Water Utility Safety and Health: Review of Best Practices
Water Utility Safety and Health: Review of Best Practices
About the Water Research Foundation

The Water Research Foundation (formerly Awwa Research Foundation or AwwaRF) is a member-supported, international, 501(c)3 nonprofit organization that sponsors research to enable water utilities, public health agencies, and other professionals to provide safe and affordable drinking water to consumers.

The Foundation’s mission is to advance the science of water to improve the quality of life. To achieve this mission, the Foundation sponsors studies on all aspects of drinking water, including resources, treatment, distribution, and health effects. Funding for research is provided primarily by subscription payments from close to 1,000 water utilities, consulting firms, and manufacturers in North America and abroad. Additional funding comes from collaborative partnerships with other national and international organizations and the U.S. federal government, allowing for resources to be leveraged, expertise to be shared, and broad-based knowledge to be developed and disseminated.

From its headquarters in Denver, Colorado, the Foundation’s staff directs and supports the efforts of more than 800 volunteers who serve on the board of trustees and various committees. These volunteers represent many facets of the water industry, and contribute their expertise to select and monitor research studies that benefit the entire drinking water community.

The results of research are disseminated through a number of channels, including reports, the Web site, Webcasts, conferences, and periodicals.

For its subscribers, the Foundation serves as a cooperative program in which water suppliers unite to pool their resources. By applying Foundation research findings, these water suppliers can save substantial costs and stay on the leading edge of drinking water science and technology. Since its inception, the Foundation has supplied the water community with more than $460 million in applied research value.

Water Utility Safety and Health: Review of Best Practices

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FOREWORD

The Water Research Foundation (Foundation) is a nonprofit corporation that is dedicated to the implementation of a research effort to help utilities respond to regulatory requirements and traditional high-priority concerns of the industry. The research agenda is developed through a process of consultation with subscribers and drinking water professionals. Under the umbrella of a Strategic Research Plan, the Research Advisory Council prioritizes the suggested projects based upon current and future needs, applicability, and past work; the recommendations are forwarded to the Board of Trustees for final selection. The Foundation also sponsors research projects through the unsolicited proposal process; the Collaborative Research, Research Applications, and Tailored Collaboration programs; and various joint research efforts with organizations such as the U.S. Environmental Protection Agency, the U.S. Bureau of Reclamation, and the Association of California Water Agencies.

This publication is a result of one of these sponsored studies, and it is hoped that its findings will be applied in communities throughout the world. The following report serves not only as a means of communicating the results of the water industry's centralized research program but also as a tool to enlist the further support of the nonmember utilities and individuals.

Projects are managed closely from their inception to the final report by the Foundation's staff and large cadre of volunteers who willingly contribute their time and expertise. The Foundation serves a planning and management function and awards contracts to other institutions such as water utilities, universities, and engineering firms. The funding for this research effort comes primarily from the Subscription Program, through which water utilities subscribe to the research program and make an annual payment proportionate to the volume of water they deliver and consultants and manufacturers subscribe based on their annual billings. The program offers a cost-effective and fair method for funding research in the public interest.

A broad spectrum of water supply issues is addressed by the Foundation's research agenda: resources, treatment and operations, distribution and storage, water quality and analysis, toxicology, economics, and management. The ultimate purpose of the coordinated effort is to assist water suppliers to provide the highest possible quality of water economically and reliably. The true benefits are realized when the results are implemented at the utility level. The Foundation's trustees are pleased to offer this publication as a contribution toward that end.

David E. Rager
Chair, Board of Trustees
Water Research Foundation

Robert C. Renner, P.E.
Executive Director
Water Research Foundation

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Participating Utilities

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South Central Connecticut Regional Water Authority, William Andres Executive
EXECUTIVE SUMMARY

INTRODUCTION

Project 3104, “Integrating Worker Safety and Health into Water Utility Management, Operations and New Facility Design,” evaluated issues, trends, and current approaches for safety and health program management among water utilities. It considered emerging technologies and identified best practices for improving worker safety and health. The findings of this study led the research team to draw the following conclusion:

“With few exceptions, water utility owners and leaders have not recognized the value of protecting worker health and safety, and therefore do not provide sufficient leadership and resources for developing and implementing effective safety and health programs.”

The intended audience for this report is water utility leaders and managers. The report identifies best practices and recommends management concepts and tools that leaders and managers can use to improve safety and health culture, and ultimately performance.

OBJECTIVES OF RESEARCH

The Water Research Foundation and the research team originally identified nine research objectives:

1. Determine types of worker injuries, how they occurred and the outcomes.
2. Identify health and safety risks posed by new and emerging technologies.
3. Identify and evaluate best practices for integrating health and safety into the design of water utility systems.
4. Assess cost effectiveness of incorporating ergonomic design into new and existing facilities.
5. Identify and evaluate various proactive and reactive programs that promote worker health and safety.
6. Identify and quantify the costs and benefits of worker health and safety programs.
7. Identify metrics that will facilitate the evaluation of health and safety programs, and if appropriate, drive change.
8. Identify and quantify the costs and benefits of disability management programs.
9. Identify approaches for analyzing cost/benefit of integrating safety into design and other health and safety management practices.

RESEARCH PROCESS

To meet the research objectives, the research team collaborated with representatives from participating utilities and the project advisory committee to develop a two-phase approach for data collection and analysis.
Phase 1. Participating utilities completed a comprehensive questionnaire and participated in a workshop. In the workshop, utilities identified and discussed injury/illness root causes, accident costs, current trends in health and safety management, and some industry best practices.

Phase 2. Based on questionnaire responses and workshop data, the researchers selected five utilities with organizational and cultural characteristics considered “best-in-industry” for closer analysis. In-depth case studies were then conducted on-site to identify specific best practices and to explore how these safety and health concepts were integrated into management and operations. Case study findings were reviewed with water utility representatives at a Phase 2 Workshop.

Throughout the study, consideration was given to how water utility cultures and resource availability were affecting the data linked to each research objective.

STATE OF HEALTH AND SAFETY IN WATER UTILITY OPERATIONS AND FACILITY DESIGN

Phase 1 essentially yielded a comprehensive view of the state of health and safety in water utilities. The following paragraphs summarize those findings. These results provided a basis for Phase 2 research of best practices, program assessment, performance goal setting and measurement, and organizational drivers of change.

Participating Water Utility Injury and Loss Experience

Injury statistics provided by fifteen of the twenty participating water utilities suggests that the participating utilities are representative of water utilities in terms of health and safety performance. Variance among questionnaire and case study responses further indicated that the participating utilities reflected the state of water utility health and safety. The most notable finding of injury and loss experience was the prevalence of strains and sprains to the upper and lower extremities compared to general industry. These data, combined with researcher observations of poor ergonomic design and inefficient equipment layout, indicate the need for Prevention-through-Design (PtD) processes to engineer out the root causes.

Organizational Accountability, Culture, and Structure

The comparatively poor safety performance of water utilities can be attributed to the widespread lack of accountability for safety and health program performance. This research provides more evidence that without leadership accountability, organizations are unlikely to develop organizational structure or to apply the resources necessary to achieve even average safety performance. An advanced safety and health culture, i.e., one that places worker safety and health at the top of organizational priorities, is the result of a sustained leadership commitment to improving worker safety and health. Utilities with top-flight safety programs realize the benefits of fewer injuries/illnesses, including decreased direct costs of worker’s compensation and property damage, as well as substantially lower indirect costs associated with lost time and operating inefficiency. Indirect costs are typically not tracked at water utilities, but have been shown to exceed direct costs in general industry by several times.
The following organizational attributes were found to be common among water utilities:

- Most water utilities do not hold senior managers accountable for implementation of safety and health policies and procedures.
- Most water utilities do not use metrics beyond raw casualty data to evaluate safety and health performance.
- Utilities attempting to establish accountability and to use safety and health performance metrics, often struggle to create and implement management systems that balance leading and lagging indicators.
- Active senior management leadership of health and safety was the single most important differentiator between utilities with below average performance and those with excellent performance.
- Water utilities lag in the hiring of safety professionals, although some utilities have recently hired seasoned safety professionals. Utilities that recently achieved excellence in safety performance reported that their significant improvement corresponded to the hiring of a safety professional.

Health and Safety Drivers and Metrics

The greatest value of metrics in an organization is to drive change and improvement. By far, the most frequently cited metrics driving change in water utility safety and health programs involved injury/accident statistics and trends in some form. One of the primary metrics of safety performance used in general industry was notably absent from lists provided by the participating utilities. That measure is cost. Since cost data were needed to meet four of the nine research objectives, this was an important discussion topic during both workshops and case study interviews. With only a few exceptions, water utilities reported that while cost data such as Workers Compensation dollars were interesting, cost did not drive decisions within their organization when it came to safety. Consequently cost/benefit analysis is rarely used to justify safety related projects and initiatives.

A number of leading performance metrics have been developed to gauge safety program effectiveness and were discussed in the workshops and with managers participating in the case studies. Those metrics are presented in Chapter 5.

BEST PRACTICES: WATER UTILITY SAFETY AND HEALTH MANAGEMENT

Phase 2 of the study identified best practices for integrating safety and health into water utility operations. Strong leadership, use of both leading and lagging metrics, and accountability at all levels were identified as attributes common to utilities achieving improved safety and health performance, and absent from those that did not. Management best practices and other findings from the Case Studies included the following:

- Without exception, the most important factor for achieving excellence in water utility safety and health performance is the active participation and high visibility of senior leadership in driving a safety culture.
- Integration of safety and health into the organization culture and business processes is a “Business Value”, and is driven by management commitment and accountability.
• Safety and health roles and responsibilities are developed, defined, and implemented for employees at every level in the organization, including Senior Leadership, Department Managers, Safety Managers, Supervisors, and employees.
• Management and staff take a co-operative approach to safety program execution and share responsibility for performance.
• Utilities with excellent safety performance have active and engaged safety committees.
• Enforcement of safety practices and policies is consistent, regardless of position or level.
• Leadership is accountable for implementing Prevention through Design (PtD) concepts for new process designs and retrofit projects.
• Safety-by-Numbers is an effective system of metrics for generating and tracking safety goals and activities.
• Leadership demonstrates commitment through value statements and policies, such as “Safety/Quality/Schedule”.
• An excellent method to assess performance and accountability involves the use of a *Balanced Scorecard* to track both lagging indicators (e.g., injury rates) and leading indicators (e.g., completion of Job Safety Analysis).
• Safety staffing levels are based on utility size and complexity.
• Managers, Operations, Maintenance and Safety Professionals receive training on the implementation of PtD concepts.
• Benchmarking with other water utilities occurs annually or bi-annually to exchange information on safety program initiatives, best practices, and new metrics for leading indicators.
• Workers involved in any incident, including first aid cases and near misses, promptly report such incidents to their supervisor.
• Accident investigation is a formal process that takes place within a few days of the initial report and includes involvement of senior managers and detailed analysis of causative factors with the goal of identifying and correcting root causes.
• Ownership and responsibility for management of the return to work process for injured workers is clearly defined.
• Formal return-to-work programs are well-managed, and include provisions for light duty and early returns.

**Best Practices in Prevention-through-Design (PtD)**

A key finding of this study is that water utilities would benefit greatly from the development and implementation of a PtD process for all new facility and retrofit projects. The PtD Process Model proposed in this report has four primary phases for integrating safety during capital project design and delivery:

1. Project specification and safety scoping
2. Intermediate design review
3. 90% review
4. Commissioning inspection.
The proposed PtD Process Model also calls for the concurrent development of operating and maintenance procedures. Several metrics are suggested to help drive PtD processes.

The project leader needs to be responsible for implementing the PtD process, and ensure the active involvement by the appropriate stakeholders at each phase. It was the recommendation of the workshop participants that PtD process ownership and leadership be assigned to a person or persons with joint accountability to BOTH Operations AND Engineering functions.

Organizations that have successful PtD processes have reported very low incident rates on new systems, and have also noted much smoother start-ups than experienced on similar projects prior to implementing PtD. Maintainability and operating efficiency are obvious gains for supervisors, these PtD benefits are difficult to account for in direct dollar savings.

**AREAS FOR FUTURE RESEARCH**

During the course of this study, the research team identified several knowledge and resource gaps which if filled, could benefit the water treatment industry. The following is a prioritized list of areas for future research.

1. Ergonomic Guidelines for Water Utilities
2. Prevention through Design Benefit Assessment
3. Maintainability of New Technology
4. Barriers to PtD Implementation
5. Safety and Health Program Metrics in Water Utilities.
CHAPTER 1
BACKGROUND, REGULATORY PERSPECTIVE, AND PROJECT PARTICIPANTS

INTRODUCTION

As the demand for efficiency in the use of water resources increases, so do the demands on the water utility workforce. These demands emanate from several stakeholders, including regulatory agencies, utility managers, and end users. Today’s water utility workforce is asked to operate and maintain water systems of ever increasing through-put, scope, and complexity. Unfortunately, many of our water systems are still being designed, constructed, operated, and maintained with worker safety as an afterthought. The overarching purpose of this study, Water Research Foundation Project 3104, “Integrating Worker Health and Safety into Water Utility Operations, Management and New Facility Design” is to provide water utility managers a definitive resource for best practices in water utility health and safety. This study will describe the state of water utility safety and health programs in 2007, and will develop concepts that may be applied to improve safety and health performance at water utilities of diverse size and organizational cultures.

BACKGROUND

A 2003 Water Research Foundation report “Identifying and Prioritizing Emerging Safety Issues in the Water Industry”, indicated that “The water industry as a whole appears to have higher recordable incidence rates, lost workday incidence rates, and severity rates when compared to other utilities (i.e. electric utilities).” This finding suggests that water utilities in general are trailing electrical utilities and other process related industries in development and implementation of effective health and safety management systems, their supporting programs, policies and procedures.

The 2003 study described water industry safety performance in terms of injury/illness rates, safety performance surveys, and comparison of water industry rates to other utilities (electric and wastewater). In addition, the report stated that “government operated water utilities operate in an environment without health and safety regulations comparable to Federal OSHA rules in almost half the states in the U.S. It should be noted that Federal OSHA standards specifically exempt municipalities from compliance. Utilities located in states covered by federal OSHA are more susceptible to complacency and poor performance because regulatory enforcement is often the most potent factor driving health and safety programs”. Utilities in states which have been delegated enforcement by OSHA (19 states) often include municipalities in their enforcement scope, often resulting in improved safety and health performance.

Indeed, the 2003 study also recognized that in contrast to other process related industries (energy, chemical,, etc), water utility conveyance, treatment and distribution facilities in general were not designed and operated with worker safety in mind. These facilities were more likely to present conditions that increased risk of lower back, shoulder, and other musculoskeletal injuries, as well as exposure to chemical hazards. The following are examples of unsafe conditions frequently seen in water utilities that contribute to increased frequency of workplace injury include:
• Vaults, basins and pipe galleries whose access and equipment clearance conditions require O&M workers to contort their bodies to perform tasks.
• Vaults, basins, silos, tanks and reservoirs without the necessary fall protection anchorages and work positioning devices.
• Chemical treatment and filtering systems that require manual material handling without consideration for chemical exposure, forceful exertion, or repetitive motion.
• Valves, pipes, and water conveyance/distribution equipment designed and installed with little consideration for accommodating safe access, disassembly, repair, and operation of the equipment.

Based on observations and data, the authors of the 2003 Water Research Foundation project report identified the top priority research needs which were in turn translated into research objectives for this project:

• Identify, document, and evaluate exemplary practices for integrating worker health and safety into the design of new and retrofit drinking water conveyance, treatment and distribution systems.
• Assess the cost effectiveness of incorporating ergonomic (and human factors) design into new and existing facilities.
• Identify metrics that will facilitate the evaluation of health and safety programs.
• Identify and evaluate various proactive and reactive programs that promote worker health and safety at water utilities.
• Identify and quantify the costs and benefits of worker health and safety best practices.

This report is intended to address the research needs list above. The work presented here identifies best practices for water utility health and safety management, operations, and new facility design. The Principal Investigators built upon the information in the 2003 report by collecting and analyzing information regarding organizational culture, accountability, structure, safety standards compliance, and safety and health motivations.

REGULATORY PERSPECTIVE

In general industry, most organizations have developed a working knowledge of the Occupational, Safety and Health Administration (OSHA) standards. In addition to complying with OSHA standards, industries that handle hazardous chemicals or frequently place workers in potentially hazardous environments often adopt unique work practices and procedures that are even more protective. While, water systems use many of the same hazardous chemicals and place their workforce in similar hazardous environments, their safety programs commonly do not have the rigor and sophistication frequently found in general industry.

When OSHA was established, government agencies were specifically exempt from regulatory compliance requirements. As a result, many water utilities that are operated by municipalities or regional governments are exempt from OSHA enforcement. Approximately half of the States operate their own “State Plan” OSHA programs that meet or exceed federal OSHA provisions. California and several other State Plan states have not granted the exemption and have chosen to regulate government agencies along with general industry. However, the proportion of water utilities regulated by either a Federal or State OSHA is fairly low.
The absence of regulatory requirements is often suggested to have a negative effect on safety performance (i.e., utilities not regulated are not likely to have developed or implemented effective safety programs). The 2003 Water Research Foundation project confirmed that utilities operating in states that enforce OSHA standards (“State Plan” states) did have lower injury/illness rates than those that operating in states where public utilities are exempt from OSHA enforcement. The compliance with OSHA-type standards in general industry is often associated with the development of formal safety programs, which seem to be less common in the water industry.

Of the twenty water utilities that participated in this study, four are exempt from OSHA or other government regulation regarding compliance with safety and health standards (See Table 1.1). Exempt and non-exempt utilities participating in this study will be compared in subsequent sections of this report.

**Table 1.1**

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<td>Medium</td>
<td>Regional Authority</td>
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<td>City of Minneapolis Water Treatment and Distribution Services</td>
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<tr>
<td>City of Oklahoma City Water and Wastewater Utilities Department</td>
<td>OK</td>
<td>Large</td>
<td>Municipality Owned</td>
<td>Yes</td>
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<td>CA</td>
<td>Medium</td>
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<td>Municipality Owned</td>
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<td>NE</td>
<td>Medium</td>
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<td>Yes</td>
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<td>Los Angeles Dept of Water and Power</td>
<td>CA</td>
<td>Large</td>
<td>Municipality Owned</td>
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<td>MA</td>
<td>Large</td>
<td>Regional Authority</td>
<td>Yes</td>
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<tr>
<td>Memphis Light, Gas and Water Division</td>
<td>TN</td>
<td>Large</td>
<td>Municipality Owned</td>
<td>No</td>
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<tr>
<td>Metropolitan Water District</td>
<td>CA</td>
<td>Large</td>
<td>Special District</td>
<td>No</td>
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<td>AZ</td>
<td>Large</td>
<td>Municipality Owned</td>
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<td>OR</td>
<td>Large</td>
<td>Municipality Owned</td>
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<td>SNG</td>
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<td>Regional Authority</td>
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<td>KS</td>
<td>Medium</td>
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<td>Yes</td>
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</table>

*AWWA Utility Size Breakdown: Small (<5000 Service Connections) Medium (5,000 - 100,000 Service Connections) and Large (100,000+ Service Connections) Utilities.

**PARTICIPATING WATER UTILITIES**

The researchers were fortunate to have excellent response from water utilities willing to contribute significant time resources of personnel in responding to the comprehensive questionnaire, supporting week-long case studies, traveling to, and attending workshops. This research would not have been possible without the contributions of the participating utilities. Table 1.1 provides an overview of the participating utilities.
Observations about the participating utilities:

- Based on American Water Works Association (AWWA) utility size convention, study participants reflected 12 large utilities (>100,000 service connections), and 8 medium utilities (>5,000 and <100,000). There were no small utilities represented in the study.
- Ten utilities are affiliated with municipalities.
- Nine utilities are special districts or regional authorities.
- One utility is affiliated with a Federal Government Agency (Army Corps of Engineers).

Geographic distribution:

- Two large international utilities (Singapore Public Utilities Board and Metro Vancouver).
- Two large utilities located in the Eastern United States (Massachusetts and Washington, D.C.)
- One large and two medium utilities located in the Southern United States (Tennessee and South Carolina)
- One large and three medium utilities located in the Central United States (Kansas and Oklahoma).
- One large and three medium utilities located in the Midwest United States (Michigan, Minnesota, and Nebraska)
- Four large and two medium utilities located in the Western United States (Arizona, California, Oregon).

Representatives of the water utilities included senior administrators, risk management professionals, safety professionals, and maintenance/operations managers. Based on discussions with the representatives of the utilities over the course project, it is apparent that participating in this study provided a valuable opportunity to benchmark their organization against other utilities in the group.

**PRINCIPAL INVESTIGATORS**

The Principal Investigator for this study is John H. Borowski, CIH, CSP of Black & Veatch, and Paul Adams PhD, CSP, CPE, of Applied Safety and Ergonomics is the Co-Principal Investigator. Collectively, this team has more than 50 years of experience analyzing, developing and implementing safe work practices and procedures, as well as extensive experience integrating hazard mitigation processes with process design and operations. The principal researchers were supported by safety, health, and engineering professionals from Black & Veatch and Applied Safety and Ergonomics. The researchers solicited participation from the utilities, developed the survey questionnaire, conducted the survey, facilitated workshops, maintained quality control, visited selected utilities to perform case studies, met the objectives as scheduled, and produced the final report.

The principal investigators’ professional experience is primarily in the development and implementation of safety and health management systems and Prevention-through-Design (PtD) concepts for manufacturing and chemical processing industries. Therefore, the best practices for
water utilities discussed in this report reflect those that were effectively implemented in participating water utilities, as well as organizations in other process-related industries.

**SIGNIFICANCE TO WATER UTILITIES**

The consensus of the participating utilities is that the integration of worker health and safety into the design of water systems will result in improved O&M efficiency, system performance/reliability, and safety performance. It is also clear that water utilities are trailing many other industries in the integration of worker health and safety in system design.
CHAPTER 2
OVERVIEW OF RESEARCH OBJECTIVES, ELEMENTS, AND PROCESS

OBJECTIVES OF RESEARCH

The objective of the research was to evaluate issues, trends, current approaches, and emerging technologies to identify best practices for enhancing water utility worker safety and health performance. The Water Research Foundation, in assembling the solicitation for proposals for Project 3104, “Integrating Worker Safety and Health into Water Utility Management, Operations and New Facility Design” used recommendations for future projects from the 2003 Report “Identifying and Prioritizing Emerging Safety Issues in the Water Industry”. The 2003 report highlighted the following areas for future study:

- Effectiveness of Techniques for Prevention of Lower Back and Shoulder Injuries and Other Musculoskeletal Disorders.
- Establishing the Full Costs of Injuries and Illnesses and Evaluating the Cost/Benefit of Prevention Programs.
- The Role of Human Factors in Injuries and Improving Safety Performance in the Water Industry.

The Project 3104 research team identified nine research elements of water utility safety and health. For each element, the researchers considered influences related to varying water utility cultures and resource availability.

The nine research elements that were addressed throughout the research:

1. Determine types of worker injuries, how they occurred and the outcomes
2. Identify health and safety risks posed by new and emerging technologies
3. Identify and evaluate best practices for integrating health and safety into the design of water utility systems.
4. Assess cost effectiveness of incorporating ergonomic design into new and existing facilities.
5. Identify and evaluate various proactive and reactive programs that promote worker health and safety.
6. Identify and quantify the costs and benefits of worker health and safety programs.
7. Identify metrics that will facilitate the evaluation of health and safety programs, and if appropriate, drive change.
8. Identify and quantify the costs and benefits of disability management programs.
9. Identify approaches for analyzing cost/benefit of integrating safety into design and other health and safety management practices.
RESEARCH PROCESS

The research team, in collaboration with representatives from participating utilities and the project advisory committee, developed a two-phase research approach to collect and analyze information in response to each of the nine elements summarized above.

Phase 1. Participating utilities completed a comprehensive questionnaire and participated in a workshop. In the workshop, utilities identified and discussed injury/illness root causes, accident costs, current trends in health and safety management, and helped to identify some best practices in industry.

Phase 2. Based on questionnaire responses and participation in the workshop, the researchers selected five utilities with organizational and cultural characteristics considered “best-in-industry” for closer analysis, and then conducted in-depth case studies on-site. Case study observations were reviewed with water utility representatives at a Phase 2 Workshop.

The following details the process and protocols as implemented by the researchers over the course of the project:

PHASE 1 – WATER UTILITY SAFETY & HEALTH QUESTIONNAIRE

The Researchers developed a comprehensive web-based Questionnaire that was completed by representatives of each participating utility. The web-based questionnaire allowed respondents to access and complete sections individually or with input from several people/departments. Feedback from utilities indicated that many questions were best answered by the site safety leader, while others were more appropriately answered by engineering, human resources, or finance. An overview of Questionnaire content and process is presented in Appendix A.

The Questionnaire was designed to identify best practices in safety and engineering program management and included detailed examination of the following aspects of water utility safety, health, engineering, and operations:

- Injury/Illness Experience.
- Inherent Hazards.
- Organization Structure.
- Safety Program Initiatives.
- Program Metrics.
- Integration of Safety in Design.
- Use of Cost Data and Cost/Benefit Analysis.
- Ergonomics.
- Best Practices.
- Injury/Illness Case Management.

The researchers assembled and analyzed the data from the Questionnaire responses from the water utilities. The findings and conclusions are summarized in Appendix B, Water Utility Safety & Health Questionnaire Summary of Results. Those results required additional analysis and clarification which was performed at the Phase 1 Workshop with representatives of each participating utility.

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PHASE I WORKSHOP OBJECTIVES

- Provide overview of Water Research Foundation Project 3104 research objectives and research methodology employed by the Black & Veatch research team to satisfy those objectives.
- Brief utility representatives on findings and conclusions from analysis of Questionnaire responses.
- Use breakout session format to evaluate and clarify gaps in questionnaire data relative to project objectives.
- Identify candidates to participate in Case Studies.

OVERVIEW OF PHASE I WORKSHOP ACTIVITIES

The research team provided an overview of the findings and conclusions from each of the 10 sections that comprised the Questionnaire. Each workshop participant was also provided a copy of the Questionnaire Preliminary Findings Report prepared by the research team. Based on a discussion of the preliminary findings, the research team developed four breakout sessions to further investigate the preliminary findings. During the breakout sessions the research team and water utility representatives discussed and analyzed the following aspects of safety management:

- Safety Program Metrics.
- The Role of Cost Benefit Analysis in Water Utility Safety.
- Water Utility Vision for Project – Format for Presentation of Best Practices.

Breakout Sessions

The utility participants were broken into four groups that stayed together for each of the four breakout sessions. The research team selected members of each group to assure that each group generally represented a cross section of water utilities based on geography, representative status (utility representatives included engineers, safety professionals, administrators, etc). Representatives of the research team circulated among the groups to facilitate discussion and answer questions. The duration of each breakout session was approximately 90 minutes.

The following provides an overview each breakout session:

**Breakout Session 1: Safety Program Metrics**

The session focused on evaluation of the methods used to gather injury/illness information and how the information is reported internally and externally. Each group was also asked to evaluate safety program activities that may be used to generate metrics that measure indicators of effective safety programs. Each group was asked to discuss and to provide answers to the following:

- Summarize methods used to collect injury/illness information and who is typically responsible for incident investigation and reporting.
• Identify breakpoint for injury/illness recording and reporting.
• What seems to work- what doesn’t?
• Identify safety activities that can be effectively measured.
• Rank those activities in terms of potential to drive change.
• Provide comments for consideration when evaluating metrics.

Breakout Session 2: The Role of Cost Benefit Analysis in Water Utility Safety

Responses to the Questionnaire did not indicate a significant role for cost benefit analysis in water utility safety and provided very little information regarding actual costs related to incidents (injury/illness/property damage). This session focused on evaluation of the methods used to gather information related to the direct and indirect costs of incidents and the use of that information in the executing cost benefit (C/B) analysis for safety programs, installation of safety related fixtures or equipment, etc. Each group was asked to discuss and to provide answers to the following:

• Is there a C/B Model that will work for water utility industry.
• Is it needed (i.e. will it drive management behaviors)?

Breakout Session 3: Safety Initiatives – What Works and What Doesn’t

This session focused on evaluation of the various safety initiatives implemented by the participating utilities to identify those that proved to be most and least effective. Each group was asked to discuss and to provide answers to the following:

• Regarding safety initiatives – list program initiatives that have and have not worked
• For those safety initiatives that are effective, rank them in order of effectiveness
• Identify initiatives that you are considering implementing, and those that you would like additional information on.

Breakout Session 4: Water Utility Vision for Project – Format for Presentation of Best Practices

During this session, participants were asked to discuss format for the presentation of best practices in water utility design. This discussion led to the presentation of findings in the final report.

Based on the conversations over the course of the workshop, it is apparent that significant gaps exist in the coordination of safety with in-house and contract engineers when considering a new or retrofit facility. This finding became a focal point for further analysis during the case studies in Phase II.

SELECTION OF CASE STUDY CANDIDATES

Over the course of the analyzing the Questionnaire and based on observations noted during Phase 1 workshop discussions, the research team identified five water utilities that demonstrate some of the characteristics of best-in-industry organizations. The research team’s
observations and conversations with representatives from the selected water utilities during the Phase 1 Workshop indicated advanced understanding of safety system development, implementation and management. In selecting the case study candidates, the research team was careful to select utilities that are diverse in terms of size, representation, geography, and scope (conveyance, treatment, and distribution). The following were selected by the research team for case studies:

1. **Tualatin Valley Water District**, Oregon: Medium size, non-union, distribution based utility.
2. **Beaufort – Jasper Water/Sewer Authority**, South Carolina: Medium size utility, non-union, with water conveyance, treatment, and distribution processes.
3. **City of Oklahoma City Water and Wastewater Utilities Department**: Medium/large size utility, union, with water conveyance, treatment, and distribution processes.
4. **Greater Vancouver Regional District**, British Columbia: Large size utility, union represented, with water conveyance, treatment, and distribution processes.
5. **Metropolitan Water District**, Los Angeles, California: Large size utility, union represented, with water conveyance and treatment.

**PHASE II – OVERVIEW OF WATER UTILITY CASE STUDY PROTOCOL**

The researchers utilized a protocol (See Appendix C – Water Utility Safety and Health Case Study Protocol) that closely resembled a safety and health audit or culture assessment. However, the overarching message that we presented to the selected water utilities was that unlike an audit or assessment, we did not seek to identify the negative aspects of the programs under study, but rather focused on those sustainable practices that proved effective in reducing worker injuries and/or illnesses. The following summarizes the objectives of the case studies, as they were applied to 5 water utilities:

- Identify and document best practices for integrating safety into both design and operations.
- Analyze the value of safety practices and activities in terms of hazard mitigation effectiveness and financial benefits.
- Analyze the effectiveness and value of safety fixtures and equipment installed at water conveyance, treatment and distribution systems.

Due to the comprehensive nature of the case study protocol and the research requirement to interview senior managers with each utility, case studies were executed over the course of 4-5 days for each subject utility during the summer of 2007. Case study utilities were briefed on the process via emails describing the protocol and were also provided with the Case Study Protocol itself (see Appendix C). The subject utilities were asked to provide documents in advance of the study and to make senior leadership, administrative, operations, and maintenance managers and staff available for interviews.

During each case study the researchers toured representative facilities to observe examples of best practices in safety at that utility and to allow utility representatives to explain the process that was used to develop the facility design.
The following summarizes the activities performed by the researchers over the course of each case study. More detailed information including case study agenda, documents reviewed and interview content is provided in the Case Study Protocol.

- Conduct on-site kick-off meeting.
- Utility tour to observe best practices.
- Detailed review of injury/illness/near miss incident reports, root cause analysis, case management files, and cost tracking systems.
- Overview of hazard assessment, operations and mitigation review process.
- Manager, supervisor and worker interviews.
- Case study findings and conclusions outline.
- Closing meeting.

OVERVIEW OF PHASE II WORKSHOP ACTIVITIES

Researchers hosted representatives from each participating water utility and the Project Advisory Committee (PAC) for a two-day workshop designed to vet the study findings. The Phase II workshop was similar in format to the Phase I Workshop with researchers providing an overview of the “State of Water Utility Health and Safety”, based on findings from the Questionnaire, discussions during the Phase I workshop, and observations from the case studies. Occasionally the case study findings conflicted with findings from the questionnaire which required reconciliation amongst the group.

An example of the value of the Phase II workshop was the enlightening session featuring representatives from each of the case study utilities. The representatives offered their perspective on the case study and the value derived from participating in the study. In each case, the utility representative discussed a safety and health management system best practice that was identified during the case study performed at their utility. This provided utility representatives an opportunity to discuss the particular best practice relative to a particular utility. The following provides a summary of the best practices discussed by each utility that participated in the case study:

- Lindle Coleman (Oklahoma City): Recognizing and Overcoming Challenges/Barriers to Success.
- Mike Jacobs (Tualatin): Importance of Leadership: Values.
- Bobbi Becker (MWD): Process to Develop Balanced Scorecard and Benefits.
- Ken Jordan (BJWSD): How to Determine Where Your Utility is in the Health & Safety Continuum and Strategies for Continuous Improvement.
- Mike Warn (GVRD) – Safety Management System (Key Elements and Benefits).

Based on discussions with the PAC and utility representatives in advance of the workshop, Researchers spent the balance of the workshop facilitating discussion regarding best practices in PtD concepts, their applicability, policies and procedures for implementation to water utilities. The following summarizes the discussion points for those sessions:
Prevention-Through-Design (PtD) Introduction

- Overview of PtD Process
- Who, When, How (Resolve conflicting data from Questionnaire/Case Studies)
  - Identify Utilities with a Formal PtD Process
  - What Group (Operations/Engineering) Own the Process?
  - Design Criteria/Fitness-for-Use?
  - When is Value Engineering Process Used?
  - Where are the Breakpoints for Internal/External Design (Small & Large)
  - Constructability Review
  - Operability/Maintainability Reviews
  - Commissioning
- Who, When, How (Resolve conflicting data from Questionnaire/Case Studies)

Fitness For Use/Project Goals & Objectives - Breakout Assignments

- Who should be involved and how?
- What should be accomplished (specifically?)
- Communication/Facilitation – how/who?
- Skill needs – identify gaps and training needs.
- Process barriers.
- Identify Ownership/Leadership of process

Intermediate 50% Review Assignments

- Who should be involved and how?
- What should be accomplished (specifically?)
- Communication/Facilitation – how/who?
- Skill needs – identify gaps and training needs.
- Process barriers.
- Identify Ownership/Leadership of process

90% Review Assignments

- Who should be involved and how?
- What should be accomplished (specifically?)
- Communication/Facilitation – how/who?
- Skill needs – identify gaps and training needs.
- Process barriers.
- Identify Ownership/Leadership of process

Construction Phase Assignments

- Who should be involved and how?
- What should be accomplished (specifically?)
• Communication/Facilitation – how/who?
• Skill needs – identify gaps and training needs.
• Process barriers.
• Identify Ownership/Leadership of process

O&M Procedures Development Assignments

• Who should be involved and how?
• What should be accomplished (specifically?)
• Communication/Facilitation – how/who?
• Skill needs – identify gaps and training needs.
• Process barriers.
• Identify Ownership/Leadership of process

Metrics/Drivers

• What needs to be driven and verified?
• Who needs to be motivated and who needs feedback?
• Value of measuring PtD process?
• What metrics are needed and appropriate?
CHAPTER 3
UTILITY INJURY AND LOSS EXPERIENCE, ORGANIZATIONAL CULTURE, ACCOUNTABILITY, AND STRUCTURE

INTRODUCTION

State of Health and Safety in Water Utilities Operations and Facility Design

Water utilities are not unlike other organizations that seek to emulate best in class performance. As with other industries, the first step is to determine how an organization stands in contrast to those they seek to emulate. As Ken Jordan with Beaufort Jasper Water and Sewer Authority (one of the best performing water utilities) found during their journey from poor performance to excellence, “you must first know where you stand before you can map a plan to improve”.

Chapters 3, 4 and 5 will describe the parameters that prove to be most important to achieving excellent health and safety performance, and will provide a generalized discussion of the state of water utility safety and health, relative to those parameters. This discussion along with information from the questionnaire and case study protocol should provide water utility managers the necessary tools to determine how they stand within the industry.

Research Parameters Describing State of Health & Safety in Water Utilities

The research elements, questionnaire, and case study process described in Chapters 1 and 2, generated data that generally describe the state of water utility occupational health and safety based on general parameters including:

- Injury and Loss Experience, Organizational Culture, Accountability, and Structure (Chapter 3).
- Strategies for Hazard Recognition and Mitigation (Chapter 4).
- Health & Safety Drivers/Metrics (Chapter 5).

This Chapter provides an overview of the injury and loss experience of the utilities that participated in this study relative to each other and to rates reported by the United States Department of Labor, Bureau of Labor Statistics (BLS). It should be noted that the findings related to injury and loss statistics are similar to those indicated in the 2003 Water Research Foundation report referenced herein. Of more importance to the research objectives for this project, the questionnaire and more specifically, the case studies provided insights regarding the state of water utilities regarding the research parameters:

- Organizational culture, accountability, structure.
- Strategies for hazard recognition and mitigation.
- Program metrics and drivers.
In recent years there has been significant discussion regarding the usefulness of injury and loss statistics as indicators of safety and health program effectiveness. Chapter 5 will discuss the concept of leading and lagging indicators and the efficacy of them.

PARTICIPATING WATER UTILITY INJURY AND LOSS EXPERIENCE

Fifteen of the twenty participating water utilities provided injury and illness data. The 5 remaining utilities did not provide sufficient data to include in this analysis or chose not to provide data for various reasons (for example, they do not routinely collect such data or they indicated that the data was confidential).

Figure 3.1 presents a graphical representation of the recordable injury data provided by each of the 15 utilities. Utility names are not presented to assure confidentiality.

Figure 3.2 presents average recordable injury rates for participating water utilities grouped by size of utility and affiliation.

The range of injury statistics suggests that the participating utilities are generally representative of a wide range of water utilities in terms of health and safety performance. This observation corroborates differences found in the questionnaire and case studies and suggests that the participating utilities provided a reasonable group to evaluate the state of water utility health and safety.

Observations from Figures 3.1 and 3.2:

- Medium size utilities affiliated with municipalities are more likely than larger facilities to have higher injury rates and higher levels of variation in year to year performance.
- Performance of medium size utilities may be skewed due to the fact that many medium-size, municipally owned utilities do not include administrative staff in rate calculations, and therefore their workforce has a much lower percentage of low-risk administrative support staff that typically bring down overall injury rates.
Chapter 3: Utility Injury and Loss Experience, Organizational Culture, Accountability, and Structure

Figure 3.1 Recordable injury data

Figure 3.2 Average recordable injury rates
• Management attention to safety tends to be much higher in states where municipalities are subject to Federal and State OSHA enforcement. Some of the highest injury rates were found in municipal utilities operating without the threat of Federal or State OSHA enforcement.

• Utilities affiliated with special districts and authorities generally demonstrate better statistical performance than those associated with municipalities. These utilities often feature leadership that was more engaged in safety performance and frequently held accountable for safety performance, unlike many municipalities.

• Special districts are typically subject to Federal or State OSHA enforcement, unlike many of the municipality-owned utilities that participated in this study.

Perhaps the most interesting injury experience data that were generated by the questionnaire are related to statistics regarding distribution of injury by body part, injury type, and injury causes relative to general industry. Figures 3.3 and 3.4 illustrate injury frequency by body part and type specifically for the participating utilities based on 2939 injuries reported 2003-2005.

The injury data presented in Figures 3.3 and 3.4 suggests that strains and sprains affecting the extremities are the most common injuries realized by water utility workers. This data generally agrees with that reported by general industry (Figures 3.5 and 3.6) for the same time frame.

In light of the occupational injury data for water utilities in 2003-2005, a key finding of the 2003 report is particularly interesting: water utility conveyance, treatment and distribution facilities in general were not designed and are not operated with worker safety in mind, and therefore were more likely to present conditions that pose an increased risk of lower back, shoulder, and other musculoskeletal injuries. Based on conversations with participating utilities, anecdotal evidence indicates that the injury experience may also be influenced by the aging workforce that is common in water utilities maintenance and operations staff. The following are examples of unsafe conditions common throughout water utilities that contribute to increased frequency of workplace injury:

• Vaults, basins and pipe galleries whose access and equipment clearance conditions require O&M workers to contort their bodies to perform O&M tasks.

• Vaults, basins, silos, tanks and reservoirs without the necessary fall protection anchorages and work positioning devices.

• Chemical treatment and filtering systems that require manual material handling without consideration for chemical exposure, forceful exertion, or repetitive motion.

• Valves, pipes, and water conveyance/distribution equipment designed and installed with little regard for the safety of the workers who must access, disassemble, repair, and operate the equipment.

The findings detailed above and the unsafe conditions common throughout water utilities strongly support the objectives of this project, namely:

• Identify, document, and evaluate exemplary practices for integrating worker health and safety into the design of new and retrofit drinking water conveyance, treatment and distribution systems.
Figure 3.3 Distribution by body part of injuries reported by 15 water utilities for 2003-2005

Figure 3.4 Distribution by injury type of injuries reported by 15 water utilities for 2003-2005
Figure 3.5  Frequency comparison of injury types reported by 15 water utilities compared to general industry experience as reported to the Bureau of Labor Statistics (BLS)

Figure 3.6  Frequency comparison of injured body parts reported by 15 water utilities compared to general industry experience as reported to the BLS
• Assess the cost effectiveness of incorporating ergonomic (and human factors) design into new and existing facilities.
• Identify metrics that will facilitate the evaluation of health and safety programs.
• Identify and evaluate various proactive and reactive programs that promote worker health and safety at water utilities.
• Identify and quantify the costs and benefits of worker health and safety best practices.

ORGANIZATIONAL ACCOUNTABILITY, CULTURE, AND STRUCTURE

As indicated above, safety and health performance of many water utilities is in part due to lack of regulatory enforcement and difficult working conditions. Throughout the course of this study the researchers identified the primary sources of sub-optimal water utility safety and performance as:
• Lack of senior manager accountability (and visibility) for program performance.
• Organizational culture that does not clearly value worker safety and health.
• Structure that does not provide sufficient resources to develop and implement effective programs.

ACCOUNTABILITY FOR SAFETY AND HEALTH PERFORMANCE

The following findings describe the characteristics of many of the participating water utilities regarding organizational accountability, culture, and structure to drive safety program performance. These characteristics contrast with organizations that value safety and health performance as a key indicator of organizational effectiveness:

• Most water utilities do not hold senior managers accountable for implementation of safety and health policies and procedures, (i.e. manager performance reviews do not typically address safety and health performance).
• Most water utilities do not generate metrics that can be used to evaluate safety and health performance. In fact, many utilities managers are not aware of even rudimentary lagging indicators such as injury/illness or days away from work (DAFW) rates.
• Municipality-owned water utilities in states regulated by Federal OSHA consider compliance with OSHA as “the standard”, but typically are not held accountable for compliance as there is little or no enforcement of OSHA standards and rarely any fines or citations.
• Utilities that do consider safety performance in manager, supervisor and worker performance evaluations often use subjective criteria such as “followed safety rules.”
• Utilities that do wish to determine accountability and performance using safety and health metrics often struggle to create and implement management systems that balance leading and lagging indicators to establish accountability.
• Most utilities do not conduct audits (internal or external) of safety and health compliance. If internal compliance audits are completed they are typically more focused on minor issues such as housekeeping.
Few water utilities have implemented clear and objective performance criteria – a safety management system that tracks performance metrics and communicates them to managers and staff on a frequent basis. Such criteria may include the following:
- Direct costs of injuries & illness.
- Injury/illness rates.
- Compliance with regulatory standards, and internal safety and health policies and programs.

Many water utilities claim to involve operations and maintenance personnel in facility design reviews but do not effectively manage or facilitate the process.

SAFETY CULTURE OBSERVATIONS

The concept of safety culture is complex as it is the product of many organizational traits such as the goals and objectives of leaders, use of discipline, human resource policies, and the relationship between management and employees (this is frequently an issue in organizations with employee representation by bargaining units/unionis). The questionnaire and case study questions regarding the above traits were designed to assess safety culture and perceptions of program stakeholders. Analysis included looking at level of agreement/disagreement among stakeholders, highly positive or negative agreement with the benchmark statement, average agreement levels by stakeholder group, variance within stakeholder groups, and perceptions of managers and staff. The following observations are based on questionnaire responses and case studies:

Safety Communications

- Managers and employees often have differing perceptions regarding the willingness of the employer to spend resources to provide a safe work environment.
- Stakeholders demonstrated consistent level of agreement for the following statements:
  - Employees openly and freely share their safety concerns.
  - Employees are encouraged to promptly report injuries.
  - There is a positive working relationship between workers and management with regards to safety.
  - Employees actively accept responsibility for each other’s safety.
  - Nearly all injuries and accidents are reported.
- Two statements were presented around the topic of safety consideration in project design:
  - Safety is considered throughout the design process for new systems, i.e., from project specification through commissioning.
  - Safety is usually an afterthought, with hazards corrected primarily after there has been an accident.

Senior management and safety leaders agreed with the first statement regarding when safety is considered on design projects, and disagreed with the second; workers slightly disagreed with the first and slightly agreed with the second. These contrasting responses suggest that the Prevention-through-Design concept is not a strong element...
within the safety culture of water utilities, and that workers are not routinely involved in the specification and review of new water utility facilities.

**Union Participation**

Seventy-nine percent (15 of 19) of the responding organizations are unionized. The perception of respondents (managers and employees) regarding safety and health performance and the role of unions was evaluated relative to involvement in safety and health:

- Without exception, responses from non-union organizations had a higher level of agreement with the positive safety program statements than did unionized organizations, and for many statements, this difference was marked.
- On 10 of the 20 positive statements, the mean response for union workers was either neutral or in disagreement.
- Management responses were also less positive than for their non-union counterparts.
- Four measurement statements sought level of agreement regarding management view of unions as a valued partner, positive union support of management’s safety efforts, constructiveness of employee participation on safety committees, and union support of management encouragement for safe practices by workers. Mean responses for all four statements were positive and consistent. This suggests at least tacit support by the unions of management safety efforts and management’s acceptance of the unions as playing a somewhat positive role.
- Case study results suggest that on occasion unions representing workers may exploit safety as a means of gaining leverage in negotiations, thus souring an otherwise cooperative approach to safety seen in many utilities.

**Employee Involvement & Discipline**

- Ninety-four percent (17 of 18) of utilities involved employees in developing safety rules.
- Regarding development of standard operating procedures (SOP) and other safety related policies and programs, 88% (15 of 17) of utilities indicated that employees participate in the development and other performance standards that define safety related behavior and performance expectations.
- Only four of the seventeen utilities that do involve workers in the development safety rules indicated employee involvement beyond safety rule and SOP development. These respondents cited various forms employee involvement, including employee-to-employee observation/feedback, participation in policy and SOP reviews, safety meetings and committees, disciplinary actions, and investigations.
- Two respondents indicated employees point out non-compliance, while 67% (8 of 12) indicated little or no employee role in execution of the enforcement program.
- Regarding disciplinary policies, 78% (14 of 18) of respondents indicated they had a written disciplinary policy for safety violations. Various forms of progressive discipline were included.
Safety Leadership

Leadership of senior management proved to be an important differentiator between utilities with below average performance and those with excellent performance. The following contrasts the level of engagement by utility leaders in the safety process relative to the level of performance demonstrated by the respective utilities:

Managers of utilities that are under-performers typically demonstrated the following characteristics:

- Tolerance of incidents and the resulting direct costs as a “cost of doing business.”
- Lack of management engagement in, or emphasis on:
  - Health and safety performance in leading and lagging indicators.
  - Monitoring of loss management costs.
  - Program development and implementation.
  - Safety and health policy enforcement.
- Observation of workers and enforcement of safe work practices and procedures by managers is a low priority relative to other administrative duties.
- No clear leadership in terms of statements directly to workers regarding importance and value of safety.

Managers of organizations that are average performers demonstrated the following characteristics:

- Leadership generally makes resources available to develop and implement programs
- Management responds reactively to issues and challenges rather than seeking to continuously monitor and improve.
- Utilities do not include safety and health performance in development of strategic planning and processes.
- Most water utilities do not include safety performance as key aspect of overall business strategy.

Managers of organizations that perform at a high level demonstrate the following characteristics:

- Safety and health practices are integrated into the culture and business processes as a “Business Value”.
- Utility leadership fosters culture through policies and actions.
- Staff and management take co-operative approach to safety performance.
- Safety practices and policies are enforced consistently regardless of position or level.
- Utility leaders assure that PtD process is implemented for new process designs and retrofit projects.
Safety Organization

This section evaluates the orientation of safety and health within the utilities’ organization structures, roles and responsibilities regarding safety, and perceptions regarding safety and health management at each level of the organization. An overview of results is presented regarding the responsibilities of dedicated onsite safety officers, corporate or agency H& S professionals, and unit operating staff or onsite engineering.

- Corporate or agency health and safety professionals appear to assume the most responsibility for safety program activities.
- External consultants were not widely used by most organizations except for providing technical safety expertise (50%; 10 of 20).
- It appears that actual program management and leadership are more centrally managed. Given the reliance on central organizations for program support, it is almost surprising that onsite safety officers are as engaged as they are. Two curious points warranting additional research include the level of involvement and role of safety professionals in the review of engineering projects, and the lack of use of external safety consultants.
- Based on conversations with water utility managers and safety professionals, it is apparent that water utilities lag in the hiring of safety professionals. Many utilities feature home-grown “safety people” that do not have the formal training and experience necessary to develop and implement effective safety programs. It is also common for those charged with safety leadership to have divided responsibilities (e.g. they “wear many hats”). Some utilities have recently hired seasoned safety professionals in an effort to upgrade their programs. Several utilities involved with this project indicated significant improvement in safety performance corresponding with the hiring of a safety professional, validating this strategy.
- When safety resources are spread thin or inadequately trained, as in some of the larger municipality-owned utilities that were studied, safety performance suffers.
CHAPTER 4
STRATEGIES FOR HAZARD RECOGNITION AND MITIGATION

Water utilities have unique health and safety challenges. This chapter will briefly identify and discuss technological concerns and then discuss how safety and engineering functions currently address safety in the planning for new technology and facilities.

Since ergonomics continues to be a significant concern, a discussion of current ergonomic program strategies will be presented. Finally, other health and safety program initiatives aimed at recognizing and mitigating hazards will be discussed. The findings and discussion points in this chapter were drawn from the questionnaire and the first participant workshop, and confirmed through case study interviews. Supporting questionnaire data are presented in the Appendix B.

WATER INDUSTRY TECHNOLOGIES OF CONCERN

Study participants were asked a series of questions about technologies currently being applied and their perceptions of the risks and hazards associated with them. Questionnaire respondents identified 21 new technologies that may pose safety challenges and risks. The most frequently cited technologies were membrane filtration, UV disinfection, sodium hypochlorite, ozonation, and chloramination. The hazards capable of catastrophic loss or fatalities that respondents most frequently cited were confined spaces / hazardous atmospheres, chlorine, vehicle / traffic, and other chemical hazards.

The responses to questions about hazards suggest that hazards unique to new technologies are not the primary safety concern for water utilities. In the Phase 1 Workshop, participants re-iterated that confined space entry and dealing with hazardous atmospheres were viewed as the most serious hazards.

Comparing the responses with actual industry incident experience reveals the most frequent sources of actual injuries (with the exception of motor vehicle accidents) do not include either the hazards or the technologies identified by the utilities as most concerning. That is, utilities express a greater concern for accidents/incidents with severe outcomes (e.g., confined space) rather than those accidents/incidents that occur most frequently (e.g. musculoskeletal disorders). However, current safety program activities appear to focus most on reducing the frequency of accidents/incidents rather than severity, and performance metrics of these systems are typically based on accident frequency rather than on activities aimed at preventing severe incidents.

The questionnaire and Phase 1 workshop assessed whether safety technologies currently being applied were aligned with the identified technologies and hazards of concern. Respondents most frequently identified the following safety strategies for reducing health and safety risks:

- Improvements in general safety of equipment and in safety practices at the facility.
- Building new or improving existing structures.
- Reducing exposures to chemical hazards.
- Personal protective equipment.
- Air monitoring and purifying improvements.
These results suggest that traditional safety program approaches are most frequently used to reduce risk; i.e., safety programs focused on equipment, practices, capital improvements and PPE. It is perhaps as important to identify safety strategies that were not cited frequently, as to find those that were cited.

- Utilities did not cite systematic analysis of technology specific hazards as a primary safety strategy even though they expressed significant concerns with new technologies,
- Although building new and improving existing facilities was cited as a strategy for reducing risks, utilities did not identify safety in design and facility planning as a fundamental risk improvement technology.
- Application of ergonomic principles was not frequently cited as a technology for reducing risks. This will be discussed more fully later in this chapter.

**HOW SAFETY AND ENGINEERING ARE PERFORMED FOR NEW TECHNOLOGY AND FACILITIES**

To achieve the goal of inherently safe facilities and operations, several stakeholders need to collaborate to assure that safety is integrated into facility and process designs. Although titles and specific responsibilities vary among organizations, stakeholders can be categorized as those performing the primary design work, those with specialized knowledge of safety technology, and those with operational experience. A major goal of this study was to determine how safety gets addressed through the engineering process, and to propose a model for improving engineering with respect to health and safety project performance.

None of the utilities included in this study relied exclusively on engineering services from within the operating unit or from a centralized engineering organization. This reliance on off-site engineering service providers may compromise information exchange with experienced operating personnel.

To determine the level and types of safety interactions that would likely be present, participating utilities were asked about their organizational structures and who was involved in various safety activities. In 80% (16 of 20) of the respondent organizations, safety and engineering are separate and distinct functions. The majority (65%) of utilities involve engineers in accident investigations on an as-needed basis, but only one utility indicated involvement of engineers in investigating all serious accidents. This suggests that engineers are not contributing technical expertise to these investigations, and that they are not sufficiently exposed to system failures to understand how design decisions contribute to accidents.

A few statistics from the Questionnaire provide evidence that there is much room for greater involvement by safety professionals on capital projects.

- Half (10 of 20) of the responding utilities reported that safety does not receive focused attention on most engineering projects
- 15% (3 of 20) indicated that Safety provided oversight on engineering projects.
- Only 50% (6 of 12) of respondents stated that safety-focused design reviews are always or often conducted on internally designed capital projects, and 43% (6 of 14) always or often conducted them on externally designed projects.
If close collaboration among Safety, Engineering, and Operations is essential for designing inherently safer processes and facilities, then it appears there is much room for improvement within many water utilities. Some additional questionnaire responses illustrate the disconnect between engineering and safety at many utilities.

- Site and project-specific safety requirements are developed and specified by only 25% (4 of 16) of respondents
- Engineers attend safety meetings in 60% (12 of 20) of organizations
- Engineering is represented on safety committees in 50% (10 of 20) of respondents
- Engineering personnel have safety as one of their key performance goals in half of the utilities (10 of 20), but on further examination, these goals address their personal safety, and not the safety performance of their projects.
- Only 35% (7 of 20) of respondents felt the safety department and engineering organization(s) worked very closely together on all capital projects. This may even be inflated given that the engineering leader was also the safety program leader in 10% (2 of 20) of the responding organizations.
- Engineering personnel receive extensive training in both operational safety and designing for safety in only 25% (5 of 20) of responding utilities.

A significant portion of the case study interviews addressed safety through design processes and activities in an attempt to uncover some of the underlying attributes that frustrate organizational attempts to integrate safety more effectively.

- It was found that engineers focus on answering the question, “Will it work?” even to the point of not considering the safety and maintainability question, “Will we be able to work on it?”
- Operating costs associated with safety procedures, such as the increased costs associated with personal fall arrest systems and confined space entries, are not considered in design.
- Water utilities generally do not have a process for collecting operational and maintenance experience with respect to design features, so informal methods are relied upon to keep from repeating design deficiencies. Without effective feedback or active involvement by operations, maintenance and safety personnel, engineers repeat mistakes from one project to the next.

The inability of organizations to capture and retain lessons learned is especially troubling given the aging workforce and anticipated turnover of operators and maintenance personnel in this industry. If water utilities are looking toward process and facility improvement as key strategies for improving long-term safety performance, as the questionnaire indicated, then collaboration among engineering, safety, and operations will need to be much closer. It will also be necessary for organizations to capture and build on the experience of senior workers prior to their retirement.
ERGONOMICS

The profile of injury types among the 14 water utilities that provided data for the study was similar to that of General Industry. Sprains and strains accounted for just over 50% of the total of all reported injuries, and cumulative trauma injuries accounted for approximately 3%. Physical exertion was identified as the most problematic activity class, both in frequency and severity as measured by number of cases and average time lost. Two of the body parts most frequently injured were the back/neck and arm/shoulder. These data indicate that musculoskeletal disorders (MSDs) warrant considerable attention, and ergonomics programs/processes should be in place to reduce MSD risk.

Less than half (8 of 18 respondents) of the participating water utilities reported having written ergonomics programs. Degreed ergonomists are not common on water utility staffs (only 17% (3 of 18) had one), but this is not surprising given the number of utilities in the study that only had one or two safety staff members.

Ergonomics programs and processes were discussed during the first workshop and case study interviews. Most of the participants indicated that their ergonomic initiatives and activities were focused on office workstations and prevention of cumulative trauma disorders in the office setting. A few utilities also reported activities aimed at reducing overexertion injuries associated with manual material handling. Employee awareness training on ergonomic risk factors and workstation (office) design were cited as the most common ergonomic activities. However several ergonomic best practices were identified during the case studies, such as a well-designed trailer to haul worksite barricades and traffic plates, well-positioned valve wheels, and consideration of accessibility and lifting devices in the design of new facilities. The Metropolitan Vancouver Water District had a more comprehensive and mature ergonomics process than was found among U.S. participants. Vancouver had also implemented a safety management system with ergonomics integrated, and had an ergonomics graduate on staff who was focusing attention on preventing MSDs in the field. Although the ergonomics initiative was relatively new at Vancouver, the process was well-positioned for success.

With the possible exception of Metro Vancouver, water utilities included in this study generally used checklists and informal assessment methods for evaluating ergonomic risk factors and improving workstations (if the utilities performed such assessments). Although these tools and approaches can often be effective, reliance on them suggests that ergonomic programs tend to be in their infancy compared to general industry. In short, the injury profile for water utilities suggests that greater emphasis should be placed on ergonomics initiatives aimed at preventing overexertion injuries. Most safety and health programs studied do not appear to be directed at attacking this single biggest source of injuries.

Oftentimes the primary safety or engineering resources do not have the knowledge and skills to proactively identify and prevent MSD risk factors. This does not mean that utilities cannot effectively reduce MSD risks, however. By learning from leading water utilities and other industries with established ergonomics processes, and by applying the best practices identified in this report, utilities should be able to achieve some MSD risk reduction for existing facilities and processes. However, reducing MSD risk through design of new facilities may require additional training for engineers and safety practitioners or the assistance of outside consultants, as well as encouragement from senior leaders.
OTHER HEALTH & SAFETY PROGRAM INITIATIVES

Health and safety programs are typically comprised of many sub-programs or elements, and the mix of these elements needs to be customized to meet the specific needs of an organization. Participants in this study were asked to identify elements of their respective programs that appeared on a broad list of initiatives related to the study objectives. The intent was to learn about the profile of safety programs in water utilities which could later be compared with other industry profiles in subsequent studies. It also provides an indication of the level of sophistication and coverage of health and safety programs.

At least 78% (15 or more of 19) of organizations responding to the questionnaire indicated that their health and safety programs included the following elements:

- Standard Operating Procedures or Job Safety Analyses for each routinely performed job or task.
- Regularly scheduled inspections of the operation(s).
- Safety committee(s) with non-management employee membership of 50% or more.
- Non-management employee involvement in incident investigations.
- Assessments of training needs.
- Significant security system enhancements.

Perhaps of equal interest are those program elements that are not typically found in water utilities. Less than 25% (4 or fewer of 19) of organizations indicated that their health and safety programs included the following components:

- Ergonomics teams.
- Ergonomics training for engineers.
- ISO 14000 or 18000 conforming management systems.
- OSHA VPPP Merit or Star program.
- Adoption of ANSI Z10 Standard.
- Off-the-job safety program.

Water treatment utilities as a group are not leaders in either ergonomics initiatives or safety management systems.

Other program elements of particular interest in this study are listed below, along with the percentage of questionnaire respondents who indicated that these elements were included in their organization’s health and safety program.

- Ergonomics job analysis and/or risk factor surveys – 42% (8 of 19).
- Ergonomic interventions to reduce manual material handling – 47% (9 of 19).
- Wellness and fitness program – 68% (13 of 19).
- Maintenance and Operations involvement in review of engineering designs and projects - 63% (12 of 19).
- Safety through design training for engineers – 26% (5 of 19).
- Design safety reviews on capital projects – 42% (8 of 19).
- Constructability safety reviews for new installations or renovations – 53% (10 of 19).
• Progressive discipline for safety violations – 68% (13 of 19).
• Random drug testing – 74% (14 of 19).
• Behavior based safety program or Culture Change program – 32% (6 of 19) and 26% (5 of 19), respectively.

These data provide further evidence that ergonomics and PtD initiatives are not widespread in the water treatment industry. This is particularly noteworthy, since overexertion injuries account for a higher percentage of injuries in this industry that any other single cause, and ergonomics programs and PtD have been effective in reducing these risks in other industries.
CHAPTER 5
HEALTH AND SAFETY PROGRAM METRICS AND DRIVERS

Success in health and safety programs has traditionally been measured in terms of injury rates. Injury rates are lagging indicators reflecting accidents that have already occurred. Lagging indicators may provide good feedback about frequent injuries, but are not well-suited for assessing risk of severe or high loss incidents that may be rare events. However, a number of leading performance metrics have been developed to gauge safety program effectiveness without waiting for accident experience data. These metrics (such as training test scores) have been demonstrated to be predictive in many other domains.

Safety and health program metrics may be used for the following purposes:

- Report status of a parameter, such as injury experience or participation level
- Track progress and trends, perhaps to adjust resource allocations
- Evaluate performance of program initiatives or personnel
- Drive change and improvement.

Some water utilities use safety program metrics for all of these purposes, while others only collect data for purposes of government or loss reporting.

USE OF METRICS TO ASSESS INJURY EXPERIENCE

Organizations participating in the study were asked to identify metrics used in their health and safety programs for various purposes. To assess injury experience, the most frequently used metrics were:

- OSHA recordable rate - 85% (17 of 20)
- Days away from work - 80% (16 of 20)
- Days of lost time or restricted duty - 80% (16 of 20).

First aid case rates, days without injuries, and workers compensation loss experience were used the least (15%, 30% and 30%, respectively). The number of injury statistics collected within any reporting water utility ranged from zero to thirteen. Some utilities also collected data on vehicle related accidents. These data typically provided status and perhaps trend information, but otherwise have limited usefulness.

ASSESSMENT OF PROGRAM ACTIVITIES

To assess whether leading indicators based on program activities were also being used, participating utilities were presented with a list of 33 additional statistics drawn from programs in general industry, and asked to identify those used by their utility. Internal safety audits were used by 16 of 20 responding utilities (80%), but the only other metrics employed by more than half of the respondents were: employee surveys of safety culture and attitudes (55%), emergency drill response assessments(55%), knowledge or skill based testing (65%) and percent of employees trained (60%).
Metrics associated with PtD on capital projects were among the least used (5%). If the old adage, “What gets measured, gets done” is true, then it is apparent that such metrics need to be implemented to help drive the PtD processes.

USE OF SAFETY METRICS IN PERSONAL PERFORMANCE EVALUATIONS

One method for elevating safety awareness and encouraging a commitment to promote a safe workplace is to include health and safety in individual performance assessments. 61% (11 of 18) of questionnaire respondents indicated that safety was included in personal performance assessments at their utility. Among the utilities that do include safety, about one third include such an assessment for all positions, and about one third use safety as performance criteria only for management positions. This suggests that future research might investigate the correlation between individual performance assessment criteria and organizational accident experience.

Individual performance metrics for safety are frequently based on incidence rates. Other criteria reported by respondents included:

- Housekeeping
- Compliance with policies, procedures, and rules
- Number of safety meetings, inspections, etc. conducted or attended
- Knowledge of safety policies and rules.

None of the respondents reported that engineers or others are held accountable on performance evaluations for conducting design reviews or other PtD activities.

Since individual performance assessments normally include a number of parameters, participating organizations were asked to identify the weighting that safety ratings were given on overall performance ratings or bonuses for key management personnel. Ten utilities responded, yielding an admittedly small sample size. For safety leaders, the mean percentage of emphasis was about 18%, with a range from 0% to 85%. For Operations or Plant Managers, the mean weighting percentage was 12%, and 10% for shift supervisors. When included, the mean performance weighting for safety among engineering managers was only 9%, and follow-up interviews with engineers revealed that their safety evaluations often reflected whether or not they themselves were injured, and not the safety of systems they designed for others.

METRICS TO DRIVE SAFETY AND HEALTH PROGRAM CHANGES

To improve understanding of safety program drivers, study participants were asked about metrics used specifically to evaluate safety program initiatives. 71% (12 of 17) respondents indicated that they attempt to evaluate the effectiveness of program initiatives, and over half of these organizations use objective evaluations. The types of responses indicating how effectiveness is evaluated included:

- Direct feedback, interviews, comments and reviews of initiatives
- Comparison of pre- and post-intervention injury/incident rates
- Employee acceptance
- Audits and employee observations.
The greatest value of metrics in an organization is to drive change and improvement. By far, the most frequently cited metrics driving change in safety and health programs involved injury/accident statistics and trends in some form. This raises the question as to whether accidents and injuries are being attributed to process and facility design features, since PtD has not received much attention among many water utilities. In general, overexertion and other ergonomic injuries often have an underlying design component as a root cause. Additional research on this question is needed.

One of the primary metrics of safety performance used in general industry was notably absent from lists provided by the participating utilities. That measure is cost. In discussions during both workshops and case study interviews, the researchers attempted to learn if incident costs were drivers. With only a few exceptions, water utilities reported that while cost data such as Workers Compensation dollars were interesting, they really did not drive decisions within their organization when it came to safety. This probably explains why cost/benefit analysis is rarely used to justify projects and initiatives. Since organizations often did not gather or maintain cost data on a case by case basis, attempts to collect the necessary data to support development of a direct/indirect cost ratio for the industry were frustrated. Further, without either the data or a driver for developing a model cost/benefit process, the researchers concluded that further study of cost based metrics was of limited value.

ADDITIONAL KEY FINDINGS ABOUT METRICS IN WATER UTILITIES

The lack of interest in costs led to the question being raised in the first workshop, “If cost is not a major driver in your organization, then what business ‘currency’ is a driver?” During one of the case studies, an astute manager informed us that what really mattered in his organization was head count or ‘wrench time’. That is, since he had to justify the number of workers, what affected his operation was having workers injured and not available to work. This cut into his ability to conduct preventive maintenance, deliver system upgrades, respond effectively to outages, and thereby affect system reliability. Further discussion at the second workshop confirmed that availability of maintenance/service hours is indeed a primary driver among most water utilities. This suggests that future research may need to consider cost/benefit concepts using labor hours instead of dollars. This would involve more complex data collection and model development than needed for traditional cost/benefit analysis.

Although there was considerable interest expressed among study participants in leading indicators, traditional lagging indicators such as injury statistics still predominate. It was found that comparisons of injury frequency rates among water utilities need to be performed with some caution, as there appeared to be significant reporting artifacts. Recording criteria and return-to-work policies vary widely among utilities. Environmental factors affecting these differences include whether or not the organization is regulated by OSHA, whether the organization distinguishes between preventable and not-preventable accidents, and policies related to Family & Medical Leave Act and return-to-work.
SAFETY & HEALTH BEST PRACTICES FOR WATER UTILITY MANAGEMENT OPERATIONS AND PREVENTION-THROUGH-DESIGN (PTD)

Based on our work with water utility managers and safety professionals, the research team is confident that water utilities can achieve notable improvement in safety performance, but this will require improvements in safety and health (S&H) program commitment and execution. As endorsed by Project stakeholders many times throughout the evolution of Water Research Foundation Project 3104 “Integrating Worker Health and Safety into Water Utility Operations, Management and New Facility Design”, this project’s overarching goal is to provide water utility managers with best practices for managing health and safety. Rather than simply describing best practices, the research team wanted to present tools and guidance that could be used by utility managers to develop and execute strategic plans. These tools and strategies can also be applied at a tactical level to guide initiatives for achieving and sustaining S&H program excellence.

THE CONTINUUM OF WATER UTILITY SAFETY AND HEALTH

The first step in on the path to improved safety and health performance is to assess the current skills, desires, and resources of the organization. Figure 6.1 illustrates the journey of Beaufort Jasper Water and Sewer District as it successfully navigated from the “swamp” of worker injuries and failed programs, to “excellence”. The S&H program at Beaufort Jasper has achieved 1,000,000 man hours without worker injury and has implemented exemplary practices such as root causes analysis of near miss incidences. Over the course of this project it became evident that many water utilities do not include safety and health considerations in the development of strategic plans or capital improvement plans and therefore do not take stock of the importance of safety and health performance and its improvement over time. Close examination of the events, hazard controls, and celebrations that marked milestones in the Beaufort Jasper Continuum reveal the importance of leadership in initiating actions, elevating the visibility and importance of safety performance, and providing the resources required to sustain continuous improvement.

As summarized in Chapters 3, 4 and 5, the water industry is faced with many challenges, among them aggressive capital improvement plans, pressure to control staffing levels, and loss of institutional knowledge due to the aging workforce. Those utilities with excellent safety and health program performance are less likely to suffer events that affect worker performance, and subsequently water quality and reliability. The following chapters present best practices for consideration by water utility managers and safety professionals as they evaluate the process to improve safety and health performance. Also presented in the following chapters are benchmarking questions that water utility managers may use to determine the status of their safety and health program relative to the Continuum illustrated in Figure 6.1. Water utilities are encouraged to benchmark against the events, hazard controls, and strategies listed in the Continuum, and to gain ideas for improving their safety program.
In addition to benchmarking questions, chapters in this Part describe best practices for the following performance parameters:

- Organizational Culture, Accountability, and Structure
- Strategies for Hazard Recognition and Mitigation
- Health & Safety Drivers/Metrics
- PtD.

In most successful organizations, senior leaders establish a structure and nurture a culture that provides the foundation for success. The most successful organizations are structured to provide stability and then resourced to achieve their goals. For employees and other stakeholders to accept those goals, they must be achievable and measurable. More importantly, the organization must provide resources for implementing systems and practices, and then hold leaders at all levels accountable for achieving those goals. This chapter discusses best practices in organizational culture, accountability and structure.

**BENCHMARKING QUESTIONS**

The following questions are intended for managers to examine their water utility’s organizational structure, culture, and accountability with respect to safety and health performance. These questions should be considered in the context of the Strategies and Controls in the Continuum presented in Figure 6.1, and with any eye toward implementing the best practices that follow.

1. Does your water utility track safety and health performance using proactive performance metrics, or does it simply count losses?
2. Do senior managers visibly demonstrate leadership and commitment to safety and health performance?
3. Are senior managers held accountable for safety and health performance?
4. Is safety and health performance considered in annual performance reviews for all managers and supervisors?
5. Are safety and health programs audited annually, and do these audits include assessments of safety practices and procedures by operations and maintenance groups?
6. Do workers or their representatives participate in the development and implementation of safety and health programs?
7. Has your water utility committed sufficient staff resources to support safety and health programs, i.e., leadership of skilled safety professional(s)?
8. Is safety and health integrated into the culture and business processes as a “Business Value”?

Observations by the research team during the case studies suggest that those water utilities able to answer affirmatively to these questions are likely to demonstrate excellent safety and health performance.
Figure 6.1 Strategies and Controls in the Continuum
The best practices described below were noted in conversations with participating water utilities and were generally confirmed during case studies. Without exception, the most important factor for achieving excellence in water utility safety and health performance was the active participation and high visibility of senior leadership in driving a safety culture. Leaders who emphasized the importance of worker safety and health in the values of the organization, who set clear S&H performance goals, who provided appropriate resources, and who held leadership accountable at all levels, led organizations that achieved excellent safety performance.

BEST PRACTICES ORGANIZATIONAL CULTURE

Safety and Health Practices are Integrated into the Culture and Business Processes as a “Business Value”

Integration of safety and health into the culture and business practices often requires an iterative approach including the following:

- Developing and Implementing “Guiding Principles” that apply to all employees, regardless of position:
  - Safety: A Core Business & Personal Value
  - All Incidents are Preventable
  - Management is Responsible & Accountable
  - Safety is a Condition of Employment
  - Management Must Audit
  - Deficiencies Must Be Corrected

- Developing and implementing safety and health roles and responsibilities for every level in the organization including Senior Leadership, Department Managers, Safety Managers, Supervisors, and employees. These roles and responsibilities should list items specific to achieving safety and health goals and should be part of performance evaluations.

Beaufort-Jasper Water and Sewer Authority and MetroVancouver have successfully implemented such programs, and incorporate high visibility and engagement by the senior managers and their direct reports. As managers at all levels become actively engaged in discussing and implementing safety activities, awareness and attention to safety and health naturally flows down to include operations and maintenance personnel.

Utility Leadership Fosters Culture Through Policies and Actions

Establishing guiding principles, roles and responsibilities are best practices that clearly define values and expectations. Specifically, it is the actions of senior leaders that reinforce and drive the culture change often required to achieve improved safety and health performance. Leaders at 3 of the 5 water utilities participating in case studies were motivated to initiate policies and actions aimed at improving safety and health performance following safety related incidents. In each case, managers at the top provided strong, visible leadership, and those utilities achieved excellence in safety and health performance.
Management and Staff take Co-operative Approach to Safety Performance

Observations from the questionnaire and case studies indicate that those utilities with active and engaged safety committees realize excellent safety performance. The most effective water utility safety committees have the following characteristics:

- Committees include representatives from management, office staff, operations and maintenance workers.
- Chairpersons are effective communicators and are often representatives of operations or maintenance workers.
- Union representatives (where applicable) are actively engaged and supportive of safety committee efforts.
- Utility managers and safety representatives support the committee by providing resources and technical support.
- Committees follow planned agendas and maintain minutes.
- Committees are consulted and involved with development and implementation of safety policies and procedures.
- Committees are briefed on accident/incident investigation findings and recommendations for future mitigation.

Safety Practices and Policies are Enforced Consistently Regardless of Position or Level

This best practice is necessary to establish that each member of the organization has roles and responsibilities for safety and health and must comply with policies and procedures. Providing exceptions to supervisors or managers at any level undermine efforts to drive change and implement effective programs.

Utility Leaders Assure that a Prevention-Through-Design (PtD) Process is Implemented for New Process Designs and Retrofit Projects

Prevention-through-Design (PtD) concepts are discussed in Chapter 9. A critical aspect of the PtD process is worker involvement in the review of water utility process and structural designs. Experienced operations and maintenance workers can often identify design attributes that compromise efficiency and increase risk. Questionnaire responses and case study observations suggest that while many utilities provide plans and specifications to workers to review on an ad hoc basis, these efforts fail. Although well-intentioned, the complexity of the plans and the lack of available time and resources preclude meaningful feedback. Best practices for PtD include design review sessions that are attended by operations and maintenance representatives with the skills required to understand engineering layout drawings, as well as by engineers and managers. Design review meetings should be facilitated by utility engineering or contract designers. Including operations and maintenance staff in facilitated design reviews is an effective means to gain buy-in for plans and improve functionality and maintainability of utility projects.
BEST PRACTICES IN ACCOUNTABILITY

Safety by Numbers – Generate and Track Metrics for Safety Goals and Activities

Water utilities typically measure performance with such metrics as utility budget, and water quality, volume, and reliability. Safety by Numbers involves setting annual goals and providing a means to track and report safety activities and metrics (See Chapter 8). Senior managers at Metro Vancouver use “Safety by Numbers” to provide data necessary for measuring progress and holding department and facility managers accountable for completing safety initiatives.

Leadership Demonstrates Commitment: Safety/Quality/Schedule

Beaufort-Jasper and Tualatin Valley have successfully implemented programs that place safety as the first priority in water utility operations: “That no job is so important that it cannot be competed safely”. Confirmation of this priority system at each level of the organization is necessary, and requires that supervisors and workers who take short cuts, or eliminate safety practices and procedures for the sake of convenience, time, or budget are disciplined.

Accountability is Based on a Balanced Scorecard

The safety metrics most frequently used to track safety and health performance are typically based on injury frequency and severity. These are lagging indicators and often do not reflect the effectiveness of the safety and health initiatives. Audits of programs and initiatives can provide more timely and objective data for assessing the effectiveness of utility leadership in driving the S&H program. Examples of leading audit metrics include:

- Compliance with utility safety and health practices (lock-out/tag-out, confined space entry, etc.).
- Manager and supervisor compliance with roles and responsibilities requirements.
- Completion of job hazard assessments for common work activities and worker understanding of job hazards.
- Use of personal protective equipment in hazardous work environments.
- Compliance with heavy equipment and vehicle practices and procedures.
- Completion of required worker training.
- Compliance of accident reporting and investigation with organization requirements.

Senior Leadership Fosters Transparency and Accountability

Providing periodic performance updates to all staff regarding safety progress toward goals often results in more engagement by the staff. The safety performance of each department should be reported at monthly/quarterly staff meetings by the most senior manager, and these reports should go to the entity that oversees the utility. Research questionnaire responses and case study observations indicate that municipality owned utilities are infrequently required to report safety performance. When this is the case, it is paramount that the most senior manager of the utility set safety performance goals for the organization, and then require each department to
follow suit. Engaging managers and supervisors in safety programs and holding them accountable for achieving goals are perhaps the most important factors in achieving excellence in safety and health performance.

**BEST PRACTICES STRUCTURE/STAFFING**

It appears that many water utilities are under-staffed at the safety function. Many large (based on AWWA utility classifications) water utilities have only one person serving in a safety leadership function. As indicated in Part II, it is apparent that water utilities lag in the hiring of safety professionals; some utilities have recently hired their first seasoned safety professional. Many utilities rely on home-grown “safety people” that do not have the formal training and experience necessary to develop and implement effective safety programs. It is also common for the person holding the safety mantle to wear many hats, rather than focusing solely on safety and health performance. Several utilities involved with this project reported significant improvement in safety performance that corresponded with the hiring of a safety professional.

**Safety Staffing Levels Based on Utility Size/Complexity**

While it is difficult to assign a ratio for safety professionals to utility employees, it is apparent that water utilities are facing growing process complexity, chemical usage, distribution areas, and regulatory requirements. In the opinion of the research team, many utilities are inadequately staffed to meet these safety related challenges. The following examples from among study participants illustrate how proper staffing can help deliver excellent safety performance.

Utility A is a medium size utility that operates a conveyance system, one water treatment plant, a distribution system (approximately 60,000 clients), a waste water collection system, and employs approximately 150 personnel. This utility has recently achieved one million man hours without recordable injury. The safety staff at this utility includes a Safety Manager, training coordinator and administrative assistant.

Utility B is a medium size utility that operates a distribution system only (approximately 70,000 clients) and has approximately 80 employees. This utility has achieved OSHA SHARP program awards and demonstrates excellent safety performance. The safety staff at this utility includes a Safety Manager and an administrative assistant that is shared with another manager.

Utility C is large size utility that provides water conveyance, storage and limited treatment facilities to four municipal clients and has a staff of approximately 300. This utility has improved its safety performance from poor to excellent in approximately 5 years. The safety staff of this utility includes a Safety Director, Two Managers, a Training Coordinator, a Field Safety Specialist, and an Ergonomics professional.

**Safety Professional Qualifications and Continuing Education**

Among the utilities participating in the study, those that employ safety professionals demonstrated the best safety performance. Observations from case studies and discussions with water utility managers revealed that the most effective safety personnel are those equipped with formal safety training and experience that was often gained from prior employment in general industry. Utilities that have recruited safety personnel with professional credentials and who are
active in the safety community, have found that those professionals are effective in gaining the confidence of managers and workers, are able to tailor programs and initiatives to fit the organizational culture, and are most likely to succeed in improving safety performance. To recruit and retain skilled safety professionals, it is important for the organization to provide opportunities for professional development, such as encouraging certification and continuing education.

Safety Culture and Safety Fundamentals Training for Water Utility Managers

To effectively manage safety and health performance, managers and supervisors at all levels must understand the basic components of a comprehensive safety program. This best practice calls for managers and supervisors to receive awareness level training on safety and health standards, utility safety policies and injury prevention programs, and their responsibilities for supporting safety initiatives. Managers need knowledge, skills and tools for recognizing unsafe activities and conditions, as well as strategies for intervention, coaching and leadership.

Prevention-through-Design (PtD) Training for Managers, Operations, Maintenance and Safety Professionals

Stakeholders in the PtD process need to understand the process and their roles. They also need the skills (such as the ability to understand layout prints) to be able to interact and effectively provide input. Managers need to understand the benefits of a properly executed PtD process and appreciate the need for their leadership in driving and supporting it. PtD is more fully discussed in Chapter 9.
CHAPTER 7
PREVALENT AND BEST PRACTICES IN SAFETY PROGRAM MANAGEMENT

The previous chapter discussed best practices that provide an environment for safety to flourish. This chapter presents best practices in the actual systems and programs that may be used to manage safety in water utilities. Organizations that demonstrate excellence in safety performance manage worker safety and health as a mission critical business system; i.e., safety management is integrated with other business management systems. As water utilities work to develop or improve a safety management program, the following domains should be carefully considered:

- Program Management Strategy, Leadership & Staffing
- Procured Services, Processes and Equipment
- Incident/Accident Management
- Training
- Technology Considerations

BENCHMARKING QUESTIONS

The following questions are intended to assist with safety program assessment, goal setting, and consideration of strategies and tactics. These questions may be considered concurrently with the Strategies and Controls in the Chapter 6 Continuum.

1. Does your organization’s safety management program include clear policies and goals, employee participation, management review, and defined processes for planning, implementing, evaluating, program initiatives and corrective actions?
2. Does your organization set annual goals for safety performance and program achievements?
3. Do safety goals seek continuous performance and include a plan to achieve it?
4. Is each utility department or business unit knowledgeable of its roles and responsibilities under the program?
5. Are incidents/accidents investigated and analyzed in detail, and are findings used to develop corrective actions that prevent recurrence?
6. Does your utility consider safety and health performance of contractors and equipment/service suppliers?
7. Is your utility’s safety training program effective in preventing incidents/accidents and does training emphasis change with new information?
8. Have you initiated an audit or safety culture assessment to evaluate safety program management?

Experience and observations from the case studies suggested to the research team that water utilities answering affirmatively to most or all of the questions were ready to consider implementing more sophisticated safety management systems. A more iterative approach may be appropriate for most other water utilities.
Best Practices in Safety Program Management

This section provides an overview of various best practice strategies for safety program management.

Management Systems

Water utilities seeking to improve safety management should consider the benefits of a safety and health management system such as American National Standards Institute (ANSI) Z10-2005, *Occupational Health and Safety Management Systems*, or work toward certification under the OSHA Voluntary Protection Program (VPP) as a “Star” site. Basic elements of management systems such as ANSI Z10 include management leadership, risk assessment and mitigation, employee participation, planning, implementation, program evaluation (audit), corrective action and management review.

- **Management System Benefits:**
  - Regulatory requirements may be satisfied and some protections against OSHA enforcement actions (both federally and in state plan states) may be realized.
  - Insurance companies encourage implementation of safety and health management systems and may offer reduced liability and workers’ compensation premiums.
  - Management system metrics facilitate performance tracking and support adjustments in emphasis and approach.
  - Metrics are used to assess manager performance and accountability.
  - Reduced frequency and severity of incidents and injuries are often realized.

- **Management System Drawbacks:**
  - Many organizations find that the level of documentation and planning required by most management systems to be burdensome.
  - Organizations often find the need to increase safety and health staffing levels to meet documentation, monitoring and audit requirements.
  - Organizations with excellent safety performance may find incremental improvements in safety performance inadequate to justify additional documentation and staffing requirements.

Experience gained over the course of this study suggests an iterative approach focused on fundamentals of safety management is likely to be effective for most water utilities, and perhaps more aligned with existing business processes than a formal management system. The remainder of this chapter presents best practices that demonstrate leadership, drive safety culture, and provide tools for improving safety performance. These practices also support implementation of a Safety Management System.

Proactive Approach verses Reactive Mode

Many of the water utilities that participated in this study had safety programs that simply focused on compliance with federal and state occupational safety and health regulations. Utilities often struggle to gain participation by workers and their immediate supervisors in pre-job work planning, hazard assessment and mitigation activities. The most successful programs exhibit a
culture with safety as a top priority, and support the culture with policies and procedures that require hazard assessment and mitigation planning for all projects, daily work activities, and tasks.

For example, Beaufort Jasper Water and Sewer District implemented a Job Safety Analysis (JSA) program called “Take Two for Safety”. This program focuses on hazard identification prior to beginning tasks by evaluating the relationship between the worker, the task, the tools, and the work environment. The concept encourages workers and their supervisors to think through job tasks at the beginning of the workday, or prior to beginning work. Figure 7.1 presents the BJWSA Field Job Safety Analysis form. Take Two for Safety is backed by a policy that identifies roles and responsibilities of supervisors and managers. It requires supervisors to develop and submit JSA’s for all tasks in their area of responsibility, train all new employees on these JSA’s and accompanying standard operating procedures, and review the JSA’s with all employees annually.

A best practice such as Take Two for Safety stands in contrast to programs that do not emphasize pre-planning, do not provide tools and structure (such as a JSA form) for such planning, do not hold supervisors accountable for pre-planning, and do not hold workers accountable for following safe work practices. Water utility safety programs like the latter tend to operate in a reactive mode, with work crews and their supervisors focusing on task completion, rather than on safe task completion. Comparatively little attention is paid to hazard assessment and mitigation.

Best Practices for Use and Reliance on Metrics to Drive Safety Process Improvement

As indicated in Chapter 5, success in health and safety programs has traditionally been measured in terms of injury rates, which by definition are lagging indicators reflecting accidents that have already occurred. A best practice for driving safety process improvement is use a balance of both lagging indicators (e.g., injury rates) and leading indicators (e.g., completion of Job Safety Analysis). A Balanced Scorecard approach of various forms was used by two of the participating utilities. Scorecard metrics were generally based on the following:

- Lagging Indicators
  - Recordable Injury Rate
  - Days Away From Work or Injury Severity Rates
- Leading Indicators
  - Direct feedback, interviews, comments and reviews of initiatives
  - Effective Use of Job Hazard Assessment Tools
  - Employee Training
  - Employee acceptance and implementation of safety initiatives
  - Audits and employee observations.
Figure 7.1 BJWSA Field Job Safety Analysis
Cost of accidents and injuries is a primary safety performance metric used in general industry. Accident cost was notably absent as a metric for water utilities. With only a few exceptions, water utilities reported that cost data such as workers compensation costs and other direct costs of injuries/incidents were not tracked. Instead, it was revealed during case study interviews that a comparable driver for water utilities was ‘wrench time’. Since most utilities have to justify the number of workers, what affects water operations is having workers injured and not available to work. Hence, availability of maintenance/service hours is a primary driver among most water utilities.

Other than AWWA Safety Committee awards, water utilities do very little safety related benchmarking with other utilities. As was noted by virtually all utilities participating in the study, the opportunity to discuss safety program performance with other water utilities, discovering best practices, and learning new metrics for leading indicators were the most valuable benefits of project participation. Annual or bi-annual benchmarking of safety program initiatives should be considered a best practice and would provide significant benefit.

Best Practices in Employee Involvement and Process Ownership

A best practice for employee involvement in water utilities is the establishment of active Safety Committees comprised of management and work force representatives. Chapter 6, Best Practices in Organizational Culture provides a description of the characteristics of highly functioning safety committees. Other best practices for employee involvement and process ownership include the following:

- Employee training and involvement in the development of Job Hazard Assessments and Standard Operating Procedures.
- Employee involvement in PtD reviews of new and retrofit processes and facilities.
- Recognition of managers and employees who demonstrate their commitment to workplace safety through leadership in recognizing and mitigating hazards. Recognition should include public acknowledgment and if appropriate, awards of value.
- Open communication channels to encourage employee suggestions and comments regarding potential hazards, unsafe actions, and questions about existing policies and procedures. Such channels should include a mechanism for acknowledging receipt, and may include an anonymous toll-free phone line, web site entries, etc.

Best Practices in Procured Services, Processes & Equipment

Water utilities are dynamic, with new processes, equipment and contractors frequently present. Unfortunately, the questionnaire and case study data indicate safety professionals are typically not involved in equipment and/or contractor selection, and that contractor safety performance is rarely a criteria for selection. This condition frequently results in avoidable hazard exposures.

Similarly, characteristics that affect the safety of operating and maintaining processes or equipment are typically given little consideration, and are frequently not adequately addressed in design specifications. One important factor that frustrates integration of safety in procurement is policies requiring acceptance of lowest bids for equipment, processes and service contracts.
Best practices for considering safety in procurement are as follows:

- **Involvement of safety and health professionals in capital projects and procurement of contract services and equipment** – Chapter 8 discusses the importance of PtD processes, including the involvement of safety professionals in the procurement process.

- **Placement of safety performance criteria in specifications for equipment and in contract documents** – This is especially important for utilities with procurement policies that require accepting low bids. Appendix D presents best practices in hazard mitigation for PtD. The examples and questions for the design of systems also suggest safety performance criteria that can be used in specifications.

- **Safety considerations in constructability and maintainability reviews** – As mentioned above, a PtD process can provide a mechanism for developing constructability and maintainability safety criteria for project contract documents.

- **Safety considerations in acceptance inspections** – Best practices include involving personnel with specific safety assurance responsibilities in acceptance inspections. Personnel assigned this task need not be safety professionals but should understand the operations and maintenance requirements for the equipment.

- **Health and safety control over Personal Protective Equipment (PPE) specification, selection, and equipment ownership** – Utilities are often underserved in this regard largely due to the fact that low bid requirements result in purchase of PPE that is not comfortable or that does not perform well. One adage is clear - PPE that is not used is not protective. Best practices in this regard place the selection, specification, and if appropriate, control of PPE with the utility’s safety and health professionals. This best practice also requires that representatives of the workforce be involved in PPE selection.

### Best Practices in Accident Management

One of the most significant opportunities for improving safety and health performance is to conduct thorough accident investigations and to manage the return to work process for the injured workers. Questionnaire responses and case studies suggest that accident investigations are not as robust as perhaps they should be and that the investigation results do not adequately support corrective actions. In many cases, the return to work process does not provide for restricted (light) duty tasks. The following provides an overview of best practices in accident reporting, investigation, analysis, and case management.

#### Initial Accident Reporting

Best practice calls for workers involved in any injury incident, including first aid cases, to promptly report such incidents to their supervisor. Failure to report injuries should result in disciplinary action. Initial reporting should trigger the following prompt actions.

- The injured party should be provided first aid and if medical attention is necessary, a management representative of the utility should accompany the worker to the clinic.
• The immediate supervisor should complete an initial incident report – if indeed the injury/incident is minor, then this report can be reviewed for consideration as a near miss. If the injury requires medical attention, the initial injury is reported and a determination is made regarding work relatedness.

• Upon receiving the initial report of injury, an incident investigation should commence. This investigation should include evaluation and photographing of the work area and any tools involved, and identifying and interviewing witnesses. No efforts to establish fault or preventability should be assigned at this time.

With many utilities, the “incident investigation” process ends with the initial injury report. Best practice calls for the initial report of accident to only be the first step in the process.

**Accident Investigation**

As indicated above, the initial report of accident is intended to ensure that the worker receives appropriate medical attention, to establish work relatedness, and to collect transient information for a complete the accident investigation. Best practices in accident investigation involve a formal process that takes place within a few days of the initial report and includes the following elements.

• Incident investigation and analysis team involving worker representatives, supervisors, work area managers, senior managers, safety professional, and engineering.
• Detailed description of incident
• Process description
• Process flow diagram
• Sequence of events
• Findings (factors contributing to the incident)
• Conclusions
• Recommendations for corrective actions to mitigate and prevent recurrence.

Best practices in accident investigation include providing formal training to personnel involved in the investigation (or at least the individuals leading the session). Some utilities use a formal process such as *TapRooT®*, a root cause analysis system, to provide a structured, systematic approach for investigating incidents.

**Corrective Actions**

Best practices for presenting corrective actions include the following.

• The results of the investigation should be “sanitized” to remove names of personnel involved and avoid declarations of fault and/or discipline.
• Findings of the accident investigation and resulting corrective actions should be communicated to all members of the workforce in terms of lessons learned.
• All corrective actions should be assigned to a supervisor/manager with a required completion date and their completion formally tracked and close-out documented.
• Any findings and corrective actions that involve management and/or engineering should be formally communicated to the appropriate parties for consideration in future management actions, safety training, Job Hazard Assessment, initiatives, facility improvement or equipment procurement.

Case Management

Water utilities often offer employee benefits that include liberal leave policies. These policies compromise employers’ ability to effectively manage injury cases. Other conditions that often undermine effective case management include practices that emphasize fault-finding (determining whether employee was at fault), unwillingness to offer light-duty and early return to work programs, and employees who “game” the system without fear of discipline. The following summarizes best practices in case management.

• Ownership of employee return to work – Responsibility for case management and return to work programs varies widely among utilities. Best practice indicates that at least one party accept responsibility for returning the worker to duty as soon as possible. The employer must be actively and directly engaged in the return-to-work program, must understand the physical requirements of the regular duties to be performed, understand the physical requirements of light duty tasks, and be in a position to follow the workers progress. The concept of “wrench time” discussed above suggests that the employing department often benefits most from having the worker available for duty, and may be best positioned to drive the return to work process.

• Formal return to work programs, including use of light duty – Best practices in case management across general industry and in water utilities validate that, with few exceptions, formal return to work programs benefit all parties. Return to work programs help workers transition back into the workforce and reduce the days away from work due to injury. They also are very effective in reducing malingering. Best practice includes job analysis and documentation of physical capacity requirements for specific operations and maintenance tasks. Assessment and documentation of physical demands requirements provide help identify light duty tasks and enable physicians to release recovering workers to work that will not compromise their health. Case study data suggest that many water utilities would benefit from identifying light duty tasks and developing return to work programs.

• Professional Case Managers - Best practice includes the use of professional case managers to track and manage medical care, for assisting the worker through the system, and for keeping the employer advised of progress. Professional case managers should be aware of available light duty tasks and coordinate efforts to return the worker to the workplace as soon as feasible.

Best Practices in Training

Employee safety training is the most visible component of water utility safety programs and typically is the primary safety and health touch point for most water utility employees. Employee training is required for compliance with federal and state safety standards, and often
accounts for a very high percentage of the safety program budget. Training should not only deliver the content required to comply with regulatory standards, but promote employee understanding of the organization’s safety goals and objectives. Safety training equips workers with the knowledge and skills needed to effectively identify, assess and mitigate hazards. Many of the best practices discussed above rely on high quality employee safety communications and training to achieve success. The following paragraphs describe best practices for safety and health training.

**Training Program Development**

Best practices for training programs provide that instruction should not only address safety standards and work rules, but should be specific to the hazards and mitigation efforts employed in the field. For instance, generic confined space or trench safety training offered by a third party trainer or municipal training specialist may not be specific to water utility operations and therefore ineffective in shaping or changing behaviors during work. Best practices found in case studies indicated that water utilities should include employee or employee representatives in the development and review of training content, as this assures content relevance and fosters content ownership.

**Orientation and New Employee Training**

High quality new employee orientation training is a best practice that achieves compliance and results in better safety performance. New employee safety training and orientation should include the following content.

- Comprehensive safety training required to comply with regulatory standards;
- Review of general work rules and policies;
- Review of accident reporting policies and procedures;
- Review of job hazard assessment for tasks to be performed;
- Review of procedures for reporting hazards identified at work.

Trainees should be tested to verify understanding of the content. Testing can be verbal or written and should be documented. Many employers now use computer based training and testing to meet training needs at this level.

**Routine Worker Safety Training and Communications**

Best practices for routine training and communications include the following attributes.

- Lessons learned from near miss and injury incidents provide excellent training points and can help drive changes in work practices.
- Training programs should be topical and specific to the operations and tasks performed by the trainees.
- Repetitive and out-of-date materials should be avoided.
- Trainers should be competent in the material being presented and understand the environment in which the tasks are performed.
• Involving representatives from the workforce in delivering training provides them the opportunity to demonstrate expertise and instills credibility among co-workers.
• Photographs and videos of workers following safe work practices provides context and is an excellent means of demonstrating and recognizing excellent performance.
• Competency testing should be performed regarding all material presented. Testing can be written or verbal, but should exercise the competency of the trainee on the subject matter and be documented.

Use of Computer Based Training/Testing

Some larger facilities use computer based training and competency testing for some safety training. The following are best practices identified for computer based training.

• Metropolitan Water District (MWD) of Southern California implemented a computerized system to develop training plans for each employee. Each employee and their supervisor are required to discuss the employee’s training needs for the year and develop a training plan. The supervisor then enters training plans for subordinates into the system. The system notifies employees of available classes, allows employees to sign-up for pre-approved classes, and notifies the supervisor when the training is completed. MWD also created a leading indicator metric that tracks the completion of training plans at the employee, facility and department levels, enabling managers to easily hold supervisors and employees accountable.
• Computer based training for general work rules, items such as defensive driving, office ergonomics, and other general safety policies are efficient and effective.
• Use of web-based training for items such as concepts in emergency response and preparedness such as offered by the US Department of Homeland Security is also very effective.

Ergonomics Training

Best practices for ergonomics training in water utilities addresses three general categories, although several additional elements could be added as programs become more sophisticated. Although organizations in general industry often include facets of all three categories in their ergonomics processes, none of the water utilities involved in this study did. The training best practices presented here for water utilities are borrowed from general industry.

Office workers and control room operators should receive training on workstation set-up to help achieve “neutral” postures. Typical content for office ergonomics training includes monitor placement and adjustment, location and use of the keyboard and mouse, and proper chair adjustment. Office workers should be encouraged to move frequently to promote circulation. Guidelines for office ergonomics are available from computer manufacturers, NIOSH, and other sources. The OSHA website has an e-tool on computer workstations that may be accessed at www.osha.gov/SLTC/etools/computerworkstations/index.html. In addition, the Human Factors and Ergonomics Society has published ANSI/HFES 100-2007, Human Factors Engineering of Computer Workstations, addressing the design of workstations, furniture, and computer systems.

A second general category for ergonomics training in water utilities is material handling. This training should emphasize the proper use of mechanical lifting equipment whenever
feasible. The training should also include manual material handling based on biomechanics. Specifically, this training should direct workers to:

- Bring the load as close to the torso as possible before attempting to lift;
- Avoid twisting while lifting or lowering loads;
- Get a secure grip so that the load will not slip during movement;
- Try to avoid lifts outside of the zone between the thighs and mid-torso.

Ergonomics training for engineers is the third best practice related to ergonomics training. This training should be part of a larger PtD program, and include such topics as designing and specifying equipment for maintainability and efficient operation, strategies to facilitate safe material handling, and control design to minimize human errors.

Flexibility exercises are often mislabeled as ergonomics training. While “ergonomics” initiatives aim to fit the job to the worker, physical training and conditioning attempt to help the worker “fit” the job. Flexibility exercises warm the muscles prior to physical activity, and may reduce the risk of muscle strains. Unfortunately, scientific research has not demonstrated a strong positive relationship between such training and the reduction of injuries in the workplace.

**Safety Culture and Safety Fundamentals Training for Water Utility Managers**

To effectively manage safety and health performance, managers and supervisors at all levels must understand the basic components of a comprehensive safety program. This best practice calls for managers and supervisors to receive awareness level training on safety and health standards, utility safety policies and injury prevention programs, and techniques and responsibilities for supporting safety initiatives. Managers need knowledge, skills and tools for recognizing unsafe activities and conditions, as well as strategies for intervention, coaching and leadership. Some utilities fulfill this need by having managers and engineers participate alongside other workers in routine training sessions.
CHAPTER 8
BEST PRACTICES FOR INTEGRATING PREVENTION-THROUGH-DESIGN (PTD) INTO WATER UTILITIES

OVERVIEW

One of the primary objectives of this project was to identify Best Practices for engineering inherently safe water utility facilities, and to develop a Best Practice model for integrating safety considerations into the design of water treatment and distribution systems. As discussed earlier in this report, systematic processes for integrating safety into design are not well-established in many water utilities. The utilities visited for the case studies were selected in part because of their questionnaire responses that suggested they had Best Practices in this particular program element, and indeed, some Best practices were found. However, the research team felt that a focused discussion was needed to develop a generic model that would be suited for broad application among Water Research Foundation subscribers.

During the second participant workshop, representatives from each of the twenty participating utilities, along with members of the Project Advisory Committee, worked in small teams to develop components of a PtD model. Results from these working groups were shared and discussed by the entire group of workshop participants, with additional structure and content support provided by the researchers who had considerable experience with PtD processes in general industry. This chapter presents the resulting consensus PtD Process Model for Water Utilities. Note that throughout this discussion, “safety” refers to consideration of safety, health, ergonomic and environmental concerns, and PtD refers to prevention of loss in each of these areas.

The proposed PtD Process Model has four primary phases for integrating safety during capital project design and delivery. It also calls for the concurrent development of operating and maintenance procedures, and includes suggested metrics to help drive the process. The process phases are identified as follows:

1. Project specification and safety scoping;
2. Intermediate design review;
3. 90% review;
4. Commissioning inspection.

Each of these phases is presented in sections below.

The overall objectives for PtD processes, including the proposed Model for water utilities, are as follows:

1. Achieve safe operations by designing and constructing systems that minimize hazards during operations and maintenance. Facilities and processes that achieve very low risk levels are commonly referred to as inherently safe systems.
2. Identify hazards, risks and process improvement opportunities as early in the design process as possible to achieve the most effective and efficient elimination or reduction of risk feasible.
3. Minimize the costs of rework and retrofitting associated with correcting and mitigating hazards that could have been avoided through diligent attention to safety in design.

4. Improve the efficiency and safety of operations and maintenance by making systems easy to access and work on, and taking into account human factors/ergonomics considerations.

5. Facilitate constructability; i.e., provide for safety during construction through such techniques as pre-fabricating anchorage points for fall protection, minimization of elevated work, eliminating permit required confined spaces, etc.

6. Control total project costs, which include engineering, construction, and operation of facilities.

One important question addressed by each subgroup was, “Who should “own” or be held accountable for completing each phase of a project?” It was the consensus of the group that the same person or small leadership team needs to assume the leadership role across all levels of design in order to achieve continuity. Continuity is an important safety concern, since identified hazards and strategies must be carried from one phase to the next, along with the reasoning behind hazard prevention and mitigation decisions. This project leader needs to be responsible for implementing the PtD process, and ensure the involvement by the participating stakeholders identified for each phase. It was the recommendation of the workshop group that project ownership and leadership be assigned jointly to a person or persons with accountability to BOTH Operations AND Engineering functions.

PROJECT SPECIFICATION AND SAFETY SCOPING

Specifications for capital projects define the project scope, performance requirements, and any special constraints or needs that designers will need to know about prior to beginning design. Safety considerations should be included in the initial project specifications, both as performance requirements and special constraints. Project specifications provide a means for measuring the success (or failure) of the engineering design, and establish acceptance criteria for designs, equipment, and processes provided by external suppliers.

For water utilities, safety objectives that should be specified in the design specifications include:

- Define project manager objectives to include safety;
- Minimization of confined spaces;
- Minimize permitting requirements for confined spaces, elevated work, hot work, etc.;
- Minimize hazardous chemicals that require special handling or precautions, or the wearing of PPE;
- Minimize potential for human contact with chemicals during material handling and connecting fluid lines;
- Minimize manual material handling that poses a risk of muscle strains;
- Provide for easy access to equipment for maintenance purposes;
- Ensure materials are compatible; e.g., reduce the risk of leaks, spills, and premature failure;
- Locate critical equipment for purposes of protection and accessibility;
Control access to hazardous chemicals, processes, and equipment;
Minimize potential exposure to electrical conductors and installations;
Facilitate egress of personnel and equipment;
Define strategy for safety controls, such as locations and paths for critical functions and emergency response.

Some specific examples of features cited by the working group included:

Motorized control for valves on frequently used equipment;
Provisions for emergency / stand-by power;
Location of both interior and exterior lighting and illumination levels;
Location of plant site with respect to highways, schools, and other environmental factors;
Provisions for valves and equipment to provide ease of lockout/tag-out;
Operational and safety labeling;
Logical and obvious process flow for chemical treatment operations;
Compatible storage facilities;
Ventilation requirements, including areas frequented by personnel and those involving confined spaces;
Noise levels, both ambient and for equipment sources;
Walking/working surfaces, including access ways, ladders vs. stairs, elimination of need for fall protection, etc.;
Grading for spill containment, precipitation run-off and flood control, and providing for firm access by vehicles;
Machine guarding, such as for pump couplings and power transmission apparatus;
Paging and communication systems;
Alarms;
Site specific life safety and fire codes requirements;
How decisions affecting risk levels will be handled;
Pre-qualification safety criteria for contractors;
Requirement to evaluate and compare alternatives of comparable treatment processes with respect to safety.

Participants in Developing Project Safety Specifications

Development of safety specifications for projects requires a thorough understanding of plant operations and maintenance activities. Persons with such experience often know what attributes of existing facilities pose hazards, create inefficiencies, and require time-consuming, complex, and/or hazardous procedures. Individuals with knowledge of regulatory standards need to ensure new facilities meet existing and anticipated requirements. Listed below are the functions that workshop participants identified as important in developing safety specifications for major engineering projects, along with brief summaries of the contributions they would be expected to make.
Project Manager (PM)

The PM is the leader who assumes overall responsibility for delivering a project that meets the specifications developed during the project scoping and specification phase. He or she needs to understand the specifications, the reasoning behind them, and the criticality of each item so that appropriate priorities can be set during design and construction.

Construction Manager (CM)

The CM provides input on issues related to constructability, and gains an understanding of facility specifications so that installation errors and rework can be avoided.

Plant Manager

As the “Owner” of the completed project, the plant manager needs to understand the specifications, contribute from his or her own experience and knowledge, and hold the project and construction managers accountable for delivering the project on spec, on schedule, and on budget.

Experienced Operator(s)

It is critical that past mistakes are identified and not repeated. Operators also need to identify those aspects of their work that pose hazards, encourage unsafe short-cuts, are difficult or time-consuming to perform, or which could be improved upon in new or remodeled facilities. Operators need to identify features that would make their work safer, faster, and easier.

Experienced Maintenance Representative(s)

Much like operator, experienced maintenance personnel need to identify tasks that are difficult to perform and the facility features that inhibit efficient and safe performance of these tasks. Input is needed on facility features that would help minimize manual handling of parts, facilitate access for personnel and equipment, and provide flexibility during process upsets and emergencies.

Safety

The primary role of the safety professional is to ensure that as many hazards as possible are identified and eliminated through design, rather than allowing facilities to be built that require the organization to rely upon PPE, training, and administrative controls to mitigate hazards. The safety function needs to lead the development of safety related specifications, emphasize their importance and value, and help hold the PM and CM accountable for meeting these specifications.
Security

Maintaining public safety for drinking water requires attention to security needs that be integrated into site plans and process plant features. In addition, security often coordinates emergency response, and provisions to facilitate efficient access and communication need to be included in facility specifications.

Environmental

Due to permitting and other environmental regulatory requirements, a person with environmental compliance responsibilities needs to be involved in the specification phase to interpret standard provisions, and to properly communicate plans to authorities for approval.

Purchasing

Procurement officers need to understand the specifications so that communications and expectations can be relayed accurately to vendors. In addition, Purchasing needs to understand what items have critical quality requirements when soliciting bids so that cost cutting does not compromise safety or performance.

Public Relations / External Affairs (PR)

If facility construction or improvement projects involve public funding, then it is often helpful for the individual responsible for external affairs to have some specific knowledge of project specifications. This allows for accurate communication with the media, as well as explaining plans and costs to Boards of Directors.

Finance

Risk management is often assigned to Finance, and support from insurers regarding safety features and specifications can be very helpful. Finance also needs to be aware of safety specifications and constraints so that appropriate funds are allocated to the project and not treated as cost overruns.

Information Technology

Control systems are critical features of water utilities, and most of these features involve computer technology. IT personnel specifying control technology need to consider and specify interface designs that promote error-free operation and efficient trouble-shooting. Poor data retrieval, reporting and communication can result in high-stress process upsets that impose elevated risks on maintenance and other personnel.

Personnel involved in developing safety related project specifications need to have technical proficiency in their respective areas of responsibility as suggested above. Additional skills and potential training needs identified by workshop participants include:

- OSHA 30-hour training for engineers.
- Team building.
• Conflict resolution training.
• Project management training.
• Meeting facilitation.
• Training on roles and responsibilities of other stakeholders (cross-training).

A written commitment from senior management supporting the development and integration of safety and health specifications is often helpful in establishing expectations and accountability.

**Mechanics for Project Specification Phase**

The process used to develop safety and health related project specifications depend on organization structure, geographical locations of the process participants, and lines of communication. Face-to-face brainstorming and discussion meetings are often preferred, with e-mail and web pages or blogs also providing conduits for communication. Other project activities and elements that foster success include:

• Documented process for developing specifications and project scope.
• Field trips to similar facilities, including discussions with operations and maintenance personnel.
• Project orientation meeting for all stakeholders.
• Establishment of design guidelines.
• Maintaining an action log to document history and reasoning behind decisions.
• Specification review sign-off.
• Time line / project plan, including deadlines for submission of specifications.

**Process Barriers**

When safety is not a deeply engrained cultural value within a utility, getting safety and health project specifications developed and accepted can be problematic. The workshop team identified the following process barriers that may be encountered.

• Narrow performance metrics that do not include safety aspects.
• Aversion to single sourcing and standardization, resulting in substandard or low quality equipment that introduce increased safety risks for operations and maintenance personnel.
• Lack of safety emphasis or leadership.
• Lack of safety knowledge or resource.
• Perceived lack of time.
• Inadequate planning.
• Too many people involved.
• Lack of process ownership by the PM or other leaders with respect to safety.
Metrics and Drivers for Safety Specification and Scoping Process

Inherently safe facilities and systems begin with sound safety specifications. Two key management questions are, 1) What is the value of focusing on safety in the project specification phase?, and 2) What metrics can be used to evaluate this phase of the project?

If the utility has never experienced the value of executing a project for which safety specifications were developed at the beginning, then it may be difficult to show clear value. Two strategies are suggested to overcome this hurdle. First, collect reports of bad experiences and descriptions of existing facility features that pose risks and problems. Reports of accidents that were affected by poor accessibility, or that involved manual material handling when better facilities would have afforded mechanical lifting, or time delays associated with confined space entries for permit required confined spaces (PRCS’s) that could have been designed out, are excellent places to start. Second, take a field trip to a peer facility to gain insights from a utility that has used and benefited from safety specifications. People often do not see the need for a product or service until they see and talk with others who have benefited from it.

Clearly, the large financial payoff for including safety specifications in the project scoping and specification phase is the avoidance of retrofitting. Financial benefits also result from increased operating and maintenance efficiency, as well as reduced injury experience. Unfortunately, the cost of accidents that do not happen is often difficult for managers to accept.

To evaluate the development of safety specifications and this phase of a project, a few suggested metrics are listed below for consideration. The reader is encouraged to develop additional metrics that are meaningful and appropriate for their own organization.

- Establish goals for participation by each of the parties described earlier, and measure the level of participation.
- Set benchmark dates for specification reviews and completion, and assess whether these deadlines were met.
- Develop a checklist of topics for inclusion, such as noise levels, material handling, maintenance access, etc., and then assess whether specifications have been provided or considered for each topic. Lists appearing earlier in this section can provide a starting point for checklist development.
- Evaluation of the specifications by an experienced external safety professional, or comparison with specifications from a peer organization that has a mature PtD process.

INTERMEDIATE DESIGN REVIEW

Water utilities typically conduct a design review (or set of reviews) for engineering projects when the design work is approximately 30 – 50% complete. Given the relatively long capital delivery process required for constructing or renovating water treatment and distribution facilities, reviews at this early stage seem logical. Government permit applications must be submitted several months before construction begins. Also, large valves and complex, customized system components necessitate long vendor lead times. As a result, utilities prepare plans and submit specifications to these external entities months before designs are finalized to avoid long delays between design and construction. Attributes such as pits, vaults, tanks and other confined spaces, as well as many other features affecting O&M safety are planned by this
stage. Consequently, it is important to review safety aspects at the same time that other project features and plans are reviewed so that changes needed to meet safety specifications are minimized.

One of the subgroups at the study’s second workshop was asked to define the process for conducting intermediate design safety reviews. The work of this team was then reviewed and discussed by the larger group of workshop participants to arrive at a consensus set of attributes for this phase. The content of this section was drawn primarily from this team of experienced utility professionals.

As with all phases of the Ptd process, the overall goals of the intermediate design review are to eliminate hazards and risk during design and avoid the costs and compromised effectiveness of retrofitting. Specifically, intermediate design reviews should accomplish the following safety integration objectives.

- Review of project safety specifications from the previous phase to verify inclusion and conformance.
- Identify ergonomic issues, including tasks that will require manual material handling, forceful exertions, or involve repetitive motions.
- Identify hazards associated facility layout and features, such as:
  - Working with electrical systems.
  - Existence of plumbed eyewashes/safety showers where appropriate.
  - Access to elevated service platforms and mezzanines—stairs vs. ladders.
  - Anchorages and other features needed to accommodate elevated work and fall protection systems.
  - Accessibility to equipment for service equipment and personnel, including consideration of postures involved in maintenance activities.
  - Confined spaces, including the potential for elimination or reclassification of PRCS’s by designing them out, or incorporating stairs and ventilation systems.
  - Provide ready access to valves for operations and maintenance.
  - Traffic patterns for vehicles and pedestrians.
- Consider constructability to facilitate safe and efficient building of structures and installation of equipment.

Participants in Intermediate Design Reviews

Many of the skills needed to conduct these reviews are the same as those required to develop safety specifications for the project. As a result, the same parties identified as valuable participants in the specification and scoping phase should participate in intermediate design reviews. The workshop team and other sources have also identified a few additional resources that should be included in intermediate reviews.

Experienced Electrician

Input should be sought on routing of electrical service, features of service vaults and rooms, and details of switchgear and other components that will need to be ordered upon completion of this review. Specifications for machine and process lockout/tag-out should be reviewed prior to procurement, and electricians are often best suited to conduct this review.
Experienced Operations and Maintenance (O&M) Personnel

If experienced O&M personnel are available who have familiarity with the technology, then it is usually valuable to include them in these reviews as well. They can often spot issues associated with accessibility and traffic interferences that are not apparent to persons less familiar with day-to-day operations.

Disinterested Engineer(s)

It can be highly advantageous to have plans reviewed by experienced, disinterested engineers. That is, engineers with experience on similar projects but not assigned to the project under review are asked to provide an outside set of eyes to catch errors and opportunities that would otherwise be missed by engineers working on the project every day.

Scheduling

Project scheduling functions may become involved in the project at this phase so that they can plan procurement and delivery of parts and systems.

Since the review activity is different than project specification, some additional skills are needed. The workshop task team identified basic blueprint reading as very helpful for participants of this phase. In addition, engineers conducting the intermediate review(s) should have received training in both safety and ergonomics. O&M personnel, as well as disinterested engineers, may need training on the new processes and technologies being addressed.

Mechanics for Intermediate Design Review

It was the consensus of the study participants that this review process needs to be formal and structured. Design review meetings should follow an agenda to systematically work through the various systems and facilities. A designated facilitator and an assigned note taker should be assigned so that the PM and other participants can concentrate their full attention on the project discussion. The reasoning behind decisions should be captured and documented, if appropriate, to enhance the defensibility of actions taken in the event of a future legal challenge. Changes to specifications and variances should be identified and recorded.

It is important that all parties participate as a team, and that comments from all parties be considered a weighed by the group. Changes made after the intermediate review may involve retrofitting and high costs, so it is critical that this review be thorough and systematic. Some organizations find checklists to be of value in guiding these reviews. A little extra time in this review can yield large savings of time and money, both during construction and operations.

Process Barriers

Workshop participants, as well as other professionals experienced in design reviews, have identified several barriers that compromise the effectiveness of the Intermediate Design Review process.
• Lack of time allocated to the process.
• Labor costs associated with conducting the review.
• Lack of availability of staff, including disinterested engineers.
• Failure to invite appropriate parties to participate, or otherwise secure their involvement.
• Lack of clear design criteria, including sufficiently detailed safety specifications.
• Projects that skip the process for some reason.
• Lack of knowledge / skill in safety and ergonomics.
• Reluctance of operators and maintenance personnel to challenge engineers and other professionals.
• Lack of planning, preparation, and facilitation for the review process.

**Metrics for Intermediate Design Reviews**

Perhaps the biggest challenge in executing a PtD process is to ensure the process is followed. Project managers need to be held accountable for holding design reviews, so one metric is simply whether intermediate design reviews are held at the appropriate time in the project schedule. Project goals can include provisions for involving various stakeholders, and comparing actual participation against these goals encourages PM’s to solicit assistance with the review process. Some organizations have the disinterested engineer participating in the review process to provide a subjective assessment of the review upon its completion. Another measure is to check the discussion notes against the original set of project specifications to evaluate whether all safety related topics have been meaningfully addressed.

One unique aspect of the phased approach to PtD is that it facilitates evaluation of each phase, albeit retrospectively. The intermediate design review process is an excellent time to assess the effectiveness of the initial safety specification and scoping phase. Similarly, subsequent process phases afford senior leaders the opportunity to evaluate the effectiveness of the intermediate design review.

**90% REVIEW PROCESS**

A final systematic review of the project design needs to occur at roughly 90% of completion for design. The objectives of the 90% review are to:

• Identify and assess hazards prior to construction and installation of equipment and processes.
• Verify that changes and questions raised during the intermediate review have been appropriately addressed.
• Verify accessibility for operations and maintenance work, including access for both equipment and personnel.
• Verify specifications for tools and equipment, and ensure that Purchasing clearly understands quality needs for critical equipment and safety systems.
• Assess the design of systems critical for handling emergencies and process upsets.
• Verify compliance with regulatory and consensus standards.
• Provide input for both constructability reviews and construction manager regarding critical features to reduce installation errors that could create hazards.
• Verify control system design with respect to control locations and functionality to facilitate efficient, error-free performance during operations, and fast response during process upsets and potential emergencies.
• Minimize the cost of rework.

Participants in the 90% Review Process

The representatives participating in the study’s second workshop concluded that persons/functions involved in conducting the 90% design review should be the same as those who performed the intermediate review. Since drawings are more complete at the 90% phase, it is often possible to present a better visualization of the final design. It is very important for both experienced operations and maintenance workers to engage in the process and provide input, and when possible, 3-dimensional drawings or simulations should be provided to assist them in visualizing the planned facility. Inclusion of O&M workers and supervisors in the process at this phase promotes communication that will need to be maintained through construction and start-up, and also begins to instill a sense of ownership.

Mechanics for 90% Reviews

Preparation is critical to have a successful 90% review. Operations and maintenance personnel may need training on basic blueprint reading so that they can understand and visualize assembly and layout drawings. They may also need training on new technologies that are being introduced so that they understand the concepts of how the systems work and can sense potential hazards. Engineers need to have a solid understanding of operational safety, including facility features to accommodate such activities as elevated work, confined space entry, material handling, safety and status communication, and equipment access.

Although some organizations rely upon individual design reviews, it was the consensus of the study group that this process is most effective when reviews are conducted in face-to-face meetings. Due to the complexity of utility projects and processes, it was suggested that reviews be broken out by function; i.e., electrical, mechanical, and facility/structures. This enables skilled trades to participate in reviews relevant to their specific work and promotes discussion at sufficient depth and detail.

Complete sets of drawings for new treatment plants, and even major upgrades, can be a few inches thick. It is virtually impossible and not necessary to review each of the hundreds of drawings. 90% design reviews are most efficiently conducted when the PM carefully selects a few comprehensive layout and assembly drawings and P&IDs for explaining the project and for use by the review team as working documents. It is advisable to keep a full set of drawings available for reference, should the need arise to answer detailed questions.

A suggested format for a 90% design safety review meeting is to begin with the PM reviewing the overall design with the assembled team. A checklist may then be used to systematically check for potential hazards and safety concerns.

Another approach for a review meeting agenda is to progress through the design geographically (or by system), and for each area, answering questions such as the following:
• What energy sources are present, and what controls are in place to prevent the unintended or uncontrolled release of energy?
• What forms of energy could personnel potentially come in contact with or be exposed to, and what provisions have been made to protect these personnel?
• How can systems be accessed by service equipment and maintenance personnel?
• What provisions have been made to accommodate elevated work or confined space entries, if these activities cannot be eliminated altogether?
• How will process upsets and emergency response activities be handled?
• What materials and equipment will need to be moved or handled during operations and maintenance activities, and what provisions have been made to reduce risks associated with manual material handling?
• How will moving parts and energized systems be safeguarded?
• How will emergency shut-down and lock-out / tag-out be performed?
• What will be the effects of chemical spills or discharges, and how will risk and damage be mitigated?
• How will weather, earthquakes, and other uncontrolled environmental conditions affect operations, maintenance, and worker safety?
• Are any special provisions needed to accommodate security?

It should be noted that this list is not complete and is only intended to exemplify some of the types of questions that need to be discussed and finalized before completion of the 90% review process.

It is recommended that an independent note taker, and perhaps a meeting facilitator, be assigned to assist with review meetings so that PMs and participants can concentrate on discussion content rather than meeting logistics.

Process Barriers

The participating utilities identified several important barriers that can compromise the effectiveness of the 90% design review process. Time constraints, primarily caused by inadequate planning and dedication to the review process, can undermine the entire review. As indicated above, it is critical that adequate time be spent in preparing stakeholders and materials for the 90% review. Meeting time needs to be allocated and included in the project scheduling, both by the PM and by review participants. Thorough design review meetings can range from a few hours for simple system upgrades, to a few days for new treatment plants. Although this expenditure of time may be viewed as burdensome by some, it is rare for this investment not to pay off with significant dividends through avoided rework, expedited construction, and dramatically improved operability.

When utility improvements involve new technology, lack of familiarity can result in potential hazards being overlooked or under-appreciated during reviews. Learning from peer organizations and system vendors is most valuable when undertaken prior to project planning and design. For a 90% design review to be most effective, operations and maintenance personnel involved in the review process need to be given the opportunity to become familiar with the technology and perhaps communicate with peers from other utilities.

Project organization and responsibility assignments can frustrate the design review process. If the design engineers are from a different organization than the PM, then information
transfer between the PM and the design professionals may be incomplete. Valuable insights and concerns raised during the previous project phases may have been lost, only to resurface during the 90% reviews. When this occurs, significant costs of re-engineering may be incurred, and the subsequent engineering corrections may be less efficient in risk elimination than if the designer had addressed the need originally. Unfortunately, these costs are often viewed by the PM and designers as overruns caused by “safety”, rather than accepting them as resulting from incomplete engineering work.

Another potential organizational issue is lack of project ownership on the part of the design engineer. If the design engineer has not had the opportunity to provide input during the specification phase, then there may not be an appreciation for the reasoning behind many of the detailed specifications. Safety priorities can be demoted if the PM fails to communicate their importance, resulting in failure to take full advantage of opportunities to eliminate hazards and risks through design.

If the PM and/or design engineer are outside service providers, communications are often less frequent and less fruitful than if these key personnel had day-to-day contact and established relationships with operators, supervisors, and other utility personnel. When planning reviews, the PM may incorrectly assume that the appropriate stakeholders are involved and invited to the review meetings, only to find out afterward that key input is missing. This can result in delays, supplementary review meetings, and compromised review quality.

**Metrics for 90% Reviews**

Metrics and drivers for 90% reviews can be exactly the same as for intermediate reviews. Assessments of participation, verification that review meetings occur, and evaluation by participating disinterested engineers can be used. Feedback forms can be completed by participants to gain subjective process assessments. Just as it will be apparent during the 90% review how well the intermediate review process was performed, the 90% review can be evaluated following the next phase. Poor performance in the 90% review inevitably results in long punch lists and costly rework following the commissioning inspection/review.

**COMMISSIONING INSPECTION**

For many utilities, the final phase of a capital project is the commissioning inspection, or what is sometimes called a Final Safety Walk-down or Walk-through. The commissioning inspection provides a final opportunity to identify and correct safety hazards as part of the engineering project. Once the project has been turned over to Operations, it is usually the responsibility of the facility management to correct any unresolved safety issues. Prior to this final project inspection, it is advisable for the PM, CM, Operations, Maintenance, and Safety personnel to conduct informal inspection of the facilities and equipment to ensure as many safety hazards as possible have been addressed.

The process recommended by participants in this study is for a utility to hold a scheduled team event to inspect the new or remodeled facility. The objectives identified for the commissioning inspection are as follows:

- Confirm that the safety objectives contained in the original project specifications have been met.
• Identify outstanding or residual items that need to be completed or corrected prior to start-up of full operations; i.e., punch list items.
• Verify that facilities, equipment and processes will facilitate safe operation and maintenance, and that they comply with utility safety standards and policies.
• Coordinate safety procedures for start-up with contractors who may be completing punch list items.
• Verify that issues identified during the intermediate and 90% design reviews have been completed and that residual risk has been minimized.
• Identify additional training needs for operations and maintenance personnel that were not previously identified in preparations for operations.
• Evaluate overall process for integrating safety into design, including the effectiveness of the specification and design review processes.
• Evaluate performance of the PM, CM, design engineers, and contractors to deliver inherently safe systems.

Participants in the Commissioning Inspection

As previously stated, commissioning inspections should be team events. Utilities participating in this study recommended the following functions or individuals as team members.

• Operations and maintenance field personnel who will be expected to work with the systems, or who have experience with similar systems.
• Project Manager
• Plant Engineer (if different than the PM)
• Utility Plant Manager
• Construction Manager
• Site Superintendent (if different than the CM)
• Local Safety/Environmental manager/coordinator.

The skills needed for effective participation on commissioning inspections differ somewhat from those needed in earlier project phases. During these inspections, it is important for the team to focus on asking “What if?” type questions, so attention to detail and the ability to visualize activities involved in operating and maintaining equipment are critical. Although it may be helpful to be able to read layout drawings, this skill is less important during this phase since the actual equipment and facilities are already present. Training and familiarization with equipment and material handling processes are helpful. In some situations, the ability to resolve conflicts and negotiate settlements may be needed.

Mechanics for Commissioning Inspections

As with the 90% review, preparation for the commissioning inspection often determines how smoothly it goes. As projects near completion, stakeholders need to be kept abreast of progress. It is usually helpful to encourage selected operators, maintenance personnel, supervisors, and safety coordinators to conduct preliminary inspections during the weeks before the final commissioning inspection. This enables the PM and CM to identify and address issues proactively and reduce the items generated during the final inspection. Some of the utilities
participating in this study suggested use of a WEB page and e-mail to keep stakeholder informed of the project status, and to post drawings, meeting minutes, preliminary inspection notes, and other files.

Commissioning inspections can be conducted in geographical or system segments, or conducted as a comprehensive inspection event. With the former approach, the PM or CM defines part of the overall project to be inspected, and invites personnel most experienced and capable of assessing that part to participate. Completion of all component parts or systems is accepted in lieu of a comprehensive inspection. This piecemeal approach works well for large, complex systems where specialized expertise is needed.

The alternative approach is to gather a team with broad experience, and then systematically walk through all of the new facility or process. This method often involves a larger inspection team. Total labor spent on the inspection is typically less, and the inspection may be less thorough than with the segmented approach, even though more eyes inspect each system component.

Whether the commission inspection is conducted as a single event or segmented, the recommended process is similar. The PM or CM assembles the team in a conference room and reviews key items discussed during the 90% review as needing attention. The scope of the inspection is defined, and any logistics and safety concerns associated with walking the construction site are addressed. If the team members are unfamiliar with the process, it is suggested that the safety representative review some common hazards that might be found. One suggestion is to encourage team members to look at each piece of equipment and system component, identify the energy sources present during both operations and maintenance, and then carefully review how the energy will be controlled.

Punch list notes are kept by the CM or his/her designee as the CM, safety coordinator, or plant manager leads the team through a systematic and careful inspection of all equipment and facilities within the pre-defined scope. Upon completion of the site inspection, the team reconvenes in a conference room where the notes are reviewed to verify that all items have been captured.

**Process Barriers**

The commissioning inspection can be thought of as the event where one of the key project deliverables, the safety of facilities and equipment as designed and installed, is scrutinized and hopefully accepted by the end-user. If previous project phases have been performed well, the commissioning inspection will likely go smoothly and only minor corrections and improvements will be noted. If the design reviews were not completed or were performed poorly, this final inspection is likely to raise numerous concerns that spawn contentious negotiations for retrofitting. If the PM, CM, and or Plant Manager are unwilling to confront the outstanding safety issues directly, then the commissioning inspection may never be scheduled with the appropriate personnel.

Similarly, if communication channels are not open and amicable between the utility management and the PM, CM, or contractors, the vendors and equipment manufacturers may be uncooperative and unwilling to participate in the commissioning inspections, or to address changes identified by the team without additional funding.

If the project is over-budget, the PM may be reluctant to participate in an inspection, knowing that additional punch list items are likely to be found that will require additional project
dollars. While the contract may require the PM to hold the commissioning inspection, the individuals most capable of providing input may simply not be invited to participate.

As projects near completion, the PM and CM are typically very busy trying to ensure contractors complete their work, and plant personnel are often busy preparing staff to assume operations. Time constraints and difficulty in scheduling can result in abbreviated, cursory, or even missed commissioning inspections. Sometimes it is left to the new process owner to insist these inspections be held prior to acceptance. If the utility demands completion of the commissioning inspection prior to project acceptance, then the PM and CM will be motivated to allocate the appropriate time.

Public opinion and permitting constraints may affect the timing of project completion and the beginning of operations. Occasionally, component systems may need to be started prior to completion of other systems. When this occurs, the commissioning inspection needs to be conducted as a series of inspections, and may be very difficult to conduct efficiently.

Large scale expansions and treatment facilities involving new technologies present a unique challenge for utilities. The utility may be relying heavily upon an engineering vendor to design and build the facility. In this situation, the utility may not have the internal resources to effectively participate in the commissioning inspection; i.e., personnel with sufficient knowledge and experience to be able to identify some of the potential issues that might otherwise be identified. It is suggested that consulting expertise from a third party be contracted to assist with these inspections in this situation.

Metrics for Commissioning Inspections

Two metrics that can easily be used to measure PM and CM performance are whether or not commissioning inspections are held, and the level of stakeholder participation in such inspections. Punch list items added during the inspection provides a good measure of the effectiveness of previous project phases, and also gives an indication of the thoroughness of the inspection. After the new/remodeled processes have been in operation for 3 – 12 months, it may be feasible to review maintenance work orders written to address items that should have been corrected as part of the capital project. Such work orders may be viewed as retrofitting and provide a direct measure of PtD and engineering performance. Comparing work orders against the commissioning inspection punch list also provides an easy assessment of the inspection process.

GAINING VALUE FROM A PTD PROCESS

Prevention through Design processes can provide significant value to organizations. Unfortunately, it is difficult to demonstrate value through traditional accounting practices, since it is impossible to know the costs of accidents or rework that are avoided. Organizations that have successful PtD processes have reported very low incident rates on new systems, and have also noted much smoother start-ups than experienced on similar projects prior to implementing PtD. Maintainability and operating efficiency are obvious gains for supervisors, but again, these are difficult to account for in direct dollar savings.

There are also some intangible, but very real benefits that PtD processes deliver. Many organizations actively promote participation by junior and newly assigned engineers in specification writing, design reviews, and commission inspections. These activities provide
exceptional learning opportunities. Much of the information discussed in these activities draws out the experience from older workers, thereby enabling the organization to instill this “corporate memory” in its next generation of engineers. Retaining corporate memory and experience was one of the biggest concerns among utilities participating in this study.

Another benefit of PtD processes is the potential legal protection they may provide. Following a systematic PtD process is strong evidence that the organization has been diligent in identifying and assessing risks. While it is impossible to eliminate all risk, following PtD processes demonstrates corporate responsibility and the exercise of due care.
CHAPTER 9
NEW PROGRAM INITIATIVES AND DIRECTIONS NEEDED TO IMPROVE AND ADDRESS NEW TECHNOLOGIES

LOOKING FORWARD - RECOMMENDATIONS FOR NEW PROGRAM INITIATIVES AND RESEARCH

Chapters 9 and 10 discuss emerging technologies, and evolving business conditions, their potential effect on water utilities, programmatic responses, and recommendations for future research to address those challenges.

One objective of this research was to evaluate the impact of emerging technologies and evolving business conditions on safety and health performance at water utilities. This chapter summarizes information regarding emerging technologies and evolving business conditions, their potential effect on water utilities, and potential programmatic responses. This information was compiled from questionnaire responses, and from discussions with water utility managers, workers and safety professionals during the case studies and workshops.

Table 9.1 lists emerging technologies and evolving business conditions that participating utilities identified as likely to drive change. These technologies and business conditions present both threats and opportunities for water utility safety performance, and the effectiveness of safety program management may depend on the industry’s ability to adapt.

<table>
<thead>
<tr>
<th>Water Treatment Technologies</th>
<th>General Technologies</th>
<th>Evolving Business Conditions</th>
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<tbody>
<tr>
<td>Membrane filtration</td>
<td>Nanotechnology</td>
<td>Aging workforce and turnover</td>
</tr>
<tr>
<td>UV disinfection</td>
<td>Renewable energy sources</td>
<td>Large need to replace existing water facilities</td>
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<tr>
<td>Sodium hypochlorite</td>
<td>Demands for water conservation</td>
<td>Increased demand for water</td>
</tr>
<tr>
<td>Energy recovery</td>
<td>Energy efficiency</td>
<td>Likely reduction in available supply</td>
</tr>
<tr>
<td></td>
<td>• Pumping stations</td>
<td></td>
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<tr>
<td></td>
<td>• Vehicles</td>
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</tr>
<tr>
<td></td>
<td>• Energy recovery stations</td>
<td></td>
</tr>
<tr>
<td>Chloramination</td>
<td></td>
<td>Increased scrutiny of operations, largely due to security concerns</td>
</tr>
<tr>
<td>Ozonation</td>
<td></td>
<td>Pressure to demonstrate sustainability</td>
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<tr>
<td>Desalination</td>
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<td>Competition for certified operators</td>
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LIKELY EFFECTS ON WATER UTILITIES

To adapt to the opportunities and challenges listed above, water utilities will need to undergo significant and continuous change. Robust and sustainable safety management programs will need to be an integral part of efforts to expand functional capabilities and improve reliability. Without effective safety programs, workers will be stressed and turnover problems will be exacerbated. The following paragraphs summarize the likely organizational effects that will be realized by water utilities.
Increased Demand for Capital Spending on Infrastructure

As water utilities seek additional raw water supplies, they will need to continue to increase capital spending on infrastructure. Each new project will be accompanied by pressure to control costs, improve worker productivity, and improve reliability.

Knowledge and Experience Gaps

The technology and business conditions presented in Table 9.1 will result in knowledge and experience gaps that will need to be addressed to meet the reliability, supply, and cost constraints. Knowledge and experience gaps may include:

- Lack of familiarity with new technologies and inherent hazards.
- Inability to predict / anticipate problems due to lack of experience.
- Loss of corporate memory due to turnover:
  - Difficulty improving maintainability without experience.
  - Inability to recognize design and installation defects.

Increased Reliance on Engineering Service Vendors to Develop Technologies

This report highlights the importance for water utilities to develop a prevention–through-design process. This effort becomes even more important as utilities attempt to accommodate the effects of increased capital spending and knowledge gaps accompanying new technologies. Specific challenges/opportunities identified include:

- Dependence on specification-design-build project model.
- Limited operating experience.
- Increased capability to utilize simulation in design.

Demand for Faster Response to Service Outages

Reliability and quality are arguably the most important goals for a water utility to achieve. As service expectations rise, water utilities will be under ever increasing pressure to meet water sustainability, conservation and user demands. Water utility managers must be vigilant against exposing workers to greater hazards that might be associated with heightened service demands. Examples include the following:

- Smaller response crews required to work extended shifts during nighttime and under other more hazardous conditions
- Operations and maintenance workforce covering more shifts with fewer personnel
- Pressure to master increasingly sophisticated water treatment systems.

Sensitivity to Energy Demands

Issues such as global warming and sustainability are requiring water utilities to decrease their carbon footprint and find ways to improve energy efficiency. This comes at a time when
there will be a growing need to expand operations. Examples of operational changes are likely to include the following:

- Fleet vehicles powered by alternative fuels
- Need for increased pump and piping system efficiencies
- Increased use of energy recovery systems.

**ORGANIZATIONAL NEEDS AND NEW PROGRAM INITIATIVES TO SUPPORT IMPROVED HEALTH AND SAFETY**

Table 9.2 presents organizational needs and opportunities for dealing with emerging technologies and evolving business conditions as identified during this study.

<table>
<thead>
<tr>
<th>Organizational Need</th>
<th>New Processes/Programs</th>
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<tbody>
<tr>
<td>Capital project design and delivery process that is more robust in identifying potential safety issues and improvement opportunities early</td>
<td>Need a process for capturing experience and lessons learned from retiring employees</td>
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<tr>
<td></td>
<td>Need a process for capturing experience and lessons learned from pilot and initial installations of new technology</td>
</tr>
<tr>
<td></td>
<td>Process to organize and disseminate lessons learned to water treatment industry (AWWA role)</td>
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<tr>
<td></td>
<td>Increased use of simulation and visualization software in design</td>
</tr>
<tr>
<td>Implement Strong PtD Processes</td>
<td>Safety, rather than simply operations</td>
</tr>
<tr>
<td></td>
<td>Managing ergonomic risk factors</td>
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<tr>
<td></td>
<td>• Accommodate aging workforce and women</td>
</tr>
<tr>
<td></td>
<td>• Reduce force demands to reduce risk of acute muscle strains</td>
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<tr>
<td></td>
<td>Reducing operator and maintenance errors</td>
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<tr>
<td></td>
<td>Maintainability – design for maintenance rather than just operations</td>
</tr>
<tr>
<td></td>
<td>• Minimize downtime</td>
</tr>
<tr>
<td></td>
<td>• Minimize labor demands (headcount)</td>
</tr>
<tr>
<td></td>
<td>• Reduce injury risk</td>
</tr>
<tr>
<td></td>
<td>• Facilitate rapid leak detection and troubleshooting</td>
</tr>
<tr>
<td></td>
<td>Promoting safe work methods</td>
</tr>
<tr>
<td></td>
<td>• Facilitating vehicle access</td>
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<td></td>
<td>• Eliminate PRCS’s</td>
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<td></td>
<td>• Minimize elevated work</td>
</tr>
<tr>
<td></td>
<td>• Promote work zone safety/security</td>
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<tr>
<td></td>
<td>• Minimize manual material handling</td>
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(continued)
<table>
<thead>
<tr>
<th>Organizational Need</th>
<th>New Processes/Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Transfer</td>
<td>Use of simulation, 3-D and visualization software to enable more effective participation by non-engineers in design reviews</td>
</tr>
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<td></td>
<td>Promote information sharing by establishing mutual aid groups</td>
</tr>
<tr>
<td></td>
<td>• Organize utilities by type of technology and size, rather than simply by geography</td>
</tr>
<tr>
<td></td>
<td>• Information can be shared electronically</td>
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<tr>
<td></td>
<td>• Enables workers from peer organizations to quickly step in and assist in the event of an emergency (e.g., Portland helping out New Orleans in Katrina)</td>
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<td></td>
<td>• Potential for pooling resources to establish shared inventories of critical parts to minimize inventory costs and part acquisition time</td>
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<tr>
<td></td>
<td>• Provides opportunities for joint development of common technology-specific training resources</td>
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<tr>
<td>Improved Training</td>
<td>Safety technology training for engineers</td>
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<tr>
<td></td>
<td>Use of simulation in system design</td>
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<tr>
<td></td>
<td>Use of simulation in both operator and maintenance training</td>
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<td></td>
<td>Use of simulation to train outage response and maintain readiness</td>
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<tr>
<td></td>
<td>Use mutual aid partners to provide pre-startup training for operators and maintenance personnel</td>
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<tr>
<td></td>
<td>Develop JSA’s at peer utilities</td>
</tr>
<tr>
<td></td>
<td>• Direct sharing of JSA’s to reduce development time among similar utilities</td>
</tr>
<tr>
<td></td>
<td>• Tap experience at peer utility familiar with new technology</td>
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<tr>
<td></td>
<td>Joint development of technology-specific training resources</td>
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<td></td>
<td>Use of computer based training and testing</td>
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<td></td>
<td>Use of web training and discussion to learn new technologies faster</td>
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<tr>
<td></td>
<td>Increased role for technology vendors and AWWA</td>
</tr>
<tr>
<td></td>
<td>Joint development of technology-specific training resources</td>
</tr>
</tbody>
</table>

(continued)
### Table 9.2 (Continued)
#### Organizational Needs and Opportunities

<table>
<thead>
<tr>
<th>Organizational Need</th>
<th>New Processes/Programs</th>
</tr>
</thead>
</table>
| Develop New Technologies to Support Safety Initiatives   | Health and safety program metrics based on risk reduction  
• Get beyond the body count mentality  
• Identify or develop risk assessment tools, including ergo risk factor analysis tools  
Assess PtD process capability (i.e., ability to reliably operate in a safe manner) rather than counting process failures. Examples include:  
• % of expected design reviews held  
• # of safety related maintenance work orders on new installations  
• % of employees trained to a specified level  
• Average employee scores on knowledge tests and simulation exercises  
• Effectiveness of communication tests  
• Mean outage duration  
Material handling devices / vehicles to reduce manual material handling of equipment and parts |
CHAPTER 10
AREAS FOR FUTURE RESEARCH

During the course of this study, the research team identified several knowledge and resource gaps which if filled could benefit the water treatment industry. This chapter briefly presents five areas for future research.

MAINTAINABILITY OF NEW TECHNOLOGY

Recent developments in water treatment and conveyance technology were frequently surfaced by utility managers and engineers during interviews for this study. These new technologies are being considered by utilities planning expansions and new facilities. One vital area of concern involves the maintenance challenges posed by these technologies.

Research is needed to identify and assess maintainability issues associated with new water utility technologies, and then to develop strategies and solutions so that such systems can be safely and efficiently maintained. It is believed that there will be significant opportunities for reducing injury risk and improving maintainability for these systems, and that these opportunities can be identified through PtD processes. However, research is needed to gather data on maintenance challenges associated with these technologies, as well as solutions. These findings could then be consolidated in the form of design review checklists or similar tools and immediately applied in the design of new water facilities.

ERGONOMIC GUIDELINES FOR WATER UTILITIES

In recent years, OSHA has developed a series of industry specific “Ergonomic Guidelines”, including guidelines for the meatpacking, retail grocery, nursing home, and shipyard industries. More recently, NIOSH released an ergonomics solutions document for the construction industry. Each of the industries targeted for Guidelines by OSHA and NIOSH are underserved by professional ergonomists.

Although several ergonomic best practices were documented in conjunction with this project, many utilities do not have the expertise to evaluate or solve ergonomic issues. The research team found that there are very few professionally trained ergonomists working in the water industry, and most utilities limit ergonomic initiatives to office workers.

Research is needed to identify opportunities and solutions related to ergonomics in water utilities, and to provide these findings in an industry specific guideline. While OSHA guidelines specifically target opportunities to prevent musculoskeletal disorders, the research team recommends that a guideline document for water utilities should take a broader view. Specifically, it is suggested that guidelines for water utilities address the design and specification of office workstations, the design of control rooms and control systems to minimize operator errors, design and safe use of equipment involved in field service activities, facility design features to enhance maintainability, and material handling of treatment chemicals and maintenance equipment/parts.
PREVENTION THROUGH DESIGN BENEFIT ASSESSMENT

One of the large hurdles confronted by the research team was the lack of financial information available for conducting cost/benefit analyses. However it was learned that labor hours is effectively the metric or “currency” that gets management attention in many water utilities. It was also observed that PtD processes are either in their infancy or simply ineffective in many utilities, and that drivers are needed to support PtD process development and integration. Given that a traditional cost/benefit approach offers minimal leverage for most water utilities, alternative research approaches are needed to demonstrate the value of PtD.

It is recommended that a cost/benefit analysis be conducted of PtD for water projects, but that costs and benefits be measured in terms of labor hours, risk profiles, and financial costs if available. The model PtD process presented in Chapter 8 should be evaluated using this approach. In addition, this approach should be used to evaluate the lifecycle cost/benefit for incorporating features identified as best practices in facility design, such as the installation of stairs to avoid permit requirements for confined spaces.

BARRIERS TO PTD IMPLEMENTATION

The current study found that many utilities have difficulty integrating safety into the design of water treatment and conveyance facilities, and some of the barriers encountered by these organizations were identified in this study. Additional research is needed to clearly identify and assess conditions within organizations that affect PtD success and failure. Some of the areas that need to be studied include education and knowledge gaps, management understanding PtD processes and their value, strategies for implementation, and other factors affecting integration and sustainability.

This research would enable safety leaders in water utilities to assess their organizations and plan strategies for PtD that are compatible with their culture and management priorities. In some cases, it may also guide leaders away from spending limited resources on strategies that have a low probability of success.

SAFETY AND HEALTH PROGRAM METRICS IN WATER UTILITIES

The questionnaire in Phase 1 of this study asked respondents to identify the metrics used by their organization to assess safety program performance. A long list of potential metrics was provided to facilitate the responses. Several organizations expressed an interest in learning more about several of the metrics listed. This suggests that the industry could benefit from a study focused on program metrics. The research team suggests that this study identify metrics currently being used by water utilities, as well as metrics developed in other industries that could potentially be applied. Further, the research should examine how metrics are currently being used, whether these metrics are driving changes, and how alternative metrics might add value.
APPENDIX A
WATER RESEARCH FOUNDATION INITIAL SURVEY
QUESTIONNAIRE

Section I: Injury / Illness Experience

List information for all injuries incurred in calendar years 2003, 2004, and 2005 in the attached Table 1. (Alternatively, provide copies of OSHA 300 and all 301 documents for each of these years, along with requested case cost data. Please delete all names and SS numbers before submitting OSHA 300 logs and OSHA 301, First Report of Injury forms.)

What was the average number of employees or Full Time Equivalents (FTE’s) working at your facility during each of the past three years?
2003 ___________________    2004 ___________________   2005 _________________

What was the injury rate for off-the-job injuries incurred in each of the past three years?
2003 ___________________    2004 ___________________   2005 _________________

(Compute as follows: Off-the-job injury rate = number of injuries requiring medical attention suffered by employees / average number of employees or FTE’s)

How many days of work were lost by employees at your facility due to off-the-job injuries in each of the past three years?
2003 ___________________    2004 ___________________   2005 _________________

Section II: Inherent Risks

Briefly describe risks in your operation that could result in catastrophic loss or fatalities. Examples: Chlorine leak or system failure; fall from mobile work platform; oxygen deficient atmosphere in settling tank resulting in worker collapse during entry; terrorism; chemical spill.

What new technologies, chemicals, or process changes have you implemented within the past three years, or plan on implementing within the next three years, that pose significant health or safety risks / challenges?

Section III: Organization Structure

Which of the following statements most accurately describes the relationship between the operating unit(s) and the parent corporation or government agency?

1. Operating unit(s) function(s) independently with minimal corporate or central government oversight.
2. Operating unit(s) function(s) semi-autonomously, with support functions shared between the unit and a central or corporate office.
3. Operating unit(s) depend on a central or corporate office for most or all functions not directly involved in day-to-day operations; i.e., human resources, safety, engineering, billing, procurement, etc. are not handled by the operating unit(s).
Please complete the following responsibility matrix; indicate where primary responsibility for the various safety activities resides by placing an “X” or check in the appropriate boxes. Please do not mark more than two boxes per activity. No marks for a given activity indicates that activity is not being performed by the organization at the time of the survey.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Dedicated Safety Officer on Site</th>
<th>Corporate or Agency Health and Safety Professional</th>
<th>Unit Operating Staff or Onsite Engineering (Not a Safety Professional)</th>
<th>External Consultant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning safety program strategies</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leading program audits</td>
<td></td>
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<tr>
<td>Leading / conducting routine safety inspections</td>
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<td></td>
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<tr>
<td>Reviewing engineering work for safety concerns</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Leading safety training</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Investigating serious loss incidents</td>
<td></td>
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<tr>
<td>Managing and selecting PPE</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Providing technical safety expertise</td>
<td></td>
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</tr>
</tbody>
</table>
Who does the person with the primary responsibility for the organization’s health and safety program report to?

1. Unit Operations Manager
2. Human Resources Manager
3. Engineering Manager
4. Law / Legal Department
5. Corporate Vice-President of Environmental, Health & Safety
6. Other __________________________

Which one of the following statements most closely describes how engineering services are provided for the organization?

1. Nearly all engineering is performed internally at the operating unit.
2. Site engineer conducts small projects, with engineering on capital projects performed by a central or division engineering organization.
3. Site engineer conducts small projects, with engineering on capital projects performed by an external engineering consulting organization.
4. All engineering functions are performed by a central or division engineering organization.
5. Most engineering is outsourced, with a minimal central staff providing oversight.
6. Most engineering is outsourced, with oversight provided locally by the operating unit management staff.
7. Mix of site, central and outsourced engineering resources.

Which of the following statements describe how safety and engineering functions relate to each other within your organization? Mark all that apply.

1. Safety and engineering are separate and distinct functions.
2. The safety department and engineering organization(s) work very closely together on all capital projects.
3. Engineering personnel receive extensive training in both operational safety and also designing for safety.
4. Safety provides oversight and technical support of engineering projects.
5. Engineers participate in routine site safety meetings, but receive no specific training on how to incorporate safety in their designs and project management.
6. Safety does not receive focused attention on most engineering projects.
7. Responsibility for safe operations rests squarely on Operations, with little or no direct involvement from engineering unless requested by Operations.
8. Communications between safety personnel (or persons with safety leadership responsibility) and Engineering are limited and primarily focused on correcting existing safety problems.
9. Engineering is represented on Safety Committees.
10. Engineering attends safety meetings.
11. Person(s) responsible for leading the safety program are included in Engineering meetings when capital planning is conducted.
12. The engineering leader is also the safety program leader.
13. Safety is a Human Resource function, so there is little overlap with Engineering.
15. Engineering personnel have safety as one of their key personal performance goals.
16. Safety is typically not included in personal performance goals for engineers.
17. Engineers actively participate in investigating all serious accidents.
18. Engineers are involved in accident investigations on an as-needed basis, typically to design system changes to prevent recurrences.
19. Engineers rarely get involved in accident investigations.
20. Safety is typically considered after systems have been designed and it is time to specify guards.
21. Engineers are routinely informed of incidents that could affect employee health and safety.
22. Incident reports are occasionally shared with engineers; i.e., other than those engineers directly involved in correcting the hazard.
23. Incident reports are typically only shared with those engineers who are directly involved in correcting the hazards that resulted in the incident.

On a scale from 1 to 5, rate the level of agreement with each of the following statements, assigning a “1” if you fully agree with the statement, and “5” if the opposite is true.

1. Safety is placed above all other considerations in this organization.
2. Individual employees are treated as valued, important parts of the organization.
3. Employees feel senior management “Walks the talk” when it comes to safety.
4. The safety program in this organization is exemplary and among the best in our industry.
5. Employees openly and freely share their safety concerns.
6. Cost is seldom an issue when it comes to correcting a safety or health hazard.
7. Management views regulatory compliance as a meaningful safety goal.
8. Safety is an important component of employee performance evaluations.
9. Safety is routinely considered in the procurement process for tools, equipment, supplies and services.
10. Employees are encouraged to promptly report injuries, accidents, and near-misses.
11. Management responds quickly to correct safety issues raised by employees.
12. There is a positive working relationship between workers and management with regards to safety.
13. Employees are routinely informed of safety incidents and concerns within the organization.
14. Employees actively accept responsibility for each other’s safety.
15. Lack of training is rarely cited as the cause of an incident.
16. All employees are empowered and expected to stop work when conditions are unsafe.
17. Nearly all injuries and accidents are reported.
18. Safety is considered throughout the design process for new systems; i.e., from project specification through commissioning.
19. Safety is usually an afterthought, with hazards corrected primarily after there has been an incident.

Are employees in the operating unit(s) represented by a labor union? If so, rate the level of agreement with each of the following statements, assigning a “1” if you fully agree with the statement, and “5” if the opposite is true.

1. Management views the union as a valued partner in achieving and maintaining a safe work environment?
2. The union is supportive of management efforts to develop a positive safety culture.
3. Employees actively participate on safety committees in a constructive manner.
4. The union supports management efforts to encourage workers to follow safe practices.

Does the organization belong to a trade association, such as AWWA? Is information received via trade association publications and meetings used to enhance the safety program?

Does the organization benchmark its safety program and initiatives against its peers?

Section IV: Safety Program Initiatives

What safety program initiatives have been successfully executed within the past 3 years which are now integrated into the overall program and way your organization does business?

What safety and health program initiatives have been terminated within the past 3 years? Please provide a brief description of the primary reason(s) for terminating each initiative listed.

Please mark the box beside each of the elements and initiatives listed below that have been adopted by your organization.

1. Development of a Safety Strategic Plan or Action Plan on an annual basis.
2. Standard Operating Procedures or Job Safety Analyses for each routinely performed job or task.
3. Regularly scheduled inspections of the operation(s).
4. Safety committee(s) with non-management employee membership of 50% or more.
5. Employee involvement in incident investigations.
7. Assessment of training needs.
8. Auditing of training effectiveness.
10. Random drug testing.
11. Hearing conservation program, including annual audiograms.
12. Ergonomics team.
13. Ergonomics job analysis and/or risk factor survey.
14. Ergonomics training for engineers.
15. Safety through design training for engineers.
16. Behavior based safety program.
17. Culture Change program.
18. Design safety reviews for capital projects
19. Constructability safety reviews for new installations or renovations
20. Violence in the workplace prevention
21. Wellness and fitness program
22. Significant security system enhancements
23. Ergonomic interventions to reduce manual material handling
24. ISO 14000 or 18000 conforming management systems
25. OSHA VPPP Merit or Star program
26. Adoption of ANSI Z10 Standard
27. External third party health & safety program audit
28. Compliance assistance from OSHA

Do you have a written disciplinary policy for safety violations?
Please describe your enforcement techniques and enforcement program. *(Description should include enforcement steps, progression or schedule of disciplinary actions, common offenses, position of person responsible for enforcement program, whether discipline is frequently meted out following an injury, and comments on the effectiveness and frequency of use of discipline as a behavioral modification strategy.)*

Were employees involved in developing safety rules?
Did employees participate in the development of Safe Operating Procedures or other performance standards that define behavior and performance expectations?
What other aspects of enforcement program development were employees involved in?
What role do employees take in the execution of the enforcement program?
If employees are represented by a labor union, is the union supportive of efforts to enforce safety rules and practices?

Section V: Program Metrics

Which of the following metrics does your organization use to assess injury experience?

1. OSHA Recordable Rate
2. Lost Workday Case Rate
3. Days away from work
4. Days of lost time or restricted duty
5. First Aid Case Rate
6. Days without a recordable case
7. Days without a lost time (away from work) injury
8. Days without a restricted or lost time injury
9. Workers Compensation dollars
10. Workers Compensation claims rate (number of cases)
11. Workers Compensation experience modifier or Mod Ratio
12. Workers Compensation case rate
13. Injury trend analysis (frequency and type)
14. Injury trend analysis (type of hazard or agent)
Which of the following metrics does your organization use to assess performance of the safety program, or elements of it?

1. Injury statistics
2. Employee surveys of safety culture and attitudes
3. Behavior safety observations
4. Internal program audits
5. External or third party audits
6. Employee comfort surveys
7. Ergonomic job analyses
8. Numbers or rates of disciplinary actions
9. Training days
10. Percent of employees trained
11. Compliance scoring based on SOPS and routine site inspections
12. Number or percent of employees participating on safety committees, ergonomic teams, or in other safety program activities
13. Training program effectiveness audits
14. Percent of capital projects for which safety design reviews were conducted
15. Response time of safety work orders
16. Level or participation at safety meetings
17. Level of participation in safety slogan contests
18. Housekeeping scores
19. Dollars spent on safety projects
20. Dollars spent retrofitting guards and correcting other safety or health hazards
21. Sound level surveys
22. Number of reported near misses
23. Number of reported safety concerns
24. Knowledge or skill based testing
25. Driver scores at lift truck rodeos or qualification trials
26. Emergency drill response assessments
27. Fire safety inspection scores
28. Loss claims
29. Unplanned or unscheduled downtime
30. Off-the-job injury rate
31. Overtime or unscheduled hours due to upset conditions
32. Percent of new and re-assigned employees receiving orientation training within 48 hours (or some other specified target)
33. Percent of accident notices or hazard alerts posted within a specified period following an incident or hazard identification
34. Number of safety work orders generated during the first year of operation for a process or system
35. Others (please list or describe): _____________________
What safety and safety related metrics have been abandoned within the past three years and why?

Does your organization directly include safety metrics in personal performance assessments?

What safety metrics are used for personal performance assessments?

Who (what positions) has safety metrics included in their performance assessments?

Approximately what percentages of the following persons’ performance ratings or bonuses are based upon safety performance (if applicable)?

1. Safety Leader for the organization
2. Safety Leader for operating unit
3. Operations/Plant Manager
4. Shift Supervisor
5. Engineering Manager

Are safety metrics used as the basis for safety incentive programs? If so, what metrics?

Are safety metrics used for other purposes in your organization? If so, what purposes or how?

How is the effectiveness of safety program initiatives / changes evaluated? Are evaluations subjective or objective? What metrics, if any, are applied?

What data, metrics, or statistics have driven specific changes in your safety programs? Please describe these changes and what metrics drove each change.

Does your organization use metrics that directly measure the effectiveness or activity level of specific safety program elements? If so, have these metrics affected the execution of these program elements?

Section VI: Integration of Safety in Design

Are safety specifications or fitness-for-use requirements an integral part of capital engineering projects and planning activities? If so, for what percentage of the total number of projects?

Are safety-focused design reviews conducted on capital projects? If so, what criteria are used to determine whether a project receives such a review?

Are constructability reviews conducted prior to construction of new installations or major refurbishments? If so, is safety a major focus of these reviews?

Are safety walk-downs or commissioning inspections conducted prior to start-up of new or revised processes and equipment? If so, what percentage of projects receive such reviews?

Are Maintenance, Operations, and Engineering personnel all involved in safety design reviews? Commissioning inspections?

Does your organization have a formal, written process for integrating safety into design? If so, briefly describe this process.

Do you use safety checklists in your design and capital procurement processes?

Do you use safety software tools for including safety in designs? If so, what software?
Appendix A: Water Research Foundation Initial Survey Questionnaire

Does your organization conduct safety risk assessments for new designs, processes, and equipment? If so, briefly describe or identify the risk assessment process used.

What other technologies, methods or approaches does your organization use to ensure safety is integrated into design processes?

What other technologies, methods or approaches does your organization use to ensure safety is integrated into procurement processes?

What technologies, methods or approaches is your organization planning, developing or initiating to ensure safety is integrated into design processes?

What challenges, organizational needs, and barriers impede the effectiveness of efforts to integrate safety into design in your organization?

If applicable, what challenges, organizational needs, and barriers do you expect to encounter in executing planned or future initiatives for integrating safety into design in your organization?

Section VII: Use of Cost Data and Cost/Benefit Analysis

Does your organization track injury and/or accident costs, other than Workers Compensation and casualty insurance claims?

Are costs of safety programs and safety initiatives tracked and accounted?

What safety related cost data are collected and reported to management?

Are cost savings data collected or estimated for safety projects and initiatives?

Does your organization apply cost/benefit analysis to safety projects?

Does your organization compute indirect costs, or is a standard indirect cost factor used? If indirect costs are computed, what types of costs are typically included?

Does your organization apply an indirect cost factor when calculating the costs of accidents? If so, what ratio of indirect to direct costs is typically used? How was this ratio established? Has it gained widespread acceptance by managers?

Is cost justification applied to safety related projects? If so, what assumptions are typically made? Examples: average cost of common injuries, expected days of lost time, value of restricted duty work, cost of overtime, indirect costs, etc.

If cost justification is applied to safety projects, what hurdle rate or pay-back period is typically applied to safety projects.

Are cost savings from safety improvements routinely included along with other financial benefits in calculations used to justify capital projects?

Who (what position) determines the final cost of accidents in your organization?

Are costs of accidents reported back to the departments where they occur?
Are accident costs charged back to the operating budgets of affected departments? If so, what costs are included? (Examples: workers compensation expenditures + reserves, costs of damages + W.C. + surcharge for non-department labor incurred.)

Does either Maintenance or Engineering track costs associated with safety work orders, cost of retrofitting for safety on capital projects, cost of accident damage, etc.? If so, what costs are tracked and to whom are they reported? Whose budget pays for these costs?

**Section VIII: Ergonomics**

Do you have a formalized or written ergonomics program?

Does your organization have a trained ergonomist on staff? If so, what level and type of training has this person had?

If you have an ergonomics process, indicate which of the following elements are included:

1. Systematic method for identifying jobs with ergonomic hazards
2. Procedure or method for employees to report hazards
3. Written ergonomics policy or other evidence showing management commitment and leadership
4. Employee participation in hazard recognition and control
5. Ergonomic job hazard analysis and control
6. Employee awareness training on ergonomic risk factors and related job hazards
7. Training in job analysis and control measures
8. Training in problem solving
9. Medical management of work-related musculoskeletal disorders (WMSDs)
10. Program evaluation
11. Access to ergonomics expertise, either internally or from a consultant
12. Site ergonomic teams to identify hazards and develop controls
13. Symptom surveys
14. Evaluations of control effectiveness
15. Pre-employment screening and job placement evaluations
16. Pre-employment physical capabilities testing
17. Productivity assessments
18. Operator error analysis
19. Workstation design using ergonomic principles
20. Ergonomic design checklists
21. Other: ____________________________

If your ergonomics process is informal and integrated with your Health & Safety program, briefly describe how ergonomic concerns are identified, evaluated, and controlled.

Are ergonomics program costs tracked or accounted?

How are ergonomic concerns typically handled by your organization?

What percentage of total workers compensation costs are attributed to WMSDs (include back strains, degenerative disc disease, tendonitis, carpal tunnel syndrome, tenosynovitis, vibration syndrome, etc.)?
What percentage of workers compensation cases involve WMSDs?

What is the total OSHA recordable frequency rate for WMSD cases? \((\# \text{ of WMSD cases } \times 200,000) / \# \text{ manhours worked}\)

Does your organization estimate costs of future WMSD cases to help cost justify interventions or engineering projects?

What approaches does your organization use to estimate ergonomic costs and benefits?

Are measures of productivity used to assess benefits of ergonomic interventions?

Provide an estimate of the annual cost of your ergonomics process (program administration, labor, interventions, etc.).

What is the approximate ratio of ergonomic process cost / incurred cost of WMSDs?

What specific ergonomic projects or interventions have been successfully implemented and accepted in the past three years?

What specific ergonomic projects or interventions have been attempted but failed in the past three years?

What specific ergonomic features have been incorporated into machine or equipment design, control designs, or system specifications?

What specific workstation changes have been adopted to reduce ergonomic risk factors?

What specific ergonomic changes have been made that were aimed at improving productivity or reducing human error?

What methods, tools, and/or procedures are used to evaluate the effectiveness of ergonomic interventions or design improvements?

What ergonomic analysis software, checklists or evaluation tools are used to assist with job analysis?

**Section IX: Best Practices**

Have you benchmarked your safety program with other utility organizations?

Have you benchmarked your safety program with other water treatment organizations?

Do you have any program elements or practices that you feel are “Best Practices”? If so, briefly describe them.

Do you have any unusual or unique approaches or implementation strategies that have significantly contributed to the success of safety program elements? If so, briefly describe them.

If you use cost/benefit assessment methods, are they effective and are they widely accepted within your organization?

Briefly describe any effective cost/benefit assessment methods you have in your organization.

What safety program initiatives have had ongoing, long-term results for your organization?
Section X: Injury/Illness Case Management

Who manages injury/illness cases for your organization?

1. Internal case manager
2. Internal human resources manager
3. Safety leader for the operating unit
4. Third party case manager or administrator; i.e., consultant
5. Workers Compensation insurer

Has the person(s) responsible for managing injury/illness cases received specialized training or had extensive experience in case management?

Does your organization attempt to account the indirect or hidden costs of accidents?

If so, indicate which of the following indirect costs are included when computing the cost of incidents.

1. Supervisor and management labor involved with accident investigation and reporting
2. Labor required for spill clean-up, and associated environmental and health remediation activities
3. Overtime for replacement workers
4. Recruiting costs for new replacement workers
5. Cost of communication meetings
6. HR and case manager labor
7. Transportation costs for patient and case manager
8. Scrap or reprocessing losses resulting from the process upset
9. Scrap or extraordinary reprocessing losses resulting from inefficiency of replacement workers
10. Incremental insurance premium effects resulting from loss experience
11. Damage to equipment and process capabilities
12. Cost of schedule disruptions for maintenance personnel
13. Cost of process downtime
14. Cost of increase in absenteeism due to reduced morale
15. Cost of expediting materials needed for process recovery
16. Cost of labor and legal counsel associated with regulatory inspections and inquiries
17. Cost of media relations, including management labor

If possible, provide estimates of typical hidden costs associated with incidents that have occurred within your organization in the past three years. (Suggested format: brief description of incident, injury/loss outcome, workers compensation cost including reserve amount, estimated indirect and other hidden costs; e.g., Fall from ladder while turning valve, fractured clavicle and concussion, WC = $48,000, IC = $123,000).
Summary of Questionnaire Content

Section I: Injury / Illness Experience

- Types of injuries/illnesses incurred: Body part, acute vs. cumulative, etc.
- How they occurred: hazard type, agent, activity class
- Severity and costs
- Off the job injury experience

Section II: Inherent Risks

- Recognized risks that could result in catastrophic or serious outcomes
- New technologies, chemicals, or process changes that may pose significant risks

Section III: Organization Structure

- Organization and management structure and where various safety responsibilities reside
- Engineering function reporting structure
- Relationship between safety and engineering functions, including communications
- Emphasis on safety; management support; safety culture
- Roles of labor unions and industry associations

Section IV: Safety Program Initiatives

- Program initiatives that are successfully integrated or executed
- Program initiatives that have been terminated and why
- Safety management practices
- Enforcement techniques and program descriptions
- Level of employee involvement in enforcement program development and execution

Section V: Program Metrics

- Metrics used to assess injury experience
- Proactive metrics of prevention program elements
- Involvement/ownership metrics
- Metrics abandoned and why
- Organization use of safety related metrics
- Use of metrics to evaluate effects of program initiatives/changes
- Effectiveness of metrics in driving specific program changes or performance
Section VI: Integration of Safety in Design

- Existing technologies, methods and approaches for including safety into design
- Practices, technologies, methods and approaches being planned, developed or initiated
- Organization needs and issues, including barriers

Section VII: Use of Cost Data and Cost / Benefit Analysis

- Use of cost or savings data within the organization with respect to safety
- Use of cost/benefit analysis or cost justification
- Assessment of safety costs by operations, maintenance, and engineering

Section VIII: Ergonomics

- Ergonomics process descriptions – active program elements
- Ergonomics program costs
- Approaches for addressing ergonomic concerns
- WMSD injury frequency and severity data, including cost
- Approaches used for estimating ergonomic costs and benefits
- Specific ergonomic projects, interventions, or features incorporated

Section IX: Best Practices

- Self-reported practices that respondents view as “Best Practices”
- Effective cost/benefit assessment methods
- Safety program initiatives with ongoing, long-term results

Section X: Injury/Illness Case Management

- Recognized incident costs (hidden and accounted)
- Accounted incident costs
- Estimates of typical hidden costs associated with accidents
- Case management program organization and administration
- Disability and case management costs
Figure B.1: Distribution by body part of injuries reported by 15 water utilities for 2003-2005
Figure B.2: Distribution by injury type of injuries reported by 15 water utilities for 2003-2005
Figure B.3: Top 10 hazards identified in accident reports from 14 water utilities during 2003-2005
Figure B.4: Frequency comparison of injury types reported by 15 water utilities compared to general industry experience as reported to the Bureau of Labor Statistics (BLS)
Figure B.5: Frequency comparison of injured body parts reported by 15 water utilities compared to general industry experience as reported to the BLS.
### Table B.1

Risks identified as having the potential of resulting in catastrophic loss, fatalities or serious outcomes

<table>
<thead>
<tr>
<th>Risk identified*</th>
<th>Number of times identified</th>
<th>Percent of respondents (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confined space/hazardous atmosphere</td>
<td>14</td>
<td>73.7</td>
</tr>
<tr>
<td>Chlorine hazard</td>
<td>13</td>
<td>68.4</td>
</tr>
<tr>
<td>Vehicle/traffic-related</td>
<td>11</td>
<td>57.9</td>
</tr>
<tr>
<td>Other chemical related hazards (spills, exposure, etc.)†</td>
<td>10</td>
<td>52.6</td>
</tr>
<tr>
<td>Slips, trips and falls</td>
<td>8</td>
<td>42.1</td>
</tr>
<tr>
<td>Shoring, trenching, and/or excavation</td>
<td>7</td>
<td>36.8</td>
</tr>
<tr>
<td>Electrical/utility/energy hazard</td>
<td>7</td>
<td>36.8</td>
</tr>
<tr>
<td>Violence/terrorism</td>
<td>6</td>
<td>31.6</td>
</tr>
<tr>
<td>Other‡</td>
<td>6</td>
<td>31.6</td>
</tr>
<tr>
<td>Natural disaster or weather</td>
<td>5</td>
<td>26.3</td>
</tr>
<tr>
<td>Personnel-related</td>
<td>3</td>
<td>15.8</td>
</tr>
<tr>
<td>Contamination or system failure</td>
<td>2</td>
<td>10.5</td>
</tr>
<tr>
<td>Back/overexertion injury</td>
<td>2</td>
<td>10.5</td>
</tr>
<tr>
<td>Flooding</td>
<td>1</td>
<td>5.3</td>
</tr>
</tbody>
</table>

*Respondents limited to five identified risks.

†Various responses include: “Ferric Sulfate, Ozone, Fluoride, Lime;” “chemical spills;” “Chemical Leak and exposure;” “Chemical exposure and/or releases;” “alum/ferric chloride, polydadmac, polymer, ammonium hydroxide, sulfuric acid, sodium hydroxide, hydrogen peroxide…sodium hypochlorite…fluorsilicic acid” (sic); “Oxygen or ozone leaks could occur within the generation building. The primary risks are related to hazardous atmospheric conditions within the building;” “Caustic, Phosphoric Acid, Hydroflousilic Acid, etc.;” “Caustic, sodium hypochlorite, and Alum;” Exposures to employees working with hazardous chemicals;” and “Chlorine, sulfuric acid, aqueous ammonia, CO2, ferrous sulfate.”

‡Other” responses included: “hazards involving raw sewage;” “Possibility of the loss of public confidence from contamination events, hurricane (sic) recovery efforts, system outages, security breaches, sewage spills ,etc.;” “Injuries form (sic) power tools and equipment;” “Technical rescue needed as a result of CS Entry, trench collapse of elevated work surface rescue;” “Heavy Equipment - employees operate small equipment, loaders, rubber tire loaders, skid steer loaders, and track hoes;” and “Asbestos pipe uncovered from old water main installations.”
Table B.2
New technologies, chemicals or process changes (implemented or planned) that pose significant health or safety risks/challenges

<table>
<thead>
<tr>
<th>Technology</th>
<th>Number of times identified</th>
<th>Percent of respondents (n=15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Membrane filtration including cleaning</td>
<td>4</td>
<td>26.7</td>
</tr>
<tr>
<td>UV disinfection</td>
<td>2</td>
<td>13.3</td>
</tr>
<tr>
<td>Sodium Hypochlorite</td>
<td>2</td>
<td>13.3</td>
</tr>
<tr>
<td>Ozonation</td>
<td>2</td>
<td>13.3</td>
</tr>
<tr>
<td>Chloramination</td>
<td>2</td>
<td>13.3</td>
</tr>
<tr>
<td>None</td>
<td>2</td>
<td>13.3</td>
</tr>
<tr>
<td>Chlorine bulk delivery</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Sodium Bisulfite</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Chlorine container size</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Polymer addition</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Flocculation</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Sand filtration</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Sewage collection/distribution</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Communication</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Forced by regulation to add filtration</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Public access to reservoir sites</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Corrosion control</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Distribution system</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Fluoridation</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Polyaluminum Chloride</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Aqueous ammonia</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Increased chlorine distribution</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>Chlorine Dioxide (with H2SO4)</td>
<td>1</td>
<td>6.7</td>
</tr>
</tbody>
</table>
## Table B.3

New technologies, chemicals or process changes (implemented or planned) that are expected to substantially reduce significant employee-related health or safety risks

<table>
<thead>
<tr>
<th>Technology</th>
<th>Number of times identified</th>
<th>Percent of respondents (n=17)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General safety practices at facility improvements</td>
<td>9</td>
<td>52.9</td>
</tr>
<tr>
<td>Build new/improve existing structures</td>
<td>8</td>
<td>47.1</td>
</tr>
<tr>
<td>Chemical hazard/exposure reduction</td>
<td>7</td>
<td>41.2</td>
</tr>
<tr>
<td>Personal protection equipment</td>
<td>5</td>
<td>29.4</td>
</tr>
<tr>
<td>Air monitoring/purifying improvements</td>
<td>5</td>
<td>29.5</td>
</tr>
<tr>
<td>General equipment safety (e.g. start-up checks)</td>
<td>4</td>
<td>23.5</td>
</tr>
<tr>
<td>Training improvements</td>
<td>4</td>
<td>23.5</td>
</tr>
<tr>
<td>Sodium hypochlorite</td>
<td>4</td>
<td>23.5</td>
</tr>
<tr>
<td>Ergonomic improvement</td>
<td>3</td>
<td>17.6</td>
</tr>
<tr>
<td>Code compliance – OSHA, HazMat</td>
<td>3</td>
<td>17.6</td>
</tr>
<tr>
<td>Fire/electrical hazard prevention</td>
<td>3</td>
<td>17.6</td>
</tr>
<tr>
<td>Monitoring various gasses (O3, SO2)</td>
<td>3</td>
<td>17.6</td>
</tr>
<tr>
<td>Trenching/shoring improvements</td>
<td>2</td>
<td>11.8</td>
</tr>
<tr>
<td>Chlorine handling, storage, etc.</td>
<td>2</td>
<td>11.8</td>
</tr>
<tr>
<td>Security systems (e.g. cameras, id cards)</td>
<td>2</td>
<td>11.8</td>
</tr>
<tr>
<td>Communication</td>
<td>2</td>
<td>11.8</td>
</tr>
<tr>
<td>Driving/traffic</td>
<td>2</td>
<td>11.8</td>
</tr>
<tr>
<td>None</td>
<td>2</td>
<td>11.8</td>
</tr>
<tr>
<td>Use of ascorbic acid for dechlorination</td>
<td>1</td>
<td>5.9</td>
</tr>
<tr>
<td>Seismic rehabilitation</td>
<td>1</td>
<td>5.9</td>
</tr>
<tr>
<td>Lime feeders – switching to batch feeder that is a closed system with fewer moving parts</td>
<td>1</td>
<td>5.9</td>
</tr>
<tr>
<td>UV disinfection</td>
<td>1</td>
<td>5.9</td>
</tr>
<tr>
<td>Chloramination</td>
<td>1</td>
<td>5.9</td>
</tr>
</tbody>
</table>
### Table B.4

<table>
<thead>
<tr>
<th>Relationship between the operating unit(s) and the parent corporation or government agency with respect to staff functions, i.e. safety, HR, engineering, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating unit(s) function(s) independently with minimal central or corporate office support.</td>
</tr>
<tr>
<td>Operating unit(s) function(s) semi-autonomously, with support functions shared between the unit and a central or corporate office.</td>
</tr>
<tr>
<td>Operating unit(s) depend on a central or corporate office for most or all functions not directly involved in day-to-day operations.</td>
</tr>
</tbody>
</table>

### Table B.5

<table>
<thead>
<tr>
<th>Activity (n=20)</th>
<th>Dedicated Safety Officer on Site</th>
<th>No.</th>
<th>%*</th>
<th>Corporate or Agency Health and Safety Professional</th>
<th>No.</th>
<th>%</th>
<th>Unit Operating Staff or Onsite Engineering (Not Safety Professional)</th>
<th>No.</th>
<th>%</th>
<th>External Consultant</th>
<th>No.</th>
<th>%</th>
<th>Other</th>
<th>No.</th>
<th>%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Planning Safety Program Strategies</td>
<td>8</td>
<td>28.6</td>
<td>13</td>
<td>46.4</td>
<td>5</td>
<td>17.9</td>
<td>2</td>
<td>7.14</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2) Leading Program Audits</td>
<td>8</td>
<td>32</td>
<td>11</td>
<td>44</td>
<td>2</td>
<td>8</td>
<td>3</td>
<td>12</td>
<td>1</td>
<td>4</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) Leading/Conducting Routine Safety Inspections</td>
<td>11</td>
<td>35.5</td>
<td>8</td>
<td>25.8</td>
<td>9</td>
<td>29</td>
<td>2</td>
<td>6.45</td>
<td>1</td>
<td>3.23</td>
<td>31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4) Reviewing Engineering Work for Safety Concerns</td>
<td>4</td>
<td>16.7</td>
<td>5</td>
<td>20.8</td>
<td>9</td>
<td>37.5</td>
<td>6</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5) Leading Safety Training</td>
<td>8</td>
<td>27.6</td>
<td>11</td>
<td>37.9</td>
<td>5</td>
<td>17.2</td>
<td>4</td>
<td>13.8</td>
<td>1</td>
<td>3.45</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6) Investigating Serious Loss Incidents</td>
<td>11</td>
<td>32.4</td>
<td>13</td>
<td>38.2</td>
<td>5</td>
<td>14.7</td>
<td>1</td>
<td>2.94</td>
<td>4</td>
<td>11.8</td>
<td>34</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(7) Managing and Selecting PPE</td>
<td>12</td>
<td>36.4</td>
<td>11</td>
<td>33.3</td>
<td>8</td>
<td>24.2</td>
<td>1</td>
<td>3.03</td>
<td>1</td>
<td>3.03</td>
<td>33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8) Providing Technical Safety Expertise</td>
<td>7</td>
<td>21.9</td>
<td>15</td>
<td>46.9</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>31.3</td>
<td>0</td>
<td>0</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Percent of activity performed by each type of leadership
<table>
<thead>
<tr>
<th>Description</th>
<th>No. responding (n=18)</th>
<th>Percentage of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix of site, central and outsourced engineering resources.</td>
<td>6</td>
<td>33.3</td>
</tr>
<tr>
<td>Site engineer conducts small projects; planning reports, feasibility studies, and some preliminary design for capital projects is performed internally; and detailed/final design for capital projects is performed by an external consulting organization.</td>
<td>4</td>
<td>22.2</td>
</tr>
<tr>
<td>Most engineering is outsourced, with oversight provided locally by the operating unit management staff.</td>
<td>3</td>
<td>16.7</td>
</tr>
<tr>
<td>Site engineer conducts small projects, with engineering on capital projects performed by an external engineering consulting organization.</td>
<td>2</td>
<td>11.1</td>
</tr>
<tr>
<td>Most engineering is outsourced, with a minimal central staff providing oversight.</td>
<td>2</td>
<td>11.1</td>
</tr>
<tr>
<td>Site engineer conducts small projects, with engineering on capital projects performed by a central or division engineering organization.</td>
<td>1</td>
<td>5.6</td>
</tr>
<tr>
<td>Nearly all engineering is performed internally at the operating unit.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>All engineering functions are performed by a central or division engineering organization.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>100</td>
</tr>
</tbody>
</table>
### Table B.7
Relationship between Engineering and Safety functions as measured by agreement with characterization statements

<table>
<thead>
<tr>
<th>Description</th>
<th>No. responding (n=20)</th>
<th>Percentage of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety and engineering are separate and distinct functions.</td>
<td>16</td>
<td>80</td>
</tr>
<tr>
<td>Engineers are involved in accident investigations on an as-needed basis, typically to design system changes to prevent recurrences</td>
<td>13</td>
<td>65</td>
</tr>
<tr>
<td>Safety provides technical support for engineering projects</td>
<td>12</td>
<td>60</td>
</tr>
<tr>
<td>Engineering attends safety meetings.</td>
<td>12</td>
<td>60</td>
</tr>
<tr>
<td>Safety does not receive focused attention on most engineering projects, i.e. codes and standards are assumed to provide adequate safety protection unless a particular problem is brought to the attention of the project team.</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Engineering is represented on Safety Committees.</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Engineering personnel have safety as one of their key personal performance goals.</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Engineers are routinely informed of incidents that could affect employee health and safety.</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Communications between safety personnel (or persons with safety leadership responsibility) and Engineering are limited and primarily focused on correcting existing safety problems.</td>
<td>9</td>
<td>45</td>
</tr>
<tr>
<td>Person(s) responsible for leading the safety program are included in Engineering meetings when capital planning is conducted.</td>
<td>9</td>
<td>45</td>
</tr>
<tr>
<td>The safety department and engineering organization(s) work very closely together on all capital projects.</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>Safety is a Human Resource function, so there is little overlap with Engineering.</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>Responsibility for safe operations rests squarely on Operations, with little or no direct involvement from engineering unless requested by Operations.</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Engineers rarely get involved in accident investigations.</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Engineering personnel receive extensive training in both operational safety and also designing for safety.</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Engineers receive no specific training on how to incorporate safety in their designs and project management.</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Safety is typically not included in personal performance goals for engineers.</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Safety is typically considered after systems have been designed and it is time to specify guards.</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Incident reports are occasionally shared with engineers; i.e., other than those engineers directly involved in correcting the hazard.</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Engineering actively contributes to the development of an annual Safety Action Plan.</td>
<td>4</td>
<td>20</td>
</tr>
</tbody>
</table>

(continued)
Table B.7 (Continued)
Relationship between Engineering and Safety functions as measured by agreement with characterization statements

<table>
<thead>
<tr>
<th>Description</th>
<th>No. responding (n=20)</th>
<th>Percentage of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incident reports are typically only shared with those engineers who are directly involved in correcting the hazards that resulted in the incident.</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Safety provides oversight of engineering projects.</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>The engineering leader is also the safety program leader.</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Engineers actively participate in investigating all serious accidents.</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>
### Table B.8*

**Safety program initiatives successfully executed within the past three (3) years which are now integrated in the overall program**

<table>
<thead>
<tr>
<th>Location</th>
<th>Initiatives</th>
</tr>
</thead>
</table>
| **Beaufort – Jasper Water/Sewer Authority (SC)** | • Take Two for Safety program is an employee job hazard analysis tool that helped change our reactive safety culture to a proactive safety culture. Take Two is a program that encourages and rewards employees for taking two minutes at the front end of a job to assess the proper tools, procedures, and equipment needed to do the job safely. This program requires our contractors to participate as well.  
• Holding safety celebrations and festivals to recognize and reward employee safe behavior periodically. Employee recognition and award programs.  
• Utilizing good, leading edge safety equipment. Authorizing any employee to tagout / take out of service safety equipment or any other equipment due to unsafe state.  
• Repetitive safety training and talks to reinforce safe work procedures.  
• Constant communications about BJWSA’s commitment to safety via email articles, newspaper events, company newsletters, family safety and health magazine, safety equipment giveaways, encouraging safety off the job by allowing PPE to be used off the job.  
• Employee participation in training, communications, safety team, design reviews, pre-startup safety reviews, policy and procedure writing and review, safety talks, inspections, etc. |
| **City of Los Angeles Dept. of Power and Water (CA)** | • Automated Safety Tours Program-Joint Labor Management Program for touring work sites and addressing safety with employees. Automated to verify that open issues are being resolved and tours are being completed in a timely manner |
| **City of Minneapolis Water Treatment and Distribution Services (MN)** | • Confined space program emphasized and enforced.  
• Lock-Out/Tag-Out program emphasized and enforced.  
• Security initiatives have had effect on safety. |
| **City of Oklahoma City Water and Wastewater Utilities Department (OK)** | • Driver training Smith system  
• Water department specific safety & health policy and procedures.  
• Semi annual safety audits for facilities.  
• Developed a safety steering committee  
• Implementing a nutrition awareness program. |
| **City of Santa Monica (CA)** | • Confined Space Training Program  
• Excavation Shoring Training Program  
• Heat Stress Training Program  
• Respirator Training Program  
• Respirator / Hazard Communication Program  
• Safety Recognition Program  
• Defensive Driving - Cars, Trucks, Specialty Vehicles like backhoes and forklifts. |
| **City of Wyoming Utilities (MI)** | • Uniform, written programs with department specific addendums.  
• Quarterly reporting, by department, for injury and illnesses and workers compensation dollars.  
• Automatic External Defibrillators in all buildings with most staff trained in CPR and unit use.  
• NFPA70E Arc Flash-we started with implementing the PPE/PPA end of the guidelines using three levels of protection based on worst case for each level. Arc flash calculations will be done with a 2007 construction project.  
• Collaborative decision making with regard to safety. If employees are given the chance they hold the answers and therefore have greater buy in for their own ideas. |

(continued)
<table>
<thead>
<tr>
<th>Safety Program Initiatives</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater Vancouver Regional District (BC)</td>
<td>The GVRD has developed and implemented a formal, integrated and sustainable Safety Management System that provides consistency and continuity in the way we manage our safety responsibilities across the business units.</td>
</tr>
<tr>
<td>Holland Board of Public Works (MI)</td>
<td>An incentive program utilizing behavior based safety which has a component for employee safety observations.</td>
</tr>
<tr>
<td></td>
<td>We conduct monthly safety meetings with employees to share safety info and conduct training.</td>
</tr>
<tr>
<td></td>
<td>There is also a central safety committee consisting of both hourly and supervisory personnel. It meets monthly to review status of safety program.</td>
</tr>
<tr>
<td></td>
<td>We added safety info to a company intranet website allowing access to most all employees.</td>
</tr>
<tr>
<td>Lincoln Water System (NB)</td>
<td>Monthly safety meetings (past 5 months)</td>
</tr>
<tr>
<td></td>
<td>Scheduled training for water section employees.</td>
</tr>
<tr>
<td></td>
<td>Poster board information centers (2)</td>
</tr>
<tr>
<td>Massachusetts Water Resources Authority (MA)</td>
<td>Establishment of Site Characterization Teams to investigate terrorism/drinking water contamination.</td>
</tr>
<tr>
<td>Metropolitan Water Board (Los Angeles, CA)</td>
<td>Use of automated questionnaire to identify EHS training needs by employee and the type of jobs/tasks that they do.</td>
</tr>
<tr>
<td></td>
<td>EHS design review function for capital projects is part of Engineering organization.</td>
</tr>
<tr>
<td></td>
<td>Pre-employment and reasonable suspicion drug testing</td>
</tr>
<tr>
<td></td>
<td>Consultant who does the annual audiogram (hearing conservation van) provides hearing conservation on same date/time as the hearing tests.</td>
</tr>
<tr>
<td></td>
<td>Significant security system enhancements at each facility.</td>
</tr>
<tr>
<td></td>
<td>Rental of 4-gas monitoring instruments for confined space and tunnel entry in lieu of purchase. Rental agreement (with Industrial Scientific) includes a predictive maintenance system, and substitute instruments for those being serviced.</td>
</tr>
<tr>
<td></td>
<td>Additional involvement of non-management employees in incident investigations (event review process - formerly called Triple T process).</td>
</tr>
<tr>
<td></td>
<td>Increased involvement of maintenance and operations employees in review of engineering designs and projects.</td>
</tr>
<tr>
<td></td>
<td>Constructability safety reviews for new installations or renovations.</td>
</tr>
<tr>
<td></td>
<td>Violence in the workplace program, procedures, and training.</td>
</tr>
<tr>
<td></td>
<td>Some wellness and fitness programs at some District facilities.</td>
</tr>
<tr>
<td></td>
<td>Outsourcing (via 3E) of MSDS access and retention functions (done more than 3 years ago, but continued part of EHS program).</td>
</tr>
<tr>
<td>Portland Water Bureau</td>
<td>Safety audits and site visits by safety committee with supervisors.</td>
</tr>
<tr>
<td></td>
<td>Strong Safety Committee and employee involvement</td>
</tr>
<tr>
<td></td>
<td>Reinstating employee incentive/recognition program</td>
</tr>
<tr>
<td>Phoenix Water/Sewer District (AZ)</td>
<td>Office Ergonomic Evaluations</td>
</tr>
<tr>
<td></td>
<td>DOT Vehicle Random Inspection Verifications</td>
</tr>
<tr>
<td>San Juan Water District (SC)</td>
<td>Monthly safety committee meetings</td>
</tr>
<tr>
<td></td>
<td>Safety audits and random checks</td>
</tr>
<tr>
<td></td>
<td>Monthly employee safety meetings</td>
</tr>
<tr>
<td></td>
<td>Annual safety bonus</td>
</tr>
<tr>
<td></td>
<td>Annual safety awards luncheon for all employees and commissioners</td>
</tr>
</tbody>
</table>
| Tualatin Valley Water District (OR) | The District actively looks for employees with experience to conduct training.  
- Certified paramedic/firefighter  
- Conducts fire safety training  
- Possibly First Aid/CPR in the future.  
- Employee with extensive experience on forklifts  
- Conducts forklift training  
- The District started an Automatic External Defibrillator (AED) program. Currently there are 49 employees trained to use the AEDs.  
- The District established rules for cell phone use while driving.  
- Job Safety Analysis (JSA) are being done by crews.  
- Procurement forms are being used for purchases of chemicals that are not in inventory. The procurement forms will allow use to make sure all chemicals are properly brought into service and that we are purchasing the safest and most environmentally friendly product available.  
- As a coordinated effort between the safety and sustainability programs, the District is analyzing the chemicals we have in inventory. We will ranking the chemicals based on health and environmental risk. Then we will work to eliminate our more hazardous chemicals and look for more safe and environmentally friendly options. As part of this program, we are currently working on a way for employees to access key information (first aid etc.) for chemicals in inventory without having to look through the MSDS.  
- Distribution crew is conducting safety walk-throughs of the facilities they enter whenever they access those sites. This replaces the quarterly walk through.  
- Trench reports are done for trenches over 4ft deep.  
- The District participates in a program that allows us to reimburse our workers comp carrier for medical only claims. This will reduce workers comp. premium over time.  
- Accident kits are in every vehicle. The kit contains an accident report and camera. Employees have been trained on how to take pictures at accident scenes. |
| Tulsa Metropolitan Utility Authority (OK) | SAFETY AUDITS of the various parts of Water Supply and Distribution. Audits check compliance with required COT safety training and policies, OSHA regulations. (Both from the State and Federal levels).  
- JOB SITE INSPECTIONS: (Inspections made at the various job sites by a member of the Safety Department). These check compliance with safety regulations on trenching, using PPE's, confined space entry etc.  
- FACILITY INSPECTIONS: Facility inspections of various COT buildings or plants. Facility inspections check compliance of the facility with OSHA and COT regulations and standards.  
- SAFETY TRAINING SHORT SESSIONS: The Safety Department provides training sessions on various topics as needed by the different work groups. Some examples are Blood Borne Pathogens, Hazardous Communications, Personal Protective Equipment Use.  
- NEW EMPLOYEE ORIENTATION: The Safety Department conducts Part II of New Employee Orientation. This covers COT policy on safety, computer use, driving policy, reporting accidents and injuries and workers compensation.  
- EQUIPMENT TRAINING: The Safety Department provides training for operation of Forklifts, Backhoes, Trackhoes, Gradalls, Graders. Get their CDL's.  
- TRUCK DRIVER TRAINING: The Safety Department provides driver training on large trucks. This enables individuals to get their CDL license. |
<table>
<thead>
<tr>
<th>Location</th>
<th>Initiatives</th>
</tr>
</thead>
</table>
| **Washington Aqueduct**  | • Updating and synchronizing our respiratory protection program and equipment. Before this was done there was different types of masks and hook-ups. Now everything can be interchangeable.  
                           | • Institute monthly training in a safety-related subject.  
                           | • Provide on-the-spot safety awards for individuals that go above and beyond to perform tasks in a safer manner. |
| **U.S. Army Corps of**   |                                                                             |
| **Engineers**            |                                                                             |
| **WaterOne (KS)**        | • Risk Management Plan  
                           | • Respiratory Protection Plan  
                           | • Emergency Response Plan  
                           | • Lock Out Tag Out |
| **Singapore PUB**        | • Set up an overall safety management system involving very senior management, operational department, operational plants and union to oversee occupational safety and health for all staff. These are: a. Board Committee for Safety. b. Safety Steering Committee chaired by CE and Senior Directors c. Operational Depts. Safety Committees d. Plants and Construction Sites Safety Committees  
                           | • Set up of a full time Div overseeing occupational safety and health conducting independent safety and health audits and reporting findings and recommendations directly to senior management  
                           | • Common safety and health training conducted for all staff centrally coordinated by a full time division overseeing occupational safety and health matters  
                           | • Put in place a focus safety culture and awareness program and disseminating message regularly to all staff and union.  
                           | • Organizing Safety Day to promote safety awareness and share best practices among all staff and partners.  
                           | • Set up open communications between staff and management on safety e.g. safety hotlines, emails, regular sharing sessions, exhibitions and talks etc |

*Responses are verbatim, except for minor corrections in spelling and grammar where possible.*
<table>
<thead>
<tr>
<th>Statement</th>
<th>% 'Yes' Response (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of a Safety Strategic Plan or Action Plan on an annual basis.</td>
<td>68.4</td>
</tr>
<tr>
<td>Standard Operating Procedures or Job Safety Analyses for each routinely performed job or task.</td>
<td>78.9</td>
</tr>
<tr>
<td>Regularly scheduled inspections of the operation(s).</td>
<td>89.5</td>
</tr>
<tr>
<td>Safety committee(s) with non-management employee membership of 50% or more.</td>
<td>84.2</td>
</tr>
<tr>
<td>Non-management employee involvement in incident investigations.</td>
<td>78.9</td>
</tr>
<tr>
<td>Maintenance and Operations involvement in review of engineering designs and projects.</td>
<td>63.2</td>
</tr>
<tr>
<td>Assessment of training needs.</td>
<td>89.5</td>
</tr>
<tr>
<td>Auditing of training effectiveness.</td>
<td>57.9</td>
</tr>
<tr>
<td>Progressive discipline for safety violations.</td>
<td>68.4</td>
</tr>
<tr>
<td>Random drug testing.</td>
<td>73.7</td>
</tr>
<tr>
<td>Hearing conservation program, including annual audiograms.</td>
<td>63.2</td>
</tr>
<tr>
<td>Ergonomics team.</td>
<td>21.1</td>
</tr>
<tr>
<td>Ergonomics job analysis and/or risk factor survey.</td>
<td>42.1</td>
</tr>
<tr>
<td>Ergonomics training for engineers.</td>
<td>15.8</td>
</tr>
<tr>
<td>Safety through design training for engineers.</td>
<td>26.3</td>
</tr>
<tr>
<td>Behavior based safety program.</td>
<td>31.6</td>
</tr>
<tr>
<td>Culture Change program.</td>
<td>26.3</td>
</tr>
<tr>
<td>Design safety reviews for capital projects.</td>
<td>42.1</td>
</tr>
<tr>
<td>Constructability safety reviews for new installations or renovations.</td>
<td>52.6</td>
</tr>
<tr>
<td>Violence in the workplace prevention.</td>
<td>68.4</td>
</tr>
<tr>
<td>Wellness and fitness program.</td>
<td>68.4</td>
</tr>
<tr>
<td>Significant security system enhancements.</td>
<td>89.5</td>
</tr>
<tr>
<td>Ergonomic interventions to reduce manual material handling.</td>
<td>47.4</td>
</tr>
<tr>
<td>ISO 14000 or 18000 conforming management systems.</td>
<td>5.3</td>
</tr>
<tr>
<td>OSHA VPPP Merit or Star program.</td>
<td>10.5</td>
</tr>
<tr>
<td>Adoption of ANSI Z10 Standard.</td>
<td>15.8</td>
</tr>
<tr>
<td>External third party health &amp; safety program audit.</td>
<td>31.6</td>
</tr>
<tr>
<td>Compliance assistance from OSHA.</td>
<td>47.4</td>
</tr>
<tr>
<td>Off-the-job safety program</td>
<td>15.8</td>
</tr>
</tbody>
</table>
### Table B.10
Metrics used by respondents to assess injury experience

<table>
<thead>
<tr>
<th>Metric</th>
<th>Percent of respondents using metric (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSHA Recordable Rate</td>
<td>85</td>
</tr>
<tr>
<td>Days away from work</td>
<td>80</td>
</tr>
<tr>
<td>Days of lost time or restricted duty</td>
<td>80</td>
</tr>
<tr>
<td>Lost Workday Case Rate</td>
<td>70</td>
</tr>
<tr>
<td>Workers Compensation Dollars</td>
<td>65</td>
</tr>
<tr>
<td>Injury trend analysis (frequency and type)</td>
<td>65</td>
</tr>
<tr>
<td>Workers Compensation claims rate (number of cases)</td>
<td>60</td>
</tr>
<tr>
<td>Injury trend analysis (type of hazard or agent)</td>
<td>60</td>
</tr>
<tr>
<td>Days without a recordable case</td>
<td>30</td>
</tr>
<tr>
<td>Days without a lost time (away from work) injury</td>
<td>30</td>
</tr>
<tr>
<td>Workers Compensation experience modifier or Mod Rate</td>
<td>30</td>
</tr>
<tr>
<td>Workers Compensation case rate</td>
<td>30</td>
</tr>
<tr>
<td>Days without a restricted or lost time injury</td>
<td>25</td>
</tr>
<tr>
<td>First Aid Case Rate</td>
<td>15</td>
</tr>
</tbody>
</table>
Table B.11
Metrics used to assess performance of the safety program

<table>
<thead>
<tr>
<th>Metric</th>
<th>Percent responding “yes”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=20)</td>
</tr>
<tr>
<td><strong>Resource Commitment and Loss</strong></td>
<td></td>
</tr>
<tr>
<td>Injury statistics</td>
<td>90</td>
</tr>
<tr>
<td>Loss claims</td>
<td>65</td>
</tr>
<tr>
<td>Dollars spent on safety projects</td>
<td>15</td>
</tr>
<tr>
<td>Dollars spent retrofitting guards and correcting other safety or health hazards</td>
<td>15</td>
</tr>
<tr>
<td>Overtime or unscheduled hours due to upset conditions</td>
<td>15</td>
</tr>
<tr>
<td>Unplanned or unscheduled downtime</td>
<td>10</td>
</tr>
<tr>
<td>Number of safety work orders generated during the first year of operation for a process or system</td>
<td>10</td>
</tr>
<tr>
<td>Off-the-job injury rate</td>
<td>-</td>
</tr>
<tr>
<td><strong>Employee Involvement and Feedback</strong></td>
<td></td>
</tr>
<tr>
<td>Employee surveys of safety culture and attitudes</td>
<td>55</td>
</tr>
<tr>
<td>Level of participation at safety meetings</td>
<td>50</td>
</tr>
<tr>
<td>Number of reported safety concerns</td>
<td>40</td>
</tr>
<tr>
<td>Number or percent of employees participating on safety committees, ergonomic teams, or in other safety program activities</td>
<td>30</td>
</tr>
<tr>
<td>Number of reported near misses</td>
<td>30</td>
</tr>
<tr>
<td>Employee comfort surveys</td>
<td>10</td>
</tr>
<tr>
<td>Level of participation in safety slogan contests</td>
<td>10</td>
</tr>
<tr>
<td><strong>Auditing and Assessments</strong></td>
<td></td>
</tr>
<tr>
<td>Internal program audits</td>
<td>80</td>
</tr>
<tr>
<td>Emergency drill response assessments</td>
<td>55</td>
</tr>
<tr>
<td>Ergonomic job analyses</td>
<td>45</td>
</tr>
<tr>
<td>External or third party audits</td>
<td>40</td>
</tr>
<tr>
<td>Sound level surveys</td>
<td>40</td>
</tr>
<tr>
<td>Behavior safety observations</td>
<td>35</td>
</tr>
<tr>
<td>Fire safety inspection scores</td>
<td>30</td>
</tr>
<tr>
<td>Compliance scoring based on Standard Operating Procedures and routine site inspections</td>
<td>20</td>
</tr>
<tr>
<td>Housekeeping scores</td>
<td>15</td>
</tr>
<tr>
<td>Percent of accident notices or hazard alerts posted within a specified period following an incident or hazard identification</td>
<td>10</td>
</tr>
<tr>
<td>Numbers or rates of disciplinary actions</td>
<td>5</td>
</tr>
<tr>
<td>Percent of capital projects for which safety design reviews were conducted</td>
<td>5</td>
</tr>
<tr>
<td>Response time of safety work orders</td>
<td>5</td>
</tr>
</tbody>
</table>

(continued)
Table B.11 (Continued)
Metrics used to assess performance of the safety program

<table>
<thead>
<tr>
<th>Metric</th>
<th>Percent responding “yes” (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td></td>
</tr>
<tr>
<td>Knowledge or skill based testing</td>
<td>65</td>
</tr>
<tr>
<td>Percent of employees trained</td>
<td>60</td>
</tr>
<tr>
<td>Training days</td>
<td>40</td>
</tr>
<tr>
<td>Training program effectiveness audits</td>
<td>25</td>
</tr>
<tr>
<td>Percent of new and re-assigned employees receiving orientation training within 48 hours (or some other specified target)</td>
<td>15</td>
</tr>
<tr>
<td>Driver scores at lift truck rodeos or qualification trials</td>
<td>10</td>
</tr>
</tbody>
</table>
Table B.12
Positions having safety metrics included in performance assessments

<table>
<thead>
<tr>
<th></th>
<th>All positions</th>
<th>No positions</th>
<th>Non-mgmt positions</th>
<th>Mgmt positions only (director, head, supervisor, etc.)</th>
<th>Both mgmt and non-mgmt positions</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of respondents</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>Percent of respondents</td>
<td>28.6</td>
<td>14.3</td>
<td>7.1</td>
<td>28.6</td>
<td>21.4</td>
<td>100</td>
</tr>
<tr>
<td>Descriptions</td>
<td>• all positions • all employees • All positions at the District have safety included in their performance assessments • all positions</td>
<td>• No one • none • Service Worker I and II • Division Directors • Department Heads, Managers, Supervisors • CAO, Managers, supervisors • Department Director Changes each year based on focus. • Non-management and limited management • Const. Ops, and Maint. section at the Supv/Mgr levels; Some supervisors are evaluating their crew leaders; Apprenticeship program • Senior Staff; Line managers; all operational staff</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table B.13
Approximate percentages of performance ratings or bonuses based upon safety performance

<table>
<thead>
<tr>
<th></th>
<th>Safety Leader for the Organization</th>
<th>Safety Leader for Operating Unit</th>
<th>Operations/Plant Manager</th>
<th>Shift Supervisor</th>
<th>Engineering Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n=10)</td>
<td>Max 85</td>
<td>80</td>
<td>40</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Min 0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Mean 17.5</td>
<td>18.5</td>
<td>12.0</td>
<td>10.0</td>
<td>9.0</td>
</tr>
<tr>
<td></td>
<td>St Dev 29.5</td>
<td>26.9</td>
<td>14.2</td>
<td>11.3</td>
<td>12.2</td>
</tr>
</tbody>
</table>
## Table B.14
Affirmative responses to cost/benefit questions, broken out by who has primary responsibility for safety program planning

<table>
<thead>
<tr>
<th>Person having primary responsibility for planning safety strategies:</th>
<th>Dedicated Safety Officer on Site</th>
<th>Corporate or Agency H&amp;S Professional</th>
<th>Unit Operating Staff or On-Site Engineer</th>
<th>External Consultant</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. of organizations</td>
<td>8</td>
<td>13</td>
<td>5</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Question 1: Does your organization track injury and/or accident costs, other than Workers Compensation and casualty insurance claims?</td>
<td>50% (4 of 8)</td>
<td>25% (3 of 12)</td>
<td>50% (2 of 4)</td>
<td>100% (1 of 1)</td>
<td></td>
</tr>
<tr>
<td>Question 2: Are costs of safety programs and safety initiatives tracked and accounted?</td>
<td>62.5% (5 of 8)</td>
<td>66.7% (8 of 12)</td>
<td>75% (3 of 4)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Question 4: Are cost savings data collected or estimated for safety projects and initiatives?</td>
<td>14.3% (1 of 7)</td>
<td>63.6% (7 of 11)</td>
<td>50% (2 of 4)</td>
<td>100% (1 of 1)</td>
<td></td>
</tr>
<tr>
<td>Question 5: Does your organization apply cost/benefit analysis to safety projects?</td>
<td>28.6% (2 of 7)</td>
<td>45.5% (5 of 11)</td>
<td>50% (2 of 4)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Question 6: Does your organization apply an indirect cost factor when calculating the costs of accidents?</td>
<td>28.6% (2 of 7)</td>
<td>-</td>
<td>25% (1 of 4)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Question 7: Does your organization compute indirect costs, or is a standard indirect cost factor used?</td>
<td>-</td>
<td>20% (1 of 5)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Question 8: Is cost justification applied to safety driven projects?</td>
<td>50% (3 of 6)</td>
<td>27.3% (3 of 11)</td>
<td>25% (1 of 4)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Question 9: Are cost savings from safety improvements routinely included along with other financial benefits in calculations used to justify capital projects?</td>
<td>16.7% (1 of 6)</td>
<td>27.3% (3 of 11)</td>
<td>75% (3 of 4)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Question 11: Are costs of accidents reported back to the departments where they occur?</td>
<td>57.1% (4 of 7)</td>
<td>54.5% (6 of 11)</td>
<td>100% (4 of 4)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Question 12: Are accident costs charged back to the operating budgets of affected departments</td>
<td>42.9% (3 of 7)</td>
<td>27.3% (3 of 11)</td>
<td>75% (3 of 4)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Question 13: Does either Maintenance or Engineering track costs associated with safety work orders, cost of retrofitting for safety on capital projects, cost of accident damage, etc.?</td>
<td>66.7% (4 of 6)</td>
<td>45.5% (5 of 11)</td>
<td>75% (3 of 4)</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>
Table B.15
Percent of respondents with ergonomic processes who include the listed element with their process

<table>
<thead>
<tr>
<th>Elements of ergonomic processes</th>
<th>Percent of respondents (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure or method for employees to report hazards</td>
<td>63.2</td>
</tr>
<tr>
<td>Employee awareness training on ergonomic risk factors and related job hazards</td>
<td>63.2</td>
</tr>
<tr>
<td>Workstation design using ergonomic principles</td>
<td>63.2</td>
</tr>
<tr>
<td>Employee participation in hazard recognition and control</td>
<td>57.9</td>
</tr>
<tr>
<td>Access to ergonomics expertise, either internally or from a consultant</td>
<td>57.9</td>
</tr>
<tr>
<td>Ergonomic job hazard analysis and control</td>
<td>52.6</td>
</tr>
<tr>
<td>Medical management of work-related musculoskeletal disorders (WMSDs)</td>
<td>52.6</td>
</tr>
<tr>
<td>Ergonomic design checklists</td>
<td>42.1</td>
</tr>
<tr>
<td>Systematic method for identifying jobs with ergonomic hazards</td>
<td>36.8</td>
</tr>
<tr>
<td>Written ergonomics policy or other evidence showing management commitment and leadership</td>
<td>36.8</td>
</tr>
<tr>
<td>Pre-employment screening and job placement evaluations</td>
<td>36.8</td>
</tr>
<tr>
<td>Pre-employment physical capabilities testing</td>
<td>36.8</td>
</tr>
<tr>
<td>Training in job analysis and control measures</td>
<td>26.3</td>
</tr>
<tr>
<td>Training in problem solving</td>
<td>21.1</td>
</tr>
<tr>
<td>Evaluations of control effectiveness</td>
<td>21.1</td>
</tr>
<tr>
<td>Program evaluation</td>
<td>15.8</td>
</tr>
<tr>
<td>Symptom surveys</td>
<td>15.8</td>
</tr>
<tr>
<td>Site ergonomic teams to identify hazards and develop controls</td>
<td>10.5</td>
</tr>
<tr>
<td>Productivity assessments</td>
<td>10.5</td>
</tr>
<tr>
<td>Operator error analysis</td>
<td>5.3</td>
</tr>
</tbody>
</table>
### Table B.16
Level of interest in learning about different cost/benefit assessment methods, broken out by who has primary responsibility for safety program planning

<table>
<thead>
<tr>
<th>Personnel Responsible</th>
<th>Number of orgs.</th>
<th>1 Very Interested</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 Not Interested</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedicated Safety Officer on Site</td>
<td>8</td>
<td>42.9% (3 of 7)</td>
<td>28.6% (2 of 7)</td>
<td>-</td>
<td>14.3% (1 of 7)</td>
<td>14.3% (1 of 7)</td>
<td>1</td>
</tr>
<tr>
<td>Corporate or Agency H&amp;S Professional</td>
<td>13</td>
<td>12.5% (1 of 8)</td>
<td>25% (2 of 8)</td>
<td>25% (2 of 8)</td>
<td>25% (2 of 8)</td>
<td>12.5% (1 of 8)</td>
<td>5</td>
</tr>
<tr>
<td>Unit Operating Staff or Onsite Engineer</td>
<td>5</td>
<td>33.3% (1 of 3)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>66.7% (2 of 3)</td>
<td>2</td>
</tr>
<tr>
<td>External Consultant</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
</tbody>
</table>

### Table B.17
Person or entity with responsibility for managing injury/illness cases

<table>
<thead>
<tr>
<th>Personnel Responsible</th>
<th>Percent of respondents (n=17)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal case manager</td>
<td>47.1%</td>
</tr>
<tr>
<td>Third party case manager or administrator; i.e., consultant</td>
<td>29.4%</td>
</tr>
<tr>
<td>Safety leader for the operating unit</td>
<td>11.8%</td>
</tr>
<tr>
<td>Internal human resources manager</td>
<td>11.8%</td>
</tr>
<tr>
<td>Workers Compensation insurer</td>
<td>-</td>
</tr>
</tbody>
</table>
APPENDIX C
WATER RESEARCH FOUNDATION PROJECT 3104 CASE STUDY
PROTOCOL MARCH 2007

Purpose and Scope

The following presents the protocol to be implemented by the Water Research Foundation Project 3104 Research Team in the conduct of Case Studies to be performed at five water utilities that are participating in the study. Five water utilities were selected as subjects for the Case Study phase based on several criteria:

- Questionnaire responses indicated excellence in performance and developing or advanced safety cultures.
- Research Team observations and conversations with representatives from the selected water utilities during the Phase 1 Workshop indicted advanced understanding of safety system management development and implementation.
- The Case Study candidates are diverse in terms of geography, infrastructure, processes, and labor representation.

Objectives

- Identify and document best practices for integrating safety into both design and operations.
- Analyze the value of safety practices and activities in terms of hazard mitigation effectiveness and financial benefits.
- Analyze the effectiveness and value of safety fixtures and equipment installed at water conveyance, treatment and distribution systems.

Research Team

The Project 3104 Principal Investigators, John Borowski, CIH, CSP, and Dr. Paul Adams, CSP, CPE, will conduct all on-site case study activities. We understand that the case study will require significant time resources of the utility. We hope that providing this protocol will provide utility personnel the opportunity to prepare for interviews, thereby optimizing the time resources of the utility. We will work with utility representatives in advance of the on-site work to schedule interviews and facility survey activities. We will establish and live-by time frames for completion of the case study tasks and will provide apple opportunity for utility managers and employees to participate in the case study, and where appropriate, to participate in case study kick-off and out-brief meetings.
Pre-visit Preparation by Site

The following lists the information that is likely to be requested by the researchers in conduct of the Case Study.

1. Collect injury/illness data, including accident reports and/or data on causative factors
2. Any cost data collected on accidents (may be a sample of 5 or so, if routinely collected)
3. Plans and specifications for new and retrofit facilities that illustrate how safety is being integrated or included in the design process.
4. Safety Committee meeting minutes for 2005 and 2006
5. Copies of all internal safety and health audits or inspections completed in 2005 and 2006.
6. Safety and Health Policy and Program Manuals.

Case Study Agenda (Tentative)

Due to the extensive nature of the case study process, we are planning to be on-site for a minimum of four and one-half days. To accomplish this, we will travel to the location one day in advance to assure that on-site activities are initiated as scheduled. The researchers will likely split the effort with one researcher conducting interviews and reviewing documents, and the other focusing on facility survey, interviews and documentation of best practices. This Tentative Agenda is intended to provide an overview of the Case Study process so that the participating utility is able to support the interview process with minimum impacts to operations.

Day One

On-Site Kick-Off Meeting

The researchers will initiate on-site activities with a brief kick-off meeting with subject utility operations, maintenance and safety managers. This meeting will provide an opportunity to review the purpose and scope of the case study, to review our findings and conclusions from Phase 1, to respond to questions and concerns of the subject utility, and to schedule on-site interviews of individual maintenance and operations workers. We will also request time to interview facility management regarding the cost/benefit nomenclature/metrics and the design and operations maintenance integration methods that they feel are noteworthy.
Utility Tour (Limited)

The researchers will conduct a utility orientation tour with representatives of the subject utility to get familiarized with the facility layout, and escort/access requirements.

Detailed review of Injury/Illness/Near Miss Incident Reports, Case Management Files, and Cost Tracking Systems

The researchers will review documentation of injury/illness initial reports, investigations, follow-up activities, and non-medical record case management records. This information will provide insight regarding the effectiveness and breadth of root cause analysis, cost tracking, enforcement and response mechanisms.

Days 2 - 4

Overview of Hazard Assessment, Operations and Mitigation Review Process

Integration of safety and health into the design and operation of water systems requires a mature hazard assessment and operations review process. The researchers will identify and evaluate hazard assessment procedures implemented by the subject utility. It is anticipated that this effort will yield hazard assessment and mitigation solutions for water utility structures, processes, maintenance, and operations. Specifically, the researchers will study how the subject utility addresses acute and chronic hazards as follows:

Identify and evaluate hazard assessment procedures:

- Focus on listed acute and chronic hazards
- Identify best practices
- Identify mitigation options in design

Costs/benefits of past hazard mitigation activities and initiatives:

- Cost/benefits of hazard mitigation integrated with design
- Costs of retrofitting facilities constructed without S&H integrated into design

Identify, evaluate and document practices, technologies and procedures for implementing safety through design:

- Methodologies used to identify and mitigate hazards prior to construction
- Methodologies used to document and retain corporate learning and experience
Management and Worker Interviews

The researchers will interview operations and maintenance workers and managers to verify the effectiveness of past and ongoing activities and to identify new and innovative methods for integrating safety and health into facility design activities. Interview duration will range from 15 minutes to approximately one hour. The following lists the personnel that we would like to interview:

- Safety and Health Manager/Coordinator/Leader
- Union Employee Representative
- Safety Committee Members (individually or as a group)
- Individual Employees (5-10 employees representing operations and maintenance)
- Director or Executive Director
- Operations Manager
- Operations Supervisor
- Maintenance Manager
- Engineering Manager
- Occupational Health Nurse or Workers Compensation Case Manager
- Purchasing Manager or Agent

Case Study Findings and Conclusions Outline

Prior to concluding on-site Case Study activities, the researchers will develop a brief outline of the Case Study findings and conclusions. This will provide the an opportunity to reflect on the findings, and complete follow-up interviews or review critical documentation as required to verify findings and conclusions prior to leaving the subject utility location.

Day 5 (am)

Closing Meeting

On-site activities will conclude with a briefing for utility representatives to share the Case Study findings and conclusions.

Interviews and Content

As indicated in the Tentative Agenda detailed above, interviews will be conducted to following verify the effectiveness of past and ongoing activities and to identify new and innovative methods for integrating safety and health into facility design activities. The following summarize the scope of issues to be explored each interview:
Safety & Health Manager/Coordinator/Leader

1. Discuss injury profile
   a. Types of injuries
   b. Types of hazards
   c. Root causes
   d. Mitigation procedures and strategies
   e. Costs, including indirect costs
2. What costs are being, or can be tracked?
   a. Who uses cost information and for what purpose?
   b. What makes cost information relevant or irrelevant?
   c. Is cost a driver for change?
   d. Are indirect costs viewed as real by the organization?
3. What role do you play in the consideration and planning for new technology?
4. Discuss safety program initiatives
   a. What works?
   b. What innovative strategies have you considered/implemented?
   c. How do you measure success/effectiveness for safety initiatives?
   d. What initiatives failed and why?
5. What role does safety play in discipline programs?
   a. If using a carrot and stick approach, what does that look like?
   b. How do you keep safety from being viewed negatively?
   c. Any innovative approaches?
6. Discuss program metrics
   a. What metrics are being used?
   b. Who uses these metrics?
   c. What effect are the metrics having on the way processes are executed?
   d. How do you assess safety culture?
   e. What aspects of the program could benefit from a targeted metric to drive action/support?
7. What is your role / interaction with contractors?
8. Discuss cost/benefit of safety program elements and practices
   a. How are costs perceived (financial or otherwise)?
   b. How are benefits measured and accounted?
   c. Does cost/benefit analysis make sense for your organization, and why or why not?
9. Discuss ergonomics process management
   a. What elements of a comprehensive process are present and what do they look like?
   b. What are the costs of the ergonomics process and initiatives, aside from direct project costs?
   c. What benefits do you see your organization getting that result from ergonomics?
   d. How is ergonomics viewed by the organization?
   e. In an ideal world, what would an ergonomics process look like in your organization?
Union or Employee Representatives, Safety Committee Members, Individual Employees

1. What improvements do you think could be made in the process from designing and retrofitting new processes?
2. What role do you play in making sure new technology is safe?
3. Discuss safety program elements and initiatives
   a. What program elements do you think are effective?
   b. What makes a safety activity or program element effective?
   c. What program elements do you think are not effective and why?
   d. What are your biggest safety and health concerns associated with your work?
   e. How do you view your safety culture?
   f. How do you view management’s concern and actions with respect to safety?
   g. How is your safety performance measured?
   h. How should your safety performance be measured?
4. What is your role in work practices enforcement?
   a. How do employees feel about the discipline system?
   b. Does the current disciplinary system affect safety performance? If so, how?
   c. In an ideal world, what should the disciplinary system look like?
5. Do you think the amount of emphasis placed on safety by management and the employees is appropriate?
6. What gaps do you see in the safety program?
Director or Executive Director

1. Discuss injury profile
   a. What types of accidents are your biggest concern?
   b. Where do ergonomic injuries fit into your hierarchy of concern?

2. How are accident costs reported to you?
   a. Are accident costs charged back to your budget? How?
   b. Do you think indirect accident costs are relevant or an important consideration?
   c. What hidden or non-accounted costs of accidents have the biggest impact on your organization, if any?
   d. Are safety related costs part of your goals or performance evaluation?

3. How do you think safety should be incorporated into capital projects?
   a. What role should the safety function play?
   b. When (at what phase) do you think safety should be given focused consideration in a capital project?
   c. How do you hold engineers/contractors accountable for safety performance on capital projects, both during construction and for operability?
   d. Do you think your organization does a good job of integrating safety into design? If not, why not?

4. Discuss safety program metrics
   a. What are your primary safety goals?
   b. Do you include safety in your performance metrics for subordinates? If so, how?
   c. What do you think are the strong points of your safety process?
   d. What are the weak points of your safety process?
   e. How do you measure the effectiveness of your safety program? Of program initiatives?
   f. How do you measure or assess your safety culture?
   g. Who assesses your safety performance and what form does that assessment take?

5. Do you think your union(s) is supportive of your safety program?
   a. How does the union support or subvert your safety efforts?
   b. How do you think the union /employees view safety at this organization?

6. Do you think safety projects should be subjected to a cost/benefit analysis? If so, what should that look like?

7. What do you think is the biggest opportunity with respect to reducing injuries and their associated costs?

8. What do you think are the primary drivers of your safety program and its initiatives?

9. What are the biggest and most prevalent obstacles to improving your organization’s safety performance?

10. How do you hold contractors accountable for safety performance?
    a. Engineering and design professionals
    b. Construction and maintenance contractors
Maintenance Manager

1. How well is safety integrated into the design of the systems at your facility?
   a. Do you frequently modify new equipment and processes to improve the safety or to correct hazards?
   b. Do you or your department get involved in capital projects and refurbishments?
   c. Do you feel that your systems and equipment are safe for the maintenance worker to maintain?
   d. Are safety and maintainability adequately considered in the design process?
   e. At what phase of the capital design and delivery process do you get involved or have input? What does that involvement/input look like?
   f. What percentage of capital projects require retrofitting to address safety concerns?
   g. How is the cost of retrofitting accounted and paid for?

2. What are the biggest safety concerns for you and your people?

3. Discuss design features on equipment and processes that create safety problems or present hazards to maintenance and operating personnel.

4. What are the most prevalent injuries suffered by your department?
   a. Types of injuries
   b. Hazards
   c. Activities

5. How can the safety of new processes, equipment and systems be most effectively improved?

6. Discuss safety metrics
   a. How is your safety performance measured/assessed?
   b. How do you measure the safety performance of your staff?
   c. Do safety program metrics change or affect the way you manage your activities and department? If so, how?
   d. What metrics could be used that would be more effective in encouraging safe performance by maintenance personnel?

7. How do you enforce safe behaviors? What processes do you use and how?

8. Discuss how you manage contractor safety
   a. How do you measure contractor safety performance?
   b. How do you treat contractor safety infractions?
   c. What methods do you use to encourage safe contractor performance?
   d. Have you ever removed a contractor from a job for safety reasons? If so, how many times?
   e. Is safety performance and accident history considered when selecting contractors? If so, how important is safety among the selection criteria?

9. Do you or your department routinely conduct or participate in safety walk-downs or commissioning inspections prior to new or modified systems being released to operations? If so, what is your role?
10. What management system constraints do you think restrict or prevent more effective integration of safety into design?
   a. Does your organization have adequate technical skills to drive safety improvement?
   b. Does cost cutting undermine safety features?
   c. Does lack of safety focus result in belated hazard recognition and mitigation?

11. Have you or anyone in your department had any ergonomics training?
   a. What did that training involve?
   b. Has anyone been trained on how to make systems user-friendly?
   c. Have you ever tried to get design contractors or other engineers to make changes to accommodate maintenance safety and ergonomic concerns? If so, were these efforts successful?

12. Discuss your organization’s safety program
   a. What are the most successful program elements?
   b. What are the weakest program elements and why?
   c. What are the gaps that you see in the safety program, if any?
Engineering Manager

1. How well is safety integrated into the design of the systems at your facility?
   a. Do you frequently modify new equipment and processes to improve the safety or to correct hazards?
   b. What percentage of capital projects require retrofitting to address safety concerns?
   c. How is the cost of retrofitting accounted and paid for?
   d. Do you measure the cost of retrofits or other measures of design changes?
   e. Do you measure the number of safety work orders on new, modified or rebuilt systems during the first year of operation?

2. How is safety considered in the design of equipment and processes?
   a. Describe your current safety through design process
   b. Are specific safety requirements written into project specifications?
   c. Do you hold design safety reviews on capital projects?
      i. At what stage
      ii. Who participates
      iii. What does the process look like
   d. Are contractors penalized for failing to meet safety requirements or for design errors related to safety that require retrofitting?
   e. Do you hold constructability reviews and is safety a prominent concern during these reviews?

3. Discuss design features on equipment and processes that create safety problems or present hazards to maintenance and operating personnel.

4. Discuss safety program metrics
   a. Is safety an important component of your performance evaluation?
   b. How is your safety performance measured?
   c. Is safety performance measured in some fashion on capital projects?
   d. How do you assess the safety performance of design professionals and contractors?
   e. How do you assess the safety performance of construction contractors?
   f. Do safety performance measures of either design or construction contractors affect their status as a bidder or with respect to financial incentives?
   g. Are financial costs attributed to accidents shared with you? If so, in what form and what costs are included?

5. Have you or your staff received safety training?
   a. Training on confined space entry, lock-out / tag-out, elevated work, machine safeguarding, material handling, and other safe maintenance and operating procedures?
   b. Training on ergonomics and making equipment maintainable and user-friendly?
   c. Training on the design of displays and controls to minimize operator error?
   d. Facility safety feature design training that goes beyond codes, including such topics as vehicle/pedestrian interfaces, lighting, signage, ADA accommodations, etc.
   e. Do you and your staff regularly attend safety meetings?
6. What barriers or constraints limit your ability to design (or have designed) inherently safer systems?
   a. Technical skill / knowledge of safety considerations and design features
   b. Cost cutting and cost constraints
   c. Time allocation
   d. Management directives
7. What involvement do you have in accident investigations?
8. How are engineering costs associated with accident / hazard mitigation accounted? Are indirect costs included in any manner?
9. What costs would be associated with integrating safety into design more than is already being done?
   a. Would the cost and retrofitting experience warrant a change in the engineering process with regards to safety & health
   b. What resources are associated with safety retrofitting – opportunity costs?
10. What role do you play in assuring design contractors incorporate safety, and in assuring safe delivery of capital by construction contractors.
Operations Manager; Operations Supervisors

1. Discuss injury/illness history and experience
   a. What types of hazards are the greatest concern?
   b. What do you see as being frequent root causes of mishaps?
   c. What corrective actions pose the biggest challenges for you?

2. Are you involved in accounting or estimating the financial costs of accidents?
   a. If so, what types of costs do you normally assign?
   b. Have you ever tracked indirect costs, such as loss of efficiency? Are such costs real for you, even if they are not accounted in dollars?
   c. Are you charged or otherwise held accountable for accident losses?

3. Discuss your involvement in capital projects
   a. Do you participate or have input into project planning, selection and specification?
   b. If so, do you include specific safety concerns in those specifications?
   c. Do you participate in design reviews? On what percentage of projects do Operations personnel participate?
   d. Do you participate in safety walk-downs of new installations? On what percentage of projects do Operations personnel participate?

4. What safety program initiatives do you feel have been most effective?
   a. What was your role in these initiatives?
   b. How do you measure or assess effectiveness?
   c. What made these initiatives effective or successful?

5. What safety program initiatives do you feel either failed or were ineffective? Why did they fail?

6. Discuss your safety enforcement program and policy
   a. What is your program and is it used?
   b. Do you feel it is effective in preventing accidents? Why or why not?
   c. If you could make any changes to the program, what would they be?

7. What metrics do you use to evaluate safety performance?
   a. Metrics for the operation as a whole
   b. Metrics for subordinates
   c. How is your safety performance assessed or measured?
   d. How does your safety performance assessment affect compensation or other benefits?
   e. Do you think safety metrics are fair and used reasonably?
   f. Do you think such metrics encourage safe behaviors and practices?
   g. What new or different metrics do you think could be applied that would effect safety performance?

8. Discuss hidden and indirect costs of accidents
   a. What are the effects of an injury accident on your operation?
   b. Can a dollar figure or other metric be applied to account for the relative losses to the operation? If not, what are the barriers?
   c. Would you or your manager have an interest in receiving accident cost information that includes indirect cost estimates?
   d. Would you consider indirect cost estimates to be credible, even if estimated by use of a direct / indirect ratio?
9. Discuss your interest and involvement in ergonomics initiatives and programs
   a. Have you or your subordinates had any training in ergonomics?
   b. What ergonomic issues do you have to deal with among your people?
   c. Do you feel inadequate machine/equipment design contributes to muscle strains and other soft-tissue injuries in your organization?
   d. What ergonomics initiatives have you been involved with? Were they successful? Why or why not?

10. Do you think safety initiatives should be required to meet cost/benefit objectives?
    a. What criteria should be used to consider the viability of safety related changes and initiatives?
    b. Should indirect accident costs be included in the calculation of cost/benefit for projects?

11. What is your role and interaction with respect to contractors?
    a. Does the safety of work practices of contractors affect the safety of your workers?
    b. Do you have the authority to stop contractors for unsafe work? Authority to remove contractors from the site?
    c. Do you have input into the selection of contractors?
    d. Do you provide feedback to Engineering on the safety of equipment and process designs that have been involved? What is the mechanism or communication channel for do this?
Occupational Health Nurse or Case Manager

1. What types of injuries do you most frequently get involved with?
2. What accident and/or injury costs do you account for?
   a. To whom do you report case costs?
   b. How do the organization’s accident injury and cost histories compare with other employers in the local area?
   c. How does the amount of lost time and/or injury severity compare with other local employers?
3. What constraints or impediments prevent earlier returns to work following injuries, illnesses, or other health issues under your management?
4. How much administrative cost is associated with managing injury cases?
   a. Total program costs?
   b. Per case rates or administrative fees?
   c. How are these administrative costs accounted and reported to the organization?
5. What hidden costs do you feel the organization overlooks or does not account for with respect to injuries and case management?
6. What performance metrics are used to assess your performance and effectiveness? Is a dollar value assigned to your contribution; e.g., dollars in savings achieved by earlier return to work?
Purchasing Manager or Agent

1. What contract language is used to address safety in the design of equipment and processes?
2. What contract language is used to address safety in the execution of maintenance and construction contracts?
3. Is safety an important consideration in the qualification of contractors?
   a. Does this extend to engineering or design firms?
   b. Describe how safety is considered and any criteria used.
   c. Discuss the level of importance attributed to safety in selecting contractors?
4. Do you verify claims of safety performance by contractors? If so, how? If not, why not?
5. Have you received complaints from operations or engineering departments about contractors failing to adequately incorporate safety in design?
   a. What have such complaints been about?
   b. Who initiated or communicated the complaint?
   c. What action(s) were taken against the contractor?
6. How is contractor safety performance measured?
   a. Is feedback and evidence of contractor performance documented?
   b. How is contractor experience remembered by the organization?
7. Are project-specific safety specifications routinely included in engineering specifications?
   a. Who develops these specifications, if used?
   b. Examples?
   c. For what types of projects are such specifications developed?
   d. How receptive of safety specifications are engineering contractors?
   e. Does inclusion of such specifications complicate the bidding process?
   f. What indirect costs are associated with the inclusion of specific safety specifications in procurement and contract management?
8. What penalties are assessed against design contractors for failing to meet safety specifications?
   a. Are safety deficiencies handled on a par with other contract performance issues?
   b. What types of penalties are used to ensure/encourage appropriate handling of safety on process or equipment design projects?
9. Are you aware of specific procedures or practices used by any of your design contractors to ensure safety considerations are integrated in designs?
   a. Describe such processes.
   b. What involvement do you have with these processes?
   c. How did you learn of these processes?
10. Have you ever awarded contracts to firms that are not the lowest cost bidder due primarily to safety concerns or previous performance (positive or negative)?
11. Do you feel your organization’s requirements for contractors with respect to safety in design and in work performance are appropriate, too stringent, or too loose?
12. Do you have a process for considering the potential costs/losses associated with accidents against the direct costs of equipment and processes without safety features?
APPENDIX D
BEST PRACTICES IN HAZARD MITIGATION
**PROCESS/STRUCTURES**

**POTENTIAL HAZARD(S)**

1. ACCESS & CLEANING/MAINT. REQUIREMENTS
2. PIPE LABELING/PROCESS COMMUNICATION
3. LIGHTING AND VENTILATION
4. CHEMICAL HANDLING
5. FALL PROTECTION
6. HAZARD COMMUNICATION

**MITIGATION OPTIONS**

1. ASSESS CHEMICAL FEED BUILDING FLOOR PLAN TO DETERMINE WORK FLOW, IDENTIFY SYSTEMS/EQUIPMENT THAT REQUIRE FREQUENT MAINTENANCE/SERVICING, AND LOCATE EQUIPMENT TO FACILITATE PERFORMANCE OF MAINTENANCE ACTIVITIES WITHOUT USE OF FALL PROTECTION OR OTHER ACCESS LIMITATIONS. (FIGURE A)

2. PROPERLY LABEL ALL CHEMICAL STORAGE AND FEED SYSTEMS. LABELING SHOULD BE LOCATED AT POINTS REQUIRING HANDLING PERIODIC/FREQUENT MAINTENANCE OR HANDLING IS REQUIRED. (FIGURE B)

3. ASSURE ALL BUILDING SYSTEMS (LIGHTING, VENTILATION, ETC.) ARE DIRECTLY ACCESSIBLE FROM THE FLOOR OR OTHER WORK PLATFORM. (SEE ELECTRICAL SYSTEM MITIGATIONS FOR LIGHTING)

4. ASSURE APPROPRIATE CLEARANCE OF VALVES, PUMPS, OTHER HEAVY EQUIPMENT FROM WALLS, FLOORS, AND EQUIPMENT TO MANIPULATE FASTENERS AND FACILITATE USE OF MATERIAL HANDLING AND MECHANICAL LIFTING TECHNIQUES.

5. CONSIDER THE FREQUENCY, DURATION, AND POTENTIAL FOR CHEMICAL CONTACT AND HANDLING WHEN SPECIFYING CHEMICAL PROCESS EQUIPMENT INCLUDING TANKS, PUMPS, PIPING, AND VALVE ASSEMBLIES.

6. ORIENT VALVE ASSEMBLIES AND ELECTRICAL/PNEUMATIC MOTORS AND CONTROL UNITS TO FACILITATE MAINTENANCE AND SERVICING. (FIGURE A)

7. WHERE FALL PROTECTION IS REQUIRED, EQUIP ACCESS POINTS WITH FALL PROTECTION EQUIPMENT INCLUDING PORTABLE SAFETY ARM MOUNT FOR MATERIAL HANDLING, FALL ARREST, AND RESCUE CAPABILITIES, ENGINEERED ANCHOR POINTS. (FIGURE D)

**WORK PRACTICE CONSIDERATIONS:**

1. PROVIDE COMPREHENSIVE HAZARD COMMUNICATION AND EMERGENCY RESPONSE AWARENESS TRAINING OF EMPLOYEES WHO HANDLE OR WORK AROUND WATER TREATMENT CHEMICALS. ASSURE UPDATED TRAINING PRIOR TO NEW CHEMICALS BEING DELIVERED TO SITE.

2. DEVELOP SYSTEMS AND PROCEDURES TO MINIMIZE DIRECT HANDLING OF CHEMICAL.

3. MONITOR MANUAL CHEMICAL HANDLING OPERATIONS (TANK FILLING, CHEMICAL TRANSFER, ETC.) WITH SYSTEM EQUIPPED WITH SAFETY OVERIDES.

4. DEVELOP SAFE WORK PRACTICES AND PROCEDURES TO LIMIT MISUSES DURING TANK FILLING AND CHEMICAL SYSTEM MAINTENANCE. ASSURE DIRECT OVERSIGHT OR OTHER MEANS TO MONITOR CONTRACTORS AND SUPPLIERS WHEN HANDLING CHEMICAL ON SITE.
<table>
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<th>MITIGATION OPTIONS</th>
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<tr>
<td>GENERAL AREAS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. ACCESS &amp; CLEANING/MAINT. REQUIREMENTS</td>
<td>8. PROVIDE EMERGENCY EYEWASH/SHOOWER EQUIPMENT PER STATES REQUIREMENTS. (FIGURE E)</td>
<td></td>
</tr>
<tr>
<td>2. PIPE LABELING/PROCESS COMMUNICATION</td>
<td>9. PROVIDE COMPREHENSIVE HAZARD COMMUNICATION AND EMERGENCY RESPONSE AWARENESS TRAINING OF EMPLOYEES WHO HANDLE OR WORK AROUND WATER TREATMENT CHEMICALS. ASSURE UPDATED TRAINING PRIOR TO NEW CHEMICALS BEING DELIVERED TO THE SITE.</td>
<td></td>
</tr>
<tr>
<td>3. LIGHTING AND VENTILATION</td>
<td>10. PROVIDE CHLORINE SENSORS TO DETECT LEAKS AND SCRUBBERS TO EXHAUST AND NUTRILIZE LEAKS. (FIGURE F)</td>
<td></td>
</tr>
<tr>
<td>4. CHEMICAL HANDLING</td>
<td>11. CHEMICAL SYSTEM ISOLATION TO INCLUDE DOUBLE-BLOCK AND BLEED VALVES OR FLANGES WITH SPECIFICAL BLINDS.</td>
<td></td>
</tr>
<tr>
<td>5. FALL PROTECTION</td>
<td></td>
<td></td>
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<tr>
<td>6. HAZARD COMMUNICATION</td>
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</tbody>
</table>

**Diagram:**
- Flow sensor to control room with flashing light at eyewash/shower location.
- Slope floor to drain.
- Install chemical monitoring systems recommended in all locations where chemicals are handled, stored, or transported.
- Connect monitors to interior/exterior alarms and to siren system.
- Chemicals can be lighter or heavier than air. Locate most exhaust vents at floor level.

**NOT FOR CONSTRUCTION**

**PREVENTION-THROUGH-DESIGN AND HAZARD MITIGATION OPTIONS**

**CHEMICAL FEED SYSTEMS**

*Figure E*

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<th>POTENTIAL HAZARD(S)</th>
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<tr>
<td>TANKS/PUMPS/PIPES &amp; FLANGES</td>
<td>1. CHEMICAL LEAKS</td>
</tr>
<tr>
<td></td>
<td>2. CHEMICAL HANDLING</td>
</tr>
<tr>
<td>Valve/Diffusers</td>
<td>3. FALL PROTECTION</td>
</tr>
<tr>
<td></td>
<td>4. ACCESS &amp; MAINTENANCE</td>
</tr>
</tbody>
</table>

**MITIGATION OPTIONS**

**STORAGE & PROCESS TANKS** – (FIGURE A – SHEET CHEM_FEED-PTD-4)
1. SIZE STORAGE TANKS FOR DELIVERY VOLUME PLUS PLANNED SURPLUS.
2. PROVIDE DEDICATED CHEMICAL TANK FILL LINES WHICH ARE CLEARLY LABELED AND ARE EQUIPPED WITH LEVEL INDICATORS AT FILL POINT.
3. PROVIDE REDUNDANT FILL POINT LEVEL INDICATORS
   - ELECTRIC (ULTRA SONIC)
   - LEVEL GAUGE (JOGLER ULSS & PUREFLEX)
4. CAREFULLY EVALUATE USE OF DAY TANKS VS. DIRECT FEED FROM STORAGE.
5. SPECIFY SIDE-ENTRY MANWAYS ON ALL CHEMICAL STORAGE TANKS. SIDE ENTRY STORAGE SIGNIFICANTLY DECREASES LEVEL-OF-EFFORT AND COSTS ASSOCIATED WITH TANK MAINTENANCE AND CLEANING. IT SHOULD BE NOTED THAT SIDE ENTRY MANWAYS CANNOT BE INSTALLED ON POLYETHYLENE TANKS. THIS LIMITS SELECTION TO FRP OR STEEL TANKS.

**PUMPS**
1. DESIGN FOR MODERATE PRESSURE DISCHARGE (80 PSI)
2. DIAPHRAGM METERING PUMP RECOMMENDED.
3. HYDRAULICALLY DRIVEN DIAPHRAGM PUMPS ARE LESS LIKELY TO REQUIRE MAINTENANCE, BUT THE MAINTENANCE IS MORE INVOLVED.
4. MECHANICALLY DRIVEN DIAPHRAGM PUMPS ARE MORE LIKELY TO REQUIRE MAINTENANCE BUT THE MAINTENANCE IS LESS INVOLVED.
5. ALL PUMPS SHOULD BE EQUIPPED WITH THE FOLLOWING:
   - STRAINER
   - DISCHARGE PRESSURE GAUGE
   - PULSATION DAMPENER
   - BULK PRESSURE VALVE
   - ANTI-SIPHON LOOP

**MITIGATION OPTIONS (CONT'D)**

**PIPING AND FLANGES**
1. PIPING, VALVES AND FLANGES SHOULD BE ROBUST AND CHEMICALLY RESISTANT.
2. CAREFULLY CONSIDER THE USE OF CARBON STEEL OR ALLOYS WHERE APPROPRIATE. THERMOPLASTIC MATERIALS ARE LESS ROBUST AND CANNOT BE USED ON SYSTEMS WITH HIGH PRESSURE.
3. RECOMMEND USE OF CARPENTER 20 PIPING, VALVES AND FLANGES ON ALL SULFURIC ACID SYSTEMS.
4. DO NOT USE GRAVITY FEED FOR CHEMICAL FEED OR TRANSFER.
5. LABEL CHEMICAL FEED PIPING.

**VALVES**
1. ASSURE ABILITY TO LOCK-OUT/TAG-OUT CHEMICAL TRANSFER ASSEMBLIES USING EITHER DOUBLE BLOCK & BLEED VALVES OR SPECTACLE FLANGES.
2. USE 2 TURN BALL OR PLUG VALVES MATERIALS OTHER THAN HYPOCHLORITE. BALL VALVES ARE EASY TO OPERATE AND DETERMINE IF THEY ARE IN AN OPEN OR CLOSED POSITION.

**DIFFUSERS**
1. ASSURE THAT IN-LINE DIFFUSERS ARE ACCESSIBLE WITHOUT DISASSEMBLY OF CHEMICAL TRANSFER OR WATER CONVEYANCE SYSTEM. PROVIDE LOCAL VALVE ASSEMBLY TO FACILITY MAINTENANCE AND SERVICE.
Appendix D: Best Practices in Hazard Mitigation

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*FIGURE - A

VERTICAL STORAGE

PREVENTION-THROUGH-DESIGN AND HAZARD MITIGATION OPTIONS

CHEMICAL FEED SYSTEMS

NOT FOR CONSTRUCTION

FIGURE

CHEM_FEED-PTD-4
<table>
<thead>
<tr>
<th>PROCESS/STRUCTURES</th>
<th>POTENTIAL HAZARD(S)</th>
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</table>
| CLOSED TOP BASINS/CHAMBERS/SUMPS/VAULTS | 1. LIGHTING AND VENTILATION  
2. ACCESS & CLEANING/MAINT. REQUIREMENTS  
3. FALL PROTECTION  
4. HAZARD COMMUNICATION  
5. ELECTRICAL SHOCK  
6. CHEMICAL SYSTEMS. |

**MITIGATION OPTIONS**

1. LIGHTS AND VENTILATION TURN ON AUTOMATICALLY WHEN DOOR OR HATCH IS OPENED (PREFERRED) OR OPERABLE FROM EXTERIOR SWITCH BY DOOR. INCLUDE INSTRUMENTATION TO VERIFY VENTILATION IS WORKING. (FIGURE A – SHEET CLOSED_TOP_PTD-2).

1a. LOCATE LIGHTS IN EASILY ACCESSIBLE LOCATION FOR CHANGING BULBS. (SEE ELECTRICAL MITIGATIONS, SHEET ELECTRICAL-SYSTEMS).

2. ASSESS ACCESS AND MAINTENANCE REQUIREMENTS, ASSURE APPROPRIATE AREA FOR WORKERS TO MANEUVER, REACH FASTENERS, AND HANDLE HEAVY EQUIPMENT. ASSURE APPROPRIATE CLEARANCE OF VALVES, PUMPS, OTHER HEAVY EQUIPMENT FROM WALLS, FLOORS, AND OTHER EQUIPMENT TO MANIPULATE FASTENERS AND FACILITATE USE OF MATERIAL HANDLING AND LIFTING EQUIPMENT. (FIGURE C – SHEET CLOSED_TOP_PTD-2)

3. PROVIDE FALL PROTECTION. EQUIP ACCESS POINTS WITH SELF CLOSING SAFETY GATE/AND OR WORK PLATFORM WITH FALL ARREST ANCHOR POINTS. INCLUDING PORTABLE DAVIT ARM MOUNT FOR MATERIAL HANDLING, FALL ARREST AND RESCUE CAPABILITIES WITH ENGINEERED ANCHOR POINTS. (FIGURE D – SHEET CLOSED_TOP_PTD-2)

4. LABEL CHEMICAL FEED PIPING. DEVELOP AND IMPLEMENT CONFINED SPACE ENTRY PROCEDURE AND VALVE LOCKOUT PROCEDURE. PROVIDE APPROPRIATE SIGNAGE FOR HAZARD COMMUNICATION.

5. MEANS FOR LOCAL DISCONNECT AND ISOLATION OF MECHANICAL SYSTEM POWER SUPPLY.

6. CHEMICAL SYSTEM ISOLATION OPTIONS INCLUDE DOUBLE-BLOCK AND BLEED VALVES OR FLANGES WITH SPECTACLE BLINDS. PLANT RATE CONTROL VALVE ASSEMBLY EQUIPPED WITH LOCKING VALVE OR FLANGES WITH SPECTACLE BLINDS.

7. HATCH/DOOR MUST BE SIZED TO PROVIDE ADEQUATE HEAD CLEARANCE 7”-0” RECOMMENDED, 6”-8” MINIMUM. (FIGURE A & C1 – SHEET CLOSED_TOP_PTD-2)

**MITIGATION OPTIONS (CONT’D)**

8. PIPELINE RISERS AND OTHER INFREQUENT ACCESSED, SMALL CONFINED SPACES MAY HAVE LADDER ACCESS ONLY.

**WORK PRACTICE CONSIDERATIONS:**

a. ASSESSMENT TO DETERMINE IF STRUCTURES ARE TO BE DESIGNATED AS CONFINED SPACES (PERMIT-REQUIRED OR NON-PERMIT-REQUIRED), RELATIVE TO THE MRWTP CONFINED SPACE ENTRY POLICIES AND PROGRAMS. LABEL SPACE APPROPRIATELY.

b. DEVELOP A FALL PROTECTION PLAN/STRATEGY BASED ON EXISTING MD EXPERIENCE, FALL ARREST EQUIPMENT, AND ACCESS FREQUENCY.
### MITIGATION OPTIONS

1. Utilize main-tie-main buses and redundant utility feeds to provide full system redundancy. This will allow individual power buses to be de-energized for maintenance and repair by opening main and tie breakers, thus allowing repair of bus feeder breakers by qualified personnel without PPE. Note that main and tie breaker compartments will still have live power feeds in the compartments and will still be susceptible to arc flash hazard. (Figure A – Sheet Electrical Sys-1)

2. Provide breakers or disconnects at the bus or transformer ahead of the main-tie-main gear to allow lock-out/tag-out ahead of the gear and de-energize the main breaker compartment completely. Provide a main-tie-main configuration to allow the primary bus tie breaker to be completely isolated from power by opening the secondary tie breaker. (Figure A – Sheet Electrical Sys-1)

3. Utilize arc-flash reduction maintenance devices on circuit breakers to provide a maintenance setting that enables a faster fault clearing time on the circuit breaker to reduce incident energy levels on buses downstream of the breaker.

4. Utilize low resistance grounding on medium voltage systems. Low resistance grounding provides a means to limit ground fault current to an acceptable level to allow ground fault relay protection on the circuit breakers in the system and can reduce the arc flash/blast incident energy levels for personnel in close proximity to the ground fault. Solidly grounded low voltage systems allow high speed sensing of ground faults.

5. Include updated specifications language to indicate completion of arc flash analysis, labeling, etc., in concert with coordination study.

6. Implement an electrical safety program compliant with NFPA 70E for all work to be performed on energized equipment.

### POTENTIAL HAZARD(S)

1. Arc flash/blast incident while performing maintenance on live electrical buses.

2. Arc flash/blast incident in open main and tie breaker compartments due to live power feeds ahead of the breakers.

3. Arc flash/blast incident in open main and tie breaker compartments due to live power feeds ahead of the breakers.

4. Electrical shock

5. Lighting

### MITIGATION OPTIONS (CONT’D)

7. Specifically required electrical contractors to comply with 70E.

8. Identify and train “qualified persons” as defined by NFPA 70E regarding implementation of the electrical safety program.

9. Use personal protection equipment (PPE) as designated in NFPA when working on energized equipment.

10. Evaluate the cost and benefits of a simple or radial electrical system. Best practice in the water industry improves safety and reliability through use of main-tie-main or main-tie-main electrical service system and use of double ended gear. This system provides redundant feeds to primary main equipment and control systems down to 480 volts.

11. Provide means for local disconnect and isolation of mechanical system power supply.

12. Equip medium voltage systems with high impedance grounding.

13. Equip low voltage systems with high impedance grounding.

14. Equip 120 volt systems with ground fault interruptions.


16. Refer to the IES Lighting Handbook for illumination categories and values and further recommendations for specific area/activities.

### WORK PRACTICE CONSIDERATIONS

a. Develop and implement an electrical safety program compliant with NFPA 70E for all work to be performed on energized equipment. Identify and train qualified persons as defined by NFPA 70E regarding implementation of the electrical safety program. Use personal protective equipment as designated in NFPA 70E when working on energized equipment.

b. Specify outdoor lighting fixtures mounted on poles at a maximum height of 14’-0” with hinged bases. If hinged bases are not possible on metal walkways over basins, mount fixtures at a lower height so ladders are not needed.

c. Specify indoor HID lighting fixtures with cable lowering devices so fixtures can be lowered to the floor.
Appendix D: Best Practices in Hazard Mitigation

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*FIGURE - A

NOT FOR CONSTRUCTION

PREVENTION THROUGH DESIGN
HAZARD MITIGATION OPTIONS

ELECTRICAL SYSTEMS

ELECTRICAL SYS-1
## GENERAL CONVEYANCE SYSTEMS

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<tr>
<td>HIGH SERVICE PUMPING</td>
<td>PUMPS, OVERHEAD BRIDGE CRANE, WET WELLS</td>
<td>1. NOISE FROM PUMPING UNITS, 2. OVERHEAD BRIDGE CRANE</td>
<td>1. SEPARATE PUMPS FROM NORMAL OPERATING AREAS, INSTALL ACOUSTICAL PANELS, 2. PROVIDE ADEQUATE SPACE AROUND EQUIPMENT, 3. PROVIDE GUARDS AROUND MOVING EQUIPMENT, 4. PROVIDE LADDERS WITH SAFETY CAGES INTO WETWELLS, 5. PROVIDE SEPARATE OPENINGS FOR ACCESS AND VENTILATION.</td>
</tr>
<tr>
<td>INTAKE PUMP STATION</td>
<td>SCREENS, PUMPS, OVERHEAD BRIDGE CRANE</td>
<td>1. STRUCK BY/PINCH POINTS, 2. NOISE, 3. CONFINED SPACE</td>
<td>1. SEPARATE PUMPS FROM NORMAL OPERATING AREAS, INSTALL ACOUSTICAL PANELS, 2. PROVIDE ADEQUATE SPACE AROUND EQUIPMENT, 3. PROVIDE GUARDS AROUND MOVING EQUIPMENT, 4. ALLOW PROPER VENTILATION, USE SCREENS THAT ARE DESIGNATED TO BE REMOVED FROM CONFINED SPACES FOR MAINTENANCE.</td>
</tr>
<tr>
<td>MICRO-FILTRATION/REVERSE OSMOSIS-DESLALIZATION-DAF FILTRATION</td>
<td>FEED PUMPS</td>
<td>1. CHEMICALS, 2. STRUCK BY, 3. CAUGHT IN-BETWEEN</td>
<td>1. PROVIDE ADEQUATE SPACE AROUND EQUIPMENT, (FIGURE A), 2. PROVIDE GUARDS AROUND MOVING EQUIPMENT, 3. PROVIDE MEANS FOR SHUTOFF OUTSIDE THE CHEMICAL FEED ROOMS.</td>
</tr>
<tr>
<td>CIP SYSTEMS/GENERAL DUTY SYSTEMS</td>
<td>COMPRESSED AIR SYSTEM</td>
<td>1. EXCESSIVE NOISE</td>
<td>1. SPECIFY MAXIMUM PRESSURE LEVELS FOR EQUIPMENT, REQUIRE MANUFACTURER TO CERTIFY, 2. MODEL POTENTIAL SOUND LEVELS WITH EQUIPMENT RUNNING, DESIGN APPROPRIATE DAMPENING SYSTEMS FOR CONDUCTIVE NOISE AND EFFECTIVE ENCLOSURES FOR NOISE REDUCTION, 3. PROVIDE MEANS FOR LOCAL DISCONNECT AND ISOLATION OF MECHANICAL SYSTEMS POWER SUPPLY.</td>
</tr>
</tbody>
</table>

**FIGURE - A**

**NOT FOR CONSTRUCTION**

**PREVENTION-THROUGH-DESIGN AND HAZARD MITIGATION OPTIONS**

**GENERAL CONVEYANCE SYSTEMS**

**GEN_CONVEYANCE**
### Appendix D: Best Practices in Hazard Mitigation

**PROCESS / STRUCTURES**

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<td>3. FALL PROTECTION</td>
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<tr>
<td>4. HAZARD COMMUNICATION</td>
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<td>5. ELECTRICAL SHOCK</td>
<td></td>
</tr>
<tr>
<td>6. CHEMICAL SYSTEMS.</td>
<td></td>
</tr>
<tr>
<td>1. PROVIDE HANDRAIL AROUND BASINS. KEEP INSTRUMENTATION AND EQUIPMENT INSIDE HANDRAILS. PROVIDE LADDERS INTO OPEN TOP STRUCTURES. ELEVATED WORK LOCATIONS THAT ARE NOT BUILDINGS OR BUILDING STRUCTURES; GUARDRAILS REQUIRED IF MORE THAN 4' FALL HAZARD; EXCEPTION -- ELEVATED LOCATIONS USED INFREQUENTLY IF EMPLOYEES ARE PROTECTED BY FALL RESTRAINT/FALL ARREST SYSTEM, ATTACHED TO ACCEPTABLE ANCHOR POINTS. (FIGURE A &amp; B)</td>
<td></td>
</tr>
<tr>
<td>2. ASSESSMENT OF ACCESS POINT REQUIREMENTS, LOCATE ACCESS POINTS TO PROVIDE MAXIMUM FLEXIBILITY, LIMIT MATERIAL HANDLING. NEVER LOCATE PERMANENT LADDER IN WATER-BEARING STRUCTURES.</td>
<td></td>
</tr>
<tr>
<td>3. PROVIDE FALL PROTECTION, EQUIP ACCESS POINTS WITH SELF CLOSING SAFETY GATE/AND OR WORK PLATFORM WITH FALL ARREST ANCHOR POINTS, INCLUDING PORTABLE DAVIT ARM MOUNT FOR MATERIAL HANDLING, FALL ARREST AND RESCUE CAPABILITIES WITH ENGINEERED ANCHOR POINTS. (FIGURE B)</td>
<td></td>
</tr>
<tr>
<td>4. LABEL CHEMICAL FEED PIPING, DEVELOP AND IMPLEMENT CONFINED SPACE ENTRY PROCEDURE AND VALVE LOCKOUT PROCEDURE, PROVIDE APPROPRIATE SIGNAGE FOR HAZARD COMMUNICATION.</td>
<td></td>
</tr>
<tr>
<td>5. MEANS FOR LOCAL DISCONNECT AND ISOLATION OF MECHANICAL SYSTEM POWER SUPPLY.</td>
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<tr>
<td>6. CHEMICAL SYSTEM ISOLATION OPTIONS INCLUDE DOUBLE-BLOCK AND BLEED VALVES OR FLANGES WITH SPECTACLE BLINDS. PLANT RATE CONTROL VALVE ASSEMBLY EQUIPPED WITH LOCKING VALVE OR FLANGES WITH SPECTACLE BLINDS.</td>
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</tbody>
</table>

**WORK PRACTICE CONSIDERATIONS:**

- **a.** ASSESSMENT TO DETERMINE IF STRUCTURES ARE TO BE DESIGNATED AS CONFINED SPACES (PERMIT-REQUIRED OR NON-PERMIT-REQUIRED), RELATIVE TO THE MNR/WP CONFINED SPACE ENTRY POLICIES AND PROGRAMS. LABEL SPACE APPROPRIATELY.

- **b.** DEVELOP A FALL PROTECTION PLAN/STRATEGY BASED ON EXISTING MID EXPERIENCE, FALL ARREST EQUIPMENT, AND ACCESS FREQUENCY.

---

**NOT FOR CONSTRUCTION**

- **PREVENTION-THROUGH-DESIGN AND HAZARD MITIGATION OPTIONS**
  - OPEN-TOP WATER BEARING STRUCTURES
  - OPEN TOP-PID

---

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**PROCESS / STRUCTURES**

**PIPE GALLERIES**

**POTENTIAL HAZARD(S)**

1. ACCESS & CLEANING/MAINT. REQUIREMENTS
2. FALLS/SLIPS/TRIPPING HAZARDS
3. HAZARD COMMUNICATION
4. LEAKS

**MITIGATION OPTIONS**

1. ASSESS PIPE GALLERY FLOOR PLAN TO DETERMINE WORK FLOW, IDENTIFY SYSTEMS/EQUIPMENT THAT REQUIRE FREQUENT MAINTENANCE/SERVICING, AND LOCATE EQUIPMENT TO FACILITATE PERFORMANCE OF MAINTENANCE ACTIVITIES WITHOUT USE OF FALL PROTECTION OR OTHER ACCESS LIMITATIONS. (FIGURE A)

2. ASSURE ALL BUILDING SYSTEMS (LIGHTING, VENTILATION, ETC.) ARE DIRECTLY ACCESSIBLE FROM THE FLOOR OR OTHER WORK PLATFORM. (SEE ELECTRICAL SYS. MITIGATIONS FOR LIGHTING)

3. ASSURE IMMEDIATE DEPLOYMENT OF FALL PROTECTION CONTROLS ON PIT COVERS AND ELEVATED PLATFORMS/WALKWAYS. ELIMINATE HOLES, AND OTHER FLOOR PENETRATIONS OR LOCATE IN EASILY CONTROLLED AREA (WITH HANDRAILS, ANCHOR POINTS, ETC.). (FIGURE C)

4. ASSURE APPROPRIATE CLEARANCE OF VALVES, PUMPS, OTHER HEAVY EQUIPMENT FROM WALLS, FLOORS, AND EQUIPMENT TO MANIPULATE FASTENERS AND FACILITATE USE OF MATERIAL HANDLING AND MECHANICAL LIFTING TECHNIQUES. (FIGURE A)

5. ORIENT VALVE ASSEMBLIES AND ELECTRICAL/PNEUMATIC MOTORS AND CONTROL UNITS TO FACILITATE MAINTENANCE AND SERVICING. (FIGURE A)

6. WHERE FALL PROTECTION IS REQUIRED, EQUIP ACCESS POINTS WITH FALL PROTECTION EQUIPMENT INCLUDING PORTABLE DAVIT-ARM MOUNT FOR MATERIAL HANDLING, FALL ARREST, AND RESCUE CAPABILITIES, ENGINEERED ANCHOR POINTS. (FIGURE C1)

7. PROVIDE DOUBLE WALL PIPE FOR DANGEROUS CHEMICALS. ARRANGE PIPING SO LEAKS WILL NOT DAMAGE OTHER EQUIPMENT.

8. ARRANGE PIPING, DUCTS, CONDUIT AND OTHER EQUIPMENT SUCH THAT ALL ARE ACCESSIBLE FROM A LADDER, LIFT OR OTHER DEVICE.

**WORK PRACTICE CONSIDERATIONS:**

a. DEVELOP A FALL PROTECTION PLAN/STRATEGY BASED ON EXISTING MID EXPERIENCE, FALL ARREST EQUIPMENT, AND MAINTENANCE FREQUENCY.
REFERENCES


ABBREVIATIONS

American National Standards Institute (ANSI)
American Water Works Association (AWWA)
Bureau of Labor Statistics (BLS)
Cost Benefit (C/B)
Job Safety Analysis (JSA)
Metropolitan Water District (MWD)
Musculoskeletal Disorders (MSDs)
Occupational, Safety and Health Administration (OSHA)
Permit Required Confined Spaces (PRCS’s)
Personal Protective Equipment (PPE)
Project Advisory Committee (PAC)
Prevention-through-Design (Ptd)
Safety and Health (S&H)
Voluntary Protection Program (VPP)