure effects**)?
5. In what way does each failure matter (**failure consequences**)
6. What should be done to predict or prevent each failure (**proactive tasks and task intervals**)?
7. What should be done if a suitable proactive task cannot be found (default actions e.g. **run to failure**)?

How We Did It

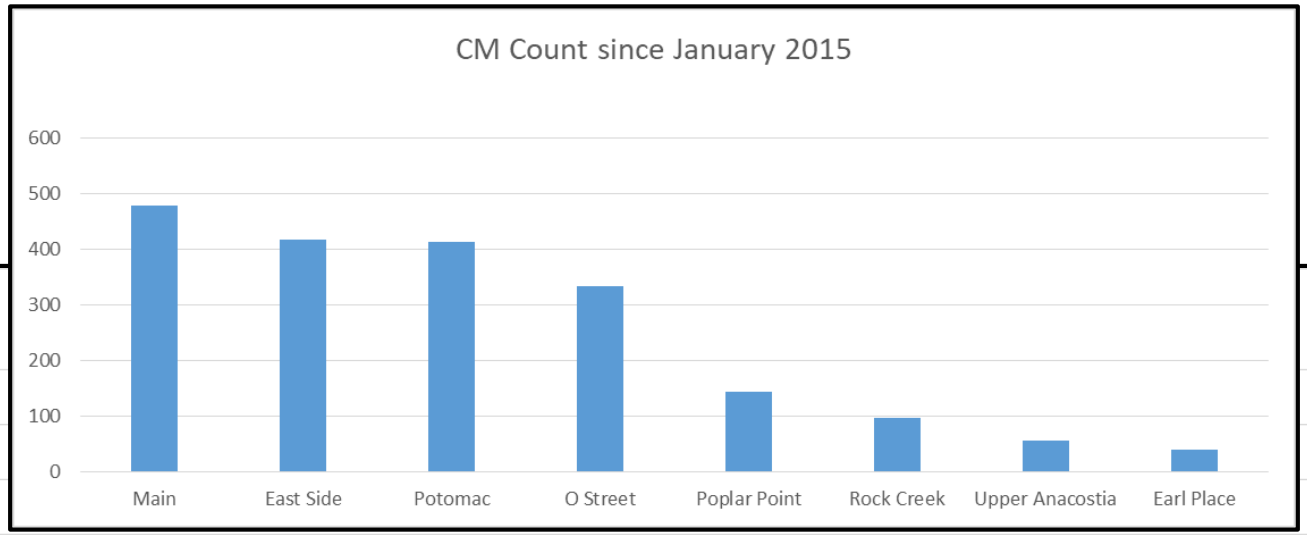
- Training – AMS Associates
- Used JMS Software
- Facilitation & Mentoring - AMS Group

What We Did

1. System Selection

Main Pumping Station

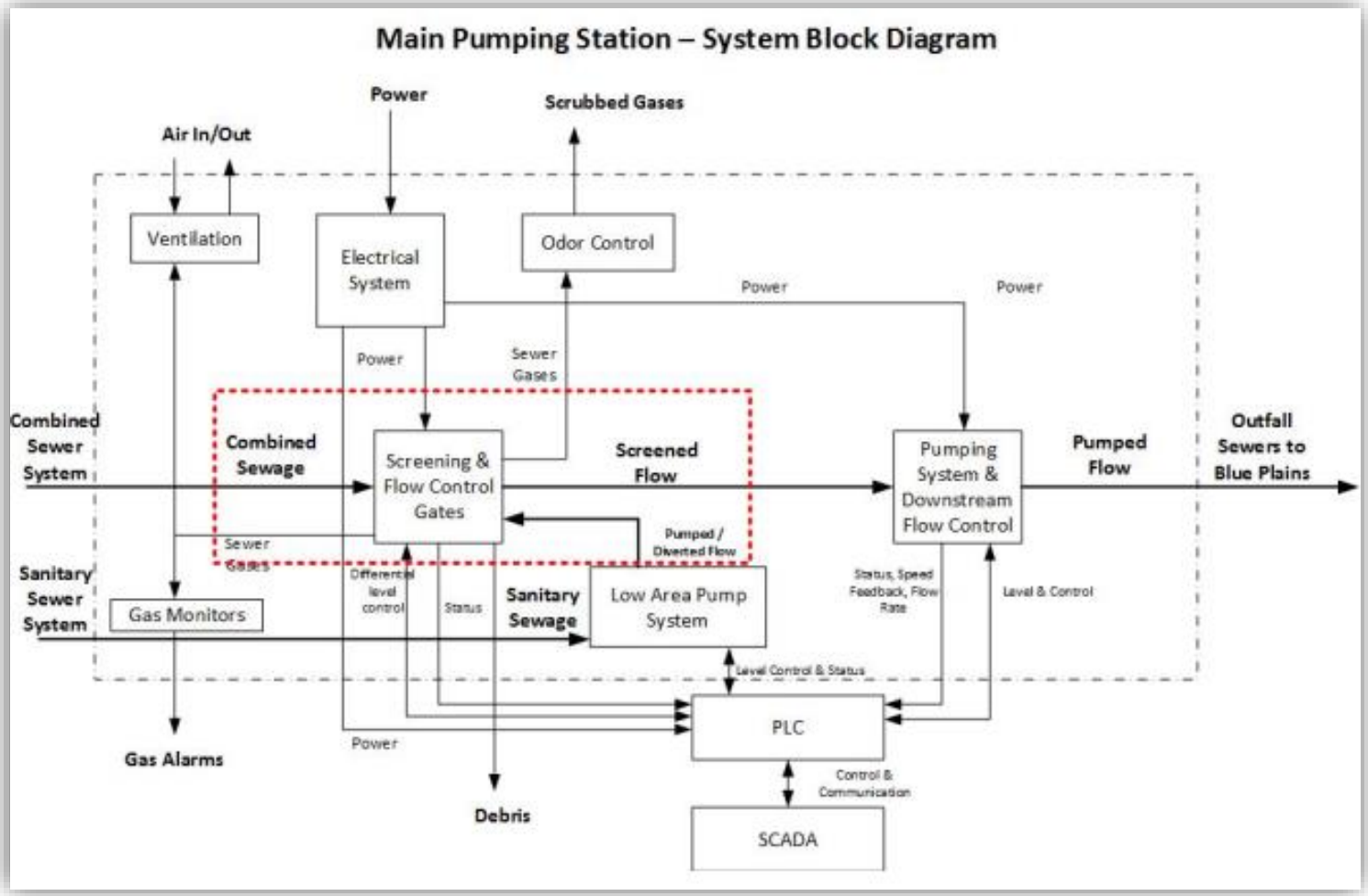
- Screening System for pilot #1
- Pumping System for pilot #2



WHAT WE DID

2. System Boundary Definition

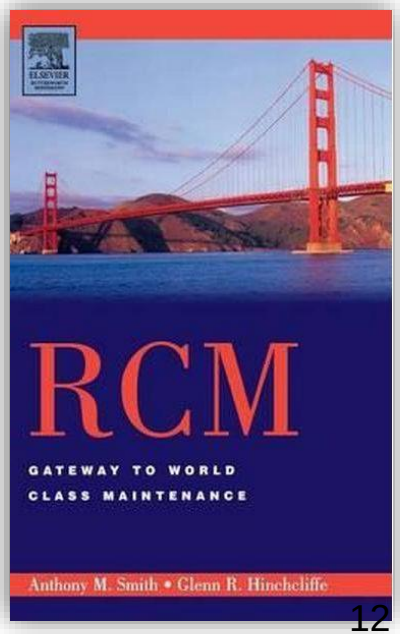
3. System Description and Functional Block Diagram



WHAT WE DID

Classical RCM

- Selected the Classical RCM Process to conduct a pilot study
  - Classical - Mimics very closely the original Study Format conducted by United Airlines in the early '60s for the 747 airplane
- Four RCM Principles
  - Preserve system function
  - How are functions defeated (failure modes)
  - What are the priorities
  - For high critical failure modes
    - Define applicable tasks
    - Select most effective one



WHAT WE DID

4. System Functions and Functional Failures

Function #/ FF #		Function/ Functional Failure Description	
01.0		*Remove large debris and allow flow of up to 240 MGD (Firm Capacity)*	
	01.1		Debris can not be removed so can not meet 240 MGD flow rate (Firm Capacity)
02.0		*Efficiently remove debris from the building*	
	02.1		Cannot efficiently remove debris from the building
03.0		*Provide control signal to PLC*	
	03.1		No signal provided
	03.2		False signal provided
04.0		*Allow sewer gases to escape from the channel*	
	04.1		Gases cannot escape
05.0		*Provide capability to manage flow and isolate sections for maintenance purposes*	
	05.1		Cannot isolate sections of the station
	05.2		Cannot manage flow

Screening System
- 5 Functions
- 7 Functional Failures

Pumping System
- 5 Functions
- 8 Functional Failures

WHAT WE DID

7. Task Selection

- High Priority Failure Modes were Identified in Step 6
- For those High Priority Failure Modes, select the proper preventive maintenance action
  - Applicable: Can prevent, mitigate, detect onset of, or discover (if hidden) a failure mode
  - Effective: The least costly choice among competing applicable PM task candidates
  - All tasks are Time Directed (TD), Condition Directed (CD), Failure Finding (FF), or intentional Run To Fail (RTF).

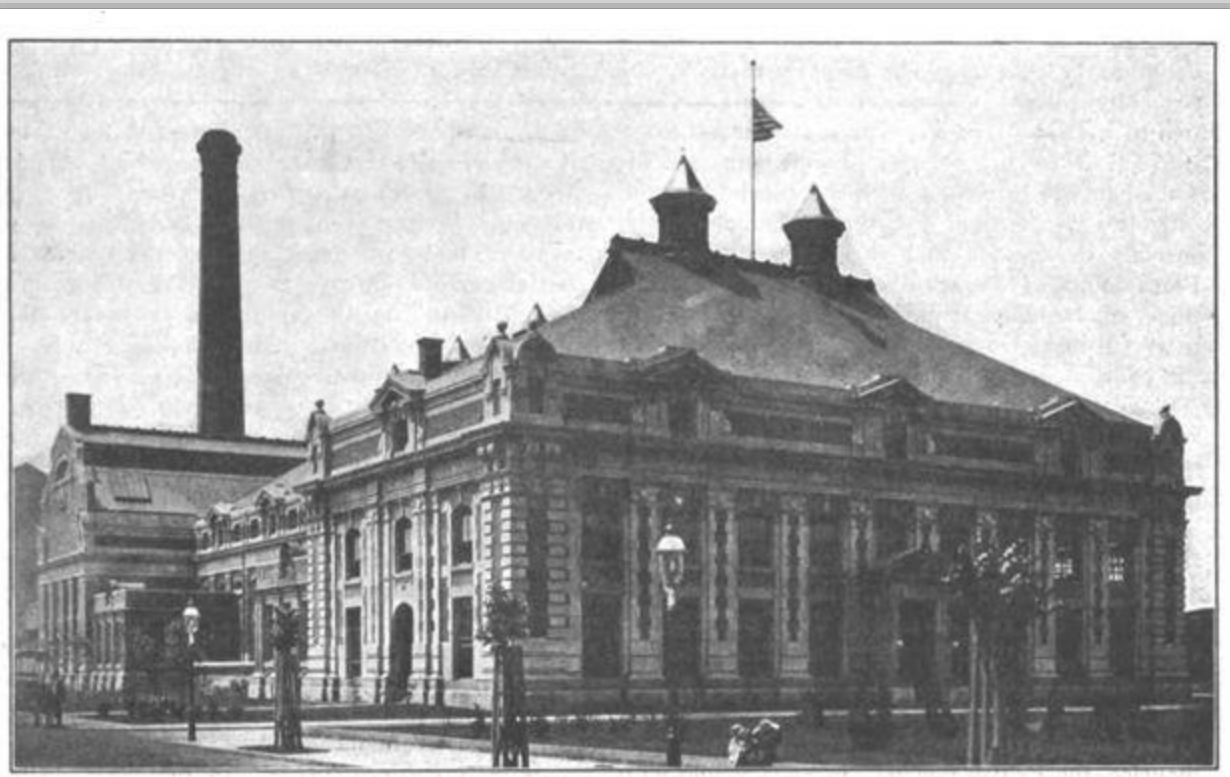
DDCS & RCM

Step 7-1: Selection Process and Decision

Comp. #	Comp. ID	Comp. Description	F.M. #	Failure Mode	F.C. #	Failure Cause	Local	System	Plant	Ste
01	222804	PUMP, CENTRIFUGAL, (MP-SANP-04)	01.01	Worn, clogged Impeller.	01.01.1	Debris or age	Loss of efficiency of the pump	loss of pumping capacity	Cannot meet consent decree resulting in fines	

F.F. #	Comp. #	Comp. ID	Component Description	F.M. #	Failure Mode	F.C. #	Failure Cause	1	2	3	4	5	6	7	Safety	Candidate Task Description & Effective Information
02.1	01	222804	PUMP, CENTRIFUGAL, (MF	01.01	Worn, clogged Impeller.	01.01.1	Debris or age	P	Y	Y	N	-	Y		Yes	1.) Run to Fail (RTF) 2.) Compare pump performance data to historical data and performance curves (TD) 3.) Perform vibration analysis (CD)
02.1	01	222804	PUMP, CENTRIFUGAL, (MF	01.03	Bearing failure/ lack of lubrication	01.03.1	Age	P	Y	Y	N	-	Y		Yes	1.) Run to Fail (RTF) 2.) Use Ultrasonic method to lubricate the bearing (CD) 3.) Perform vibration analysis (CD)
02.1	01	222804	PUMP, CENTRIFUGAL, (MF	01.05	Mechanical Seal Failure	01.05.1	Vibration				N	-			Yes	1.) Run to Fail (RTF) 2.) Check the pressure and flow of water. Log any adjustment as needed. (TD) 3.) Visually check for water leaks on the seal
02.1	02	280001	RELAY, DRIVE CONTROL, 02, 03	02.01	Burnt out	02.01.1	Age, power surge				N	-			Yes	1.) Run to Fail (RTF)
05.1	03	211747	PUMP, SUMP, (MP-SP-01, 02)	03.01	Pump failure	03.01.1	Wear				N	-			Yes	1.) Run to Fail (RTF) 2.) Verify that the check valve lever is up on the primary (lead) pump when running (TD)
05.1	04	280148	VALVE, SWING CHECK, (M 02)	04.01	Inoperable	04.01.1	Wear and Debris				N	-			Yes	1.) Run to Fail (RTF)

SIGNIFICANT FINDINGS



The New Sewage Pumping Station at Washington, D. C.

Analysis Pilot No. 1

RCM Systems Analysis Profile For The Screening and Gates System	
Subsystem Functions	5
Subsystem Functional Failures	7
Components in Subsystem Boundary	49
Failure Modes Analyzed • Critical • Non Critical • Hidden	128 83 (65%) 45 (35%) 69 (54%)
PM Tasks Specified (includes 47 RTF tasks)	158
Active PM Tasks	111 (70%)
Items of Interest	35

Note:
The details for the above topics are located in the "RCM WorkSaver" software that was completed by the RCM Team.

ANALYSIS PILOT NO. 1

PM Task Types – Comparison(By Failure Mode) For The Screening and Gates System		
Task Type	**RCM**	**Current**
Time Directed • Non-Intrusive (TD) • Intrusive (TDI)	 38 (24%) 20 (13%)	 17 (11%) 63 (40%)
Condition Directed (CD)	29 (18%)	5 (3%)
Failure Finding (FF)	27 (17%)	9 (5%)
Run to Failure (RTF)	47 (30%)	--
None	--	64 (40%)
Total	158 (100%)	158 (100%)
Total Active	111 (70%)	94 (60%)

- RCM Tasks have significantly reduced intrusive tasks and dramatically increased Condition Directed tasks.
- All RCM PM task categories contributed to this positive development.

ANALYSIS PILOT NO. 1

PM Task Similarity Comparison(By Failure Mode) For The Screening and Gates System	
I RCM Task = Current Task	11 (7%)
II RCM Task = Modified Current Task	35 (22%)*
III RCM Specifies Task, No Current Task Exists	39 (25%)*
IV RCM Specifies Task, Current Specifies Different Task	25 (16%)*
V RCM Specifies RTF, Current Task Exists	19 (12%)*
VI RCM Specifies RTF, No Current Task Exists	28 (18%)
Total	158 (100%)

- A quarter (25%) of the study failure modes have no PM task currently (III).
- Another 22% of current task are significantly modified with some modifications documenting current tribal knowledge
- RCM changes or modifies 75% of current program (*)

ANALYSIS PILOT NO. 2

RCM Systems Analysis Profile For The Pumping System	
Subsystem Functions	5
Subsystem Functional Failures	8
Components in Subsystem Boundary	41
Failure Modes Analyzed • Critical • Non Critical • Hidden	71 70 (98%) 1 (2%) 22 (30%)
PM Tasks Specified (includes RTF)	109
Active PM Tasks	96 (88%)
Items of Interest	24

Note:
The details for the above topics are located in the "RCM WorkSaver" software that was completed by the RCM Team.

Analysis Pilot No. 2

PM Task Types – Comparison (By Failure Mode) For The Pumping System		
Task Type	**RCM**	**Current**
Time Directed • Non-Intrusive (TD) • Intrusive (TDI)	 34 (30%) 18 (17%)	 18 (17%) 24 (22%)
Condition Directed (CD)	32 (29%)	4 (3%)
Failure Finding (FF)	12 (12%)	3 (3%)
Run to Failure (RTF)	13 (12%)	--
None	--	60 (55%)
Total	109 (100%)	109 (100%)
Total Active	96 (88%)	49 (45%)

- RCM Active PM tasks almost doubled over current active PM tasks.
- RCM has a dramatic increase in Condition Directed Tasks over existing tasks

ANALYSIS PILOT NO. 2

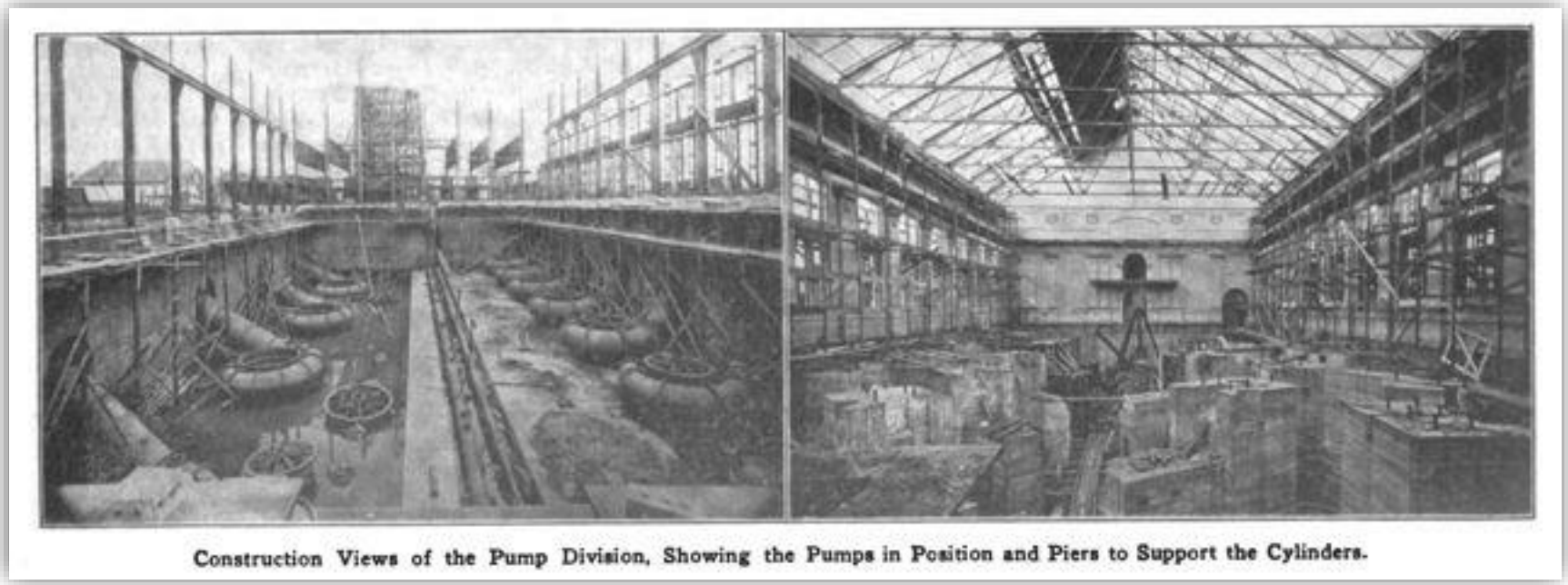
PM Task Similarity Comparison(By Failure Mode) For The Pumping System	
I RCM Task = Current Task	5 (4%)
II RCM Task = Modified Current Task	24 (22%)*
III RCM Specifies Task, No Current Task Exists	53 (49%)*
IV RCM Specifies Task, Current Specifies Different Task	14 (13%)*
V RCM Specifies RTF, Current Task Exists	6 (6%)*
VI RCM Specifies RTF, No Current Task Exists	7 (6%)
Total	109 (100%)

- About half (49%) of the study failure modes have no PM task currently (III) .
- Another 22% of current task are significantly modified with some modifications documenting current tribal knowledge
- RCM changes or modifies 90% of current program (*)

STUDY FINDINGS

- Both of the subsystems in pilot #1 and #2 reflect the need for two very important beneficial actions
  - Upgrade the selected PM tasks in the existing program to eliminate tribal knowledge as the basic procedure “modus operandi”
  - Add PM tasks to a large number of components that currently have no coverage to prevent possible failure modes
- Both of the Subsystems in Pilot #1 and #2 also suggest the need to progressively replace the large percent of the Time Directed Intrusive (TDI) PM tasks with the non-intrusive PM Technology available with use of the Predictive Maintenance Methodology(PdM)

LESSONS LEARNED



Construction Views of the Pump Division, Showing the Pumps in Position and Piers to Support the Cylinders.

Lessons Learned

- Consistent membership in the **team** proved to be very beneficial
- Highlighted the need for continual asset verification
- Just because you have a PM program does not mean it is effective
- Value of having a team made up of **maintenance and operations**
- Visits and **encouragement** from **management** was a motivator for the team
- Highlighted the critical need for documentation of SOPs (**capturing tribal knowledge**)
- Better knowledge of our systems and **how equipment can fail**

LESSONS LEARNED

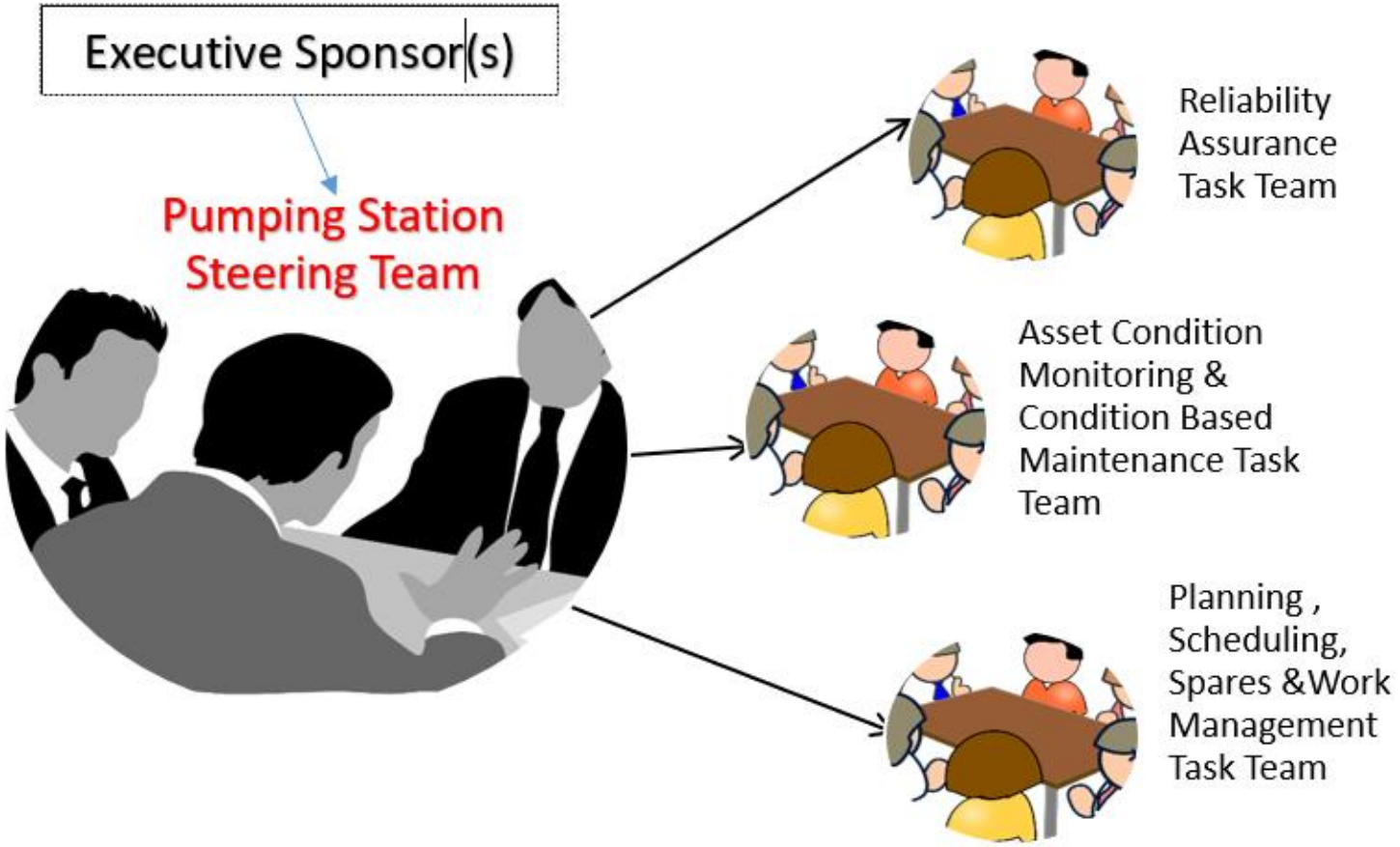
- Work management process disconnect between what is expected and what is happening
- This is a real opportunity to improve the Maintenance program – we now see that **we can influence change** and are more optimistic about it – we view the cup as half full…
- Importance of taking time out from day to day responsibilities to focus on the study and improvement
- RCM process has provided an environment for information exchange between technicians that does not consistently occur

LESSONS LEARNED

- Specific Examples:
  - Sluice Gate G
  - Operating Sequence for lead and lag equipment (80/20) – potential savings of 60% on pump maintenance.

    Operate on a 12 week cycle
    - #1 pump is lead for 10 weeks
    - #2 pump is lead for 1 week
    - #3 pump is lead for 1 week
    - #4 pump tested and ran for approx. 1 hour every 3 months.

TASK TEAMS CREATED TO SUSTAIN MOMENTUM



Draft charters for the Steering Committee and Reliability Assurance Team

Steering Committee Charter

DDCS Operational and Reliability Excellence

Vision

To achieve world class Operational and Reliability Excellence

Mission

Provide strong leadership and personal commitment for the successful execution of Operations and Maintenance to deliver superior water and wastewater services at an excellent value.

Supporting Blue Horizon 2020 Strategic Plan objectives:

1. Achieve distribution system optimization to enhance water quality
2. Ensure compliance with sewer and water systems permits and regulations
3. Optimize the ratio of preventive versus corrective maintenance
4. Develop, Measure and evaluate specific indices of efficiency
5. Achieve top quartile asset management performance against benchmarks
6. Increase adoption of sustainability processes and programs
7. Increase adoption of innovative processes and programs

Executive Sponsors

Biju George

Charles Kiely

Charles Sweeney

Members

Carlos Almeida

Kenrick St. Louis

Samant Garg

Key Activities:

- Establish strategic goals for Reliability Assurance, Asset Condition Monitoring, and Planning & Scheduling focus areas.
- Allocate resources for Operational and Reliability Excellence initiative.
- Sponsor and empower task teams.
- Attend task team meetings as applicable.
- Attend Steering Committee progress meetings.
- Review and provide timely feedback on progress, reports, and recommendations.
- Actively lead change to ensure acceptance of objectives, goals, and solutions.
- Develop and implement a framework to monitor and widely communicate progress, benefits, and results.
- Provide updates to Executive Sponsors
- Collaborate with industry leaders on best practices, and encourage innovation

Acknowledgement:

Reliability Assurance Team Charter

Vision

To achieve world class Operational and Reliability excellence through the application of state of the art Reliability Practices

Mission

Provide a core team of committed members to learn, practice, train, and implement world class Operational and Reliability Excellence.

Reliability Assurance Team Objectives:

1. Build on pilot RCM Analysis and ensure it's implementation

2. Establish, document, and implement reliability best practices, procedures, measures, and continuous improvements.

3. Share knowledge with applicable staff to ensure business efficiency and continuity

4. Ensure that existing assets and new assets are protected by a proactive reliability assurance program to maintain high equipment and infrastructure reliability.

5. Acting in a steering capacity, specify and prioritize work team activities, assign resources, lead/ sponsor work teams, decide on policy recommendations from work teams, and monitor progress of work teams.

Team Leader

Kenrick St. Louis

Members

Sam Banks

Everald James

Dwayne Jones

Calvin Smalls

Quinton Jones

Gregory Stephens

Victor Edozie

Engineering rep (design) TBD

Key Activities:

- Select locations and conduct RCM Analysis.
- Implement new job plans, PMs, ACM tasks developed through RCM Analysis.
- Meet to track goals and objectives.
- Identify requirements for, and conduct, Root Cause Failure Analysis.
- Provide updates to the steering committee.
- Provide recommendations to training.
- Operate as the liaisons to appropriate branches.

Acknowledgement:

ONE YEAR PLAN CREATED

TENET	DUE DATE (By end of)	ITEM OWNER
Management	**Due by**	**Owner**
RCM Champion – roles & responsibilities	2017	Group select champion
ACM Champion	2017	Group select champion
RCM Process		
Document "Process"	2018	
PM Jon Plans		
PM/PdM Strategies		2017
CBM		
CBM Strategy Development	2018 1st Quarter	Carlos
IOI		
Tracking checklist	2017	David Gisborn/ Kenrick
Planning / Scheduling		
Reading/ Understanding job plans		Ken
Maximo		
Work flow process (cradle to grave)	Ongoing (tweaks)	Victor
Training		
Skills assessment (up front) Self or external?	December 2017	Carlos
Metrics **(Reliable and accurate)**		
Benchmarks / KPIs (Define)	1st Quarter 2018	RCM Team
Communication		
Articles	2018	Anyone! (Gian Cossa to facilitate)
Supply Chain		
Vendor/ Contractor parts "lock in"	December 2017	Sam Banks / Everald James (ensure procurement co-op)

The Living Program and Sustainment

- RCM is a living program
  - RCM decisions should be revisited every 2-5 years
  - We will look to see if processes or technology has changed, as well as if our program is effective
- Develop and implement a 5 year masterplan
  - Created by task teams and reviewed annually

Measuring Progress
Key Performance Indicators

- WO types
  - PM — Preventive Maintenance Work Orders
  - CM_PM — WOs resulting from a PM tasks
  - CM_PdM — WOs resulting from a PdM tasks
  - CM_CS — WOs resulting from SCADA
  - CM_IN — WOs resulting from Operations routes
  - CM_RE — Unscheduled reactive work
  - PROJ — Project/Engineering Support
  - CM_STRM (recommendation) — WOs resulting from storm damage or response
- Recommended KPIs
  - % Reactive (by count) = CM_RE/(PM + CM_RE)
  - % Effective PMs (by count) = CM_PM/(PM + CM_PM)
  - % PdM effectiveness (by count) = CM_PdM/(PM* + CM_PdM)
  - % Storm Impact (by count) = CM_STRM/(PM* + CM_STRM)

*Only PdM PMs are counted

Work Already Initiated By RCM Team

- Operations checklist – Capturing Tribal Knowledge and based on RCM Tasks

Department of Distribution & Conveyance Systems

DATE:_____
INITIALS:_____

MAIN PUMPING STATION – DAILY INSPECTION

FORM RCM-01

Instructions: Complete the form for the equipment stated that is in operation. All inspections are visual. If the equipment is not operational (not needed/ out of service) note as **OK** and comment N/A. Equipment marked **NOT OK** should be followed up with a work order number. If issue pertains the following day, note the same work order - do not create a duplicate.

SCREENING SYSTEM

#	TASK DESCRIPTION	OK?	NOT OK?	WORK ORDER NUMBER & COMMENTS
A	**Screen #1**			
1	Listen for unusual noise from screen motor			
2	Listen for unusual noise from the screen gear box			
3	Observe the gear box for signs of oil leakage			
4	Inspect the bearing for cracking and grease leakage			
5	Listen for unusual noise from the bearing			
6	Inspect bolts for obvious looseness and wear on the rakes			
7	Inspect the back plate for signs of scraping from teeth. Listen for scraping sounds.			
8	Inspect the top sprocket for obvious wear and broken teeth			
9	Inspect spring shock absorber for smooth operation. Listen for unusual noise and observe smooth operations			
10	Inspect the wiper bar for signs of wear, damage, and bends.			
B	**Screen #2**			
11	Listen for unusual noise from screen motor			
12	Listen for unusual noise from the screen gear box			
13	Observe the gear box for signs of oil leakage			
14	Inspect the bearing for cracking and grease leakage			

CONCLUSIONS

- Having the team put together and focused on RCM has yielded numerous positive results
- The process has spilled over into our day to day activities in positive ways. One example is increased cooperation between our groups
- The team is committed and excited to move forward with implementation and sustainment
- The RCM results point out the significance of where positive actions will be beneficial in streamlining our maintenance program with over 90% of the program experiencing some form of change
- The process has caused a paradigm shift in the way we think, talk, and conduct maintenance
- The group has become of like minds…