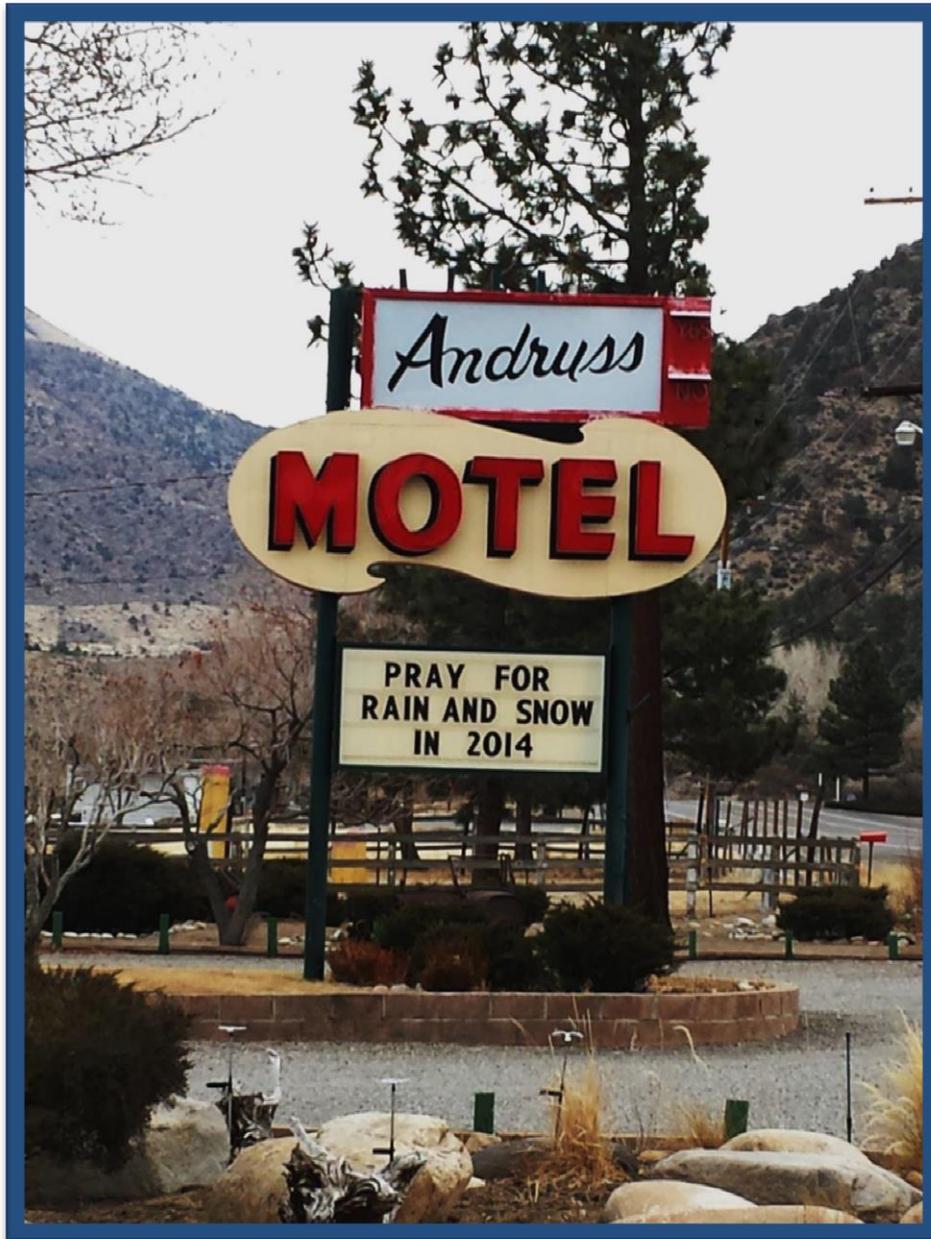


An Evaluation of *Climate Change Handbook for Regional Water Planning*



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Executive Summary

In 2011, the California Department of Water Resources, in partnership with four other agencies and organizations, completed and distributed the *Climate Change Handbook for Regional Water Planning*, which is a document designed to aid Integrated Regional Water Management practitioners and other water planning entities in incorporating climate change into regional water planning efforts. After more than two years of the *Handbook's* availability, DWR wished to evaluate the *Handbook's* use by IRWM regions and its effectiveness and opportunities for improvement. This report details an investigation into the experiences of IRWM practitioners who used the *Handbook* to conduct part or all of their climate change analyses within their IRWM Plans. This report does not attempt to provide an exhaustive description of every region's experience; rather, it depicts a representation of experiences from a regions around the state to provide a realistic picture of how the *Handbook* has been used and how it could be improved. This information was gathered through an online survey distributed to IRWM practitioners and through individual conversations with IRWM practitioners. The results of the survey are discussed, as are implications of the results for the future of climate change analysis in the IRWM Program. The final section contains a number of recommendations based on the survey results, conversations with IRWM practitioners and DWR climate change staff, and the author's own experiences. These recommendations are geared towards improving future iterations of the Handbook how DWR might move forward with respect to climate change requirements for IRWM Plans, and thus they fall into the following categories:

- Updating the Handbook
- Outreach
- Building local/regional capacity
- Climate Change Plan Standard
- Developing local information
- California Adaptation Planning Guide
- Regional differences, State standardization
- Replicate success of vulnerability assessment checklist
- Considerations for rural and inland communities
- Regions need assistance
- Increasing collaboration and information sharing among IRWM regions
- Agricultural water use

Introduction

Climate change has become an increasingly large and important part of water resources planning in California, from the state level (through such efforts as the periodic California Water Plan Updates) to the regional and local levels (through the Integrated Regional Water Management [IRWM] Program and associated IRWM Plans). Due to the spatial resolution of most general circulation models as well as the large scale of many of the state's water storage and conveyance systems, most climate change/water resources analysis in California has, in the past, occurred at the state level. More recently, there has been more emphasis on developing climate change information and response actions at the regional and local levels. The California Department of Water Resources (DWR) has put a climate change staff in place to deal with the various kinds of impacts experienced in the state, including regional coordinators to help IRWM groups and other regional water managers develop their own climate change analyses. *When considered together, such a suite of regional climate change analyses, if properly conducted, would create an additional state-level depiction of how climate change is impacting the state's water resources.*

In 2010, the Department of Water Resources partnered with U.S. Environmental Protection Agency Region 9, U.S. Army Corps of Engineers South Pacific Division, Resources Legacy Fund, and U.S. Environmental Protection Agency Office of Research and Development to produce a guidance document for incorporating climate change into regional water planning in California. Although not specifically targeted at IRWM regions, this document was intended to reference steps in the IRWM planning process in order to give direction on incorporating climate change information. The resulting document and subject of this report, *Climate Change Handbook for Regional Water Planning* (hereafter "*Handbook*"), was released in November 2011.

At about the same time, the DWR climate change staff was working with the DWR-IRWM staff to revise the climate change Plan Standard in the *IRWM Proposition 84 and 1E Guidelines* ("*Guidelines*"). Plan Standards describe minimum requirements that each IRWM Plan must meet and cover many different topics relevant to regional water planning, from region descriptions to stakeholders to financing. The previous version of the *Prop. 84 and 1E Guidelines* (2010) had required only a very cursory consideration of climate change in IRWM Plans. The treatment of climate change in IRWM Plans resulting from the 2010 set of *Guidelines* is fully discussed in *Climate Change and Integrated Regional Water Management in California: A Preliminary Assessment of Regional Approaches* (Conrad 2012).

The revised climate change Plan Standard in the 2012 *Guidelines* requires an intermediate step towards a more rigorous and thorough analysis of climate change in individual IRWM regions. This updated Plan Standard requires a discussion of potential impacts of climate change on the region, an evaluation and prioritization of climate change vulnerabilities in the region, a description of a process that considers greenhouse gas emissions when choosing among project alternatives, and identification of further data gathering and analysis. Within the *Guidelines*, the *Handbook* is referenced several times as a key resource to guide IRWM practitioners through the process of addressing the requirements of the Plan Standard. Several other resources are cited in the *Guidelines* as well.

About a year-and-a-half after the 2012 *Guidelines* were released and IRWM regions began updating their climate change sections, DWR and Resources Legacy Fund wished to evaluate the use of the *Handbook* and determine if its use should continue and focus the direction of future work related to the *Handbook*. DWR and RLF contracted with Holly Alpert (the author of this report), who works with the Inyo-Mono Integrated Regional Water Management Program and is actively involved in climate change and water issues, to conduct an evaluation of the *Handbook's* use. What follows is a description of the methodology used for and results gathered from an investigation of IRWM practitioners' experiences using the *Handbook*. The report ends with a series of recommendations related to the future use of the *Handbook* and assisting IRWM regions with performing more rigorous climate change analyses.

Survey Methodology

A survey was created to quickly and efficiently gather information from IRWM-related users of the *Climate Change Handbook* about their experiences using the *Handbook* and about additional information or tools they might need to continue their region-specific climate change analyses. Both Sacramento and regional DWR climate change staff were enlisted to help develop survey questions and identify people and IRWM regions that should be targeted. The survey questions are presented in Box 1. A cursory review had also been performed of most of the IRWM regions' climate change analyses to get a sense of where the *Handbook* was used and where it was not used. This knowledge helped to shape the survey questions and to determine what IRWM regions to target. Although there was a large amount of variation over the approximately three dozen plans viewed, the *Handbook* was most consistently used for the regional vulnerability analyses. There will be more discussion of these general observations later on.

From this brief review of the IRWM Plans, and using existing knowledge of IRWM regions and their representatives, an initial list was developed of people to invite to participate in the survey. This list was shared with DWR staff, whose feedback was then incorporated into the final list. An initial request to participate was sent to 23 people who have represented and/or worked with at least 28 IRWM regions. Six favorable responses were received from people who wished to participate. In the end, the link to the survey (which was created on SurveyMonkey) was provided to all 23 people, including the six who indicated they would likely participate. The survey was left open for 12 days, and a reminder email was sent about five days before the survey was closed.

By the end of the response period, seven responses had been received. Because respondents had been informed that their answers would not be associated with particular IRWM regions (and a few respondents expressed concern about having their answers be anonymous), the participating regions will not be listed here. However, the following generalities can be made about the responding regions:

- The seven responses represent at least 10 IRWM regions and up to 30. This discrepancy is due to the fact that a few consultants responded to the survey and did not indicate for how many IRWM Plans they had prepared climate change analyses (nor were they asked to indicate such a number).
- Geographically, the regions represent the following areas of California: central coast,

southern Central Valley, northern Sacramento Valley, and southern California coast (in addition to the author's experience in eastern California through the Inyo-Mono IRWM Program).

- The responding regions represent both urban and rural areas and contain a number of economically disadvantaged communities (DACs; defined as communities whose median household income is 80% or less of the statewide median household income), although some of the responding regions do not contain any DACs.
- Based on what could be discerned from respondents' answers, only one responding region is a "headwaters" region. Some regions are somewhat higher in the watershed than "end-point" downstream users, but no other upper watershed regions are represented (other than the Inyo-Mono IRWM region through the case study [Appendix C]).

BOX 1.

The following 10 questions were included in the survey:

1. Who performed the climate change analysis for your region's IRWM Plan (name and/or affiliation)?
2. What level of experience did the person/organization have with climate change science and/or analysis?
(Scale of 1 to 10, with 1 being no experience and 10 being long-time expert)
Explanation:
3. What kinds of resources did your region have access to for conducting the climate change analysis (e.g., in-house expertise; funding to hire a consultant; partnership with academic institution or government agency, etc.)?
4. What parts of the *Climate Change Handbook* were used for the IRWM Plan climate change analysis? (Check all that apply)
 Greenhouse gas emissions inventories (Section 3)
 Vulnerability analysis (Section 4)
 Measuring regional impacts (Section 5)
 Evaluating projects, resource management strategies, and benefits (Section 6)
 Implementing under uncertainty (Section 7)
Comments:
5. What sections, sub-sections, figures, tables, case studies, etc. were especially helpful in the *Handbook*?
6. If the *Handbook* was not used for certain parts of the analysis, why not?
7. What other tools and resources (besides the *Handbook*) were used to aid in the analysis?
8. Is there a plan for further climate change analysis for the region? If so, what would increase your use of the *Handbook* in the analysis?
9. What additional tools and information do you need to do a thorough climate change analysis for your region?
10. Was there any analysis done specific to agricultural water use? If so, was the *Handbook* used? If the *Handbook* was not used, what information and tools would be helpful to conducting climate change analysis for agriculture?

Survey link: <https://www.surveymonkey.com/r/F5H3BC8>

Survey Analysis

Survey responses were not analyzed quantitatively as the sample size was small and some responses represented more than one IRWM region (though how many IRWM regions are represented in total is uncertain). Instead, survey responses were gathered into one document (see Appendix B for the complete responses) and viewed qualitatively. The ten questions of the survey lent themselves to a few simple groupings in the analysis, as presented below.

Questions 1-3: Who performed the climate change analysis, and with what resources

Of the seven survey responses, only one indicated that someone other than a consultant prepared the IRWM Plan climate change analysis (it was prepared in partnership with an academic institution). All the other regions used consultants: either larger, California-wide (or multi-state) consulting firms or smaller, individual-owned and -run consulting firms. Some of these regions indicated that the same consultants prepared their entire IRWM Plans. One response indicated that the Regional Water Management Group helped to prepare the analysis in partnership with the consultant. Another respondent indicated that there were multiple entities involved in overseeing the preparation of the climate change analysis by the consultants, such as RWMG stakeholders and workgroups, climate scientists, and DWR staff. From the review of other regions' (non-respondents') climate change analyses, there was one region that partnered with a federal agency to do the climate change work for the IRWM Plan.

It therefore appears that, by and large, climate change analyses have thus far been performed by private consulting firms with help from RWMG and other regional stakeholders. When asked what kinds of resources regions had available to perform climate change analyses, most people responded that they had funding available to hire consultants. To a lesser degree, respondents indicated that they had the ability to partner with outside entities – such as DWR staff, Stockholm Environmental Institute, academic institutions, climate scientists, etc. – to help them complete their analyses. Only one respondent indicated that there was any kind of in-house expertise to prepare components of climate change analyses or review consultants' (or others') work. The Inyo-Mono IRWM region would also fall into this last category.

One primary take-away message results from the answers to these three questions. There is a need to develop skills within IRWM regions related to climate change analysis, and simply providing the guidance in the *Handbook* does not seem to be enough. Climate change science may appear to be very technical or intimidating for some water-related stakeholders, so they turn to expensive professional environmental consultants to perform their analyses. Yet by developing the capabilities of IRWM regions and their associated water systems and stakeholders to conduct their own climate change analyses, the State would likely save money, and climate change analyses would be more region-specific and better reflect regional priorities. In addition, capacity is built within the regions, furthering the goal of becoming more self-reliant.

Questions 4-7: How and why was the *Climate Change Handbook* used/not used?

The first question of this grouping asks about which parts of the *Handbook* were used in regions' climate change analyses. The possible answers were broken down by section, though space for comment was also provided (see Box 1). All regions surveyed utilized Section 4 (Vulnerability Analysis). This fact is not surprising given that a vulnerability analysis was required of all IRWM Plans through the 2012 IRWM Plan Standards. This heavy reliance on Section 4 was also apparent after the cursory review of climate change Plan sections. Almost every IRWM Plan specifically referenced the guidance in Section 4, and several respondents in fact stated that the *vulnerability assessment checklist in Section 4 was the most useful guidance of the entire document*.

All of the other sections of the *Handbook* that contain guidance were cited at least once among the seven survey respondents:

- Section 3 – Greenhouse gas emissions inventories
- Section 5 – Measuring regional impacts
- Section 6 – Evaluating projects, resource management strategies, and benefits
- Section 7 – Implementing under uncertainty

Some of the responses about these four sections were surprising because the IRWM Plans did not necessarily reference these sections by name, nor did the text in the Plans necessarily reflect the guidance from these sections of the *Handbook*.

Also in response to this first question, one respondent stated that the *Handbook* helped to structure the RWMG's thinking about climate change impacts in the region because the *Handbook* provided an organized approach to doing a vulnerability analysis. As stated in the Inyo-Mono case study, the categorized list of questions in Section 4 helped to jump-start thinking about the various aspects of regional climate change impacts. This survey question also elicited conflicting answers. One respondent wrote that Section 4 only provided for a very high-level climate change/vulnerability analysis, though others state elsewhere that the guidance in the *Handbook* was too specific and too detailed for the types of analyses they were able to perform.

Respondents were asked to list elements of the *Handbook* that were especially helpful (Question #5). In addition to the vulnerability assessment checklist in Section 4, the following elements were cited by respondents:

- Data sources (such as those found in Appendix D-1, though respondent did not specify which one[s])
- East Bay MUD Vulnerability Assessment case study (p. 4-16; several respondents answered that the case studies in general were very helpful)
- Section 4.3 and Box 4-1 (Identifying key indicators of potential vulnerability; contains the question checklist)
- Section 5.2.4, which provides guidance on combining qualitative and quantitative methods for characterizing and measuring regional climate change impacts
- Section 5.3, which provides guidance on conducting an impacts analysis across many water-related sectors; the respondent also mentioned the data sources cited within each resource

- sector and the potential performance metrics as being particularly useful
 - More specifically, Section 5.3.5, which addresses conducting impacts analysis specific to sea level rise
- Figure 6-2 – a flow chart showing the process of soliciting, integrating, evaluating, and ranking projects in the IRWM process, and how climate change elements can be integrated into the process
- Section 6.3, which discusses incorporating projects and resource management strategies into a region’s IRWM Plan to help meet its climate change objectives
 - Table 6-2: depicts the relationship of California Water Plan Update 2009 resource management strategies to eight recognized water resources-related climate change adaptation strategies
- Table 6-4 – examples of technical analyses used to assess impacts of climate change on performance of resource management strategies
- Figure 7-2 – a flow chart showing a sample adaptive management decision-making process

The next question in this section asked respondents to indicate why the *Handbook* was not used for certain parts of their region’s climate change analysis. Only a portion of the respondents answered the question. One complaint was that the *Handbook* guidance was not always relevant or applicable to rural and/or inland regions (away from the Delta and the coast). Another respondent answered that his/her region’s climate change analysis was more general and high-level than the specificity of the guidance provided in the *Handbook* (contrary to the comment on p. 5 that the vulnerability analysis guidance was too high-level), although another respondent said that the level of their analysis matched the level of analysis presented in the *Handbook*. Finally, one person posited that his/her region did not use sections of the *Handbook* that were not specifically required by Plan Standards and/or grant requirements.

The views presented in this last question have relevance to the statewide IRWM Program and DWR’s administration of the Program. Most regions seem to be doing the minimum amount of required climate change analysis, which indeed does not necessitate full utilization of the *Handbook*. It is likely that the *Handbook* will not be fully utilized by IRWM regions unless all major topics within the *Handbook* are required to be addressed in IRWM Plans through *IRWM Guidelines* and Plan Standards. Such a requirement, together with strong encouragement to use the guidance and methods set forth in the *Handbook*, would provide for more comprehensive and consistent regional climate change information to be developed, which would in turn create a more standardized statewide treatment of climate change, its impacts, and adaptation and mitigation options.

The final question of this section asked about what other resources IRWM regions are using in developing their climate change analyses. The answers, not surprisingly, largely reflect the resources available (through funding or access) to those preparing these analyses. Some people answered in general terms, such as referencing using websites, other DWR documents, and publications from other agencies, such as the Coastal Conservancy. Other, more specific resources cited include:

- Specific literature citations (included in Appendix A)

- Localized climate projections prepared by climate scientists
- Regional climate change analyses prepared by U.S. Forest Service
- Local planning documents, such as urban water management plans
- Multiple species habitat conservation plans
- Papers by Gary Freeman of Pacific Gas & Electric, which explore the impacts of climate change on the hydroelectric sector and in PG&E-managed watersheds (for an abbreviated list of citations: <http://almanorpost.com/tap/issues/water/climatology/gary-freeman/>)
- Cal-Adapt (cited by numerous respondents; <http://cal-adapt.org/>)
- King County, WA, climate change adaptation guidance
- Resources fromICLEI – Local Governments for Sustainability, such as its climate change adaptation guidebook for local, regional, and state governments (<http://www.iclei.org/action-center/planning/adaptation-guidebook>)
- Resources from the Pacific Institute, such as *Water Scarcity and Climate Change: Growing Risks for Businesses and Investors* (2009; <http://pacinst.org/publication/water-scarcity-and-climate-change-growing-risks-for-businesses-and-investors/>)
- InVEST decision support tool from the Natural Capital Project (http://www.naturalcapitalproject.org/pubs/InVEST_Intro_GVerutes.pdf)
- City of Santa Cruz vulnerability analysis
- California Adaptation Planning Guide
- Colorado River Supply and Demand study

Some of these documents/resources are already listed/cited in the Literature Review (Appendix A) and Climate Change Tools (Appendix D) sections of the *Handbook*. Others were found and accessed by IRWM regions apart from using the *Handbook*. A key finding from the responses to this question is that local and regional information and tools are particularly important in developing regional climate change analyses. While the *Handbook* does provide some examples of local/regional climate change analysis and planning through the case studies and the Literature Review, it is nearly impossible to include references to all local/regional analyses in California (and, indeed, in other Western states with similar water issues). This element is discussed further in the next section and the Recommendations section.

Questions 8 & 9: Further climate change analysis and needed information and tools

The third set of questions asked respondents whether they will be initiating further climate change analyses for their IRWM regions, what would help increase their use of the *Handbook*, and what additional tools and information would help them complete such further analyses.

All but one respondent indicated that they would be performing further climate change analyses for their regions. The one respondent that was “unsure” about future analyses indicated that the climate change analysis would likely only be furthered or updated if required by *Guidelines* and Plan Standard requirements. Regarding use of the *Handbook* in future climate change work, respondents indicated both how they would use the *Handbook* in the future and what changes or improvements would increase their use of the *Handbook*.

Responses to how the *Handbook* will be used in the future:

- “The handbook was a useful reference and resource but was very long and involved - we only had the funds to scratch the surface of the items available in the handbook. As we dive into more in-depth analysis we’ll likely use other parts of the handbook that we didn’t use initially.”
- “During annual Plan reviews, revisiting the checklist to see where and if there have been changes or modifications to data and conditions in the Region, and revisiting the Plan’s goals and objectives to see what measurable outcomes have addressed climate impacts would be useful.”
- “We will use section 6.1 as additional SLR [sea level rise] impact data is developed.”

Responses to what changes and improvements would increase use of the *Handbook*:

- “Future analysis could include updated climate change projections to reflect new data, methods, or understanding of climate change, and evaluation of river flow data for evidence of climate change.”
- “Perhaps some workshops on specific topics within the Handbook. Specifically, a workshop on Chapter 5 would be helpful. As I go through the handbook to answer these questions, I am reminded that it is a good document and would be valuable in IRWM planning as well as my agency’s countywide planning. I think one thing that may have affected our use of the Handbook in the IRWM Plan was that we were down to the wire on completing our plan and didn’t have the time to do as good a job as we would have liked. As we continue plan implementation and evaluation, periodic reminders that the Handbook is out there might increase our use.”
- “The climate change analysis will be updated as part of the next IRWM Plan update. The region was only interested in doing a high level, qualitative analysis on climate change for this IRWM Plan update. Though there are many useful citations for data that can be used to conduct an analysis, having the data more readily available by region might be helpful (like in the California Adaptation Planning Guide), or tools available that would make it simpler to do a quantitative analysis.”

The last question of this set asked what additional information and tools stakeholders need to perform thorough climate change analyses for their IRWM regions. The responses varied:

- More collaboration among regions to share information and not “reinvent the wheel”. Most regions face similar challenges and impacts.
- “As climate science is refined, localized climate projections for temperature, precipitation, frost-free season, snow-melt dates, and peak run-off dates would be extremely helpful for climate analyses and water managers. Also up-to-date studies on species adaptation, esp. water- and wetland-dependent species in the face of climate change.”
- Assistance with using downscaled models.
- Flood conveyance, water use, etc. data are available, but it is costly to compile and analyze data.
- “Tools available to do a local-scale, quantitative analysis of the projected effects of climate change on future precipitation and water resources in the region.”

From the survey responses and from the experience derived from the Inyo-Mono climate change analysis, regional climate change practitioners seem to need assistance with two primary and related aspects: modeling (presumably climate models and impacts models) and gaining access to more local-level climate change data and information. While increased and improved modeling will help to develop local climate change information, there are other kinds of information available for local and regional areas of California. The bottom line, in the context of the *Handbook's* guidance, is that practitioners need help with developing more localized and quantitative climate change analyses for their IRWM regions.

Question 10: Climate change analysis specific to agricultural water use

The final question of the survey dealt with how IRWM regions are addressing agricultural water resources management in the context of climate change. Not all respondents performed this type of specific analysis, mostly because agriculture is not a major industry in all IRWM regions. Most regions simply identified agriculture-related vulnerabilities through the use of the checklist, which includes a few agriculture-related questions. One region went a step further and examined adaptation strategies presented in the Handbook to identify next steps with respect to climate change and agriculture.

The responding region that did the most in relation to agriculture and climate change used the vulnerability checklist as a way to lead agriculture stakeholders through a thought exercise on potential impacts of climate change to agricultural water supply and demand. Once completed, these vulnerabilities were further researched and included in the Plan. The same region also worked with an outside consultant to begin development of a model to determine impacts of climate change on the region's water supply and demand, including the agricultural sector.

Because so few regions responded to the survey, it is difficult to say whether the trend is to not conduct much analysis related to climate change and agriculture apart from the existing vulnerability checklist, or whether the regions responding to the survey are simply not representative of the majority of regions, whose IRWM Plans have included analysis of agriculture and climate change. Some of the respondents represent regions with little agriculture, but agriculture is well-represented in some of the other responding regions.

Analysis and Recommendations

It is no coincidence that the section of the *Handbook* that was a primary focus of the 2012 climate change Plan Standard requirement – the vulnerability analysis checklist – is the section with which IRWM practitioners have the most experience. Even though developing additional regional climate change information might be beneficial for IRWM groups, it is unlikely to happen unless required by Plan Standards or facilitated through funding mechanisms. *Thus, it is clear that the Handbook is currently being underutilized by IRWM practitioners in California.*

In general, based on survey results, discussions with other IRWM region representatives, and direct experience and observations, *it is recommended that the Handbook continue to be promoted and used for climate change analysis in regional water planning.* Below are specific recommendations

about how the *Handbook* can be improved and how DWR can assist with regional climate change analyses while obtaining the information it needs for statewide analysis. Because the information-gathering component of this project included questions about IRWM regions' general experiences in conducting climate change analyses, not every recommendation directly addresses the *Handbook*, but taken together, all of the recommendations below are aimed at improving the quality and overall experience of performing regional climate change analyses, a major component of which is the *Handbook*. There is some overlap among portions of some of the recommendations.

Updating the *Handbook*

The IRWM representatives that responded to the survey explicitly stated that the *Handbook* is a useful source of information (e.g., literature, tools, data, etc.). Several survey respondents indicated that they would like to see the *Handbook* continue to be used and be updated to reflect current research and information. Indeed, because climate change science and projections evolve so quickly, if the *Handbook* is going to continue to be a go-to resource for DWR and IRWM regions, it is imperative that it be kept current. **Recommendation: DWR should update the literature review, references, climate change projections, climate change tools, and other relevant sections of the *Handbook* on a biennial basis.** It is not recommended that the entire *Handbook* be overhauled biennially; rather, only out-of-date sections and appendices should be targeted. Such updates could take the form of addenda to the *Handbook* and could be made available online as well as in print.

Outreach

Through survey responses and conversations with *Handbook* users, several people said that they would like to see more outreach around the *Handbook* from DWR staff. While it is recognized that IRWM representatives need to take responsibility in acquiring knowledge and resources for themselves, it would undoubtedly be beneficial to both DWR and IRWM regions to periodically conduct outreach about the contents of the *Handbook*, recent updates, how to use it, etc. Outreach regarding the *Handbook* should also be targeted to individual water purveyors and other water management agencies, either through IRWM networks or outside of such networks.

Recommendation: after each round of *Handbook* updates, DWR climate change staff, in partnership with DWR-IRWM staff, should conduct an outreach campaign that includes emails, website posts, conference calls/webinars, and, if possible, in-person meetings to increase the visibility of the *Handbook*, promote its usefulness, give basic instructions about its use, and provide information on recent updates.

Building local/regional capacity

Beyond simply conducting more outreach about the availability of the *Handbook* and the resources it contains, it is in the interest of DWR and the State to help provide the resources necessary to complete regional climate change analyses. Many IRWM region representatives have expressed that they do not have the expertise on-hand to conduct climate change analyses. In most cases, they hire expensive outside consultants to perform their climate change analyses, and this practice does not contribute to building the capacity of IRWM regions and associated stakeholders. In particular, IRWM practitioners cite an inability to develop, read, and interpret the more quantitative climate change information that results from models. If IRWM Programs were able to perform these

analyses internally, they would be able to (1) more efficiently and effectively spend bond funds, (2) develop more informed and region-focused climate change analyses, and (3) develop capacity and skills within IRWM regions to understand climate change and its potential impacts on regional water resources and water-dependent ecosystems. **Recommendation: DWR, in partnership with other State agencies, local organizations, and/or capacity-building organizations (e.g., California Rural Water Association) as necessary, should endeavor to provide climate change capacity- and skill-building trainings to IRWM regions that focus on the analyses discussed in the *Handbook*.**

Climate Change Plan Standard

Conducting climate change analyses is an intimidating prospect for some IRWM practitioners. There is a large range of abilities and interests in examining climate change impacts and response options at the regional level. In general, however, IRWM Plans only address the minimum requirements of the climate change Plan Standard, and it is *unlikely that most of these regions will do much further analysis if not required for the IRWM Plan and for eligibility for IRWM funding*. It is not by chance that the most consistent parts of the climate change sections across the current iterations of IRWM Plans are the vulnerability analyses, since the current Plan Standards largely focus on creating these assessments. If we are to improve the state of knowledge and information about climate change and water resources throughout the State, it is necessary to increase the rigor and requirements, with support, contained in the climate change Plan Standard. **Recommendation: in future IRWM Guidelines, the climate change Plan Standard should require more in-depth qualitative or quantitative regional climate change projections and impact analyses, and more specific analysis of adaptation options.**

Developing local information

Many IRWM regions have expressed that they do not have adequate access to local/regional-level climate change information for their areas, including climate projections at a reasonable resolution. Without information on climate change impacts specific to their regions, IRWM representatives are unable to adequately prioritize vulnerabilities or develop mitigation and response strategies. **Recommendations: DWR should (1) create more emphasis in the *Handbook* on how the analysis described therein will help to develop much-needed regional and local climate change information, (2) encourage the use of simple tools, such as Cal-Adapt, that can be used to view climate change information locally and regionally, and (3) provide more technical and financial resources to assist IRWM regions in developing climate change information pertinent to their regions.**

California Adaptation Planning Guide

One survey respondent suggested that the *Handbook* should point to other sources of regional/local information about climate change. This respondent pointed in particular to the *California Adaptation Planning Guide* (2012; more specifically, the “Understanding Regional Characteristics” supplemental document). In this supplemental document, the state is broken down into 11 regions, and basic geographic and demographic data about the region are given, as well as a short analysis of potential climate change impacts for several sectors in the region. Although these regions do not match up with current IRWM regions, the Adaptation Planning Guide would provide an excellent

starting point for climate change analyses and also provides suggestions of additional resources.

Recommendation: insert references to appropriate sections of *CA Adaptation Planning Guide* into the *Handbook* (this is also a way to highlight regional differences while promoting greater access to regional climate change information).

Regional differences, State standardization

The challenge of requiring all IRWM regions to conduct regional climate change analyses is that they should be encouraged to develop region-specific information while at the same time providing the State with information it can use at a larger scale. Being able to scale up regional climate change analyses to the State level would be incredibly powerful. The *Handbook* should encourage these regional differences while providing a standardized method of conducting climate change analyses for scaling purposes. It is recognized that IRWM regions have varying types of resources available to conduct climate change analysis and that regulating the level and sophistication of analysis will disadvantage certain IRWM regions. The goal should be to set a standard within which regions can be flexible and creative based on their abilities and interests. **Recommendations: DWR should (1) review and revise the *Handbook* to emphasize development of local/regional-level information and provide additional examples and case studies, (2) consider revisions to Plan Standards to require standardized methods for conducting some elements of the climate change analysis in order to scale up such analyses to the state level, and (3) make technical and/or financial resources available to less resource-rich IRWM regions so that they may successfully improve and complete their analyses.**

Replicate success of vulnerability assessment checklist

One way to encourage standardization of climate change analyses would be to replicate the success and usage of the vulnerability assessment checklist. Because a vulnerability assessment was required in the 2012 Plan Standards, and because the checklist developed for the *Handbook* was straightforward, easy to use, and unthreatening, there are now almost 50 vulnerability assessments representing regions throughout the state that have been completed in a very similar manner and are thus comparable and may be able to be scaled up. Similarly, if tools and methodologies are developed for other parts of the climate change analysis process (within the *Handbook*) that are so easy to use that it does not make sense to seek out other methods, further standardization would be encouraged. **Recommendation: DWR should consider what other sections of the *Handbook* might benefit from developing standard methodologies and perform an assessment of the comparability and scalability of the 45-plus IRWM region climate change vulnerability analyses.**

Considerations for rural and inland communities

One response to the survey question about improving the *Handbook* for future use was that the document is not always relevant for rural and/or inland regions in California. Indeed, the only case study currently in the *Handbook* that deals specifically with a rural area is the Bonneville Cutthroat Trout/Ecological Impacts Analysis case study. Two case studies (Bonneville Cutthroat Trout and Inland Empire Utilities Agency) address impacts in inland regions. Already, rural regions generally have less access to resources and information compared to larger urban areas with well-funded water agencies. The State should do what it can to ensure that IRWM regions with high percentages

of rural communities have access to the resources they need to conduct climate change analyses. **Recommendations: (1) review the *Handbook* to find places and ways to provide suggestions for tailoring parts of climate change analyses for rural and inland communities, and (2) provide more case studies of climate change analysis in rural and inland communities, particularly within California.**

Regions need assistance

As mentioned previously, climate change analyses can be costly – even more so when hiring consultants to perform the analysis. A repeated theme in the survey results and conversations with IRWM region representatives is that they would like to see more technical and financial assistance provided to the IRWM regions specifically for climate change analysis, particularly if the climate change Plan Standard were to become more rigorous. **Recommendations: (1) consider ways to increase funding available to IRWM regions to perform climate change analyses and to provide for a stable, ongoing funding source for continued and updated climate change analysis, and (2) provide topic-based technical workshops aimed at layperson stakeholders (similar to recommendation under Building Capacity above).**

Increasing collaboration and information sharing among IRWM regions

As one survey respondent astutely observed, many IRWM regions are facing similar climate change impacts, and we should strive to increase collaboration and information sharing across regions. Indeed, increased collaboration could reduce costs associated with gathering non-IRWM region-specific information and could help to make the process of performing climate change analyses more efficient and less costly. In addition, standardizing requirements for climate change analyses would allow for even greater inter-regional collaboration. **Recommendations: (1) through the climate change Plan Standards, the *Handbook*, and other climate change guidance distributed to IRWM regions, encourage collaboration and information sharing among regions, (2) set up a central portal accessible through DWR’s climate change website on which regions can find each other, contact each other, and publicly post climate change information, and (3) use gathering opportunities such as the biennial IRWM Conference to provide venues for regions to share climate change information with each other and collaborate on future work.**

Agricultural water use

It does not appear as though climate change analysis with respect to agricultural water use is being conducted independent of other water sectors. Several survey respondents indicated that their analysis of agricultural water use and climate change simply followed the vulnerability checklist and questions. However, there are many other resources available for considering agricultural water use in the context of climate change (Cal-Adapt, CA Water Plan Update, etc). Again, it is unlikely that IRWM regions will focus on agricultural water impacts without an express requirement by the Plan Standards, particularly if agriculture is not a primary economic driver in the region. **Recommendation: (1) even though agricultural water use is related to several of the categories already used in the vulnerability analysis, consider pulling it out as its own category in the *Handbook*, and (2) provide a more comprehensive listing of climate change resources specific to agricultural water resources, including a website specific to**

agricultural adaptation to climate change in Yolo County but that contains information and suggestions relevant for many parts of California (<http://agadapt.ucdavis.edu/>).

Conclusion

In many of the IRWM Plans reviewed for this project, climate change is often the last chapter (if it is its own chapter at all). This may be because climate change is the last Plan Standard discussed in the *Guidelines*, and many IRWM regions use the order of Plan Standards as their basic table of contents. Yet it seems that, for some regional plans, climate change is the last chapter because it is somewhat of an afterthought. A number of water management practitioners still do not take climate change seriously or have not integrated climate change into their thinking about water management. Requiring a treatment of climate change in IRWM Plans through the *Guidelines* is a major step towards awareness of impacts and response options. The *Handbook* is an excellent tool for guiding climate change novices and experts alike through applying climate change considerations to their water management regime. Unfortunately, neither the *Guidelines* nor the *Handbook* cannot force the sea-change of thinking that is needed around water management and climate change; IRWM practitioners must come to that on their own.

Appendix A: Climate change literature cited in Question #7 responses

Bashford, K.E., Miller, N.L., and Strem, E., Climate Change Sensitivity Study of California Hydrology: A Report to the California Energy Commission, LBNL Technical Report No. 49110, November 2001

California Department of Water Resources, Climate Change Adaptation Strategies for California's Water, October 2008

California Natural Resources Agency, 2009 California Climate Adaptation Strategy, 2009

California State University at Fresno, Harmsen, F., Hunsaker, D., Van de Water, P., and Luo Y.V., Mitigation and Adaptation Strategies for Climate Change in Fresno California, August 2008

Climatewise, Maintaining Resilient Natural Systems in Fresno County and Surrounding Counties: A Summary, 2010

Conrad, E., Climate Change and Integrated Regional Water Management: A Preliminary Assessment of the Report to IRWM Climate Change Requirements, Final Draft for Comments, University of California Berkeley, Department of Environmental Science, Policy and Management, February 2012

National Center for Conservation Science and Policy, Koopman, M.E., Leonard, J.L., and Nauman, R.S., Future Climate Conditions in Fresno County and Surrounding Counties, July 2010

Pitzer, G., Linking Climate Change Science to Water Management Decisions, Water Education Foundation, 2010

Ruddiman, W.F., Earth's Climate: Past and Future, W. H. Freeman and Company, New York, NY, 2002

Sierra Nevada Alliance, Sierra Climate Change Toolkit, 2nd Edition, 2007

U.S. Global Change Research Program, Global Change Impacts in the United States, June 2009

Appendix B: *Climate Change Handbook* use survey responses (2 tables)

Questions 1-5:

Response Number	Q1. Who performed the climate change analysis for your region's IRWM Plan?	Q2. What level of experience did the person/organization have with climate change science and/or analysis?	Q3. What kinds of resources did your region have access to for conducting climate change analysis?	Q4. What parts of the <i>Climate Change Handbook</i> were used for the IRWM Plan climate change analysis?	Q5. What sections, sub-sections, figures, tables, case studies, etc. were especially helpful in the <i>Handbook</i> ?
1	Consultant	No answer Consultant prepared our 2012 IRWMP update; however, all sections of the updated plan including climate change were explored and vetted through various work groups that included DWR climate change staff and environmental stakeholders among others.	Funding to hire consultant, partnership with other entities	Vulnerability analysis (Section 4); Measuring regional impacts (Section 5); Evaluating projects, resource management strategies, and benefits (Section 6)	Section 4 was the most useful for us - including the checklist for vulnerability assessment
2	Consultant	Consultant worked for 10 years for The Nature Conservancy-Montana Chapter and during that time prepared climate change policies and plans in conjunction with conservation organizations throughout the northern Rockies. She then researched and prepared the climate chapters for three IRWMPs in conjunction with climate scientists and CA DWR climate change staff.	Funding to hire a consultant, stakeholder expertise, participation on the Climate Change Handbook Technical Advisory Committee	Greenhouse gas emissions inventories (Section 3); Vulnerability Analysis (Section 4); Measuring regional impacts (Section 5); Implementing under uncertainty (Section 7) Greenhouse gas emissions inventories (Section 3); Vulnerability Analysis (Section 4); Measuring regional impacts (Section 5); Evaluating projects, resource management strategies, and benefits (Section 6); Implementing under uncertainty (Section 7); The Handbook's checklist helped organize an approach to thinking through all aspects of climate change impacts with stakeholders. It also allowed for a more consistent approach between IRWMP preparers. The one area that could be improved is to try and make more of a distinction between what very urban, populated, and well-funded regions can and are expected to prepare vs what rural, less populated and often economically challenged regions can provide. Perhaps a two-tiered system?	no answer
3	Consultant		In-house expertise, Stockholm Environmental Institute, climate modeling scientists at UCSD		The Checklist and some data sources.
4	Consultant and RWMG Member	No answer	Funding to hire a consultant to conduct the impacts analysis; in-house expertise to review consultant's analysis; in-house staff to conduct the vulnerability analysis	Vulnerability analysis (Section 4)	The EBMUD case study was especially helpful.

Response Number	Q1. Who performed the climate change analysis for your region's IRWM Plan?	Q2. What level of experience did the person/organization have with climate change science and/or analysis?	Q3. What kinds of resources did your region have access to for conducting climate change analysis?	Q4. What parts of the <i>Climate Change Handbook</i> were used for the IRWM Plan climate change analysis?	Q5. What sections, sub-sections, figures, tables, case studies, etc. were especially helpful in the <i>Handbook</i> ?
5	Academic partner from local institution	Partner from local marine lab has written climate mitigation plans, lead vulnerability analysis and aided the completion of adaptation planning for inclusion in Hazard mitigation plans. He has also evaluated wetland resource threats and adaptive capacity due to sea level rise and changing weather patterns.	IRWMP partnered with Moss Landing Marine Labs to complete the evaluation	Vulnerability analysis (Section 4); Measuring regional impacts (Section 5); The Handbook was very useful but the budget for our analysis was limited so we could not implement most of the recommended actions. We have discussed with DWR staff the need for identified funding set aside to aid regions to implement the guidance in the Handbook. Our resources were several orders of magnitude less than needed to benefit from the guidance in this document	Section 4, 4.3, Box 4.1, 5.2.4, 5.3.5, 6.3,
6	Consultant	Consultant has water resources planners with knowledge of climate change science and who had been following water resources related climate change science leading up to the IRWM Plan Update. Consultant had also conducted climate change analyses for several other regions as part of their IRWM Updates.	Funding to hire a consultant	Vulnerability analysis (Section 4); Measuring regional impacts (Section 5); Evaluating projects, resource management strategies, and benefits (Section 6); Implementing under uncertainty (Section 7); Given that the IRWM Plan only conducted a high level (very general) climate change analysis, Sections 4-7 were found to be helpful. Section 3 was only not given that a detailed GHG analysis was not conducted.	Box 4-1, Section 5.3 (data citations by water resource and potential performance metrics), Figure 6-2, Section 6.3, Table 6-2, Table 6-4, Figure 7-2
7	Consultant	The consultant utilized the vulnerability checklist.	Funding to hire a consultant	Vulnerability analysis (Section 4); The vulnerability checklist was used for the climate change analysis.	The vulnerability checklist

Questions 6-10:

Response Number	Q6. If the <i>Handbook</i> was not used for certain parts of the analysis, why not?	Q7. What other tools and resources were used to aid in the analysis?	Q8. Is there a plan for further climate change analysis for the region? If so, what would increase your use of the <i>Handbook</i> in the analysis?	Q9. What additional tools and information do you need to do a thorough climate change analysis for your region?	Q10. Was there any analysis done specific to agricultural water use? <i>Handbook</i> used? What info and tools would be helpful?
1	No answer	Websites, other DWR documents and publications from other entities like Coastal Conservancy	Yes. Not sure at this point. The handbook was a useful reference and resource but was very long and involved - we only had the funds to scratch the surface of the items available in the handbook. As we dive into more in-depth analysis we'll likely use other parts of the handbook that we didn't use initially.	More collaboration among regions to share info and not "reinvent the wheel". Most of us face similar challenges and impacts	No

Response Number	Q6. If the <i>Handbook</i> was not used for certain parts of the analysis, why not?	Q7. What other tools and resources were used to aid in the analysis?	Q8. Is there a plan for further climate change analysis for the region? If so, what would increase your use of the <i>Handbook</i> in the analysis?	Q9. What additional tools and information do you need to do a thorough climate change analysis for your region?	Q10. Was there any analysis done specific to agricultural water use? <i>Handbook</i> used? What info and tools would be helpful?
2	No answer	<p>U.S. Global Change Research Program, Global Change Impacts in the United States, June 2009 - The National Center for Conservation Science and Policy, Koopman, M.E., Leonard, J.L., and Nauman, R.S., Future Climate Conditions in Fresno County and Surrounding Counties, , July 2010 - Sierra Nevada Alliance, Sierra Climate Change Toolkit, 2nd Edition, 2007 - Ruddiman, W.F., Earth's Climate: Past and Future, W. H. Freeman and Company, New York, NY, 2002 - Pitzer, G., Linking Climate Change Science to Water Management Decisions, Water Education Foundation, 2010 - Conrad, E., Climate Change and Integrated Regional Water Management: A Preliminary Assessment of the Report to IRWM Climate Change Requirements – Final Draft for Comments, University of California Berkeley, Department of Environmental Science, Policy and Management, February 2012 - Climatewise, Maintaining Resilient Natural Systems in Fresno County and Surrounding Counties: A Summary, 2010 - California State University at Fresno, Harmsen, F., Hunsaker, D., Van de Water, P., and Luo Y.V., Mitigation and Adaptation Strategies for Climate Change in Fresno California, August 2008 - California Natural Resources Agency, 2009 California Climate Adaptation Strategy, 2009 - California Department of Water Resources, Climate Change Adaptation Strategies for California's Water, October 2008 - Bashford, K.E., Miller, N.L., and Strem, E., Climate Change Sensitivity Study of California Hydrology: A Report to the California Energy Commission, LBNL Technical Report No. 49110, November 2001</p>	<p>Yes. Future analysis could include updated climate change projections to reflect new data, methods, or understanding of climate change, and evaluation of river flow data for evidence of climate change.</p>	No answer	Yes

Response Number	Q6. If the <i>Handbook</i> was not used for certain parts of the analysis, why not?	Q7. What other tools and resources were used to aid in the analysis?	Q8. Is there a plan for further climate change analysis for the region? If so, what would increase your use of the <i>Handbook</i> in the analysis?	Q9. What additional tools and information do you need to do a thorough climate change analysis for your region?	Q10. Was there any analysis done specific to agricultural water use? <i>Handbook</i> used? What info and tools would be helpful?
3	The Handbook did not always have relevance to rural or inland regions away from the Delta or coastline.	Localized climate projections prepared by climate scientists, regional climate analyses prepared by the US Forest Service that made specific reference to regional phenomena and natural resources, localized weather data, hazard mitigation plans. PG&E's climate projection papers prepared by Freeman were fabulous for the Sierra regions	Yes. During annual Plan reviews, revisiting the checklist to see where and if there have been changes or modifications to data and conditions in the Region, and revisiting the Plan's goals and objectives to see what measureable outcomes have addressed climate impacts would be useful.	As climate science is refined, localized climate projections for temperature, precipitation, frost-free season, snow-melt dates, and peak run-off dates would be extremely helpful for climate analyses and water managers. Also up-to-date studies on species adaptation, esp. water- and wetland-dependent species in the face of climate change.	Yes. Consultant led stakeholders, including agricultural water purveyors, through an exercise to fill out and refine the Handbook checklist's relevant sections. Once this exercise was complete, the agricultural water vulnerabilities were further researched and developed in the Plan text. In addition, the Stockholm Environmental Institute modeled specific impacts on the region's water supply and worked with local agricultural water purveyors with full knowledge of the Handbook's contents. SEI's work is ongoing in the region and may further refine climate vulnerabilities for ag water users over the next year. It might be useful to talk with SEI staff about this specific question.
4	No answer	Cal-Adapt	Yes. Perhaps some workshops on specific topics within the Handbook. Specifically, a workshop on Chapter 5 would be helpful. As I go through the handbook to answer these questions, I am reminded that it is a good document and would be valuable in IRWM planning as well as my agency's countywide planning. I think one thing that may have affected our use of the Handbook in the IRWM Plan was that we were down to the wire on completing our plan and didn't have the time to do as good a job as we would have liked. As we continue plan implementation and evaluation, periodic reminders that the Handbook is out there might increase our use. Or, maybe I should print out the entire thing (instead of just Chapter 4, which I refer to often).	Assistance with using downscaled models to conduct quantitative analysis	No. We identified increased ag demands as a high vulnerability, but that was about it.
5	Our Analysis was general and not as in-depth as the handbook outlines.	King County Adaptation Guidance, ICLIE guidance, Pacific Institute 2009, Cal Adapt, City of Santa Cruz vulnerability analysis, InVEST decision support tool	Yes. We will use section 6.1 as additional SLR impact data is developed.	Flood conveyance data, water use records etc. data available but significant costs to compile and analyze these data.	Yes. Handbook adaptation and response strategy list was used to identify next steps to reduce vulnerabilities.

Response Number	Q6. If the <i>Handbook</i> was not used for certain parts of the analysis, why not?	Q7. What other tools and resources were used to aid in the analysis?	Q8. Is there a plan for further climate change analysis for the region? If so, what would increase your use of the <i>Handbook</i> in the analysis?	Q9. What additional tools and information do you need to do a thorough climate change analysis for your region?	Q10. Was there any analysis done specific to agricultural water use? <i>Handbook</i> used? What info and tools would be helpful?
6	The Handbook was used for all parts of the analysis.	California Adaptation Planning Guide, Colorado River Supply and Demand Study, Cal-Adapt, Local planning (MSHCP, 2010 UWMPs),	Yes. The climate change analysis will be updated as part of the next IRWM Plan update. The Region was only interested in doing a high level, qualitative analysis on climate change for this IRWM Plan update. Though there are many useful citations for data that can be used to conduct an analysis, having the data more readily available by region might be helpful (like in the California Adaptation Planning Guide), or tools available that would make it simpler to do a quantitative analysis.	Tools available to do a local-scale, quantitative analysis of the projected effects of climate change on future precipitation and water resources in the region	Yes. Agricultural water use was generally examined in the same was as other water resources - by answering the vulnerability questions provided in Box 4-1.
7	Either not required or not needed to meet grant requirements	None	Unsure. If additional analysis is required for future rounds of Prop 84 funding then the climate change analysis may be updated per any additional requirements.	Unsure, but likely modeling	Yes. The checklist which had questions pertaining to agriculture

Appendix C: Inyo-Mono IRWM Program Climate Change Handbook Use Case Study

**Climate Change Handbook for Regional Water Planning
Inyo-Mono IRWM Program Case Study
October 31, 2014
Holly Alpert, Inyo-Mono IRWM Program**

Interest in climate change in Inyo-Mono IRWM region

The Inyo-Mono Integrated Regional Water Management (IRWM) Program was one of the early users of the Climate Change Handbook for Regional Water Planning (“Handbook”), which was a joint effort of the California Department of Resources, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, and Resources Legacy Foundation. In this case study, I will describe the aspects of the Inyo-Mono IRWM Program that led to its use of the Handbook; the experience of staff in applying the Handbook to the climate change analysis included in the Inyo-Mono IRWM Plan; and the lessons learned and recommendations regarding the use of the Handbook

From its inception, the Inyo-Mono IRWM Program was somewhat unique relative to incorporating climate change analysis into its planning because it hired a staff member (Holly Alpert, the author of this paper) who had an extensive interest in climatic changes and their impacts on water resources management in eastern California. At the time of her hiring, this staff member was completing her doctoral dissertation on climate change impacts to human and natural systems in the eastern Sierra region of California. One aspect of her research was focused on estimating potential changes in hydrology for the Mammoth Lakes area and examining possible adaptation options that the local water agency might consider. A part of this research included interviewing the (at the time) one climate change specialist at the California Department of Water Resources (John Andrew; 2007) in order to understand the state’s position on climate change and water management and to learn about various resources available regarding climate change. This initial contact led to several conversations with John Andrew over the next 2-3 years at various meetings and conferences.

Holly Alpert was hired as the Program Administrator for the Inyo-Mono IRWM Program in July 2008. Given her interest in and knowledge of climate change and water resources, it quickly became apparent that she would lead the effort to understand climate change in the context of the Inyo-Mono IRWM Plan and Program. In the very first Inyo-Mono IRWM Plan, little region-specific climate change analysis was performed, although an entire chapter of the Plan was still devoted to this subject. However, a more thorough analysis was included in the Program’s budget for the Round 1 Planning Grant, which was fully funded. This money allowed the Program staff to conduct enough of a climate change analysis to bring the Plan into compliance with the 2010 IRWM Plan Standards.

At about the same time as the Planning Grant was being awarded, DWR and its partners were ramping up development of the Climate Change Handbook. Holly participated in an early web-based meeting about the Handbook and became interested in further participating in the Handbook’s development. She attended the feedback workshop convened by DWR climate change program staff and partners at the 2011 IRWM Conference in Sacramento and submitted several comments. She continued to review the Handbook through the effort’s Technical Advisory Group and provided input through more conference call meetings. Furthermore, Holly joined the DWR Climate Change Technical Advisory Group in 2012. Holly’s familiarity with the Handbook from its early stages, as well as the ongoing contact with the DWR climate change team, directly contributed to the degree of use of the Handbook to conduct climate change analysis for the Inyo-Mono IRWM Plan.

Use of Climate Change Handbook for Inyo-Mono climate change analysis

Based on the funding available in the Round 1 Planning Grant and level of expertise of the Inyo-Mono staff, the following climate change analysis steps were taken, following the flow chart on page 1-13 of the Handbook (also included below as a graphical representation of what parts of the Handbook were used and which were not):

Initial Vulnerability Assessment: literature review, region characterization, key vulnerability indicators, and identify vulnerabilities

Impact Measurement: future climate projections, current/historic observations

Strategy Evaluation: characterize existing strategies, adaptive and mitigation strategies

Implementation Under Uncertainty: none

We did not have the tools or knowledge at the time to quantify many of the expected impacts, apart from changes in climatic variables, nor did we have access to quantitative hydrologic impacts models, such as CalSim or WEAP. Yet following the handbook guidance allowed us to develop a mostly-qualitative climate change analysis that provided substantially more region-specific information than what had previously been available. The motto was “some information is better than no information.”

Each of the major steps of the analysis is further discussed below.

Assessing Regional Vulnerability to Climate Change

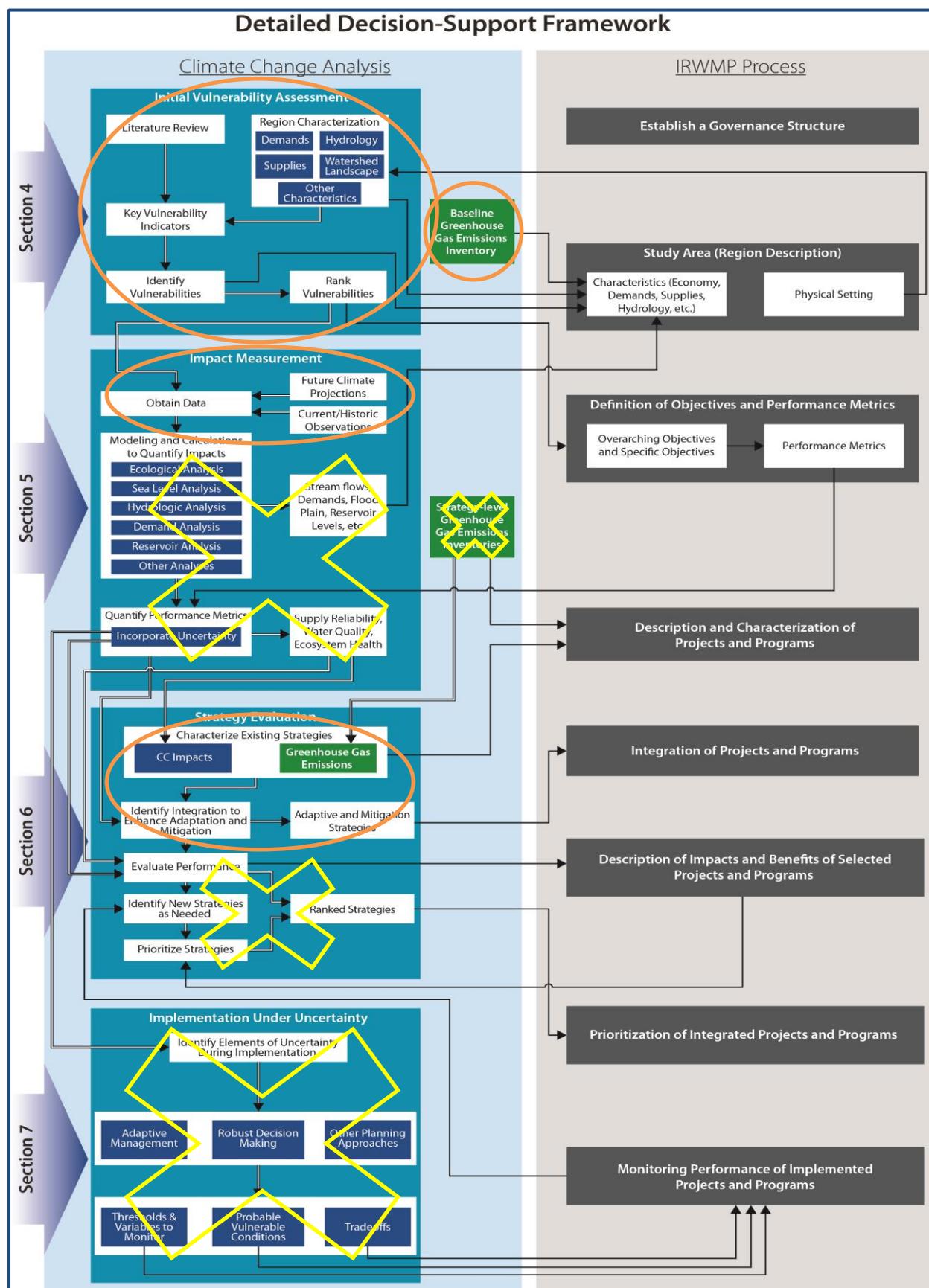
This was the step we followed most closely during the analysis. The section begins with an overview of the current state of climate change science that is relevant for the region. The expertise of the staff with respect to general climate change science and specific likely impacts in the eastern Sierra, along with the ability and access for an in-depth up-to-date literature review, allowed for an overview discussion of climate change and water resources management in the Inyo-Mono region. The region-specific knowledge of eastern Sierra water stakeholders was also key in developing this section.

The next step in the vulnerability analysis is to characterize the region. Fortunately, Inyo-Mono IRWM Program Office staff had already performed an extensive region characterization for the IRWM Plan (<http://inyo-monowater.org/inyo-mono-irwm-plan-2/inyo-mono-irwm-plan/>; Chapter 2 – Region Description) that also meets the needs of the vulnerability analysis, so additional effort and expense were not necessary.

Next is a broad-brush treatment of expected climate change impacts relevant for water resources management in the Inyo-Mono region. Following the guidance of the handbook, this discussion of impacts is divided into five categories: Water Supply, Water Demand, Water Quality, Flooding, Terrestrial and Aquatic Ecosystems. This qualitative analysis is based on climate change grey literature and journal articles; the author’s own knowledge; and input from regional water stakeholders. We desire to develop a more quantitative impacts analysis, but because there is such little climate change impacts information specific to the Inyo-Mono region, much of the information would need to be newly developed.

The substance of the vulnerability analysis is contained in the Climate Change Vulnerabilities section. This analysis uses both the categories and the series of questions provided in the Climate Change Handbook (Box 4-1, beginning on page 4-9). As a region with limited in-house experience in developing formal vulnerability analyses and minimal resources for hiring outside experts, this guidance on the vulnerability analysis was extremely helpful. The vulnerability analysis was another section in which input from regional stakeholders was very important as they have extensive knowledge of the history of water resources management in the region as well as current issues. This input was particularly helpful in the Water Supply and Flooding categories. Being able to use this series of questions as a first cut at a vulnerability assessment allows the users to then hone in on the vulnerabilities most present in their regions. As a last step in the vulnerability analysis, a table was developed to summarize the important impacts

and vulnerabilities for the region.



One of the major climate change-related additions to the 2012 IRWM Guidelines was to add a requirement in the climate change Plan standard to prioritize a region’s climate change vulnerabilities using the RWMG-approved decision-making process. This prioritization was not included in the version of the Inyo-Mono Phase II IRWM Plan adopted in November 2012 but was added in late 2014. The Handbook’s guidance for prioritizing vulnerable resources was considered in a general sense but was not used specifically to prioritize Inyo-Mono vulnerabilities. At this point, region-specific information and concerns are more important for assigning priority to regional vulnerabilities.

Measuring Regional Impacts

On page 5-3 of the Handbook, Figure 5-2 lays out a roadmap for measuring impacts based on

the vulnerability analysis. The roadmap suggests basing the impacts analysis only on those resources the region has deemed vulnerable. Because we did not have the resources to do resource-specific impacts analysis, we skipped the step of determining resource-specific models and moved directly to analyzing climate change projections generally for the region.

The Handbook provides several different methods of quantitatively and qualitatively analyzing climate change projections. We chose to pull downscaled climate model output directly, using the CMIP3 archive of downscaled climate projections (http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html#About), rather than using some of the other – and perhaps more user-friendly – summaries of climate change projections, for one primary reason: there has been little climate change analysis performed in the past specific to the Inyo-Mono region. This was an opportunity to develop region-specific climate projections at a scale that would actually be useful for water management. In an attempt to increase the spatial resolution of these analyses, particularly in the more topographically-complex areas of the region, the region was divided into six sub-regions. Using six general circulation models and two greenhouse gas emissions scenarios, temperature and precipitation projections were calculated for each sub-region through 2100.

The downscaled projections analysis was the most quantitative effort in the larger regional climate change analysis. While there was funding through an IRWM Planning Grant to develop an initial climate change analysis to meet IRWM Plan Standards and basic regional needs, more resource-specific and/or quantitative analyses were beyond the Program's capabilities at the time. Thus, no further steps were taken in measuring potential impacts.

Given the information collected and developed so far, it is desired to further understand potential impacts to specific water resources in the region, such as streamflow and groundwater. With available resources, our next priority would be to engage in hydrologic modeling for the region using WEAP or another appropriate model. This step would require not only additional funding to access WEAP but more hydrologic and modeling technical expertise than the RWMG currently possesses. Based on these results, perhaps modeling could also be utilized for other water-related resources, such as impacts to groundwater and water quality. We would refer back to the Handbook for ideas and guidance on what types of analyses could be performed.

Identifying Adaptation Strategies

The next step in the analysis for the Inyo-Mono IRWM region consisted of identifying potential adaptation strategies pertinent to water resources management in the region. Adaptation strategies are discussed in the Handbook in the context of Resource Management Strategies from the California Water Plan and IRWM Plans. In the case of the Inyo-Mono analysis, staff already had familiarity with DWR-specific adaptation strategies from the 2008 report *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water*. Although the report is dated in terms of climate change information, the strategies it contains are still relevant and are largely reflected in more recent reports and documents. For each of the 10 strategies discussed in the *Managing an Uncertain Future* report, a brief qualitative discussion describes how the strategy is or is not relevant for the Inyo-Mono region, how the strategy has been utilized this far, and what further steps regional water managers could take to fully implement the strategy.

A more thorough and specific analysis of adaptation options is needed to help guide regional water managers on specific actions to be taken in order to reduce climate change impacts on water resources. The Handbook leads the user through the California Water Plan Resource Management Strategies as a way to identify adaptation strategies. This would be one way to explore more specific adaptation options for local water managers. More specific guidance might also be available after a more targeted impacts analysis.

Greenhouse Gas Emission Inventories

The last step in the first Inyo-Mono climate change analysis was to perform a few initial water-related greenhouse gas emissions inventories for area water systems. Because by chance we were working with an organization (the Sierra Nevada Alliance) with staff members who had

expertise in conducting GHG emissions inventories, we did not specifically follow the guidance on GHG emissions inventories in the Handbook, though we do not think the inventories conducted for Inyo-Mono water systems conflicted in any way with the Handbook guidance. We conducted inventories for the three largest water systems in the region, only two of which are considered “urban” water agencies (>3,000 connections). Not only did these water systems have readily available electricity and energy-use records, but they also served as pilots to help determine whether the chosen methodology would be effective for small water systems. We used the findings from the inventories to conduct additional inventories through a separate grant.

Analysis: Benefits, Challenges, and Recommendations

To summarize, the experience of the Inyo-Mono IRWM Program Office in using the Climate Change Handbook to conduct its first formal climate change analysis for the region was that when guidance or direction was needed to take the first or next step of the analysis, the Handbook was a useful tool, but that we diverged from the work suggested in the Handbook when in-house experts recommended a different method or approach. This very fact may be both an advantage of the Handbook as well as a disadvantage. The Handbook is useful because it can be followed to various degrees and its use can be tailored to meet many different water planning needs and objectives. On the other hand, because IRWM groups still have the freedom to choose whatever methods they want to conduct climate change analysis, these analyses are not likely to be comparable across regions and statewide.

The three sections below enumerate benefits of the Handbook, challenges and opportunities of the Handbook, and recommendations for future iterations of the Handbook, based on the perspective of the Inyo-Mono IRWM experience in using the Handbook.

Benefits

- The graphics in Chapter 1 laying out the IRWM planning process (even though the Handbook is not expressly targeted at IRWM planning) and relating climate change analysis to steps in this process are particularly useful for helping the reader (and novice IRWM practitioners) develop a mental framework. It is helpful to be able to go back to these graphics (Figure 1-5 and Box 1-3 are good examples) during the climate change analysis process to remember where one is in the process.
- Use of the Handbook can be tailored to meet a particular regional water management group’s regional water needs and objectives. It does not “judge” one particular method over another and recognizes that regional water planners and groups have varying resources and levels of expertise to devote to climate change analysis. In other words, the document strikes a good tone, right from the Foreword.
- It is not necessary that all climate change analyses proceed in the same order as presented in the Handbook; analyses should proceed in a way that makes sense for regional priorities.
- The Handbook is particularly useful when those doing climate change analysis do not have experience in a certain area or need direction on how to start. Those that have previous experience will likely use their previous knowledge and tools to conduct analysis and use the Handbook as an extra reference.
- The literature search table at the end is very thorough and helpful, though it will need to be updated quite often.

Challenges/opportunities

- Realistically, someone with little or no background in climate change science would probably have a difficult time opening this document and understanding what to do. Section 2 gives an excellent overview of basic climate change science but is still likely too technical for some. Two recommended ways forward: state early on (Foreword or early in Section 1) that someone with no climate change background attempting climate change analysis will have a difficult time, or point novice readers to some other very basic climate change resources or primers to study before attempting a climate change analysis as described in the Handbook.
- There is a lot of information in this document, and it might seem intimidating to some to

start in on the process. Much of the language used in the Handbook tends to be that used by consultants and trained climate change practitioners. Terms and meanings might be foreign to others attempting climate change analysis. Figures in Section 1 help to provide a roadmap, but it might be good to give repeated reminders that this is not an impossible task.

- Regional water management groups with high proportions of DACs and/or small/rural water systems are going to have difficulty conducting even simple climate change analyses, even with the availability of tools such as the Handbook. Targeted technical expertise should be made available to these regions.

Recommendations for improvements

- Incorporate the new information and graphics on water/energy nexus from the CA Water Plan Update 2013.
- Section 2 (Science of Climate Change) needs to be updated with more recent information, such as Representative Concentration Pathways, CMIP5, new information on climate models, new projections of impacts on water resources, etc. This section could probably use an update every 2-3 years.
- There are many mentions of the various tools available to do GHG emissions inventories and adaptation analysis, which is good. Do we also want to provide a list of people/organizations that can be hired to do this analysis? Is the State even allowed to provide such a list? Or do we just recommend that people consult experts (caveat being that not all regional water planners can afford to consult experts)?
- Mentions of various documents throughout the Handbook should be checked to see if they are still current or updated with new or updated (such as the impacts overview in Section 4).
- It would be helpful to provide more specifics on what resources users need to operate some of the quantitative tools and models discussed – i.e., money, expertise, data, etc.?
- Update Section 6 with California Water Plan Update 2013 Resource Management Strategies.
- Start a glossary with technical climate change terms.

Conclusion

The Inyo-Mono IRWM Program found the Climate Change Handbook for Regional Water Planning to be a useful document in two main ways: providing direction when the user lacked experience in a particular element of climate change analysis, and serving as a reference document for information about climate change, its impacts, and adaptation and mitigation opportunities. As for the future of the Handbook, the first question we should ask ourselves is “do we want this to be a living document that continues to be a tool for regional water planning into the future”? I would strongly recommend that the Handbook continue to be used, maintained, and made available. However, if this is the case, the document will need periodic reviews and updates to keep current. Much effort is put into understanding the science of climate change and potential future climatic scenarios; considerably less effort is put into how to translate this science into planning tools – in this case, for water resources. The Handbook largely fills this need in California, at least with respect to regional-level water planning.