

FINAL REPORT OF THE CALIFORNIA INTEGRATED WATER QUALITY SYSTEM (CIWQS) REVIEW PANEL



Southern California Coastal Water Research Project

Technical Report 561 - May 2008

FINAL REPORT OF THE CALIFORNIA INTEGRATED WATER QUALITY SYSTEM (CIWQS) REVIEW PANEL

Review Panel Members

Dr. Brock Bernstein
Curtis Cude
Dr. John Helly
Ken Lanfear
Tony Lavoie
Jeffrey Rosen
Deb Soule
Dwane Young

Facilitated by:
Dr. Stephen Weisberg

May 2008

Technical Report 561

Table of Contents

| | |
|--|--------|
| Executive Summary | 1 |
| Introduction | 4 |
| CIWQS Background and History | 5 |
| Preliminary Findings and Recommendations | 6 |
| Preliminary Recommendation 1: Reduce the project's scope | 7 |
| Preliminary Recommendation 2: Restructure CIWQS project management..... | 9 |
| Preliminary Recommendation 3: Validate the system requirements | 11 |
| Preliminary Recommendation 4: Rebuild key constituencies..... | 12 |
| Preliminary Recommendation 5: Address data quality issues | 13 |
| Preliminary Recommendation 6: Produce key reports | 14 |
| Preliminary Recommendation 7: Improve user interfaces..... | 15 |
| Final Findings and Recommendations..... | 17 |
| Evaluation of preliminary recommendations | 17 |
| Implementation challenges: Final Recommendations..... | 22 |
| Final Recommendation 1: Develop a deployment plan for the system and its data | 22 |
| Final Recommendation 2: Develop end-to-end tests to demonstrate the system works | 23 |
| Final Recommendation 3: Build a non-CIWQS interface with ICIS-NPDES..... | 23 |
| Final Recommendation 4: Fund CIWQS at an appropriate level..... | 24 |
| Appendix 1: CIWQS Review Panel Members..... | A1 - 1 |
| Appendix 2: Questions Posed to the CIWQS Review Panel | A2 - 1 |

Executive Summary

This report presents both the preliminary and final findings and recommendations of the California Integrated Water Quality System (CIWQS) Review Panel¹, which was convened in response to a request from the State Water Resources Control Board to conduct an external review of CIWQS. This review was prompted by serious concerns about the State Water Board's and Regional Water Quality Control Boards' (Regional Water Boards) ability to use CIWQS to fulfill core responsibilities related to water quality permitting, enforcement, and reporting. The Panel held an initial meeting in May 2007 to identify issues and make recommendations and a follow-up meeting in February 2008 to check on progress and make a final set of additional recommendations.

At its second meeting in February 2008, the Panel was tremendously impressed by the program's receptivity to external comments and by the amount of tangible progress at resolving the fundamental weaknesses identified during the Panel's first meeting. Most importantly, CIWQS' management has been completely restructured, concerns about the system's technical validity are being addressed, and key user constituencies are now directly engaged in the program and strongly support it. This remarkable turnaround was due to a profound cultural shift in the program that was fully supported by upper management in the State Water Board. As a result of these changes, the Panel believes that the program is now on a path to success.

The situation the Panel found in February 2008 was in striking contrast to the one observed in May 2007. Presentations and discussion at that meeting made it clear that CIWQS was a dysfunctional program on the verge of collapse. There were serious and unresolved concerns about the technical soundness of the underlying database design and its implementation. Concerns were based on unacceptably high error rates in both raw data and in the compliance determinations derived from the data. As a result, several major dischargers refused to use the system. There were fundamental flaws in the program's management structure and decision-making processes, which had contributed to CIWQS' technical problems and continued to prevent the implementation of effective solutions. As a result of these shortcomings, the program lacked credibility. Key constituencies within the State Water Board and Regional Water Boards, the discharger community, and United States Environmental Protection Agency (USEPA) had little confidence in the system and, in fact, were calling for CIWQS' termination.

The Panel's first set of recommendations were based on the findings of the first review in May 2007. The Panel believed that successfully addressing these issues would be critical to the program's survival and eventual success. These recommendations included:

Preliminary recommendation 1: Reduce the project's scope.

The original scope was so broad it prevented the program from effectively achieving any of its goals. Therefore, CIWQS needed to identify a core set of functions related to permitting and compliance and define the major external interfaces required to exchange data with other key state and federal systems².

Preliminary recommendation 2: Restructure CIWQS' project management.

CIWQS' management structure was ineffective and dysfunctional. Therefore, decision-making authority needed to shift from the Office of Information Technology (OIT) and be placed under the direction of the Division of Water Quality (DWQ). This would allow decision making to be guided by managers with specific knowledge of program requirements and users' needs.

¹ Throughout this report, the CIWQS Review Panel will be referred to as the "Panel".

² Throughout this report, information management systems will be referred to as "systems".

Preliminary recommendation 3: Validate the system requirements.

Initially, there was near-universal skepticism about CIWQS' essential technical soundness. Therefore, the program needed to assess the system's basic functionality with empirical tests using representative complex permits and fully define all business rules. The potential for future problems should be minimized by conducting this and all future design and implementation efforts using formal systems engineering best practices.

Preliminary recommendation 4: Rebuild key constituencies.

CIWQS' key constituencies have little confidence in the system and many have developed shadow systems to avoid having to use CIWQS. Therefore, the program needed to create a steering committee that would include a broad cross-section of key user groups, report directly to the State Water Board's Chief Deputy Director, and be required to sign off on design and implementation decisions.

Preliminary recommendation 5: Address data quality issues.

There were broad concerns about the accuracy of legacy data imported into CIWQS, as well as the system's propensity to create false violations as faulty compliance algorithms were applied to dischargers' self monitoring reports. Therefore, the program needed to resolve these fundamental data quality issues by quantifying the extent of the problem, identifying and fixing the source(s) of errors, and correcting errors in existing data. As needed, underlying data structures, data entry procedures, and quality control tools should be revised.

Preliminary Recommendation 6: Produce key reports.

Initially, CIWQS lacked the ability to provide the full range of needed reports to support internal system management and to meet the needs of key user groups. Therefore, the program needed to identify and prioritize needed reports, and begin producing them on an explicit schedule.

Preliminary Recommendation 7: Improve user interfaces.

The original user interfaces appeared complex and difficult to use, did not always accurately reflect business rules, and lacked context-sensitive documentation and help. The program needed to redesign user interfaces to better reflect users' workflow and to simplify data entry and retrieval procedures. These changes should be evaluated with formal usability testing.

Each of the Preliminary Recommendations was associated with specific benchmarks and milestones for achieving them. Between May 2007 and February 2008, the CIWQS project team and its State Water Board management considered the Panel's preliminary report and began to implement plans to respond to the Panel's recommendations. The program succeeded at reducing the project's scope, restructuring its management, validating the system requirements, and rebuilding its key constituencies (Preliminary Recommendations 1 - 4, respectively). However, additional work remains to be done with respect to Preliminary Recommendations 5 - 7. As a result of this progress, the Panel believes CIWQS has laid the foundation for future success, and the additional Final Recommendations below are intended to solidify this foundation:

Final Recommendation 1: Develop a deployment plan for the system and its data.

CIWQS fixes and system updates have been released on sometimes arbitrary schedules without comprehensive testing or evaluation of their implications for data quality or ease of use. Therefore, the Panel recommends that the CIWQS project team base its plans for release of subsequent versions of the system on a systematically scheduled process that includes software design and comprehensive testing, data input and quality control, and an assessment of hardware and software needs across the entire user community.

Final Recommendation 2: Develop ongoing, end-to-end testing to validate the system throughout its lifetime.

The Panel was impressed by the success of the end-to-end testing conducted to identify and resolve questions about the system's basic technical soundness. This process produced changes in both the program and its scope that resulted in significant improvements. Therefore, the Panel recommends that CIWQS incorporate the rigorous evaluation of realistic test cases as an integral part of its future system design, development, and deployment process.

Final Recommendation 3: Build a non-CIWQS interface with ICIS-NPDES.

The federal Integrated Compliance Information System associated with the National Pollution Discharge Elimination System (ICIS-NPDES) reporting system is a key CIWQS client whose needs have not been met. Therefore, the Panel recommends that the State Water Board evaluate available alternatives for transferring needed data among dischargers, CIWQS, and the federal ICIS-NPDES system. Because state and federal reporting and decision-making requirements differ, this interface should accommodate both state and federal needs and be developed in cooperation with the USEPA.

Final Recommendation 4: Fund CIWQS at an appropriate level.

CIWQS has suffered from a mismatch between its stated goals and its funding. Therefore, the Panel recommends that CIWQS conduct a budget analysis with consideration to the Panel's recommendations. Based on this analysis the State Water Board and the Legislature should then fund CIWQS at a level sufficient to accomplish the Panel's recommendations, as well as to support long-term system maintenance, operations, and continuous improvement.

Introduction

This report presents both the preliminary and final findings and recommendations of the California Integrated Water Quality System (CIWQS) Review Panel (Appendix 1), referred to throughout this report as the “Panel”, which was convened in response to a request from the State Water Board to conduct an external review of the CIWQS program. The Panel was originally presented with a list of four specific questions (Appendix 2) focusing on management, technical, and resource issues. The Panel heard presentations from CIWQS staff and users, as well as representatives of other related programs, over a two-day meeting in May 2007. The Panel then met in executive session on the third day to develop its preliminary findings and recommendations. These findings and recommendations were provided verbally to the CIWQS project team at the May meeting and in a more formal written report in July 2007.

Each of these recommendations was associated with a number of specific benchmarks of progress with timeframes for achieving them. Between May 2007 and February 2008, the CIWQS project team and its State Water Board management developed and began to implement plans for addressing the Panel’s recommendations. The Panel reconvened in February 2008 to hear and assess the CIWQS project team’s progress in meeting the required benchmarks. Based on the presentations and discussion at the February meeting, the Panel then prepared this final report which contains an assessment of CIWQS’ progress, along with a number of additional recommendations.

The following sections provide background on the CIWQS program and present the Panel’s preliminary and final recommendations:

- **CIWQS Background and History**
Describes CIWQS’ original goals, as well as the history and rationale for decisions about the development of the information management system (referred to in this report as “system”)
- **Preliminary Findings and Recommendations**
Presents the results of the Panel’s May 2007 meeting by including the preliminary report submitted separately in July 2007
- **Final Findings and Recommendations**
Based on the Panel’s February 2008 meeting, evaluates overall program progress and progress toward each of the preliminary recommendations, provides supplementary recommendations and benchmarks, and presents four final recommendations

CIWQS Background and History

State and federal water quality regulations define a permitting, enforcement, and reporting structure that requires the collection and integration of data from across the state. The efficient and accurate functioning of this structure depends on effective information management. Activities related to required functions include:

- Issuing permits
- Assisting permittees with compliance
- Inspecting facilities
- Reviewing discharger self monitoring reports
- Investigating complaints
- Taking enforcement action against violators
- Tracking results of compliance and enforcement
- Meeting state and federal reporting requirements

In the past, these regulatory requirements have been addressed in a variety of ways by the State Water Board and the nine semi-independent Regional Water Quality Control Boards (Regional Water Boards). Beginning in the late 1990s, several, but not all, of these functions were incorporated into a collaborative data management program, State Water Information Management system (SWIM). While SWIM represented an improvement over prior approaches, it had significant limitations that increased as time went on. For example, the following issues arose: duplication of data entry and reporting efforts, significant difficulties maintaining legacy database systems, gaps in the coverage of key functions such as permitting, poor access to data for decision making, and limitations on World Wide Web access. These issues continued to limit the State Water Board's and Regional Water Boards' overall performance.

Given ongoing pressure to meet key management and statutory requirements, the State Water Board and Regional Water Boards continued to develop and use a variety of hardware and software systems, along with paper tools, to fulfill these requirements. Such approaches, including SWIM, were partly effective, but did not enable the standardization, integration, or sharing of data. Nor did they provide a basis for resolving fundamental inefficiencies and sources of inaccuracy in the water quality regulation system. As a result, the Water Boards had failed to fully meet their basic water quality mission and California routinely failed to report water quality permit information and discharger monitoring results to the United States Environmental Protection Agency (USEPA).

In response to these acknowledged problems, the State Water Board in 2001-2002 defined the specifications of a new system, called SWIM2. This new system was intended to encompass not only the permitting and enforcement tasks described above, but all water quality related data, including ambient monitoring and assessment functions. The data definitions and program processes involved in these functions were captured in a formal Enterprise Data Model (EDM) that was to form the basis for the detailed development and implementation of the SWIM2 system. However, SWIM2's broad scope meant that the EDM did not directly reflect the specifics of the business practices in any of the State or Regional Water Boards' programs. Rather, the EDM was abstract and generalized in ways that required extensive a priori standardization and the precise definition of business rules for its successful use, efforts that have not yet been completed. Further, the data model that resulted from the attempt to generalize the data requirements to the broad range of issues identified in the original scope was so complicated that only a very few database administrators could understand it. This complexity led to the implementation of unnecessary work arounds by a variety of contractors to meet specific program requirements and

deadlines. These work arounds were an important contributor to the failure of the system observed by the Panel in May 2007.

SWIM2 was budgeted at just over \$6 million, but funds were never approved by the Legislature. Because of the need to move beyond SWIM, the State Water Board accepted an offer from the USEPA to jointly fund the development of a more limited information management system that would focus only on permitting and enforcement and on reporting key compliance data to the USEPA's Permitting and Compliance System (PCS). The USEPA committed approximately \$0.5 million of direct grant funds and the State Water Board approximately \$1 million of Clean Water Act Section 106 grant funds to this new system, which was called the California Integrated Water Quality System (CIWQS). Following this agreement, a Feasibility Study Report (FSR) was generated in 2003 to guide CIWQS' development.

Because the State Water Board hoped at some point in the future to expand CIWQS beyond the core permitting and enforcement functions, it retained the broader EDM as the basis of the system design. This required the use of generic data models, parameter names, data entry screens, and other system features, a decision that later led to problems with training, user satisfaction, contractor implementation and data quality that have yet to be resolved. Finally, in hindsight it is apparent that the roughly \$1.5 million budget was inadequate for both design and implementation. Despite known deficiencies, the system went "live" on July 1, 2005, with key features, such as reporting, inoperable. Much of the subsequent effort devoted to CIWQS has focused on completing the implementation process, correcting problems caused by apparent incompatibilities between the EDM and the more restricted set of core permitting functions, and addressing users' concerns about the system's usability and the integrity of its data.

Preliminary Findings and Recommendations

The May 2007 presentations, along with follow-up comments from CIWQS program participants, clearly showed that the program was facing severe challenges on three levels:

- Technical, related to the validity and robustness of the underlying system design and its implementation
- Managerial, related to the program's decision-making process and its structure for maintaining accountability
- Credibility, related to the degree of confidence and support among CIWQS' key constituencies within the State Water Board, the Legislature, the USEPA, the discharger community, and the public

The Panel agreed that the decision to develop CIWQS was a response to a valid need within the State Water Board and among the Regional Water Boards. The existing database, SWIM, had a number of limitations that reduced its effectiveness and its increasingly obsolete technology made it extremely difficult to address these limitations. In this context, many aspects of CIWQS represented a logical step forward in improving the state's ability to manage and report on water quality data.

However, the system's original scope was overly broad and highly complex, reflecting the State Water Board's intent that CIWQS be an enterprise data system that incorporates all data related to water quality. Due in part to this complexity, CIWQS' implementation was flawed in important ways virtually from its inception, resulting in persistent concerns about the underlying integrity of the database design itself. These concerns were only heightened by the system's tendency to create false violations from dischargers' monitoring reports and by the significant data error rate created when historical data was imported into the system. CIWQS' flawed management structure, which located decision-making authority within the Office of Information Technology (OIT), was an important cause both of these problems and of the program's inability to effectively resolve them. This was because the OIT was

insulated from user input and had no reporting responsibility to the Division of Water Quality (DWQ) which was ultimately accountable for the system's successful implementation.

As a result of these technical, management, and fiscal problems, the program was overwhelmed and unresponsive to users' concerns. Critical aspects of user buy-in and support, along with the system's ability to integrate with other databases, were damaged or not adequately developed. These problems, combined with the project's limited budget, resulted in persistent uncertainty about the system's fundamental integrity, a legacy of damaged relationships with the user community, and slow progress toward resolving problems and meeting users' needs. In order to accomplish their responsibilities, State Water Board and Regional Water Boards staff, as well as dischargers, have often resorted to the use of an inconsistent collection of alternate databases and tools, as well as paper-based processes, that enabled them to bypass CIWQS. The Panel agreed with the Legislative Analyst that, as a result of these problems, permit management had become less functional than it was before CIWQS was implemented.

The Panel believed that the system's basic concept, despite its design and implementation shortcomings, was essential to the State Water Board's ability to operate. The Panel therefore recommended a number of specific steps the State Water Board must take to meet its goals with respect to CIWQS and to provide a recovery path for CIWQS and the State Board. The following subsections discuss each of the Panel's preliminary recommendations in turn. Please note that the recommendations are interdependent and mutually supportive. They are not intended to be considered and/or implemented in isolation from one another.

Preliminary Recommendation 1: Reduce the project's scope

Finding and analysis

The rescoping that carved CIWQS from the original SWIM2 design did not narrow the system's scope sufficiently, with the result that the available budget was inadequate for accomplishing essential design, development, and implementation tasks. When the Legislature did not fund SWIM2, CIWQS was funded with approximately \$1.5 million of USEPA and State Water Board funds. Because the bulk of these were federal, rather than state, funds, the project did not require Legislative budget approval, but the Feasibility Study Report did undergo the usual review and approval process by the Department of General Services. Despite this review, the project's assumptions about the level of effort needed to design, build, and then implement the system were not seriously challenged.

Despite the rescoping that created CIWQS, SWIM2's broad EDM was retained to provide the basis for expanding the system's scope again in the future should adequate funding become available. In addition, as the Feasibility Study Report shows, several other business processes were retained within the scope, including groundwater monitoring data (GeoTracker), ambient surface water monitoring (SWAMP), and water quality assessment conclusions as required by sections 303(d) and 305(b) of the Clean Water Act (GeoWBS). Thus, while the scope to be implemented was reduced from what was envisioned for SWIM2, the underlying system development philosophy remained similar to that which motivated SWIM2, namely to develop the ability to house and integrate the full range of California's water quality data.

The degree of generality and centralization envisioned for SWIM2, and apparently still underlying CIWQS, requires a degree of centralization and control that can be extremely challenging to achieve in a complex environment such as California's water quality management system. Different business processes, and their attendant data types and formats, can be incompatible in multiple ways. Accommodating this diversity abruptly within a single system demands an unrealistic degree of rapid standardization and procedural compromise that can cause unintended results. This centralized approach

also requires a very complex data model that includes many components whose intended functionality is not understood. This complicates the implementation and was a major factor in the initial difficulties in implementing CIWQS. In contrast, an alternative system design philosophy, termed federation, involves constructing separate systems that are designed for specific business processes and then implementing interfaces between these systems that allow for interoperability through data transfer and protocol integration. For example, under a federation approach, CIWQS might use XML-based protocols to query an independent SWAMP system about ambient monitoring data, and SWAMP could automatically query CIWQS about permit information. An important benefit of this approach is that each of the individual systems are dramatically simplified while standards are imposed that optimize merging data from the separate but related systems.

Many of the comments the Panel heard during the May 2007 meeting acknowledged that, if CIWQS were to be designed now, a federated systems architecture would be preferred over the centralized one originally envisioned. In fact, Tetra Tech's 2006 report to the USEPA and the State Water Board proposed moving directly to a federated approach by abandoning the EDM and rewriting CIWQS with a separate data model focused strictly on the core regulatory functions of permitting, enforcement, and reporting.

Recommendations

CIWQS should move away from a strictly centralized design philosophy and carefully evolve to a federated system structure. CIWQS' scope should be redefined to focus on what have been called its "core regulatory" functions. These include permitting, enforcement, reporting, and electronic self monitoring tasks. In addition to the original functions included in SWIM, the State Water Board has completed two stormwater modules and a sanitary sewer module. These should be retained, since they are operating and focus on regulatory issues. However, the planned ambient monitoring module should not be implemented and the SWAMP's efforts to develop an information management system for ambient monitoring data should be continued as a separate effort. Similarly, the GeoTracker system should be kept as a separate system for the present, with dedicated resources for its maintenance.

More specifically, in terms of the functional requirements defined in Table 2 of the Feasibility Study Report, this would involve:

- 2.D.1. – 1. Refocus to exclude GeoTracker and GeoWBS
- 2.D.1. – 5. Refocus to include only data related to core regulatory functions related to permitting
- 2.D.1. – 21. Refocus to include only data related to core regulatory functions related to permitting
- 2.D.1. – 23. Delete functions related to ambient monitoring data
- 2.D.3. Refocus to include only data related to core regulatory functions.

Reducing CIWQS' scope will require the project to define major external interfaces with other systems so that data can be readily transferred as needed. While this reduces CIWQS core functionality, it also requires resources for working with the developers of these other systems to define, implement, and test interfaces to ensure interoperability. Since reporting to the USEPA's PCS/ICIS is a core CIWQS function, an explicit interface with PCS/ICIS should be defined and implemented as soon as possible. Concepts for interfacing with other State systems such as SWAMP's ambient monitoring database, GeoTracker, and the California Environmental Data Exchange Network (CEDEN) should be developed and detailed interface procedures then implemented once CIWQS can demonstrate the ability to perform the core regulatory functions.

Benchmarks

The following benchmarks were set for February 2008 progress review:

- Develop an explicit definition of CIWQS' core regulatory functions
- This definition has been reviewed and approved by the Steering Committee
- All members of the CIWQS team understand and agree with the new scope

Preliminary Recommendation 2: Restructure CIWQS project management

Finding and analysis

The implementation of the CIWQS project was flawed in several important respects that, in combination, made it extremely difficult for the project to succeed. These failings can be traced to a series of decisions, most of which stemmed from three related causes:

- An ineffective division of labor and responsibility between the State Water Board's and USEPA's contractors
- A fundamental split in the project's management structure between the Division of Water Quality (DWQ) and the Office of Information Technology (OIT)
- A model of institutional change that involved compelling change in the Regional Water Boards' business processes through the implementation of new information management systems

The following paragraphs describe the series of problematic decisions and the ways in which they either flowed from or were exacerbated by the project's management structure and its model of change.

The USEPA directly contributed one-third (approximately \$0.5 million) of the project's funding, but did not provide the bulk of the contractor support through Clean Water Act Section 106 grant funding. The USEPA and State Water Board contractors and staff worked independently, with poorly defined system requirements and a lack of both strong engineering leadership and clear system engineering procedures. This predictably resulted in a separation of responsibility and authority that was reflected in divergent goals for the system. Those responsible for the underlying data structure disagreed about fundamental engineering issues with those responsible for application development. It is likely that much of the confusion apparent in aspects of the system design was due to the allocation of design and implementation tasks to these two inadequately coordinated teams. This problem was amplified by contractors' failure to fully understand the complex nuances of the design and by their resultant use of work arounds that short circuited internal safeguards of database integrity.

As it became clear that the project's budget was inadequate for completing all elements defined in the Feasibility Study Report, the system's scope was progressively trimmed over the months leading up to the formal release date of July 1, 2005. By all accounts, this decision process was disorganized, not well informed by user input, and beset by conflicts between Regional Water Board staff, DWQ, and OIT staff about priorities. The lack of a consistent process for prioritizing system changes continues to bedevil the project. CIWQS was initially released in July 2005 without a reporting function. From a program perspective, this meant that the system had minimal functionality. However, the system had been judged ready for release by OIT, which in part reflected inherently different perspectives between program staff and OIT staff that were never reconciled. Effective user input would have clearly identified that the system was not ready for release.

Just prior to July 2005, the Regional Water Boards' Executive Officers recommended strongly to the Management Coordinating Committee that CIWQS not be released and that SWIM continue to be used in

parallel until CIWQS reached full functionality. Despite this recommendation, CIWQS was released as planned and SWIM almost simultaneously shut down, which forced users to use CIWQS though it was not yet fully functional. The Executive Officers' recommendation was disregarded for two main reasons. First, pressures to meet the Feasibility Study Report's schedule and budget had more weight than concerns (primarily from the Regions) about the system's functionality. Second, State Water Board staff were determined to foster change in the Regional Water Boards' business practices. Past conflicts between the State Water Board and the Regional Water Boards over centralization and coordination contributed to the State Water Board's determination to force this issue by shutting down SWIM, despite the risks involved in the startup of any major new information management system.

The decision to release CIWQS in July 2005 was made in concert with the related decision not to submit a Special Project Report (SPR) to the Department of Finance seeking a budget and schedule extension. Within state agencies, submitting such a report can have unpredictable results, but typically involves stopping work on the project. The desire to maintain momentum, and to avoid the unpredictable consequences of an SPR led to a further cascade of problematic decisions as the State Water Board attempted to complete the system while it was operating, with the result that the project fell further and further behind as problems mounted, some users abandoned the system, and confidence in the system's usability declined.

Recommendations

The State Water Board must ensure that users' needs have a central place in management decisions about system design and implementation. Thus, project control should reside with those who have knowledge of the business mission and direct responsibility for its implementation and success. This could be accomplished by establishing a CIWQS team, consisting of staff from DWQ and OIT, and with a dedicated project lead drawn from DWQ and reporting to the Chief Deputy Director. Panel members heard, subsequent to the May review meeting, that the State Water Board in fact has an existing mechanism for this approach, termed an "enterprise-level technical project with executive level sponsorship".

This restructuring will provide immediate benefits. It will identify a single point of accountability for decision making and for ensuring that these decisions adequately reflect users' needs. By creating a distinct CIWQS team, it will alleviate tensions stemming from DWQ's and OIT's different institutional priorities. In addition, in the event that a future case must be made for a Special Project Report to the Department of Finance, it should be made by a project lead from the perspective of the involved business group.

In future attempts to foster change in business practices within the State Water Board and among the Regional Water Boards, the State Water Board should use an approach that integrates attention to both business practices and their supporting information technology. The Panel believes that the lesson apparently being drawn from CIWQS, namely that change should be driven primarily through business processes rather than through information technology, is equally mistaken. Changing existing business processes without taking account and advantage of available information technology runs the risk of embedding existing inefficiencies in the new system.

Finally, a balanced approach to improving business practices would provide a useful framework for more directly involving the Regional Water Boards' Executive Officers in fundamental information management decisions. Had that been the case historically, the Executive Officers' recommendation in July 2005 may well have carried more weight with the State Water Board.

Benchmarks

The following benchmarks were set for the February 2008 progress review:

- A CIWQS project lead has been identified and is in place
- The new project structure is fully operational
- All members of the CIWQS team have been identified and have been assigned to the project

Preliminary Recommendation 3: Validate the system requirements

Finding and analysis

As described above, the CIWQS design was largely an abstraction that had little correspondence to the way the regional boards did their work. The State Water Board's objective, beginning with the definition of the EDM for SWIM2, and continuing into the implementation of CIWQS, was to develop a system that would accommodate a broad range of water quality data and business functions (see Preliminary Recommendation 1 for more detail). This decision is the ultimate source of concerns about and difficulties with the project's scope (Preliminary Recommendation 1), key constituencies' lack of confidence in the system (Preliminary Recommendation 4), problems with data quality (Preliminary Recommendation 5), the lack of reporting capability (Preliminary Recommendation 6), and ineffective user interfaces (Preliminary Recommendation 7).

The Panel heard from the USEPA and its contractor, Tetra Tech, that the EDM was not appropriate to the functions CIWQS was intended to support and that continued reliance on the EDM would prevent CIWQS' effective implementation. They have argued that the database design underlying CIWQS is so convoluted and abstract, and so detached from the specifics of actual users' needs, that it is extremely difficult for programmers to understand and accurately employ. Compounding this underlying problem is the fact that the business rules, reflecting both user requirements and programming logic constraints, do not exist. These business rules are needed to compensate for the abstraction of the database and the poor quality of the legacy data, as well as to ensure the overall integrity of the database.

The absence of standardized business rules creates the possibility that data entry will create new errors as users draw different conclusions about how to interpret the generalized data structures and entry screens, which do not match program-specific terminology used by permit managers. The generalized data model, with its ability to integrate data from multiple State Water Board programs, also creates the possibility that users can change key fields (e.g., facility or place name) entered by other users, thus corrupting reports or queries needed to fulfill statutory reporting requirements. This concern has created a great deal of uncertainty within USEPA Region IX regarding the basic legitimacy of California's water quality data.

The Panel agrees that the EDM is far more generalized than is suited to the budget and time allocated to the project, or to the reduced scope described in Preliminary Recommendation 1. A more targeted data model focused on specific water quality applications would have been easier to design, more efficient to implement, and would have provided appropriate data integrity constraints. The Panel also agrees that the EDM's complexity led to many implementation problems. However, a subcommittee of the Panel, working with USEPA and State Water Board staff, and the contractors involved in subsequent additional phases of the project, found that there are no fundamental flaws that would prevent a reduced-scope version of CIWQS from servicing core functions, although this would be somewhat inefficient to operate and maintain. For example, the complexity of the underlying database structure will require strict constraints on data entry procedures and additional effort to map the generalized data model onto the State Water Board's and the Regional Water Boards' specific requirements and business practices.

Recommendations

Despite the inefficiencies inherent in CIWQS' current design, the Panel does not believe the system should be abandoned. The enthusiasm of the CIWQS team, their awareness of the database's problems, and their confidence that these issues can be successfully addressed, lead us to conclude that the State Water Board deserves the opportunity to demonstrate they can succeed in making CIWQS fully workable. Thus, the Panel recommends moving forward with the existing data model, even though it is not optimal, provided three essential steps are taken.

First, the business rules must be completed. These must reflect users' business practices, down to the lowest level of raw data entry by both dischargers and Regional Water Board staff. They must also reflect the more global constraints on system procedures and administration required to ensure data integrity as the generalized data model is adapted to the core regulatory functions defined in Preliminary Recommendation 1.

Second, State Water Board staff must conduct a cradle-to-grave test to empirically demonstrate CIWQS' full functionality. This test should include a representative sample of the most complex permits from multiple regions. Each permit should be worked through the system from its inception, through data entry and QA/QC, to final reporting. This test should document all deficiencies at a level of detail adequate for developing plans to address them.

Third, in order to help prevent a reoccurrence of the design and implementation problems that have hampered CIWQS' development, the State Water Board should establish and implement a formal system engineering process. This would involve, at a minimum, clear definitions of users' requirements, including for report output; procedures for identifying, defining, prioritizing, and tracking system modifications; and an overall plan for integrating system design, development, implementation, and updating.

Benchmarks

The following benchmarks were set for the February 2008 progress review:

- Define the business rules
- Cradle-to-grave test completed and assessed, with all deficiencies documented in detail
- Formal system engineering process in place

Preliminary Recommendation 4: Rebuild key constituencies

Finding and analysis

CIWQS' key constituencies are skeptical of the system's functionality and reliability. This has resulted in damaged working relationships at many different levels and reduced confidence in the accuracy and reliability of the data currently in the system. For example, one major discharger stated that they no longer enter their monitoring data into CIWQS because incorrect algorithms for calculating violations result in false violations being posted to a public database. The USEPA remains frustrated that California does not report NPDES compliance data to PCS in a timely or accurate manner. Many of the Regional Water Boards are hampered in their day-to-day activities by the absence of the information management tools needed to fulfill their responsibilities.

Recommendations

The State Water Board should act immediately to rebuild the constituency for CIWQS by creating a Steering Committee drawn from the user community. The Steering Committee should include representatives of Regional Water Boards, USEPA Region IX, dischargers, and the public, at a minimum. The committee should include skeptics as well as supporters of CIWQS and should report to the State Water Board's Chief Deputy Director. While the Panel appreciates that such committees can be challenging to manage, it is crucial that users' needs and perspectives be directly included over the next year as CIWQS' problems are dealt with. Therefore, the Panel recommends that the Steering Committee should explicitly sign off on both CIWQS' system requirements (as redefined under Preliminary Recommendation 1) and the design and implementation priorities (as defined under Preliminary Recommendations 5 – 7) established to fulfill these requirements.

Benchmarks

The following benchmarks were set for the February 2008 progress review:

- The Steering Committee has been impaneled and met at least twice
- Steering Committee members attend the February 2008 progress review and state that the project is making adequate progress

Preliminary Recommendation 5: Address data quality issues

Finding and analysis

The data in CIWQS are of questionable quality. When data from SWIM were imported into CIWQS, existing inaccuracies were not corrected and new errors were created by forcing legacy data into the new CIWQS database structure. Such problems are not uncommon when data are migrated from one system to another. However, in this case the data transfer was completed under time pressure without proper safeguards in place and neither the existing nor the newly created errors have been thoroughly catalogued and corrected. As a result, CIWQS contains many instances of duplicate records, inconsistent facility names, and missing fields.

The combination of poor data quality and its impact on user confidence has created a downward spiral for CIWQS. Thus, poor implementation led to data quality problems, which reduced user confidence, which then increased users' tendency to use shadow, or parallel, systems to meet their data management and reporting needs. The proliferation of shadow systems increased the likelihood of data quality problems (as data were increasingly stored in duplicate and/or uncoordinated databases), which reduced users' confidence in CIWQS even more. As described in Preliminary Recommendation 4, the Panel heard a dramatic example of this lack of confidence at the May 2007 meeting, when a major discharger reported that they refuse to enter their monitoring data into CIWQS because false permit violations are generated and posted to a public database. In the Panel's view, such examples of outright refusal to use CIWQS demonstrate the urgency of resolving data quality issues.

A major source of such errors, as well as a reason they have not been corrected, is the lack of consistent business rules that define the data fields, their relationships, and how they are associated with the State and Regional Water Boards' business processes (see Preliminary Recommendation 3 for more detail). The lack of formal and complete business rules also hinders the development and finalization of standardized data entry procedures that would act to prevent new errors from being created and then propagated within the database. For example, incomplete and/or inaccurate algorithms for calculating violations (a key business rule) continue to create fresh errors as new data are entered into the system.

The Panel also heard that CIWQS lacks a formal QA/QC process that is linked to data entry to provide immediate feedback on errors and an opportunity to correct them as soon as possible.

Recommendations

The legacy data should be corrected and new errors prevented by completing and correcting the business rules (see Preliminary Recommendation 3), including those that lead to inaccurate violations. Based on the business rules, standardized data entry procedures should be developed and implemented. Quality control checks should be included as an integral part of the data entry process and be connected to a formal QA/QC process that addresses all aspects of the data flow. These efforts should be carried out in close coordination with the findings from the evaluation of the database structure described in Preliminary Recommendation 3 to ensure that any potential problems inherent in the data structure are addressed by the business rules, data entry procedures, and QA/QC process.

Benchmarks

The following benchmarks were set for the February 2008 progress review:

- Data quality issues have been categorized and quantified
- A detailed plan exists for addressing sources of continuing errors and correcting historical errors
- This plan has been validated with representative data samples
- Substantive progress toward correcting major categories of errors

Preliminary Recommendation 6: Produce key reports

Finding and analysis

CIWQS does not readily produce the full range of reports needed to assist staff at the Water Boards in meeting their day-to-day responsibilities, fulfill the state's statutory requirements to report data to the USEPA, or provide system managers with adequate feedback on key aspects of system function and status. As mentioned previously, CIWQS was released in July 2005 without a fully developed reporting capability and the system's developers have been playing catch-up with users' needs ever since. Because of the resulting priority placed on meeting such needs, there is a virtual absence of internal process reports on metrics related to data entry, system performance, and quality control.

In addition to preprogrammed reports that fill routine requirements, there is frequently a need for users to create ad hoc reports to obtain information about specific management issues or to review the status of a particular permit or compliance action. Because of the complex and generalized database structure (see Preliminary Recommendation 3 for more detail) such reports require cumbersome queries, even when the request is conceptually simple.

Recommendations

The CIWQS team should work with the Steering Committee (see Preliminary Recommendation 4) to prioritize the reports required by each major user group. The CIWQS team and the Steering Committee should develop an explicit set of criteria for prioritizing reports and should devote a portion of the team's resources to developing these reports on an explicit schedule. The CIWQS team should ensure that internal system process reports are included on the prioritized list, in order to improve the team's ability to manage the system itself and to track progress toward benchmarks related to data entry, error correction, broader quality control measures, and other performance issues.

Benchmarks

The following benchmarks were set for the February 2008 progress review:

- Prioritized list of reports
- Schedule for report production
- Example reports that demonstrate the team's approach to report design and production

Preliminary Recommendation 7: Improve user interfaces

Finding and analysis

There is broad discontent among CIWQS users with the user interface. Data entry screens are confusing, generic terminology does not match that typically used by current users, pull-down lists do not always contain appropriate choices, and linking among related aspects of the data entry process is poorly designed. Many of these characteristics reflect the project's initial decision to base CIWQS on the EDM and to design data entry screens and other elements of the user interface in a nonspecific manner so that they would be applicable to a wide range of water quality applications. In addition, contextual help is not available within the system. For example, clicking on "help" in many cases brings up a nine-megabyte users manual.

The existing user interfaces require an unacceptably long and complex training period, which adds to the burden on project staff. Users' difficulties are compounded by the project's inability to respond quickly to users' questions and requests for help. In response to such problems, many users employ an inconsistent collection of alternative databases, tools, and paper-based processes.

Recommendations

The CIWQS team should improve the system's user interfaces. The team, together with the Steering Committee, should agree on an explicit and prioritized list of revisions and actual changes should be based on input from a subset of representative users. User interfaces should reflect the business rules and processes that are directly relevant to users and revisions should focus, at a minimum, on simplifying data entry forms, redesigning linking to be easier, prompting for linkage (where required) to reduce errors, and developing contextual help and more appropriate pull-down lists.

The CIWQS team should implement formal usability testing to obtain relevant feedback about how and where user interfaces are confusing or create other problems for users. Formal testing typically includes giving test subjects specific data entry and retrieval assignments and observing them while they complete, or fail to complete, the assignment. The process provides an objective means of determining how well an interface meets its desired purpose. This will involve a shift in the direction of information flow, from the top-down flow that characterized the prior emphasis on training to a more interactive and predominantly bottom-up flow that emphasizes users' experience in actual work settings.

Benchmarks

The following benchmarks were set for the February 2008 progress review:

- Prioritized list of revisions
- Sample of prototype screens
- Explicit plan for usability testing

GeoWBS

The Geospatial Water Body System (GeoWBS) was in past years an integral element in the development of the State's 305(b) report and 303(d) to the USEPA. This system provided the Regional Water Boards the ability to georeference information from the 303(d) listing process and to aggregate it by waterbody in order to assess which water bodies were meeting which beneficial uses. Once reported to the USEPA, this information is used by the USEPA to identify waters for restoration activities, measure progress on water quality improvement, and report to Congress on the overall quality of the Nation's waters (as required by section 305(b) of the Clean Water Act).

GeoWBS was used by the Regional Water Boards through the 2002 305(b) reporting process. However, the 303(d) and 305(b) reporting efforts were centralized at the State Water Board in 2004 and 2006 and, during that time frame, the GeoWBS functionality was lost as CIWQS was developed. The State Water Board has decided to once again involve the Regional Water Boards in these reporting efforts, but the Regional Water Boards no longer have GeoWBS, or any other comparable capability, to perform this function.

Due to the limited time frame of the CIWQS review, the Panel did not directly evaluate the GeoWBS database. However, the Panel understands that this capability is critical to the State's ability to prepare the required 303(d) and 305(b) reports due in 2008, which the USEPA now requires be integrated. The Panel understands that there are a number of options for resolving this problem, which include using the USEPA's existing national database system or recreating GeoWBS in a design that will address the new integrated reporting requirements. The Panel does not have a specific recommendation on this issue, other than to highlight the importance of this functionality and to emphasize that it must be recreated in a timely manner.

Final Findings and Recommendations

At its second meeting in February 2008, the Panel was tremendously impressed by the program's wholesale shift in attitude and by the amount of tangible progress at repairing the program's underlying weaknesses. Most dramatically, CIWQS has fundamentally changed its management philosophy and completely restructured its management. Serious concerns about the system's technical validity have been resolved, though some business rules remain to be finalized, and key user constituencies are now directly engaged in and strongly supportive of the program. This remarkable turnaround is due to a profound cultural change in the program that was fully supported by the State Water Board's upper management. This combination of management restructuring, a more rigorous approach to system development and testing, and strengthening relationships with key constituencies establishes a foundation for future success.

The following two sections focus on the CIWQS program's efforts since the May 2007 program review from two distinct perspectives:

- An overall assessment of the CIWQS program's understanding of the Panel's Preliminary Recommendations and its degree of progress in addressing these, while providing additional suggestions for continuing implementation of these recommendations
- Four Final Recommendations, for both the CIWQS program and the State Water Board, that focus on issues that can be addressed now that CIWQS' revised scope, management, and technical approaches are becoming clear

Evaluation of preliminary recommendations

Preliminary Recommendation 1: Reduce the project's scope

Evaluation

CIWQS has significantly decreased the project's scope and formally defined it to focus on core regulatory issues and functions. This has in turn increased the probability of the project's success by enabling increased resources to be concentrated on a smaller number of key issues and by improving confidence and buy-in from the program's users and other constituencies.

In regards to electronic self monitoring reports (eSMR), the CIWQS project team described a phased development approach for four levels of program sophistication, with the immediate goal of successfully implementing an intermediate level (eSMR Level 2) of functionality. The Panel believes that this is a reasonable approach, given the overall breadth of issues the program must address and the complexity of automating reporting for discharges with often widely varying reporting requirements. Implementation of eSMR Level 2 would substantially improve the functionality of the current system and fulfill the State Water Board's basic reporting requirements. It would accomplish this by enabling reports to be uploaded with accompanying data in a digital format suitable for entry to the database and for use in subsequent analyses. However, the Panel also believes that ultimate implementation through eSMR Level 3 would clearly be beneficial to the State Water Board and Regional Water Boards and other program users. Level 3 would add automated checks to ensure that all required data points have been submitted, enabling verification that the monitoring plan is being followed. The Panel also acknowledged the complexity inherent in eSMR Level 4, which would involve checking actual data values against compliance threshold values. Attempting to achieve Level 4 at this time would be counterproductive because of the effort required to code the large number of complex compliance computations that often differ from discharger to discharger.

Recommendations

While the review of the EDM (see Preliminary Recommendation 3) has reassured the Panel that the CIWQS data model does not contain any fatal flaws that would prevent it from functioning, the Panel remains concerned that the underlying complexity of the database implemented based on the original enterprise data model may engender costly overhead related to system maintenance. There are many aspects of the original data model that the reduced program scope no longer requires but that must be accounted for in the database during system updates and testing. The Panel recommends that the project, as a secondary priority, consider trimming unneeded parts of the database to better correspond to the reduced project scope. This would also be consistent with the program's stated preference for evolving to a federated design.

Benchmarks

The following benchmarks should be met by December 31, 2008:

- Database entities and attributes trimmed to better match reduced scope, i.e., deliver an updated formal (and documented) model and its related federated design
- eSMR Level 2 properly tested, implemented, and users are satisfied with product
- Significant development planning on eSMR Level 3 initiated

Preliminary Recommendation 2: Reconfigure CIWQS' project management

Evaluation

CIWQS and the State Water Board have dramatically reconfigured the program's management structure and decision-making process. As recommended, a CIWQS project team was established, including appropriate staff from DWQ and OIT and reporting to a CIWQS Executive Team and a Management Coordinating Committee that both reside within DWQ. In addition, the State Water Board is in the process of formalizing the creation of a new office in the Board, to be headed by a new manager, that will oversee projects such as CIWQS with a large information management component. The new CIWQS management structure is providing effective strategic and tactical direction for the program and ties it more closely to the State Water Board's core management mission. In addition, the program has established a number of issue-specific workgroups (see Preliminary Recommendation 4: Rebuild key constituencies) that provide operational input to the development process. This structure both reflects and encourages active support from senior management within the State Water Board and from the broader user community. The Panel appreciates that such changes can be difficult to accomplish in large organizations and was particularly impressed with the speed, assertiveness, and far-reaching nature of the management restructuring.

Recommendations

The program has effectively resolved this issue and is encouraged to maintain the current structure since it appears to be working well.

Preliminary Recommendation 3: Validate the system requirements

Evaluation

The CIWQS program conducted a careful evaluation of the adequacy and robustness of the system design by walking through end-to-end (or cradle-to-grave) test cases that involved generating new orders and producing self monitoring reports. This evaluation showed that the system was unable to fully meet the original CIWQS scope, particularly with respect to the automated calculation and reporting of compliance

violations. The compliance and monitoring requirements in discharge permits are extremely complex. This complexity is needed to reflect real-world conditions and meet the decision-making needs of both the Regional Water Boards and permittees. While accommodating this level of complexity within the automated features of an information management system is theoretically possible, in practical terms it requires unrealistic levels of effort and expense. Therefore, the team has concluded that continued attempts to fulfill CIWQS' original scope would be neither reasonable nor desirable. The Panel fully agrees with and supports this conclusion and believes that this demonstrates a considerable growth in the team's technical and managerial understanding of how CIWQS must function.

In addition, the CIWQS project team investigated in greater depth whether CIWQS meets the fundamental requirement for referential integrity, which has significant implications for data quality. This review identified significant problems with key fields and critical links between tables (entities) in the database. Certain links are created automatically by the database. Others are created by programmers as they define meaningful information such as permittee or permit number. Many of CIWQS' problems with referential integrity stemmed from the fact that contractors, when implementing the database design, created work arounds that bypassed, or shortcut, the safeguards intended to ensure that these two types of link remain synchronized. Decisions to use such work arounds stemmed from a lack of understanding of the complex data model and these problems were the source of many of the errors created by the system as well as of continuing uncertainty about CIWQS' basic reliability.

The testing and correction effort was an important step in the program's implementation of a more formal systems engineering process that rigorously defines requirements and testing procedures and documents all system modifications. As a result of this effort, the Panel believes that the program has fundamentally improved CIWQS' design and put the project on a path to a successful implementation. The Panel concluded that the system's data model and database implementation can be made to work and that the revised system requirements better reflect users' needs.

Recommendations

The CIWQS program should continue evaluating and correcting all business rules, ensuring that they are internally consistent throughout the system. Once this is completed, a periodic updating and revision cycle should be established consistent with the deployment plan (see Final Recommendation 3). This should be included as part of an expanded and disciplined systems engineering process, which should be applied to all aspects of system design and implementation, including team members' roles, responsibilities, and activities; data quality; reporting; and all other aspects of the data path. As part of this process, the program should develop well-defined test cases which should be conducted prior to any major revision release in order to demonstrate successful resolution of all referential integrity issues (see also Final Recommendation 2 regarding formal system testing).

Benchmarks

The following benchmarks should be met by February 2009:

- Complete the evaluation and correction of all business rules
- Complete correction of the primary and secondary fields and the development of internal checks to make sure these problems cannot be reintroduced.

Preliminary Recommendation 4: Rebuild key constituencies

Evaluation

The CIWQS program has achieved a truly remarkable turnaround in its relationships with key constituencies. This stems from a fundamental cultural shift in the program's orientation toward the need

for and the value of user input. A number of effective structures for involving users directly in program development and evaluation have been developed and aggressively implemented. For example, the Management Coordinating Committee meets monthly to consider strategic issues and has as a standing agenda item input from a Steering Committee made up of a range of user groups. At the operational end of the spectrum, the Water Quality Data Team, responsible for CIWQS implementation, works directly with a number of business unit teams, some of which meet on a weekly basis. This structure goes well beyond the Panel's preliminary recommendation and has succeeded in engaging users in most areas of the program. As evidence of this engagement, the Panel noted that many users attended the February Panel meeting and voiced strong support for the program's new attitude and direction. The one exception to this pattern of successful engagement was the stormwater group, which expressed its frustration at not having its needs addressed by the CIWQS program. This was evidence that the program's cultural improvements still have not been extended to all aspects of the program. However, the fact that the stormwater group's concerns were heard during the preparation for the February 2008 review and were being immediately addressed at the highest level of CIWQS program management is a positive change from past practice. This is a striking contrast to the situation the Panel heard described last May, in which users' concerns were being virtually ignored because of the program's inability to respond appropriately.

Recommendations

The CIWQS program should continue to apply structured mechanisms for user involvement to all aspects of system development and implementation. The operation of the eSMR business team can provide a model for this approach because of its tremendous success in focusing users' expertise on difficult design and implementation issues central to CIWQS' success.

Benchmarks

The following benchmarks should be met by August 31, 2008:

- Stormwater program issues addressed in user group meetings and program development activities
- Continued review and public input from user groups at regularly scheduled meetings
- Continued expressions of satisfaction by all user groups

Preliminary Recommendation 5: Address data quality issues

Evaluation

The CIWQS project team has convincingly acknowledged the need for the systematic application of quality assurance and quality control (QA/QC) principles to all aspects of CIWQS' design. The database integrity problems that were the source of some of the errors have been investigated and the scope of each type of problem defined and quantified. However, despite the fact that some existing data errors have been corrected, the program achieved less progress than was expected. This was due in large part to the necessity of first evaluating and then correcting the system design, a complex effort, as well as to the number and variety of errors. The program has drafted a quality assurance plan, established standard operating procedures for many activities, involved users in developing and reviewing the quality assurance plan, and begun planning for an external quality control audit. The Panel finds these steps encouraging but believes that the approach to QA/QC is piecemeal in many respects and too focused on procedures instead of on quantitative measurements. Concerns about QA/QC remain overly focused on existing data errors and have not yet extended to other key aspects of the program, such as reporting and user interfaces. As another example, plans for the external audit are not well developed and it is unclear how the audit will be used to assess and improve the program's performance.

Recommendations

The CIWQS program should continue to devote focused effort to data QA/QC. This should be accomplished in the context of an explicit plan that prioritizes categories of data cleanup, identifies needed resources, establishes a timeframe for progress, and develops quantitative metrics of success. The program should also make QA/QC an integral part of all aspects of deployment planning. This is especially important for data entry screens and in preliminary data analysis. Some errors introduced into the data could have been prevented by including quality control functions in the data entry process; this should become standard practice for all data entry and reporting programming. For example, when critical fields are entered or changed, the interface should maintain referential integrity by ensuring that such changes are made consistently throughout the system.

Benchmarks

The following benchmarks should be met by December 31, 2008:

- Revised QA/QC plan that includes all aspects of data processing and management
- Completed detailed plan for an external quality audit, with explicit metrics, that describes the condition of current data, addresses the full range of data quality issues, and identifies specific technical or management actions to be taken based on the audit's results
- Correction of data errors identified in the evaluation of referential integrity completed and continuously measurable progress on correcting other errors
- Provided one or two pilot data entry applications that demonstrate how the integrity of key fields will be maintained

Preliminary Recommendation 6: Produce key reports

Evaluation

The CIWQS program has made progress in identifying and prioritizing key reports and establishing a mechanism, centered on a Reports Team, for keeping this list current. In addition, the program has made some progress on developing needed automated reports to respond to specific user needs. However, less progress was achieved in this area than the Panel had hoped. This was due to the fact that it was necessary to validate and stabilize the system design before reporting routines could be developed. The Panel believes that improving CIWQS' ability to produce a full range of reports remains an essential element in ensuring the system's ultimate utility to users.

Recommendations

The CIWQS program should accelerate the production of prioritized reports and should also increase users' ability to create ad hoc reports. This will lessen users' reliance on the programming staff to create reports, thus removing a key bottleneck limiting report development and production. Reports should also be used as another method for validating the revised database design, by explicitly demonstrating that required reports can be produced from the core CIWQS system. This is also an example of how a QA/QC perspective can be embedded in all aspects of system design and implementation (see Preliminary Recommendation 5).

Benchmarks

The following benchmarks should be met by February 2009:

- Current list of prioritized reports generated
- Current schedule for report production
- Significant development of prioritized reports

- Methods for ad hoc report production implemented and evidence that users are creating their own reports with these tools provided
- Reports used to demonstrate validity of database design provided

Preliminary Recommendation 7: Improve the user interfaces

Evaluation

In contrast to users' comments during the May 2007 Panel meeting, users at the February meeting expressed overall confidence and satisfaction with the layout and functioning of the data entry screens and other user interfaces. They were particularly pleased with the ease of use of the new Sanitary Sewer Overflow (SSO) module, which was developed with extensive user input. This reflects the development of effective mechanisms for gathering and then applying input and feedback from users. While there are still improvements to be made, the program appears to have dramatically improved its approach to designing and improving user interfaces.

Recommendations

The CIWQS program should create context specific drop-down menus and online help. These are two areas that have generated a large number of user complaints. The program should also address the earlier recommendation to implement formal usability testing of all key aspects of user interfaces. This will help ensure that essential user feedback is obtained before interfaces are finalized.

Benchmarks

The following benchmarks should be met by December 31, 2008:

- Context specific drop-down menus and help modules implemented
- Explicit plan for usability testing developed

Implementation challenges: Final Recommendations

As noted in the Panel's preliminary report, CIWQS' ultimate success depends on the ability to implement the recommended changes in program scope, management structure, and key technical processes and procedures, as well as the availability of the necessary support from the State Water Board throughout this process. CIWQS' progress in implementing the Panel's Preliminary Recommendations enabled the Panel to identify a second set of recommendations considered essential to the program's continued progress and ultimate success. Of the following four Final Recommendations, the first three are addressed to the CIWQS project team and the last to the State Water Board. As with the Preliminary Recommendations, these are interrelated and the Panel believes that they must all be addressed for the program to succeed.

Final Recommendation 1: Develop a deployment plan for the system and its data

The CIWQS program has suffered in the past from decisions to release system updates and/or new features without thorough testing or consideration of how these would impact system infrastructure, user acceptance, data quality, and other key aspects of overall system performance. While the program has made considerable progress in changing this mindset and practice, such changes should be expanded and instituted through a policy requiring formal deployment plans for every significant system release, e.g., for each phase of eSMR development. System releases should be defined and managed according to industry-standard practices typified by modern software version control systems. These deployment plans should be a part of the overall systems engineering process and include consideration of specific elements

related, at a minimum, to software, hardware, data, quality control, and users. Deployment plans should include the end-to-end testing described above (Final Recommendation 2).

Benchmarks

The following benchmarks should be met by September 30, 2008:

- Comprehensive systems engineering process defined and demonstrably operational with a deployment plan and release schedule
- Deployment plan concept integrated into the QA/AC plan
- Deployment plan concept integrated into the software engineering culture

Final Recommendation 2: Develop end-to-end tests to demonstrate the system works

The Panel is encouraged by the CIWQS program's progress in using well-defined test cases to assess the validity of the data model and the overall system. The Panel believes that this approach should be used as a routine part of the systems engineering process discussed above (Preliminary Recommendation 3). More specifically, the CIWQS program should develop and maintain a library of test cases with known results that can be used to test the performance and reliability of the system as future changes are made. Such testing should be implemented as part of all deployment plans (see Final Recommendation 1).

Benchmarks

The following benchmarks should be met by December 31, 2008:

- A section added to the QA/QC manual that specifies regular use of established test cases for evaluation of all systems and major releases
- Testing protocol reviewed by an outside party
- Identified test cases to be developed as test case library
- Test cases implemented in ongoing development

Final Recommendation 3: Build a non-CIWQS interface with ICIS-NPDES

The State of California is delegated authority by USEPA under the Clean Water Act to issue water quality permits to dischargers within the state. As part of this delegated authority, the state is required to report both permitting data as well as inspection and enforcement action data. However, discharger monitoring results are currently reported directly to both the USEPA and the Water Boards by the dischargers. The State Water Board has been attempting to develop a single reporting site to enable discharges to fulfill simultaneously both the state and federal requirements for reporting monitoring results.

Against this background, a major concern expressed at the May 2007 Panel meeting stemmed from CIWQS' inability to fulfill these reporting requirements accurately and in a timely manner. There was little confidence in CIWQS' output because of uncorrected errors in the legacy data in the database, the fact that the algorithms for calculating violations produced false violations, and uncertainty about the magnitude of these problems. The Panel also heard suggestions that the State should consider scaling back its effort on CIWQS and simply use the federal reporting system, ICIS-NPDES, to fulfill both state and federal reporting requirements.

After extensive discussion with programmers and regulatory staff of the State Water Board, Regional Water Boards, and the USEPA, the Panel has concluded that there are enough differences between the state and federal reporting needs that the ICIS-NPDES will not meet the State Water Board's needs. The key difference is that the state of California requires more rigorous reporting by the dischargers than that

required at the federal level. This difference in the level of required reporting makes it a significant challenge to reconcile the state and federal systems, especially with regards to how the federal system calculates violations (the federal system can produce erroneous violations because it does not include all details of permit-mandated compliance formulas). At the same time, the Panel's recommendation to defer the implementation of eSMR Level 4 (which would calculate violations) means that CIWQS alone will not have the capability to fully meet federal reporting requirements.

The Panel also believes that the reporting issue must be resolved as soon as possible in order to bring the State into compliance with its reporting requirements. During discussion at the February 2008 Panel meeting, key parties representing the State Water Board, dischargers, and the USEPA agreed that any attempt to address this issue should meet three criteria: first, avoid any possibility of data contamination from the transfer of erroneous data from CIWQS that is a legacy of the unresolved CIWQS data quality problems; second, implement reporting tools that do not increase existing work loads; and, third, avoid duplication of effort by making the reported data readily available to both state and federal systems. There are a number of ways to meet these criteria, and the parties to this discussion agreed to collaborate on developing a solution, which will likely include the following elements:

- Discharger submission of required discharger monitoring reports (DMRs) directly to the USEPA, using one of two mechanisms, either eDMR (electronic Discharger Monitoring Report), which is a file-based tool, or netDMR (internet Discharger Monitoring Report), which is an interactive, web-based tool; both of these tools are still under development, with the plans to be released in 2008, and the State will need to coordinate their efforts with those occurring at the federal level
- Data submission through a portal that bypasses CIWQS, thus removing any concerns about the reliability of data in the CIWQS system
- Development of an interface for CIWQS to obtain data from the DMRs needed to fulfill state reporting needs; the USEPA staff have agreed to help develop such a data download capability using data currently in the federal system

The State Water Board should proceed quickly on the above list to take advantage of the USEPA staff's offer to work together on a data interface between CIWQS and ICIS-NPDES. This solution, once implemented, should be external to CIWQS to accommodate USEPA's concerns about data quality and should modify existing procedures so that CIWQS and ICIS-NPDES are both provided the data and information they require with the minimum amount of redundant effort.

Benchmarks

The following benchmarks should be met by August 31, 2008:

- Completion of a plan, developed jointly with the USEPA and users, for implementing a system to ensure compliance with federal requirements for reporting discharger data; the plan should include careful consideration of the fact that any reporting to ICIS of monitoring data will likely result in erroneous determinations within the federal system regarding permit compliance
- Provided evidence that a plan to ensure that the correct compliance data can be maintained separately within CIWQS to offset erroneous compliance determinations expected in the federal system

Final Recommendation 4: Fund CIWQS at an appropriate level

The Panel is greatly encouraged by the progress the CIWQS program has made since May 2007 and believes that the changes made will result in a system that meets the State Water Board's needs for data management and reporting for the future. However, the desired level of success will be achieved only if the Panel's Preliminary and Final Recommendations are fully implemented and all benchmarks are met. This in turn will occur only if the program is funded at a level that enables it to meet these benchmarks by

maintaining and, in some areas, accelerating the development efforts undertaken over the past nine months.

The Panel is reluctant to recommend a specific budget figure or to suggest that the program's budget be increased because a recommended budget analysis was not conducted as part of its review. However, the Panel is aware that the program has experienced funding pressures/uncertainty and believes that, over the long term, such uncertainty can impair the program's ability to operate effectively and efficiently. The Panel therefore recommends that the program conduct an analysis of the funding that would be required to meet all recommendations and benchmarks within the next year and to maintain the program over time. The Panel strongly recommends that this budget analysis then become the basis for any future funding requests.

Benchmarks

The following benchmarks should be met by August 31, 2008:

- Completed budget analysis

Appendix 1: CIWQS Review Panel Members

Dr. Brock Bernstein

Brock was a member of a National Academy of Sciences panel on data integration in the climate change research program. For that project, he was the primary author for the section on data integration challenges and also authored three of the six case studies, on the CalCOFI Program, the Carbon Dioxide Information Analysis Center, and the ISLSCP field experiment (a complex data gathering and modeling effort across many spatial scales). Brock has also provided external peer review for the State of Alaska's regional monitoring and research information management system in Prince William Sound and managed the design of the Orange County Stormwater Program's comprehensive monitoring and reporting database.

Curtis Cude

Curtis is an environmental information exchange expert with the Oregon Department of Environmental Quality. He is project manager for development and implementation of the Pacific Northwest Water Quality Data Exchange. He is the Chair of the Information Strategies Work Group for the National Water Quality Monitoring Council. He co-chaired (with Ken Lanfear) the Data Management and Access Team for the development of the National Monitoring Network for U.S. Coastal Waters and their Tributaries, and co-chaired the Water Team for development of the Environmental Sampling, Analysis and Results standards for the Environmental Data Standards Council.

Dr. John Helly

John is Associate Director of Computing for the National Science Foundation Center for Multi-scale Modeling of Atmospheric Processes. He is also Laboratory Director for Earth and Environmental Science at the UCSD Supercomputer Center. John has a Ph.D in Computer Science from UCLA with research interests in environmental modeling, remote sensing, and visualization.

Ken Lanfear

Until his retirement in 2006, Ken served as Chief of the Water Information and Computer Applications Support Group within the US Geological Survey. Mr. Lanfear managed Unix systems that support water researchers at USGS Headquarters, and directed the *water.usgs.gov* website. He consulted on a variety of projects to increase the use of USGS water data, and coordinated with EPA to establish a common USGS/EPA interface for water data. Mr. Lanfear is a past president of the American Water Resources Association and, since his retirement, he has served as editor for the Journal of the American Water Resources Association.

Tony Lavoie

Tony is Chief of the Coastal Information and Application Division for NOAA's Coastal Services Center where he is responsible for managing their IT network and ensuring compliance with all IT security mandates. Tony serves as the NOAA representative to the Federal Geographic Data Committee (FGDC), the Geospatial One-Stop Board of Directors, and the Ocean.US Data Management and Communications Steering Team. He chairs both the NOAA GIS Committee and the Marine and Coastal Spatial Data Subcommittee of the FGDC, and leads development of the National Ocean Service Data Explorer GIS data portal.

Jeffrey Rosen

Jeff is Vice President of Environmental Information Services for Clancy Environmental Consultants. Prior to that, he was Vice President of the Environmental Information Services Division for Perot Systems Government Services. Mr. Rosen specializes in the processing and analysis of environmental data. His principal areas of expertise are marine monitoring and drinking water. Mr. Rosen was responsible for establishing the data management system for the EMAP Coastal Resources component and served as liaison with information management efforts within NOAA, USGS, and the EPA National Estuaries Program. He currently supports both the American Water Works Association and the USEPA on a number of data management and analysis projects related to drinking water monitoring and regulation development. He is also supporting the development of permitting systems and compliance monitoring for the Papahānaumokuākea Marine National Monument.

Deb Soule

Deb is a Business Systems Analyst for the State of New Hampshire where she supervises the Data Management Section, including GIS services. She is the project manager for the State's Environmental Monitoring Database and the STORET conversion to the Water Quality Exchange. Other data systems she oversees include beach monitoring and notification, shellfish shoreline inspection and boat wastewater inspection databases, as well as a supplemental assessment database to automate waterbody assessments.

Dwane Young

Dwane is an IT Specialist at EPA and is the technical lead for EPA's Water Quality Exchange. He currently manages EPA's STORET database and is overseeing transition of that system to a new XML-based data flow. His previous experience includes developing database applications for the National Park Service and U.S. Environmental Protection Agency (EPA), including EPA's effort to georeference state's Water Quality Standards, 303(d) Impaired Waters, and 305(b) Assessed Waters to the National Hydrography Dataset.

Dr. Stephen Weisberg - Facilitator

Steve is the facilitator for the review panel. He is Executive Director of the Southern California Coastal Water Research Project Authority, where he specializes in designing, implementing and interpreting data from environmental monitoring programs. He serves on a variety of federal advisory committees, including the National Science and Technology Council's Ocean Research and Resources Advisory Panel and the Alliance for Coastal Technology Stakeholders Council. He also serves on numerous state/regional advisory committees, including those for the University of Southern California Sea Grant Program, the State of California's Clean Beach Task Force and the California Ocean Science Trust.

Appendix B: Questions Posed to the CIWQS Review Panel

1. Are the Water Boards' goals for CIWQS clearly articulated and appropriate?
 - a. Have users been adequately identified, and do they agree with existing goals?
 - b. Are the performance measures appropriate, and are they being met?

2. Is the Enterprise Data Model and server network effective for accomplishing the Water Boards' goals for CIWQS?
 - a. Are there adequate provisions to ensure the desired level of data quality?
 - b. Are there adequate provisions in the technology solution to ensure security, privacy, and confidentiality of information?
 - c. Does the system have the potential to meet goals for viewing geospatial (GIS) information?
 - d. Is the data entry work-flow appropriate for the required work load?
 - e. Are the reporting capabilities of the system adequate to meet the needs of staff, management, and the public?

3. Is the implementation strategy for CIWQS appropriate?
 - a. Is communication effective between CIWQS staff and data providers?
 - b. Is communication effective between CIWQS staff and data users?
 - c. Is documentation and training effective in meeting data provider and user needs?

4. Have resource needs been adequately identified and met?
 - a. Have resource needs for CIWQS development, maintenance and outreach been identified?
 - b. Have existing resources been optimally leveraged through coordination with other programs?