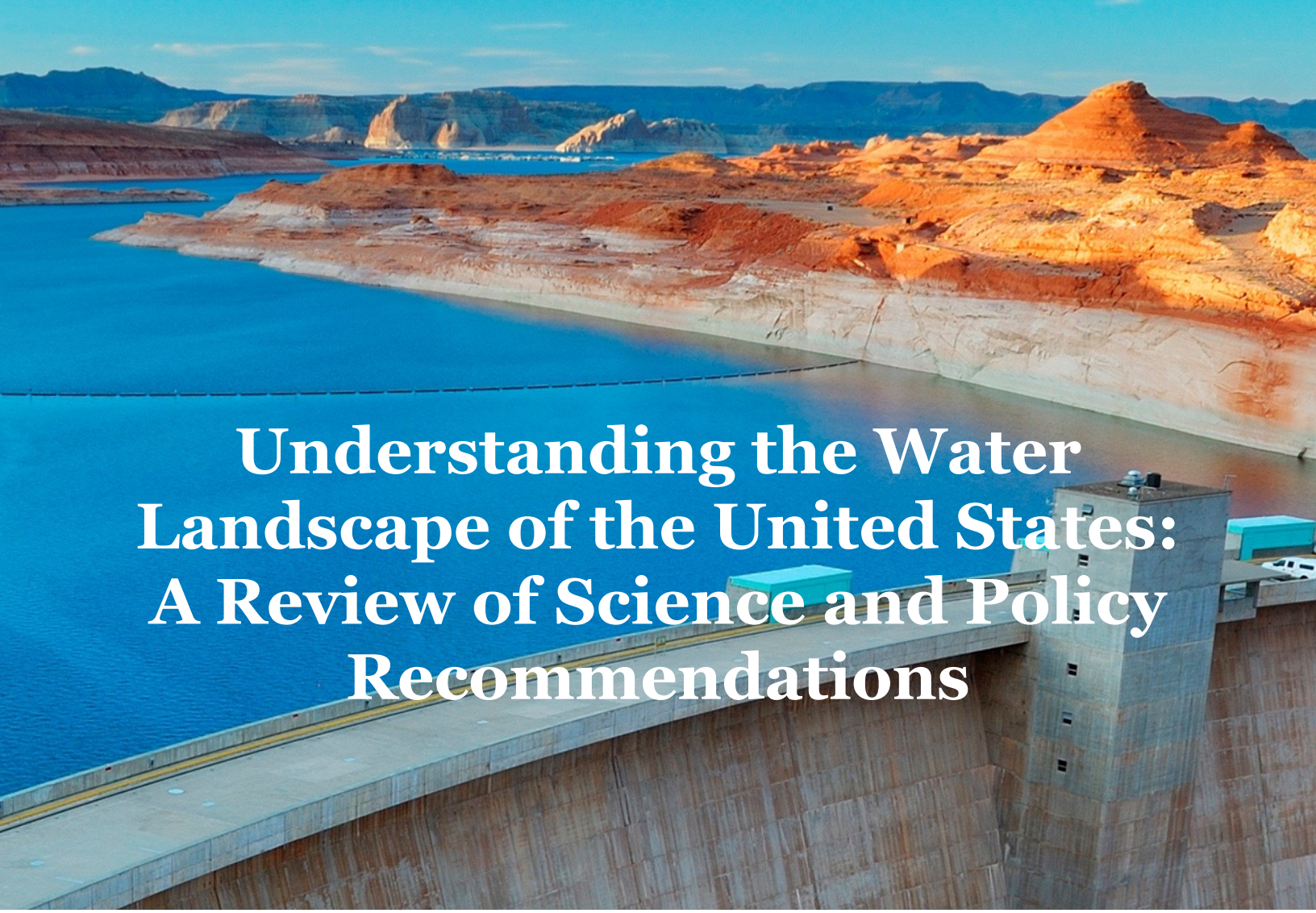

Understanding the Water Landscape of the United States: A Review of Science and Policy Recommendations

American Meteorological Society
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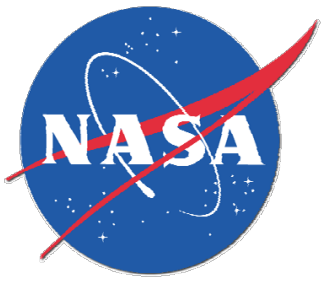

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About the AMS Policy Program

The AMS Policy Program has two primary goals. The first is ensuring that policy choices take full advantage of information and services relating to weather, water, and climate. The second is making sure that policy makers understand how much the broader society's welfare depends on information and services relating to weather, water, and climate. Meeting these two goals will help ensure that the scientific community receives the support and resources it needs to be able to make critical information and services available and, most importantly, will help the nation, and the world, avoid risks and realize opportunities related to the Earth system.

The Policy Program uses three primary approaches to help meet these two goals.

- We develop capacity within the AMS community for effective and constructive engagement with the broader society.
- We inform policy makers directly on established scientific understanding and the latest policy-relevant research.
- We help expand the knowledge base needed for incorporating scientific understanding into the policy process through research and analysis.

Through these activities, we create new ways to reduce society's vulnerability to weather and climate events by sharing our resources and information with policy makers and the public.

Executive Summary

Water is essential; at a very basic level, we require water of the right quality, at the right time, and in the right amount as a fundamental building block for life. Our nation's management of water resources is crucial for ensuring public health and prosperity.

There is an ongoing national dialogue on water, which has produced a vast number of reports, studies, and analyses containing hundreds, if not thousands, of recommendations for water science and policy. There is great opportunity in understanding the assessments and recommendations that have come before, in order to inform the future – we can build on existing knowledge, and identify common priorities and unmet needs.

A review of thirty reports on hydrologic science and management reveals twelve common recommendations:

1. Improve data collection
2. Improve data management
3. Increase scientific understanding for water resources decision making in a changing climate
4. Advance modeling capacity
5. Expand and tailor products for water resources managers
6. Support integrated approaches to water management
7. Address water rights
8. Expand and protect water supplies
9. Invest in water infrastructure
10. Establish federal coordination and planning processes
11. Invest in training and workforce development
12. Expand education and outreach

The literature highlights how crucial it is to identify and manage competing objectives; there are many different goals in water resources management, and failing to explicitly address the multiple, and possibly competing, goals can lead to suboptimal outcomes. In addition, virtually every report emphasizes the importance of making the most of existing resources, of doing a better job with the resources that we already have.

We also identify six topics that are not well covered in the national dialogue on water:

1. Increasing public knowledge and understanding
2. Planning for "big data"
3. Increasing public-private engagement
4. Preparing for hydrologic extremes
5. Understanding and managing surface and groundwater interactions
6. Understanding international dimensions

However, it is important to note that some of these gaps are more from lack of integration than because nobody is thinking about them. For example, the conjunctive management of surface water and groundwater has received a lot of attention in specific communities, but it has not been integrated with the general national dialogue on water. Similarly, the meteorological and emergency management communities have an overriding concern about adequately forecasting and preparing for hydrologic extremes, but this is not represented to the same degree in the national dialogue. This synthesis focuses on studies that address the nation's water management broadly, and identifies a few key issues that the national conversation has overlooked.

Finally, some recommendations appear within the reviewed literature with much greater frequency than others. This synthesis identifies the seven recommendations that were mentioned most often and by the highest number of reports. This serves as a rough measure of how recommendations have been prioritized within the existing literature.

Introduction

Water is essential; at a very basic level, we require water of the right quality, at the right time, and in the right amount as a fundamental building block for life. Our nation's management of water resources is crucial for ensuring public health and prosperity.

The importance of water is most apparent when something goes wrong. Crises in Flint, Michigan, Toledo, Ohio, and Elk River, Virginia in recent years illustrate the significance of water quality. The ongoing drought in the West and the major flooding events in South Carolina, Oklahoma, and Texas in 2015 call attention to the ways that timing and quantity matter. Moreover, nearly every aspect of water management faces challenges due to an aging water infrastructure system and the impacts of a changing climate.

At the same time, we are faced with vast potential for innovation and technological development. The growth of "big data," rapid increases in computing power, and new technologies to expand water supplies all hold promise for mitigating and overcoming the challenges we face. In order to ensure the adequacy of water supplies in the Twenty-First Century, as a nation we must improve the ways we predict and manage water.

There is an ongoing national dialogue on water, as illustrated by the vast number of reports, studies, and analyses containing hundreds, if not thousands, of recommendations for hydrologic science and water policy. There is great opportunity in understanding the assessments and recommendations that have come before in order to inform the future – we can build on existing knowledge. In addition, a comprehensive understanding of the status of the national dialogue on water will allow us to identify common priorities and unmet needs.

Specific agencies and groups emphasize different issues and have differing priorities. For example, science agencies tend to focus on data collection and modeling, while management agencies focus more on watershed-based management, and states and utilities are often concerned with water rights and pricing issues. However, it is the same water in the atmosphere, reservoirs, and municipal pipelines. An integrated understanding of water is beneficial, regardless of specific focus.

Water is essential; at a very basic level, we require water of the right quality, at the right time, and in the right amount as a fundamental building block of life.

In Section 1, we review the literature and identify recommendations that are common in the included reports. In section 2, we highlight gaps and opportunities in the existing literature. Finally, in section 3, we identify the recommendations that receive the most attention in the reviewed reports.

Synthesis of Literature

Federal agencies, interagency task forces, and non-governmental organizations alike all emphasize the importance of water resources management.

We examined 30 different reports in the literature review. These include reports focused on national and regional scales, and reports authored by federal agencies, inter-agency task forces, and non-governmental organizations and coalitions. Not all of the reports went subjected to an equally rigorous process during their creation. However, the inclusion of a diverse set of reports helps to ensure that our synthesis more comprehensively captures the broad scope of water management issues.

From the reviewed reports, we developed a database of over 800 specific recommendations, and sorted them, qualitatively, into 12 high-level categories (Table 1). There is broad agreement on many of the challenges and opportunities the nation faces, and on the steps needed to address them:

1. Improve data collection
2. Improve data management
3. Increase scientific understanding for water resources decision making in a changing climate
4. Advance modeling capacity
5. Expand and tailor products for water resources managers
6. Support integrated approaches to water management
7. Address water rights
8. Expand and protect water supplies
9. Invest in water infrastructure
10. Establish federal coordination and planning processes
11. Invest in training and workforce development
12. Expand education and outreach

These recommendations are broken into three different categories: Information Services; Management and Response; and Organizational Elements.

Table 1: Synthesis of High-Level Recommendations

Recommendation	Specific Components
Information Services: Assessing and Understanding Risks	
1. Improve data collection	1.1 Maintain existing monitoring networks, especially in locations relevant to water resource managers
	1.2 Expand data collection, including of national water availability and use, water quality, and ecosystem monitoring
	1.3 Develop, and support development of, technology for more effective, accurate monitoring
2. Improve data management	2.1 Develop and apply nationwide data standards
	2.2 Integrate monitoring networks for national consistency and make databases interoperable
	2.3 Make data access and use easier, including through increased access to real-time data and the development of data portals and websites
3. Increase scientific understanding for water resources decision making in a changing climate	3.1 Understand climate change impacts on water resources
	3.2 Understand water in ecosystems
	3.3 Understand social science aspects of climate change and water resources management
4. Advance modeling capacity	4.1 Develop advanced distributed, physics-based Earth-system hydrologic models
	4.2 Link hydrologic models with climate and sector models, and develop better ecosystem models
	4.3 Develop models at watershed and sub-watershed scales
	4.4 Transition hydrologic models to operational services, and develop community standards for model inter-comparison
5. Expand and tailor products for water resources managers	5.1 Expand and improve two-way communication with users/ stakeholders
	5.2 Develop and improve climate change products and other products tailored to needs of water resources managers
	5.3 Improve precipitation and seasonal forecasting

	5.4 Improve products for full natural flow (FNF), ecosystem services, and ecosystem health (some overlap with 4.2)
Management and Response	
6. Support integrated approaches to water management	6.1 Use and support a watershed and/or regional approach
	6.2 Use and support IWRM at local, regional, and federal levels
	6.3 Use and support collaborative processes
	6.4 Use and support an adaptive management approach
	6.5 Increase anticipation and management of hydrologic extremes
	6.6 Integrate climate change considerations into water planning and management
7. Address water rights	7.1 Support efforts to address local, regional, and national water rights issues
	7.2 Develop innovative approaches to water rights management, including water transfer agreements and water markets
8. Expand and protect water supplies	8.1 Develop metrics and standards for water use efficiency
	8.2 Expand water supplies, including through promotion of water use efficiency and reuse
	8.3 Develop, and support development of, technology for expanding water supplies
9. Invest in water infrastructure	9.1 Adequately maintain and rehabilitate the nation's water infrastructure
	9.2 Develop innovative financing mechanisms for water infrastructure
Organizational Elements	
10. Establish federal coordination and planning processes	10.1 Identify national priorities for water
	10.2 Improve coordination and communication within the federal family and with other partners
11. Invest in training and workforce development	11.1 Support the development of a skilled and well-educated workforce, and build the capacity of stakeholders and the nation to integrate scientific and climate information in their decision making.

	11.2 Develop "toolboxes" of best practices and resources for water resources managers, and syntheses of relevant literature
	11.3 Engage academia, and specifically Water Resources Research Institutes, in water resources management and climate change adaptation research
12. Expand education and outreach	12.1 Build public awareness of the importance and value of water, and about contemporary and future water issues
	12.2 Develop materials and strategies for communicating uncertainty (both for technical communities and the general public)

After sorting the database of recommendations into the categories contained in Table 1, we used a quantitative analysis of the database for refinement and fine-tuning (see Appendix B for more detail). There are three remaining issues with Table 1 that are highlighted by the quantitative analysis.

First, there are 16 different science recommendations that do not fit within any of the Table 1 science categories (3.1, 3.2, 3.3). However, this may reflect that Table 1 does not include a category for basic science. Instead, category 3 focuses on special areas of focus for scientific research rather than the general need for basic research in hydrology and other related sciences.

Second, there are only four recommendations in the database that fall within category **8.1 Develop metrics for water use efficiency**. However, this topic has received recent attention from the White House, and may become a larger part of the national dialogue on water.[1]

Finally, there are several recommendations in the database regarding the pricing of water – three by the Johnson Foundation (2010, 2014), and two by the Western Governors Association (2008). Utilities in particular are concerned with adjusting the price of water to reflect its value as a commodity, and not just the price of treating and delivering it. The pricing of water is under local and state jurisdiction, which may explain why it is not featured more prominently in the literature. In addition, the literature review stretches back over the past fifteen years, while the issue of water pricing has gained prominence only in the past few years with the onset of the Western drought.

Our results and conclusions depend, at least in part, on the reports that were included in the review. We attempted to include all the high-profile domestic reports on national

[1] https://www.whitehouse.gov/the-press-office/2015/12/15/fact-sheet-administration-announces-public-private-innovation-strategy

water resources management as of November 2015, as well as additional reports with local and regional foci to calibrate the nationally focused reports. We believe that the synthesis recommendations (Table 1) will largely hold up to the inclusion of new and different reports, especially if the suggestions below are incorporated. However, the frequency analysis, discussed in the Frequency of Recommendations section and in Appendix A, may not.

Analysis of Literature and Recommendations

There are many goals for water resources management, including water supply, public safety, economic growth, and environmental health.

Additional analysis reveals some strengths and weaknesses of the existing body of literature. In this section we highlight two important lessons learned from the literature, as well as six crucial gaps and opportunities.

Important Lessons

1. Managing competing objectives

There are many goals for water resources management, including water supply, public safety, economic growth, and environmental health. Often these are considered separately. Managing for a single goal can lead to sub-optimal outcomes in the other areas. Sometimes balancing goals requires subjective value judgments. Integrated water resources management (IWRM) is seen as a way of managing these conflicts, and emphasizes that using good processes for decision making is important for balancing competing, equally valid, objectives.

2. Making the most of existing resources

Virtually every report emphasizes the importance of doing a better job with the resources that we already have. These resources include data, products, and programs. Stakeholders continually express a need for more accessible, usable data. Improved coordination of existing programs and initiatives, across agencies and all levels of government, has considerable potential to maximize the value of existing resources.

The existing body of literature also has some gaps. Below, we highlight opportunities for improvement in the ways we think about and manage water.

Gaps and Opportunities

1. Increasing public knowledge and understanding

Public awareness of the value of water influences individual behavior (e.g., when people are aware of the sources of their water, they are more likely to conserve it[2]) and public attention helps determine federal funding for water science and policy issues. Therefore,

[2] Baselice & Associates, Inc. (2014), *Texas Statewide Water Conservation Survey.* http://www.texaswater.org/wp-content/uploads/2014/09/Texas-Statewide-Water-Conservation-Survey.pdf <Last accessed 11/17/15>

efforts to improve public knowledge and understanding can improve water resource management. Some groups emphasize this point, but federal reports generally do not; this reflects a possible mismatch in priorities and an opportunity for federal agencies to contribute to an underserved need.

2. Planning for "big data"
Big data represents both an important opportunity and a potential disruptor. Although it has received recent attention (e.g., partnerships with Amazon, Google, IBM, etc.), there is relatively little thought given to it in the existing literature. It may be necessary to more deliberately and thoughtfully integrate big data efforts into national planning for water resources management.

3. Increasing public-private engagement
Most reports emphasize that the federal government should take a collaborative approach to planning and decision-making, and that products should be developed with input from users and stakeholders. However, comparatively little is explicitly said about engaging the private sector in strategic planning discussions. There are growing efforts within the private sector (e.g., utilities, energy companies, and agriculture) to address water management issues, and creating a dialogue with the private sector would increase the effectiveness of the products and services provided by the public and scientific communities.

4. Preparing for hydrologic extremes
Perhaps surprisingly, the importance of managing hydrologic extremes (e.g., floods and droughts) is not emphasized strongly in the existing body of literature, though drought does receive comparatively more attention than flooding. Hydrologic extremes are important in the forecasting and prediction communities, but this has not been reflected in the broader national discourse.

5. Understanding and managing surface and groundwater interactions
Groundwater and surface water are inextricably connected and interdependent, but they have traditionally been managed separately. Conjunctive management is crucial to future water sustainability. Groundwater data collection needs are well-assessed in the literature, and there is some discussion of the need for integrated surface and groundwater models, but discussion of conjunctive management is lacking in the reviewed reports. It could be included as an aspect of Integrated Water Resources Management.

6. Understanding international dimensions
The reports included in this analysis focus on domestic water issues. There is a separate body of literature on international aid and water concerns, but it is not well integrated into the domestic-focused discussion. An integrated consideration of domestic and international issues could help build our capacity to 1) understand international and national security implications of water issues; 2) identify and advance international business opportunities; and 3) continue our role as a "good neighbor" in the international community.

Frequency of Recommendations

Table 1 characterizes the broad range of topics covered within the national dialogue on water. However, the recommendations presented in Table 1 receive unequal attention, with some heavily emphasized across multiple reports and others appearing less frequently. We analyzed the level of attention received by the recommendations among the reports as a rough measure of relative priority.

We created a database of the recommendations from the 30 reports reviewed, and sorted them according to the categories in Table 1. We then performed a simple analysis of the number of recommendations that fall within each category (a "mention"). We also counted how many different reports make recommendations within each category, allowing a rough idea of the relative priority of each category (see Appendices A and B). Note that this approach can be misleading because some reports mention a category of recommendation multiple times, and some reports have common authors.

Table 2 highlights the top five categories and two categories of special note.[3]

Table 2: Priority Recommendations

Water Information Services: Assessing and Understanding Risks	
1.2 Expand data collection	59 mentions, from 18 different reports
2.3 Make data access and use easier	21 mentions, from 11 different reports
5.2 Develop and improve products tailored to needs of water resources managers	41 mentions, from 15 different reports
Management and Response	
6.1 Use and support a watershed and/or regional approach	40 mentions, from 10 different reports
6.2 Use and support IWRM at local, regional, and federal levels	55 mentions, from 11 different reports
6.6 Integrate climate change in water resources management	24 mentions, from 11 different reports
Organizational Elements	
10.2 Improve coordination and communication	63 mentions, from 16 different reports

[3] Categories 2.3 and 6.6 did not make the cutoff for the top recommended categories, but are included because of their broad base of support. Both are mentioned in 37% of the reports reviewed, despite their low total count.

1.2 Expand data collection is the most broadly recommended category – it is mentioned in 60% of the surveyed reports. **2.3 Make data access and use easier** is remarkable for receiving such a broad base of support (i.e., appearing in 37% of the reviewed reports) with relatively few total mentions. **5.2 Develop and improve products for water resources managers** is one of only four categories that are mentioned in fifteen or more reports.

While **6.1 Watershed- and regional-based management** and **6.2 IWRM** receive 40 and 55 mentions respectively, a disproportionate number of mentions come from U.S. Army Corps reports. However, the Council on Environmental Quality (CEQ), Western Governors Associations (WGA), and NOAA, among others, also list them as high priorities. **6.6 Integrate climate change,** while receiving approximately half the mentions of **6.1** and **6.2**, appears in a similar number of reports — 37% of those reviewed.

10.2 Improve coordination and communication receives 63 mentions, in 16 different reports. Important to note, this category is not just targeted at the federal family. Recommendations within this category address coordination within the federal family, between the federal family and partners, and among non-federal organizations. Many recommendations are specifically addressed to various partners, including the private sector, local and state government, and NGOs.

Fifteen of the specific components in Table 1 had 25 or more mentions in the database. Further analysis is available in Appendix A, including all 15 highest totaling categories, 3 additional noteworthy categories, and the frequency table.

Conclusion

Reflecting the importance of water to societal health and prosperity, there is an extensive literature on water science and management in the United States. Reviewing a diverse cross-section of reports reveals many areas where the reports agree on recommendations for improving the nation's management of water. Many of our current weaknesses and opportunities for improvement are well understood.

However, improvement in the ways we think about and manage water remains possible. Increasing public awareness of the importance of water, planning for "big data," increasing public-private engagement, integrating hydrologic extremes and conjunctive management of groundwater, and understanding international dimensions will allow the nation to better avoid risks and realize opportunities related to water in the Earth system.

Appendix A

We created a database of the recommendations from the 30 reports reviewed, and sorted them according to the categories in Table 1. We then performed a simple analysis counting the number of times recommendations within a given category appeared (a "mention"). We also counted how many different reports make recommendations within each category, allowing a rough idea of the relative priority of each category.

This approach is helpful, but can still be somewhat misleading. Some reports mention a category of recommendation multiple times, and some reports have common authors. In Table 4, and in the discussion sections above, we attempt to call attention to cases where the analysis may be misleading.

Table 3: Frequency Analysis

The "Category" column refers to the categories from Table 1. The "Total" column counts the number of recommendations in the database that fall into each category, and the "Reports" column counts the number of different reports with recommendations in that category. Categories with 25 or more mentions are highlighted in green. Categories with 20 to 24 mentions are highlighted in yellow.

The "R/Total Reports" column calculates the percentage of reports (30 total) that mention a particular category. Percentages greater than or equal to 30 are highlighted in green; percentages between 20 and 29 are highlighted in yellow.

Category	Total	Reports	R/Total Reports
1.1	10	8	0.27
1.2	59	18	0.60
1.3	5	4	0.13
2.1	5	4	0.13
2.2	9	7	0.23
2.3	21	11	0.37
3	15	7	0.23
3.1	34	10	0.33
3.2	32	9	0.30
3.3	29	7	0.23
4.1	4	3	0.10
4.2	12	7	0.23

4.3	3	3	0.10
4.4	7	4	0.13
5.1	29	7	0.23
5.2	41	15	0.50
5.3	8	2	0.07
5.4	19	3	0.10
6.1	40	10	0.33
6.2	55	11	0.37
6.3	35	13	0.43
6.4	8	7	0.23
6.5	25	12	0.40
6.6	24	11	0.37
7.1	10	4	0.13
7.2	9	5	0.17
8.1	4	3	0.10
8.2	28	10	0.33
8.3	12	5	0.17
9.1	26	6	0.20
9.2	9	5	0.17
10.1	18	5	0.17
10.2	63	16	0.53
11.1	45	18	0.60
11.2	28	8	0.27
11.3	6	3	0.10
12.1	22	10	0.33
12.2	16	7	0.23

Frequency Analysis

Below, we highlight the 15 highest-totaling categories and 3 additional noteworthy categories.

1.2: Expand data collection, including of national water availability and use, water quality, and ecosystem monitoring: This category receives 59 mentions. Several specific data collection programs are mentioned multiple times. 18 different reports have recommendations that fall within this category. This is one of only four categories that are mentioned in fifteen or more different reports.

All of the science categories receive a relatively high number of mentions, likely because many of the recommendations are very specific.

3.1 Understand climate change impacts on water resources: This category receives 34 mentions. 10 different reports have recommendations in this category. 15 of the recommendations, nearly 50%, come from the CCAWWG 2011 report, and 7 come from the USGS 2009 report. However, CEQ 2013 and 2013a, NOAA 2010, and WGA 2006 (all broader in scope) also make this recommendation.

3.2 Understand water in ecosystems: This category receives 32 mentions. 9 different reports have recommendations in this category. 15 of the recommendations, nearly 50%, come from the NRC 2012 report; 7 come from the NRC 2013 report. However, SWAQ 2007, CEQ 2011, and NOAA 2010 (all broader in scope) also make this recommendation.

3.3 Understand social science aspects of climate change and water resources management: This category receives 29 mentions. 7 different reports have recommendations in this category. 12 of the recommendations, about 40%, come from the NRC 2004 report, and 5 come from the CCAWWG 2011 report.

5.1 Expand and improve two-way communication with users/stakeholders: This category receives 29 mentions. 7 different reports have recommendations in this category. Showing NOAA's recent strong emphasis on communication with stakeholders, 24 of the mentions are in NOAA reports: 16, over 50%, come from the NOAA 2014 report, and 6 come from the NOAA 2015 report. This concept may also be captured in category 6.3, "Use and support collaborative processes," which receives 35 mentions, with heavy attention (16 mentions) from USACE in particular.

5.2 Develop and improve climate change products and other products tailored to needs of water resources managers: This category receives 41 mentions, from 15 different reports. It shows a broad base of support, with mentions in a diverse selection of reports, although 10 of the specific mentions (~25%) come from the CCAWWG 2013 report. Several specific products are mentioned; the rest of the mentions are more general. This is one of only four categories that are mentioned in fifteen or more different reports.

6.1 Use and support a watershed and/or regional approach: This category receives 40 mentions, from 10 different reports. Watershed- and regional-based management is a point of emphasis for the U.S. Army Corps. Its 2010 reports mentions it 25 times, though this does include similar recommendations to different stakeholders and levels of government.

6.2 Use and support IWRM at local, regional, and federal levels: This category receives 55 mentions, from 11 different reports. Similar to 6.1, this is important to the U.S. Army Corps: their 2010 report addresses it 36 times. IWRM, whether or not the exact title and acronym is used, is also addressed by CEQ, the WGA, and NOAA, among others.

6.3 Use and support collaborative processes: This category receives 35 mentions, from 13 different reports. 16 are from the USACE 2010 report.

6.5 Increase the nation's ability to anticipate and manage hydrologic extremes: This category receives 25 mentions, from 12 different reports. The highest number of mentions from any one report is 4.

8.2 Expand water supplies, including through promotion of water use efficiency and reuse: This category receives 28 mentions, from 10 different reports. The Johnson Foundation 2014 report accounts for 13 of those mentions.

9.1 Adequately maintain and rehabilitate the nation's water infrastructure: This category receives 26 mentions, from 6 different reports. 7 are from the USACE 2010 report, 10 from the WGA 2008 report, and 6 from the WGA 2006 report. Combined, the Western Governors Association accounts for 62% of mentions in this category, and the U.S. Army Corps for 27%.

10.2 Improve coordination and communication within the federal family and with other partners: This category receives 63 mentions, from 16 different reports. About two-thirds are targeted at the federal government, while the rest are targeted at various partners. Recommendations cover a continuum from specific to general. 16 mention specific coordinating bodies or plans. This is one of only four categories that are mentioned in fifteen or more different reports.

11.1 Support the development of a well-educated workforce, and build the capacity of stakeholders and the nation to integrate scientific and climate information in their decision-making: This category receives 45 mentions, from 18 different reports. This is one of only four categories that are mentioned in fifteen or more different reports.

11.2 Develop "toolboxes" of best practices and resources for water resources managers, and syntheses of relevant literature: This category receives 28 mentions, from 8 different reports. 10 mentions, all from USACE 2010, reference the Federal Support Toolbox.

Three categories did not make the cutoff for frequency analysis, but deserve additional attention. Categories 2.3, 6.6, and 12.1 all receive over twenty mentions. What makes them noteworthy is the broad support they receive in the literature.

2.3 Make data access and use easier, including through increased access to real-time data and the development of portals and websites is mentioned 21 times in 11 different reports. It is mentioned in 37% of the reports reviewed.

6.6 Integrate climate change considerations into water planning and management is mentioned 24 times in 11 different reports. It is mentioned in 37% of the reports reviewed.

12.1 Build public awareness of the importance and value of water, and about contemporary and future water issues is mentioned 22 times in 10 different reports. It is mentioned in 33% of the reports reviewed.

Appendix B

Table 4: Categories

The Mentions column totals the number of items coded under each category from Table 1. The Reports column totals how many reports make a recommendation under that category, followed by the report citations and the number of times the recommendation is mentioned in each report (in parentheses). The Notes column highlights additional issues for each synthesis category.

Recommendation		Men.	Reports	Notes
1. Data collection	1.1	10	**8**: ACWI 2014, CCAWWG 2013 (2), JF 2010, NOAA 2010, NRC 2012a, USACE 2010, WGA 2006 (2), WGA 2008	
	1.2	59	**18**: ACWI 2014, CCAWWG 2013 (3), CEQ 2011 (2), CEQ 2013a, CEQ 2013 (2), ERG 2014 (2), FIP 2011 (8), IWRSS 2014, JF 2010 (2), NOAA 2014 (4), NRC 2004 (2), NRC 2012 (2), NRC 2013 (5), NRC 2014 (3), SWAQ 2007 (4), USACE 2010 (8), WGA 2006 (3), WGA 2008 (6)	
	1.3	5	**4**: FIP 2011, JF 2010, NRC 2004, SWAQ 2007 (2)	
2. Data management	2.1	5	**4**: CEQ 2011, CEQ 2013, FIP 2011, SWAQ 2007 (2)	
	2.2	9	**7**: ACWI 2014, IWRSS 2009 (3), IWRSS 2014, NOAA 2014, SWAQ 2007, USACE 2010, WGA 2006	
	2.3	21	**11**: CEQ 2011 (2); CEQ 2013 (2); ERG 2014 (3); FIP 2011; IWRSS 2009 (2); IWRSS 2014, NOAA 2014; NRC 2004, NRC 2014, USACE 2010 (3); WGA 2008 (4)	Overlaps some with 11.2, Toolbox development
3. Science	3	15	**7**: CCAWWG 2011; CEQ 2011a; CEQ 2013a; IWRSS 2009; NOAA 2010; NRC 2004 (6); NRC 2012 (5)	Basic science recommendations

	3.1	34	**10**: CCAWWG 2011 (15); CEQ 2011; CEQ 2013; CEQ 2013a; FIP 2011 (2); NOAA 2010 (2); NRC 2004; NRC 2012 (3); USGS 2009 (7); WGA 2006	15 from CCAWWG 2011; 7 from USGS 2009
	3.2	32	**9**: CCAWWG 2011, CEQ 2011; ERG 2014; NOAA 2010; NOAA 2014 (2); NRC 2004 (3); NRC 2012 (15); NRC 2013 (7); SWAQ 2007	7 from NRC 2013; 15 from NRC 2012
	3.3	29	**7**: CCAWWG 2011 (5); IWRSS 2009 (3); NOAA 2014; NRC 2004 (12); NRC 2013 (3); SWAQ 2007 (2); USGS 2009 (3)	5 from CCAWWG 2011; 12 from NRC 2004
4. Modeling	4.1	4	**3:** IWRSS 2009 (2); IWRSS 2014; USGS 2009	
	4.2	12	**7**: CCAWWG 2011 (4); ERG 2014; NOAA 2010; NOAA 2014; NOAA 2015; NRC 2012; SWAQ 2007 (2); USACE 2010	
	4.3	3	**3**: ERG 2014; NRC 2012a; SWAQ 2007	
	4.4	7	**4**: IWRSS 2009; NOAA 2014 (2); NRC 2012a (2); SWAQ 2007 (2)	
5. Products	5.1	29	**7**: IWRSS 2009 (2); NOAA 2010; NOAA 2014 (16); NOAA 2015 (6); NRC 2012a (2); WGA 2006; WGA 2008	16 from NOAA 2014; 6 from NOAA 2015
	5.2	41	**15**: CCAWWG 2011 (3); CCAWWG 2013 (10); CEQ 2011 (3); CEQ 2011a; CEQ 2013 (2); ERG 2014 (2); FIP 2011; IWRSS 2009 (4); IWRSS 2014; NOAA 2010; NOAA 2014 (5); NOAA 2015 (2); NRC 2004; USGS 2009; WGA 2008 (4)	About half mention specific products; 10 from CCAWWG 2013
	5.3	8	**2**: CCAWWG 2013 (3); NOAA 2014 (5)	
	5.4	19	**3**: ERG 2014; NOAA 2014 (4); NOAA 2015 (14)	14 from NOAA 2015; 4 from NOAA 2014

6. IWRM	6.1	40	**10**: ACWI 2014 (2); CEQ 2013; CEQ 2013a; ERG 2014; NOAA 2014 (2); NRC 2004; NRC 2014; USACE 2010 (25); WGA 2006 (4); WGA 2008 (2)	25 from USACE 2010
	6.2	55	**11**: ACWI 2014 (2); CEQ 2011; JF 2010; JF 2014; NOAA 2010; NOAA 2014; NRC 2004; NRC 2012 (4); USACE 2010 (36); WGA 2006 (4); WGA 2008 (3)	36 from USACE 2010
	6.3	35	**13**: CEQ 2013a (3); ERG 2014; FIP 2011; IWRSS 2009; JF 2010 (2); JF 2014 (2); NOAA 2015; NRC 2004; NRC 2013; NRC 2014 (2); SWAQ 2007; USACE 2010 (16); WGA 2006 (3)	16 from USACE 2010
	6.4	8	**7**: CEQ 2011; CEQ 2013; JF 2010 (2), NRC 2004; NRC 2012; NRC 2013; NRC 2014	
	6.5	25	**12**: ACWI 2014 (2); CEQ 2011; CEQ 2013; CEQ 2013a; JF 2010 (2); NOAA 2010 (2); NOAA 2014 (3); NRC 2004; NRC 2014 (4); USACE 2010 (4); USGS 2009 (2); WGA 2008 (2)	
	6.6	24	**11**: CEQ 2011 (3); CEQ 2013; JF 2010 (3); JF 2014; NOAA 2010 (2); NRC 2012; NRC 2014; USACE 2010 (2); USGS 2009; WGA 2006 (3); WGA 2008 (6)	
7. Rights	7.1	10	**4**: NRC 2004 (3); USACE 2010 (2) WGA 2006 (3); WGA 2008 (2)	
	7.2	9	**5**: JF 2010 (2); JF 2014; NRC 2004 (2); NRC 2012 (2); WGA 2008 (2)	
8. Supply	8.1	4	**3**: ACWI 2014 (2); CEQ 2011; CEQ 2013	

	8.2	28	**10**: ACWI 2014; CEQ 2011; CEQ 2013; CEQ 2013a (2); JF 2010 (3); JF 2014 (13); NRC 2004 (2); NRC 2012; WGA 2006; WGA 2008 (3)	13 from JF 2014
	8.3	12	**5**: CEQ 2011a; NRC 2004 (3); SWAQ 2007 (3); WGA 2006; WGA 2008 (4)	
9. Infrastructure	9.1	26	**6**: JF 2014; NRC 2004; NRC 2012; USACE 2010 (7); WGA 2006 (6); WGA 2008 (10)	7 from USACE 2010; 10 from WGA 2008; 6 from WGA 2006
	9.2	9	**5**: JF 2010; JF 2014 (3); USACE 2010 (2); WGA 2006; WGA 2008 (2)	
10. National	10.1	18	**5**: CEQ 2011; JF 2010; NRC 2014 (3); SWAQ 2007; USACE 2010 (12)	12 from USACE 2010
	10.2	63	**16**: ACWI 2014 (5); CEQ 2011 (4); CEQ 2011a; CEQ 2013 (2); CEQ 2013a; FIP 2011 (4); JF 2010; JF 2014; NOAA 2010; NOAA 2014 (3); NOAA 2015 (4); NRC 2012 (2); NRC 2013; NRC 2014 (6); USACE 2010 (25); WGA 2006 (2)	About 2/3rds directed at federal agencies; 16 reference specific coordinating groups
11. Training and workforce	11.1	45	**18**: ACWI 2014 (3); CCAWWG 2011 (8); CCAWWG 2013 (3); CEQ 2011 (3); CEQ 2013 (3); CEQ 2013a; FIP 2011; JF 2010; IWRSS 2009 (3); NOAA 2010 (2); NOAA 2015; NRC 2012; NRC 2012a (2); NRC 2014 (2); SWAQ 2007; USACE 2010 (8); WGA 2006; WGA 2008	
	11.2	28	**8**: CCAWWG 2011 (3); CEQ 2011 (2); CEQ 2013; ERG 2014; JF 2010 (2); NRC 2013; USACE 2010 (16); USGS 2009 (2)	10 mention the Federal Support Toolbox, all from USACE 2010
	11.3	6	**3**: ACWI 2014; CEQ 2011 (2); CEQ 2013 (3)	

12. Outreach	12.1	22	**10**: CEQ 2011; CEQ 2013; IWRSS 2009; JF 2010 (3); JF 2014 (2); NOAA 2010 (2); SWAQ 2007; USACE 2010 (9); WGA 2006; WGA 2008	9 from USACE 2010
	12.2	16	**7**: CCAWWG 2011 (6); CEQ 2013a (2); ERG 2014; IWRSS 2009 (2); NRC 2012; NRC 2012a; USGS 2009 (3)	

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