Federal Hydropower – Corps and Reclamation

June 21, 2016

Agenda

Introductions

FCRPS Hydropower Program Overview

Capital Investment Review

- Identifying investment needs
- Hydro investment strategy
- Capital program improvements

Integrated Program Review

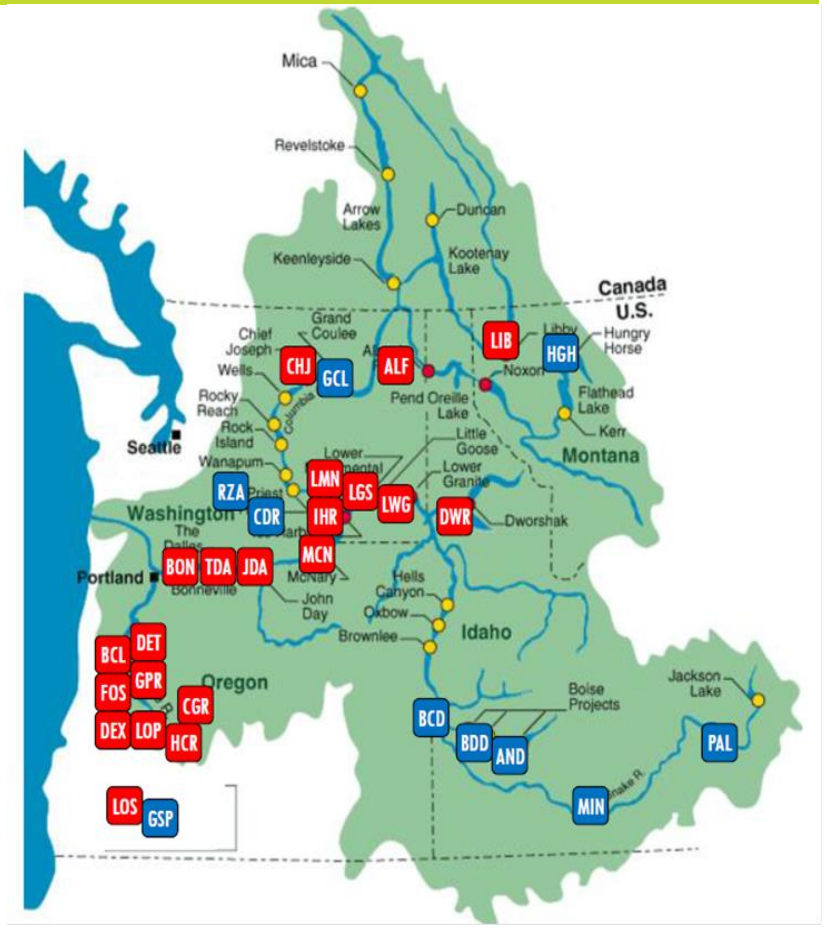
- O&M program spending drivers
- Corps & Reclamation O&M program funding levels
- FCRPS cultural resources (Corps and Reclamation)
- CORPS Fish and Wildlife O&M
- Reclamation Leavenworth hatchery facilities
- CORPS Columbia River Fish Mitigation (CRFM)

System overview

The Federal Columbia River Power System is a partnership between the US Army Corps of Engineers, the US Bureau of Reclamation and the Bonneville Power Administration.

- 31 powerplants (21 Corps, 10 Reclamation)
- 22,060 megawatt capacity
- 196 generating units
- 76,000 gigawatt hours of electricity per year
  - $1.9 billion value at 5-year Mid-C market index average
- Displaces fossil-fired generation that would result in emissions in excess 40 million tons of carbon dioxide per year
  - $1.4 billion benefit based on the Environmental Protection Agency's social cost of carbon.

The FCRPS also provides balancing and voltage support as well as the protection, mitigation and enhancement of fish and wildlife.



Program description and objectives

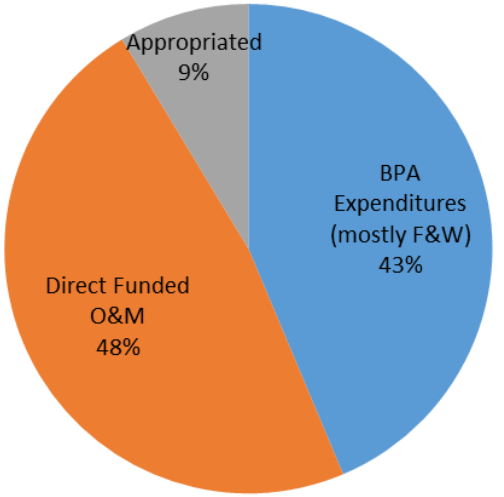
- Program description:
  - U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration work together to provide and implement funding for capital investments, operations and maintenance activities, non-routine extraordinary maintenance projects, and Fish and Wildlife and Cultural Resources mitigation activities at 31 hydroelectric facilities throughout the Northwest.
- BPA priorities supported:
  - Physical Assets
  - Sustainable Finance & Rates
  - Reliable, Efficient, & Flexible Operations
  - The Natural Environment

Key products and outputs

- 8,800 average megawatts of generation provided to the Northwest valued at nearly $2 billion.
- Reliable generation and transmission system performance through voluntary compliance with WECC/NERC reliability standards.
- Safe work environments with a focus on safety at the generating facilities (i.e. complying with new standards for arc flash, lockout/tagout, hydraulic steel structure inspections, asbestos, emergency management systems, etc.).
- Compliance with biological requirements for fish passage and clean water, and cultural resources section 106 requirements.
- Avoidance/minimization of CO_2 emissions.
- Support for the integration of wind and renewables.

FCRPS cost benchmarking

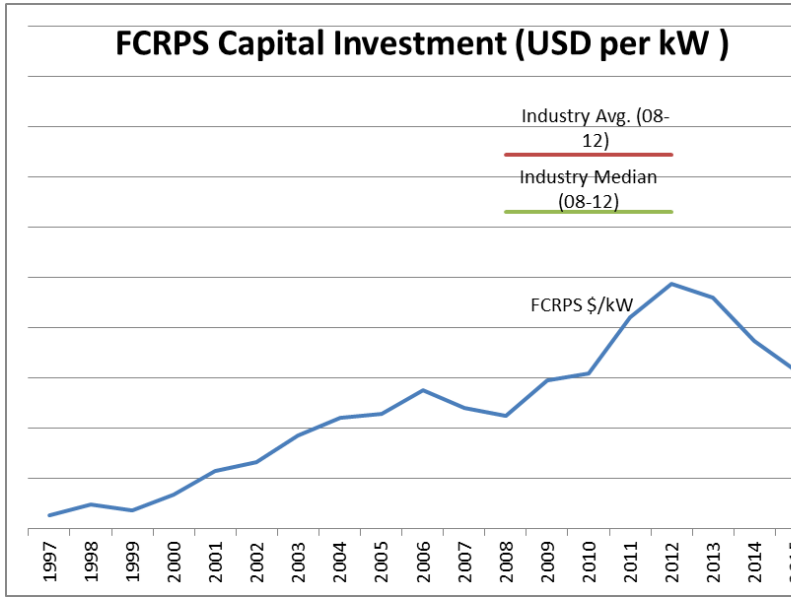
- The FCRPS benchmarks its hydro program annually through the Electric Utility Cost Group (EUCG) in order to identify best practices and potential for improvement.
- Costs benchmarked include Corps and Reclamation costs for hydropower, recreation, cultural resources, fish & wildlife mitigation and joint-use purposes; Bonneville costs for generation planning, asset management and fish & wildlife mitigation are also included.
- Because direct funding program costs are only a subset of all costs benchmarked, one-to-one comparisons cannot be made between the direct funded hydro program and the benchmarks.
- But the results do provide useful information on large-scale trends in the hydro industry and context for FCRPS program levels.
- Reclamation was previously benchmarking through Navigant Consulting, and will be switching to EUCG in FY 2016.

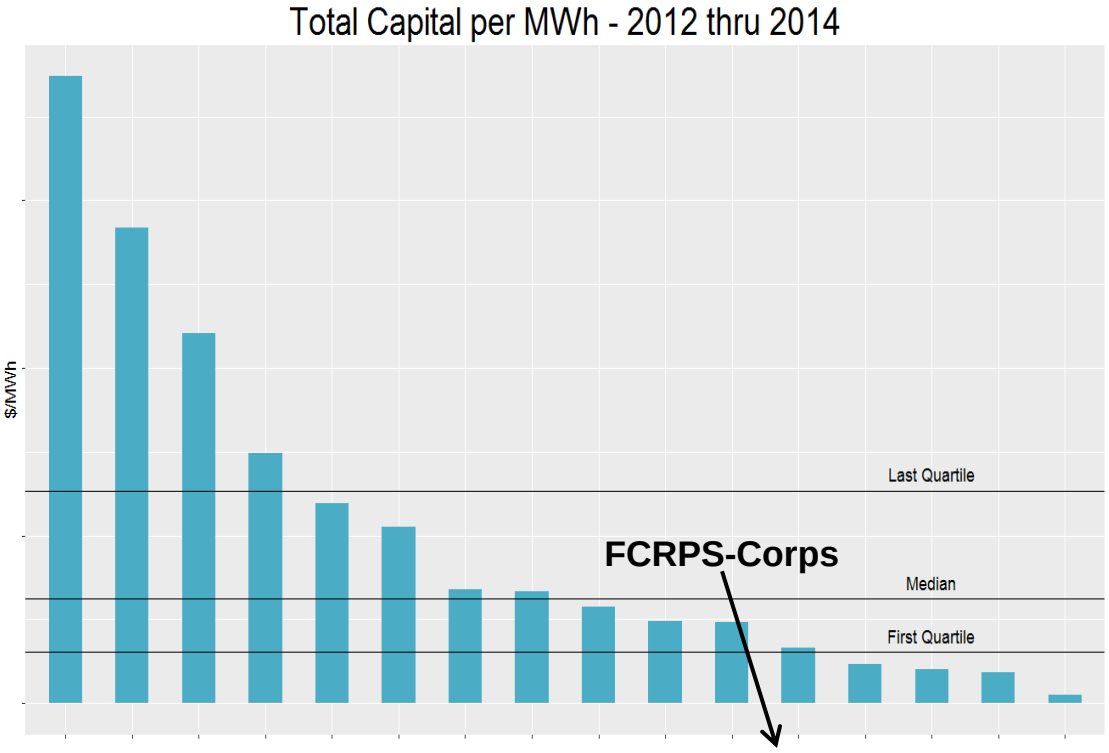


FCRPS Benchmarking Cost Distribution

FCRPS cost benchmarking

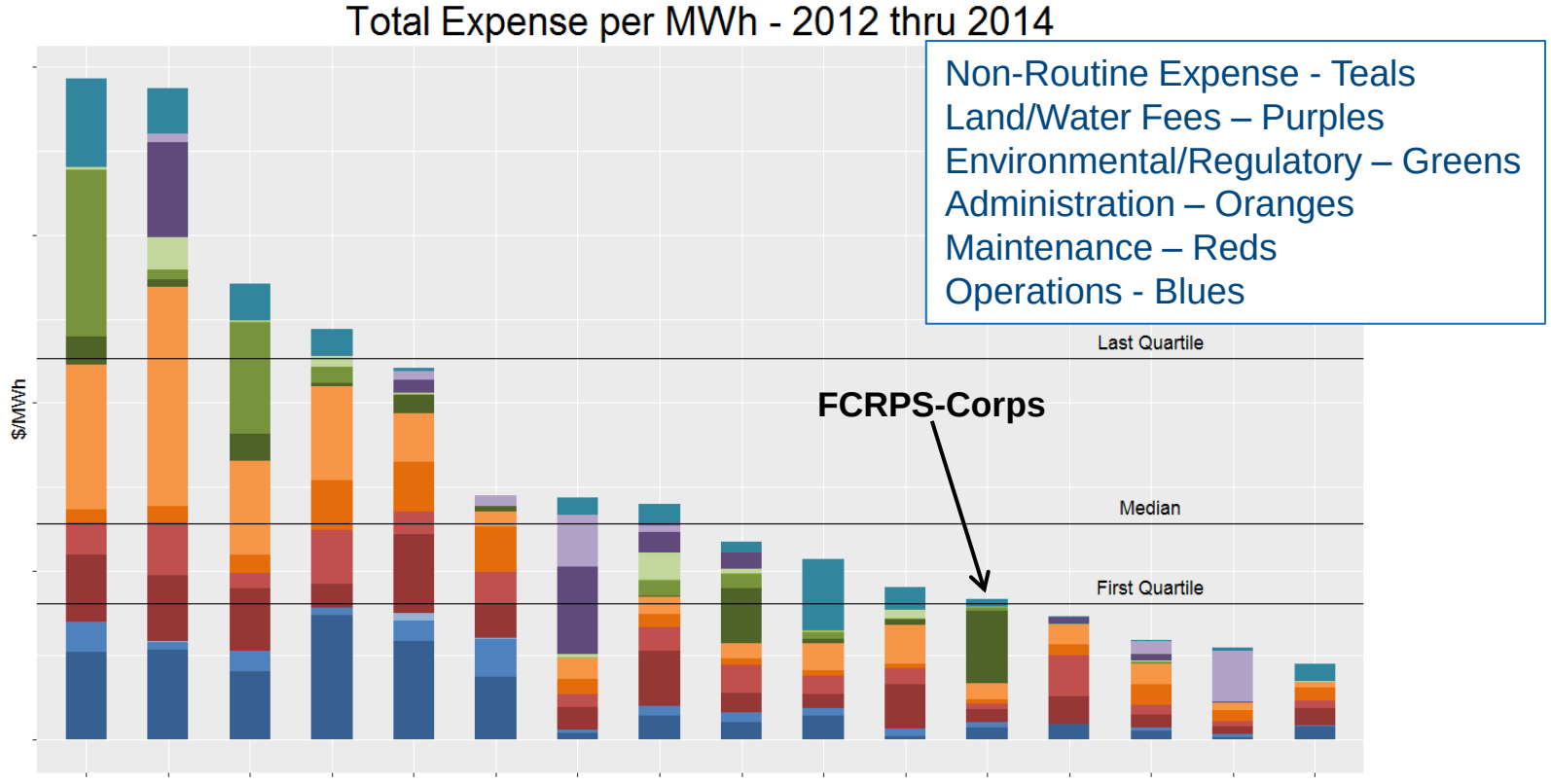
- Of the 16 North American utilities in EUCG (representing over 64,000 MW in capacity), the Corps plants in the FCRPS have spent the 5th lowest amount in capital investment per MWh.
- This was at the peak investment level of the FCRPS capital program in fiscal years 2012 – 2014.





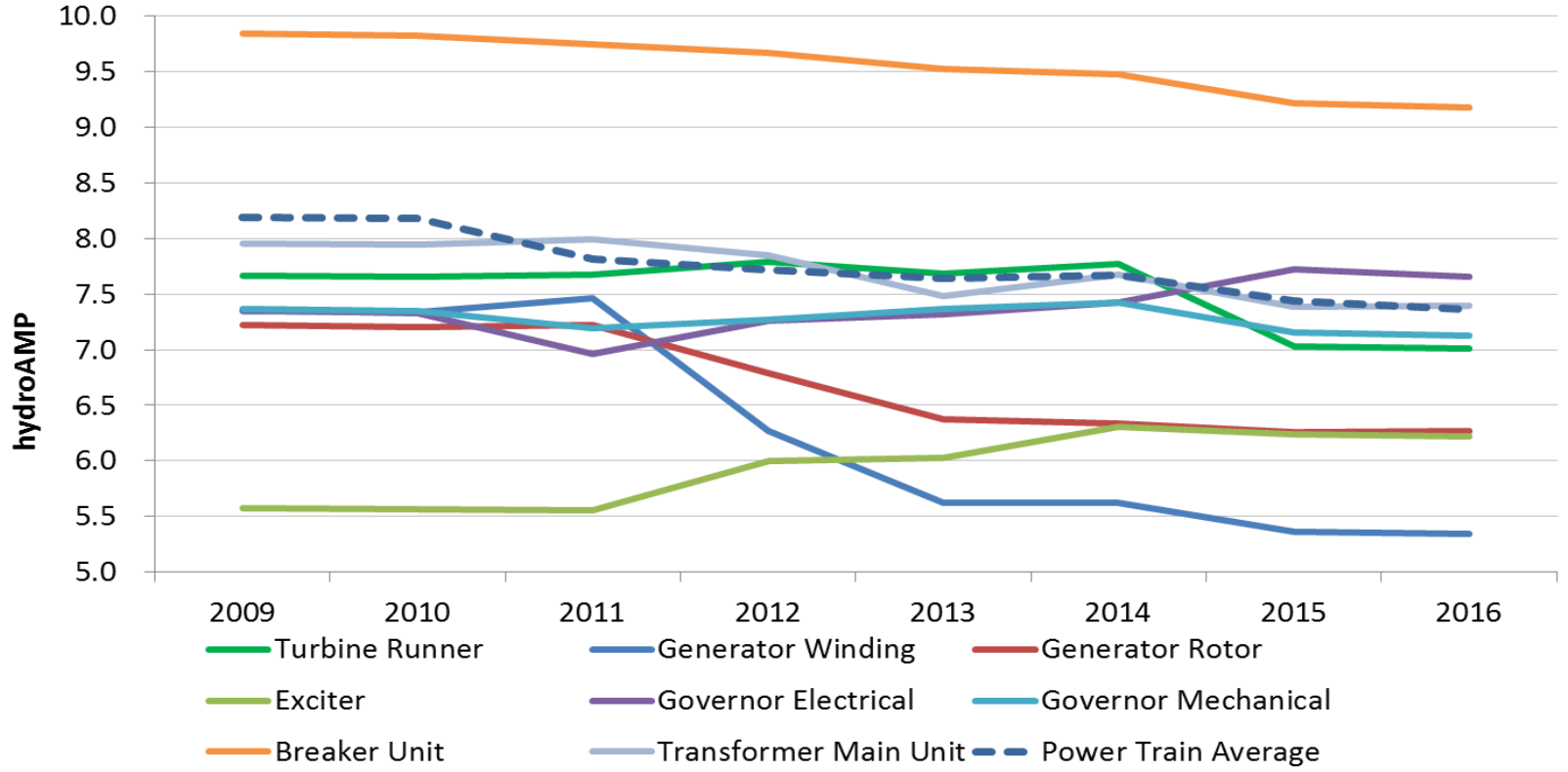
FCRPS cost benchmarking

- Of those same 16 utilities, the Corps plants in the FCRPS have also spent the 5th lowest amount in total O&M expenses per MWh.
- When environmental, regulatory, fees and non-routine costs are not considered, the Corps is 2nd lowest in routine operations, maintenance and administration costs.



Trend of condition rating (2009-2016)

The megawatt weighted average condition for the system has declined from 7.7 to 7.4 over the past five years. The components in the best overall condition are unit breakers which have recently undergone a system-wide replacement program. The condition of generator windings declined significantly since 2011, in part due to a change in the condition indicator weighting algorithm which placed more emphasis on age, but also due to other factors at several plants, including Grand Coulee and more recently, John Day. Turbines and main unit transformers have also experienced declining average condition in recent years.



Capital Investment Review

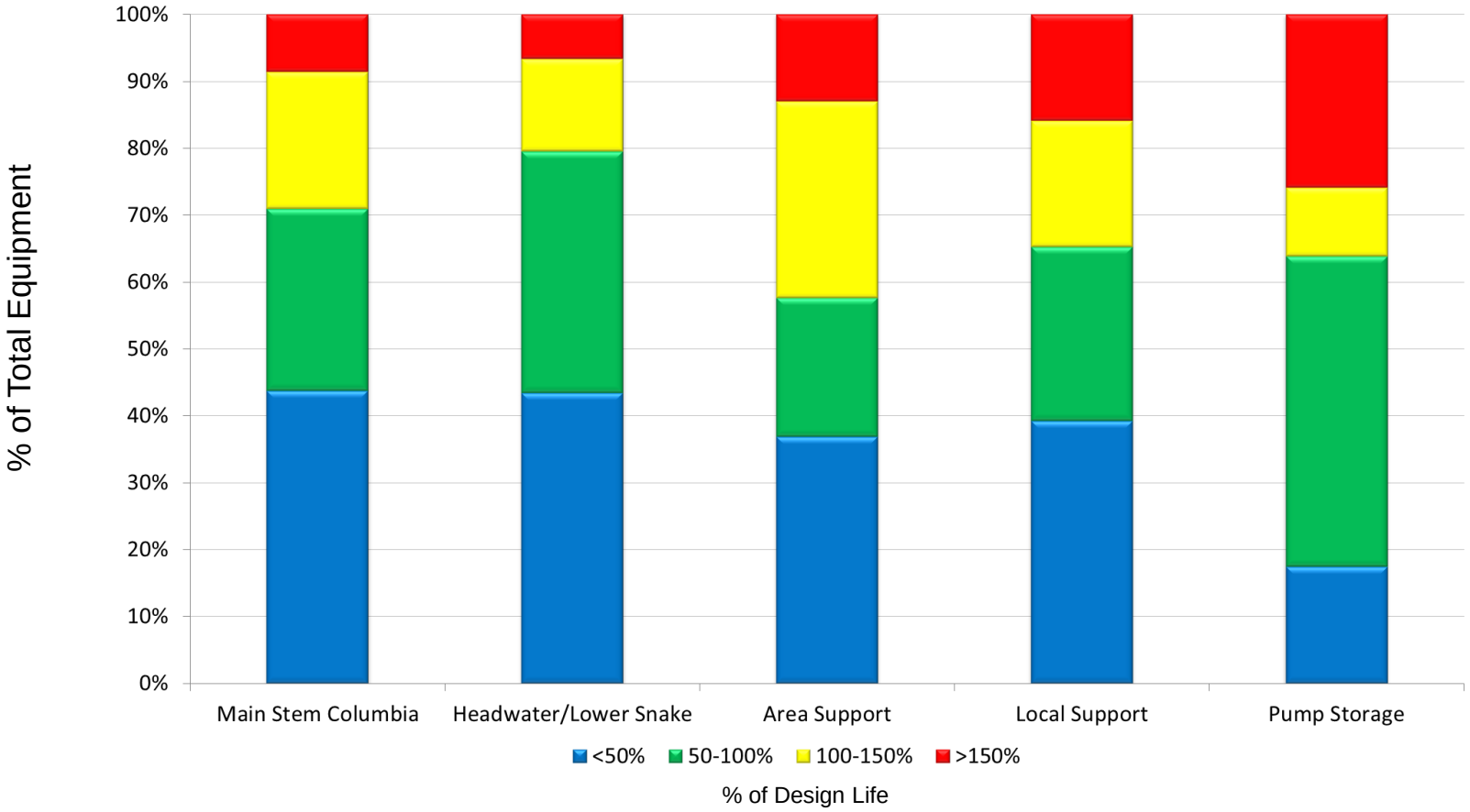
Criticality of plants

The plants are grouped within strategic classes and according to their criticality, based largely on the quantity of energy produced, particularly during peak periods and by the relative cost of unavailability, i.e., the financial consequence of the loss of generation at the margin. Five plants – **Grand Coulee, McNary, Chief Joseph, John Day and Dworshak** – are considered particularly critical to the power system based on the significant financial impact of generating unit outages at these facilities. The program outlined in this strategy targets a significant portion of investments at these five plants to improve condition and reliability.

FCRPS Hydro Plant Classification

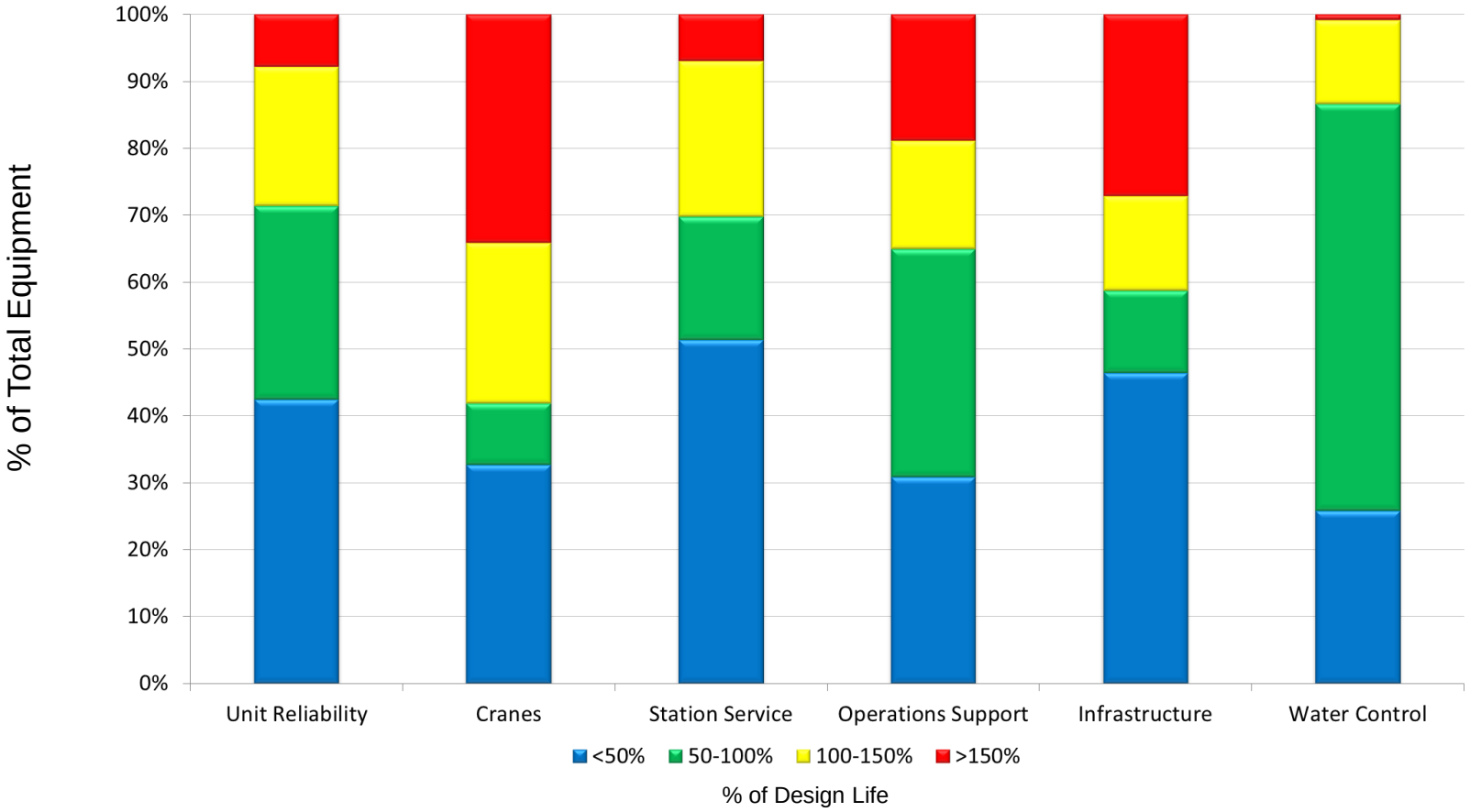
Relative Cost of Unavailability (RCU)	Local Support	Area Support	Headwater/ Lower Snake	Main Stem Columbia
Severe >$40m/yr				CHJ GCL MCN
Extreme $10 - $40m/yr			DWR	JDA
Major <$10m/yr	AND, BCD BDD, MIN, ROZ, CDR, GSP	BCL, DEX, LOS, DET, GPR, LOP, HCR, CGR, FOS, ALF, PAL	LIB, HGH, IHR, LGS, LWG, LMN	BON TDA

Current equipment age by strategic class



- About 30 percent of the equipment in the FCRPS are at or exceeding their respective design-lives. Of that equipment, 60 percent have a direct impact on generation in the event of failure.

Current equipment age by equipment type



Equipment condition

Condition ratings for each equipment type are based on a set of objective condition indicators related to operational performance, maintenance history, physical inspection and age. Condition indicators are weighted and summed to derive a condition rating, ranging from 10 to 0. Numeric scores are further described qualitatively as follows:

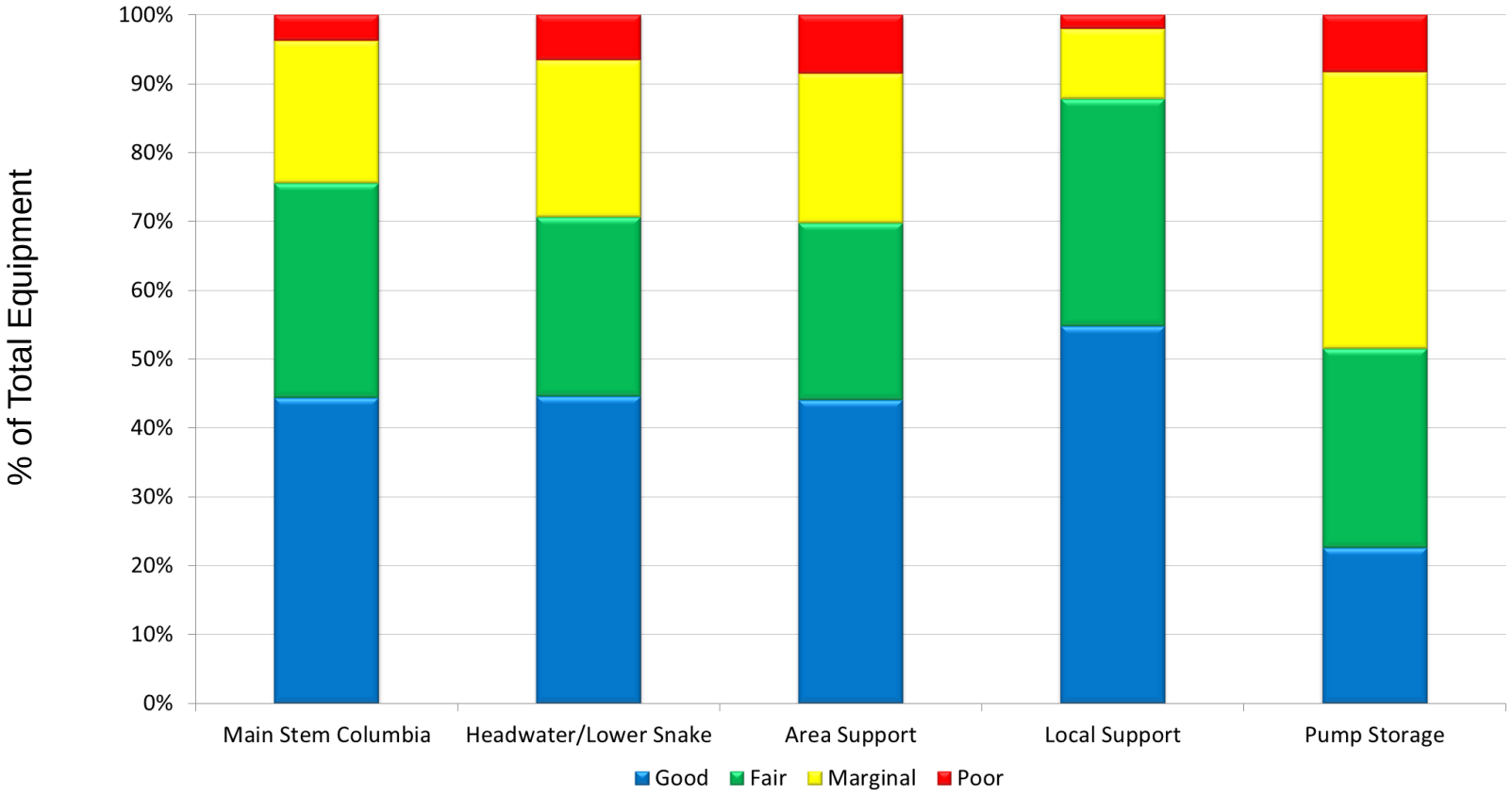
- 8.0 – 10.0 Good
- 6.0 – 7.9 Fair
- 3.0 – 5.9 Marginal
- 0.0 – 2.9 Poor

Condition is assessed using the hydroAMP condition assessment framework, a methodology supported by over fifty hydroelectric utilities worldwide.

The hydroAMP guide contains objective condition scoring instructions for equipment in the unit reliability and crane equipment categories. A more generic assessment guide is applied to the station service, operations support, infrastructure and water control equipment categories.

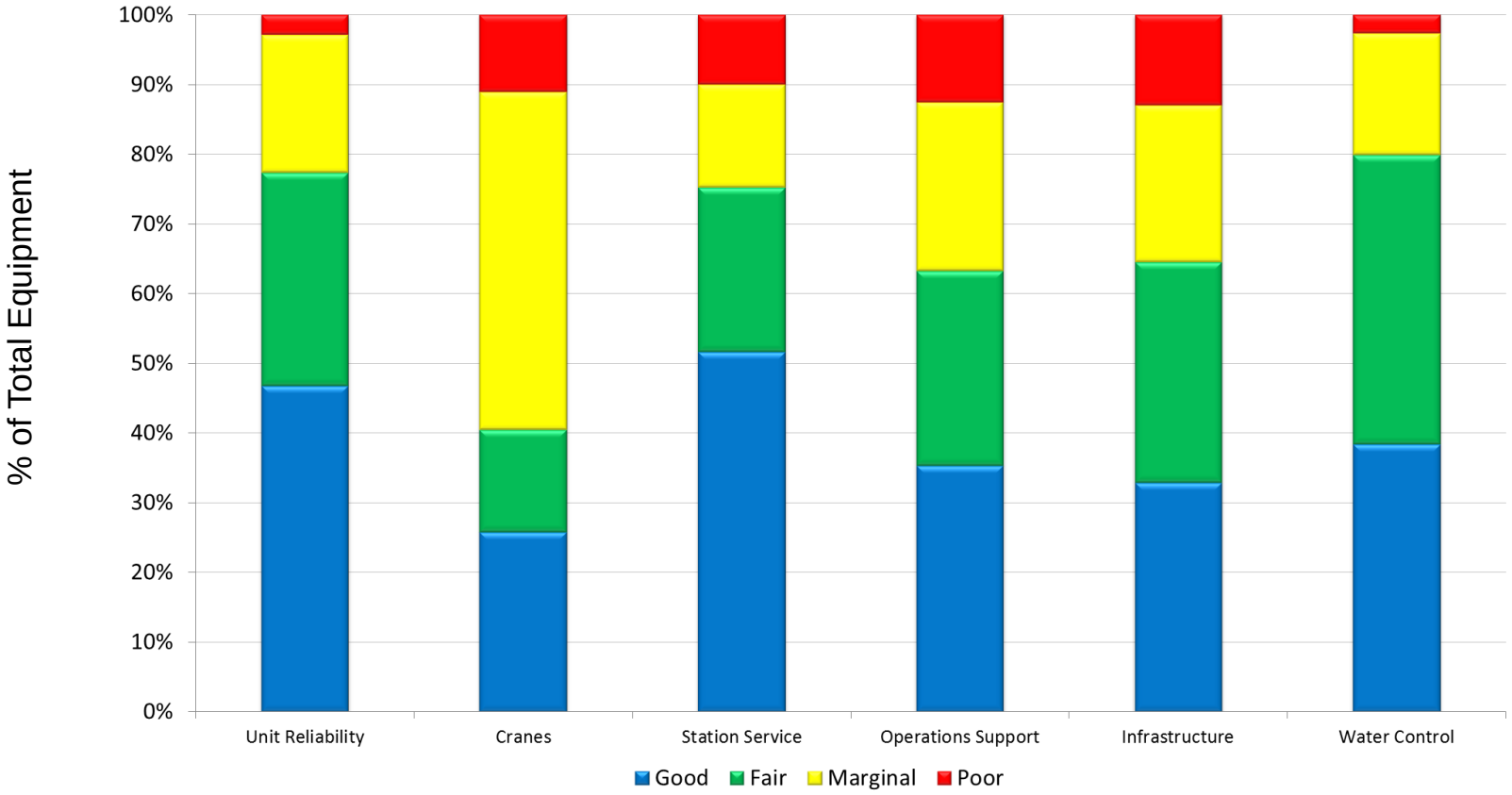
Condition assessments are performed annually for powertrain components and biennial for remaining components.

Current asset condition by strategic class



- 26 percent of the equipment in the FCRPS is in marginal or poor condition.

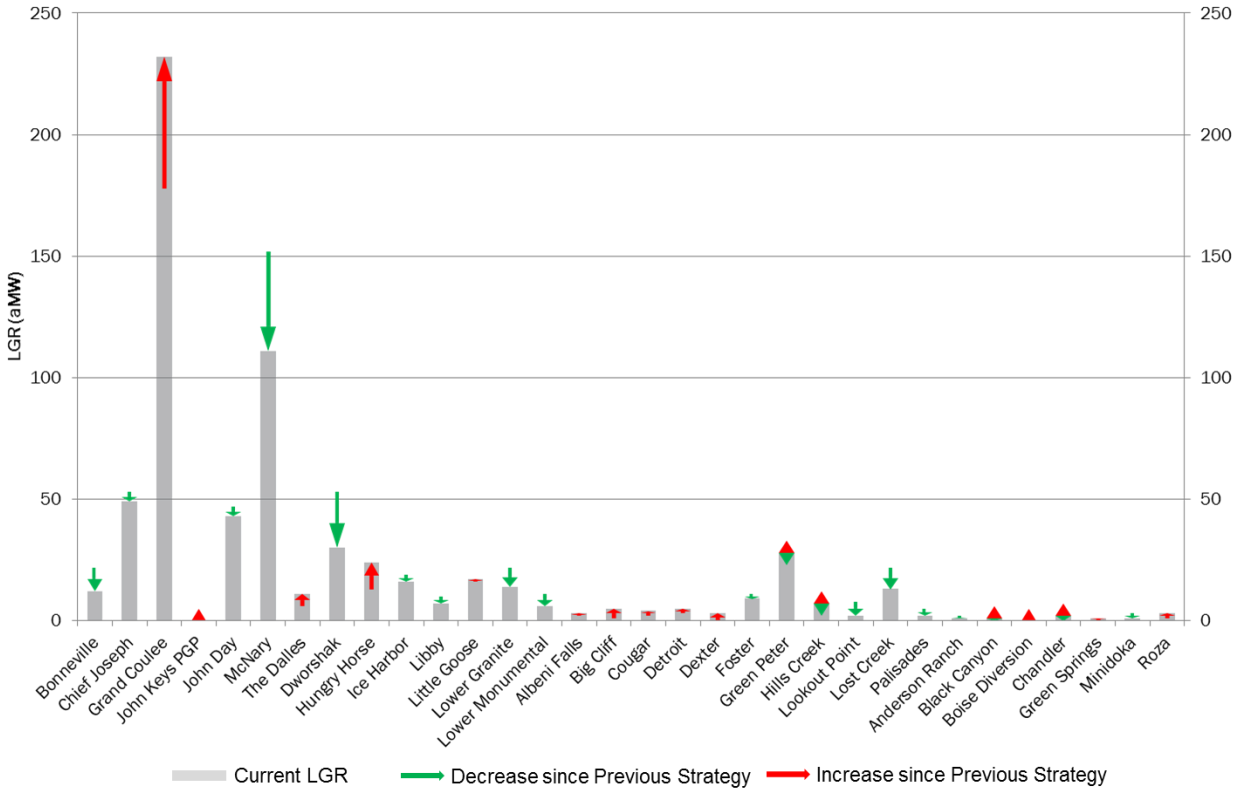
Current asset condition by equipment type



Current lost generation risk

Equipment condition is used to forecast the risk of lost generation at each plant in the FCRPS.

Change in lost generation risk (LGR) since the 2014 CIR



- Current LGR for the system is about 668 aMW, down from 702 aMW two years ago and very close to the 678 aMW forecast from the previous hydro asset strategy.
- Net reduction primarily driven by the completion of six generator rewinds at McNary since the 2014 CIR as well as improved condition scores at Bonneville and Dworshak.

Identifying investment needs

Timing of investments

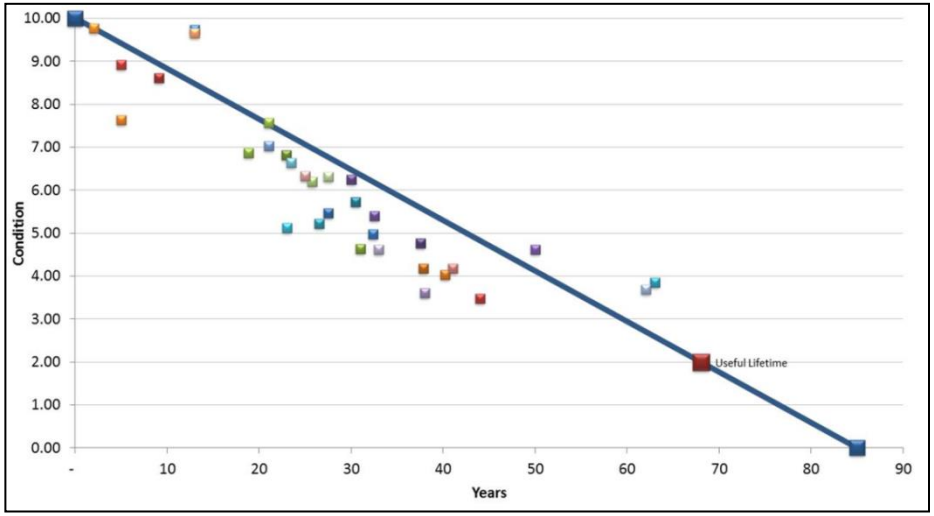
At a high level, the optimal replacement timing for equipment is identified by:

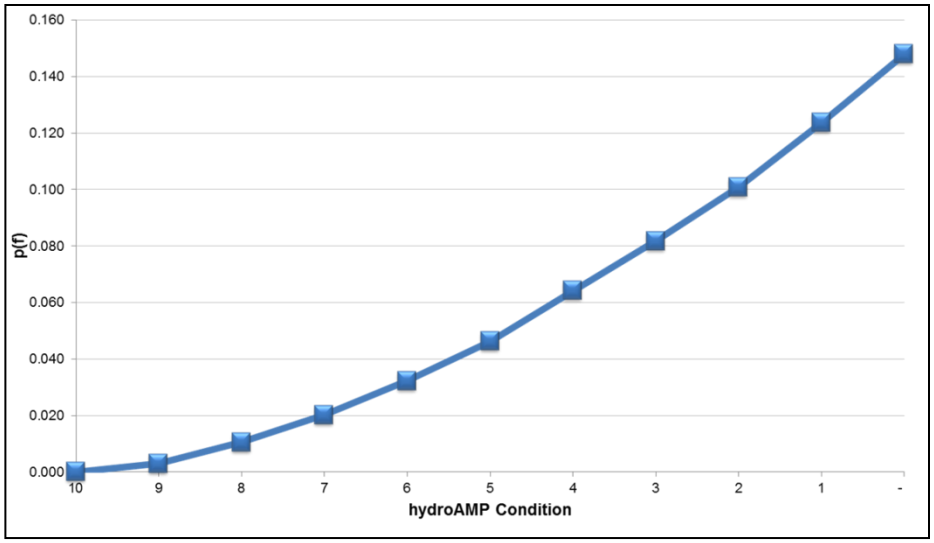
1. Forecasting equipment condition over time for each component.
2. Relating condition to a probability of failure.
3. Using the annual equipment failure probabilities to calculate lost generation and direct cost risks as well as lost efficiency opportunities.

$$Probability\ of\ failure\ * consequence = risk$$

4. Minimizing total lifecycle cost (the sum of the present value of risk, lost efficiency opportunities and replacement cost).

Condition and probability of failure





hydroAMP condition ratings are projected over time for each piece of equipment. Degradation curves are derived using regression analysis on historical hydroAMP condition data. These curves vary by equipment type and are updated periodically.

This analysis also produces an effective age for a given condition rating which is used to map hydroAMP condition to industry failure curves for each equipment type.

Using the degradation and failure curves, probability of failure is forecast over time as equipment ages and condition degrades.

Risks and costs

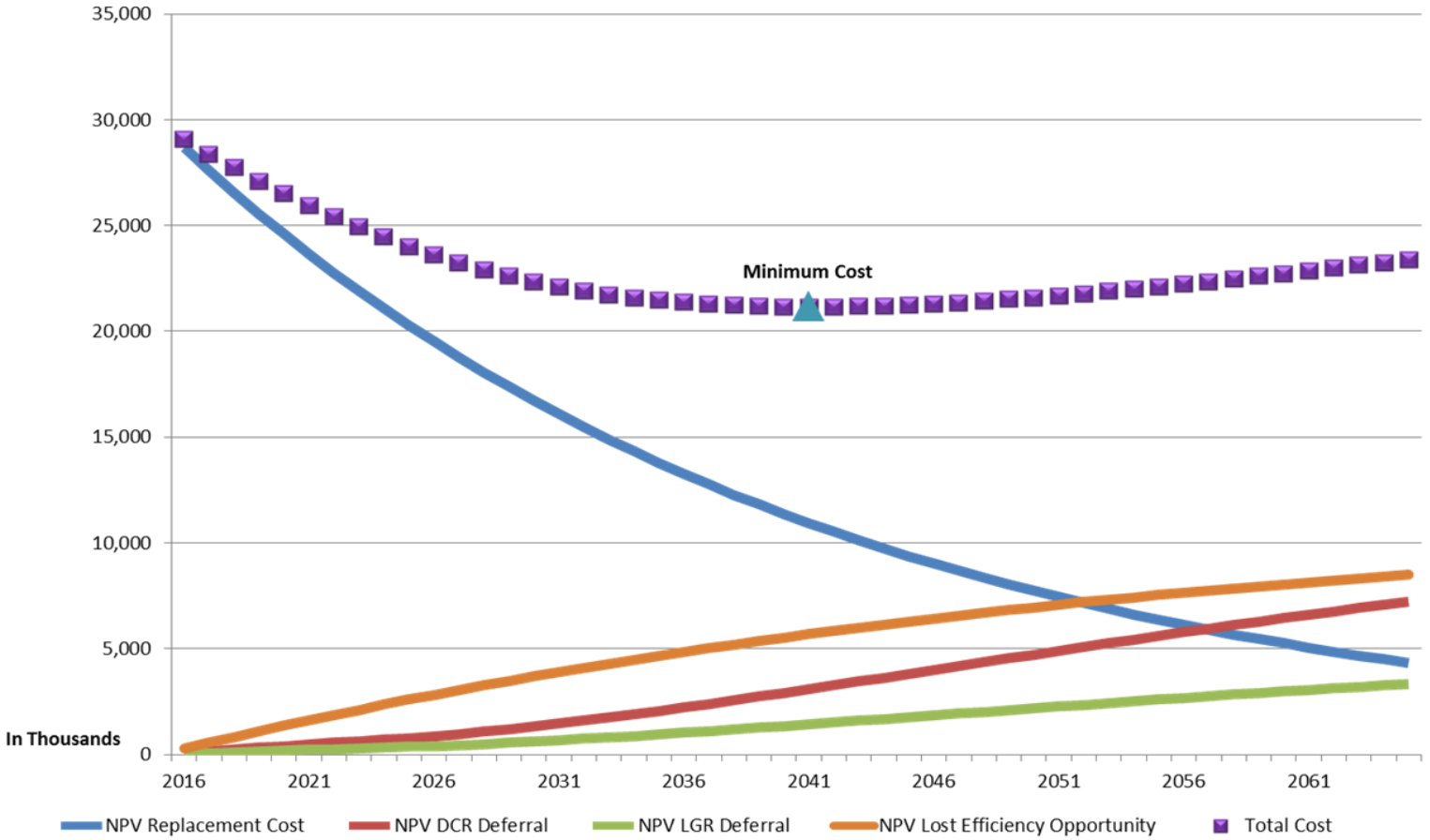
Lost generation risk:
Equipment failure may also result in longer outages and therefore more lost generation than if replaced on a planned basis. This cost risk increases as equipment condition degrades over time.

Direct cost risk:
If equipment fails during the deferral period, intervention costs may be incrementally higher for collateral damage and planning, procurement and scheduling inefficiencies (i.e. overtime, emergency hiring, contract premiums, etc.). This cost risk also increases as equipment condition degrades over time.

Lost efficiency opportunity:
Some equipment replacements (turbine runners, transformers and generator windings) reduce efficiency losses. Deferring replacement results in a lost opportunity to capture increased generation from higher efficiency equipment.

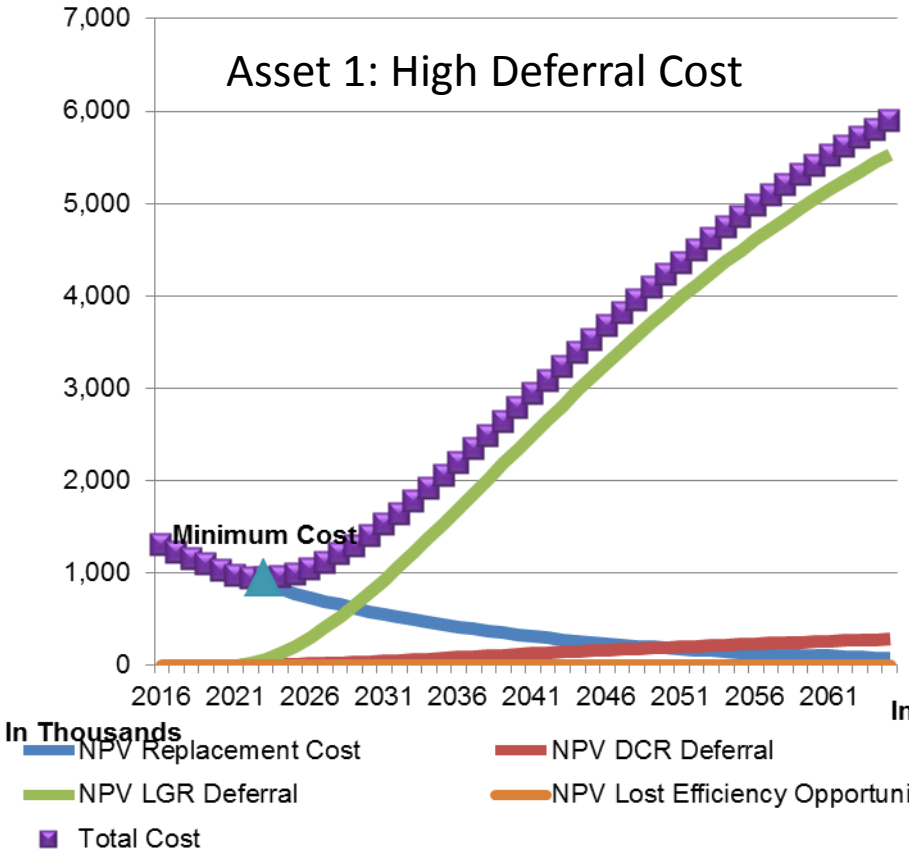
Replacement cost:
Typically, the longer the replacement can be deferred, the lower the present value of its cost.

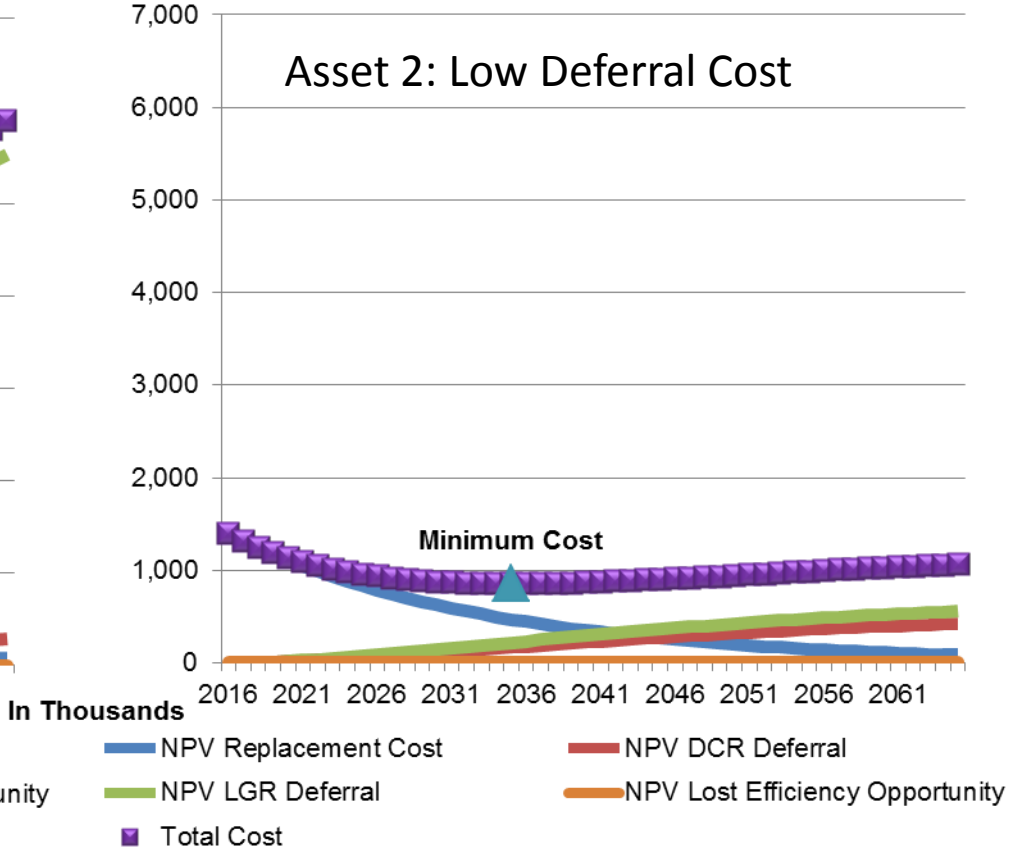
Timing of investments



The **Total Cost** is the present value sum of replacement costs, risk costs and the opportunity cost of deferring a replacement resulting in efficiency gains (lost efficiency opportunity). The cost minimum on this curve is the point at which financial risk is forecasted to begin growing faster than the benefit of investment deferral and represents the optimum time to forecast replacement to minimize lifecycle cost.

Prioritization under constraints





- Asset 1 has a significantly higher deferral cost than Asset 2. Deferring replacement on Asset 2 has a minimal cost and replacement will continue to be deferred in favor of higher deferral cost assets until there is room in the budget or the asset fails.

Hydro investment strategy

Modeling assumptions

Assumption	Value	Source	Comment
Discount rate	8.0 percent	BPA Generating Assets	6 percent real
Inflation rate	1.9 percent	BPA Finance	Average annual rate, 20-yr forecast
Forward energy price curve	20-yr, by month, HLH, LLH, flat $36 – Levelized Energy Value $25 – Capacity Value	BPA Power Services resource program	Includes spot prices and a component for long-term firm capacity consistent with rate case demand rate.
Equipment cost	Varies by equipment type	FCRPS hydro program	Based on industry cost data
Real cost escalation	0 percent	BPA Finance	Global Insight
Failure curves	Varies by equipment type	BPA Generating Assets	Based on industry data for certain equipment
Outage duration for LGR	Varies by equipment type	FCRPS hydro program	Based on industry experience
Environment and safety	Risk	BPA Generating Assets	Treats all high risk items as “must do”
Value of avoided CO_2	$35/ton	BPA Corporate Strategy	Based on Presidential Directive
Alternative resource for hydro lost generation	Natural gas-fired combined-cycle combustion turbine	BPA Agency Asset Management	0.48 tons of CO_2 per MWh of generation

Exclusions

For the focus period of this strategy, a limited amount of civil features, primarily gates, have been identified in the analysis of risk and investment needs. The exclusion of costs for other **dam safety civil features** likely underestimates the total funding need forecast in later years. As the hydro system continues to age, anticipating funding needs for all civil features will require more explicit attention in future strategies.

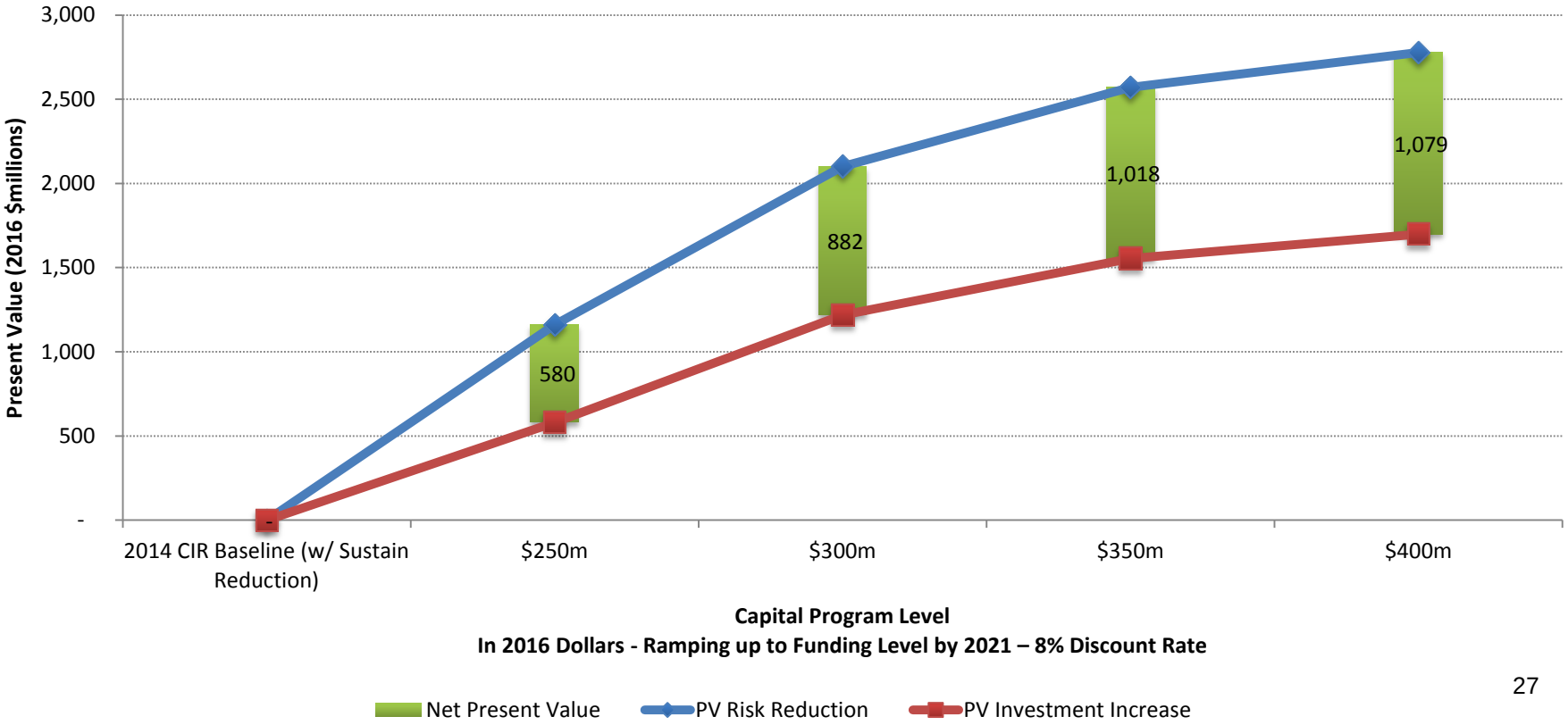
The strategy does not yet consider **program management and implementation issues** such as succession planning, skill gaps, automation or mechanisms for planning and executing major projects.

The strategy does not include a risk assessment of **changes in fuel supply** based on factors such as changes in weather patterns or fish operations. Additional capital projects could be mandated to address fisheries concerns, and any change in fuel supply could affect the economic value of generating assets and, therefore, the selection of projects.

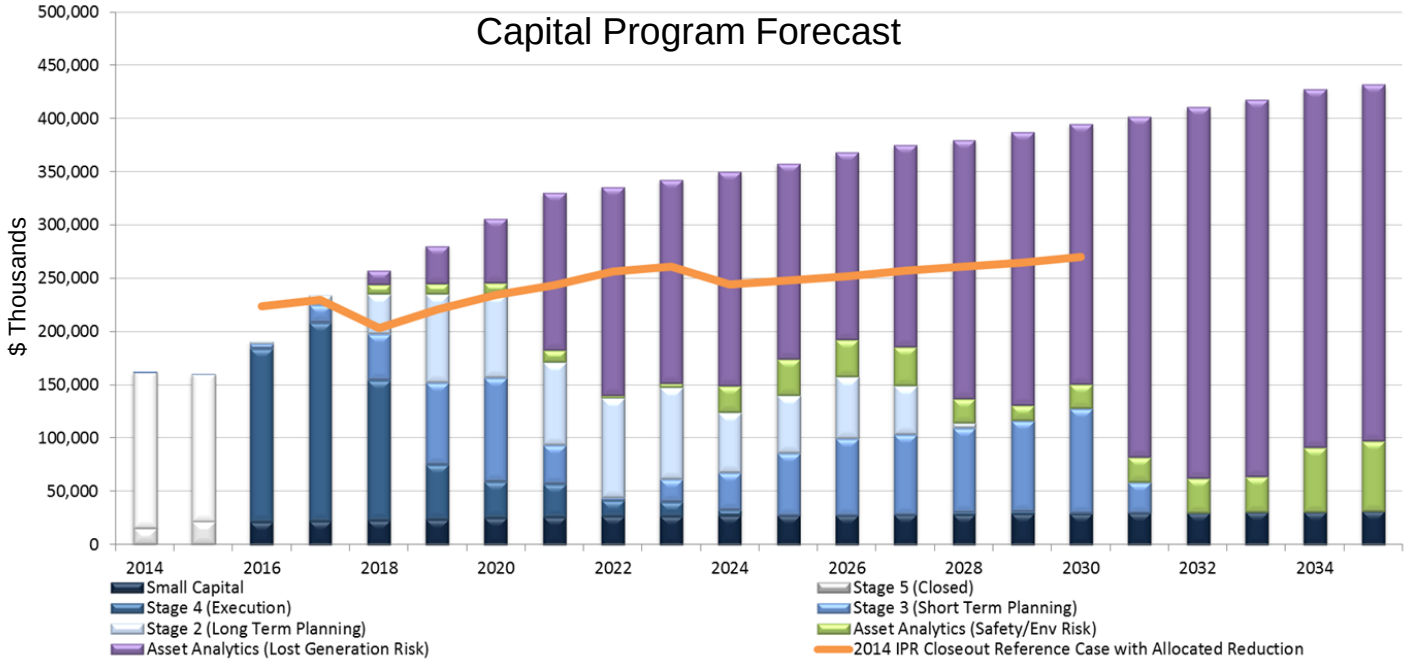
The Asset Investment Excellence Initiative (AIEI) has begun with the goal of incorporating a number of these exclusions into future strategic planning efforts.

NPV of capital investment levels

Compared to the $200 million annual investment level approved in the 2014 CIR, the net present value (NPV) of higher funding scenarios increases fairly substantially up to an investment level of $300 million per year in 2016 dollars, after which it increases more slowly. For a $300 million investment level, the present value of costs increases by $1.25 billion, but the present value of risk reduction increases by more than $2.1 billion, resulting in a NPV of $882 million.



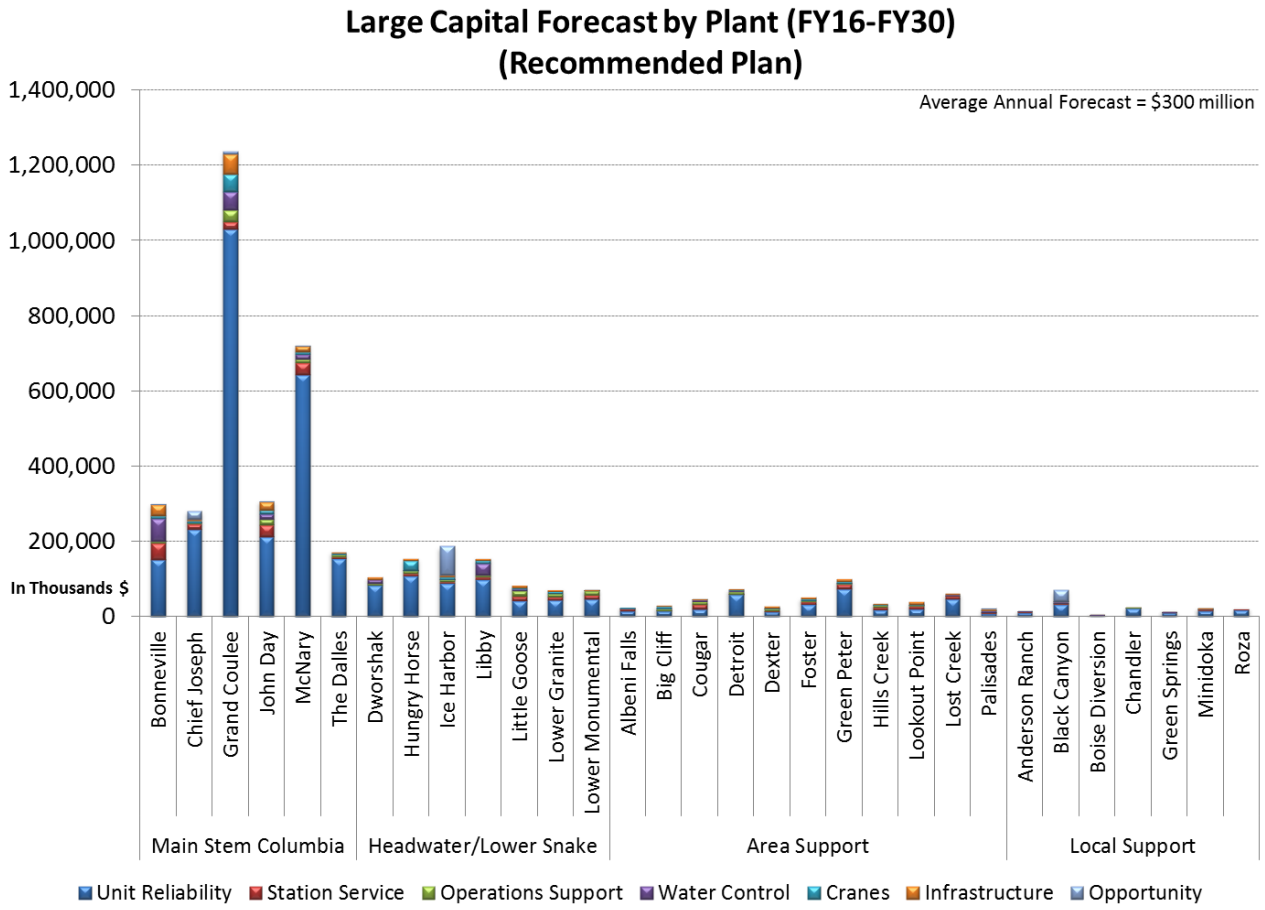
Recommended capital program



($ Millions)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
2014 CIR Recommended Plan	190	205	232	248	257	282	307	332	349	355							
2016 CIR Recommended Plan	164	160	196	236	258	281	306	331	338	344	351	358	365	373	380	388	395

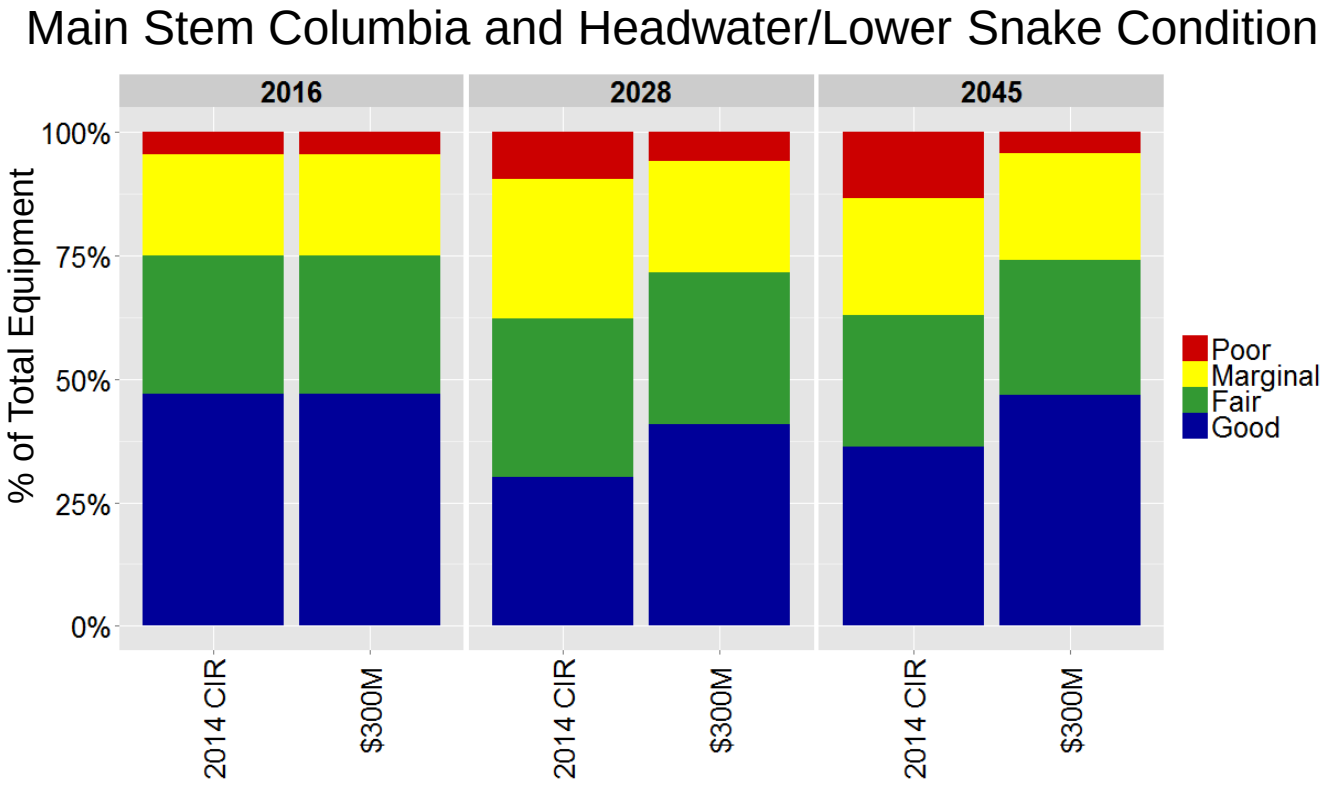
- Consistent with the 2014 CIR, a $300 million annual capital investment levels remains the recommended investment for the hydro system.
- Investments in a planning or execution stage are represented in blue in the chart above. Replacements modeled through the lifecycle cost minimization algorithm are shown in purple while replacements triggered due to high safety or environmental risks are shown in green.
- As part of the AIEI, these modeled results will be more fully developed into a rolling 20-Year system asset plan with consideration for resources, unit outages and logical replacement groupings.

Capital investment by plant



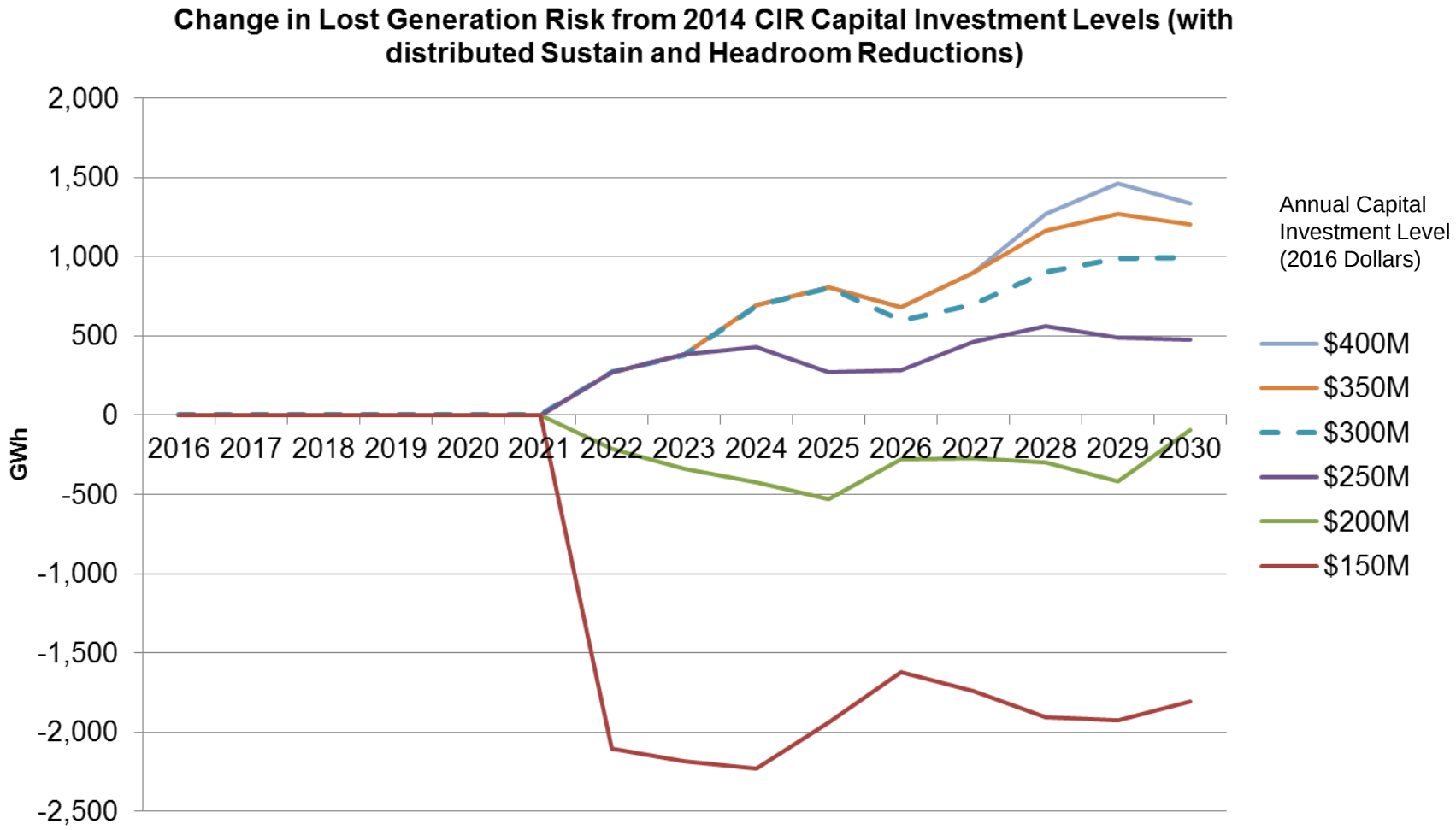
- Nearly half of the total capital investment over the next 15 years is targeted at Grand Coulee and McNary dams.

Condition impacts



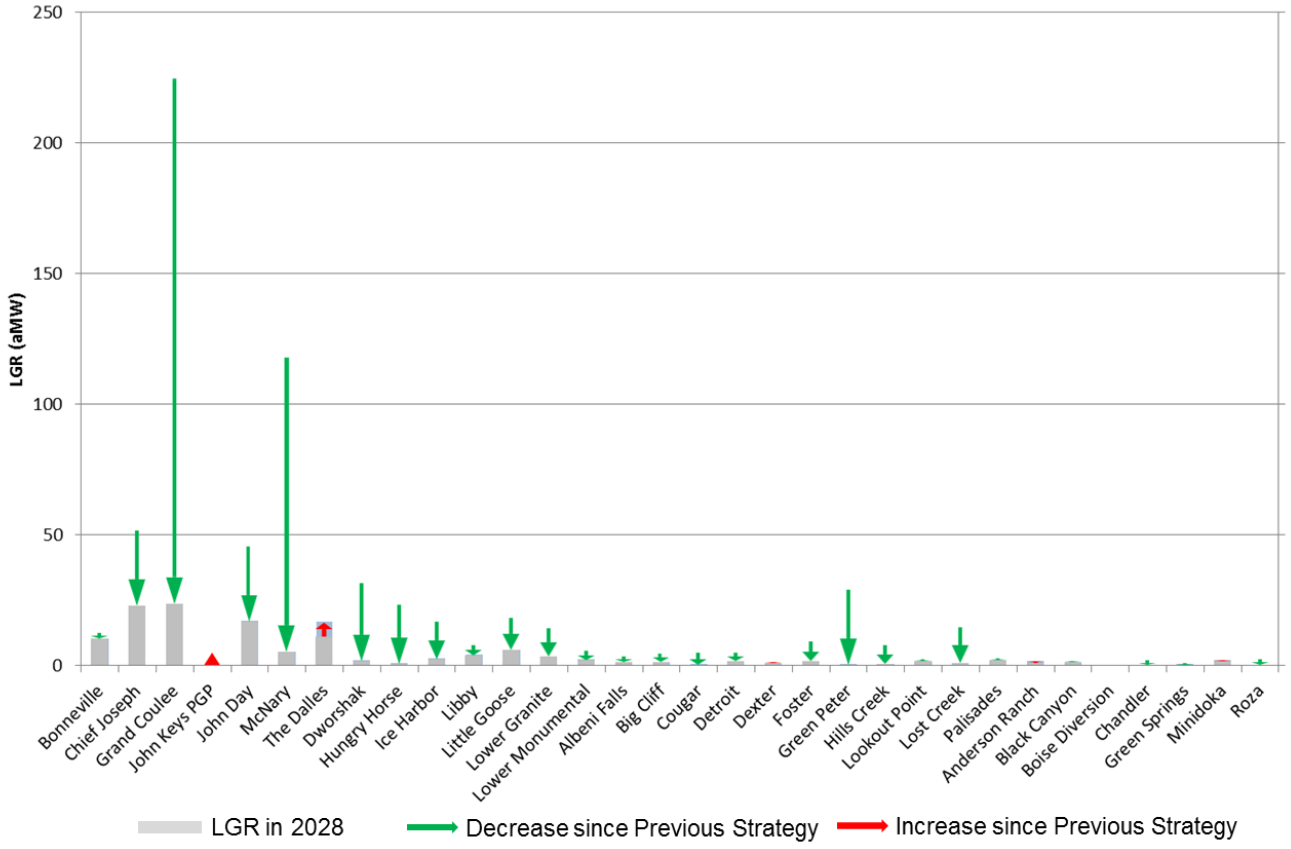
- Condition is expected to degrade at the $200 million 2014 CIR investment levels. By 2028, the percentage of equipment in marginal and poor condition is expected to increase from 25 percent to 40 percent.
- At a $300 million investment level, the overall condition of the system is expected to stay relatively constant through time.

Lost generation risk impacts



Lost generation risk impacts by plant

LGR in 2028 ($300 million annual investment level)

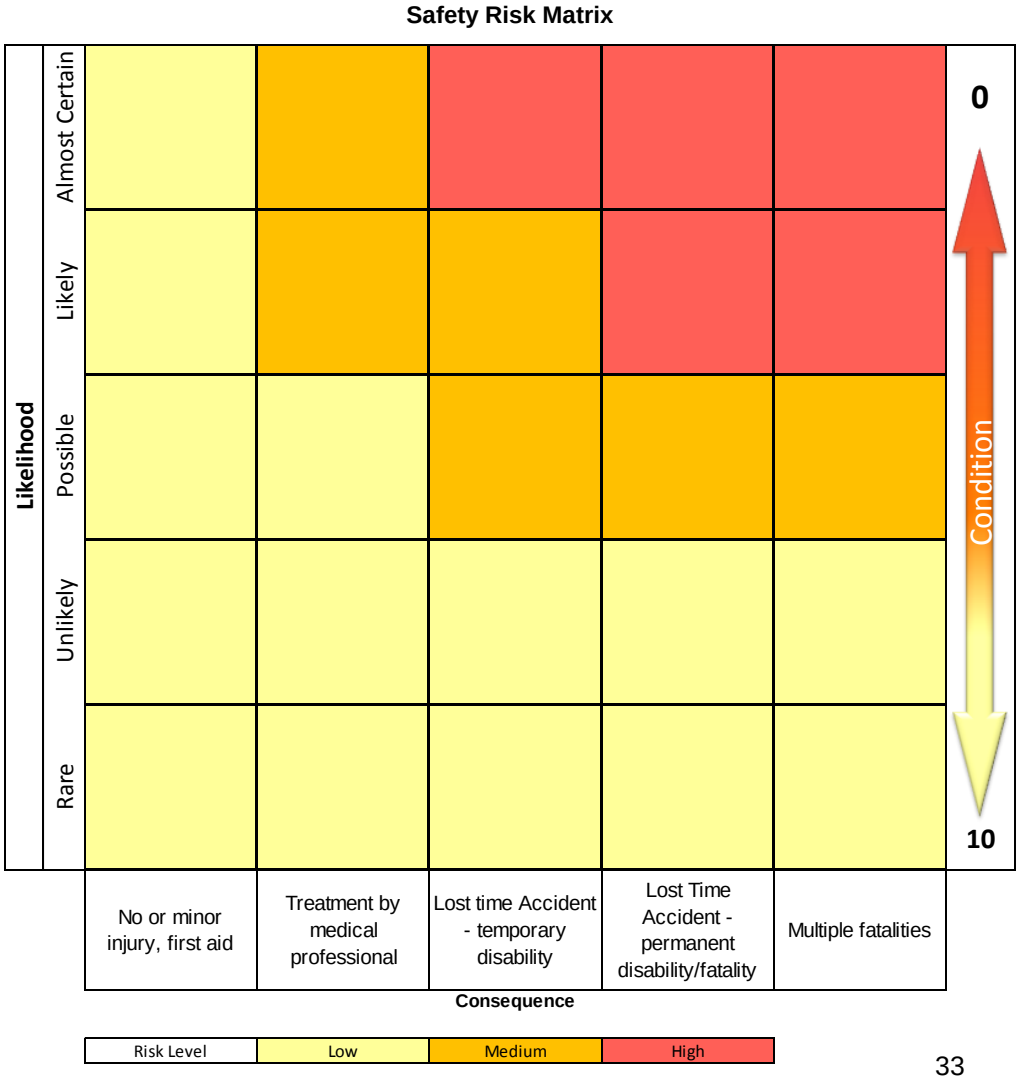


By 2028, LGR is expected to decline from 668 aMW to 140 aMW under the $300 million investment level compared to 308 aMW under a $200 million investment level.

FCRPS risk matrices

Safety and environmental risks associated with equipment failure are forecast on risk matrices. Similar to the lost generation risk calculation, safety and environmental risk are the product of the probability of failure and the safety or environmental consequence of failure for each respective asset.

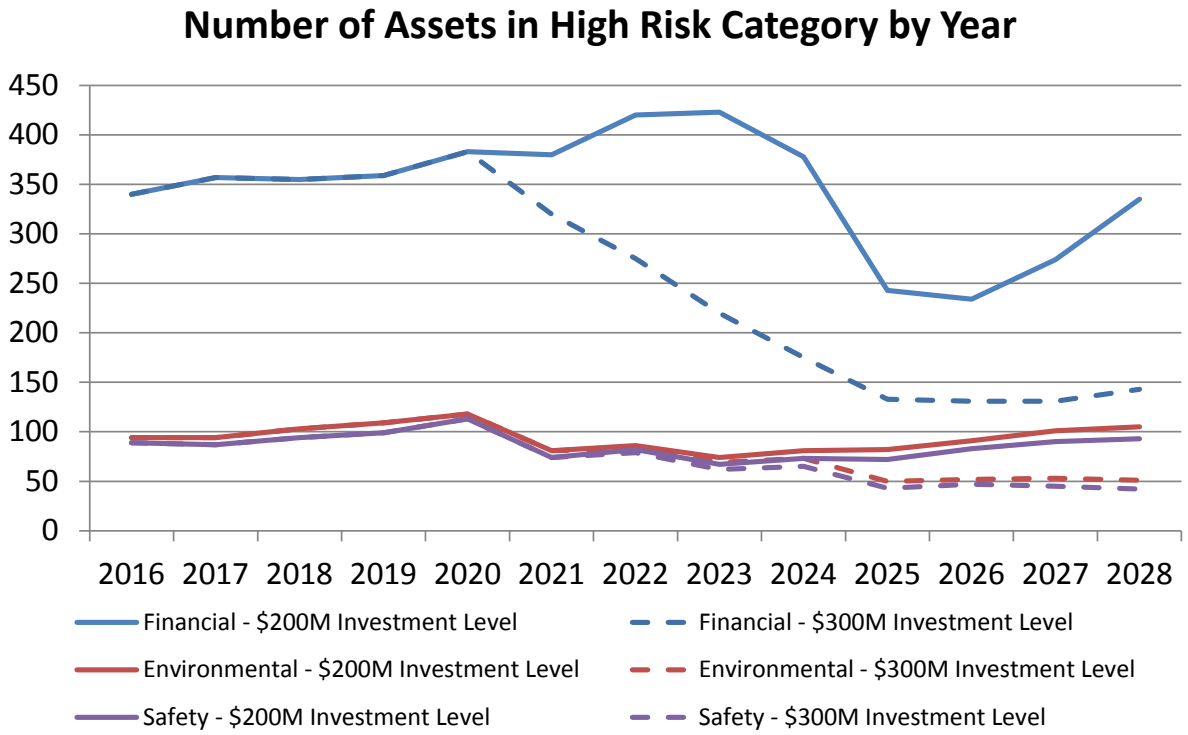
An asset that reaches the high risk category of the risk matrix is automatically triggered for replacement by the investment analytics. The high risk areas of the risk matrix are shaded in red.



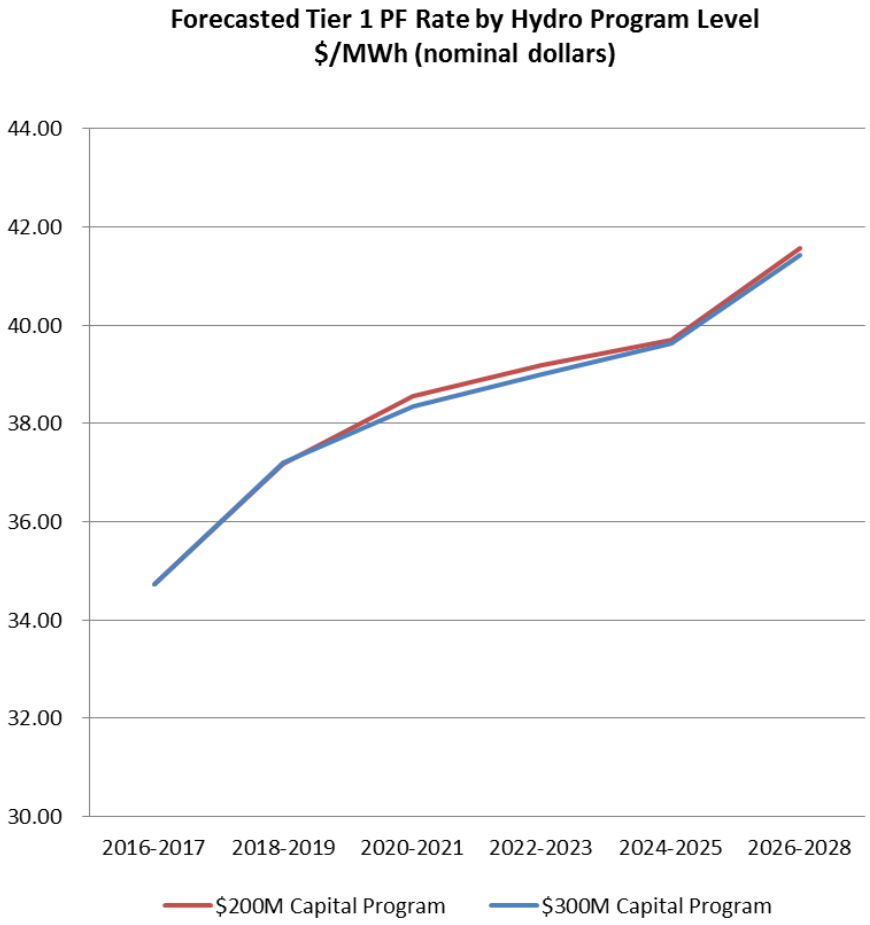
Financial, safety and environmental risk impacts

- A $300 million investment level has significant impacts on the number of assets in the high risk category of the financial, safety and environmental risk matrices. By 2028, the number assets that pose a high safety and environmental risk is expected to be reduced by 50 percent and the number of assets that pose a high financial risk is expected to be reduced by almost 60 percent relative to today.

- A $200 million investment level reduces the number of high risk assets briefly in the 2020s. However, the number of assets in high risk categories is expected to increase effectively back to today's levels by 2028.



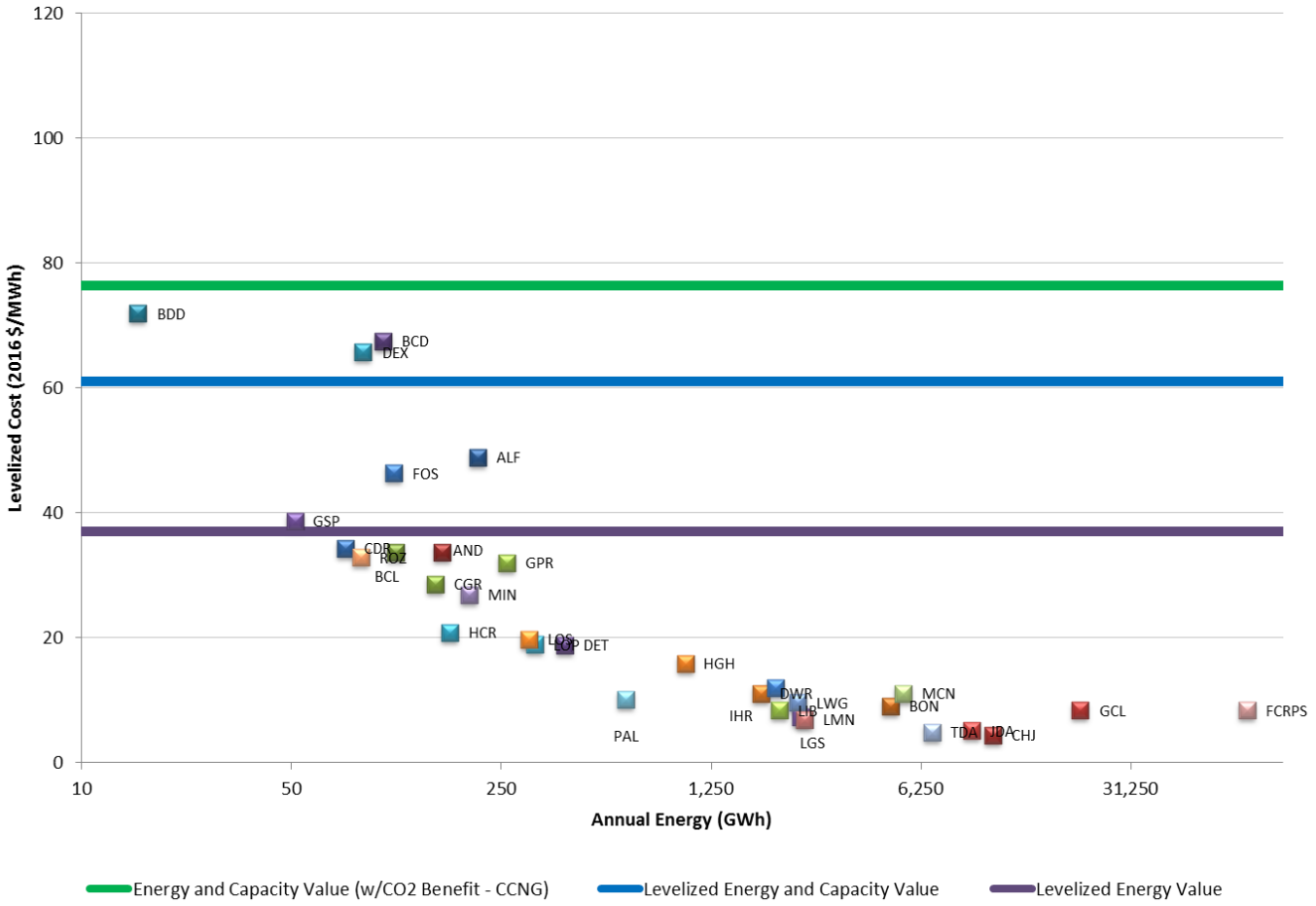
Rate impacts



- The rate impacts of increased capital investment in the hydro system were studied using the reference case. Results from the study suggest that the Power rates will be slightly lower in 2028 with the $300 million per year Recommended hydro capital program level than with the $200 million per year baseline program.

- Relative to the $200 million program level, a $300 million program level results in increased generation capability due to higher unit availability at critical plants.

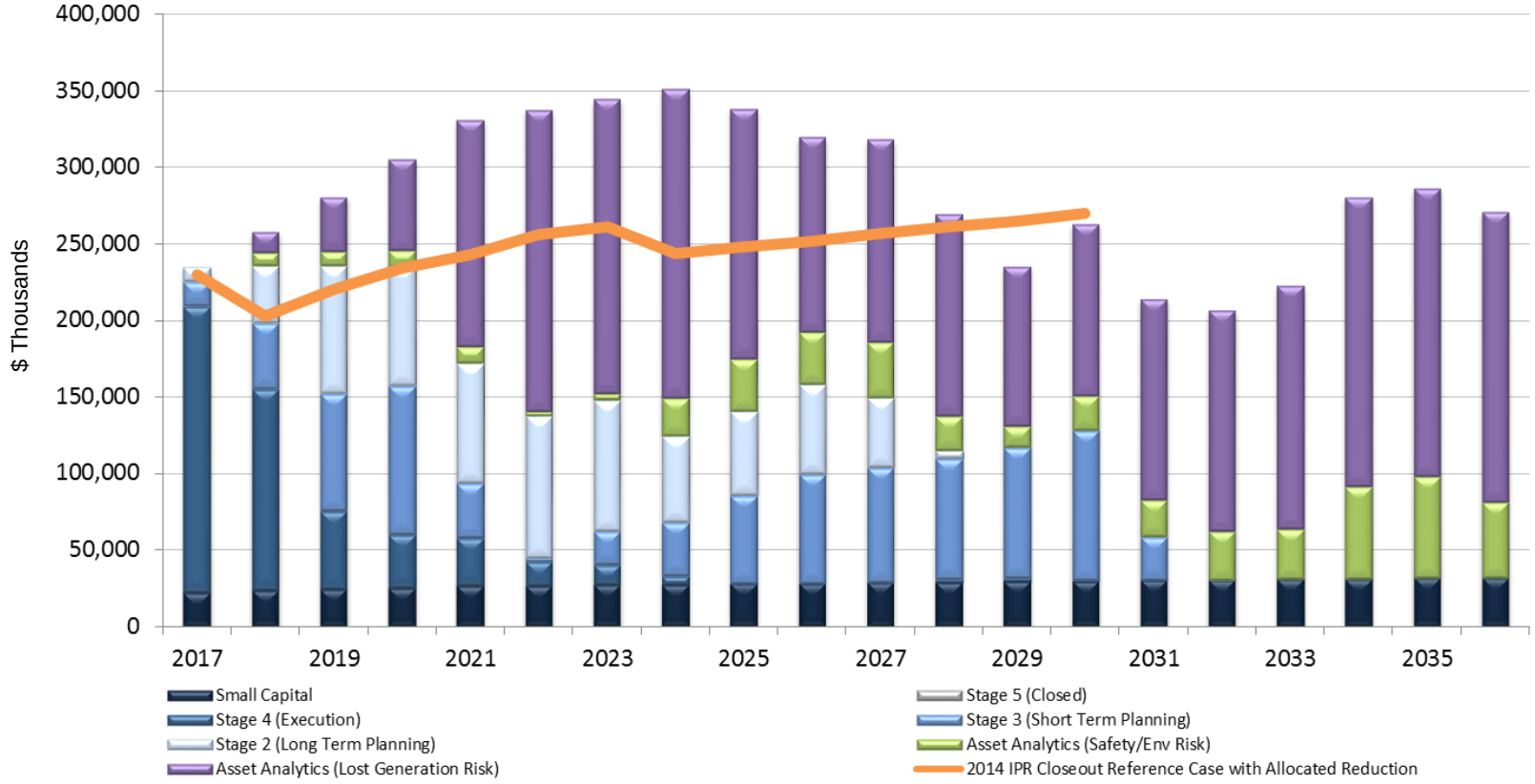
Levelized cost of generation



- The levelized incremental cost of generation is $8.40/MWh in 2016 dollars for the FCRPS hydro system and below $16 per MWh for all plants in the main stem Columbia and headwater/lower Snake strategic classes.

Sensitivity analysis

The impacts of prolonged low energy prices were also studied to determine the impacts on suggested capital investment levels. Assuming a hypothetical $20 real energy price, no value for capacity or ancillary services, no value for avoided carbon emissions and an 8 percent discount rate, the analytics still suggest that it is optimal to spend approximately $300 million through the mid 2020s. This program has a NPV of $121 million relative to the baseline program.



Capital program improvements

Asset Investment Excellence Initiative

- In 2015, the Asset Investment Strategy Initiative (AIEI) was implemented at the direction of the senior executives at BPA, the Corps and Reclamation in order to further develop capital program planning processes and methodologies as well as improve execution.

- The Asset Investment Excellence Initiative has already taken significant steps in moving the FCRPS Asset Management program forward.
  - A three agency Asset Planning Team was formed in December 2015, charged with developing long term System Asset Plans.
  - A value framework has been developed that will allow for the optimization of FCRPS investments.
  - The impacts of capital investment on hydro system output have been incorporated into the Long Term Rates Forecast screening tool.

- Future goals of the AIEI include:
  - Further development of the portfolio optimization tools to include outage and resource considerations.
  - Expansion of the asset inventory, specifically for non-powertrain assets and civil features that lack consistency from plant to plant.

Value Framework

- The Asset Planning Team has developed a “Value Framework” that will work in concert with the lifecycle cost minimization analytics to optimize the FCRPS investment portfolio.
  - Aligns Financial, Safety, Environmental, Compliance and Public Perception and other risks and benefits to a common, dollar-less scale.
    - The financial benefits are also preserved in their dollar form in order to illustrate the quantifiable value of the investment portfolio.

- The optimization can change investment start dates as well as choose between various investment alternatives to deliver the highest portfolio value.

- The upcoming 20-Year System Asset Plan will be the first to use this new method.

- Within the next 5 years, the portfolio optimization capabilities will expand to consider resource and outage constraints in addition to budget constraints.

Integrated Program Review

Corps and Reclamation operation and maintenance expenses

O&M program overview

- About 60 percent of expenses go to the salaries and benefits of the approximately 1,600 employees.
- About 10 percent is for materials & supplies.
- The remaining 30% is for support services & contracts.

- The O&M program includes funding for mitigation activities:
  - **About 15 percent** of O&M program costs are **Fish and Wildlife O&M** for screens, hatcheries, fish bypass facilities, trap and transport, etc.
  - **About 2 percent** of O&M program budget is for the **FCRPS Cultural Resource** program and mitigation activities associated with section 106 compliance

- Other routine programs include dam safety, clean water, water management, employee safety, engineering, contracting, physical and cyber security, reliability compliance and other support services.

- **About 16 percent** of O&M program costs are for non-routine extraordinary maintenance (NREX), the large infrequent repair activities associated with failed or failing equipment, as well as the Grand Coulee third power plant overhaul.

FCRPS performance program

- Performance indicators are established each year to monitor the health and performance of the hydro system.

- Categories include:
  - Safety (Lost Time, DART Rate)
  - Financial Execution (Capital and O&M)
  - Operational (Availability, Forced Outage, etc.)
  - Maintenance (work completion)

- Results are actionable – monthly reviews and inquiry into missed targets.

FCRPS Performance – Plant Dashboard

Libby

Hydro Plant Dashboard
FY 2016 thru April

FCRPS Index = 58
out of 100

Safety

	April	Last 365	Target	FCRPS Index Points
DART Rate	0.0	0.0	1.5	10 / 10
Lost Time Acc. Rate	*0.0*	*0.0*	0.95	10 / 10
TCIR Rate	*0.0*	*0.0*	3.7	0 / 10

Maintenance Management

	Total #	Rate	Target	
Critical PM Rate (YTD)	302	86.4%	90%	2.4 / 6
PM Completion Rate (YTD)	1,008	85.8%	85%	4.8 / 6
Completion of Work (last 365 days)			83%	0 / 6

Facility Management

	YTD	Target	
Generation System Reliability	100%	100%	5 / 5
hydroAMP Update Status	29%	100%	0 / 10
Operations Coordination	98%	95%	1.6 / 2

Miscellaneous Plant Info

	YTD
Generation (GWh)	1,050
YTD Gen. Value ($000's)	15,456
Cost of Generation ($/MWh)	$4.48
Capacity Factor	34%

Generation

	April	YTD	Target*	
Availability Factor	85.8%	87.1%	84.4%/86.6%	
Forced Outage Factor	0.0%	0.1%	1.2%	10 / 10
Scheduled Outage Factor	*14.2%*	*12.8%*	*12.2%*	2 / 5
Planned Generation Capacity A	101.3%	100.6%	98%	2.5 / 2.5
Planned Generation Capacity B	0	100%	67%	2.5 / 2.5

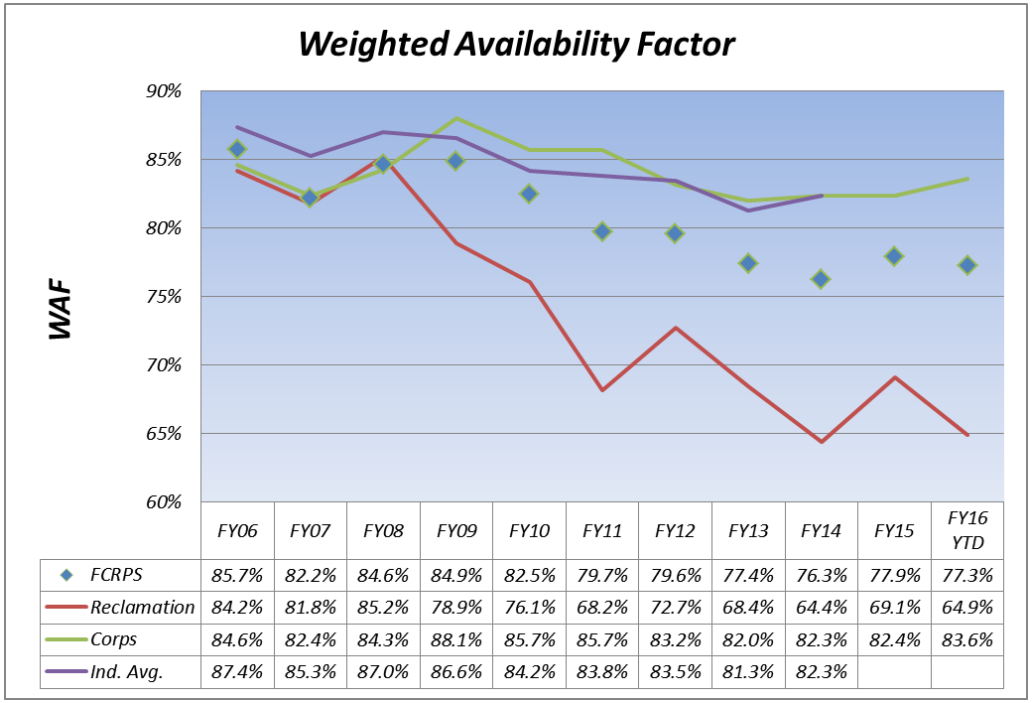
*Monthly and YTD targets shown for Availability Factor in the format Monthly Target/YTD Target

Funding Execution

	Base Expense		Small Capital		Large Capital		NREXpense		Total Expense	
	($000's)	Rate	($000's)	Rate	($000's)	Rate	($000's)	Rate	($000's)	Rate
Annual Budget	$ 10,046	-	$ 396	-	$ 6,647	-	$ 25	-	$ 10,071	-
YTD Target	$ 5,860	58.3%	-	-	$ 3,318	49.9%	$ 15	58.3%	$ 5,875	58.3%
YTD Actuals	$ 4,701	46.8%	$ 229	57.8%	$ 4,073	61.3%	$ -	0.0%	$ 4,701	46.7%
Expenditure Rate		80.2%				122.8%		0.0%		80.0%
FCRPS Index Points		0 / 7.5		7.5 / 7.5						

FCRPS availability

- As unit condition has degraded, capital investment increased and the Grand Coulee Third Powerplant overhaul begun, system availability has declined.
- With less capacity available and decreased flexibility, additional outages have larger revenue impacts.
- Funding routine and non-routine maintenance becomes even more critical in order to maintain needed reliability and minimize lost revenue.



	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16 YTD
FCRPS	85.7%	82.2%	84.6%	84.9%	82.5%	79.7%	79.6%	77.4%	76.3%	77.9%	77.3%
Reclamation	84.2%	81.8%	85.2%	78.9%	76.1%	68.2%	72.7%	68.4%	64.4%	69.1%	64.9%
Corps	84.6%	82.4%	84.3%	88.1%	85.7%	85.7%	83.2%	82.0%	82.3%	82.4%	83.6%
Ind. Avg.	87.4%	85.3%	87.0%	86.6%	84.2%	83.8%	83.5%	81.3%	82.3%		

Availability and outage planning

- A rigorous annual outage planning process (with weekly updates) identifies planned outages for routine, capital and non-routine work.
- A detailed water and market analysis identifies time periods and projects that risk impacting revenue due to lack of available units.
- Plants are asked to reschedule work in order to minimize lost revenue and the outage plan is optimized to the extent possible.
- Monthly availability targets are set based on the coordinated plan and tracked throughout the year to measure schedule adherence.

FY 16 Availability (Page 1 of 2) through April

		YTD	EOY*	Oct	Nov	Dec	Jan	Feb	Mar	Apr
FCRPS	Target	75.1%	76.7%	72.2%	71.1%	77.5%	74.6%	75.4%	76.1%	78.6%
	Actual/Forecast	77.3%	78.0%	72.5%	73.0%	78.5%	78.6%	78.5%	78.0%	81.8%
Corps	Target	82.3%	82.1%	77.7%	78.4%	86.0%	83.8%	82.7%	83.4%	84.4%
	Actual/Forecast	83.6%	82.8%	77.2%	78.1%	87.1%	87.5%	86.5%	84.3%	84.3%
Chief Joseph	Target	82.9%	83.8%	62.0%	85.8%	85.3%	86.4%	87.8%	86.9%	87.2%
	Actual/Forecast	83.2%	83.9%	60.6%	84.5%	92.1%	90.6%	87.9%	84.9%	82.3%
Libby	Target	86.6%	86.9%	96.5%	85.9%	98.8%	80.9%	80.6%	78.8%	84.4%
	Actual/Forecast	87.1%	87.2%	91.1%	88.9%	99.2%	82.2%	82.4%	79.8%	85.8%

O&M initiatives

- Grand Coulee world class hydro
  - Centralized planning group
    - Planning manager providing the vision and guidance
    - Employing knowledge management ingenuity
    - Increased compliance with FIST
  - Enhanced maintenance management technology
    - Effective work force
    - Realized efficiency
    - Increased wrench time
- National O&M standards are being adopted by the Corps
    - Practices are moving further towards needs-based maintenance
    - ISO 55000 type asset management practices are being implemented across the enterprise
    - Maintenance standards will be utilized as a common baseline
- Corps' Maintenance Management Improvement Program
    - Identify critical assets
    - Standardize use of maintenance management software
    - Prioritize and schedule maintenance more efficiently

IPR Program Spending Drivers

O&M program spending drivers

- Aging infrastructure / non-routine maintenance
- Compliance
  - Electric reliability
  - Physical and cyber security
  - Environmental
  - Legal mandates
  - Safety
- Staffing and salaries
- Appropriations – highly variable; depends on Congressional action

O&M program spending drivers

- Aging infrastructure / non-routine extraordinary maintenance:
  - From 2012 through 2015, the Forced Outage Factor has averaged 3.5 percent for the system, driven by several long-term unit outages. Industry average is 2.4 percent for large hydro units.
  - Seeing large costs associated with repairing failed generating units across system, though NREX costs for returning failed units to service are usually recovered quickly.
  - GCL TPP overhauls will cost about $6 to $7 million more per unit due to additional needed repairs discovered once work began.
  - Found conditions can extend outages for maintenance and increase costs due to unforeseen repairs needed.
  - Reacting to unplanned forced outages creates additional demands on staff/OT/contract.
  - Resources are often shared between power plants to respond to unit failures, optimizing the level of staffing and the expertise needed to return equipment to reliable operation.

O&M program spending drivers

- $400M+ in NREX currently identified for 2016-2023
  - Unit Reliability
    - Grand Coulee Third Powerplant and Hungry Horse Cavitation Repairs
    - Numerous turbine oil replacement, EAL, & oil containment projects
    - BLH turbine repairs at John Day and Lower Snake projects
    - Winding repairs at John Day
    - Transformer refurbishment at The Dalles
    - Numerous intake gate, bulkhead & trashrack projects
    - Minidoka Unit 8 & 9 Overhaul
  - Water Control
    - Grand Coulee G1-18 Penstock and Draft Tube Coating Repairs
    - A wide variety of system-wide spillway related work in the Corps
    - Grand Coulee Dam Drum Gate Overhaul
    - Grand Coulee Dam Ring Seal Gate Refurbishment
    - Keys Pump Generating Plant Coaster, Reverse Flow, Bypass Valve and Piping
  - Cranes
  - Fire suppression systems
  - Numerous Balance-of-Plant Items

O&M program spending drivers

- **Safety**
  - Corps Safety Engineering Manual 385-1-1 was recently updated. It includes new requirements for fatigue management. Also, full compliance with other safety requirements are ongoing.
  - The continued emphasis on safety requires additional measures and a more rigorous and robust program. Emphasis on hazardous energy controls and industry-wide lessons learned.
  - Increased emphasis on job hazards analysis (JHA) and stop work.
- **Cultural Resource**
  - Mitigation requirements have increased as the program has moved from inventorying to mitigation (resolving adverse effects).
  - Additional resources needed to execute the program and ensure National Historic Preservation Act and section 106 compliance.

O&M program spending drivers

- **Environmental Compliance**
  - To settle a suit by the Columbia Riverkeepers, the Corps must investigate the use of environmentally acceptable lubricants (EAL) for its facilities along the Snake River and lower Columbia River.
  - In connection with the suit and to comply with a new Corps policy, we are required to implement an oil accountability plan.
  - These unexpected costs have been prioritized within the non-routine program by deferring other work so that budgets have not increased in total.
  - Reclamation has been notified of the intent to sue for Grand Coulee by the Columbia Riverkeepers as well.
  - Aquatic nuisance species (zebra and quagga mussels)
  - Responses to orders from the federal court regarding the Biological Opinion that governs F&W and CRFM programs are required under both the National Environmental Policy Act and the Endangered Species Act
  - CRFM for the Columbia FCRPS is reaching completion.
    - We have started receiving O&M funds through appropriation and it requires a $4 million match to be incorporated into the annual power budget.
    - These needs will continue to grow and require routine and NREX funds.

O&M program spending drivers

- **WECC/NERC compliance**
  - The program continues to see evolving standards, especially Critical Infrastructure Protection (CIP) for cyber security.
    - The CIP standards that become effective July 1, 2016 will increase requirements at all Bulk Electric System cyber assets .
    - Increased requirements for coordination, testing, training and communication.
    - Resource and implementation costs are expected to increase at all FCRPS facilities.
  - Additional coordination and agreements, specifically for compliance, between BPA, the Corps and Reclamation required.
    - Inter Control Center Protocol (ICCP)
    - 3 Agency Non-Disclosure
    - BlackStart/System Restoration
    - Delegation
  - WECC Audits – routine and spot
  - Cyber and physical security threats are increasing.
    - Multiple requirements for recurring assessments, accreditations and continual improvement.
    - Highly skilled personnel are needed to assess, develop, implement and manage physical security systems, power plant control systems and other cyber security systems.

O&M program spending drivers

- **Staffing/salaries:**
  - Recruiting and retaining qualified staff
    - Remote projects typically struggle to maintain staff and have high vacancy rates, which puts pressure on existing staff to maintain the routine work load and the growing non-routine extraordinary maintenance.
    - Over the last ten years, Grand Coulee has had a turnover rate of 50 staff per year. Relocation costs and training at Grand Coulee are up to $3.75 million per year.
  - Reclamation is nearing completion of the staffing plan for 43 additional staff at Grand Coulee that was approved in the 2014 IPR.
  - Corps Maintenance Engineering Training Program
    - The Corps continues the program at Lower Granite for benefit across the FCRPS.
    - Provides the next generation of maintenance engineers.
    - Expanding enrollment from 12 to 18 interns.
    - Needed to support O&M efficiencies, AIEI and execution of capital projects.
    - The projected cost of this program is about $1.8 million a year.
  - Increased staff (5 positions so far) to support the AIEI. The program also requires additional effort from existing staff to support improved scopes, schedules and budgets for proposed investments as well as a more consistent and accurate condition assessment program.

O&M program spending drivers

- **Staffing/salaries:**
  - Corps' trades and crafts (T&C) employees were subjected to a wage freeze along with all Federal GS employees. Now that the freeze has lifted, T&C wages have been realigned with prevailing rates based on a regional survey of the hydro industry.
  - While GS Employee wages were frozen, they still received within grade increases based on time in grade, usually around a 3 percent raise based on time in grade.
  - The correction in T&C wages and GS Employees' recent ~1 percent raises results in an average wage inflation of ~3 percent for the past eight years.
  - For Reclamation, the T&C salaries are negotiated or surveyed at the prevailing regional rate.
- **Historical T&C Wage Rate Increases**

	2009	2010	2011	2012	2013	2014	2015	Total 08-15	Annualized
Corps	4.6%	3.1%	0%	0%	0%	5.9%	3.7%	18.4%	2.4%
Reclamation	4.9%	2.0%	3.0%	3.5%	1.5%	3.0%	5.1%	25.3%	3.3%

* Corps wage rates for most common level – "I Grade"

O&M program spending drivers

- Appropriated expenses:
  - This amount is variable and depends on priorities in the appropriations, but needs to be covered as an in-year expense.
  - An example of this type of cost would be an emergency repair of a joint project feature associated with the dam structure that congress makes a high priority.
  - For example, in 2009 the Corps had $5.9 million in appropriated expenses and accounting cost reversals that had to be incorporated into the program that year.
  - Joint feature funding is related to congressional budget priorities.

IPR Program Funding Levels

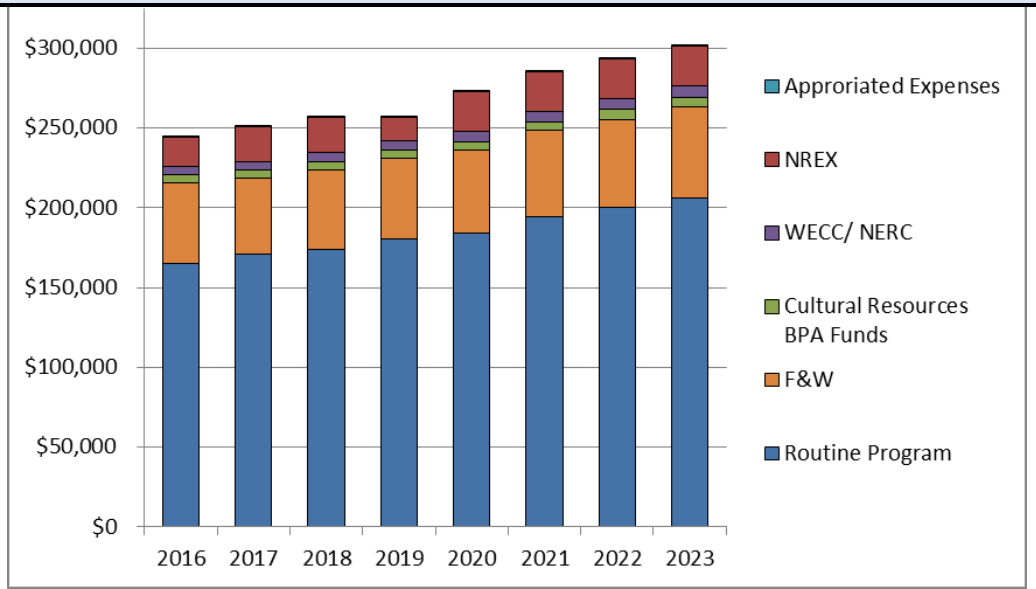
Corps O&M program funding levels

	Rate Case		Proposed IPR		
($1000s)	FY2016	FY2017	FY2017	FY2018	FY2019
Corps of Engineers	$243,885	$250,981	$250,981	$256,957	$256,957

- Corps budgeting process:
  - Establishes the minimum funding level required for routine Power and Joint Programs at hydropower projects, with no contingencies built in.
  - Provides justification for the budget request for BPA's Integrated Program Review.
  - Informs the annual power budget development for subsequent fiscal years.
  - The Corps plans to execute 98-100% of its expense budget every year.
  - Proposed spending levels for the Corps are decreased for FY2018-19 from levels identified in the 5-year O&M budget plan that was presented in the 2014 IPR.

Corps O&M budget for FY2016-2023

Initial Need Identified	Fiscal Year	Total Budget	WECC/ NERC	Fish & Wildlife BPA Funds	Cultural Resources BPA Funds	Routine Program	NREX	Appropriated Expenses No CRFM
	2016	$243,885	$5,348	$50,223	$4,954	$165,360	$18,000	$500
	2017	$250,981	$5,318	$47,494	$5,186	$170,983	$22,000	$500
$262,662	2018	$256,957	$5,583	$50,226	$5,334	$173,514	$22,300	$500
$270,300	2019	$256,957	$5,862	$50,613	$5,494	$180,288	$14,700	$500
	2020	$272,719	$6,155	$52,131	$5,658	$183,775	$25,000	$500
	2021	$285,482	$6,463	$53,695	$5,828	$194,496	$25,000	$500
	2022	$293,296	$6,786	$55,306	$6,003	$200,201	$25,000	$500
	2023	$301,345	$7,125	$56,965	$6,183	$206,072	$25,000	$500



Corps O&M budget pressures

The Corps baseline budget process defines minimum funding levels to maintain system capabilities. Despite identifying increased needs in the next rate period above what identified in the 2014 IPR, the Corps is proposing lower budget amounts than what was presented then.

- Starting in FY2014, CRFM O&M was funded at an appropriations level that requires a power match of about $4 million annually, an expense that had not been budgeted for in the IPR, so NREX funds were re-allocated to meet the need.
- The Corps took a total of $22.4 million in undistributed reductions in the BP-12 and BP-14 rate periods.
- In response to rate pressures, the Corps budget levels for ’18-’19 have been reduced by $19 million from the initial need identified
- All of these reductions, a cumulative $58 million in total, directly results in deferring non-routine maintenance work into future rate periods. Pushing this work out creates a bow wave of delayed work activities that will need to be addressed to maintain reliability.

Reclamation O&M program funding

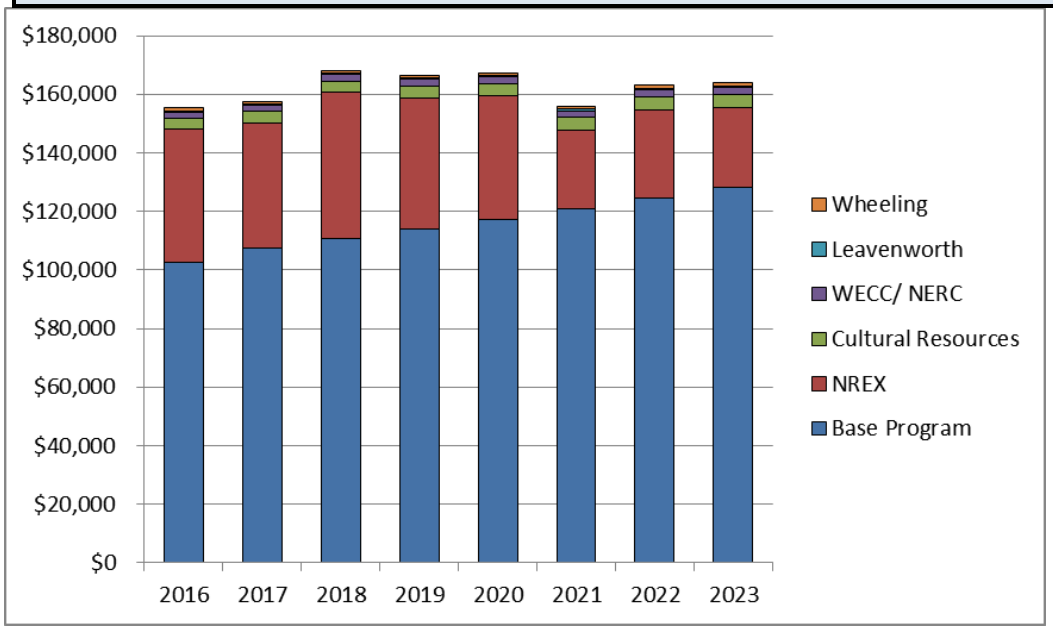
	Rate Case		Proposed IPR		
($1000s)	FY2016	FY2017	FY2017	FY2018	FY2019
Bureau of Reclamation	$156,818	$158,121	$158,121	$168,179	$166,603

- Reclamation baseline budgeting process:
  Similar to the Corps, proposed spending levels for the Bureau of Reclamation are consistent with levels identified in the 5-year O&M budget plan as presented in the 2014 IPR and confirmed through a rigorous baseline budgeting process. These processes determine the minimum funding required to meet operating reliability and performance requirements.

  - Establish the minimum funding level required for routine hydropower program, no contingencies are built in.
  - Provide justification for the budget request for BPA's Integrated Program Review.
  - Informs the Annual Power Budget Development for subsequent fiscal years.
  - Provides a common platform to construct and compare budgets across the FCRPS.

Reclamation O&M budget for FY2016-2023

Initial Need Identified	FY	Total Budget	WECC/ NERC	Cultural Resources	NREX	Wheeling	Base Program	Leavenworth Appropriated Expenses
	2016	$155,272	$1,860	$3,874	$45,260	$1,000	$102,778	$500
	2017	$157,621	$2,082	$3,847	$42,902	$1,000	$107,290	$500
$170,679	2018	$168,179	$2,164	$3,966	$49,928	$1,000	$110,621	$500
$169,717	2019	$166,603	$2,228	$4,084	$44,829	$1,000	$113,962	$500
	2020	$167,351	$2,296	$4,207	$41,967	$1,000	$117,381	$500
	2021	$155,897	$2,363	$4,333	$26,796	$1,000	$120,905	$500
	2022	$163,144	$2,434	$4,463	$30,217	$1,000	$124,530	$500
	2023	$163,934	$2,508	$4,597	$27,065	$1,000	$128,264	$500



Reclamation O&M budget pressures

The Reclamation baseline budget process defines minimum funding levels to maintain system capabilities. Despite identifying increased needs in the next rate period above what we had identified in the 2014 IPR, Reclamation is proposing to lower budget amounts from what was presented then.

- Reclamation took a $9.5 million per year reduction in the BP-14 rate period
- In response to rate pressures, the Reclamation budget levels for the next rate period have been reduced by $5.6 million below the initial need identified
- All of these reductions, almost $25 million in total, directly result in deferring non-routine maintenance work into future rate periods. Pushing this work out creates a bow wave of delayed work activities that will need to be addressed to maintain reliability.

Grand Coulee staffing status

- Grand Coulee and Hungry Horse are currently staffed at 509 positions
  - By end of the fiscal year, they should be close to being fully staffed.
  - Significant hiring since last IPR include new training office, increased reliability compliance staff and increased O&M staff.
- Remaining 41 FTE's include staffing positions in the following areas;
  - Safety
  - Security
  - Operations and Maintenance
  - Engineering
  - Long Range Planning
- Grand Coulee Power Office is currently evaluating additional staffing requirements for the following areas:
  - Apprenticeship Program
  - Reliability Compliance Office

Third Powerplant Overhaul Program

- **Grand Coulee Generator G24 Status**
  - Unit G24 overhaul was started in March 2013 and took 37 months to complete.
  - G24 Overhaul Schedule delays
    - Stop work orders issued in 2013 due to hazardous materials found in the shaft uncoupling and asbestos encountered in gasket materials.
    - Wicket Gate Condition: found extreme wear, requiring extra work to refurbish, amounting to 162 days delays and a $1.3 million contract modification.
    - Other contract modifications required extra work for various machining of mechanical surfaces, repairs to operating ring and generator shaft defects, replacement of the thrust bearing base ring, additional coatings and surfacing repairs, and other.
    - After initial commissioning in October 2015, contractor punch list items incl. wicket gate galling, leakage into the shaft and other extended repair work into March 2016.
  - G24 returned to BPA for commercial service on April 13, 2016.
  - Several G24 lessons learned meetings were held including a two-day workshop with the contractor in March 2016; we are already applying lessons learned to next unit to mitigate risk of further delays on Units G22 and G23.
- **Grand Coulee Generator G23 Status**
  - Unit G23 overhaul was started in April 25, 2016.
  - On track to complete by October 2017.

Third Powerplant Overhaul Program

- **Contract Modifications for G22-G24** (62 for G24 Alone)

• Pre-overhaul, misc. work	$ 500k
• Wicket Gates*	$ 1.3 million
• Servos/Mech Seal, Head covers	$ 1.1 million
• Coatings (Scroll case, Turbine Pit)	$ 600k
• Machining of various components, shaft repairs	$ 960k
• New Base Ring, Operating Ring	$ 1.5 million
• Field Coils, Rotor, Misc. refurbishment	$ 900k
Total G24 (assume the same for G22-G23)	$ 6.9 million
Total G22-G24 (incl. Operating Ring)**	**$20.0 million**

* = Wicket Gate Issues on G24 caused a 5 + month project delay. We already purchased new Gates (capital funding) for Units G22-G23 to mitigate this issue. It is expected that new wicket gate design for G22-G23 may show up to a 0.2% efficiency gain.

** = Operating Ring on G24 found to be near marginal to reuse; Project has been funded to purchase of spare Operating Ring(s) for each unit to mitigate this issue.

Third Powerplant Overhaul Program

$millions	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27
G22-24	$20	$27.1	$30	$30	$20	-	-	-	-	-	-	-
G19-21 (NREX)	-	$0.5	$0.5	$0.5	$1	$3	$3	$3	$3	$3	$3	$3
G19-21 (Capital)	$2	$1.8	$2.5	$10	$61	$60.3	$57.4	$60.5	$61.6	$62.2	$63.3	$18

- Reclamation completed studies confirming feasibility of uprating G19-22 from 690 MW to 770 MW.
  - Reclamation and BPA are evaluating the cost effectiveness of the uprate.
  - G19-21 will be funded primarily with capital funds, in contrast to the G22-24 Overhaul Project, which was primarily expense funded (non-routine).

Risks to FCRPS hydro program performance

- Cost increases due to Federal court-ordered action on BiOp and NEPA.
- Non-routine extraordinary maintenance funding does not include contingency for unplanned events.
- Advanced age and degradation of the equipment has reached a critical juncture requiring more non-routine maintenance and more frequent preventive maintenance.
- O&M budget reductions jeopardize effective execution of maintenance and response to forced outages.

Risks to FCRPS hydro program performance

- Electric reliability compliance requirements continue to increase.
- Cyber and physical security assessments and protection measures must be funded to mitigate vulnerabilities to system integrity and resilience. DOD and DOI requirements must be met.
- FCRPS commitment to environmental stewardship
  - National Pollutant Discharge Elimination System permits
  - BiOp, NEPA, fish passage and fish hatcheries
- Aquatic nuisance species (zebra and quagga mussels)

Appropriations challenges

- Mitigation responsibilities
  - Hatcheries – Many hatcheries for the FCRPS are in need of rehabilitation.
  - Fish Passage – BiOp requirements are increasing at both mainstem and tributary locations.
  - $2.9 billion of CRFM-constructed infrastructure will increasingly require O&M and NREX funding.
- Joint Program
  - The appropriated share of joint activities are expected to become more difficult to match in the future.

Supplemental Information

- FCRPS Cultural Resources (Corps and Reclamation)
- Corps Fish and Wildlife O&M
- Reclamation Leavenworth Hatchery Facilities
- Corps Columbia River Fish Mitigation (CRFM)

FCRPS Cultural Resource Program

- **Program purpose**
  - Federal agencies are required to address impacts to cultural resources resulting from operation and maintenance of FCRPS hydroelectric projects.
    - Must comply with National Historic Preservation Act, Archaeological Resources Protection Act, and Native American Graves Protection and Repatriation Act, and the FCRPS Systemwide Programmatic Agreement (2009).
    - Compliance is accomplished through eight system wide cooperative working groups composed of regional tribes, state historic preservation officers and other affected land management agencies.

Cultural Resources Program Funding Proposal

- FY 2018 –19 Projected Budget Needs

	FY 2018			FY 2019		
	Power Share	Appropriated Share	Total	Power Share	Appropriated Share	Total
Corps	$5,334	$822	$6,156	$5,494	$846	$6,340
Reclamation	$3,966	$444	$4,410	$4,084	$457	$4,541
TOTAL	**$9,300**	**$1,266**	**$10,566**	**$9,578**	**$1,303**	**$10,881**

- In addition to routine O&M requirements, funding is supplied as-needed for non-routine requirements (e.g. emergency shoreline stabilization).

FCRPS Cultural Resource Program

- **Key factors supporting proposed funding levels**
- Program scope and compliance requirements
  - Conduct identification and inventory, National Register and adverse effect determinations and mitigation for effects on archaeological sites and traditional cultural properties.
  - Maintain staffing levels to ensure effective program execution and compliance with Systemwide Programmatic Agreement; includes staff support for shoreline stabilization projects such as engineering design, GIS and NEPA.

FCRPS Cultural Resource Program

- **Program activities are guided by long-term goals tied to procedural steps in the National Historic Preservation Act.**
  - Inventory of historic properties
  - Evaluation of National Register significance
  - Resolution of adverse effects (Mitigation)
- **Program accomplishments at 14 hydro projects as of FY2015:**

SURVEY - Archaeological	Total Project Acres Affected by O&M	Total Acres Surveyed to date
	559,000	**135,000**
SURVEY - TCP	Number of Studies Completed as of FY15	
	122	
NR ELIGIBILITY DETERMINATIONS	Total Number of Sites Identified	NR Eligibility Determinations Completed
	4,235	**1,296**
RESOLUTION OF ADVERSE EFFECTS	Shoreline Stabilization Projects	Other Mitigations
	34	**192**

FCRPS Cultural Resource Program

- **Projected program needs in FY2018 and FY2019:**
  - Continue inventory of project lands.
  - Continue National Register evaluations of about 3,000 sites.
  - Continue mitigation actions to resolve adverse effects* of project operations on archaeological sites and traditional cultural properties.

*Resolution of Adverse Effects includes bank stabilization, data recovery, site restoration, construction of interpretive trails at public parks, limiting public access to sites, invasive weed control, artifact curation, educational displays, brochures, posters, short films, popular books, funding public service announcements, installation of signs, site monitoring, training, and public presentations.

Corps mitigation/treatment

Bear Paw Rock monitoring
Albeni Falls project

BOR Mitigation/Treatment

Stabilization of reservoir bank to reduce erosion of artifacts from an archaeological site
Grand Coulee project

US Army Corps of Engineers

Joint Funded Operations and Maintenance Budget
for the
Fish and Wildlife Program

Portland, Seattle and Walla Walla Districts

FCRPS Biological Opinion uncertainties

- In May 2016 Judge Michael Simon issued an opinion and ordered federal agencies to complete a new BiOp by March 2018
- The Court directed the Action Agencies to continue to fund and implement the 2014 BiOp until the new BiOp is in place.
- Cost estimates for the FY 2018-19 rate period may be affected by findings or changes in approach recommended by the new BiOp
  - The FCRPS F&W Program – expense
  - CRFM Program -- construction

Corps F&W Program

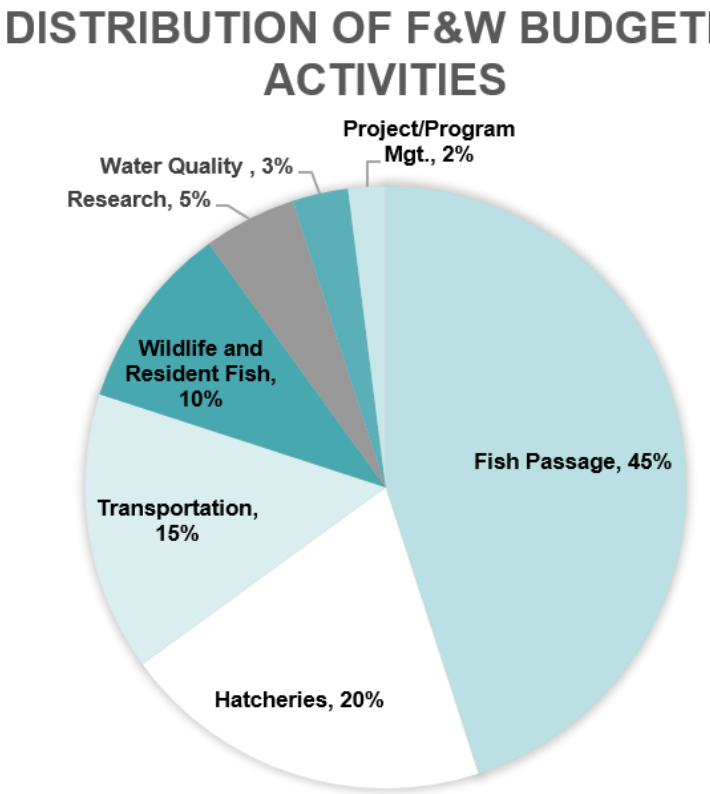
Funding Sources

- Appropriated funding from Congress (approximately 25 percent):
  - Environmental Stewardship
  - Budgeted two years out
  - Sometimes differences in the President's budget and actual Appropriations from Congress
  - Uncertainty in funding levels from year-to-year, plus or minus
- Direct Funded BPA Program (approximately 75 percent):
  - Matched on a project-by-project basis
  - BPA percent varies by project (15 to 100 percent)

Program Emphasis

- Anadromous Fish (87 percent):
  - Operation/maintenance of fish passage facilities at dams, mitigation hatcheries, smolt transportation and multi-year fish passage research
- Wildlife and Resident Fish (10 percent):
  - baseline wildlife management, habitat mitigation, mitigation hatchery maintenance and invasive species coordination
- Water Quality (3 percent):
  - Total dissolved gas and temperature monitoring/modeling/coordination

Distribution of F&W budgeted activities



Program risks:

- New infrastructure requires O&M funding.
- Uncertainties in BiOP compliance and approach.
- Unknown cost growth in labor, materials and supplies.

Minto adult fish facility during construction

Foster adult fish facility under construction

Corps routine direct funded F&W expense budget

Year	Total ($000's)
2016	$50,223
2017	$47,494*
2018	$50,226
2019	$50,613

Starting in FY 2016, these budgets may include CRFM O&M, but may not include additional funding required for NREX and small capital.

* Some appropriations for CRFM in FY 2017 were applied to a capital project and not O&M

Big issues on the horizon

- **More Fish and Wildlife Program requirements are putting a <u>direct</u> strain on the budget:**
  - BiOp requirements for the Columbia and Willamette Rivers.
  - Additional Clean Water Act requirements.
  - Hatchery management requirements.
  - Invasive species.
    - Quagga and zebra mussels
  - Nationwide appropriated funds.

Operations, Maintenance, and Replacement Budget
Leavenworth Fisheries Complex

Leavenworth fisheries complex

- Reclamation has a continuing responsibility to mitigate, to acceptable levels of abundance, the salmon resources adversely impacted by the construction and operation of Grand Coulee Dam (1991 IG audit).
- Leavenworth, Entiat and Winthrop National Fish Hatcheries was constructed from 1938-1940. The facilities were transferred to the U.S. Fish and Wildlife Service in 1949.
- The budget covers operations of the three hatcheries as well as a portion of the Mid-Columbia Fisheries Resource Office (MCFRO) and the Olympia Fish Health Center (OFHC).
- The MCFRO provides monitoring and evaluation program, tagging, marking programs, permit compliance, biological assessments, hatchery and genetic management plans, ESA compliance, supplies and materials.
- The OFHC provides diagnostic fish health services at Leavenworth, Entiat and Winthrop NFH's monthly fish health inspection throughout the entire rearing cycle of the salmon (egg to adult), diagnostic work, supplies and materials.
- LFC fish production programs support mitigation efforts in the Columbia River Basin. Production goals are set in the Columbia River Fisheries Management Plan under the U.S. v. Oregon decision of 1969.

Leavenworth fisheries budgets

- O&M Budget Allocation:
  - Facilities operations: ~ 60 percent
    - For Leavenworth, Entiat and Winthrop hatcheries
  - MCFRO support: ~ 20 percent
  - Olympia Fish Health Center support: ~10 percent
  - Facilities maintenance: ~ 10 percent
- O&M Budget Levels

	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23
Approp Funding	$5.8	$7.5	$4.9	$15.8	$8.6	$2.1
Direct Funding	$6.5	$6.7	$6.9	$7.2	$7.4	$7.6

Fiscal years 2017 – 2023 program drivers

- Regulatory compliance:
  - New requirements to comply with terms and conditions of consultations and permits.
    - Leavenworth fish screens
    - Addressing phosphorus issues
- Aging infrastructure:
  - Original construction in 1939.
  - Significant rehabilitation/modernization of hatcheries required.
- Appropriations:
  - Flat and/or declining budgets.

Columbia River Fish Mitigation Project (CRFM)

Columbia River Fish Mitigation Program

- Purpose: Mitigate impacts of the dams to anadromous fish passage in the Columbia, Lower Snake and Willamette rivers to meet Biological Opinion requirements.
  - CRFM (Col/Lower Snake River) initiated in 1991.
  - Willamette River Basin efforts initiated in 2008.
  - Implement fish passage improvements on both systems that were not part of the original dam construction for juvenile and adult fish passage.
- Authority: Original Congressional Acts for project construction and operation.
- Funding source: Congressional appropriations. BPA repays U.S. Treasury for "power share" of costs.
- Transfers to "Plant-in-Service"
  - Costs transferred when new facility goes into operation or study completed.

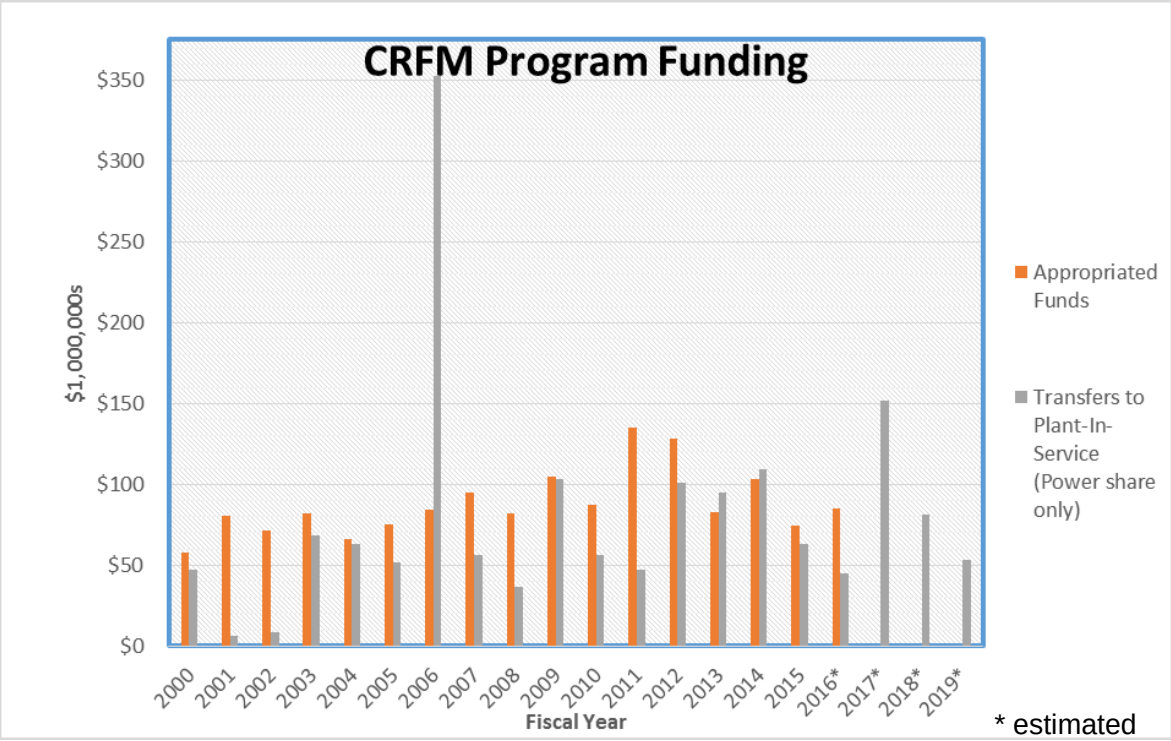
Columbia River Fish Mitigation Program

- Primary focus: Implement Biological Opinions and Fish Accord agreements.
  - Hydro improvements for juvenile and adult salmon and steelhead passage at Corps dams.
  - Avian predation management actions.
  - Pacific Lamprey passage actions.
  - Research and evaluation, including avian predator management, fish passage improvements at dams and estuary habitat restoration.
- Goals: Comply with the FCRPS and Willamette Biological Opinions while continuing the benefits of the multi-purpose projects (hydropower, navigation, recreation, flood damage reduction).
  - Improve and address impacts to fish survival that were not considered when the dams were originally built.
  - Achieve BiOp requirements to avoid jeopardizing endangered species while maintaining authorized purposes of Willamette, Columbia and Snake River dams owned and operated by the Corps.

CRFM – costs and schedule

- The current Federal cost estimate is $2,795,775,000.
  - $449 million increase from that previously presented to Congress (FY 2016).
  - Increase is for the Willamette River authorized modifications and contingency.
- Funds allocated through 2015: $1.98 billion.

- Current BiOp completion is 2023.



Columbia River Fish Mitigation Project

- Future – way forward :
  - FCRPS BiOp
    - Continue implementing the 2014 FCRPS BiOp.
    - Consult with NMFS to complete a new BiOp.
    - Complete NEPA requirements per opinion and order issued by the U.S. District Court of Oregon.
  - Willamette BiOp
    - Complete adult collection facility improvements at Foster and Fall Creek dams.
    - Using a phased approach, evaluate downstream passage improvements at Cougar and Detroit dams and implement if warranted. Prior to fully designing and constructing Detroit downstream passage, prove the concept at Cougar.

Financial Disclosure

This information has been made publicly available by BPA on June 20, 2016, and contains information not sourced directly from BPA financial statements.