PIONEERING ASSET MANAGEMENT IN THE WATER QUALITY INDUSTRY – MWRA's MODEL FOR CHANGE

John W. Fortin, John P. Colbert and Ted Regan
Massachusetts Water Resources Authority
P. O. Box 100
Deer Island Treatment Plant
Winthrop, MA 02152

INTRODUCTION

The Massachusetts Water Resources Authority (MWRA) is responsible for providing wholesale water and sewerage services, in whole or in part, to sixty-one communities, and 2.6 million people. In addition to its operating responsibilities, MWRA is responsible for rehabilitating, repairing and maintaining the regional water and sewerage systems. Since its assumption of the ownership and operations of these systems in 1985, MWRA has undertaken an ambitious program of water and wastewater system capital improvements with estimated expenditures for fiscal years 1986 through 2009 of over $7 billion. Under one massive construction effort, the Boston Harbor Project, the MWRA assumed maintenance responsibility of the $3.8 billion dollar Deer Island Treatment Plant (DITP). As the second largest wastewater treatment facility in the nation, it is designed to treat 1.2 billion-gallons-per-day.

Aerial Photo - Deer Island Treatment Plant

In addition, the Agency had embarked on several other large capital projects that would require similar asset care including a new water filtration plant.

Given the significant value and critical nature of the MWRA assets, maintenance is of paramount importance. In 1996 the Facilities Asset Management Program (FAMP) initiative was created as a

comprehensive, agency-wide effort to most efficiently and effectively manage the region's water and sewer infrastructure.

PIONEERING ASSET MANAGEMENT THROUGH BENCHMARKING

Initially, the multi-phased program was focused on standardization of maintenance practices, adoption of best practices and optimization of labor and material resources. In order to facilitate the Phase I program and obtain expertise in the area of asset management a consultant was selected to support MWRA staff.

A maintenance and asset lifecycle strategies survey at outside facilities/industries of similar size and complexity was completed to help develop the FAMP initiative. Survey questions ranged from business and maintenance strategy, organizational structure, staffing and computerized maintenance management systems (CMMS) to asset management, procurement and warehousing policies. Although the survey of water/wastewater facilities found "pockets of excellence", none had an overall asset management model to follow. Upon the consultant's recommendation, the team initiated investigations into the private sector. Fortune 500 and 1000 companies and organizations were contacted and relationships developed. Collaboration efforts were initiated at leading industries including a steel mill in Canada, a manufacturer in Massachusetts and a process plant in Colorado. In addition, several team members attended and subsequently joined a new professional maintenance association, the Society for Maintenance and Reliability Professionals (SMRP).

Research outside of the water quality field helped the MWRA team identify asset management best practices and the MWRA's program model (Figure 1) and schedules were updated. The benchmarking efforts were a critical turning point in the program's success allowing the team to identify, understand and incorporate the elements of a comprehensive asset management program.

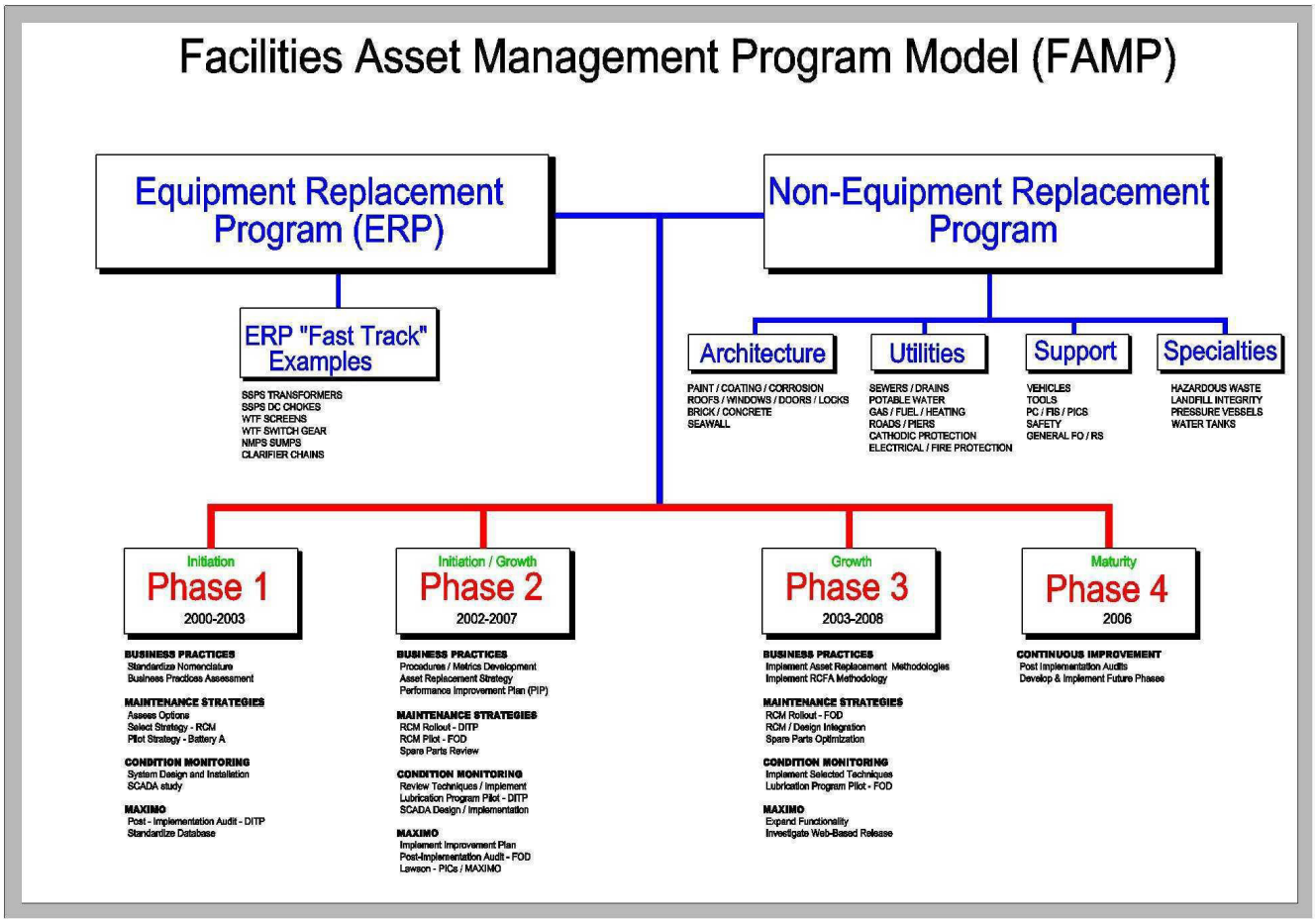


Figure 1 - FAMP Model

The MWRA continues to benchmark with other organizations and to share their efforts, knowledge and experience with both private and public entities. To date, the MWRA FAMP initiative has received national attention including:

- the Association of Metropolitan Sewerage Agency's (AMSA) 2002 National Environmental Achievement Award,
- feature article in the nationally distributed, Maintenance Technology Magazine and
- Host site and case study for MRO Software, Incorporated – a leading provider of solutions for strategic asset management.

In addition, technical papers and collaborative sessions continue with entities (associations, public and private organizations) such as

- Water Environment Federation (WEF)
- New England Water Environment Association (NEWEA)
- American Water Works Association (AWWA)
- Institute for International Research – Best Maintenance Practices
- General Accounting Office (GAO)
- Society for Maintenance & Reliability Professionals (SMRP)
- Detroit Water and Sewerage Department
- Seattle's King County Wastewater Treatment Division

- Gillette Worldwide
- Coors Brewing
- Intel Corporation
- Massachusetts General Hospital and
- Massachusetts Institute of Technology (MIT).

The MWRA's benchmarking research and commitment to program implementation has quickly advanced into a recognized benchmark and host site for asset management.

DEFINING ASSET MANAGEMENT

Benchmarking efforts have helped identify key components to a successful asset management program. Asset management is a formal and integrated body of asset lifecycle management practices. It can be further described as an integrative optimization process that enables a utility to determine how to minimize the total life-cycle cost of owning and operating infrastructure assets while continuously delivering service levels demanded by customers.

The definition "Formal" means that it has been recognized in the organization's business plan and is being treated like a capital project with a manager, budget, scope, schedule and implementation team. "Integrated" means that it touches all business units and applicable processes. "Body of asset lifecycle management practices" means that there are a combination of tools and techniques, that when combined, offer a cost-effective approach to the management of assets throughout their lifecycle (design, construction, operation, maintenance and renewal).

Benchmarking efforts have allowed the MWRA to re-define their program to include a variety of tools and techniques. The overall objective of asset management is to put an optimal program in place that includes the use of industry best practices. As depicted in the MWRA's "FAMP Wheel" (Figure 2), there are many elements to a successful program. However there are also key components ("spokes") such as a maintenance strategy (Reliability Centered Maintenance-RCM), a computerized maintenance management system (CMMS – MAXIMO), Condition Monitoring, Materials Management, Training programs and a regular Communication Plan (all further detailed below). Combined, these elements have led industry leaders to world-class results.

Note that regulations such as the EPA's Capacity, Management Operation and Maintenance (CMOM) for the wastewater collection system and the Governmental Accounting Standards Board Statement Number 34 (GASB 34) are only programs that drive ("drivers") utility owners towards asset management. Systems such as Computerized Maintenance Management Systems (CMMS) and Geographic Information Systems (GIS) are only tools that help collect, store and track asset information.

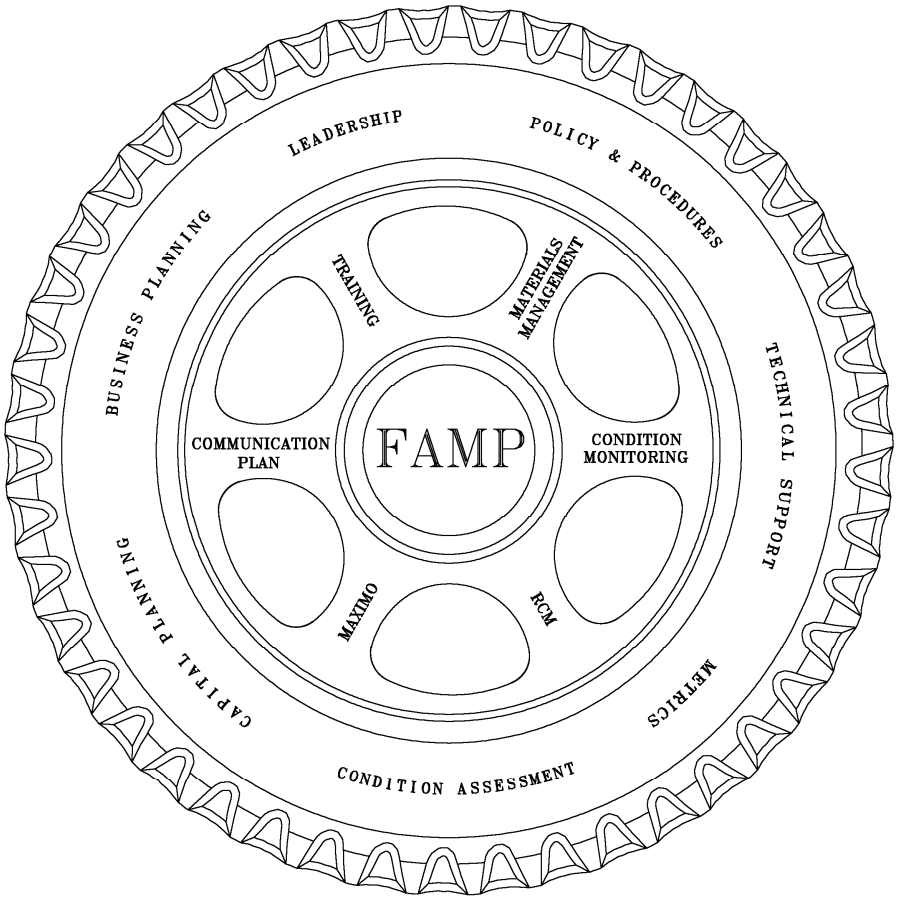


Figure 2 - FAMP Wheel

The Wheel Model was selected to identify the interrelationship of business practices. The wheel concept was initially conceived to support the development of an Intranet site as well as clarify the confusion between program terminology such as FAMP and RCM.

The wheel concept offers the following:

Spokes: There are several key components that serve as program supports. If one is missing the wheel will still turn, but it will be unstable.

Tire: Many business practices fit into the tire and are integral to the asset management process. If one or several are not in place (low on air) the wheel will still turn, but inefficiently.

Air Pump (not shown): Signifies continuous improvement through research and benchmarking. On occasion, air is lost in the wheel and the air pump is there to maintain proper pressure allowing peak operating performance.

Oil Can (not shown): As indicated, for the program to move ahead with ease a master plan / schedule is used to set goals, objectives and milestones. Without such a plan, a program can get "bogged down" and be ineffective.

Tacks (not shown): As with any initiative there are always obstacles/challenges to overcome.

Key Components:

Maintenance Strategy: A maintenance plan or strategy needs to be identified for both equipment (active) and non-equipment (passive) assets. For critical equipment assets, the MWRA has selected Reliability Centered Maintenance (RCM) to define the best preventive and predictive tasks based on the asset's site-specific operating scenario. For second tier assets, the original equipment manufacturer (OEM) maintenance recommendations will be reviewed and adjusted (optimized) and for support equipment assets, the OEM recommendations will be followed.

Is RCM for all Assets?

No. It is not appropriate for our non-equipment assets, and it wouldn't make sense from a cost / benefit perspective to use it for all of our equipment assets. MWRA is applying RCM to only critical / problematic equipment assets (see below), which account for approximately 40% of all equipment.

Equipment	*Maintenance Strategy*
1. Critical / Problematic (e.g. water pumps)	*RCM*
2. 2nd Tier Systems (e.g. DITP hydro turbine)	*PM Optimization*
3. Support Systems (e.g. sump pumps)	*OEM Recommendations*
Non-Equipment	
1. Architecture (e.g. roofs, concrete)	*Condition Monitoring*
2. Utilities	*Condition Monitoring*
3. Support (e.g. vehicles, PC's)	*Condition Monitoring*
4. Specialties (e.g. water tanks, landfill)	*Condition Monitoring*

The non-equipment asset maintenance strategy (infrastructure, storage tanks, roofs, etc) includes condition monitoring/assessment and inspection tasks followed by corrective actions such as maintenance, small projects or capital projects. The MWRA's current program is being reviewed including optimal inspection intervals along with appropriate technique(s) and required skill level.

CMMS: An accurate and maintained computerized maintenance management system (CMMS) is an essential component of a successful asset management program. Maximo (MWRA's CMMS) is a powerful maintenance management tool that is used to manage all aspects the maintenance program including work order management, preventive maintenance, an equipment database, planning and scheduling, asset management, recording maintenance costs, and generating reports (i.e. monthly and annual maintenance performance reporting).

Condition Monitoring: Monitoring of the equipment's health is an important component of a proactive maintenance program. Condition monitoring techniques such as vibration, temperature and oil analysis on rotating machinery are utilized at the MWRA. This non-intrusive approach assists staff in tracking and trending the condition of the equipment over time allowing repair work to be scheduled versus catastrophic failure and associated costs resulting from unplanned reactivity.

Materials Management: Inventory and spare parts play an important role in the asset management program. The challenge is to have the right spares at the right time. Programs are in place to remove obsolete parts, reduce non-critical inventory levels and reduce lead times for materials. There is a strong incentive to reduce inventories to the right levels since there is a 12% holding cost for each part.

Training programs: Training is essential to support the adoption and sustainment of new tools and techniques. For a truly successful program to take hold, it is important to ensure staff understands the new programs and their associated benefits. In addition to training on specific applications such as the CMMS and condition monitoring, training should also be developed for new maintenance work management procedures.

Communication Plan: Early on in the FAMP initiative and as a result of a meeting with another large industrial facility, it was made clear that change management tools would be needed to facilitate change at all levels within the organization. There is a need to communicate that status and results of project activities and their related impacts on maintenance business practices. The communications plan is an essential component to a successful maintenance management optimization campaign allowing connectivity between workforce members and business goals. As expected, the Communication Plan is a key spoke in the wheel.

MODEL FOR CHANGE

"Leading Change", by John P. Kotter can provide a detailed road map to implement change in an organization through an eight-step change process. Although the MWRA was well along in its program prior to attending an in-house change management course (based on Kotter's book), the change process closely mirrored the initiative's development. Therefore, the authors believe that when combined, the 8-step model and MWRA experience can serve as a framework for successfully implementing an asset management program.

The "model for change" information is organized as follows a) step definition, b) utility opportunities and c) MWRA's experience.

Step 1 - Establish a Sense of Urgency - Implementing change at any organization is very difficult. Establishing a sense of urgency to gain support from staff is critical to success. Competitive realities, potential crisis, or major opportunities can establish a sense of urgency.

The sense of urgency to implement an asset management program at a water quality facility can be driven by the threat of privatization or by mandated federal regulations.

The current economic climate has resulted in a continuing effort by privatizers to take over the maintenance and operation of water quality facilities with the promise of reduced rates and better service. The implementation of an asset management program can be a deterrent to privatize by lowering maintenance expenditures through extended asset life, implementation of proactive maintenance approaches that lower costs, and communication of proper stewardship of public assets.

A sense of urgency can also come from regulatory "drivers" such as EPA's CMOM programs for buried wastewater infrastructure and GASB's Statement 34 accounting for fixed assets (asset identification, valuation and remaining service life).

The MWRA was created because the wastewater facilities failed prematurely from lack of funding and maintenance (previous control was under the Metropolitan District Commission) resulting in the pollution of Boston Harbor. MWRA's showpiece DITP project, known as the Boston Harbor Project, cost $3.8 billion dollars to construct. The capital expenditures resulted in significant rate increases throughout the MWRA service area. Subsequently, these rate increases drove legislation to study privatization of the MWRA maintenance and operations. The legislation was ultimately defeated but the threat of privatization remains. The threat of privatization and the need to protect the new wastewater treatment plant assets established the sense of urgency that led to the establishment of an asset management program.

Step 2 - Create a Guiding Coalition - A guiding coalition is a group with enough power to lead the change. The group must work together like a team to guide the agency through the change process. The group must work toward a common goal that is pragmatic and can be embraced by staff.

An asset management steering committee composed of all operation staff could be developed for a water quality organization. The steering committee should meet regularly to discuss the design and implementation of the asset management program. The committee needs to include maintenance, operations, finance, planning and engineering staff. It also needs to include strong upper management support to facilitate and sustain the change process – "*don't tell them, show them*".

The MWRA formed a Steering Committee composed of senior managers that continues to meet monthly to discuss the progress and status of the FAMP program. The steering committee is composed of a diverse group of maintenance, operations, engineering, planning, and finance staff that represent the various agency divisions. The steering committee role has been to guide task team efforts and facilitate new maintenance practice implementation.

Step 3 - Develop Vision and Strategy - A vision must be created to direct and communicate the change effort. The strategy for achieving the vision must be developed and implemented. The vision is used to clarify the general direction of change, motivate people to take action in the right direction, and coordinate the actions of different people in a fast and efficient way.

A utility's vision needs to be documented in the organization's business plan and communicated to all staff. The vision is essential to provide staff with a clear picture of the future. A typical vision for an asset management program could be "It is our goal to become a leader in the water quality industry for asset management within the next five years. The goal is to reduce maintenance costs through the use of proactive maintenance strategies."

The MWRA Business Plan 2000-2005, the MWRA 5-Year Progress Report 1995-1999 and the FAMP project documents articulated the vision. These documents clearly provided the vision and strategy to initiate and develop a comprehensive program.

Business Plan: The overall MWRA Mission statement is "To provide reliable, cost effective, high quality water and sewer services that promote public health, promote environmental stewardship, maintain customer confidence and support a prosperous economy." The Operations and Maintenance goal is to "Operate the systems safely, within design parameters, and extend the useful life of physical assets." One Operation and Maintenance objective is to "Maintain systems to achieve optimum performance" and Strategy #21 is to "Develop and implement an agency-wide multi-year maintenance plan." Strategy #21 led to the development of the Facilities Asset Management Program "request for proposals" (outsourced consultant support).

The 5-Year Progress Report states: "Looking ahead, a number of imperatives are presented…MWRA must invest in maintenance and equipment. MWRA must press forward on equally important new expenditures for maintenance and normal replacement and renewal of equipment in its facilities. It would be fiscal folly not to properly maintain the huge investment that ratepayers are making in new water and wastewater infrastructure systems."

The FAMP project bid document states that "The initiative is designed to plan, manage, and coordinate the engineering maintenance, operation, and financing required to maintain MWRA facilities to regulatory requirements. FAMP can be further described as having two objectives:

1. Cost-effectively replace capital components at the appropriate time to ensure reliable plant operation and preserve the value of the original investment.

2. Prolong the equipment life and control the rate of replacement (i.e. avoid large spending spikes)."

Step 4 - Communicate the Change Vision - Every vehicle possible must be used to constantly communicate the new vision and strategies. Guiding coalition member's behavior must serve as the role model for employees.

As a first step, a water quality utility needs to layout a communication plan. The plan should include all elements expected to inform and encourage staff to participate in the program. Elements should include presentations by senior staff to reinforce management's commitment to the program and that it is not the "flavor of the month" program. It is also important that staff be recognized for program accomplishments. Finally, management must continually communicate the importance of the program.

The MWRA employed various means to communicate the change vision. The following table (Table 1) is a listing of all the activities (including frequency and responsibility) used to communicate the FAMP program objectives. As noted, program goals and objectives were communicated through meetings, presentations, posters, hats, awards, and daily discussions with staff. One important first step in the communication plan was that the Director of Deer Island, John P. Vetere, met with all staff to introduce and discuss FAMP concepts and terminology and openly express his support of the program. In addition, tri-annual "forums" are held with task teams and others staff, to not only communicate program status and benefits, but to "drive" task team activity to completion. Lastly, an Information Kit was developed and subsequently converted to an Intranet web page providing details and updates to a wider audience. Communication of the change vision continues daily.

METHOD	FREQUENCY	AUDIENCE
RCM Briefings	As needed	DITP – All Staff
RCM II Hats	As needed	RCM Analysis Members
FAMP Project Meetings	Bi-Weekly	FAMP Project Team Members
FAMP Steering Committee Meetings	Monthly	MWRA Senior Management
FAMP Task Team Meetings	As needed	Task Team Members
Board Staff Summaries	As needed	MWRA Board of Directors
RCM 3-Day Training	As needed	MWRA Staff
RCM 1-Day Training	As needed	MWRA Senior Management
Site Visit / FAMP Presentations	As needed	MWRA Staff
FAMP *This Week* Articles	Monthly	All MWRA Staff
All-Staff Status Memorandums	Quarterly	DITP – All Staff
RCM Pilot Project Status Board	Monthly	DITP Staff / Visitors
RCM *Welcome to Pilot* Board	Continuous	DITP Staff / Visitors
Maintenance Performance Report	Monthly	MWRA Senior Management
Reliability Process Model (Poster)	Continuous	DITP – All Staff
RCM Implementation Plan (Poster)	Continuous	DITP – All Staff
Staff Informational Update Meetings	Monthly	DITP Staff
FAMP Intranet site	Continuous	All MWRA Staff

Table 1 – Communication Plan

Step 5 - Empowering Broad Based Action - Broad based action can only be achieved by removing obstacles, changing systems and structures that undermine the change vision, and encouraging risk taking and nontraditional ideas and actions.

The steps in broad-based action for a water quality utility could include:

- Reorganize to support the asset management initiative
- Define areas of improvement that provide the highest return on investment
- Implement pilot programs to start change process
- Benchmarking

The organization structure for an asset management program requires a "champion" at the highest level in management. Division champions then need to be assigned at each facility and finally staff schedules must allow availability to work on the program.

One method to target areas for improvement is to utilize a consultant to perform a GAP analysis. A GAP analysis is a process where a maintenance consultant reviews your maintenance processes and identifies areas for improvement/weaknesses that can result in long term maintenance savings. The GAP analysis results are shared with staff and a corrective action plan (CAP) developed. The CAP could include the use of pilot programs to help provide cost-benefit justifications prior to full implementation.

A second method to determine improvement target areas is to benchmark against other agencies/organizations and to attend conferences dedicated to asset management such as the Society for Maintenance Reliability Professionals (SMRP). The benchmark effort should be with both water quality agencies that are working on asset management and outside industries that have adopted an asset management approach. Site visits should be attended by staff responsible for program implementation allowing a collective agreement and approach to the required improvements.

MWRA Reorganization

The MWRA's reorganization approach created a steering committee to oversee the development and implementation of the program with representatives throughout the agency. Two (2) full-time positions were created to assist in the design, implementation and sustainment of the program. A capital program manager position is responsible for related contract development, oversight and support (outsourced support such as consulting and condition monitoring services). The maintenance asset manager is responsible for program implementation and performance monitoring. The initial focus of these positions was to manage the Phase I maintenance consultant's contract and implement subsequent improvement recommendations. The Phase I scope can be summarized into three (3) categories; maintenance strategy development, CMMS implementation, and condition monitoring. To support the consultant's effort and facilitate staff buy-in, three (3) task teams were formed that were composed of all levels of staff throughout the agency – "*involvement breeds commitment*". The Phase I organization chart (Figure 3) is shown below.

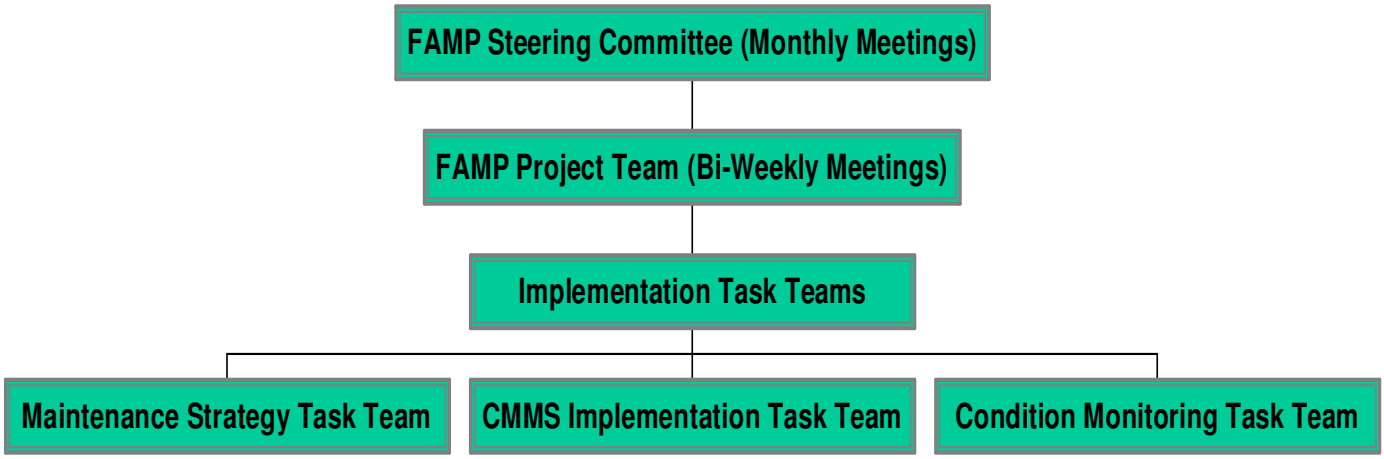


Figure 3 – Phase I Organization Structure

MWRA Areas Selected for Improvement

The three areas initially selected for improvement were maintenance strategy improvements, CMMS implementation, and condition monitoring.

- Maintenance Strategy Review

  The consultant reviewed various maintenance optimization strategies including Reliability Centered Maintenance (RCM), Total Productive Maintenance (TPM) and Failure Mode Effect and Criticality Analysis (FMECA) for use in the wastewater treatment industry. A detailed report recommended the DITP pilot the use of the maintenance strategy, RCM.

  Initiated in the aviation industry, RCM is a process where plant maintenance, operations, and engineering staff review failure modes and effects and develop a preventive/predictive maintenance program based on the equipment's operating context. History has shown that the equipment vendor's preventive maintenance (PM) recommendations tend to be conservative and do not always adjust for varying operating scenarios (i.e. does the pump run continuously for 24 hours or cycle on-off every 40 minutes, or run once a week for 10 minutes).

  RCM was selected because historically, its review process was found to be more effective in process plants where the TPM strategy better supports a manufacturing (close operator to machine interface) environment. Over all, RCM has been able to meet the MWRA's main objective - gain efficiency of maintenance resources while maintaining or increasing plant reliability.

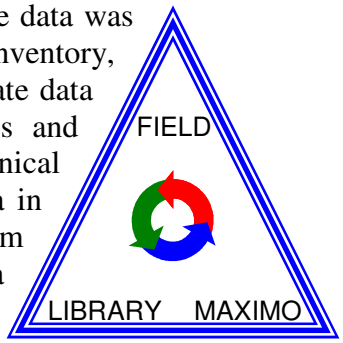
- CMMS Improvements

  Deer Island has been using MAXIMO as its computerized maintenance management software since 1995. This software package is a powerful maintenance management tool that is used by the Work Coordination Group to manage all aspects of the Deer Island maintenance program.

  The maintenance consultant completed a post-implementation audit of Deer Island's MAXIMO database that included a review of its data quality and its present utilization.

Data Quality

The audit concentrated 1,250 pieces of plant equipment in a section of the plant - Primary Clarifier Battery "A". The review included a three pronged approach where data was cross-compared between the Maximo database (Equipment, Inventory, Preventive Maintenance and Work Orders modules), field nameplate data and technical information (Operation and Maintenance Manuals and Process and Instrumentation Diagrams) located in the on-site technical library. As expected, the audit concluded that the quality of data in Maximo needed to be improved because equipment was missing from the database, not all equipment data was completed, and data conflicted between MAXIMO, the field and the library. A corrective action plan is underway where 30% of the Maximo data has been corrected with a target completion date of 2006. To avoid future data quality issues, new procedures (noted below) have been developed and implemented – "*garbage in is garbage out*".



Data Integrity Triangle

Utilization of the MAXIMO system

The review revealed that Deer Island was utilizing approximately two thirds of the available MAXIMO features (termed "functionality") that, reportedly, is the case with most other maintenance organizations. To enhance the data quality and support a new asset management initiative, the consultant recommended additional utilization of specific MAXIMO modules and programming enhancements including Failure Reporting, Safety Plans and Required Fields. A CAP was developed as a result of the audit and Failure Reporting and Required Fields for work orders were completed in 2002.

Other recommendations were made to support the initiative included, a) programming for performance metrics reporting, b) programming for run-time PMs versus calendar based maintenance reducing work load/costs, c) QA/QC procedures to protect MAXIMO data that is used to make business decisions such as equipment replacement and d) programming to link MAXIMO to the financial software package (Lawson) to allow automatic tracking of non-stock items and improve the planning process for parts and kitting of materials.

- Condition Monitoring

The Authority recognized that the project's maintenance optimization process would require expanding predictive maintenance tasks, including vibration and temperature trending and analysis. Phase I included the design and installation of permanent vibration and temperature monitoring on critical rotating equipment such as pumps, motors, compressors and turbines.

The new condition monitoring system design has been completed and installation is anticipated to begin in 2003.

MWRA Pilot Implementation

A pilot of the new RCM maintenance strategy was completed under consultant guidance. The RCM Pilot consisted of twelve (12) systems from a cross section of equipment located in a section of the

plant - Primary Clarifier Battery "A". The pilot system's performance were compared to adjacent equipment (which use OEM based PM tasks and frequencies) for a six month period.

The pilot results included a significant decrease in PM hours (25% reduction in PM labor hours) and 10% overall decrease in maintenance costs. In addition, the pilot area has resulted in higher equipment availability and overall improved performance. The major outcome of the RCM review process is a revised, optimal mix of predictive and preventive maintenance tasks and frequencies that best meets the plant's operating goals.

Early on in the asset management program's history, the pilot was a major contributor to the organization's cultural change. Commitment to the RCM methodology was significant and over 100 staff were involved in the pilot.

Benchmarking

A key component to the change momentum was through research. At various stages of the program, teams of in-house staff collaborated with outside companies and organizations to understand time and cost saving approaches, views and benefits. The focus was put on other organizations of similar size and complexity. It was quickly determined that advanced knowledge in the area of asset management was limited within the water quality facilities arena, so the need to look at outside entities was required. Collaboration efforts were initiated at leading industries including a steel mill in Canada, a manufacturer in Massachusetts and a process plant in Colorado. In addition, several team members attended and subsequently joined a new professional maintenance association, the Society for Maintenance and Reliability Professionals (SMRP). SMRP offers an opportunity to gather best practice information from a large network of maintenance and operation professionals at Fortune 500 companies. Research helped team members communicate the benefits of a comprehensive asset management program to all levels of staff through the use of real life success stories

Step 6- Generating Short-Term Wins - To continue to show the importance of the change it is important to have short-term wins to show staff the success and importance of the change. "Wins" needs to be planned/created and people visibly recognized and rewarded for making the wins possible. An effort to plan for visible improvement in performance (wins) should be developed.

One method to consider in generating short-term wins is to leverage pilot results to provide opportunities for staff recognition and awards. A second method is to communicate program (i.e. pilot) results and benefits to all staff through presentations, staff meetings, memorandums and posting information in high-traffic areas. A third method is to publish articles in professional organizations or recognized trade magazines.

The MWRA generated wins through communicating the results of the RCM pilot, status and results of other FAMP program implementation efforts and distribution of related case-study articles from trade magazines such as Maintenance Technology Magazine. The benefits included actual cost savings as well as soft benefits such as increased staff knowledge and improved operations and maintenance teamwork. To recognize staff dedication to the program while balancing normal workloads, the internal "Excellence in Performance" award was presented to all program participants by the Executive Director and Chief Operating Officer.

In May 2002, the MWRA's FAMP initiative also received national attention at the Association of Metropolitan Sewerage Agency's (AMSA) 2002 National Environmental Achievement Awards in the

Operations category. In addition, the program was recognized in a feature article in the nationally distributed, Maintenance Technology Magazine. These short-term wins helped fuel the program's momentum and furthered management and staff support.

Technical papers and presentations detailing program success were also accepted at local, national and international organizations such as the New England Water Environment Association (NEWEA), the Society for Maintenance and Reliability Professionals (SMRP) the Water Environment Federation (WEF) and the Institute for International Research – Best Maintenance Practices. More importantly, these wins were shared with staff to communicate the program success.

Step 7 - Consolidating Gains and Producing More Change - Gains should be used to produce more change. Increased credibility should be used to change all systems, structures, and policies that don't fit together and don't fit the transformation vision. People should be hired, promoted, and develop who can implement the change vision. The process should be reinvigorated with new projects, themes, and change agents.

A water quality organization needs to move forward from the pilot programs to a full rollout of the selected initiatives. The rollout of the program requires a greater commitment of staff resources and management support.

The MWRA's approach to consolidate gains and produce more change was to a) rollout the initiatives developed during the Phase I activities and the pilot and 2) expand the program based on benchmark findings. An expanded multi-phase program model and master asset protection plan (schedule) or MAPP (Figure 4) were developed detailing a comprehensive asset management program.

Figure 4 - MAPP

The program was expanded from three (3) to ten (10) task teams to guide the Phase II rollout. Each task team developed a charter with goals and responsibilities to facilitate the implementation of best practices throughout the organization. The task teams have support throughout the Authority and include representatives from maintenance, operations, process control, finance, budgeting, planning, warehouse, and management. The task teams and their charters include:

- Metrics – Develop consistent metrics to monitor program implementation drive higher plant reliability and availability.

- RCM Implementation - Ensure that the RCM program is implemented uniformly throughout the Authority including:
  - Monitor and track effectiveness of the RCM program.
  - Develop and monitor organization-wide rollout plan and schedule.
  - Implement RCM recommendations and associated tracking/reporting.

- Criticality Analysis - Develop and implement a criticality analysis agency wide to help prioritize systems for RCM analysis as well as assist in the prioritization of corrective maintenance (CM) work.

- Condition Monitoring Program - Develop and implement a condition monitoring program to further assist the change from reactive maintenance to proactive maintenance. This team's focus is to expand current programs such as oils analysis and vibration monitoring into a comprehensive program to providing early indication of failures and preventing costly repairs. A needs assessment and implementation and training plan is underway and involves other areas including infrared, ultrasonics, and motor current signature analysis (MCSA).

- Permanent Condition Monitoring System Installation - Oversee the design, installation, and testing of permanent vibration and temperature monitoring on critical equipment to provide higher equipment availability and improve maintenance efficiency.

- Maintenance Procedures – Develop and implement new practice procedures and training to ensure adoption and change sustainment.

- Asset Replacement Strategy - Develop a comprehensive and consistent agency strategy to identify and prioritize asset replacement needs, resulting in more accurate spending forecasts and determination of appropriate funding sources.

- Warehouse Optimization - Develop and implement consistent and efficient warehouse activities in an effort to support maintenance including; spare part analysis, work order kitting, purchasing inventory replenishment, spare parts maintenance policies and obsolescence of identified materials.

- Work Coordination/Maximo - To ensure efficient use Maximo to assist in the timely coordination and execution of maintenance and asset replacement planning activities.

- Lubrication Program - Improve the handling, storage, sampling, application and purchasing of lubrication products leading to extended asset life.

- Root Cause Failure Analysis – This future team that will review and implement the consultant's recommendations associated with a preferred RCFA methodology. A RCFA program focuses on investigating and eliminating chronic problems.

Each task team is led by a staff "facilitator" who coordinates regular meetings to detail progress and future plans. The task team approach and expanded scope has impacted all areas of Authority business and has been effective in the change process.

Step 8 - Anchoring New Approaches in the Culture – As the last step in the 8-step process, the new business practices need to be anchored in the organization's culture. The connections between new behaviors and organizational success need to be articulated. There is a need to create better performance through productivity-oriented behavior, better leadership, and more effective management.

A utility can anchor change by conducting presentations/ meetings to communicate the culture change that detail not only the scope of work and progress to date, but also the benefits of the program. In addition, adoption of leading and lagging performance metrics can be utilized to move the organization to more proactive and productive behavior. These metrics need to be shared (even posted in common areas) with all staff and be frequently reviewed by management.

The MWRA has begun anchoring the new approaches through conducting regular FAMP forums, implementing the Productivity Improvement Program (PIP), the MAPP, monitoring implementation status, and by adopting new maintenance metrics.

FAMP forums, attended by the task team members, management, and plant staff, are regularly held to discuss the status, progress, and benefits of the task teams. The forum provides a global perspective of the entire FAMP program to approximately 80-100 staff members over a 2-3 hour session. At each forum, the Chief Operating Officer, Mike Hornbrook, reinforces the commitment of management to the FAMP initiative.

PIP was a multi year negotiation with two unions in an effort to institute cross-functional job descriptions. The areas concentrated on were cross-functional (mixed) crews and operations staff performing "light maintenance" duties.

In March of 2002, mixed crews were implemented in all plant areas. A mixed crew includes electricians, I&C, M&O Specialists, HVAC, and plumbers, all lead by a single unit supervisor. The mixed crew format increases efficiency by reducing downtime waiting for specific trades to support a multi-discipline work order. In addition, light maintenance such as HVAC filter changes, light bulb replacements, and lubrication are now assigned to an area maintenance team and/or Operations, not to a specific trade. In the Maintenance Group, this has allowed the unit supervisor flexibility to assign these tasks to any one of a number of staff based upon their availability, the priorities of the week and day.

A portion of the preventive maintenance (PM) "light maintenance" tasks have been assigned and performed by Operations staff include inspections and lubrication. Metrics are utilized to anchor the new culture as noted below.

- Tasks performed represent 11 % of PM hours and 15% of all PMs.
- This represents a 14% increase in work orders assigned to Operations staff since the start of PIP implementation in March 2002.
- The best in class goal accepted by the Society for Maintenance and Reliability Professionals (SMRP) is 10-15% of all PM hours.
- The improved productivity of plant staff has resulted in maintaining plant backlog (to within industry guidelines of 4-6 weeks) with fewer staff and increased plant availability.

The Master Asset Protection Plan (MAPP) was developed to layout a long-term schedule for the four elements of the program: Business Practices, Maintenance Strategies, Condition Monitoring, and Maximo. This schedule is posted in common areas cementing management's commitment to staff.

On a regular basis, the Implementation Status Report is provided to senior management and includes a compilation of task team activities and status of completion helping to drive task team activity.

Metrics were developed for proactive and productivity initiatives. Annual goals are monitored through monthly metric reporting. Metrics are reviewed by senior staff and are available to staff via the MWRA Intranet site.

The proactive metrics included a) the percentage of preventive maintenance work orders that are kitted and b) the percentage of predictive maintenance work orders. The kitting metric is driving change for both the work coordination/planning department and the warehouse in an effort to ensure parts are

available prior to work initiation resulting in work efficiency (increased "wrench" time). The planners identify all PM parts in the Maximo system and the warehouse retrieves the parts each month and places them on pallets for maintenance pickup. The predictive maintenance metric is driving change for the maintenance staff and the condition-monitoring group. A goal has been set to increase predictive maintenance tasks. To reach that goal, the condition-monitoring group has initiated training of staff and has increased the oil and vibration sampling programs.

The productivity metric is the percentage of PMs performed by Operations. This metric has driven both Maintenance and Operations to add light maintenance tasks to Operations staff as discussed above. The use of metrics has been successful in anchoring change.

Challenges – Along with any change initiative there are challenges (tacks) along the road to improvement. Initiating any new program has many challenges and obstacles and Asset Management is no exception. Trying to design and implement a comprehensive, organization-wide program will have more obstacles because of the magnitude of required change across departmental boundaries. The use of a "steering committee" whose body includes broad representation can lessen the impact. Outlined below are some common challenges to implementation.

- Executive Sponsorship and a Communication Plan are critical to effect culture change.
- Program elements require leaders with a clear charter and diverse membership.
- Funding and resources must be reserved and used to help maintenance during the implementation period. Remember – folks are balancing normal workloads while implementing change.
- Treat the Asset Management program as a capital project with a budget, dedicated staff, schedule with milestones and involvement from all business functions.
- Do not expect overnight change or results - it is a multi-year implementation project – *"how do you eat an elephant? In small bites!"*
- Staff Buy-In – "But we've always done it this way" or "I recommended this, but nobody listened" are some common responses from staff when it comes to implementing change. Learn to "let go" and invite staff to become team members and get involved – "*involvement breeds commitment*".
- Show staff "what's in it for them" - For example, understanding that feedback on work orders is to identify repetitious problems and/or poor products. "Documented" problems can lead to a design change that will eliminate the "headache". In the public world of "low bid" the "documented" poor product can be removed from the specification.
- Change agent characteristics include optimism, organization and persistence.
- Individual or team recognition should be posted when goals are met.
- Track and document results and benefits. Communicate these broadly - early and often.
- The CMMS must be populated with accurate data. Poor data results in incorrect and inaccurate work orders and reporting that impacts morale and business decisions. Ensure a budget line item is in place for a post-implementation audit of your system.
- Original Equipment Manufacturer (OEM) preventive maintenance tasks are "guidelines" and typically not operation specific. A maintenance optimization review will ensure proper tasks and frequencies to ensure extended asset life and heightened reliability.
- Training (even on new procedures) must be provided to ensure staff feels they will be prepared for the new program.

GETTING STARTED

A water quality utility can get started with an asset management program with strong senior management support and a few dedicated resources working on the program. On key step is to identify a "management champion" who has enough power to drive the organizational change. Most organizations have some portions of the model of change in progress. Referring to the 8-step process described above, usually Step 1 is in place. To get started, Steps 2 through 5 need to be developed.

BENEFITS

It is inherent that there are tremendous benefits associated with implementation of an asset management program. In addition, there is a tremendous amount of resources and data available to help utilities justify an investment in such a program. To assist readers, an **Asset Management Resources Guide** has been provided as an attachment. Until a utility's program is mature enough to recognize benefits and results, benchmarking and case studies can certainly help.

The MWRA has experienced significant benefits to date including cost savings, extended asset life, enhanced teamwork, better communication and process efficiencies. A representative sampling is provided below.

Maintenance Strategy – RCM

- The DITP RCM pilot demonstrated a 25% reduction in preventive maintenance (PM) hours by eliminating duplicate work by maintenance and operations staff, and eliminating low value PM work. In some cases PM hours have increased to provide additional protection for plant assets.

- Extended asset life through a revised operating context. An RCM review revised a headwork's standard operating procedure (SOP) to rotate the grit pod inlet nozzle in quarter turn increments to equalize wear from abrasive grit extending the pod's life by four. There are twelve pods in all.

- Enhanced O&M staff teamwork as a result of the RCM process. Together, O&M staff jointly analyze critical asset operation and failure modes. Each comes away with a greater appreciation of the others knowledge and experience. In addition, the audit process builds bridges between management and O&M staff where management audits and approves of the staff-authored maintenance program.

CMMS

- Cost savings from meter-based PM program. A distributed control system (DCS) to Maximo interface has been developed to automatically generate work orders based upon equipment run-hours. Previous approach was calendar-based maintenance that sometimes recommended maintenance on equipment that had limited operating time and did not require maintenance. In two pump stations, only 8 out of 12 pumps received PM. If a calendar- based system were in use, four units would have potentially received unnecessary maintenance.

- Utilization of "work backlog" information to support staffing business decisions. For example - instrumentation backlog is high (greater than industry average of 4-6 weeks) and additional staff may be required to maintain these assets.

- Scheduling work one week in advance over a three month pilot at DITP resulted in reducing work backlog and a 25% increase in work order completion.

- A program has been written to capture duplicate work requests resulting in efficiencies such as 1) eliminated duplication of labor efforts and 2) can also serve to combine multiple work efforts resulting in reduced visits to the same asset.

Condition Monitoring

- Asset life is extended through the adoption of oil sampling and vibration analysis programs that identify potential problems early and are resolved prior to extensive asset damage.

- Cost savings were realized from an oil-sampling program versus calendar-based oil changes. Annual oil changes on aerator and mixer gearboxes were revised to a 6-month sample of the oil (on condition task). The benefit was avoiding 33 annual oil changes resulting in a saving of approximately $20,000 in synthetic oil purchase and a disposal cost of 640 gallons of oil in one year.

- Oil analysis results facilitated replacement of 480-volt transformer before failure. Electrical distribution system component (bus ducts) failures caused electrical stressing of other system components, specifically 480-volt transformers that service the power plant. The oil-sampling program identified an increase in combustible gas in the transformer's oil. Regular testing and trending of the data provided an early failure warning and a need to replace the unit – a unit that requires a 14-week lead-time for delivery. Oil condition monitoring allowed timely replacement of a long lead item and prevented a catastrophic failure, potential safety incident and secondary damage and associated costs.

- A wastewater pump shaft bearing had abnormal vibration readings. The bearing was greased and vibration returned to normal vibration levels. Work was completed during normal work shift. The cost avoidance was $25,000 dollar bearing replacement and maintained availability of a critical asset.

- DITP Residuals Digester Gas Compressor Chiller had high vibration readings. The repair included checking hardware and adding oil prior to returning the unit to service. Action prevented failure and replacement of a $10,000 compressor.

- Staff morale has increased from involvement in activities such as the lubrication task team. Team members are allowed to develop and implement a comprehensive program based on their research.

Materials Management

- Kitting ensures spare parts are available prior to work initiation resulting in work efficiency.

- A spare parts prioritization process has been developed and implemented leading to the identification of critical spares and cost savings from reduced spares inventory.

- A spare parts preventive maintenance program has been expanded to adequately maintain spare parts held in inventory. Proper maintenance of spares eliminates premature failure (termed "infant mortality") upon use.

Training

- Increased staff morale from involvement in condition monitoring equipment training. Training on new ultrasonic equipment and vibration analysis now provides mechanics a tool for timely and effective monitoring of equipment health.

- PIP, RCM and condition monitoring training has been provided to trade staff and has served as a good tool to anchor change.

Communication Plan

- Extensive commitment to regular communication of program progress, results and benefits have indicated to staff that it is not the "flavor of the month" initiative. Dialog between all levels and staff involvement has increased significantly.

- Staff buy-in has been facilitated from timely program implementation of FAMP initiatives.

- Serving as a "host site" for Fortune 500 companies and other organizations has enabled change agents to solidify the program's goals and objectives and maintain momentum.

- The review and adoption of new metrics have engaged senior staff in the new program. Detailed research and discussion has led to the improvement of performance reporting to include leading and lagging indications – leading metrics help "drive" the program towards proactive maintenance and lagging metrics "track" progress. As shown in Table 2 below, significant advancements have been made by the FAMP initiative.

Benchmark	DITP (2000)	DITP (2003)	Goal
Leading Indicators			
Operations Light Maintenance	0.5%	11%	10-15%
Preventive Maintenance	85%	91%	100%
Lagging Indicators			
Backlog (weeks)	7	5.2	4-6
Emergency Maintenance	<1%	< 1%	< 5%
Overtime	9%	5%	< 5%

Table 2 – DITP Metrics Comparison

CONCLUSION

An asset management program is a combination of tools and techniques whose success requires careful planning and a commitment of resources. This is a difficult task with pressures of normal workloads and competing corporate initiatives. Executive sponsorship, designated champions in each business unit along with a roadmap or model and continuous communication at all organizational levels can facilitate the change required to maintain a successful asset management program.

The overall objective of asset management is to put an optimal program in place that includes the use of industry best practices. To be successful and fully realize maximum benefit, all components need to be fully integrated and implemented in a comprehensive initiative. Key components such as a

Maintenance Strategy, CMMS, Condition Monitoring, Materials Management linked with Training programs and a regular Communication Plan have led industry leaders to world-class results.

The MWRA's research and drive to establish a complete and cost-effective asset management program has led to a model that can serve to assist other water quality utilities. The adoption of best practices will assist in protecting our ratepayer's investment and extending the life of our assets and facilitate our becoming more efficient and competitive in the changing world of privatization.

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The following is a list of MWRA supporters who have made it possible for the FAMP initiative to advance into a recognized, leading model for the water quality industry: Mike Hornbrook, Chief Operating Officer; John Vetere, Deer Island Director; Gerry Gallinaro, Deer Island Deputy Director, Maintenance and Dan O'Brien, Deer Island Capital Programs Manager.

ASSET MANAGEMENT RESOURCES GUIDE

Many resources have been collected and utilized in the development and implementation of the MWRA's program. In an effort to further assist readers in the research and development of their asset management program, the following resource information is provided.

REFERENCE BOOKS

- Penn State Handbook – "Operating Equipment Asset Management-Operating Your 21st Century Competitive Necessity" Penn State University, Applied Research Laboratory Pennsylvania State University, P.O. Box 30, State College, PA 16804, (814) 865-9036, found at site: www.bmpcoe.org/
- "International Infrastructure Management Manual" National Asset Management Steering Group, C/- Ingenium Executive Officer, PO Box 118, Thames, New Zealand, Ph/Fax 64-7-868 3930, Email jeff@ingenium.org.nz, site: www.ingenium.org.nz/publications/iimm/
- NASA – "Reliability Centered Maintenance Guide for Facilities and Collateral Equipment" site: www.hq.nasa.gov/office/codej/codejx/jxdocuments.htm, go to "Reliability Centered Maintenance (RCM) Guide, March 2000"
- "Leading Change" John P. Kotter, 1996, Harvard Business School Press
- "Reliability Centered Maintenance" John Moubray, 1992, Industrial Press Inc

MAGAZINES

- Maintenance Technology Magazine (free) www.mt-online.com
- Reliability Magazine www.reliability-magazine.com
- Plant Maintenance Magazine (free) www.plant-maintenance.com
- Machinery Lubrication (free) www.machinerylubrication.com
- Practicing Oil Analysis (free) www.practicingoilanalysis.com

WEB SITES

Asset Management

- New England Water Environment Association AM Resource Center www.newea.org/AMRC
- Society for Maintenance and Reliability Professionals www.smrp.org
- Brown & Caldwell www.bcwaternews.com
- Strategic Asset Management Inc. www.samicorp.com
- New Dimension Solutions www.nds.greatjakes.com
- MCP Consulting Group www.mcp-cg.com
- The Institute of Asset Management www.iam-uk.org
- Reliability Web www.reliabilityweb.com
- Management Resources Group, Inc. (MRG) www.mrginc.net
- Best Manufacturing Practices www.bmpcoe.org
- Maximo www.mro.com

Condition Monitoring (Monitoring asset health via vibration, oil, infrared, ultrasonic and motor current signature analysis)

- Bently Nevada www.bently.com

- Entek www.entek.com
- Computational Systems Inc. - CSI www.csimeans.reliability.com
- Mobil www.mobil.com
- Predict DLI www.predictusa.com
- Machinery Lubrication www.machinerylubrication.com
- Practicing Oil www.practicingoilanalysis.com
- Framatome ANP www.us.framatome-anp.com
- Flir Infrared www.flir.com

Condition Assessment

- Vanderweil Facility Advisors www.vfa.com
- TechniScan www.techniscan.com

CMMS

- Maximo www.mro.com
- Ivara www.ivara.com
- Synergen www.synergen.com
- Hansen Information Technologies www.hansen.com
- Indus www.indus.com
- Datastream www.datastream.net
- New Standard Institute (CMMS Planner & Scheduler Training) www.newstandardinstitute.com

Maintenance

- Maintenance Resources www.maintenanceresources.com
- Pumps and Systems www.pump-zone.com
- Maintenance Benchmarking www.maintenancebenchmarking.com
- Best Practices, LLP www.globalbenchmarking.com
- Maintenance Tips www.maintenance-tips.com
- New Standard Institute (Maintenance Training Programs) www.newstandardinstitute.com
- Aladon (Reliability Centered Maintenance II) www.aladon.co.uk