Workshop – Review of 2012 Drought and preparing for Water Year 2013 Drought Possibilities

- Purpose: Discuss WY13 Drought Possibilities, Contingency Planning and Science Needs
- When: 6-7 November 2012 (Tues-Weds)
- Where: Boulder, CO (NOAA Earth System Research Laboratory (ESRL), Room 1D-708) http://www.esrl.noaa.gov/about/visiting.html); also offering GoToWebinar.
- Sponsors: Reclamation R&D, NIDIS, and NOAA Earth System Research Laboratory
- Themes[1]: focus on drought-stricken basins in 2012, review hydrology and operations; consider 2013 hydrologic outlooks and associated operations; science needs
- Outcomes/Products:
    - WY13 hydrologic scenario information and post-workshop summary of discussion.
    - Communication strategy for how we are trying to enhance our projections of the combined impacts of drought and climate change on WY13 supplies.
    - Summary of science needs regarding forecasting and tracking effects of drought on current and future water supplies.

Agenda

November 6

8:00-8:30 Introductions (Reclamation R&D, NIDIS)

8:30-Noon 1. What happened in Water Year 2012? Assume an Oct-Sep water year (definitions vary). Focus on Reclamation's four regions that experienced drought in 2012 (all except PN). Invite 20-minute briefing (with 10-minute Q&A) characterizing water year hydrology, drought development, operations response, and interactions with customers and stakeholders on supply forecast, allocations and management, any expectations for coming year, etc.

8:30-9:00 UC – Upper Colorado River (Heather Hermansen) presentation

Q: Were there pumping impacts? What was the role of water rights? A: Groundwater levels were impacted in 2012; there's limited adjudication control.

9:00-9:30 LC – Lower Colorado River (W. Paul Miller) presentation

Q: For the cumulative risk plots shown, is climatology assumed? A: Index Sequential Method was used to generate the plots and climatology is implicitly assumed (based on 103-year period of hydrologic observations).

Q: Will WaterSMART Basin Study hydrology projections[2] inform these cumulative risk plots in future issues? A: Probably not since the plots are only meant to illustrate cumulative risk through the term of

[1] Random thoughts on Drought challenges, 8/14: (1) Agriculture concerns, (2) FY13 vulnerability dependent on FY11-12 carryover storage, (3) Conjunctive aspects of drought not well-understood, (4) U.S./Mexico response to Rio Grande/Pecos drought, (5) Colorado River Storage System – long-term and sustained drought - compact issues?

interim guidelines for coordinated operation of Lake Powell and Lake Mead (2026). However, the new tool being developed to generate cumulative risk plot (Mid-Term Operations Model) could be used to translate projected hydrologies into cumulative risk. But for formal short-term reporting, stakeholders still need to gain comfort.

Q: How do hydrologic projections through 2026 compare to past hydrology? A: By the 2020s, there's expected to be a flight decease in mean-annual runoff at Lees Ferry.[3] This would cause the probability of shortage by 2026 to increase slightly over assuming climatology.

Q: On the use of minimum, most, and maximum probable shortage, how is this information communicated to stakeholders? A: They receive a monthly issue of the 24-month study's "most probable" results; every 3 months, the issued study also includes "minimum probable" and "maximum probable" results.

9:30-9:50 break

9:50-10:20 MP – Truckee/Carson Basins (Tom Scott) presentation

Q: Who is MP-LBAO collaborating with to develop their model that permits development of ensemble operations outlooks? A: On the matter of technically incorporate all members of ESP hydrologic forecasts in the basin, and ensuring that forecasts are made at all runoff locations necessary for making operations outlooks, LBAO is working with NOAA NWS CNRFC. On the matter of building awareness and trust in the resultant operations model to generate reasonable operations outlook members in the ensemble operations results, LBAO is working closely with the stakeholders, and this process is ongoing.

10:20-10:40 GP – Oklahoma/Texas (Collins Balcombe) presentation

Q: What is the water availability outlook for Twin Buttes Reservoir in TX? A: Currently, local managers estimate they have ~18 months of remaining water supply. There has been some precipitation relief in the region, but it's mostly occurred downstream of the reservoir. The local managers are responding to shortage risk by developing a well field with advanced water treatment.

Q: What is Reclamation's role in developing water management or reservoir operations outlooks in the OTAO area? A: All of Reclamation's reservoir systems are transferred works in this portion of Great Plains region, and therefore Reclamation is not very involved in development of such outlooks. Much of OTAO's efforts are spent on long-term water development proposals and dam safety issues.

10:40-11:00 GP – Eastern Colorado (Andrew Gilmore / Valda Terauds) presentation

Q: Do local water managers given much consideration to ENSO to anticipate spring-summer water supply? A: They primarily focus on snowpack development and try to anticipate snowmelt patterns and seasonal melt volume.

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[2] http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html
[3] http://www.usbr.gov/climate/SECURE/docs/SECUREWaterReport.pdf

Q: For the Colorado Big-Thompson system, on the timing of reservoir drawdown during the cold season and subsequent permitted refill during spring season, would better hydrologic predictions from NOAA matter? A: The drawdown period is from November through March, so having a better forecast of Nov-jan precipitation in October would not really matter in the spring because drawdown would still have to occur in Feb-Mar. However, this is a topic that interests water managers and stakeholders … what is the rationale for how much drawdown is necessary, and how does that change during the transition from winter to spring?

11:00-11:20 GP – Nebraska/Kansas (William Peck / Jack Wergin) presentation1, presentation2

11:20-Noon Open Discussion

Noon-1:00pm Lunch

1:00-3:00 2. Looking Ahead in Water Year 2013 - Hydrology. Focus hydrologic information available from NWS River Forecast Centers, and schemes for adjusting forecasts to (1) account for warming trend, (2) account for basin carryover-effects from prior-year drought, and (3) be consistent with NOAA CPC seasonal climate/drought outlooks.

1:00-1:05 Quarterly Climate Impacts and Outlooks (Robin Webb, NOAA ESRL) handout

1:05-1:35 NOAA drought outlook (Ed Olenic, NOAA CPC) presentation

1:35-2:00 How do RFCs develop ESP hydrologic forecasts? (Brenda Alcorn, Colorado Basin River Forecast Center) presentation

Q: What are the next steps in HEFS implementation? A: CNRFC is getting familiar with running it. CBRFC has gained that familiarity and is planning to pilot it in the Delores Basin in 2013.

Q: How are the forecasts blended from the initial deterministic period driven by weather forecasts to the subsequent period informed by past weather years (climatology)? A: Temperature inputs to ESP hydrology simulations are blended over a 5 day period; Precipitation inputs are not blended (there's a step-change from the deterministic period when P inputs are determined by weather forecasts to the subsequent period where P inputs are from past weather years).

Q: On QPF, is reforecast information or skill information available? A: QPFs have been issued for only about a decade, which is a short-period for assessing skill; need to do modeling to extend QPF estimates historically.

Q: HEFS plan for the ABRFC and MBRFC? A: ABRFC is implementing HEFS; no comment from MBRFC (they may be implementing – could not confirm).

Q: What are the key initial condition assumptions in ESP hydrologic forecasting? A: basin soil moisture and snow water equivalent (SWE) at the start of the forecast period.

Q: Do RFCs use station observations of soil moisture or SWE to adjust areal model states for soil moisture and SWE at the start of the forecast? A: This is hard to do, and generally the answer is no (or at least the approach is not prescribed). This means that the soil moisture or SWE at the start of forecast (particularly soil moisture) is a modeled state inherited from historical simulation of basin conditions.

2:00-2:50 Hydrologic Scenarios for 2013 (Subhrendu Gangopadhyay, Reclamation Technical Service Center) presentation

- Regions submitted short menus of locations
- RFCs provided ESP forecasts at these locations
- TSC converted forecasts into hydrologic scenarios corresponding to forecast-adjustment schemes developed collaboratively with NIDIS/NOAA

2:50-3:10 break

3:10-5:00 3. Looking Ahead in Water Year 2013 - Operations. Narrow focus to two basins, translating WY2013 hydrologic scenarios into operations outlooks, reflecting the different forecast adjustments above. Identify communications options based on results. Discuss utility of these hydrologic scenarios and development of Fall-lead operations outlooks for the coming water year.

3:10-3:40 MP-LAO, Truckee and Carson River operations (Shane Coors, Precision Water Resources Engineering) presentation

3:40-4:10 UC Green and Gunnison River Operations (Heather Hermansen): Transitioning from the old to the new while looking ahead in 2013. presentation

4:10-5:00 Open Discussion

November 7

8:30-10:00 4. Science Needs. On state of science and needs, we propose to focus on hydrologic information available from NWS River Forecast Centers, and schemes for adjusting forecasts to (1) account for warming trend, (2) account for basin carryover-effects from prior-year drought (e.g., groundwater impacts modulating surface water conditions the following year), and (3) be consistent with NOAA CPC seasonal climate/drought outlooks. Session involves a facilitate discussion (Brekke/Brown) with a panel of climate/drought outlook specialists and climate scientists from NOAA ESRL (Marty Hoerling, Kathy Pigeon, Matt Newman)

Roundtable discussion re: anticipating, preparing for, and managing through drought

1. GP-Region: better ability to predict May-June precipitation (April lead is sufficient; longer-lead even better)… plays a big role in modulating snowmelt during spring season … enhanced snow monitoring at high elevations (>10000', more SnoTel sites?)

2. GP-NKAO: enhance network and/or continued support for soil moisture monitoring (s.m. sensors / automated weather stations?); groundwater monitoring

3. GP-ECAO: better snowmelt information during the snowmelt season, how it translates into import estimates … Hindcasting has values… let's go back and understand years when forecasts departed significantly from actual, look for driving factors and opportunity to make improvements; … also improved monsoon precipitation forecast

4. LC-BCOO: better water demand projections during drought; enhanced soil moisture monitoring … better understanding about key hydrologic processes affecting Colorado River runoff predictability (getting the precipitation regime correct; s.m.-snowpack-runoff relationships) … understanding and better use of serial relationships between forecasts (e.g., if we know that March issue of April-July runoff volume, can we say anything about what the April issue is likely to be?) … better prediction of drought onset and completion

5. MP-LBAO: better forecast of spring-season runoff volume … align RFC's ESP forecasts with CPC climate outlooks (either through pre-processing the weather going into the ESP forecast, or through post-processing like the member-weighting discussed Nov 6)

6. PN-Region: better ability to predict May-June precipitation (April lead is sufficient; longer-lead even better); plays a big role in modulating snowmelt during spring season … forecasting the timing and magnitude of peak reservoir inflow during the snowmelt season

7. UC-Region: better upper basin tributary forecasts, seasonal runoff volumes during spring-summer, finer resolution during snowmelt period

8. UC-AAO-Pecos: more SnoTel sites for snow monitoring, better prediction of warm season precipitation, better understanding of groundwater interaction with surface water

9. UC-AAO-RioGrande: refined estimate of evapotranspiration estimates (via ET-toolbox) or stream loss to groundwater

10. NOAA NWS CNRFC: they're focusing on use the new HEFS (Hydrologic Ensemble Forecasting System?), which will ingest information from Climate Forecast System v2 (CFSv2, which is run out several months) to affect the weather inputs to the simulated hydrologic forecasts; CFSv2 is a major input to the NOAA CPC outlooks, but not perfectly aligned.

11. NOAA NWS CBRFC: In Upper Colorado and Northern CA, the ENSO signal is weak. The CPC places a lot of ENSO … Are there other larger-scale modes of climate variability that offers predictability for the latitude band including Upper Colorado and Northern CA? Do those larger-scale modes influence seasonal runoff forecast reliability? (e.g., does a decadal-scale mode of variability modulate seasonal runoff predictability? If so, how?) → using such information begs issuing of probabilistic hydrologic forecasts … To what extent are these modes of climate variability captured in CFSv2 (see 13.)?

12. NOAA NWS NWRFC: Better long-range temperature and precipitation forecast products (e.g., 30-day products) – it would help the RFCs to have more frequent updates. … RFCs would benefit from receiving more frequent updates of reservoir regulation information (e.g., during spring, would love to have weekly updates)

NOAA – Marty – messages heard:

- Type of drought to focus on: low runoff volume during winter-spring (e.g., lower tercile of runoff volume possibilities during January through June period)
- Question of antecedence: July-December
    - Basin: soil moisture condition, snowpack during Fall (thru Dec) … How much do these antecedent conditions constrain the probability of having low runoff volume occurring? → this speaks to monitoring needs during July-December
    - Monitoring supports characterizing basin conditions from gross aspects to detailed aspects. What is the sensitivity of hydrologic forecasting to more spatially resolved (finer resolution) monitoring?
- Question of meteorology during winter-spring:
    - What is the meteorology (T and P) expected to be during Jan through June (leads of 1 month or more)? (e.g., April 1st issue of May-June Precip?)
    - What aspects of meteorology is the runoff forecast most sensitive to? (e.g., precipitation during winter vs. spring? Precipitation regime during spring? Other) … Sensitivity answer depends on the hydrologic modeling approach (model choice, application, etc)
    - Are there other climate variability modes that are significant? ENSO is the biggest game in town … other modes of variability

NOAA-Reclamation Discussion on Marty's messages heard as well as two common predictability problems shared during the Roundtable discussion: (1) anticipating 3+ month climate as it relates to spring-summer runoff (or winter-spring runoff); (2) anticipating sub-seasonal climate from 2-week to 3-month period, particularly during spring.

- Kathy: Be aware of the National Multi-Model Ensemble (NMME) being developed by NOAA NCEP to support seasonal climate prediction; CFSv2 is one of the contributing dynamical models.
- Marty: A series of events leads to a drought… What phenomena are in the antecedent conditions (that we could monitor better) versus in the target season that limit drought predictability?

- Matt: re: one-month climate outlooks during spring: This subject does not receive as much research support as looking into climate predictability for 3+ month periods, or for summer monsoon. … The problem has not been well looked at, perhaps because the relevance may not be well understood by the science community and as a result the problem hasn't received adequate attention (that said, spring predictability is a tough problem, and that may also explain lack of attention). Perhaps the user community could explain the importance of understanding spring weather variability and inspire more dialogue on research strategy to address this predictability problem.

- Marty: Proposed predictability exercise: apply watershed simulation model w/ data assimilation of observations for Jan-Jun period using the following general procedure: Focusing on drought anticipation, first make two runoff volume forecasts on Feb 1st for the Jan-Jun period with one informed by Oct-Dec obs and the other informed by Oct-Jan obs. Next, make two forecasts on Mar 1st, one informed by Oct-Jan and the other informed by Oct-Feb obs. Keep following this pattern, advancing forecast issue dates monthly until May 1st. This will help us understand our predictability limits given best efforts to assimilate all observations (*Post-meeting question – has someone already done this?*)

- Kathy: The National Multi-Model Ensemble for seasonal climate prediction is Informed by 8 dynamical models that have been applied to produce hindcasts and forecasts going forward.

- Marty: Can we leverage hindcast NMME output to understand seasonal climate predictability and how that might be used to constrain ESP application at RFCs? (Kevin – they're looking into a similar exercise, but focusing on CFSv2 reforecasts)

- Roger: To what degree does characterizing "drought onset" matter? (responses: water customers appreciate having information that helps them anticipate reduced water supplies)

10:00-10:15 Break

10:15-11:30 5. Take-Aways and Next-Steps.

- Communications – key messages?
- Utility of Fall-lead Hydrologic and Operations Scenarios?
- Highest priority science needs/research activities?

Key Messages - What Happened in 2012?

- We heard from UC, LC, MP and GP about basins in their region that experienced low precipitation and runoff conditions during 2012.

- The consequences varied a lot across the basins due to various factors (e.g., whether the basin is a snowmelt dominated or rainfall-runoff dominated basin, the degree to which precipitation deficits translated into scarce surface water supplies, whether water users had access to ample carryover reservoir storage from 2011, whether water users have access to groundwater as an alternative supply). When we search for tools and solutions, we're going to seek to align them to really different types of basins. (e.g., storage rich to storage poor, types of users, type of precipitation regime, user sophistication, environmental requirements, types of expected water supply reliability).

- The overall amount of water management constraints in a basin affects the range of options for responding to drought.

- A question emerges - how we make sure Reclamation has the authorities it needs to respond to situations caused by drought, or facilitate response by others. (e.g., our authorities under Reclamation States Emergency Drought Relief Act of 1991 expired as of 30 September 2012).

- Problem: Reclamation actions during a drought tend to be scrutinized and there's general lack of clarity in the minds of our stakeholders and the public about the roles played by Reclamation and others during drought. This sets up a communication imperative to make sure our stakeholders and the public understand the delineation between the authority to establish priority under changing supply (e.g., for M&I, ag, or env. use) versus Reclamation's authority to manage and release the water according to contractual obligations.

    - Related questions: How can NIDIS help with this communication? How can we work with Western States Water Council or WestFAST on this communication?

Key Messages - Anticipating possible effects of continuing drought on 2013 Hydrology and Operations

- We heard about the Quarterly Drought Outlooks issued by NOAA/NIDIS/WGA.

- We heard about how NOAA CPC develops 3-month climate outlooks and the associated drought outlook. We heard from that in years that we do not experience strong El Nino or La Nina conditions, it's hard to predict seasonal climate with skill that is any better than just forecasting based on climatology. This sets up questions about seasons and places where we have some climate predictability skill and/or opportunities to improve skill.

- We heard about how NOAA NWS River Forecast Centers apply Ensemble Streamflow Prediction (ESP) to develop and issue hydrologic forecasts for flexible periods, and how they're moving towards the capability to better incorporate short-range weather to seasonal climate predictions (e.g., those from CFSv2) via Hydrologic Ensemble Forecast System (HEFS). Discussion focused on forecasting of monthly to seasonal runoff volumes.

- While we wait for HEFS and ESP assimilation of seasonal climate predictions, we can explore member-weighting schemes to adjust ESP forecasts consistent with seasonal climate

predictions. A scheme was presented that is adaptable to different types of climate forecasts. In the member-weighting schemes that were discussed, the probabilistic seasonal climate outlook information shared by Ed Olenic was used. There was interest in seeing access to this information improved (e.g., in a tabular / database format rather than values annotated on a graphic).

- We heard from MP and UC region on how they're able to translate ESP hydrologic forecasts into associated ensemble operations outlooks using Riverware applications of their systems.
    - Ensemble operations outlooks are not common in Reclamation. Most operations offices employ a manual process where operations outlooks are informed by system conditions, hydrologic forecasts, foreseen demands and operating constraints, and the operator's ability to synthesize information and judge an appropriate operational course of action to feature in the outlook. In order to develop ensemble operations outlooks, this manual process is too time and labor intensive. Instead, the manual operator's synthesis and course determination must be translated into logic that can be simulated and permit automated determination of operations courses given hydrologic forecasts.
    - The benefit of producing ensemble operations outlooks is that we provide stakeholders information that is rich in the sense that it provides probabilistic outlooks for operational conditions. However, the information is complex, and there's a significant amount of time and investment required to orient stakeholders and interested parties on what this information is telling them.
    - A challenge of building capacity to develop ensemble operations outlooks is that the operations office must develop a model that simulates the operator's synthesis of information and determination of operations course. The resultant model must be developed collaboratively with operators (whose logic is being modeled) and with stakeholders so that all concerned parties trust the operations courses generated by the model. This process requires considerable time and investment. However, a significant benefit is that there's greater understanding among stakeholders at the end of this process about Reclamation operations. The model can also be used as a common tool to facilitate interactions/negotiations amongst stakeholders.

Key Messages - Science Needs

- We heard a variety of needs from operators, most of which are consistent with Reclamation and USACE needs recently characterized through CCAWWG (http://www.ccawwg.us/index.php/activities/short-term-water-management-decisions-user-needs-for-improved-climate-weather-and-hydrologic-information).
    - monitoring basin soil moisture and snowpack conditions
    - monitoring groundwater conditions, particularly in the Great Plains

- monitoring and forecasting evapotranspiration conditions, as it relates to hydrologic prediction and water use (irrigation)
- forecasting: seasonal runoff volume prediction
- forecasting: snowmelt pattern during the spring season (daily to weekly runoff pattern, relation with peak flow)
- forecasting: spring weather affecting (2), particularly May-June precipitation as it affects Columbia and Missouri basins
- forecasting: summer precipitation over the U.S. Southwest.

- On climate predictability, we discussed two problems: (1) anticipating 3+ month climate as it relates to spring-summer runoff (or winter-spring runoff); (2) anticipating sub-seasonal climate from 2-week to 3-month period, particularly during spring.
    - On (1) we heard that CPC focuses a lot on ENSO and that much of the climate prediction community is focuses on dynamical modeling to improve seasonal prediction (e.g., release of CFSv2, investment in NMME). We also heard that the River Forecast Centers are building capacity to utilize such seasonal climate predictions in their ESP process, using the new Hydrologic Ensemble Forecasting System (HEFS, in various stages of implementation by RFC). NIDIS is funding the prototyping of HEFS at CBRFC and is poised to fund some of the transfer to other RFCs (which are also exploring implementation).
    - On (2), we heard that perhaps there's opportunity to explore research strategies to improve predictability on this problem. NOAA offered perceptions that this problem of spring sub-seasonal predictability hasn't been received as much attention as seasonal+ predictability problems. It's questioned whether this is just a really difficult problem or whether users have failed to emphasize the relevance of this problem. It's not clear that we've fully explored the strategy space.

Final Thoughts

- Robin: On communication, is there anything NOAA and Reclamation could do to help with anticipating potential drought persistence into 2013? What can we do in the next 2 to 3 months to help? Are there routine observations on dust-on-snow and are these available for the water user community?
    - Action: Perhaps Reclamation, NOAA ESRL and NIDIS can collaboratively develop a Reclamation-tailored 2-pager similar to the regional quarterly shared by Robin. Suggestion was to pick a couple of systems and prototype the 2-pager (Fry-Ark system and ?).

- UC-AAO: How do we get people to understand that groundwater has a lot influences that have longer-term memory in the regional gw system? E.g., this is an issue in the Pecos. The state has a groundwater model. Levi to follow-up with Carolyn to clarify.
- Action (Curt): We would like to invite RFC forecasters and Reclamation water managers to share descriptions of how they're communicating 2012 drought and 2013 drought possibility information with their stakeholders. We'd like to collect descriptions of those approaches and disseminate them. This is a start of a conversation on communication…

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