“Answering the Most Important Question of 2017……

What is an environmentally sustainable water project?”

Kelly R. Schaeffer, Senior Project Manager and USSD Chair, Committee of Environment and Sustainability
Workshop AM Agenda

- Safety Message
- Workshop Overview & Goals
- Moderated Panel
  - USACE
  - The Nature Conservancy
  - San Francisco Public Utilities
  - Low Impact Hydro Institute
  - Bureau of Reclamation
- What is our definition?
- Lunch
PM Agenda

- 1:15 PM - *Now That We've Defined It, Can We Be Heard By Communicating It?*
- Small Group Exercises
- Wrap Up and Evaluation
Workshop Goals

1) Define
2) Contribute to our understanding
3) Learn through case studies
4) Advance our understanding
   - advocating for sustainable projects;
   - educating stakeholders
   - collaborating with other entities; and
   - cultivating best practices

PRACTICE, PRACTICE, PRACTICE COMMUNICATING IT!
“After all, sustainability means running the global environment - Earth Inc. - like a corporation: with depreciation, amortization and maintenance accounts. In other words, keeping the asset whole, rather than undermining your natural capital”

Maurice Strong
If it can't be reduced, reused, repaired, rebuilt, refurbished, refinished, resold, recycled or composted, then it should be restricted, redesigned or removed from production.

-Pete Seeger
on energy sustainability...

“Sustainability is a popular term in today’s energy and environmental markets, one that conveys a business’s approach to delivering products and services in ways that protect the environment, reduce and reuse natural resources, meet long-term environmental compliance and clean energy objectives and respect community needs and lifestyles.”

George Gantz
SVP - Distributed Energy Resources
Sustainability Principles

- Sustainable development meets needs of the present without compromising the needs of the future to meet their needs.

- Sustainable development embodies reducing poverty, respecting human rights, changing unsustainable patterns of production and consumption, long-term economic viability, protecting and managing the natural resource base, and responsible environmental management.

• Sustainable development calls for **considering synergies and trade-offs amongst economic, social and environmental values**. This balance should be achieved and ensured in a transparent and accountable manner, taking advantage of expanding knowledge, multiple perspectives, and innovation.

• **Social responsibility, transparency, and accountability** are core sustainability principles.

• **Hydropower, developed and managed sustainably, can provide national, regional, and local benefits, and has the potential to play an important role in enabling communities to meet sustainable development objectives.**

PRESENTATION OUTLINE

A. USACE Overview
   A. Evolution and Water Resources Challenges
B. USACE Sustainability Initiatives
   A. Guiding Principles
   B. Past and Ongoing Activities
C. Case Study: Sustainable Rivers Program
D. Q&A
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D. Q&A
EVOLUTION OF THE CORPS OF ENGINEERS

1775: General Washington’s Revolutionary Army

1800

1850

1875

1824: Gibbons v. Ogden

(1824: Supreme Court permits federal gov’t to finance and construct river projects)

1850

1866: Swamp Land Acts

(1849 & 1850: floodplain reclamation)

1900

1936 Flood Control Act

“federalization” of flood control: Dams, levees, & channelization

1950

1986 Water Resources Development Act

2000

Ecosystem Restoration

Flood Control

Navigation

Military Support

1986 Water Resources Development Act

US Army Corps of Engineers
U.S. ARMY CORPS OF ENGINEERS TODAY

1) 33k civilian employees and 800 military personnel
2) More than 700 dams; average age 56 years
3) 75 hydropower plants, incl. 353 generating units (21,000 MW cap.)
4) 14,700 miles of levees in inventory; 2,000 miles O&M
5) 12,000 miles of inland waterways maintained
6) 6.9B gal/day water supply
7) 370 million visits/year at 403 lake and river projects in 43 states
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1) Foster *sustainability as a way of life* throughout the organization.

2) Proactively consider environmental consequences of all Corps activities and act accordingly.

3) Create mutually supporting *economic and environmentally sustainable solutions*.

4) Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the Corps, which may impact human and natural environments.

5) Consider the environment in employing a risk management and systems approach throughout the life cycle of projects and programs.

6) Leverage *scientific, economic, and social knowledge to understand the environmental context and effects* of Corps actions in a collaborative manner.

7) Employ an open, transparent process that respects views of individuals and groups interested in Corps activities.

APPROACH TO A MORE SUSTAINABLE WATER FUTURE, 2010

1) Integrated Water Resources Management
2) Governance and Management
3) Future National Water Resources Direction
4) Collaboration
5) Water Resources Investment Strategies
6) Managing Extreme Events
7) Knowledge & Technology Transfer
8) Water Resources Leadership
9) Communications and Education

Source: USACE, 2010
Title: Sustainable Solutions to America’s Water Resource Needs

Vision: Contribute to the strength of the Nation through innovative and environmentally sustainable solutions to the Nation’s water resources challenges.

Goals:

1) Transform the CW Program to deliver sustainable water resources solutions through IWRM.
2) Improve the safety and resilience of communities and water resources infrastructure.
3) Facilitate the transportation of commercial goods on the Nation’s coastal channels and inland waterways.
4) Restore, protect, and manage aquatic ecosystems to benefit the Nation.
5) Manage the life cycle of water resources infrastructure systems in order to consistently deliver sustainable services.

“Competing water uses must be balanced to provide multiple benefits such as economic security, environmental health, social well-being, and public safety.”
PRIOR/ONGOING USACE SUSTAINABILITY ACTIVITIES

1. Sustainable Project Rating Tool (SPiRiT), 2001
3. Sustainable Rivers Program, 2002 – Present
4. 12 Actions for Change – #6: Focus on Sustainability, 2006 – Present
5. USACE Campaign Plans, 2007 – Present
7. USACE Sustainability Plan (SP), 2010
8. Corps of Engineers Reduced and Abridged FEMP Tool (CRAFT), 2010 – Present
9. Strategic Sustainability Performance Plans (SSPP), 2010 – Present
10. Strategic Sustainability Committee (SSC), Formed 2010
12. CW Strategic Plan 2011-2014: Sustainable Solutions to America’s Water Resources Needs
13. Sustainable Activities Steering Committee (SASC), Formed 2014
PRIOR/ONGOING USACE SUSTAINABILITY ACTIVITIES (CONT’D)

17. A Vision of USACE Sustainability, Under Development
20. Project Sustainable Infrastructure Rating System and Guidance, Under Development
OMB SUSTAINABILITY COMPLIANCE SCORECARD

Energy and water conservation, greenhouse gas emissions, renewable energy use, and other federal sustainability metrics.

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>FY 2016 Target</th>
<th>FY 2018 Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal 1: Greenhouse Gas (GHG) Reduction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scope 1 &amp; 2 GHG Emissions</td>
<td>-21.1%</td>
<td>-14.3%</td>
</tr>
<tr>
<td>Scope 3 GHG Emissions</td>
<td>-7%</td>
<td>-13.3%</td>
</tr>
<tr>
<td><strong>Goal 2: Sustainable Buildings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Intensity</td>
<td>30% CAFB compared to FY 2009 baseline</td>
<td>-20%</td>
</tr>
<tr>
<td>Sustainable Buildings: Energy use intensity by 2025 compared to FY 2009 baseline</td>
<td></td>
<td>15%</td>
</tr>
<tr>
<td><strong>Goal 3: Clean and Renewable Energy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renewable Energy: Achieve 10% renewable energy use, when compared to real FY 2015 electricity use</td>
<td>10%</td>
<td>16.6%</td>
</tr>
<tr>
<td><strong>Goal 4: Water Use Efficiency &amp; Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Intensity: Reduce public sector end use intensity by 20% annually through the end of FY 2020, based on FY 2007 baseline</td>
<td>-14%</td>
<td>-13.7%</td>
</tr>
<tr>
<td><strong>Goal 5: Fleet Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fleet Petroleum Reduction</td>
<td>-20%</td>
<td>-20.1%</td>
</tr>
<tr>
<td>Fleet Alternative Fuel Increase Relative to FY2005: Increase fleet alternative fuel consumption by 10% annually by FY2015, compared to FY2005 baseline</td>
<td>159.4%</td>
<td>13.3%</td>
</tr>
<tr>
<td>Fleet Alternative Fuel Use Relative to Total Fuel: Ensure that at least 5% of all fuel consumption is alternative fuel</td>
<td>1%</td>
<td>1.8%</td>
</tr>
<tr>
<td><strong>Goal 6: Sustainable Acquisition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sustainable Acquisition: Ensure that at least 95% of applicable contracts actions demonstrate compliance with sustainable acquisition goals in EO 13426 (based on a quarterly 5% sample of contracts awarded)</td>
<td>95%</td>
<td>55.6%</td>
</tr>
<tr>
<td><strong>Goal 7: Pollution Prevention and Waste Reduction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid Waste Disposal: Ensure that at least 90% of non-hazardous solid waste is diverted, through recycling, from the landfill</td>
<td>90%</td>
<td>90.4%</td>
</tr>
<tr>
<td>Construction and Demolition (C&amp;D) Waste Disposal: Ensure that at least 50% of C&amp;D waste is diverted, through recycling, from the landfill</td>
<td>50%</td>
<td>50.4%</td>
</tr>
<tr>
<td><strong>Goal 8: Energy Performance Contract</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Performance Contract: Award $113M in energy performance contracts to 31 December 2015</td>
<td>$113M</td>
<td>$115.9M</td>
</tr>
<tr>
<td><strong>Goal 9: Electronic Stewardship and Data Centers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronic Procurement: At least 95% of computers, PCs, and laptops acquired must environmentally sustainable electronic criteria (EPEAT registered)</td>
<td>95%</td>
<td>100%</td>
</tr>
<tr>
<td>Power Management: 100% of computers, laptops, and monitors have power management features enabled</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
HIGH-PERFORMANCE SUSTAINABLE BUILDINGS
(UFC 1-200-02, DEC. 2016)

A. Requirements for new and existing buildings.

B. Energy and water conservation, indoor air quality, consideration of climate change impacts, and other requirements.

C. Widely followed by Military Programs Directorate; less applicable to Civil Works

Source: DoD, 2016
SUSTAINABILITY CONCEPTS AND DEFINITIONS
REFERENCE GUIDE

A. Greater context/depth of understanding of Civil Works sustainability.

B. Inconsistent definitions and interpretations.

C. Varying ideas on how best to become sustainable.

D. Federal mandates narrowly focused on specific metrics (e.g., energy, water, GHG).

Dictionary Definitions:
– **Sustain**: keep up, prolong – Merriam-Webster Dictionary
– **Sustainable**: able to be maintained at a certain rate or level – Oxford Dictionary
– **Sustainable**: able to be maintained or continued – Cambridge Dictionary

**United Nations WCED (1987)**: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

**World Bank (1994)**: “Development is sustainable if it involves a non-decreasing average quality of life”

**Exec. Order 13514 (2009)**: “Sustainability and Sustainable mean to create and maintain conditions, under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations.” (Note E.O. 13693 superceded E.O. 13514 in 2015 and removed these definitions)

**UFC 1-200-02 HPSB Requirements (2016)**: “Sustainable Site: Based on the selection process, a site is considered sustainable when it uses less energy, water, and natural resources, generates less waste, and minimizes the impact on land compared to conventional design,
USACE SUSTAINABILITY BEST PRACTICES MANUAL

A. Inventory and descriptions of best practices.

B. Assists planners, designers, operators, and others in the identification and integration of sustainable practices.

C. Incorporates information from multiple industry sources. Includes references to obtain additional information as needed.
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MAPPING SEASONAL STREAMFLOW PATTERNS ON TO LIFE HISTORIES OF BIOLOGICAL TARGETS DETERMINES ENVIRONMENTAL FLOW REQMTS.

Source: The Audubon Society, 2000
## SUSTAINABLE RIVERS PROJECT (SRP) – ORIGINAL EIGHT SITES

<table>
<thead>
<tr>
<th>Phase of the Process</th>
<th>Example Tasks</th>
<th>Number of Dams</th>
<th>Estimated Affected River Kilometers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Initiating the Process</td>
<td>• Engage stakeholders</td>
<td>5</td>
<td>703</td>
</tr>
<tr>
<td></td>
<td>• Orientation meeting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Defining Environmental Flows</td>
<td>• Science summary</td>
<td>20</td>
<td>1,271</td>
</tr>
<tr>
<td></td>
<td>• Expert workshop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Implementing Environmental Flows</td>
<td>• Modeling (ResSim, HEC-RAS)</td>
<td>10</td>
<td>805</td>
</tr>
<tr>
<td></td>
<td>• Test changes in dam operations</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Monitoring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Adaptively Managing Dams</td>
<td>• Revising water control plan</td>
<td>1</td>
<td>189</td>
</tr>
<tr>
<td></td>
<td>• Monitoring</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Periodic review</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td><strong>36</strong></td>
<td><strong>2,968</strong></td>
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Ohio River Basin (84 USACE reservoirs). Secured division agreement to advance basin-scale e-flows through adaptive operations. States engaged. Basin-wide opportunity assessment conducted.

Secured division agreement to advance basin-scale e-flows through adaptive operations. States engaged. Basin-wide opportunity assessment conducted.
### SUSTAINABLE RIVERS PROJECT (SRP) – PROJECT EXPANSION

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<td>189</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td>36 62</td>
<td>2,968 5,112</td>
</tr>
</tbody>
</table>

**SRP Program Leads:**
USACE: John Hickey, john.hickey@usace.army.mil
TNC: Tara Moberg, tmoberg@tnc.org
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QUESTIONS?

For additional information, please contact:

- Christian Manalo, M.S., P.E., DEE, USACE Headquarters, Engineering & Construction Division, Booz Allen Hamilton, christian.j.manalo@usace.army.mil

- Kathleen White, Ph.D., P.E., USACE Headquarters, Engineering & Construction Division, kathleen.d.white@usace.army.mil
2017 U.S. Society on Dams Annual Meeting
April 6th Sustainability Workshop

Tara Moberg, Freshwater Science and Policy Advisor
Alva B. Adams Tunnel

1942 – U.S. Bureau of Reclamation Archives
Mission
conserve the lands and waters
on which all life depends

Vision
a world where the diversity of
life thrives, and people act to
conserve nature for its own
sake and its ability to fulfill our
needs and enrich our lives.
The Penobscot River Restoration Project
The Penobscot River Restoration Project

Map: Penobscot River Restoration Trust
The Penobscot River Restoration Project

Map: Penobscot River Restoration Trust
Green River, Kentucky - Sustainable Rivers Project
Green River, Kentucky - Sustainable Rivers Project
Green River, Kentucky - Sustainable Rivers Project

October 2016
Green River, Kentucky - Sustainable Rivers Project

April 2017
Green River, Kentucky - Sustainable Rivers Project
<table>
<thead>
<tr>
<th>Environmental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downstream Flow Regimes</td>
</tr>
<tr>
<td>Erosion and Sedimentation</td>
</tr>
<tr>
<td>Water Quality</td>
</tr>
<tr>
<td>Biodiversity and Invasive Species</td>
</tr>
<tr>
<td>Social</td>
</tr>
<tr>
<td>Resettlement</td>
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<tr>
<td>Indigenous Peoples</td>
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<tr>
<td>Public Health</td>
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<tr>
<td>Cultural Heritage</td>
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<tr>
<td>Technical</td>
</tr>
<tr>
<td>Siting and Design</td>
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<tr>
<td>Hydrological Resource</td>
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<tr>
<td>Infrastructure Safety</td>
</tr>
<tr>
<td>Asset Reliability and Efficiency</td>
</tr>
<tr>
<td>Economic / Financial</td>
</tr>
<tr>
<td>Financial Viability</td>
</tr>
<tr>
<td>Economic Viability</td>
</tr>
<tr>
<td>Project Benefits</td>
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<tr>
<td>Procurement</td>
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<tr>
<td>Cross-cutting</td>
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<tr>
<td>Climate Change</td>
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<tr>
<td>Human Rights</td>
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<tr>
<td>Gender</td>
</tr>
<tr>
<td>Livelihoods</td>
</tr>
</tbody>
</table>
Hydropower Sustainability Assessment Protocol

Planning–Design–Construction–Operation–Maintenance–Decommissioning
Thank you

Tara Moberg, Freshwater Science and Policy Advisor
tmoberg@tnc.org
WATER SYSTEM IMPROVEMENT PROGRAM

Rebuilding Today for a Better Tomorrow

Daniel L. Wade
WSIP Director
Hetch Hetchy Regional Water System

Service Area
Why Fix The System?
END OF USEFUL LIFE

LACK OF REDUNDANCY
3 Major Earthquake Faults
It’s not “If” but “When”

San Francisco 1906

Hayward 1868

Loma Prieta 1989
**Water System Improvement Program**

- 87 Projects
  - 2 dams
  - 3 tunnels
  - 3 treatment facilities
  - Pipelines, pump stations, reservoirs, tanks, etc.
  - Bioregional Habitat Restoration (BHR) Sites
- 7 Counties
- $4.8 Billion
- 2019 Completion
OUR GOALS

• Seismic Reliability
• Delivery Reliability
• Water Quality
• Water Supply
• Environmentally Sustainable
A (Very) Public Program

With Many Stakeholders

Governmental/Regulatory Agencies

Special Interest Groups

Labor/Contractor

Elected Officials

Oversight Bodies

Impacted Communities

Wholesale/Retail Customers
**Environmental Strategy**

- **Commitment and stewardship**
- **Pre-Construction**
  - Avoidance of Impacts
  - Minimization of Impacts
  - Mitigation of Impacts
- **Construction**
  - BMPs
  - Training
  - Monitoring / Reporting
- **Operations**
  - Adaptive Management
PROGRAM TRANSPARENCY

Transparency + Accountability = Public Trust

- Reaching out to stakeholders
- Accountability to oversight bodies
- Reviews by independent panels
- Extensive reporting
- WSIP Website (sfwater.org/wsip)
- Use of social media
Calaveras Dam

• 1918 Dam Almost Completed
• 1918 Dam Failure
• 1925 Completion
**Scope of Work**

- Replacement Dam
- Spillway
- Stilling Basin
- Intake/Outlet Works
- Borrow Areas
- Disposal Sites
- Haul Road
- Staging Areas
- Fish Passage
- Habitat Restoration
Start of Embankment Dam Construction
PROTECTION OF SPECIAL STATUS SPECIES
Upper Alameda Creek

Lower Alameda Creek
STEELHEAD RESTORATION APPROACH

– Alameda Creek Fisheries Restoration Workgroup Established (multiple agencies MOU in 2006)

– Sunol and Niles Dams removed (October 2006)

– Fish Passage Studies on other man-made barriers, natural barriers and critical riffles

– Alameda Watershed Habitat Conservation Plan

– Calaveras Dam Replacement Project
Bioregional Habitat Restoration (BHR)
BHR Training Program
WHAT IS ONEWATER?

“One Water is an integrated planning and implementation approach to managing finite water resources for long-term resiliency and reliability, meeting both community and ecosystem needs.”

Benefits of OneWater

- Provides greater resilience and reliability
- Opportunities to optimize water infrastructure
- Addresses climate change, water shortages, water quality protection, and aging infrastructure challenges
- Encourages programs and projects that provide multiple benefits
Optimize the use of our finite water and energy resources to balance community and ecosystem needs, creating a more resilient and reliable future.

OneWaterSF

A Vision for San Francisco
**OneWaterSF Guiding Principles**

1. Match the right resource to the right use.

2. Look holistically at water, wastewater, and power systems to develop projects that provide multiple benefits.

3. Plan for variable outcomes and be flexible to adapt to future changes.

4. Develop projects that conserve resources and promote ecosystem health.

5. Work across traditional boundaries to foster collaboration that results in the efficient use of water, wastewater, energy, and financial resources.

6. Engage communities to foster awareness around OneWaterSF.

7. Pursue partnerships with other agencies, the private sector, and other stakeholders to generate new and creative ideas.

8. Pilot state-of-the-art technologies, and test new approaches to develop new business practices.
PRODUCING FIT FOR PURPOSE WATER
Realizing the Water Supply Benefits of Daylighting a Historic Creek

- Showcase new technologies in stormwater management and non-potable reuse at McLaren Park
- Establish the SFPUC’s first creek daylighting project in San Francisco
- Reuse stormwater for irrigation of the creek bed and soccer field at McLaren Park
KEYS TO SUCCESSFUL & SUSTAINABLE PROJECTS & PROGRAMS

• Visionary leadership
• Clearly defined needs and accepted goals
• Encourage “out of the box” strategies to incorporate sustainable elements
• Thoughtful implementation strategies
• Strong and diversified staff
• Communication and collaboration across traditional organizational boundaries
• Transparency & accountability
• Trust of stakeholders
Agenda

• Overview of LIHI
• Definition of Low-Impact
• Assessment of Projects
• Example: Skagit Hydropower Project
The Low Impact Hydropower Institute

Problem Statement: Accepting that hydropower is an important source of renewable energy, how do we encourage decisions that result in improved and effective stewardship that increases healthy river habitats?
Hydropower is complex
River ecosystems are complex
“Low-impact” is reflectively comprehensive
Eligibility:

• The dam has not been recommended for removal
• The dam or diversion was in place in 1998
• New facilities at existing dams did not result in worsened habitat conditions
• Must be located in the US
• Cannot be pumped storage, marine or hydrokinetic technologies
Definition of Low Impact

- **Water quality** supportive of fish & wildlife resources and human uses
- Safe, timely & effective **upstream and downstream fish passage**
- Protection, mitigation & enhancement of the soils, vegetation, & ecosystem functions in the **watershed**
- **Ecological flow regimes** that support healthy habitats
- Protection of **threatened and endangered species**
- Avoidance of impacts on **cultural and historic resources**
- **Recreation access** is provided without fee or charge
An applicant uses an appropriate standard to demonstrate they meet the goal of each criterion.
Assessment of Projects

Goals

Each Criterion has an accompanying clearly stated goal:

Criterion C – Upstream Fish Passage

Goal: The facility allows for the safe, timely, and effective upstream passage of migratory fish. This criterion is intended to ensure that migratory species can successfully complete their life cycles and maintain healthy, sustainable fish and wildlife resources in areas affected by the facility.
Assessment of Projects

The method by which an applicant demonstrates adherence with the goal of each criterion

- Not Applicable/De Minimis
- Agency Recommendation
- Site-Specific Studies
- Best practices/Best Available Technology
- Acceptable Mitigation
- Enforceable Protection
- Recovery Planning and Action (Threatened and Endangered Species)
- Approved Plans (Cultural and Historic Resources)
- Assured Accessibility and Use (Recreation)
**Assessment of Projects**

**Zones of Effect** – ensure all criteria are satisfied in all areas affected by a project
Example: Skagit Hydroelectric Project

Owner: Seattle City Light
FERC Lic: 553
LIHI Cert: #5 – 2008
Size: 689.94 MW
Facilities: 3
River: Skagit River
River miles: 33

Example: Skagit Hydroelectric Project

Flows

• Project provides flows that adequately protect fish species
• Have made voluntary changes to flow regime in response to concerns that the high flows window was too narrow
• Agency staff were satisfied with the project’s flow management
• Salmon returns have consistently increased during new flow regimes
Water Quality

• No 401 WQC yet project waters have a Class AA designation (“Extraordinary”)
• Settlement allows for one bypass reach to have higher temperatures because of its lower quality habitat and in order to ensure financial viability of flow regime supportive of higher quality habitat
Example: Skagit Hydroelectric Project

Fish Passage and Protection

• Natural barriers and low quality habitat exist at lowest of three dams
• No fish passage was required or recommended
• Flows were focus for supporting anadromous fisheries

Photo: pixnio.com; Chinook Salmon;
Example: Skagit Hydroelectric Project

**Watershed Protection**

- Within and adjacent to three national or state parks
- Skagit River is a federal wild and scenic river
- $17MM in land acquisition for habitat manipulation and enhancement
  - By 2008, lands totaling 5x the size of the project were conserved
- “Above and beyond”

Photo: Seattle City Light Website
Example: Skagit Hydroelectric Project

Threatened and Endangered Species Protection

- Active and fully supportive in recovery plans
- Project “not likely to affect” listed terrestrial species
- Aquatic species populations have remained stable or improved
- Sponsoring joint migrational study with Canada
Example: Skagit Hydroelectric Project

Cultural and Historic Resource Protection

- Meeting all protections outlined in settlement

Recreation

- Provides funding and support for visitor serving facilities far beyond project boundaries

Photo: Seattle City Light Website
Example: Skagit Hydroelectric Project
Thank you

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Reservoir Sedimentation and Sustainability

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Sedimentation and River Hydraulics Group
Dam and Reservoir Benefits

- Benefits of dams and reservoirs:
  - Water storage for irrigation, municipal, and industrial use
  - Flood risk reduction
  - Navigation
  - Recreation
  - Hydroelectric power
All Rivers Naturally Transport Sediment

- Clay
- Silt
- Sand
- Gravel
- Cobble
- Boulder
Sediment Balance

- Initial stable river profile
Sediment Balance

- Reservoirs can disrupt sediment transport

- Sediment Design Life (typically 50 or 100 years) sets the outlet works intake elevation above the stream bed
Sediment Imbalance

- Reservoir sedimentation
- Sediment Design Life reached
Sediment Imbalance

• Upstream aggradation

• Downstream degradation
Reservoir Sedimentation

- **Delta deposits**
- **Pre-dam alluvium or bedrock**
- **Bedrock**

**Pool el.**

**Buried outlet**
Reducions in Global Reservoir Storage

Global Storage (billions m$^3$)

Global Storage per Person (m$^3$/capita)

Global Storage (billions m$^3$):

- Original Storage
- Net Total Storage
- Net Per Capita Storage

Global Storage per Person (m$^3$/capita):

- Horizontal line (Red) represents
- Dotted line (Red) represents

Timeline:

- 1940
- 1950
- 1960
- 1970
- 1980
- 1990
- 2000
- 2010
- 2020

George Annandale, 2013
Effects of Reservoir Sedimentation

- Reduction in water storage capacity

Matilija Dam, California

Paonia Reservoir, CO

Japan

Taiwan
Effects of Reservoir Sedimentation

- Bury dam outlets, water intakes, boat ramps, and marinas
Paonia Dam and Reservoir, CO

70 ft

July 1961

See Sean Kimbrel’s talk on Wednesday, Session 5B
Effects of Reservoir Sedimentation

- Reduce the surface area for recreation
- Impair boat navigation
Effects of Reservoir Sedimentation

- Sand or gravel is very abrasive to dam outlets, turbines, and spillways
Effects of Reservoir Sedimentation

- Reservoir deltas propagate over time toward the dam and the upstream river channel. Ground water elevations and flood stage increase, which may affect upstream infrastructure and property.
Effects of Reservoir Sedimentation

• Clear water releases from the dam can lead to erosion of the downstream channel, the impairment of habitat for fish and wildlife, and a reduction of sediment delivered to coastal deltas.
Potential Dam Safety Concerns

- Reservoir Sedimentation generally begins as an Operation and Maintenance Problem
- However, if neglected, sedimentation can become a dam safety problem
  - Reduced flood storage capacity
  - Plugging of intakes
  - Abrasion of outlets and spillways
  - Increased loading on concrete dams
Long Term Outlook

• Population and water demand will increase over time while reservoir storage capacity reduces due to sedimentation.

• In some regions, climate change may lead to increased hydrologic variability.
  – Droughts reduce water supply reliability
  – Floods refill reservoirs with water, but also sediment and at an accelerated rate
In the United States, reservoirs are functioning as originally authorized and designed, which also means they trap sediment.

Decision makers likely are not aware that the numerous benefits provided by the nation’s reservoirs are not sustainable over the long term without sediment management.
Old Best Management Practice

• NO ACTION, let the reservoir eventually fill with sediment (hopefully before you retire).
• INTERGENERATIONAL INEQUITY
  – 1\textsuperscript{st} generation conceives, plans, designs, and constructs a dam and reservoir.
  – 2\textsuperscript{nd} generation starts receiving benefits, repays capital costs, and pays O&M costs.
  – 3\textsuperscript{rd} or 4\textsuperscript{th} generation pays O&M costs, but not for sediment management.
  – Last generation is stuck with retirement bill and has to develop water storage elsewhere at a higher cost.
Sediment Design Life

- Planning, Design, Construction Costs
- O&M Costs
- Sediment Management Costs
- Project Benefits

Sediment Life Cycle

- Planning, Design, Construction Costs
- O&M Costs
- Sediment Management Costs
- Project Benefits

Costs and Benefits
Typically, reservoir sediment can’t be seen from the dam.
Lake Mills
2009

Delta

Glines Canyon Dam
Need for Monitoring

• The first obvious signs of a sediment problem may be the plugging of a dam outlet or reservoir water intake with wood and sediment.

• Reservoir surveys are periodically needed to monitor & forecast problems and avoid crisis management.
Reservoir Surveys

- Survey costs have substantially decreased over past few decades while the quantity of data has dramatically increased.
  - Survey-grade GPS
  - Multi-beam depth sounders
  - Less personnel

Lake Mead and Hoover Dam
Subcommittee on Sedimentation

- Composed of Federal agencies, NGO’s, and university research organizations
- Working to compile information and educate decision makers and the public
U.S. Secretary of the Interior

Assistant Secretary for Water and Science

Advisory Committee on Water Information

Subcommittee on Sedimentation (SOS) and Subcommittee on Hydrology (SOH)
Subcommittee on Sedimentation Activities

- Resolutions
- National reservoir sedimentation information (RSI) database
- National Reservoir Sedimentation and Sustainability Team
- Dam removal guidelines
Resolution on Reservoir Sedimentation and Sustainability

- The SOS encourages all Federal agencies to develop long-term reservoir sediment-management plans for the reservoirs that they own or manage by 2030. These management plans should include either the implementation of sustainable sediment-management practices or eventual retirement of the reservoir.
SOS National Reservoir Sedimentation and Sustainability Team

- Volunteers from agencies, universities, and consultants
- The team provides:
  - Short courses (in person and webinars)
  - Frequently asked questions
  - Encourage reservoir sediment surveys and national reservoir sedimentation database
  - Formulation of a white paper
New Reservoir Construction

Onstream Reservoir
- All floodwater passes through onstream storage, trapping sediment

Offstream Reservoir
- Only a small percent of the flood is diverted to storage
- Sediment-laden flood water bypasses storage pool

RECLAMATION
Reservoir Sustainability Solutions

• Reduction of sediment loads reaching the reservoir (watershed management)
• Prevention of sediment deposition within the reservoir (sediment bypassing or sluicing).
• Removal of sediments already deposited in the reservoir (drawdown flushing, dredging, or excavation), or a combination of these strategies
Reduction of sediment loads

• Reduce the sediment yield entering a reservoir:
  – Prevent landslides
  – Reduce soil erosion
  – Reduce stream-bank erosion
  – Capture sediment loads before they reach the reservoir
Prevention of sediment deposition

• Venting of turbidity currents through a low-level outlet in the dam
• Reservoir drawdown and sediment sluicing
• Bypassing sediments through a tunnel around the reservoir during periods of high concentration
Removal of Reservoir Sediments

- Flushing sediments near the dam outlet
- Emptying the reservoir to allow river erosion
Removal of Reservoir Sediments

• Mechanical or hydraulic dredging or dry excavation
  – slurry pipeline, truck transport, or conveyor belt
  – discharged into the downstream river channel or to a disposal site
  – Beneficial use of sediments
Sediment Continuity

- Sediments passed through a reservoir may slow, stop, or reverse channel erosion and degradation.
- Sediment deposition may be acceptable so long as there is not unmitigated harm to people, property, or native species.
Some endangered fish evolved under high sediment concentrations and used turbidity as cover from predators.

• Endangered Humpback Chub
Sediment Management Strategy

• Focus on controlling future sedimentation rather than past sedimentation
• Control sedimentation each year
• Don’t overload the downstream sediment transport capacity
• Downstream passage of sediment may help native species, but harm introduced species.
Conclusions

• Monitoring is now more important because most reservoirs are in the 2\textsuperscript{nd} half of their sediment-design life.

• A decade or more may be needed to plan and implement sustainable sediment management plans

• No action will lead to the eventual retirement of the dam and reservoir.
Conclusions

• The cost and impacts of reservoir sediment management need to be compared against the eventual costs of retiring the reservoir and the cost of constructing additional water storage elsewhere.

• Future generations should be considered when choosing a reservoir sediment management plan.
Conclusions

• Sustainable reservoir sediment management may harm introduced sport fisheries, but those fisheries cannot be sustained over the long term.

• Releasing sediments at a point downstream of valuable fisheries may be a method to avoid impacts.
Sustainable sediment management in reservoirs and regulated rivers: Experiences from five continents

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Abstract By trapping sediment in reservoirs, dams interrupt the continuity of sediment transport through rivers, resulting in loss of reservoir storage and reduced usable life, and depriving downstream reaches of sediments essential for channel form and aquatic habitat. With the acceleration of new dam construction, there is a need to understand and manage reservoir sediments.
Example: Paonia Dam
Site Map

- Located in Western Colorado on Muddy Creek
  - Snowmelt with Summer T-Storms
- Drains from South Facing Lower Elevation Mountains with Landslides
Dam Facts

• Reservoir Volume
  – 1962 – 20,950 AF (26x10^6 m^3)
  – 2002 – 15,980 AF (20x10^6 m^3)
• Drainage Area = 255 mi^2 (660 km^2)
• Mean Annual Rainfall = 8.14 in
• Avg. Annual Sed. Rate = 104 AF (14.8 x 10^4 m^3)
• Res Cap/ Mean annual flow = 0.16
Dam Facts

- Zoned Earthfill Embankment
- Dam Height – 199 ft
- Dam Completed – 1962
- Outlet Works (cap. 1,130 ft³/s)
  - Right Abutment
  - Square Intake Tower (60 ft)
  - Tunnel
  - Twin HP Gates (2.75 ft x 2.75 ft)
- Spillway (cap. 12,600 ft³/s)
  - Uncontrolled Ogee Crest and Open Chute
- Common Outlet/Spillway Stilling Basin
Project Goals

• Outlet Works Rehabilitation
  – Repair the damaged intake structure
  – Modify the outlet works to allow for full range of operations

• Sediment Management
  – Maintain water supply for users
  – Minimize reservoir storage loss
  – Manage inflowing debris
  – Minimize abrasion
  – Minimize downstream impacts
Paonia Dam
Paonia Dam
Paonia Dam
Paonia Dam
Paonia Dam
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Paonia Dam
Paonia Dam
Paonia Dam
Paonia Dam
Potential Alternatives

- Sluicing (approximately 80% efficiency)
  - New Intake
  - Modify Existing Intake
    - Additional Intake with Lower Sill Elevation
    - Low Level Gate and Re-open Bypass
    - Modification to Facilitate Debris Management
  - Gated Tunnel Bypass
  - Sluiceway (Multiple Elevations?)
  - Construction Methods
    - New intake near delta interface
    - New intake 5-10 feet below current intake
    - New intake 70 feet below current intake
Potential Alternatives

• Additional Alternatives
  – Upstream Sediment Traps/Check Dams
  – Dredging
  – Hydrosuction
  – Dam Raise
    • Raise Spillway Crest
  – Excavation in the Dry
  – Selective Excavation to Facilitate Sediment Erosion
  – Upstream Watershed Management (Upstream Landslides)
  – Downstream modifications to reduce impacts (sediment traps, etc.)
Project Constraints

- Limited access
- Limited land
- Limited construction season
- Limited budget
- Permitting
- Normal operations
  - Maintain Irrigation Storage During Construction
The End

Thank You
References

References (cont.)

Exercise #1

- Having selected one example from the panel presentations in the morning session, we have been told that a CNN news crew is in the front lobby of the hotel and wants to give us 20 seconds of airtime within which we need to describe an environmentally sustainable dam or levee project in the context of the one example used from the morning.

- Each group needs to write the 20-second script [35 words] for Gene to use with the news crew. You have 15 minutes to write the script, then each group posts and reports its results.
Exercise #2

• Having selected one example from the panel presentations in the morning session, we need to post a Tweet in the USSD Twitter account that, within 140 characters, describes an environmentally sustainable dam or levee project in the context of the one example used from the morning. Each group needs to write a 140 character tweet [without a link to other material]. You have 15 minutes to write the tweet, then each group posts and reports its results.
Exercise #3

• We have been invited to present testimony before the House Energy and Commerce Committee on the subject of what environmentally sustainable dam or levee projects are, and how policy makers should shape legislation providing direction to Executive Branch agencies and the private sector for how to incorporate best practices that lead to environmentally sustainable dam and levee projects.

• We have three [3] minutes for introductory remarks to the committee, or about 390 words.

• Each group needs to write the 390 words and be prepared to deliver the introductory remarks for critique by the other groups. **You have 20 minutes to write the 390 words and be prepared to deliver the presentation to the other groups.** The groups will rank order the quality of the other presentations as we work toward selecting what we collectively believe is the best three [3] minute presentation of this issue.