

# **GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM**

## *TECHNICAL WORK GROUP MEETING*

*JUNE 16-17, 2021*

*DAY 1*

**Start Time:** 9:03 AM Pacific Daylight Time (PDT)

**Conducting:** Seth Shanahan, Technical Work Group (TWG) Chair

**Meeting Recorder:** Carliane Johnson, SeaJay Environmental LLC

## Welcome and Administrative

- **Introductions and Determination of Quorum (16 members):** [Seth Shanahan, Southern Nevada Water Authority (SNWA) and TWG Chair] Quorum was reached with 16 TWG members/alternates.
- **Adoption of Prior Meeting Minutes:** [Paul Harms, State of New Mexico (NM)] One revision noted on page 2 of the [April meeting minutes](#) is to correct Michelle Garrison's affiliation to the Colorado Water Conservation Board (CWCB). [Seth Shanahan, SNWA/TWG Chair] With that change made, the minutes were adopted without objection.
- **Next Meeting Date(s): October 13-14, 2021 (webinar).**
- **Review Action Items, Motions, and Votes Form:** The [Action Items list](#) was reviewed.
  - [Charlie Ferrantelli, State of Wyoming (WY)] Steve Wolff is still listed on the [Flow Ad Hoc Group](#) (FLAHG) and can be removed.
  - [Larry Stevens, Grand Canyon Wildlands Council (GCWC)] The Administrative History Ad Hoc Group (AHAHG) will convene prior to the next annual reporting meeting. Dr. Paul Hirt is now retired. AHAHG will continue to explore how to engage the system Dr. Hirt developed and will include the Glen Canyon Dam Adaptive Management Program (GCDAMP) 101 information.
  - [Seth Shanahan, SNWA/TWG Chair] The Budget Ad Hoc Group (BAHG) is to start considering criteria for prioritizing the Fiscal Year (FY) 2022 budget, which will need to be discussed after this TWG meeting.
- **Update on Program Funding:** [Lee Traynham, Bureau of Reclamation (Reclamation)] Reclamation has received full funding for the environmental program for FY21 with funds currently being distributed to partners. The President's FY22 budget was released in May at full funding levels (\$21.4 million) for GCDAMP and the Endangered Fish Recovery Program.
- **Science Advisors Program Status:** [Clarence Fullard, Reclamation] A joint contract is being developed for the Science Advisor Program with Reclamation's Lower Colorado River Multispecies Program for a five-year contract awarded by September.
- **Update on Activities Impacted Due to COVID-19 Restrictions:** [Mike Moran, Grand Canyon Monitoring & Research Center (GCMRC)] No trip cancellations due to COVID since January.
- **Update on Monitoring and Research Trips to Occur from Today Until Next Meeting:** [Mike Moran, GCMRC] See [table of all trips](#) for this calendar year through November 2021. The post overflight trip will ground truth the aerial information.

## TWG Chairperson and Vice-Chairperson Election

[Clarence Fullard, Reclamation] Refer to the [TWG's Operating Procedures](#) for a description of the responsibilities of Chair and Vice-Chair positions. The current Chair and Vice-Chair have expressed

interest in continuing. **[Jessica Neuwerth, Colorado River Board of California (CRBC)]** Nominates Seth Shanahan as TWG Chairperson, and Michelle Garrison as TWG Vice-Chairperson. **[Peggy Roefer, Colorado River Commission of Nevada (CRCN) and FLAHG Chair]** Seconded those nominees. **[Paul Harms, NM]** Made a motion that the TWG reappoint Seth Shanahan to the position of Chair and Michelle Garrison to the position of Vice Chair to the Glen Canyon Dam Technical Work Group for the Fiscal Year 2022. **[Larry Stevens, GCWC]** Seconded. **[Seth Shanahan, SNWA/TWG Chair]** The nominees are approved to their respective positions by consensus.

## Panel Discussion –7.48 Million-Acre-Feet (MAF) Release Year in WY2022:

**[Seth Shanahan, SNWA/TWG Chair]** The BAHG has been discussing this item regarding whether there needs to be changes made to budget activities in response low water levels in Lake Powell. **[Craig Ellsworth, Western Area Power Administration (WAPA) and Budget Ad Hoc Group (BAHG Chair)]** This is a big issue related to temperature and non-native fish. This is where the program ought to focus. **[Craig McGinnis, Arizona Department of Water Resources (ADWR)]** The last 7.48 MAF release in 2014 resulted in many effects to native fish and invasive species, so this conversation is intended to consider any monitoring that may be needed to identify effects of the next 7.48 MAF year.

### Q&A and Discussion

*Comments on Additional Items to Add to the List of Effects* **[Larry Stevens, GCWC]** The list of effects could include Benthic & Hypoxic Anoxia (BHA) because warm temperatures and low steady flows promote that process, particularly because drought conditions might exacerbate BHA farther downstream than Lees Ferry. **[David Rogowski, Arizona Game and Fish Department (AZGFD)]** Decreasing levels in Lake Mead, increasing habitat in the Colorado River for native fish, increasing river temperatures, and the development of Pearce Ferry rapid may have all played a part in non-native fish decline. **[Melissa Trammell, NPS]** Would it be more accurate to say that the razorback sucker decline began after 2014 and continued? **[Ted Kennedy, GCMRC]** Some of the premises in the model are more solid than others.

*Comments on Phosphorous* **[Ted Kennedy, GCMRC]** Phosphorous is a primary driver of fish condition. **[Josh Korman, Ecometric]** The primary hypothesis in 2014 was that the big rainbow trout biomass could not be supported during the drop in prey availability. They are now less abundant and there might not be a collapse associated with low prey. It is a different community now, which may affect the population. **[Seth Shanahan, SNWA/TWG Chair]** Is there confidence in the model to predict chub numbers based on phosphorous? **[Josh Korman, Ecometric]** Charles and Bridget have been cautious on making predictions about forecasting phosphorous levels. The correlations are not great and there are no guarantees it is going to be low. **[Larry Stevens, GCWC]** Conditions are complicated by the tributaries. Macrophytic seasonality is much more complicated than was previously known given their increase from June through October when downstream temperatures increase. This might be an ideal time to get more data on temperature in the ecosystem. **[Ted Kennedy, GCMRC]** The relationship of phosphorous and food base dynamics breaks down farther from the dam. A new citizen science project will start this year to sample water during tributary flooding to better understand phosphorus contributions.

*Comments on Temperature* **[Ted Kennedy, GCMRC]** Regarding temperature, low volume flows with slower travel time and less water to warm up, could result in 2-3 degrees warmer water by Diamond

Creek. For humpback chub and suckers, more warming is good, but maybe not so good for other fish. **[Mike Yard, GCMRC]** Temperature mediates growth, but growth requires energy (primary production up through invertebrate and fish prey). Under low water conditions and without sediment inputs, the water will be clearer and there will be an increase in primary productivity. The warmer temperatures may also increase bacterial growth from the organics, resulting in a double dose of energy production.

*Comments on Dissolved Oxygen* **[Josh Korman, Ecometric]** There have been low values of dissolved oxygen (DO) in recent years, which coincides with warmer temperatures and greater need for food, and that makes them metabolically inefficient. It is probably not possible to tease this out. **[Ted Kennedy, GCMRC]** It is probably not possible to make predictions on DO and it is likely independent of release volume. **[Larry Stevens, GCWC]** The concern about DO is that it is not just emergency low DO, but the persistently low levels that promote BHA and the production of non-native macrophytes.

*Comments on Foodbase and Natural Processes* **[Ted Kennedy, GCMRC]** The pattern is probably related to drift biomass, which led to reduced spawning. It is likely more related to phosphorus than volume. **[David Topping, GCMRC]** Don't forget that the period July 2013 through June 2014 was the largest Paria River sand input year we have had in the last 20 years. One of the key reasons 2014 was so "good" for sand was the result of the Paria River activity, not only the low dam releases.

*Comments on Humpback Chub in Little Colorado River (LCR)* **[Ted Kennedy, GCMRC]** The low numbers of adult fish in 2015 and 2016 were during low flood years. Flooding in the LCR is a strong predictor of chub spawning, which has to do with dynamics in the LCR and not what followed a low release year. **[Kirk Young, USFWS]** There might be other hypotheses on that. Sampling shows there were higher numbers of fish stacked up above the confluence of the LCR after 2015 and 2016. It is not known whether chub did not go into the LCR because they did not have the energy to put into spawning or because conditions were poor due to the lack of spring runoff, so they did not stay there.

*Comments on Humpback Chub in Western Grand Canyon (WGC)* **[David Rogowski, AZGFD]** Don't think the 7.48 MAF release in 2014 had anything to do with what is occurring in the WGC. It seems related to the river emerging from the lake as Lake Mead continues to decline resulting in more turbid conditions, which humpback chub prefer. **[Kirk Young, USFWS]** Agrees that temperature is the primary driver in the WGC, which is probably related to reservoir level. It made habitat available with fewer predators for chub to move into and to recruit. **[Josh Korman, Ecometric]** The river is clearer in WGC due to lower sediment inputs and lower volume flows, which will increase primary productivity that supports higher biomass. Maybe temperature and fewer predators are also part of that, but it is unresolved.

*Comments on flannelmouth and bluehead sucker* **[Larry Stevens, GCWC]** Would speckled dace be a useful surrogate for humpback chub? Would monitoring them be useful to expand that knowledge? **[David Rogowski, AZGFD]** AZGFD does not find speckled dace in the samples until below River Mile 100 and then they become more abundant around River Mile 150.

*Comments on razorback sucker* **[David Rogowski, AZGFD]** AZGFD only catches one adult razorback sucker every other year. It is not possible to say whether the monitoring trend shown after 2014 was an aberration or an actual decline. **[Scott VanderKooi, GCMRC]** It is hard to make inferences on the data given the rarity of razorback sucker.

**[Melissa Trammell, NPS]** What is the reason that high sand input from the Paria did not result in high phosphorus input, too? In 2014? **[David Topping, GCMRC]** High sand inputs do correspond with high phosphorous inputs. Trying to get those measurements now, but the Paria is not flooding.

## Report Out and Recommendation from the Budget Ad Hoc Group for the Fiscal Year 2022 Budget and Work Plan

**[Mike Moran, GCMRC]** Presentation on GCMRC's FY 22 Budget Overview. **[Clarence Fullard, Reclamation]** Presentation on Reclamation's FY22 Budget and Work Plan. **[Peggy Roefer, CRCN/FLAHG Chair]** Presentation on BAHG's recommendations to the TWG on the FY22 Budget and Work Plan.

### Q&A and Discussion

**[Jim Strogon, Fly Fishers International (FFI)/Trout Unlimited (TU)]** What are the "additional proposal detail and completion of compliance requirements" for the Aquatic Vegetation Removal Pilot in Lees Ferry (Item #3). Is it realistic to do within this Triennial Work Plan and would another low flow event be important to accomplish? **[Ken Hyde, NPS-Glen Canyon National Recreation Area (GLCA)]** This is a reconsideration of the research, and these details are not available. During the 4,000 cubic feet second low flow, many places were high and dry, which made brown trout move. The interest is to see whether this can be done in other areas that are used by brown trout. Would also have to determine if this includes native aquatic plants that only got established because of the dam. **[Scott VanderKooi, GCMRC]** There are indications that brown trout take advantage of these habitats. This is an idea to try to disadvantage brown trout. It would be important to do this quickly based on data collected in Glen Canyon over last few years. Not sure if low flows are needed or if it can be done during normal operations during spring maintenance flows. **[Kelly Burke, GCWC]** Is the urgency also related to the food base? **[Scott VanderKooi, GCMRC]** There has been a change in aquatic vegetation over the years. That is something to think about, as well as compliance issues related to removal of natives versus non-natives. **[Ken Hyde, NPS-GLCA]** This is possibly a tool that could be used to knock back significant numbers of brown trout. **[Ted Kennedy, GCMRC]** A robust experimental design could be made by looking at untreated and treated reaches.

**[Ben Reeder, Grand Canyon River Guides (GCRG)]** What is the name of the study for the High Flow Experiment (HFE) down ramping rates? **[Ted Kennedy, GCMRC]** It was in Project B.6 but that was not moved forward because of the larger needs of Project O. This was not part of the BAHG discussions. **[Seth Shanahan, SNWA/TWG Chair]** There is space for that in the budget under Experimental Funds. **[Ben Reeder, GCRG]** With respect to Project O.2, the WGC seems to be changing all the time and is one of the most dynamic places on the river. Understanding this would be beneficial to the GCDAMP.

## Development of Budget Recommendation to the Adaptive Management Work Group (AMWG)

**[Cliff Barrett, Utah Municipal Power Agency (UMPA)]** Made the following motion of the TWG's recommendation to the AMWG. **[Ben Reeder, GCRG]** Seconded. **[Seth Shanahan, SNWA/TWG Chair]** The motion was passed by consensus.

*The Technical Work Group recommends that the Adaptive Management Work Group recommend for approval to the Secretary of the Interior, the Fiscal Year 2022 budget as described in the attached worksheets, with the following revisions:*

*First, the addition of the following prioritized list of Grand Canyon Monitoring and Research Center projects to be considered as appropriate sources of funding become available (e.g. Triennial Work Plan carryover funds from prior years or through annual review of the Triennial Work Plan or other Reclamation considerations).*

1. *Juvenile Chub Monitoring-West (2023)*
2. *Additional Trout Recruitment and Growth Dynamics Site (2023)*
3. *Aquatic Vegetation Removal Pilot in Lees Ferry (202?) (Subject to additional proposal detail and completion of compliance requirements.)*
4. *Decision Analysis - Project O.11 - and Bug Flow Review. (Additional proposal detail requested following Science Advisor review.)*
5. *Aquatic Food Base – Project O.1 (2022)*
6. *Sediment Mapping Below Diamond Creek - Project O.2 (2022)*

*Second, the addition of a Dissolved Oxygen Risk Assessment to be completed by Reclamation in 2022 as appropriate sources of funding become available.*

## Update on Hydrology, Operations, and Water Quality Conditions and Progress Toward a Low Dissolved Oxygen State-of-Practice Review

**[Rick Clayton, Reclamation]** The June mid-month forecast projects 31% (3.367 maf) of average annual inflow to Lake Powell in WY 2021. The total release from Glen Canyon Dam for WY 2021 will be 8.23 maf. The Most Probable release for WY 2022 is 7.48 maf. Due to ongoing transformer replacements, only six of eight generating units are expected to be available to make releases from the GCD powerplant for much of WY 2021 and WY 2022. **[Lee Traynham, Reclamation]** Presentation on water quality (temperature) at Lake Powell and during dam releases. **[Clarence Fullard, Reclamation]** Presentation on state-of-practice and risk assessment review on DO, which will be accomplished by Reclamation's Technical Service Center (TSC).

### Q&A and Discussion

**[Jim Strogon, FFI/TU]** When will information be available to inform decisions at Glen Canyon Dam? Will this dovetail into the work on temperature control devices? **[Clarence Fullard, Reclamation]** It will probably take at least a few months. An update will be provided on the next TWG call. The initial work will inform the rest of the project. **[Larry Stevens, GCWC]** As temperatures increase, that fosters bacterial and other microbial growth, which creates increased risk of human health concerns. Where is management's understanding of that? **[Jan Balsom, NPS]** The NPS has a new public health officer. There have been outbreaks of norovirus in the last couple of weeks. Will follow up with the public health officer about this issue.

## Colorado River System 5-year Projected Future Conditions

**[Alan Butler, Reclamation]** [\[DOWNLOAD\]](#) Presentation on 5-year projected future conditions. It is a near certainty that Lake Mead will be below 1090 elevation by next year and below 1045 by 2024. This [link](#) provides additional information on the Alternative Future Hydrology Scenarios.

### Q&A and Discussion

**[Shane Capron, WAPA]** This is an interesting look out to five years, but it is striking how close the different option scenarios were. When WAPA modeled projections out to 20 years, the scenarios get “stuck” for 3-5 years when the water levels are at their lowest. **[Alan Butler, Reclamation]** At least for first few years, the similarities in the initial conditions are closer, but then the numbers start to diverge in 2025. **[Jim Strogon, FFI/TU]** Have there been discussions or a plan in place to prolong the operational capacity below penstock levels and provide temperature control? **[Lee Traynham, Reclamation]** The focus of discussions has been on preserving Lake Powell elevations above 3490. **[Sara Larsen, Upper Colorado River Commission (UCRC)]** The Upper Colorado River Commission issued a [press release](#) about the drought operations plan and what kind of releases can be made from Lake Powell within the parameters of the Record of Decision. **[Rob Billerbeck, NPS]** Is it correct that these projections 1) were based on the April starting point rather than June; 2) that 1.4 MAF were lost between April and June; and 3) did not include water from the Drought Response Operations Agreement (DROA)? When will the model be updated? **[Alan Butler, Reclamation]** The first point is correct. Regarding the second point, there is an algorithm in the model that tries to move water down from Blue Mesa, Flaming Gorge, and/or Navajo. The DROA is to look at conditions in all three of those reservoirs. The model is currently a gross approximation of this. The model will likely be updated before August because the conditions have changed so much. **[Shane Capron, WAPA]** Requests that Heather Patno add that to her presentation. Rick Clayton to pass this request to Heather. **[Kelly Burke, GCWC]** How are the state-level and county-level water management projects integrated into Reclamation’s reservoir protection efforts? **[Michelle Garrison, CWCB]** Reclamation staff work with the local reservoirs to keep track of what is going on. Information about the other reservoirs will also be sent to CBRFC’s modeling contractor to include in short-term forecasts. Some of these reservoirs in Colorado might only get 5-10% of their water needs this year, others are faring better.

## Development of Monitoring Metrics

**[Lee Traynham, Reclamation]** This effort has been on the tracking list for a long time and the current FY21-23 TWP included funding to develop focused and achievable metrics. **[Helen Fairley, GCMRC]** [\[DOWNLOAD\]](#) Presentation on proposed approach and timeline to define metrics for tracking Long-Term Experimental and Management Plan (LTEMP) goals. Comments on the draft plan requested by June 30.

### Q&A and Discussion

**[Kurt Dongoske, Pueblo of Zuni]** Concerned about using quantifiable metrics on canyon resources that will adversely affect Zuni values or will exclude Zuni understanding to sacred areas. Has Secretary Haaland weighed in on this program? It is important to understand how certain communities have been disproportionately disadvantaged due to federal environmental compliance requirements. **[Helen Fairley, GCMRC]** This concern has been recognized in GCMRC’s internal discussions and would encourage a dialogue to determine how to meet each goal even if it might not include a metric. **[Erik Stanfield, Navajo Nation]** Encourages tribal representatives to discuss this concern. There are new

models that include Native American methodologies. There might be common ground to bring a united decision to the group. Will send an email to the tribal group to start this discussion. **[Leslie James, Colorado River Energy Distributors Association (CREDA)]** Will speak with Bill Davis to get his perspective.

**[Ryan Mann, AZGFD]** AZGFD developed performance metrics for rainbow trout in the Lees Ferry Fishery Management Plan. Will share this 2015 document and requests that these metrics be included.

**[Seth Shanahan, SNWA/TWG Chair]** There is a need to be as simple as possible by using “key metrics” versus every metric that might be possible. **[Helen Fairley, GCMRC]** It is a challenge to determine how many metrics to capture while recognizing there are many variables that feed into the outcomes.

**[Kelly Burke, GCWC]** Suggests doing a “test run” on certain goals that have quantifiable values (like humpback chub and rainbow trout) compared to others that might not already have measurable goals. Perhaps a test run could also include tribal values like compassionate treatment of fish and other species. **[Helen Fairley, GCMRC]** That suggestion is compatible with the approach that will be taken on the draft plan, which is to present metrics for several of the goals at the October TWG meeting.

## Public Comment

None.

**Meeting adjourned at 3:52 PM PDT**

## **GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM**

TECHNICAL WORK GROUP MEETING

JUNE 16-17, 2021

DAY 2

**Day 2:** June 17, 2021

**Start Time:** 9:02 AM PDT

**Conducting:** Seth Shanahan, TWG Chair

**Meeting Recorder:** Carliane Johnson, SeaJay Environmental LLC

### Welcome and Administrative

**[Seth Shanahan, SNWA/TWG Chair]** The WAPA discussion on “Additional Information Regarding Purchase Power Cost Estimates” will be moved to the next TWG meeting.

- **Introductions and Determination of Quorum (16 members):** **[Seth Shanahan, SNWA/TWG Chair]** Quorum was reached with at least 16 TWG members or alternates in attendance.
- **Unresolved Issues from Yesterday’s Meeting:**
  - **[Larry Stevens, GCWC]** Has concerns about the way the metrics discussion is going and will submit comments. Metrics can be chosen, but they may not be the correct ones. **[Seth Shanahan, SNWA/TWG Chair]** The TWG will continue to track this as an item to address. **[Peter Bungart, Hualapai Tribe]** There are opportunities to include both qualitative and quantitative knowledge into this approach, which should be viewed on an equal footing. **[Ted Kennedy, GCMRC]** An important next step will be to reach out to partners, especially tribal members, to get their input on natural processes.
  - **[Lee Traynham, Reclamation]** TWG nominee packages are moving concurrently with the AMWG nominee process. Reclamation will continue to provide updates.

### The Influence of Pearce Ferry Rapid as a Fish Barrier

**[Ron Kegerries, Bio-West]** Presentation of data about the change in fish species above the rapid (natives) compared to below (mostly non-natives). **[David Rogowski, AZGFD]** Presentation that shows a significant difference in fish assemblages above and below the rapid.

#### Q&A and Discussion

**[Larry Stevens, GCWC]** Carp have been seen swimming upstream of Lava Falls by moving along the shoreline. Is the Pearce Ferry rapid different as to why fish are not able to move upstream? **[David Rogowski, AZGFD]** There are no shallow areas along the edges and fish cannot boulder hop from one level to another. That is one reason to place antennas upstream of the rapid during different water levels. **[Ron Kegerries, Bio-West]** Still have photographs from the high flow event that need to be processed to look at this, which will be incorporated into the final report. **[Bill Davis, CREDA]** What is the significance of this barrier from a long-term standpoint when lake levels are higher? Is it a temporary feature when lake levels are low? **[David Rogowski, AZGFD]** It is assumed that climate change is not going to be much different over next 10 years and the rapid is expected to persist through then. **[Ron Kegerries, Bio-West]** It will persist until lake elevations are at 1100 feet and higher. The rapid is also

moving west, too. **[David Rogowski, AZGFD]** As the lake recedes, it is downcutting the riverbed at the rapid, so it will not be the same as before when lake levels rise.

**[Seth Shanahan, SNWA/TWG Chair]** What is the influence of the 2011 flow as a cue for movement of native and non-native fish? **[David Rogowski, AZGFD]** It depends on when the high flow is. Carp and striped bass will move upstream in the springtime, but it is not known whether they can get past that barrier. Only found 11 carp and one channel catfish on sampling this past year in the mainstem. They used to be numerous. **[Ron Kegerries, Bio-West]** The high flow seems to spur razorback suckers that had sonic tags. As far as non-native fish, there was a tagging study on striped bass that suggested they were moving toward the rapid, but no one was really tracking the fish up there. They are using the flowing portion of the river, but they may not be effective predators in turbid waters. The barrier prevents influx of razorback suckers, too.

**[Jim Strogon, FFI/TU]** Has there been any attempt to move native fish upstream of the rapid? **[Ron Kegerries, Bio-West]** The decision whether to stock razorback sucker into the Grand Canyon would need to be discussed with the science panel. **[Jan Balsom, NPS]** This is something we may need to discuss. The barrier is great on non-natives, but the natives might need help. **[Melissa Trammell, NPS]** This is already being done on San Juan arm of Lake Powell. It is worth continuing this discussion.

**[Larry Stevens, GCWC]** With low lake levels and non-natives prevented from moving upstream, would it be effective to place a permanent fish barrier there? **[David Rogowski, AZGFD]** The only type of barrier might be electric and do not see that happening given the flow fluctuations.

**[Seth Shanahan, SNWA/TWG Chair]** Is the threat of non-natives higher than the benefits to natives if lake levels are lower? **[David Rogowski, AZGFD]** Most fishery biologists would probably agree that it is more of a risk to have non-natives move upstream than to increase native exchange. **[Brandon Albrecht, Bio-West]** It is believed that a lot of the young produced from the fish that moved upstream, need to get back to Lake Mead to achieve this backwater state that is important for razorback sucker. By preventing non-natives from coming up achieves this goal. **[Kirk Young, USFWS]** The alternative of having a non-native dominated system means that the natives would not be successful. It is a tradeoff.

**[Ryan Mann, AZGFD]** It seems the rapid has been changing enough in the last few years that it may be diminishing as the downcutting occurs. **[David Rogowski, AZGFD]** That rapid is constantly changing and shifting more toward the left bank. It also seems to be downcutting more. It might be completely different and might not even exist in 5-10 years. **[Larry Stevens, GCWC]** What is the future of monitoring at the barrier? **[David Rogowski, AZGFD]** Funding is currently available from USFWS for another year and the hope is to extend this for another year beyond that. **[Helen Fairley, GCMRC]** The characteristic of that barrier changed during the spring pulse flow becoming a pure waterfall during lower elevations.

## Informational Updates

### Spring Overflight

**[Mike Moran, GCMRC]** Presentation on the overflight project, which ended about two weeks ago.

### Q&A and Discussion

**[Jan Balsom, NPS]** What is the timeline for processing of the photographs and when they will be available? In the past it has taken years. **[Mike Moran, GCMRC]** Should have delivery of the final

products by November 2021. **[Helen Fairley, GCMRC]** In Rick Clayton's presentation yesterday, there was a brief spike in releases. How was that dealt with, how long did it last, and how might it have affected downstream flow levels? It could have influenced how the photographs are interpreted. **[Ted Kennedy, GCMRC]** The spike is prominent, but it was only 30 CFS that lasted for 10 hours. It is probably not a big concern. **[Larry Stevens, GCWC]** Have you contemplated putting together a review of past aerial overflights given the length of time (4 or more years) that occurs between them? This would clarify the need for them. **[Mike Moran, GCMRC]** Will speak to Joel Sankey about this and present at a future TWG. He had prepared a review during the justification for this project. Such a review would make clear the value of these overflights and maybe make it possible to schedule them more frequently.

### Spring Disturbance Flows:

**[Ted Kennedy, GCMRC; Dave Lytle, Oregon State University (OSU)]** Presentation on the March disturbance flow and angler surveys.

### Q&A and Discussion

**[Jim Strogon, FFI/TU]** Was this helpful for quagga and mud snails? **[Ted Kennedy, GCMRC]** Lees Ferry contained lots of quagga mussels and mud snails especially on the upper pulse flows. It is still to be determined if this had a population-level effect, but it did lead to mortality of those taxa. **[Dave Lytle, OSU]** The samples were from cobble bars that had just been exposed. Don't know if there will be a difference between species that don't move around much. **[Ben Reeder, GCRG]** Could the river become unrunnable? **[Ted Kennedy, GCMRC]** With lower releases over next two years, it may make navigation more challenging.

### Rainbow and Brown Trout Abundances in Lees Ferry:

**[David Rogowski, AZGFD]** Presentation on Lees Ferry fish monitoring in March and creel survey data.

### Q&A and Discussion:

**[Ken Hyde, NPS-GLCA]** Was there any effect on rainbow trout spawning that occurred after the spring disturbance flow? **[David Rogowski, AZGFD]** Started to see young-of-the-year in the fall. **[Seth Shanahan, SNWA/TWG Chair]** What are thoughts on the influx of kayakers? The guiding community would like this to be more controlled because it interferes with launching from the boating ramp. Kayakers will also pass right next to fishing lines from the boats, and they are filling up the camping spots; however, the guides are making money from hauling. **[Jim Strogon, FFI/TU]** Many kayakers are not using lifejackets. **[David Rogowski, AZGFD]** They get rescued often. **[Cliff Barrett, UMPA]** One chart showed population of brown trout increasing in the Lees Ferry. What is happening in Lower Colorado River? **[David Rogowski, AZGFD]** They are at the lowest numbers ever seen. **[Helen Fairley, GCMRC]** Any insights into the disparity between guided and non-guided incentivized harvest program? **[David Rogowski, AZGFD]** Yes, it has always been a catch and release fishery and would like to catch the biggest fish, which are the brown trout. They discourage the harvest of brown trout. **[Ben Reeder, GCRG]** Heard from one fly fishing guide from Northern Arizona who was very anti-harvesting and the high flow experiments. **[Ken Hyde, NPS-GLCA]** The guides during the whole planning effort from 2017-2109 made it clear that they did not want to change. Can only remind them that the program is available and that heavier-handed tools will be needed if the program is not successful.

### Incentivized Harvest Program Implementation:

**[Ken Hyde, NPS-GLCA]** Presentation showing results from the "Brown Trout Bonanza".

## Q&A and Discussion

**[Leslie James, Colorado River Energy Distributors Association (CREDA)]** The National Water Resources Association is planning its annual meeting for Scottsdale in mid-November. Can provide information for those coming into town. **[Ken Hyde, NPS-GLCA]** Maybe the angler from Michigan who did so well during April could be the first one to make a video. Only one fish was turned in that was over 24 inches even though the guides have said they have tossed some back that were over 30 inches, which are the best spawners. We might have to figure out how to incentivize for these larger fish. **[Bill Davis, CREDA]** Have any comparisons been made with Dave Rogowski's observations on brown trout to see if the program is having any effect? **[Ken Hyde, NPS-GLCA]** This is just the first year. The interest has been focused on getting higher participation. At the end of the year, the program will be reassessed to see if it has had any impact on rainbow trout recruitment rates. **[Scott VanderKooi, GCMRC]** There will be a trip at the end of June in Glen Canyon that is part of the trout recruitment monitoring that will help to understand what is happening. The mark-recapture data from GCMRC will also help determine if there have been any changes in the population. **[Seth Shanahan, SNWA/TWG Chair]** As GCMRC researchers present their data from those trips, they should include a comparison table to see how things match up. **[Erik Skeie, State of Colorado]** Did not see much signage information about the incentivized harvest program. It was only at one kiosk. It might be helpful to place information at the Lees Ferry campground and the Paria Beach parking lot. **[Ken Hyde, NPS-GLCA]** Two more kiosks were finished in March; one of them was near Paria Beach. Brown trout numbers still seem to be low with the walk-in fishers. **[Jim Strogon, FFI/TU]** What are you doing in local areas to generate interest? **[Ken Hyde, NPS-GLCA]** Did radio interviews, newspaper press releases, and talking to people. There are only a couple of boat ramps in the water and the traffic is picking up, which should generate more interest. **[Kirk Young, USFWS]** What were the harvest objectives? It reinforces the need to continue looking at all the possible tools. **[Ken Hyde, NPS-GLCA]** It was a guesstimate of about 200-250 fish per month, and more PIT tags needed to be turned in to develop the model. Current numbers are about a quarter of that. The Bonanza showed that it takes time for anglers to figure out where brown trout can be found. **[Clarence Fullard, Reclamation]** What is the timeline to determine how many fish need to be harvested to get an effect? **[Ken Hyde, NPS-GLCA]** The funding package was for three years. Will be looking at data after this first year to determine which bonuses helped the most or if other things can be tried. Still thinking a couple fishing tournaments could really open this up. It is the tail end of COVID in Arizona so that will not happen until fall or next spring.

## Biological Opinion Conservation Measures and Triggers:

**[Kerri Pedersen, Reclamation]** The final rule for listing the Kanab Ambersnail is going to be published in the Federal Register on June 18, 2021. The rule will go into effect 30 days after. Regarding humpback chub triggers, there are a series of threshold levels for adults and sub-adults. A Tier 1 trigger was met meaning additional conservation actions are required to reverse the decline to prevent the need for Tier 2 mechanical removal actions. Reclamation is working with USFWS to develop a plan that is a balance of adapting to current conditions within the constraints of the biological opinion. The document on the triggers will also be undergoing a 5-year review this summer. Ideas or comments should be sent to Kerri or Kirk. **[Kirk Young, USFWS]** The Tier 1 conservation actions include collecting and moving larval fish. Because of the lack of spring runoff in the LCR, the year 1 humpback chub were not as abundant as expected but were able to translocate 533 year-one fish to Chute Falls. Did not find any humpback chub larvae although it is certain they were there.

## Q&A and Discussion

**[Jim Strogon, FFI/TU]** Any information from young-of-year at the translocation sites and to use these sites for future translocation? **[Kirk Young, USFWS]** See some recruitment above Havasu Falls but it is not a lot. It may not be enough to supply extra fish for the translocations. **[Jim Strogon, FFI/TU]** What is the format and process to provide comments? **[Kirk Young, USFWS]** Will accept comments in any format, especially any ideas on conservation actions that are not being considered or about the trigger document that can lead to building a more effective tool to reduce effects on humpback chub.

## Discussion About Possible Experimental and Management Actions That May be Implemented in the Next 12 Months and Any Budgeting Issues

**[Clarence Fullard, Reclamation; and Mike Moran, GCMRC]** Presentation of the LTEMP experiments that may be implemented in next 12 months; update on current sediment conditions in the river, trout management flows (TMF), and macroinvertebrate flows (“bug flows”). Reclamation may have a draft TMF white paper by end of this year and GCMRC is preparing a synthesis of bug flow data that is expected to be delivered by October.

## Q&A and discussion

**[Seth Shanahan, SNWA/TWG Chair]** Can the TMF white paper be presented in October? **[Clarence Fullard, Reclamation]** Not sure that can be promised, but will provide an update on the white paper status at the next TWG.

## Monitoring Native Fish and Invasive Aquatic Species System-wide

**[David Rogowski, AZGFD]** Presentation on systemwide monitoring of fish from Lees Ferry to Pearce Ferry rapid.

## Q&A and Discussion

**[Jan Balsom, NPS]** Do you see brown trout migrating beyond upper Marble Canyon? **[David Rogowski, AZGFD]** Still find them throughout Marble Canyon, but only catching one or two fish. Brown trout does not tend to migrate like other salmonids do. **[Jim Strogon, FFI/TU]** Any word on numbers or changes of rainbows or brown trout at the confluence of LCR? **[David Rogowski, AZGFD]** This is usually presented at the Annual Reporting Meeting. There was probably no change but only 17 brown trout and a couple of rainbow trout were caught just below there, which was like past years. **[Scott VanderKooi, GCMRC]** Do not recall rainbow trout numbers increasing at the juvenile chub monitoring site, which is at the LCR confluence. Regarding the earlier presentation about Pearce Ferry as a barrier, it appears that the drop in non-natives preceded the development of the rapid. **[David Rogowski, AZGFD]** The rapid is one part of the theory about the decline. The water is more still and warmer upstream of Pearce Ferry as Lake Mead declines. This created favorable reproductive (backwater) areas for common carp and channel catfish. **[Scott VanderKooi, GCMRC]** This shift to native species in the canyon is a great story and likely the result of a few things. It is opposite of what is being seen in almost all other Western rivers. **[Seth Shanahan, SNWA/TWG Chair]** Are you exploring models to explain these responses? **[David Rogowski, AZGFD]** Working on a paper now to do that. The effect appears to be caused by a variety of factors, which are difficult to tie together with no definitive answers.

## Discussion about Invasive Nonnative Fish Passage and Temperature Control Methods at Glen Canyon Dam

**[Clarence Fullard, Reclamation]** Presentation on recent progress made on temperature control and fish passage at Glen Canyon Dam.

### TWG Member Discussion:

**[Seth Shanahan, SNWA/TWG Chair]** How can these big ideas be pursued while balancing the costs and the reasons for doing them? **[Bill Davis, CREDA]** This issue has been raised since the 1980s. Until the remaining biological questions can be answered, nothing can be designed. In 1989, the idea was to warm up the water to help natives, but that did not work. **[Ted Kennedy, GCMRC]** The objectives have shifted since the 1970s. It was thought this was a cold-water system. Then the concepts of climate change and the long-term drought shifted those views of the future. Reclamation's projections about Lake Powell, temperature, and basin warming are accurate. The objectives to disadvantage non-native fauna need to be done in a warm-water system. **[Bill Davis, CREDA]** There needs to be consensus from the biologists on whether we want a cold-water system and then move forward on the design. **[Ted Kennedy, GCMRC]** Would like to know what are their concerns? **[Larry Stevens, GCWC]** The temperature range regarding a warm versus cool-water system is significantly different in design. Agrees with Bill that we need to understand what it is that we are trying to get at? **[David Ward, GCMRC]** The problem is a need for flexibility to do both regarding temperature because there could be bad outcomes if natural conditions create either scenario. **[Melissa Trammell, NPS]** There are definitely concerns about warmer water, and there needs to be flexibility for both cool and warm options; otherwise, the system is going to move out of its sweet spot for native fish. **[Seth Shanahan, SNWA/TWG Chair]** How important is it to have a surveillance program and for our capacity to rapidly respond to a concern? **[Bill Davis, CREDA]** Maybe it is time to review this again with all the changes over the past 20-30 years. Perhaps the experts could convene a workshop on what needs to be done on the river. **[Ken Hyde, NPS-GLCA]** This was covered in the NPS's recent non-native aquatic planning efforts. Many of these things were not in place in 2014. Managers have more options now. **[Scott VanderKooi, GCMRC]** What is being asked going forward? Is there a need for a workshop? GCMRC is always interested in improving its methods and meeting its partners' needs. **[Seth Shanahan, SNWA/TWG Chair]** There is no request yet, but Bill is suggesting a workshop. **[Scott VanderKooi, GCMRC]** In terms of temperature control, this has been an issue for decades and where to go for the future is something that management has to decide, not the scientists. **[Seth Shanahan, SNWA/TWG Chair]** The risk has increased from additional habitat warming. What are the thresholds on when to determine to take action? **[David Ward, GCMRC]** Monitoring programs for early detection are good, but biologists are concerned about not having rapid response methods. The temperature tools would be helpful for this. **[Ken Hyde, NPS-GLCA]** In another 25 or 30 feet, a lot more fish are going to come through the penstock especially green sunfish and smallmouth bass. **[Jim Stroger, FFI/TU]** Temperature control devices and fish passage efforts are preventative, while the NPS environmental assessment on brown trout are reactive. We need to be more preventative than reactive. **[Bill Davis, CREDA]** The history of the river system before the dam was 90% channel catfish. **[Seth Shanahan, SNWA/TWG Chair]** There is the longer-term preventative path (because it takes a long time to get things in place), but we have shorter terms such as next year with lower levels in Lake Powell. What if the monitoring program found 3 walleye? Would that be enough to respond? **[David Ward, GCMRC]** That would not be enough as 3 walleye are found all the time; there would be a problem if 300 walleye were found. Pretty informed decisions can be made with the

monitoring data. The real crux is what to do about it. **[Ken Hyde, NPS-GLCA]** NPS can respond to short-term concerns, but it does not have responses to chronic, long-term issues, which is probably not feasible given the costs that would be required. An expert panel or workshop might be helpful. Also still need to know temporal temperatures that are beneficial to non-natives of concern, and to look at tools that would be able to cool water. The bypass is the only one that is probably currently feasible. All these tools need to be assessed. **[Melissa Trammell, NPS]** A cooling temperature control device is preferred. **[Ryan Mann, AZGFD]** In addition to temperature control devices for non-natives, there is also management of the rainbow trout fishery and future projections are pushing the boundaries of allowable habitat for that fishery to exist. **[Larry Stevens, GCWC]** In relation to this five-year planning effort, it is not known whether the minimum pool stage will be met in Lake Powell. In this case, the river would probably return to a pre-dam temperature regime, which was at or exceeded 89 degrees at Lees Ferry during low flow summers. This needs to be included in the worst-case scenarios. **[Kirk Young, USFWS]** If the water has to go through the by-pass tubes, the opposite might be true, making this a cold-water system. **[Seth Shanahan, SNWA/TWG Chair]** Would like the TWG to consider the workshop idea between now and October.

## Discussion of Emerging Issues, Updates on Items of Interest That Are in Consideration for Implementation Before Next TWG Meeting, and Request for Agenda Items for Next Meeting

**[Shane Capron, WAPA]** Given the new study, WAPA expects \$72 million in purchase power costs in water year 2021, and with 7.48 MAF in water year 2022, it is expected to be \$98 million with possibly the same in 2023. Looking at \$77 million in the Basin Fund for FY21. Prices keep getting higher. Brian Sadler will give a presentation on this information at the August AMWG meeting.

**[Larry Stevens, GCWC]** Downstream waters have been clear because of a lack of monsoon rains. Where are we with understanding caddisflies at the lower end and has there been any assessment of the quagga mussel invasion in the main river? **[Ted Kennedy, GCMRC]** GCMRC is working on caddisflies to try to resolve whether those increases were because of bug flows or other factors such as water clarity. GCMRC is doing monitoring in Bright Angel Creek, but that is the only tributary with funding available to look at invertebrates in the side streams. There had been a proposal in the TWP throughout the canyon, but that did not make the final cut. Dave Lytle participated in a river trip in April in which his lab collected samples for e-DNA analysis. They sampled throughout the mainstem, near the mouths of the tributaries and a kilometer upstream. He plans to focus on insect taxa and may also be looking at all the invertebrates, in general. He is leveraging funding with the Department of Defense. This could give insights as to the extent of quagga mussel in the side streams. **[Larry Stevens, GCWC]** There is interest by GCWC in this. **[Seth Shanahan, SNWA/TWG Chair]** The hydrologic forecasting community does a lot of work on this and greater coordination with them could be useful to feed into the ecological models.

**[Leslie James, CREDA]** As a result of the hydrology and market prices, WAPA is also starting a rate review process. This might be posted soon in the Federal Register. Any peak use customers are urged to defer anything that is not considered essential that could impact the Basin Fund. Going into the worst month of the year for utilities. The numbers on the purchase power amounts and impacts to Basin Fund are uncommon and extreme. Everyone is looking closely at how to mitigate those impacts.

**[Ken Hyde, NPS-GLCA]** With the historic low water levels, the Glen Canyon NPS management team is doing everything possible to keep two ramps out of 11 open to the water. It is important to the local economies and to the economies of Utah and Arizona.

**[Kirk Young, USFWS]** We should discuss how the GCDAMP will deal with the effects of climate change. Modeling projections for the Southwest is that it will become hotter and more arid, which means less precipitation. Flexibility to release water from the dam could be seriously compromised in the future and how to manage downstream resources. Perhaps scientists can be invited at the next Annual Reporting Meeting. **[Seth Shanahan, SNWA/TWG Chair]** What was the planning analysis done during the LTEMP? **[Rob Billerbeck, NPS]** Mike Runge and Jim Prairie made sure there were a series of drier climate change runs in the model to ensure that the one chosen performed the best under both regular hydrology scenarios and drier climate change conditions. They could give a more detailed explanation. **[Scott VanderKooi, GCMRC]** There was a recent paper by Kim Dibble and Charles Yackulic that did many of those things that addressed reservoir projections and fish impacts. **[Peter Bungart, Hualapai Tribe]** Some of the underpinnings of LTEMP might be stale given these current projected changes. They might need to be re-evaluated.

**[Kurt Dongoske, Pueblo of Zuni]** Climate change will have a disproportionate impact on indigenous communities. How will the federal government recognize this fact?

**[Ben Reeder, GCRG]** Suggests a presentation by the Colorado Plateau Foundation whose mission is to protect the lands and waters of the Colorado Plateau. They provide funding for tribal initiatives.

**[Craig McGinnis, ADWR]** Suggests continuing the 7.48 MAF discussion because that had been cut short.

**[Helen Fairley, GCMRC]** Maybe there needs to be a special TWG meeting with more discussion and fewer presentations? **[Seth Shanahan, SNWA/TWG Chair]** Perhaps there could be a 2-4-hour informational discussion session by webinar on a topic. These would not be formal TWG meetings. *[Several others agreed to this idea; no one objected.]* **[Mike Moran, GCMRC]** Maybe an Informational Sharing Ad Hoc group could be created, and then someone could take the lead on this. **[Michelle Garrison, CWCB]** If there are more workshops, should they occur just before a TWG meeting or be spread out from the TWG schedule? **[Leslie James, CREDA]** It is very hard to remain engaged when there are two days of the TWG meeting followed by the informational discussion.

## Public Comment

**[Alicyn Gitlin, Sierra Club - Grand Canyon Chapter]** The Sierra Club supports the comment to reanalyze LTEMP in light of climate change. The Sierra Club had made many suggestions on LTEMP that have since come up from other groups, but there has never been a response as to why the Sierra Club's suggestions could not be analyzed (i.e., assess other alternatives, consider more flexibility for spring or summer high flows, slower ramp downs, consider effects of a climate future). Would love to see that document re-analyzed.

**Adjourned at 2:50 PM PDT**

## Attendees

### [TWG Members and Alternates](#)

Jan Balsom, NPS-GRCA  
Cliff Barrett, UMPA  
Peter Bungart, Hualapai Tribe (Alternate)  
Kelly Burke, GCWC (Alternate)  
Shane Capron, WAPA  
William "Bill" Davis, CREDA  
Kurt Dongoske, Pueblo of Zuni  
Craig Ellsworth, WAPA (Alternate)  
Charlie Ferrantelli, State of Wyoming (Alternate)  
Michelle Garrison, CWCB (Vice-chair)  
Jessica Gwinn, USFWS (Alternate)  
Paul Harms, State of New Mexico  
Ken Hyde, NPS-GLCA

#### USGS/GCMRC Staff

Lucas Bair  
Helen Fairley  
Ted Kennedy  
Michael Moran  
Emily Palmquist

#### Reclamation Staff

Tara Ashby  
Alan Butler  
Kathy Callister  
Rick Clayton  
Clarence Fullard

#### Interested Persons

David Alberg, NPS  
Brandon Albrecht, Bio-West  
Richard Begay, Navajo Nation  
Rob Billerbeck, NPS  
Sarah Creachbaum, NPS  
Kevin Dahl, NPCA  
Fred Daniel, Fireflies.ai  
Derek Fryer, WAPA  
Alicyn Gitlin, Sierra Club  
Carlaine Johnson, SeaJay Environmental  
Kristen Johnson, ADWR  
John Jordan, FFI/TU  
Ron Kegerries, Bio-West  
Michelle Kerns, NPS  
Josh Korman, Ecometric

Leslie James, CREDA (Alternate)  
Jakob Maase, Hopi Tribe  
Ryan Mann, AZGFD  
Craig McGinnis, ADWR (Alternate)  
Jessica Neuwerth, CRBC  
Bill Persons, FFI/TU  
Ben Reeder, GCRG  
Peggy Roefer, CRCN (Alternate)  
David Rogowski, AZGFD (Alternate)  
Seth Shanahan, TWG Chair and SNWA  
Larry Stevens, GCWC  
Jim Strogon, FFI/TU  
Kirk Young, USFWS

David Topping  
Scott Vanderkooi  
Mark Wimer  
David Ward  
Michael Yard

Zachary Nelson  
Kerri Pedersen  
Ernie Rheume  
Lee Traynham

McKenna Murray, State of Utah  
Amy Ostdiek, State of Colorado  
Stanley Palmer, Salt Lake Community College  
Justin Pattison, NPS  
Mary Plumb, NPS  
Sara Price, CRCN  
Shana Rapoport, CRBC  
Ted Rampton (no affiliation given)  
Matt Rice, American Rivers  
Gene Seagle, NPS  
William "Billy" Shott, NPS  
Erik Skeie, State of Colorado  
Todd Smith, NPS  
Erik Stanfield, Navajo Nation  
Gary Tallman, Northern Arizona University

Angelika Kurthen, Oregon State University  
Sara Larsen, Upper Colorado River Commission  
Dave Lytle, Oregon State University  
Kevin McAbee, USFWS  
Scott McGettigan, State of Utah  
Betsy Morgan, State of Utah

Brenda Todd, NPS  
Melissa Trammel, NPS  
Jerry Wilhite, WAPA  
Jonathan Winters, NPS  
Mark Wondzell, NPS

### Abbreviations

ADWR - Arizona Department of Water Resources  
AZGFD - Arizona Game and Fish Department  
AHAHG - Administrative History Ad Hoc Group  
AMWG - Adaptive Management Work Group  
BAHG - Budget Ad Hoc Group  
BHA - Benthic & Hyporheic Anoxia  
CFS - cubic feet per second  
CRBC - Colorado River Board of California  
CREDA - Colorado River Energy Distributors Association  
CRCN - Colorado River Commission of Nevada  
CWCB - Colorado Water Conservation Board  
DO - dissolved oxygen  
DROA - Drought Response Operations Agreement  
FFI - Fly Fishers International  
FLAHG - Flow Ad Hoc Group  
FY - fiscal year  
GCDAMP - Glen Canyon Dam Adaptive Management Program  
GCMRC - Grand Canyon Monitoring & Research Center  
GCNP - Grand Canyon National Park  
GCRG - Grand Canyon River Guides

GCWC - Grand Canyon Wildlands Council  
GLCA - Glen Canyon National Recreation Area  
HFE - High Flow Experiment  
LCR - Little Colorado River  
LTEMP - Long-Term Experimental and Management Plan  
MAF - million-acre-feet  
NPS - National Park Service  
PDT - Pacific Daylight Time  
PIT - passive integrated transponder  
Reclamation - Bureau of Reclamation  
SNWA - Southern Nevada Water Authority  
TSC - Technical Service Center  
TU - Trout Unlimited  
TWG - GCDAMP Technical Work Group  
UCRC - Upper Colorado River Commission  
UMPA - Utah Municipal Power Agency  
USFWS - United States Fish & Wildlife Service  
USGS - United States Geological Survey  
WAPA - Western Area Power Administration  
WGC - Western Grand Canyon