

ENHANCING **the vision**

for Managing
California's Environmental Information



Produced by the Environmental Data Summit Organizing Committee under the leadership of the Delta Stewardship Council's Delta Science Program

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A satellite-style map of North America, showing the United States and parts of Canada and Mexico. The map is overlaid with four concentric white circles. The innermost circle is centered on the western United States, specifically over the state of California. The other three circles expand outwards from this center, covering larger and larger areas of the continent. The text is positioned on the right side of the map, within the area covered by the second and third circles.

**You can't do your science without
sharing your data in the geosciences . . .
NSF (The National Science Foundation)
has always had a data-sharing policy.
If you create data using NSF funds,
then you must share them broadly . . .
and promptly**

**—JENNIFER SCHOPF,
DIRECTOR OF INTERNATIONAL NETWORKING,
INDIANA UNIVERSITY**

*Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX,
Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community*

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OUR WORK IS TO ESTABLISH A VISION THAT CAN BE BROADLY SHARED AMONG AGENCY, NGO, TRIBAL, ACADEMIC, AND PUBLIC STAKEHOLDERS. BY FOSTERING PRINCIPLED CONSENSUS, WE WISH TO DEMONSTRATE THAT CALIFORNIA HAS A BROAD PLAN FOR ADDRESSING ITS ENVIRONMENTAL DATA MANAGEMENT CHALLENGES.

Executive Summary



Only a synthetic, integrated, analytical approach to understanding the effects of suites of environmental factors (stressors) on the ecosystem and its components is likely to provide important insights that can lead to enhancement of the Delta and its species.”

—National Research Council 2012

The Environmental Data Summit, convened under the auspices of the Delta Stewardship Council’s Delta Science Program in June 2014, witnessed remarkable participation from experts across California, the nation, and even the world. Summit attendees from the public, private, federal, and non-profit sectors shared their views regarding the urgent needs and proposed solutions for California’s data-sharing and data-integration challenges, especially pertaining to the subject of environmental resource management in the era of “big data.” After all, this is a time when our data sources are growing in number, size, and complexity. Yet our ability to manage and analyze such data in service of effective decision-making lags far behind our demonstrated needs.

In its review of the sustainability of water and environmental management in the California Bay-Delta, the National Research Council (NRC) found that “only a synthetic, integrated, analytical approach to understanding the effects of suites of environmental factors (stressors) on the ecosystem and its components is likely to provide important insights that can lead to enhancement of the Delta and its species” (National Research Council 2012). The present “silos of data” have resulted in separate and compartmentalized science, impeding our ability to make informed decisions. While resolving data integration challenges will not, by itself, produce better science or better natural resource outcomes, progress in this area will provide a strong foundation for decision-making. Various mandates ranging from the California Water Action Plan to the President’s executive order demanding federal open data policies demonstrate the consensus on the merits of modern data sharing at the scale and function needed to meet today’s challenges.

This white paper emerges from the Summit as an instrument to help identify such opportunities to enhance California’s cross-jurisdictional data management. As a resource to policymakers, agency leadership, data managers, and others, this paper articulates some key challenges as well as proven solutions that, with careful and thoughtful coordination, can be implemented to overcome those obstacles. Primarily featured are tools that complement the State’s current investments in technology, recognizing that success depends upon broad and motivated participation from all levels of the public agency domain.

This document describes examples, practices, and recommendations that focus on California's Delta as an opportune example likely to yield meaningful initial results in the face of pressing challenges. Once proven in the Delta, however, this paper's recommended innovations would conceivably be applied statewide in subsequent phases.

For the purposes of this executive summary, here we highlight some of the findings and recommendations found within the white paper. This subset should provide insight into some of the white paper's primary assertions. The full list of findings and recommendations follows this executive summary.

FINDINGS

- The State's data-governance policies are lacking in definition and current application. A new governance framework—a process to facilitate rights and accountability for information-related processes—should be established that facilitates broader decisions and standards regarding the State's data management.
- "Transparency" is a fundamental attribute of public data, but its definition has changed over time with advances in technology. The public stakeholders and peer agencies alike now seek data on demand.
- Clear and careful documentation of data quality and data formats through metadata (background information about the data) avoids misunderstandings and misapplication of information—increasing the effectiveness of management decisions, reducing disputes, and obviating some basis of litigation. Clear standards also help to promote compatibility among datasets for purposes of aggregation and analysis.
- Coordinated and collaborative data management must be conducted using business models that foster sustained, incremental investment and partnership with non-governmental partners.

RECOMMENDATIONS

- Data governance oversight: applying data standards, documenting data, and seeking strategic alliance with national and global initiatives
- Develop a system where all environmental data can be accessed from a single source point (data federation strategy) with a specific, time-bound roadmap. This effort must complement the work of the data standards implementation.
- Develop a business case and adopt a funding strategy in service of a sustainable business model.



This document describes examples, practices, and recommendations that focus on California's Delta as an opportune example likely to yield meaningful initial results in the face of pressing challenges.

CALIFORNIA MUST STRATEGICALLY POSITION ITS DATA MANAGEMENT PLANS TOWARD NATIONAL AND INTERNATIONAL INITIATIVES AND STANDARDS. OUR RECOMMENDATIONS BUILD UPON THE STATE'S EXISTING INFRASTRUCTURE AND NASCENT INITIATIVES WHILE ALSO OFFERING NECESSARY OPPORTUNITIES FOR GROWTH AT A TIME WHEN OUR NATURAL RESOURCE MANAGEMENT REQUIRES WELL-INFORMED AND TIMELY DECISIONS.

Full Findings & Recommendations



Once proven in the Delta, this paper's recommended innovations would conceivably be applied statewide in subsequent phases.

The following is a collection of the findings and recommendations located in the white paper's three sections. For additional information and context on each item, please consult the pertinent sections cited among the recommendations.

FINDINGS

In many key ways, California's technology infrastructure and approaches to problem-solving are "behind the curve" of the mounting challenges it faces with respect to natural resource management. Specific findings related to this assessment follow:

Evolving Data Stewardship

1. Data sharing is one of the most fundamental building blocks in effective scientific and resource-management collaboration.
2. The State's data-governance policies are lacking in definition and current application. A new governance framework—a process to facilitate rights and accountability for information-related processes—should be established that facilitates broader decisions and standards regarding the State's data management.
3. Innovative initiatives are already underway that make data accessible, understandable and shareable—and these efforts are already reaping significant rewards in terms of saved time, enhanced collaboration among different organizations, and accelerated knowledge discovery that provides better information to make decisions on California's ecology and water-supply challenges.
4. "Transparency" is a fundamental attribute of public data, but its definition has changed with advances in technology. The public stakeholders and peer agencies alike now seek data on demand.
5. Data used in decision-making are often aggregated or transformed. The "reproducibility" of any data transformations is a measure directly related to transparency. Expectations and needs outpace the current capabilities to deliver such data stewardship information to the public and interested agencies.
6. Clear and careful documentation of data quality and data formats through metadata avoids misunderstandings and misapplication of information—increasing the effectiveness of management decisions, reducing disputes, and obviating some basis of litigation. Clear standards also help to promote compatibility among

datasets for purposes of aggregation and analysis.

7. When making natural resource management decisions, best available science must align with best available data. With exceptions for confidential data, the recommendation in any litigation or other public hearings must be confined to the data available at the time. Of course, making data more readily available will greatly expand the horizons of understanding.
8. Modern techniques for data curation not only ensure proper attribution but also encourage data sharing.

Data Visualization

9. Close proximity and access to data promotes more effective data visualizations. Metadata (information about data) can convey proper data usage reliably as a proxy for direct access to the data producer.
10. The availability of cheap and open-source tools for visualization challenges the State to produce more robust, authoritative and informative data visualization tools to foster meaningful public engagement in critical environmental decisions.
11. Because data visualization often aggregates multiple data sources, data standards can help to streamline the development of visualization platforms.

Sustainable Business Models

12. Coordinated and collaborative data management must be conducted using business models that foster sustained, incremental investment and partnership with non-governmental partners.
13. There are many revenue and funding models from which to choose. A hybrid, diversified approach to funding the adopted solutions will likely protect against any single failure in the funding stream.
14. Over many years, we have seen a significant investment in agencies and organizations to conduct their data management. What is lacking is a business model to sustain the development and maintenance of data standards, integration points, web services, and data federation to facilitate synthesis across agency and issue boundaries. A sustainable, large-scale, partnership-driven infrastructure would facilitate a more comprehensive understanding of the complex California socio-environmental system.

RECOMMENDATIONS

Facing the challenges detailed above will require unprecedented levels of collaboration, creativity, and transparency. The solutions must build upon present investments while also disrupting the current dependency on highly centralized systems and processes if the State is to foster ambitious, agile technology innovation. These solutions will reside not among an exclusive cadre of insiders but at the broader intersection of all interested parties including the public, agencies, local governments, NGOs, and tribes.

To help organize the anticipated effort, we have organized our recommendations according to a schedule of near-term, mid-term, and long-term actions. Where possible, we have also indicated the expected duration of the recommended activity.

Near-term

A comprehensive data federation strategy should be adopted by the State to bring data

together into a single, virtualized data repository, while still preserving the autonomy of individual repositories. The State's individual data systems participating in the federation may continue to evolve in alignment with their own individual mandates and stakeholder needs, but in addition, they can be enhanced to offer integration options for inclusion into a statewide, interagency, federated system. Such a federated resource will result in a holistic understanding of the State's ecosystems while accelerating analysis and discovery for each individual member system. Implementation can be accomplished in an incremental fashion to allay concerns from resource-limited data managers and address substantial decision points. The tasks ahead call for the empowerment of one or more broad-based, collaborative, interagency workgroups to achieve the following implementation-related goals:

1. Data governance oversight (p.17)
 - a. review available interoperability standards for environmental data,
 - b. document common metadata standards (or set of standards),
 - c. seek strategic alliance with national and global initiatives that can contribute tools and web services.
 - i explore what web services / integration points exist and what needs to be developed to facilitate sharing of data.

Duration of engagement: 1 year

2. Developing a data federation strategy with a specific, time-bound roadmap. This effort must complement the work of the data standards implementation. (p.13, 30)

Duration of engagement: 2 years

3. Develop a business case and adopt a funding strategy in service of a sustainable business model, optimizing cost-benefit for the public good. The funding strategy and business case, once shared with strategic partners, will inspire the collaboration and cooperation necessary to motivate further efforts. (p. 25)

Duration of engagement: 2 years

Points of information:

- Whether these workgroups are singular or multiple depends largely on institutional capacity, scheduling matters, and jurisdictional concerns.
- Such efforts are currently underway. For instance, the Data Management Workgroup and the Wetland Monitoring Workgroup, both associated with the California Water Quality Monitoring Council, are conducting inventories of the State's metadata and data standards for select environmental data. Work such as this must continue, in whatever form is appropriate, to collect standards used by all of California's high-priority environmental data.
- Furthermore, data integration projects, such as those pursued by the Strategic Growth Council and Delta Restoration Network, should be encouraged as learning opportunities. Lessons gleaned from these pilots should in turn inform the data federation strategy.
- Regarding data standards, they should be promoted but not at the expense of data repository heterogeneity. Such heterogeneity enhances security and guards against the possibility of a total shutdown under a cyber-attack. Data federation preserves data heterogeneity while still advancing the dynamic sharing of data.



Innovative initiatives are already underway and these efforts are already reaping significant rewards in terms of saved time, enhanced collaboration among different organizations, and accelerated knowledge discovery that provides better information to make decisions on California's ecology and water-supply challenges.

Mid-term

4. Embrace data of differing quality, resolution, and sources, provided that these attributes are documented according to standards. (p.17)

Duration of engagement: ongoing

5. The State should devise a strategy for cultivating a common set of visualization tools. By leveraging talents across agency boundaries, the State can develop a knowledge-base and common set of technology libraries for data visualization development. This can decrease expenses while fostering modeling efforts, outreach support, and management engagement for more effective decision-making. (p.23)

Duration of engagement: 2 years

6. Adopt open-source software experimentally where appropriate. (p.12,28)
 - a. A mix of open-source and proprietary solutions and tailored web services can meet ongoing needs while addressing emerging demands. Increasingly, technology must be easily upgradeable and versatile. A hybrid mix would lend stability and flexibility while also encouraging cost-effective innovation.
 - b. The State must continue to recruit and retain the best and brightest technologists. For software developers and technology support staff, open-source software holds the greatest promise for career advancement, knowledge enrichment, and solution development. The State must cultivate opportunities to employ open-source software through training and challenging career tracks for these critical positions.

Duration of engagement: ongoing

7. Investigate opportunities for supercomputer, cloud computing, and massive distributed computing projects. Initiatives led by national programs are spearheading several new systems. Investigations of California's water challenges could be accelerated or enhanced by partnering with this massive computational and data storage capability. (p.30)

Duration of engagement: ongoing

Long-term

8. Develop and implement data management plans for all data acquired that clearly incentivize data-sharing. California should tie future funding opportunities to data transparency, similar to the National Institutes of Health and the National Science Foundation's present policies, such that the requisite time to post data are clearly defined. Recognizing that some data must necessarily be restricted at least for specified time (for example due to litigation or implications for sensitive or endangered resources), data-sharing policies should be clearly articulated with reference to state and federal laws as appropriate. California must strategically position its data management plans toward national and international initiatives and standards. Consulting contracts related to data generation should also be subject to these guidelines. (p.30)

Duration of engagement: ongoing

These recommendations build upon the State's existing infrastructure and nascent initiatives while also offering necessary opportunities for growth at a time when our natural resource management requires well-informed and timely decisions. More than ever before, we must work together across jurisdictions and disciplinary boundaries, for our success will be measured by our collective advancement.

Conclusion



Now, by linking standards to federation, conferring a broader context and goal for this foundational work, this vision will accelerate the implementation of standards. In other words, the ends will incentivize the means.

This document articulates a vision for enhancing California’s environmental data management to keep pace with the rate of technological and environmental change. We have examined the challenges primarily through the lenses of data stewardship, data visualization, and sustainable business models, all of which require a new and enhanced level of collaboration among scientists, agencies and data providers.

In the course of this collective effort, we have promoted the benefits of data federation, data standards, and a process for adopting sustainable business models, noting their respective capacity to expand the possibilities for data providers and data consumers alike. The challenges that lie in the path of implementation are formidable, and we have taken some effort to catalog those obstacles in each section, but there will still be as-yet-unknown roadblocks to a sustainable solution.

Implementation will require a strong initiative. Which organization, which agency should serve as the standard bearer for this effort? We recommend a partnership-based approach to ensure maximum participation and willing cooperation. This task force or task forces, per se, must be collectively knowledgeable in the challenges articulated in this document and adequately resourced to carry out the work specified. Key decisions—whether a single or multiple task force can undertake the recommendations, existing partnerships can be leveraged, or new partnerships formed—must be determined as the first step in this process.

Whatever the challenges, we must keep our eyes focused on the ultimate goal: more robust data sharing among data consumers resulting in accelerated knowledge discovery. Federation, along with the associated steps outlined in this paper, offers the most efficient vehicle to advance this goal. It can be implemented following a pathway that leads to smart sustainability, effective collaboration, and clear standards. Interagency relationships and external partnerships will form the foundation of our initiative. Accordingly, our advocated solutions should build upon

the foundation of the State's established infrastructure. As the vision articulated above reaches implementation, our success will be measured, not by a single agency's innovation or a single insight, but by our State's collective advancement.

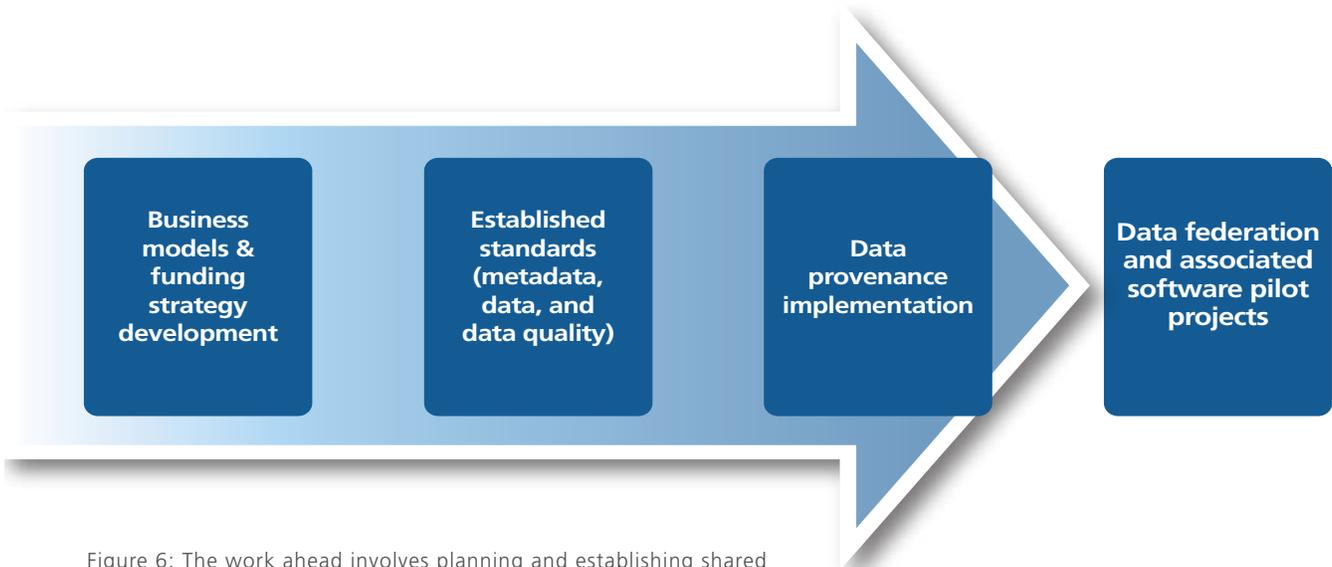


Figure 6: The work ahead involves planning and establishing shared data governance policies at a level detailed and durable enough to lead to data federation. Although represented here linearly, the overall process will likely be recursive and non-linear in nature, given limited resources and competing interests.

Appendix A



To effect a cultural shift in California that would incentivize data sharing, California should develop and implement data management plans for all data acquired that clearly incentivize data-sharing.

The following list represents descriptions of various revenue/funding models possibly applicable to State technology initiatives:

Product based:

In this strategy, each product project provides the funding that is needed for the datasets or use of datasets required in their product. While product-specific funding is the predominant means of funding product development, it may be used to fund core fundamental data development as well. Although product projects are often viewed (and properly so) as a primary source of funding, they may be reluctant to pay for aspects of the core fundamental data operations that they feel are the responsibility of someone else.

Portfolio of projects:

Multiple groups agree to form an alliance (MOU) and jointly fund the cost of developing a resource to be used by all, pooling data investments across a portfolio of projects. Demonstrate reuse of the data to illustrate “value”—e.g. four restoration projects, two research projects need x data. Projects would share costs of making data available.

Fee/Usage Based Funding:

Charge a fee proportional to their usage of the core assets. This strategy is similar to enacting a license fee for using a commercial product. Charging such fees is one possible way of obtaining funds for sustaining a program/product.

Taxing of participating projects:

This strategy involves funding selected elements of the product line by levying a tax on each participant/stakeholder. This taxing strategy can use a flat tax or a prorated tax that is based on some particular product attribute (such as product funds, project size, or estimated number of lines of code). The “product-side tax on customers” and “fee based on core asset usage” strategies described here can be viewed as special cases of a taxing strategy.

Legislated Funding:

Legislate mandatory contribution by participant agencies or the development of a new organization with adequate funding. A budget change proposal could ensure sustained funding and promote the greatest degree of transparency for such a measure.

Technology Innovation Fund:

State sponsored investment in projects with uncertain costs and benefits. Examples of this approach are experimental, with adequate incubation and a problem-solving orientation. They are typically shielded from a multi-stakeholder process except during application phase.

Examples of such an approach include:

- The Victorian Government Fund
- Michigan Seed Fund
- Texas Emerging Technology Fund

Sponsorship/Grant Funding:

Funding is granted by foundations or State Bond measures. Money is usually for single projects or a short term without commitment to long-term funding.

Corporate Funding:

This strategy is based on having a corporate-level/program sponsor fund elements of the project—e.g., server infrastructure. In-kind donation for corporate value can accrue added benefits.

Public/Private Partnerships:

A public-private partnership (PPP) is a government service or private business venture which is funded and operated through a partnership of government and one or more private-sector companies. A PPP involves a contract between a public sector authority and a private party, in which the private party provides a public service or project and assumes substantial financial, technical and operational risk in the project. In some types of PPP, the cost of using the service is borne exclusively by the users of the service and not by the taxpayer. In other types (notably the private finance initiative), capital investment is made by the private sector on the basis of a contract with government to provide agreed services and the cost of providing the service is borne wholly or in part by the government. Government contributions to a PPP may also be in-kind (notably the transfer of existing assets). In projects that are aimed at creating public goods, as in the infrastructure sector, the government may provide a capital subsidy in the form of a one-time grant, to make it more attractive to the private investors. In some other cases, the government may support the project by providing revenue subsidies, including tax breaks or by removing guaranteed annual revenues for a fixed time period.

Prorated Cost Recovery:

The object of this strategy is to have the projects that have benefited from the product line pay back their fair share of the costs of any software development efforts or services that the product line organization performed on their behalf. This strategy could be extended to include prorating all of, or just elements of, the total cost of sustaining product line operations among the participating project/product developers.

Infrastructure Provision:

Re-Classify data and knowledge as infrastructure for the State of California.
Request money from different government funding sources or budgets.

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DATA MANAGEMENT FOR CALIFORNIA'S ENVIRONMENTAL RESOURCES WILL REQUIRE THE EFFECTIVE LEVERAGING OF THE FULL CONTINUUM OF SOFTWARE FROM COMPLETELY OPEN SOURCE TO PROPRIETARY. GENERALLY, IN PUBLIC AGENCIES, OPEN SOURCE IS SHUNNED, BUT THERE ARE OPPORTUNITIES TO MARRY OPEN-SOURCE AND PROPRIETARY SOLUTIONS TOGETHER INTO A PRODUCTIVE WHOLE. IT IS NOT A QUESTION OF "EITHER-OR," BUT A STRATEGY FOR BOTH.

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A sunset over a body of water with tall grasses in the foreground and background. The sky is a mix of blue and orange, with the sun low on the horizon. The water reflects the colors of the sky, and the grasses are silhouetted against the bright light.

There is no turning back the clock on our interconnected world, but we could jeopardize its benefits if we fail to invest in a trusted data environment.

—ELLEN RICHEY,

CHIEF ENTERPRISE RISK OFFICER, VISA, USA

DELTA
STEWARDSHIP
COUNCIL



A California State Agency