STRATEGIC ASSET MANAGEMENT PLAN

For the Federal Columbia River Power System

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1.0 EXECUTIVE SUMMARY

The Federal Columbia River Power System (FCRPS) consists of 31 multipurpose dam and operating projects owned by the U.S. Army Corps of Engineers (the Corps) and the Bureau of Reclamation (Reclamation). As a multipurpose system, the FCRPS produces both power and non-power benefits for the Pacific Northwest. The Corps and Reclamation operate and maintain the facilities with a combination of Bonneville Power Administration (BPA) direct funding and federal appropriations. BPA solely funds activities related to power generation and jointly funds activities that support the multiple purposes of the facilities. With 196 hydro generating units and a capacity of 22,050 MW, the FCRPS is the largest hydro system in the United States.

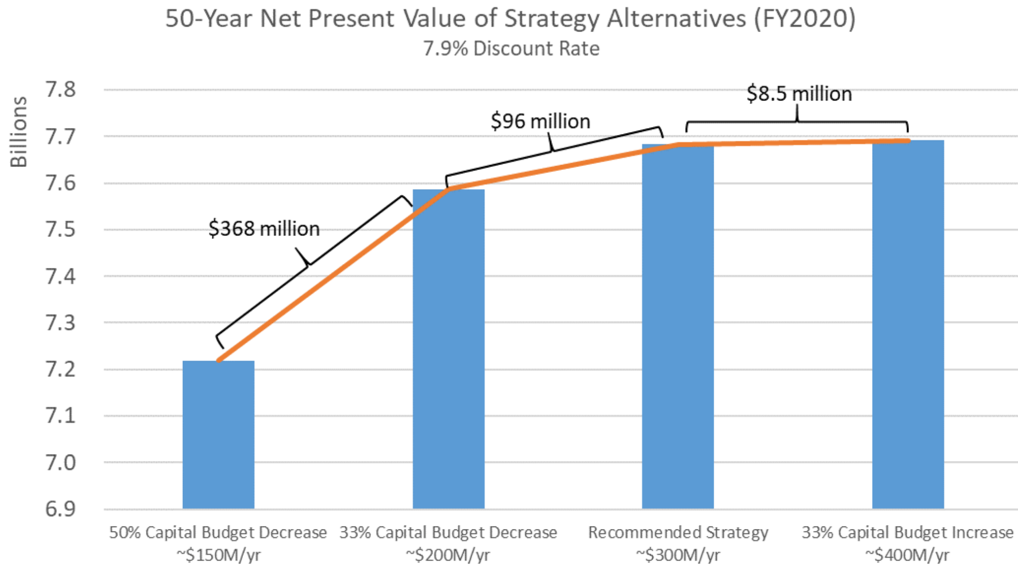
For decades, the FCRPS has been an engine of economic prosperity. It provides low-cost, carbon-free electricity, flood risk mitigation, irrigation, navigation, municipal and industrial water supply and recreation opportunities throughout the region. Today, the hydro system's flexibility supports the integration of over 2700 MW of renewable capacity and is integral to BPA's future participation in an Energy Imbalance Market. As trusted stewards of these assets, the Three Agencies also have an obligation to mitigate for the environmental and cultural impacts of the system.

Effective management of FCRPS assets requires balancing the many uses of these shared resources as efficiently as possible. The Three Agency asset management strategy is to make decisions that maximize the value of the FCRPS while meeting each agency's various obligations. This means identifying optimal investment timing to mitigate safety, environmental and financial risks, tailoring maintenance programs to the level of service necessary to meet obligations and efficiently planning and operating the power system. In these areas, decision making is more mature for capital investments than for operations and maintenance decisions. Since 2008, the Three Agencies have used decision making tools to identify the optimal level of capital investment in the FCRPS based on asset condition, criticality and risk. Starting in 2017, the Asset Investment Excellence Initiative (AIEI) expanded the use of these tools to develop a 20-year portfolio of capital projects that is optimized on an annual basis. With the Corps' Operations and Maintenance Optimization Initiative (OMOI) and a similar initiative beginning at Reclamation, a focus on including condition, criticality and risk in operations and maintenance decisions is underway.

Recommended funding levels for the capital and expense programs are similar to those presented in the 2018 SAMP. Long-term planning analyses have shown the benefits of increased levels of capital investment in the FCRPS for many years. Although the Three Agencies and ratepayers generally agree on investment needs, capital investments have yet to ramp up to the levels identified in previous Integrated Program Reviews (IPRs). Several major powertrain investments are core to the business case for a higher level of investment. These projects have taken longer than expected to plan, approve and execute. Due to their size and complexity, advancing other projects to fill in the gaps is not always possible nor is it always the best business decision. The result is a $36 million reduction in capital for the 2022-2023 rate period and a one-year delay in ramping up to $300 million as compared to 2018 IPR forecasts.

	Rate Case FYs		Future Fiscal Years							
$ millions	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Total Capital	264	281	300	307	314	320	328	335	342	350

This level of investment has a $7.7 billion Net Present Value (NPV) through reductions in failure risk and incremental efficiency benefits. Levels of investment higher than the recommended level show little incremental value while lower investment levels have increasingly lower NPVs.



The expense program is held flat for the 2022-2023 rate period and then limited to rate of inflation in future years. Over the last 10 years, total actual expenses grew by 5% per year, on average. Holding increases closer to 2% per year without affecting critical Corps and Reclamation programs will be no easy task. For the 2020-2021 rate period, the Corps and Reclamation already made hard decisions to support BPA's goal to achieve no power rate increase. The Three Agencies will leverage the OMOI to find further efficiencies and mitigate risk associated with holding to these levels.

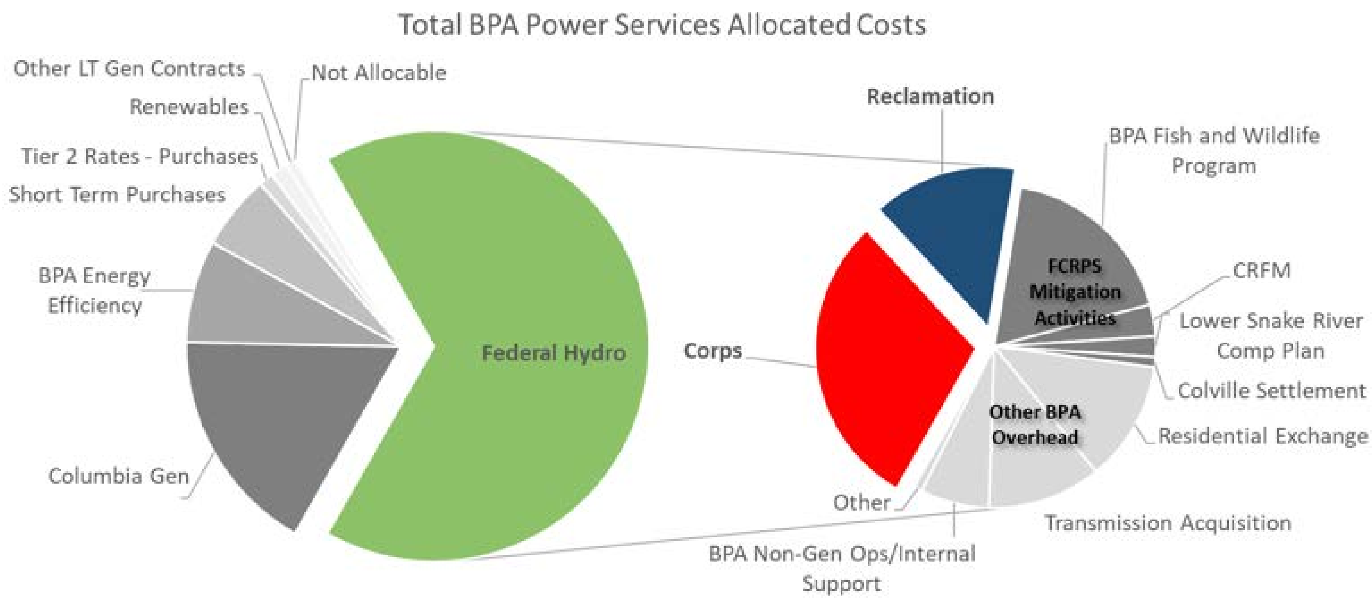
	Rate Case FY's		Future Fiscal Years							
$ millions	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Total Expense	405	405	415	420	428	434	440	447	454	460

In general, the strategy drives capital and expense funding to align proportionately with each plants' contribution to average annual generation. Although Area and Local Support plants appear high relative to their generation importance, a higher percentage of funding for those facilities supports multipurpose activities compared to other Strategic Classes.

Overall, the direct funded capital and expense forecasts addressed in this SAMP are expected to result in a 50-year levelized cost of generation of $9.56/MWh. The 50-year fully loaded cost of the 31 plants in the FCRPS is $22.00/MWh when all costs allocable to the Federal Hydro System are allocated.

Strategic Class	% of FCRPS Average Annual Generation	% of 50-Year Capital Forecast	% of 50-Year Expense Forecast	50-Year Cost of Generation ($/MWh)	50-Year Fully Loaded Cost ($/MWh)
Main Stem Columbia	77%	61%	64%	$7.54	$19.04
Lower Snake	12%	15%	14%	$12.13	$29.80
Headwater	6%	8%	8%	$11.76	$23.56
Area Support	4%	11%	10%	$30.07	$45.52
Local Support	1%	5%	4%	$42.48	$56.06
FCRPS	100%	100%	100%	$9.56	$22.00

Corps and Reclamation costs account for 44% of all costs allocated to Federal Hydro. Costs allocated to Federal Hydro account for 66% of Power Services total costs. Allocable costs are allocated to the various energy resources Power Services utilizes based on an agreed upon methodology developed by BPA Finance. All of these costs ultimately contribute to BPA's Priority Firm (PF) rate.



2.0 ACKNOWLEDGEMENTS

2.1 Senior ownership

2.1.1 FCRPS Asset Management Commitment

In 2019, the Corps, Reclamation and BPA developed the FCRPS Asset Management Commitment. This commitment outlined the asset management mission, vision and values of the FCRPS and was signed by the Corps' Northwestern Division Commander, Reclamation's Columbia Pacific Northwest Regional Director and BPA's administrator.

FCRPS Asset Management Commitment

Vision

The FCRPS agencies will strive to sustain the efficiency, affordability and reliability of the System's long-term value through business processes that reflect industry best-practices in asset management. These processes include all aspects of planning, resourcing, and approving work, while informing strategies for operations, maintenance, and reinvestments of FCRPS assets.

Background

The U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, and Bonneville Power Administration act together through a strong three-agency alliance as responsible stewards of the Federal Columbia River Power System (FCRPS). The FCRPS is comprised of billions of dollars in assets and provides great economic and social benefits for the Pacific Northwest and beyond.

Mission

The FCRPS exists to deliver benefits to power, irrigation, navigation, and other customers and key stakeholders. We owe it to those customers and stakeholders to proactively implement and utilize industry leading asset management practices. This will enable us to provide those products and services with the highest regard to safety, environment, reliability, reputation, and cost.

Asset Management Values

Customers

- Embrace the FCRPS' role as a service provider to a broad range of customers and stakeholders. Cultivate a culture of commitment as federal partners to deliver demonstrated value to those customers.
- Establish ourselves as competent and transparent providers of the services expected by our customers and stakeholders while being good stewards of the public's assets.

People

- Value safety above all else – every process and action first identifies risks and preventative measures to protect our greatest asset, our employees.
- Ensure that roles and responsibilities of our organizations are clear, meaningful, valuable and rewarding.
- Enable staff to exercise leadership and appropriate levels of decision-making.
- Invest in employee training and development to effectively accomplish their function.

Process/Information

- Balance cost, performance, and risk through a consistent and credible decision-making process. Key stakeholders understand and have confidence in its integrity.
- Manage and utilize information and knowledge to enable informed decisions and effective work execution.
- Leverage innovative solutions and industry best practices to continuously improve achievement of FCRPS objectives.

Plant

- Operate, maintain, and invest in our facilities to optimize their value to customers and stakeholders over the long-term that is consistent with the financial health and stability of the FCRPS.
- Identify the business value of each facility, asset, and component and align performance expectations with that value, including all areas listed below:
  - Generation & Capacity
  - Cost
  - Risk tolerance
  - Health & safety
  - Environmental responsibilities
  - Legislative risks/requirements
  - Regulatory requirements
  - Cultural Resource responsibilities

Brigadier General D. Peter Helmlinger
Commander, Northwestern Division
U.S. Army Corps of Engineers

Ms. Lorri Gray
Regional Director, Pacific Northwest Region
U.S. Bureau of Reclamation

Mr. Elliot Mainzer
Administrator
Bonneville Power Administration

2.1.2 BPA Senior Ownership

The Federal Columbia River Power System is a tremendous asset to the Pacific Northwest, producing low cost, reliable, carbon-free power for the region. As Trusted Stewards of the FCRPS, it is critical that BPA and its federal partners employ sound Asset Management principles to ensure the system is operated safely, efficiently and remains a competitive resource for years to come. The Asset Management Commitment signed by all three agencies is the next step in the evolution of the FCRPS Asset Management program.

We are also committed to working with our partners in support of the BPA 2018-2023 Strategic Plan by improving our cost management discipline, continuing to advance our asset management practices, modernizing system operations and related technology, and positioning FCRPS assets to take advantage of new market opportunities. These actions will put us in the best place to realize BPA’s long-term objective of resubscribing the federal system to its customers in 2028.

Joel D. Cook
Senior Vice President for Power Services

2.2 Strategy Development Approach

2.2.1 Key Contributors

Agency	Group	Contribution
Bonneville Power Administration	Generating Assets (PGA and PGAF)	• Lifecycle cost minimization models (C55 - Predictive Analytics) • Equipment degradation rates • Risk assessment • Economic analysis • Author of SAMP
	Power Forecast and Planning (PTM)	• Long Term Price Forecasts
	Operations Planning (PGPO)	• Consequences of Unit Outages
	Revenue Requirement, Repayment and Financial Strategy (FTR)	• Discount Rate • Inflation Rate
Army Corps of Engineers	Portland, Seattle, Walla Walla Districts, Northwestern Division	• Project costs estimates and valuation • Joint Investment Identification • SAMP Review
	Plant Staff	• Project information • hydroAMP Condition Assessments
	Hydroelectric Design Center	• Equipment Failure Curves • Technical Expertise
Bureau of Reclamation	Columbia Pacific Northwest Region	• Project cost estimates and valuation • Joint Investment Identification • SAMP Review
	Plant Staff	• Project Information • hydroAMP Condition Assessments
	Technical Services Center	• Technical Expertise
Three Agency Teams	Various	• FCRPS Goals, Objectives and Initiatives

The SAMP is reviewed internally by Generating Assets (PGA and PGAF) staff and externally by the Army Corps of Engineers (Portland District, Seattle District, Walla Walla District, and Northwestern Division) as well as by the Bureau of Reclamation (Columbia Pacific Northwest Region).

2.2.2 Key Activities

Activity	Description
Equipment Condition Assessments	• Plants perform annual condition assessment update
Update Modeling Parameters	• Price Forecast • Inflation Rate • Discount Rate • Condition Degradation Rates • Failure Curves • Equipment Outage Durations • Equipment Outage Consequences • Budget Constraints
Asset Management Maturity Assessment	• Conduct Asset Management maturity assessment by surveying FCRPS employees of various disciplines
Review and Update Goals, Objectives and Initiatives	• Goals, Objectives and Initiatives are reviewed by FCRPS leadership, incorporating results from the maturity assessment
Run Predictive Analytics	• Analyze costs, benefits and risk of investment at different budget levels • Identify the optimal level of achievable investment
Share preliminary results with federal partners	• Review Optimal Replacement Dates of equipment • Communicate any major changes to modeling
Develop SAMP	• Produce charts, tables and analysis describing the benefits costs and risks of pertinent investment scenarios • Create/update SAMP document
Review SAMP	• Review SAMP with Federal Partners • Present SAMP summary at Joint Operating Committees
Publish SAMP	• Incorporate changes from review and finalize document • Provide SAMP to Asset Planning team for input into Asset Plan

3.0 STRATEGIC BUSINESS CONTEXT

3.1 Alignment of SAMP with Agency Strategic Plan

This SAMP is intended to outline a strategy that meets the Federal Columbia River Power Systems' (FCRPS) three long-standing goals of Low-Cost Power, Power Reliability and Trusted Stewardship. These goals are achieved through strategies that seek to maximize the value of the FCRPS while balancing the various missions of BPA, the Corps and Reclamation. The goals are in direct alignment with the near-term objectives of the BPA 2018-2023 Strategic Plan. The Asset Management Strategies and Plans presented in this SAMP support the following Strategic Plan objectives:

Strategic Plan Objective	FCRPS Goal	Supporting Strategy, Action or Process	Status
Objective 1a: Improve cost-management discipline	Low-Cost Power	Integrate asset condition, criticality and risk into operations and maintenance decision making	New Initiative
		Hold total expense program increases at or below the rate of inflation	On-going
		Optimize capital investment plan to do the right projects, at the right time, for the right cost.	On-going
Objective 2a: Administer an industry-leading asset management program	Low-Cost Power Power Reliability Trusted Stewardship	Develop and maintain asset strategies and plans that are informed by asset condition, criticality and risk	Continuous Improvement
		Perform alternatives analyses that consider total lifecycle costs and long term need of assets	Continuous Improvement
Objective 2b: Modernize federal power and transmission system operations and supporting technology	Low-Cost Power Power Reliability	Reduce the risk of lost generation and direct cost of failure through replacements that improve unit reliability	On-going
		Seek efficiency improvements through turbine replacements and dispatch optimization	On-going
		Grid Modernization: Automatic Generation Control, Fed Data, Metering	On-going

Strategic Plan Objective	FCRPS Goal	Supporting Strategy, Action or Process	Status
Objective 3a: Increase power revenues through new market opportunities for clean capacity	Low-Cost Power Power Reliability	Understand seasonal unit availability requirements at each plant, providing availability *where* and *when* it is needed.	New Initiative

3.2 Scope

The SAMP outlines strategies for both the FCRPS Asset Management program and FCRPS hydro system assets. Asset Management maturity is assessed and specific gaps are described with plans for improvement. For asset strategies, optimal levels of investment are identified based on the condition, criticality and risk of FCRPS assets. These results are intended to drive investment identification and, in combination with input from the 31 hydropower facilities, form the basis for the FCRPS System Asset Plan.

Within the FCRPS there are 196 main generating units at 31 hydro plants. There are an additional 16 station service, fish attraction, and pump turbine units. The SAMP primarily covers powertrain and critical ancillary components that are either directly related to power production or are critical supporting equipment for day-to-day operations. About 17% of the inventoried assets are joint-use assets. Typically, assets that serve the multiple authorized purposes of a facility, not solely hydropower, are deemed joint-use. For these assets, the Corps and Reclamation must acquire both federal appropriations for the joint-use portion and funding from BPA for the power share. Due to these complexities, joint-use assets are underrepresented in the asset inventory and the ability to effectively plan their replacement or refurbishment is challenging. For 2020, the Three Agencies piloted optimizing investment in joint assets separately from power funded assets and compared the results to the Corps' prioritization of appropriated projects. The goal is to further align these processes by expanding the joint asset inventory and ensuring that the value of investment in joint assets is accurately captured.

Specific areas in which asset planning is still maturing are Reclamation-owned switchyards, fish facilities funded under Columbia River Fish Mitigation (CRFM) and dam safety civil features. Although some investments in each area are included in the Asset Plan, a Three Agency proactive asset strategy has not been developed for these assets. It is not anticipated that excluded costs would increase total Capital budget forecasts once incorporated into the SAMP. Rather, the Capital investment portfolio would be reoptimized under existing budgets.

3.3 Asset Description and Delivered Services

The FCRPS is comprised of 31 hydroelectric plants, 21 owned and operated by the Corps and 10 by Reclamation, and has an overall capacity of 22,050 MW. In an average water year, the FCRPS produces 76 million megawatt-hours of electricity. The 31 plants are located throughout the Columbia River Basin in Washington, Oregon, Idaho and Montana. Each plant is grouped into one of four Strategic Classes, which describe their respective roles in the FCRPS.

Table 3.3-1, Assets

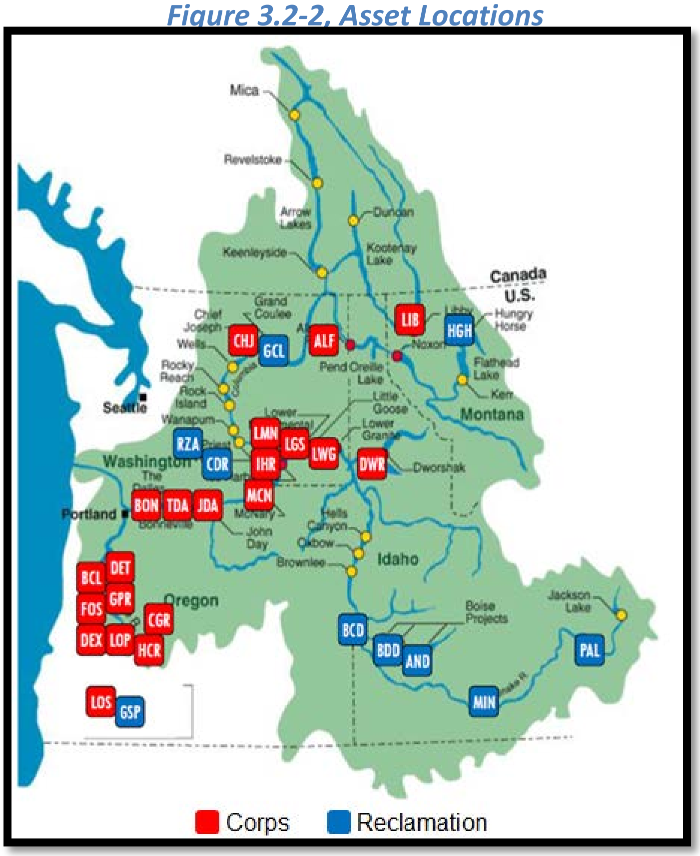
Plant	ID	Units	MW Capacity	aMW Energy	Strategic Class	Operator
Grand Coulee	GCL	24	6,735	2,422	Main Stem Columbia	Reclamation
Chief Joseph	CHJ	27	2,614	1,377	Main Stem Columbia	Corps
McNary	MCN	14	1,120	549	Main Stem Columbia	Corps
John Day	JDA	16	2,480	1017	Main Stem Columbia	Corps
The Dalles	TDA	22	2,052	805	Main Stem Columbia	Corps
Bonneville	BON	18	1,195	552	Main Stem Columbia	Corps
Dworshak	DWR	3	465	216	Headwater	Corps
Lower Granite	LWG	6	930	250	Lower Snake	Corps
Little Goose	LGS	6	930	255	Lower Snake	Corps
Lower Monumental	LMN	6	930	300	Lower Snake	Corps
Ice Harbor	IHR	6	693	227	Lower Snake	Corps
Libby	LIB	5	605	227	Headwater	Corps
Hungry Horse	HGH	4	428	94	Headwater	Reclamation
Albeni Falls	ALF	3	49	21.6	Area Support	Corps
Detroit	DET	2	115	49	Area Support	Corps
Big Cliff	BCL	1	21	12.2	Area Support	Corps
Green Peter	GPR	2	92	29.3	Area Support	Corps
Foster	FOS	2	23	11.9	Area Support	Corps
Lookout Point	LOP	3	138	41.1	Area Support	Corps
Dexter	DEX	1	17	11.2	Area Support	Corps
Cougar	CGR	2	28	19.9	Area Support	Corps
Hills Creek	HCR	2	34	22.5	Area Support	Corps
Lost Creek	LOS	2	56	45.4	Area Support	Corps
Palisades	PAL	4	176	84	Area Support	Reclamation
Minidoka	MIN	4	28	16.6	Local Support	Reclamation
Anderson Ranch	AND	2	40	19.6	Local Support	Reclamation
Boise Diversion	BDD	3	3	1.3	Local Support	Reclamation
Black Canyon	BCD	2	10	7.5	Local Support	Reclamation
Roza	ROZ	1	13	7.6	Local Support	Reclamation
Chandler	CDR	2	12	6.3	Local Support	Reclamation
Green Springs	GSP	1	18	7.3	Local Support	Reclamation
TOTAL		**196**	**22050**	**8705**		

Table 3.3-1, Strategic Classes

Purpose	Main Stem Columbia	Headwater/Lower Snake	Area Support	Local Support
Power	Provides 76% of energy and capacity, and 30% of storage from the FCRPS Provides nearly all the reserves and other ancillary services for supporting the 500 KV grid	Provides 20% of energy and capacity, and 50% of storage from the FCRPS Provides supplementary ancillary services for supporting the 500 KV grid	Provides 3% of energy and capacity, and 18% of storage from the FCRPS Provides voltage support to specific areas of the regional transmission grid	Provides 1% of energy and capacity, and 2% of storage from the FCRPS Provides limited voltage support to local areas of the Pacific Northwest
Flood Damage Reduction	Seasonal flood reduction and water management storage affecting significant parts of the Columbia River basin	Seasonal flood reduction and water management storage affecting significant parts of the Columbia River basin	Provides flood reduction benefits primarily in the Willamette Valley, but does not contribute significantly to the flood reduction capability of the overall Columbia River basin	Provides flood reduction benefits in a local area
Navigation	Provides navigation for the lower Columbia River from below Cascade Locks to the Tri-Cities	Provides navigation for the lower Snake River from the Tri-Cities to Lewiston, ID	None	None
Irrigation	Primary source of irrigation for the Columbia River Basin	Provides incidental irrigation	Primary source of irrigation within a specific region (Palisades Dam only)	Primary source of irrigation within a specific region
Recreation	Significant recreation for boating and camping Includes several “destination” recreation sites and numerous local sites	Major recreation for boating and camping Includes several “destination” and local sites	Major recreation for boating and camping Includes several “destination” and local sites	Some boating and camping at local sites

The FCRPS provides the following services to BPA's preference customers:

Figure 3.2-2, Asset Locations



Load Following Product: BPA firm power service that meets the customer's Total Retail Load less any firm energy from the customer's Dedicated Resources on a real-time basis.

Block Product: BPA firm power service sold in a specific amount each hour, offered as a flat hourly block or with Shaping Capacity.

Slice Product: BPA power service that includes requirements power, surplus power, and hourly scheduling rights.

Industrial Firm Power: BPA firm power service sold to direct service industrial customers in the Pacific Northwest as defined in the Northwest Power Act.

Renewable Energy Certificate: A derivative product that represents the benefits associated with the generation of electricity from renewable energy sources (including incremental hydropower efficiency improvements).

The FCRPS also provides the following ancillary services:

Reactive Supply and Voltage Control from Generation Sources Service: Required to maintain voltage levels on BPA's transmission facilities within acceptable limits.

Regulation and Frequency Response Service: Necessary for the continuous balancing of resources with load and for maintaining frequency.

Energy Imbalance Service: Provided when a difference occurs between the scheduled and actual delivery of energy to a load located within a Control Area.

Spinning Reserve Service: Needed to serve load immediately in the event of a system contingency.

Supplemental Reserve Service: Needed to serve load in the event of a system contingency, not immediately, but within a short period of time.

Generation Imbalance Service: Provided when there is a difference between scheduled and actual energy delivered from generation resources.

Variable Energy Resource Balancing Service: Comprised of regulating reserves, following reserves and imbalance reserves.

Dispatchable Energy Resource Balancing Service: Provides reserves to compensate for differences between a thermal generator's schedule and actual generation.

Contingency Reserves: Deployed to meet the Disturbance Control Standard (DCS) and other NERC and Regional Reliability Organization contingency requirements.

Surplus Power: Generation in excess of BPA's obligations to preference customers is sold to wholesale parties.

3.4 Demand Forecast for Services

The Pacific Northwest Loads and Resources Study, commonly called "The White Book", is the Bonneville Power Administration's (BPA) annual publication of the Federal system and the Pacific Northwest (PNW) region's loads and resources for the upcoming ten-year period.

The White Book is used by BPA as a planning tool, as a data source for the Columbia River Treaty studies, as an information source for customers, and as a published source of loads and resources information for other regional interests.

As of the development of this SAMP, the most recently published White Book is from 2018. With increasing coal retirements and operational changes resulting from the Columbia River System Operations Environmental Impact Statement (CRSO EIS), many changes are on the horizon. These will be captured in the 2022 SAMP once the CRSO EIS is complete and results are captured in an updated White Book. The highlights of the 2018 White Book are:

Federal System Analysis—forecast of Federal system firm loads and resources based on expected load obligations and different levels of generating resources that vary by water conditions. The results are summarized below:

Annual Energy Surplus/Deficits: Under critical water conditions; the Federal system is projected to have small annual energy surpluses in the first year of the study, 79 aMW, with annual energy deficits, as large as -438 aMW, over the rest of the study period. These annual energy deficits projections are similar to those projected in the 2017 White Book. Under average water conditions, the Federal system is projected to have annual energy surpluses through the study period.

January 120-Hour Capacity Surplus/Deficits: Under critical water conditions; the Federal system is projected to have January 120-Hour capacity deficits over the study period, ranging from -969 MW to -1,406 MW. These 120-Hour capacity deficits are similar to those projected in the 2017 White Book. Under average water conditions; the Federal system is projected to have January 120-Hour capacity surpluses over the study period.

PNW Regional Analysis—forecast of regional firm loads and resources, based on expected retail loads and different levels of generating resources that vary by water conditions. The decommissioning of existing resources, the availability of uncommitted PNW Independent Power Producer (IPP) generation, and new resource additions are key variables in the results of this analysis. The results are summarized below:

Annual Energy Surplus/Deficits: Under critical water conditions; the PNW region is projected to have annual energy surpluses as large as 4,058 aMW in 2020, slowly decreasing to 403 aMW by OY 2029. These annual energy projections are similar to those presented in the 2017 White Book. Under average water conditions; the PNW region would see even larger energy surpluses over the study horizon.

January 120-Hour Capacity Surplus/Deficits: Under critical water conditions; the PNW region is projected to have January 120-Hour capacity deficits over the study period, ranging from -246 MW to -4,891 MW. These deficit projections are larger than those shown in the 2017 White Book. Under average water conditions; the PNW region has January 120-Hour capacity surpluses through the final year of this study.

More information can be found at:

https://www.bpa.gov/p/Generation/White-Book/Pages/White-Book-2018.aspx

BPA, the Corps and Reclamation will be performing further demand analysis to determine the seasonal availability needed at each facility to meet each agency's missions and obligations. This analysis will be performed in FY 2020 and FY 2021 to inform availability targets in the 2022 SAMP.

Surplus Energy and Ancillary Services

BPA's Strategic Plan calls for increasing power revenues through new market opportunities for clean capacity and improved approaches for ancillary and control area service offerings. Demand for low-carbon generation products is increasing as utilities, high tech facilities and other organizations seek to reduce their carbon footprint.

3.5 Strategy Duration

The analysis conducted in this SAMP covers a 50-year study period, primarily to capture the benefits associated with reinvestment in long-lived equipment in the hydroelectric facilities. However, the primary focus of this strategy and the associated System Asset Plan is on the first 20 years. This strategy is intended to be updated and reviewed every two years to align with the BPA IPR cycle.

4.0 STAKEHOLDERS

4.1 Asset Owner and Operators

The Corps and Reclamation own and operate the hydropower projects while BPA markets the power they produce. BPA directly funds the power-related capital and operations and maintenance costs of the two agencies through a series of Direct Funding agreements. There are four separate agreements:

- Reclamation capital costs, effective January 15, 1993
- Corps capital costs, effective December 6, 1994
- Reclamation operations and maintenance expense, effective October 1, 1996
- Corps operations and maintenance expenses, December 22, 1997

These agreements established the Joint Operating Committee (JOC) which is tasked with overseeing the implementation of the terms and conditions of the agreements, including the development of expense and capital budgets, coordination of operations, and performance metrics.

A Three Agency Executive Steering Committee (ESC) provides strategic direction to the hydropower program. Sub-committees of the Joint Operating Committee provide direct oversight of specific aspects of the responsibilities outlined in the agreements:

- Capital Investment Program
- Asset Planning
- Performance Indicators
- River Management
- Hydro Optimization
- Technical Operations & Implementation Subcommittee
- Reliability Implementation Team
- Cultural Resources

4.1.1 Corps and Reclamation Owned Transmission Assets

The Corps and Reclamation own and operate a number of switchyards in the FCRPS including, Grand Coulee 500kV, 230kV, 115kV switchyards; Palisades switchyard; Minidoka switchyard; Hungry Horse switchyard; and Bonneville Powerhouse No. 1 rooftop switchyard. These switchyards provide a dual purpose benefit to both BPA's Power Services (PS) and Transmission Services (TS) customers as they interconnect federal hydropower resources to the greater transmission network, and they support the operation of the high voltage transmission network in their respective geographic areas. This arrangement necessitates that both PS and TS account for these assets in their asset management planning, as well as pay for capital and expense costs associated with the switchyards.

- As the assets are owned by the Corps and Reclamation, PS supplies the total expense costs as they are spent, and directly funds the Corps and Reclamation through the direct funding agreements indicated above. Similarly, PS supplies all funds to the Federal Treasury for debt service of these assets, and bonds with the treasury to secure capital funds, which PS then directly funds to the Corps and Reclamation. Transmission Services' share of the capital debt service and expense costs are paid to Power Services through an inter-business allocation each year. Bonding for capital costs are coordinated between PS and TS. When investments in these assets necessitate a capital funding requirement, additional space is made available in PS's borrowing authority that year, which is offset by a decrease in TS's borrowing authority for that year. This process is known as the Transfer of Budget Authority.

4.2 Stakeholders and Expectations

The FCRPS has a wide variety of stakeholders with expectations that can be both overlapping and conflicting. BPA, the Corps and Reclamation must balance these varying expectations in order to cost effectively meet the region's needs.

Stakeholders	Expectations	Current Data Sources	Measures
BPA Power and Transmission	Unit Availability for generation and ancillary services	Outage Tracking System (OTS), hydroAMP, SCADA, PI, THOR, GDACS	Availability, Equipment Condition (hydroAMP), Generation Data
Canada	Columbia River Treaty Compliance	Columbia River Treaty	Assured Operating Plan Detailed Operating Plan Treaty Storage Regulations
Customers	Competitive Rates	Integrated Program Review, Long Term Rates Forecasting Tool, Focus 2028	Tier 1 PF Rate forecast from Reference Case and LTRF Scenarios

Stakeholders	Expectations	Current Data Sources	Measures
	Reliability	OMBIL (Corps), PO&M (Reclamation)	Availability Metrics (Weighted Scheduled Outage Factor, Weighted Forced Outage Factor)
Corps and Reclamation	Direct Funding	Sub-agreements, Annual Power Budget	Capital and Expense Expenditure Rates, Equipment Condition (hydroAMP)
	Safety	Corps and Reclamation Safety Management Systems	Safety Metrics (Lost Time Accident Rates, Days Away, Restricted or Transferred, Total Case Incident Rate)
	Employee Satisfaction	Human Resources Databases	Turnover statistics, surveys
Environmental Interests	Water Quality – Temperature	Corps and Reclamation Monitoring Systems	State Water Quality Standards
	Water Quality – Total Dissolved Gas	Corps and Reclamation Monitor Systems, Fish Passage Center Smolt Monitoring Program	State Water Quality Standards, Gas Bubble Trauma Incidences
	Water Quality - National Pollutant Discharge Elimination System (NPDES) Permits	Corps and Reclamation Monitoring Systems	NPDES requirements, Oil Accountability Measures
	ESA Listed Salmonid Population	Corps, USFWS, and NOAA Fish Monitoring	Fish Counts, SARs (Smolt to Adult Returns, Juvenile Travel Time, Performance Standards for juvenile Dam Passage Survival)
Irrigation Customers	Unit Reliability	Sub-agreements, Annual Power Budget, hydroAMP, Reclamation PO&M database	Equipment Condition (hydroAMP or Corps Operational Condition Assessments)
Navigation Customers	Joint Funding for Corps Investments	Sub-agreements, Annual Power Budget	Equipment Condition (hydroAMP or Corps Operational Condition Assessments)
NERC/WECC/CIP	Comply with Regulations	Corps and Reclamation Systems	Reliability Metrics (Standards Compliance, Inherent Risk Assessments)
Northwest Power and Conservation Council	Pursue Actions in The Seventh Power Plan	White papers, analysis results and documentation	Report out to the Council on analysis and results.
Public	Safety	Corps/Reclamation Dam Safety Programs	Operational Condition Assessments
	Recreation	THOR, Corps Reservoir Control Center	Rule Curves, Elevation Data
Tribal Interests	Trusted Stewardship	FCRPS Cultural Resource Program, Colville Payment, Spokane Payment	Cultural Resources KPIs, Colville Payment Data Spokane Payment Data

5.0 EXTERNAL AND INTERNAL INFLUENCES

Table 5.0-1, External and Internal Influences

External Influences	Affects and Actions
Customers	Customers continue to encourage that BPA, the Corps and Reclamation find ways to control spending and make the most efficient, economic investments. The Asset Investment Excellence Initiative (AIEI) began in 2015 in order to improve the selection, optimization and execution of large capital expenditures. These processes are now established and continue to mature. The Operations and Maintenance Optimization Initiative (OMOI) was officially kicked off in 2019 to identify similar improvements in the operations and maintenance program for the Corps and Reclamation is standing up a similar initiative.
Energy Markets	BPA's rates are impacted by the ability to market surplus generation produced by the FCRPS. With energy markets at historic lows due to an abundant supply of cheap natural gas powered resources and renewables, the value of surplus energy production has been diminished in recent years. The extent to which units are rehabilitated or replaced as well as the number of units within a powerhouse that are addressed by an investment are considered in the context of both the upside and downside market risks. Energy markets could also be impacted by future regulations with respect to carbon taxes, making carbon-free hydropower more attractive.
Load Growth/Changes in Load Characteristics	The 2018 Resource Program notes that BPA has seasonal heavy load hour energy needs, specifically in the winter, as well as a growing deficit in the summer 18-hour Capacity metric. Although it was determined that BPA can rely on market purchases and conservation to meet system needs, efficiency and capacity improvements on hydro units as well as new units were not modeled as potential resources in the Resource Program. These upgrades can help reduce pressure on the energy and capacity deficits at little to no incremental cost while the units undergo modernization. Power Services staff are evaluating efficiency and capacity improvements including hydro upgrades in future resource programs.
Water Supply/Climate Change	Changing weather conditions and the resulting changes in water supply create a degree of uncertainty unique to hydropower production. Between years, the difference in energy production from FCRPS hydro can vary by several thousand average megawatts. This presents unique challenges to managing the entire portfolio of power supply needed to meet the demands of BPA customers. Climate change poses additional uncertainty into future energy production in the form of a changing runoff shape. This translates into greater Heavy Load Hour energy deficits in the late summer due to decreased snow pack as well as reduced deficits in the winter due to warmer temperatures and reduced winter loads.
Fish Operations and Mitigation	The Biological Opinions (BiOps) and Fish Passage Plan are major contributing factors into the water supply available for generation and the points at which generating units can operate to facilitate fish survival. In order to improve conditions for fish passage, significant investment in new systems as well as reinvestment in existing systems may be required in addition to changes in juvenile fish passage spill requirements. Improved fish passage turbine design has the potential to reduce some of the impacts to power generation.
Intermittent Renewables Integration	Integrating renewable resources such as Wind and Solar has presented a challenge to the hydro system, resulting in operations that were not anticipated in their original design. Increased starts and stops, frequent ramping and operating in or passing through rough zones are potentially increasing the risk of failure and reducing the lives of generating units. Across the industry, the impacts on unit reliability are not well understood. Continued participation in industry forums and further analysis as more data becomes available should improve the ability to quantify these impacts. As powerhouses undergo rehabilitation and replacement, the opportunity presents itself to better align unit design with current operating conditions.
Energy Policy	Renewable Energy Credits, such as those claimed by Wind and Solar resources, are only available for Small Hydro facilities and incremental efficiency improvements at Large Hydro projects. In addition to electricity generation, the hydro system plays an integral role in the integration of renewable resources, for which it is believed to be undercompensated. The Department of Energy's long-term National Hydropower Vision has called out the need to better compensate hydroelectric generation for these ancillary services and the issue has been raised in front of the US House Energy Subcommittee. An energy imbalance market has the potential to better compensate the FCRPS for these services.
NERC/WECC Regulation	Generation facilities are required by NERC, CIP and WECC to undergo testing to ensure that they are in compliance with reliability standards. Increasing reliability requirements have resulted in increased operations and maintenance costs, primarily from the necessity to hire staff to oversee regulatory compliance programs. Additionally, physical and cyber security requirements continue to expand requiring more time and investment at the plants.
Joint Asset Condition and Appropriations	BPA is obligated to fund the power share of a portion of the non-power specific assets ("Joint Assets") at FCRPS facilities. The power shares were set by congress when the plants were authorized and were intended to be proportional to the benefits received by each authorized purpose of the facility. Approval and execution of work is contingent on the Corps and Reclamation receiving appropriations from congress. The uncertainty in the federal appropriations process makes integration of joint assets with the rest of the FCRPS System Asset Plan difficult. The

	FCRPS may not be able to execute the right projects at the right time if appropriations are not available. Completing the Joint asset inventory and refining how Joint assets are modeled will lead to better communication between the agencies around planned joint work and may improve the Corps and Reclamations ability to receive appropriations.
Interdepartmental Challenges	The three agencies that make up the FCRPS are part of three separate departments of government. Each is subject to their own policies, codes and requirements driven by each department's respective headquarters. This can present challenges to project planning, procurement. From a national perspective, hydropower is not the core mission of the Corps or Reclamation which are part of the Department of Defense and Department of the Interior, respectively. Critical pieces of the Asset Management System, such as contracting, are largely outside of the authority of FCRPS leadership.

Internal Influences	Affects and Actions
Asset Condition	About 25% of FCRPS assets are in Marginal or Poor condition. This percentage is expected to increase over the next ten years, even with significant investment in the system. This suggests that the likelihood of unit outages may continue to increase. To effectively manage risk over the next ten years, investments will primarily target the equipment in Marginal and Poor condition that present the most risk to the system and deliver the highest value.
Aging Workforce	With a large portion of FCRPS staff nearing retirement eligibility, considerable amounts of knowledge with respect to the operations, maintenance and powerplant design are at risk of being lost. The FCRPS is attempting to preserve this knowledge through the Hydropower Apprenticeship Program, Hydropower Intern Program, Engineer Intern Program as well as through the documentation of maintenance activities with video recordings and written instructions.
Remote Locations	Many FCRPS facilities are located in remote locations to which it is becoming increasingly harder to attract new employees. Retention has also proven difficult in recent years with staff taking positions closer to larger cities as they gain experience. A special salary rate was implemented in 2019 for engineering positions that work directly with hydropower as an aid in retention of qualified and uniquely trained employees
Unit Reliability	Unit reliability improvements are made to reduce the impacts of unit failure. These can be financial, safety or environmental impacts, but can also affect public perception, employee satisfaction and the ability of the FCRPS to comply with regulations. The FCRPS asset planning capabilities provide a common framework to evaluate and optimize these risks within constraints to deliver a portfolio that maximizes the overall value of investment (maximizing benefits and risk mitigation for all Three Agency mission for the portfolio as a whole).
Powerhouse Characteristics	Due to the inherent characteristics of the plants (number of units, unit rating, transmission system support, location within the river system, storage capability, etc.), unit reliability is more important at some plants than others. While plants are undergoing rehabilitation and replacement, it makes sense to evaluate the potential for unit uprates at plants that have low powerhouse capability relative to total plant flow in order to reduce the risk of future unit outages. Equipment in these plants should be prioritized ahead of equipment in plants that have a relatively low impact to unit outages due to excess powerhouse capacity.
New Technologies	New technologies have the capability to reduce future costs or increase revenues, improving the viability of FCRPS hydro resources. Through improvements in turbine design since original construction, turbine replacements have provided efficiency improvements in the range of 3 to 6 percent in the FCRPS. Improved fish passage turbine design has the additional benefit of potentially improving fish passage and allowing for fish screen removal. This would not only relieve the need to replace deteriorating fish screens but would remove generation limitations at some plants.

5.1 SWOT Analysis

Table 5.1-1: SWOT

Favorable	***Unfavorable***
Strengths	***Weaknesses***
• **Economies of Scale:** Due to their size, large FCRPS facilities produce an abundance of power at a low relative cost. The FCRPS as a whole is a first quartile performer among the 16 utilities benchmarked in the EUCG Hydro Productivity Committee for total cost per MWh. • **Carbon Free Generation:** The hydro system provides an average of 76 million megawatt-hours of carbon free energy production per year, which, if produced by a carbon-emitting resource, equates to 32 million tons of avoided CO2 emissions. With increasing pressure on utilities and businesses to reduce their carbon footprint, FCRPS power could be very valuable. • **Flexible and Dispatchable:** Provides critical services to integrate non-dispatchable forms of renewable energy such as wind and solar. • **Abundance of Data:** The Three Agencies have an abundance of condition and performance data nationwide that puts the FCRPS in a unique position among hydro utilities to develop lifecycle models to inform Asset Strategies and Plans. • **Asset Management Tools:** The FCRPS employs sophisticated asset management tools to optimize capital investment plans and develop the best investment alternatives.	• **Environmental Impact:** The original construction of the facilities resulted in impacts to affected resources (e.g. fish and wildlife, cultural resources) for which the Three agencies continue to mitigate to this day. • **Weather Dependence:** The FCRPS has very little water storage compared to other basins in North America. The ability to generate is highly dependent on within year precipitation, snowpack, temperatures and runoff. • **Market Forces and Ancillary Service Compensation:** The FCRPS' flexibility is undercompensated in today's markets. Reliance on the hydro system to integrate renewable energy may also be leading to increased wear-and-tear. • **Three agencies, Three Departments of Government, Multiple Missions:** The hydropower facilities are multi-purpose projects and the Three agencies that collectively own, operate and market the power from them have overlapping and occasionally competing missions. Having the various Asset Management functions spread across the Department of Energy, Department of the Interior and Department of Defense is a challenge, especially when those functions are not specific to hydropower or dams. Although the agencies have an abundance of data, it exists in disparate systems across the Three Agencies. The flow of data is often restricted due to departmental policies and silos.
Opportunities	***Threats***
• **Energy Imbalance Market:** An Energy Imbalance Market could compensate the Federal System for ancillary services that are currently undercompensated. • **Efficiency Improvements:** Replacements to improve unit reliability provide the opportune time to increase efficiency or capacity of units at little incremental cost. • **Fish Passage Improvements:** New turbine designs have focused on improving fish survival through the units. If the improved fish passage can be proven in practice, there is potential for removal of fish screens in the future. In addition to avoiding replacement costs for fish screens that are nearing then end of their useful lives, annual installation and removal costs would also be avoided and many units would see an increase in efficiency. • **Optimizing Plant Configuration:** During powerplant modernization projects, the design, capacity and number of units and possible future standardization on other components can be evaluated given the expected future operating environment. Right-sizing and standardizing equipment at the powerplant facilities can reduce long term capital and O&M costs while increasing efficiency.	• **Climate Change:** Changes in weather patterns, specifically to more precipitation falling as rain than snow, may present challenges to operations and flexibility in the future. • **Dam Breach:** Continued pressure has been put on BPA and the Corps to breach the lower Snake River dams to potentially support fish and wildlife recovery. Breaching the dams would result in significant regional reliability impacts unless replacement resources are acquired and installed. Until replacement resources are operational, the loss of the four lower Snake River dams would diminish the Federal power system's ability to support regional reliability, particularly during extreme weather events, and to integrate new renewables resources. The cost of replacement resources, combined with the other operational and power impacts of dam breaching, would also cause significant upward rate pressure for BPA ratepayers. • **Energy Price Competition:** Pressure to keep rates low has constrained operations and maintenance budgets. In addition to long term impacts on

	reliability, collecting information needed to make asset management decision may be impacted depending how activities are prioritized. • **Fish Passage Costs:** Fish protection infrastructure will require significant reinvestment in the coming years. New requirements may also result in the design and construction of new structures to support fish passage. These costs could have dramatic impacts on the economic viability of some FCRPS facilities. • **Operational Changes:** Changes in operations to support fish passage could result in more spill, less hydropower production and less flexibility, increasing the risk of regional power shortages. (Note the current regional risk of outages is already above the Northwest Power and Conservation Council's target.) • **Industry Experience Loss:** Loss of experience at the plants and in the industry may result in longer outages and costlier repairs. Some FCRPS units are unique or among the first of their kind. Original documentation is lacking for some plants which has led to reverse engineering and even tracking down long-retired original designers. • **Market forces:** Lower market rates for wind and solar appear to not reflect the lack of voltage support and inability to provide loss reduction for these technologies.

6.0 ASSET MANAGEMENT CAPABILITIES AND SYSTEM

BPA, the Corps and Reclamation began developing an asset management program in the late 1990s coinciding with the signing of the direct funding agreements. The three-agencies developed the first FCRPS asset management strategy in 1999 at the direction of congress. It called for the development of a strategy that maximizes the value of the FCRPS through, "assessing the condition of the system, comparing it to industry benchmarks, identifying investments, evaluating cost effectiveness, and undertaking actions that increase reliability and enhance revenues." With many of the processes and systems called for by the 1999 asset management strategy now in place, particularly with respect to capital investment, much of the original vision has been realized. However, with advancements in asset management practices in the last 20 years, there are still opportunities for refinement and improvement.

BPA has adopted the Institute of Asset Management (IAM) model for Asset Management agency-wide. The IAM provides guidance for developing and implementing an Asset Management program compliant with ISO 55000, the international standard for Asset Management. None of the Three Agencies are currently considering ISO 55000 certification but are instead using the IAM model as a guideline.

6.1 Current Maturity level

In addition to guidelines for ISO 55000 implementation, the IAM also provide a maturity assessment model to determine assess the asset management maturity of an organization relative to ISO 55000 and IAM guidance. The IAM model focuses on six subject areas shown in the following diagram.

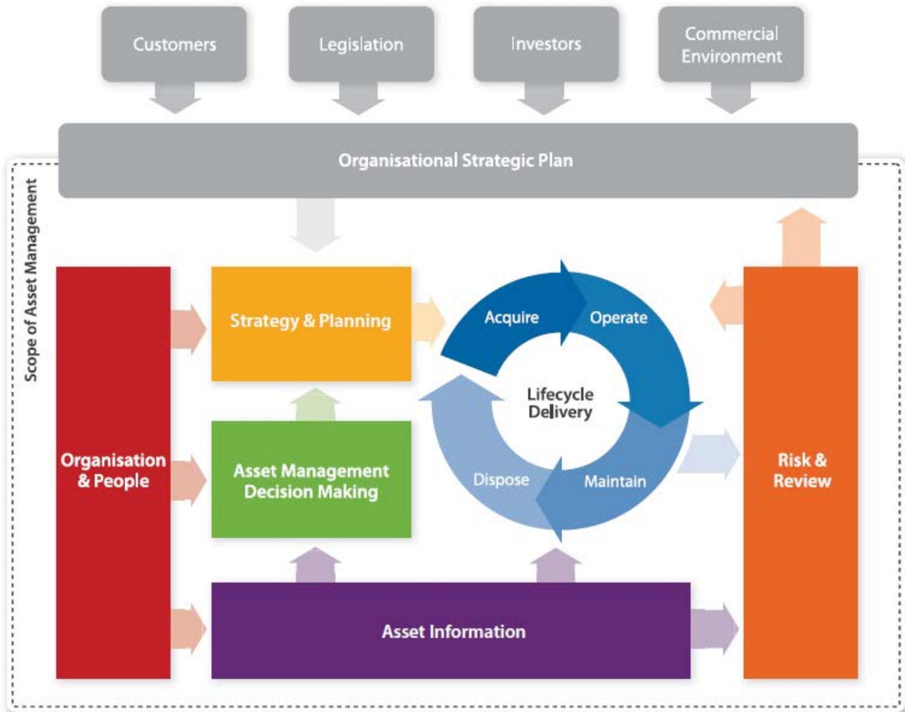


Figure 3: The IAM's Conceptual Asset Management model

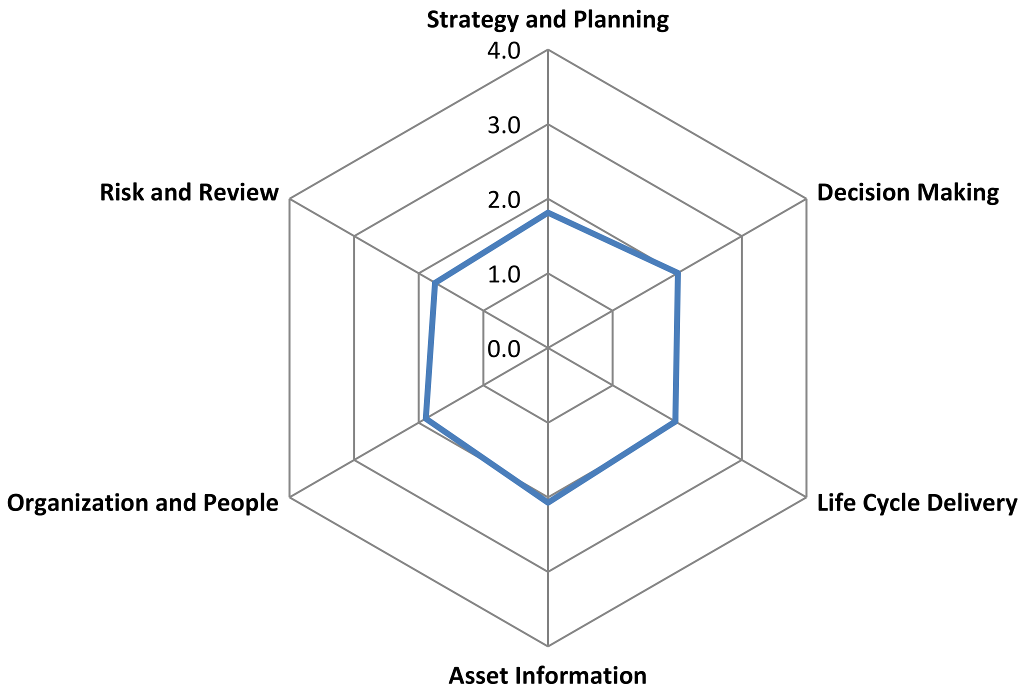
The IAM maturity assessment has 39 questions spanning the subject areas with each question assessed on a scale of from 0 to 5. A description of the IAM maturity levels is shown below.

Innocent	Aware	Developing	Competent	Optimising	Excellent
Maturity Level 0	Maturity Level 1	Maturity Level 2	Maturity Level 3	Beyond	
The organisation has not recognised the need for this requirement and/ or there is no evidence of commitment to put it in place.	The organisation has identified the need for this requirement, and there is evidence of intent to progress it.	The organisation has identified the means of systematicaly and consistently achieving the requirements, and can demonstrate that these are being progressed with credible and resourced plans in place.	The organisation can demonstrate that it systematically and consistently achieves relevant requirements set out in ISO 55001.	The organisation can demonstrate that it is systematically and consistently optimising its asset management practice, in line with the organisation's objectives and operating context.	The organisation can demonstrate that it employs the leading practices, and achieves maximum value from the management of its assets, in line with the organisation's objectives and operating context.

A simplified survey based on the IAM Maturity Model was sent to individuals across the FCRPS in 2019. In total, there were 117 respondents across the Corps, Reclamation and BPA with a range of disciplines and years of experience.

Results from the 16 simplified questions were mapped back to the 39 IAM questions to complete Table 6.1-1. Compared to the previous SAMP, this survey was much broader in scope and a better gauge of how well Asset Management policies, principles and activities are being communicated.

On average, FCRPS asset management is still in a developing phase with most subject areas having an average score near 2. Some areas of Strategy and Planning and Decision Making possess elements of a level 3 (competent) maturity. However, they are held back by a lack of communication and understanding of the SAMP as well as operations, maintenance and investment decisions often made in silos. Risk and Review is the least mature subject area as the three agencies have not come to a common understanding of risk with respect to each agency's missions. Table 6.1-1 describes the strengths and weakness for each subject area in more detail.



6.1-1 Maturity Level

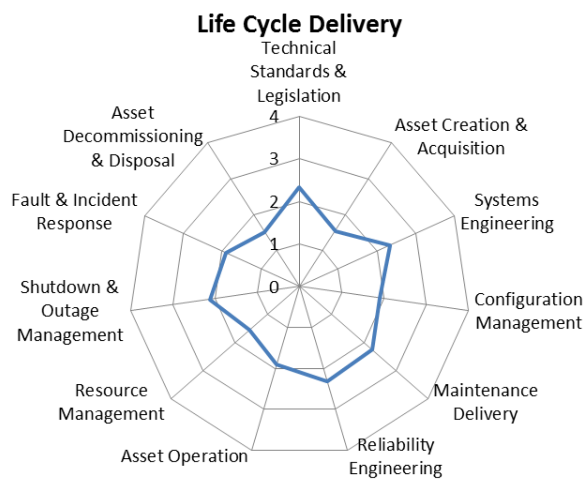
Subject Area	Maturity Level
Strategy & Planning	**Average Maturity**: 1.8 (Developing) **Strengths:** Although the average results for most subject areas were just above Level 2 (Developing), the FCRPS Asset Management processes possess many elements of Maturity Level 3 (Competent). Asset Management objectives have been outlined and align with the agency objectives. A structured approach is in place to develop Asset Plans in an iterative way that combines top down direction with bottom up assets needs. Investments in the asset plan are optimized using an agreed upon methodology 

	documented in this SAMP. **Weaknesses:** Line-of-sight, demand analysis and integration with human resources and procurement are the major factors in holding the FCRPS back from Level 3 (Competent). The survey conducted this year made it clear that an understanding of the SAMP and Asset Plans is not ubiquitous throughout the three agencies, especially in the field. Development of the SAMP has historically been done by BPA and it is not seen as a Three Agency document. Human resources and procurement also present a challenge as these functions at the Corps and Reclamation are not specific to the FCRPS and must abide by their respective departments' policies and regulations. The policies and regulations of the Department of Defense and the Department of the Interior differ from each other and were not created with the strategies and plans of the FCRPS in mind. Thus, implementation of the strategies and plans is occasionally hindered. The needs and level of service in order to meet the various missions of BPA, the Corps and Reclamation is not well understood. A formal demand analysis is being planned in FY20 as part of the Operations and Maintenance Optimization Initiative. The goal is to determine the value and importance of the facilities and the hydropower assets with respect to water quality, water passage, fish operations, generation of power and power ancillary services.
Decision Making	**Average Maturity**: 2.0 (Developing) **Strengths:** Capital Investment Decision Making and Life Cycle Value Realization contain many elements of Level 3 (Competent). For capital investment planning, a maturing process is in place to identify, plan and execute investments such that the Asset Management objectives of Low Cost Power, Power Reliability and Trusted Stewardship are met. Capital Investment plans are developed through an understanding of Asset Criticality which evaluates risk throughout an asset's lifecycle. This understanding of risk, in addition to an assessment of the benefits and costs of an investment, are then used to optimize the capital investment plan and seek to maximize the value of the FCRPS. These methods are applied across all large capital investments in the FCRPS.  **Weaknesses:** Maintenance at FCRPS facilities is primarily time-based and not fully informed by equipment condition or risk. Maintenance data is inconsistent across the FCRPS, the sharing of data between agencies, ease of access to documented maintenance data and sharing of this data is challenging and limited. These areas will be under evaluation as part of the Operations and Maintenance Optimization Initiative. Decision Making for both capital and non-routine expense is primarily based on deterministic analysis, with some stochastic elements incorporated into major investment decisions. Mentioned earlier, the resourcing strategy is not yet well integrated with the Strategic Asset Management Plan, which is one of the reasons that the Asset Plan

<table>
<tr><td></td><td>has been difficult to execute. Efforts are ongoing between the Three agencies for improved and more consistent procurement practices.</td></tr>
<tr><td>Life Cycle Delivery</td><td>

Average Maturity: 2.0 (Developing)

Strengths: Technical Standards & Legislation, System Engineering, Maintenance Delivery and Reliability Engineering had among the highest scores among the subsections. The Corps' Hydroelectric Design Center (HDC) and Reclamation's Technical Services Center (TSC) are the centers of design and engineering expertise for the respective agencies. These organizations establish standards for their respective agencies. Reclamation maintains a series of manuals that are used by hydro utilities throughout the world called the Facilities Instructions, Standards and Techniques (FIST) manuals. These manuals have information on hydro plant operations, mechanical, electrical and general maintenance, safety, and facility management. The FIST manuals also set standards for preventative maintenance intervals for most assets. Some areas of the FCRPS have elements of maturity level 3 (competent) but maturity varies from plant to plant.



Weaknesses: Lifecycle delivery had the lowest response rate of any subject area, suggesting that visibility throughout the Three agencies is low. Up to date Asset Condition information is still a challenge to overcome and is inconsistently used to inform asset operations strategies or outage plans. Standardized and regularly updated operational strategies based on asset condition could extend the operating life and reduce maintenance and outage costs. Resource management, specifically procurement, was found to be one of the weakest areas in the survey. Usage, movement history and repair cost information were identified as gaps for consumable and spare parts. The lack of a procurement and supply chain management strategy was also identified. Best practices and lessons learned are not consistently tracked or captured.

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<tr><td>Asset Information</td><td>

Average Maturity: 2.1 (Developing)

Strengths: A common framework, hydroAMP, is used to inventory and assess asset condition. The hydroAMP condition assessment framework was originally developed by the Corps, Reclamation, BPA and Hydro Quebec and has become the de facto industry standard for hydro equipment condition assessment. Over 9000 assets are currently inventoried. Nearly all equipment defined as Powertrain and Critical Auxiliary components are inventoried and assessed on a regular basis.

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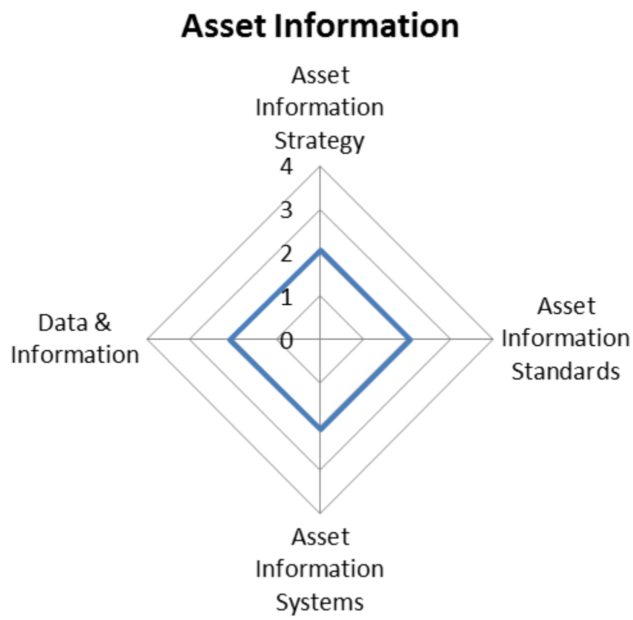
Weaknesses: Although guidelines exist for asset information through hydroAMP, formal asset information strategies and asset information standards do not exist. Development of BPA's asset information strategy can be leveraged by the Three agencies and adapted to the FCRPS. Development of a hydroAMP condition assessment process document is currently under way which will improve the consistency, completeness and recency of condition assessments. Asset Information is not directly integrated with performance information or failure data. Balance of Plant assets are inconsistently inventoried across facilities and standard assessment intervals are not aligned with criticality. Personnel tasked with hydroAMP assessments are often also tasked with NERC/CIP requirements. Increased regulatory requirements have reportedly impacted time spent on hydroAMP condition assessments.



Organization & People

Average Maturity: 1.7 (Developing)

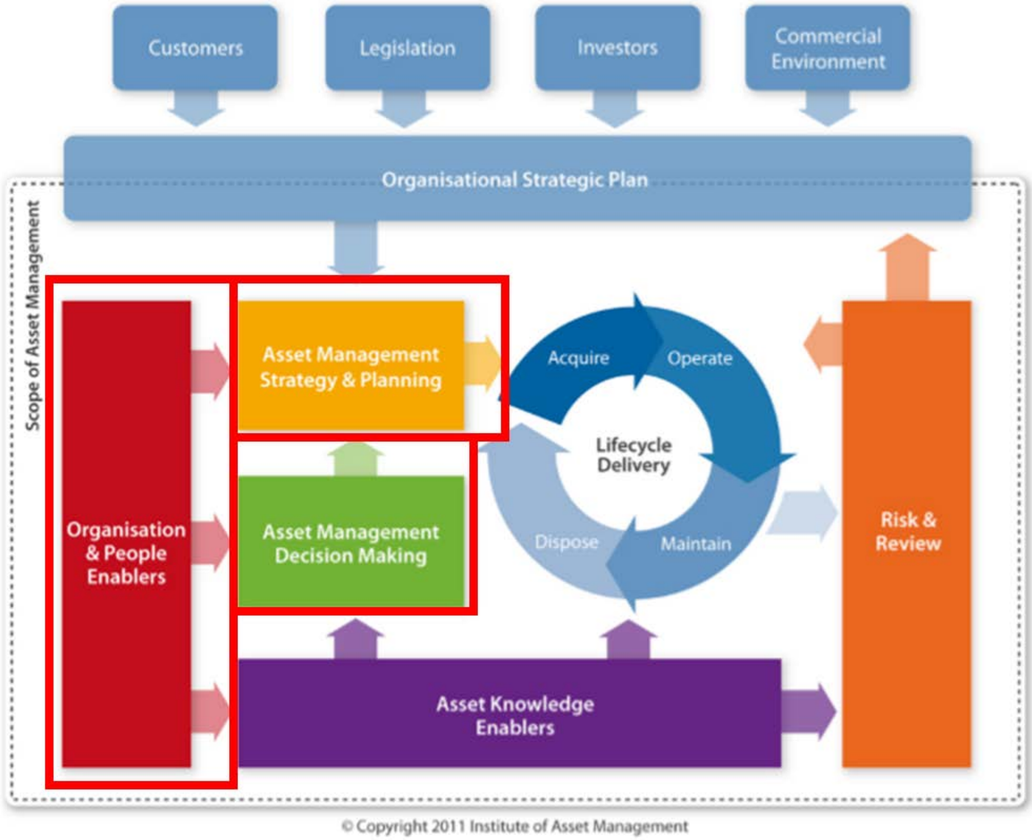
Strengths: About 70% of respondents were split fairly evenly between 2 (Developing) and 3 (Competent). This suggests that most respondents recognize how they fit into their organization, are committed to achieving the goals and objectives of the Three agencies and understand the need for collaboration. Training and Competence appears to be strong in some areas and developing in others.

Weaknesses: About 20% of the respondents selected that they were unsure how their role supports leadership's vision and goals. Although the majority responded with higher levels of maturity, this suggests that there are pockets where the Asset Management vision is not being communicated. Organizational structure was consistently recognized as a weakness with the majority of respondents choosing a maturity level of 0 (unaware). This reflects the Three Agency structure and the structures within the Three agencies that makes implementation of a coordinated SAMP challenging. Obtaining the resources needed to complete tasks in a timely manner is also seen as an issue. This has contributed to the under execution of the Asset Plan.

Risk & Review	**Average Maturity**: 1.9 (Developing) **Strengths:** FCRPS leadership has hosted roadshows at FCRPS plants, district and area offices to talk about BPA's Strategic Plan and how it influences FCRPS Asset Management decisions. Outside of the Integrated Program Review, FCRPS leadership and staff regular present to the Public Power Council about current performance and the status of FCRPS initiatives.  **Weaknesses:** Scores in risk and review were generally low, with many respondents select 1 (Aware). Metrics to assess the performance of the Asset Management system are being studied within the FCRPS and through hydro industry forums. Risks to each mission are not well documented, including each agency's tolerance and overall risk appetite.

6.2 Long Term Objectives

With a long term goal of reaching competency in each of the six subject areas, FCRPS leadership has created two specific goals as an initial starting point that will improve maturity in the Organization & People, Asset Management Strategy & Planning and Asset Management Decision making subject areas. Although these were not the weakest subject areas, they are foundational to an Asset Management program and all three agencies contribute to their success.



A Three Agency team is actively developing these goals and objectives for presentation to Three Agency executives in 2020. Specific targets, milestones and measures will be developed upon executive team approval.

Goal 1: Effectively communicate the FCRPS strategic objectives to improve line-of-sight throughout the three agencies.

Objective	Current State	Method to Achieve Desired End State	Timeframe*
1.1) **Improve literacy of Asset Management principles among the workforce**	Awareness of Asset Management principles, including the broader context of FCRPS strategic direction, is mostly limited to those directly involved in asset management.	Identify FCRPS positions that require IAM or similar training. Set training targets and coordinate Asset Management trainings.	FY21: Identify training needs) FY22 and beyond: Train positions
1.2) **Update FCRPS Strategic Objectives with Three Agency collaboration**	FCRPS strategic objectives have been the same for nearly 20 years. Awareness of objectives is low throughout three agencies.	Three Agency review of FCRPS strategic objectives. Include revisions, omissions and/or additions in 2022 SAMP	FY21-22

Objective	Current State	Method to Achieve Desired End State	Timeframe*
1.3) **Document and disseminate decision making processes for O&M and capital**	Capital and O&M decision making processes are not understood by all stakeholders, including Corps and Reclamation employees at the plants.	Document decision making processes and share throughout three-agencies.	FY21-22
1.4) **Create more avenues for leadership to communicate priorities**	Line-of-sight is not always clear, especially between the three agencies. Some FCRPS employees can't see how day-to-day activities support mission/leadership direction.	Identify and implement an communication plan for asset management and FCRPS strategic direction.	FY21-23
1.5) **Review/improve Asset Management governance processes**	Review and approval of SAMP and Asset Plan documents and asset planning assumptions are ad hoc.	Document existing governance processes. Establish a 3 Agency AM governance board. Develop an Asset Management System Manual.	FY21-24

Goal 2: Expand FCRPS Strategies and Plans based on asset condition and criticality to include all missions that assets support and all programs, including capital, operations, and maintenance. Align performance expectation with the value that each asset provides for the various missions of the three agencies.

Objective	Current State	Method to Achieve Desired End State	Timeframe*
2.1) Understand all sources of value at FCRPS facilities, including non-power, by performing a demand analysis	Demand and necessary level of service for FCRPS equipment with respect to non-power missions is not well defined.	Perform demand analysis for power and non-power products and services.	FY21-22
2.2) Define risk appetite and risk tolerance for each business line and agency	Common risk tolerance and risk appetite have not been defined for the FCRPS between the three agencies.	Develop a Three Agency risk register. Define and document Three Agency risk tolerance and risk appetite.	FY22-24

2.3) Develop regional O&M strategy and incorporate into SAMP	The SAMP is heavily focused on capital. O&M strategies are not unified and vary from plant to plant.	Use understanding from demand analysis to inform regional O&M strategies and include in 2022 SAMP.	FY22-23
2.4) Develop plant-specific asset plans that integrate and implement O&M and capital strategies	Capital and O&M planning are generally performed independently. O&M is timed-based and not necessarily influenced by criticality.	Compile plant asset plans that integrate the capital and O&M strategies for each facility, incorporating the demand analysis and Three Agency risk tolerance.	FY23-24

*Timeframes identified are subject to approval by Three Agency executives

6.3 Current Strategies and Initiatives

6.3.1 Asset Investment Excellence Initiative:

The Asset Investment Excellence Initiative (AIEI) continues to build enhancements and improvements to the FCRPS capital program. Over the course of the Initiative, the AIEI has focused on building and enhancing the 3-agency System Asset Plan (SAP) and using that plan to bring efficiencies to planning and acquisition processes. These improvements continue, though the past year has brought an increased focus on improving the business processes of the 3-agency capital program. Specific improvements include:

Life Cycle Framework: A recent notable AIEI milestone was July, 2019 when regional FCRPS leaders endorsed the FCRPS Project Lifecycle Framework as the preferred guide in the development and execution of FCRPS capital program projects.

The FCRPS Project Lifecycle Framework was collaboratively developed by the FCRPS partner agencies to improve communication, define agency-to-agency expectations and document processes as capital projects move from concept to implementation. Brand new projects start at a defined step and move through the next steps after exit criteria for each step is met. Projects currently in progress are assessed as to the current applicable step, with the expectation that all remaining steps will be observed.

System Asset Plan (SAP) Improvements: SAP refinements continue with each annual update, resulting in a well-defined process to produce a 20-year FCRPS asset investment plan that aligns with the Agencies' strategies. A few 2019 SAP enhancements include:

- An increased portfolio of projects up to 20 years out
- Improved quality control of Value Framework data
- Proactive planning for high-impact (or high dollar) projects scheduled several years out
- Process Improvements to increase cross-agency alignment and certainty of near term projects

The FCRPS is continuing to identify and build improvements for the future. A few on the radar include:

- Continue improving capital program processes to build efficiencies
- Develop training to improve acquisition and share best practices
- Identify additional steps to increase project execution
- Develop and align regional asset prioritization strategies

- Identify labor resource constraints in asset management program
- Non-routine expense projects' asset optimization
- Develop SAP technical review team

6.3.2 Operations and Maintenance Optimization Initiative:

The goal of the Operations and Maintenance Optimization Initiative (OMOI) is to understand and evaluate the value and importance of hydropower assets in order to optimize how the assets are operated and maintained. The value and importance of the assets will be determined by assessing the needs for water quality, fish passage/attraction, power generation, and ancillary services at each plant. Once the value of the hydropower facilities/assets are established, the business needs of those assets or the value of the output of those assets (power and water) will be used to develop optimized operations and maintenance activities in order to align the level of effort of O&M to the value of the asset. This approach is aligned with asset management life cycle's purpose of ensuring that the benefits or purpose of the assets continue to meet the needs of the organization and that the levels of effort (O&M) is optimized to ensure that those efforts are performed in the most cost effective manner. Many of the long term objectives listed in Section 6.2 are addressed under the OMOI.

7.0 ASSET CRITICALITY

7.1 Criteria

There are two levels of asset criticality assessment performed on FCRPS assets. A screening level assessment based on an asset's asset type, location and condition produces an initial indication of safety, environmental and financial risk. This provides a look at current and future criticality for each asset in the system. Additional analysis performed as business cases develop captures additional information unique to each asset that may have been not captured by the screening level analysis.

At the screening level, safety and environmental consequences of failure are determined for each asset type on a five-level consequence scale. Financial consequences (lost generation and direct costs resulting from failure), are determined at the asset type *and* asset level. Outage durations are established for each asset type but the resulting lost generation and direct costs are specific to each plant and generating unit. Combined with asset condition, which informs a likelihood of failure, this information provides a high-level assessment for the criticality of each asset in the FCRPS asset registry.

At investment creation, any additional or unique information about the asset is captured. Corps, Reclamation, and BPA staff assess the likelihood and consequence of failure with respect to safety and the environment on the same five-level consequence scale as the screening analysis. However, the assessment is tailored to the unique conditions in which the specific assets operate. This could either raise or lower failure consequences and potentially modify the likelihood of occurrence. Criticality with respect to public perception and compliance are also assessed during the business case development phase.

The likelihood of non-financial consequences are determined on a five-level probability scale, shown below. Financial consequence likelihoods are calculated based on equipment condition, but are mapped into the five-levels for illustrative purposes.

Rare	Unlikely	Possible	Likely	Almost Certain
1.0% Annual Probability	2.0% Annual Probability	7.7% Annual Probability	20% Annual Probability	50% Annual Probability

Lastly, the Corps and Reclamation are developing mission criticality measures with respect to the non-generation purposes of their plants. Both the Corps and Reclamation expect to have the criteria for these measures complete for inclusion in the 2022 SAMP.

7.1.1 Value Measure Consequence Levels

Safety: Safety Risk is used to capture the impact of an injury, disability or death of an employee or member of the public. The FCRPS does not purposefully expose employees or the public to safety hazards. Typically, when a hazard is identified the risk is assessed and either eliminated or mitigated. Mitigation can be through barriers or procedures. The safety risk evaluated per asset type is based on the most likely outcome due to failure that has not already been mitigated.

Insignificant	Minor	Moderate	Major	Extreme
No or minor injury, first aid	Treatment by medical professional	Lost time accident - temporary disability	Permanent disability	Fatality

Environmental: Environmental risk is assessed based on the cost of remediation efforts to reverse any damage potentially caused. Damage so severe as not to be reversible is ranked using the most severe consequence classification. Any fines associated with an environmental consequence are captured as compliance risk.

Insignificant	Minor	Moderate	Major	Extreme
No impact	Impact to on-site environment (simple remediation) or where the remediation costs < $100k	Limited impact off-site (localized remediation required) or where the remediation costs < $1M	Detrimental impact on- or off-site (long-term remediation required) or where the remediation costs < $10M	Detrimental or catastrophic impact off- site (mitigation impossible) or where the remediation costs > $10M

Compliance: Compliance risk is used to capture the impact of an event or a failure which would cause the FCRPS to fail to comply with a government or regulatory mandate or with an internal policy.

Insignificant	Minor	Moderate	Major	Extreme
No or insignificant effect on operations or administrative flexibility or annual mandated costs < $10k	Change in operations or administrative flexibility or inability or annual mandated costs < $100k	Adverse impact on beneficial legal principles or precedents; project operations noticeably affected for compliance; inability to maintain system frequency or voltage or annual mandated costs < $1M	Adverse effect on existing beneficial legal principles or precedents; substantial changes needed in project operations or administration or annual mandated costs < $10M	Extremely difficult to meet fundamental statutory obligations; extremely unreliable system; extreme changes needed in project operations or administration or annual mandated costs > $10M

Public Perception: Public Perception risk represents the risk that a failure or event will cause the organization's customers or other external stakeholders to lose confidence in the organization.

Insignificant	Minor	Moderate	Major	Extreme
No or isolated internal complaints	Local media attention; widespread internal complaints; some public embarrassment	Transitory local media / federal / customer attention and criticism; some damage control; congressional enquiry; short duration loss of power to islanded community	Ongoing media / federal / customer attention; major damage control; significant impact on staff morale; congressional enquiry; extended duration loss of power to islanded community	Adverse and ongoing media / federal / customer attention, criticism and agency intervention; extreme damage control; parliamentary secretary called to congress; permanent duration loss of power to islanded community

Financial: Unlike other value measures, financial value is directly monetized when possible. For illustrative purposes, the directly monetized values are mapped into the following five-level consequence scale for comparison to the other value measures. In the absence of direct quantification, these categories are used to evaluate financial risks for a limited number of investments to capture risks that are not typically evaluated.

Insignificant	Minor	Moderate	Major	Extreme
<$10k	$10k - $100k	$100k - $1M	$1M - $10M	>$10M

Financial criticality is primarily based on the marginal outage cost at each plant. The marginal outage cost can be thought of as the annual value that would be lost from the next unit to go out service, given a base level of availability. In other words, the marginal outage cost is the value of the last-on-first-off unit after accounting for a base level of outages.

Marginal outage costs are calculated for each plant, by month, over an 80-year water record. This analysis determines a base availability for each plant, derived from each plant's 5-year outage plan and incorporating recent unit performance. In addition, a number of units are also held out of service at specific plants to represent the amount of reserves that are typically carried at these facilities . To determine marginal outage cost, generation is first simulated by using the base availability assumptions described above. Generation is then simulated again with one additional unit out of service at each plant. The difference in simulated generation between these two scenarios establishes the marginal outage cost at each plant. Marginal outage costs are summarized to average annual values for use in FCRPS long-term planning models, but more granular information is used for individual investments as business cases are developed.

A weakness in this methodology is that using only the marginal outage cost, or the cost of the next unit to go out of service, ignores the fact that each successive unit out is costlier than the last. Plants with a high capacity relative to the amount of water available will have a low marginal outage. In the near term, this reflects that these plants can take on a higher risk of unit outage because the impact will be relatively low. What is lacking is a recognition that availability will decline without investment in the long-term and the marginal outage cost will become more substantial over time.

The chart below was created to illustrate the relationship between marginal outage cost and total plant generation value. The intention is to classify plants and groups of units based on their marginal outage cost and total value in order to identify the most critical areas and guide the level of analysis required.

> **Red:** High marginal outage cost and total generation value. Unit availability is critically low or plant capacity is inadequate. The financial impact of an unplanned outage is severe in the near-term and potentially detrimental in the long-term if not mitigated. Marginal outage cost methodology is not sufficient for business cases and more sophisticated analysis is required.
> **Orange:** High marginal outage cost, high total generation value or combination of moderate marginal outage cost and total generation value. Financial impact of outage is high in the near-term and potentially detrimental in the long-term if availability declines. Marginal outage cost methodology is not sufficient for business cases and more sophisticated analysis is required.
> **Yellow:** Moderate marginal outage cost or moderate average plant generation value. Financial impacts are manageable in the near-term and lower availabilities may be acceptable in the long term. Marginal outage cost methodology may be sufficient for business cases but more sophisticated analysis is considered.
> **Blue:** Low marginal outage cost or low total generation value. Financial impacts of outages are not detrimental to the FCRPS. Marginal outage cost methodology may be sufficient for business cases but more sophisticated analysis is considered.

At some plants, families of units with significantly different capacities are broken out to show the difference in marginal outage cost. However, each point plots the annual value for the *entire* plant as operations are interrelated between the families of units within the plant. Plant groupings are bound by blue-dashed boxes. Both axes are shown using a logarithmic scale but note the differences in magnitude.

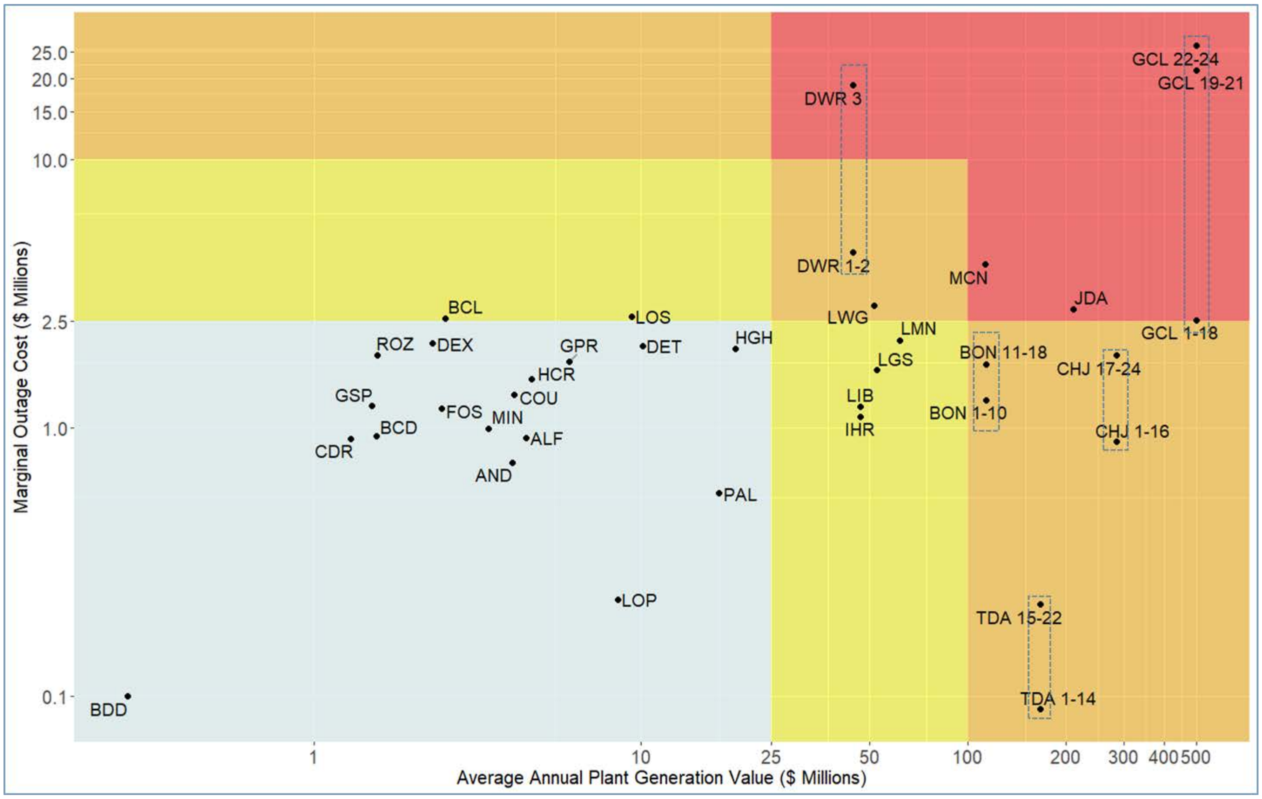


Figure 7.1-1

Note that for the illustrative purposes, average annual plant generation value on the x-axis in Figure 7.1-1 is valued using 5-year average Mid-Columbia energy prices. This represents a lower bound on the value of each plant as it is unlikely, especially for the larger plants, that total plant power production could be reliably replaced with spot market purchases. It also includes no value for the ancillary services and flexibility that the hydropower plants provide.

Mission Importance:

The Corps is developing a relative value versus importance matrix for their FCRPS plants. This effort will rank the relative generation value of units at Corps plants against their relative importance to non-hydropower missions. Larger plants with more units and higher capacities generally have a higher total value of generation. Plants where hydropower assets are frequently used for water management in coordination with other water conveyance features at the plant generally have a higher importance. Reclamation is going through a similar process to evaluate unit importance for their mission objectives.

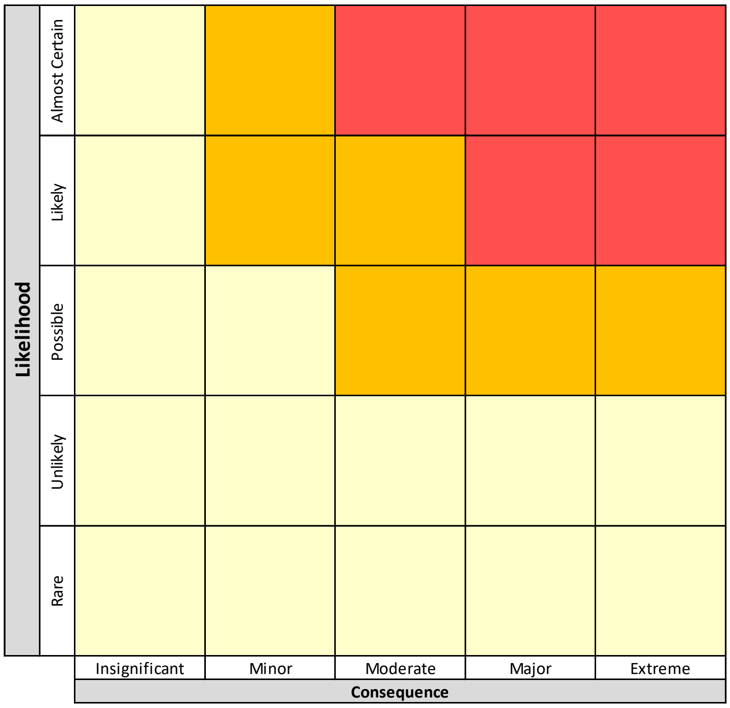
7.2 Usage of Criticality Model

Referenced earlier, there are two different levels of assessment for asset criticality. At both levels, financial risks and benefits are directly monetized, so the five-level consequence and likelihood scales simply categorize risk. For non-monetized benefits or benefits that are difficult to quantify, the five-level scales *are* the primary method of evaluation. Benefits and risks are calculated based on the selected likelihood and consequence on the five-level scales. The table below shows the value measures used at both levels of analysis.

Value Measure	Predictive Analytics	Investment Portfolio Optimization

Safety	✓	✓
Environmental	✓	✓
Compliance		✓
Public Perception		✓
Financial	✓	✓
Operational		

Predictive Analytics: Predictive Analytics is the first, high-level assessment run on all assets to determine their respective recommended intervention dates and identify the long-term funding levels for the system. Economics are the first driver in the optimal intervention date calculation. The Predictive Analytics model calculates the optimal intervention date by sminimizes quantified financial costs (see the detailed description in Section 10). Safety and Environmental criticality can override this calculation. Predictive Analytics triggers an intervention in the year in which an asset crosses into the high risk category of the Safety or Environmental risk map based on the asset's condition and likelihood of failure. High-risk regions are shaded red on the risk map.



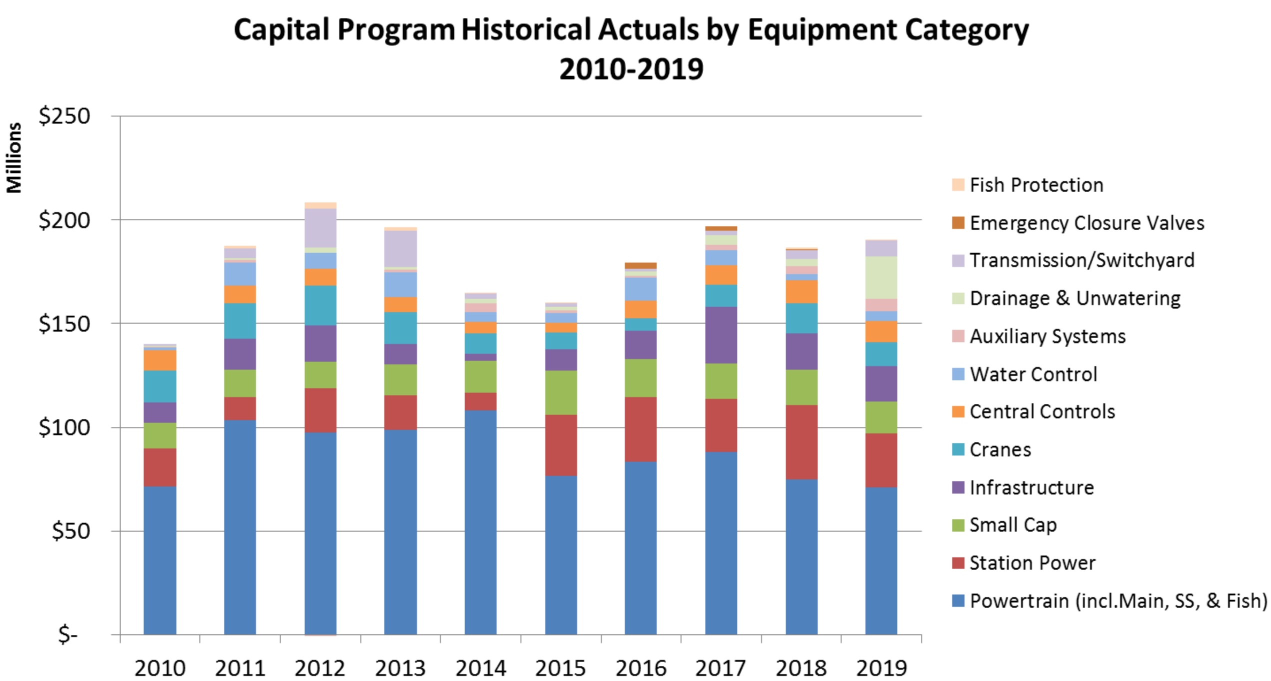
Investment Portfolio Optimization: For most investments, financial risks and benefits are quantified directly using the same models that drive Predictive Analytics. More sophisticated analyses are performed as major powertrain investments progress through the scoping and design phases. Benefits calculated in these analyses replace the benefits that Predictive Analytics produces. Safety and Environmental benefits and risks are treated differently at the Investment Portfolio Optimization stage. An assessment of the safety, environmental, compliance and public perception risks is made specific to each identified investment. This refines the high level analysis that is performed for each asset based on its asset type. These measures are assigned a value based on the consequence and likelihood levels selected from the five-level consequence and likelihood scales. The value is then equated to the equivalent five-level financial consequence scale and any value measure weightings are applied. Currently, safety and environmental consequence receive a weight of 2 and 1.5 respectively. This means a major safety consequence receives twice the value of a major financial consequence when the portfolio is optimized.

8.0 CURRENT STATE

8.1 Historical Costs

Capital investments have hovered between $150 and $200 million over the last 10 years. Although analyses have supported higher levels of capital investment for many years, the FCRPS has been unable to ramp up to the levels identified in previous IPRs.

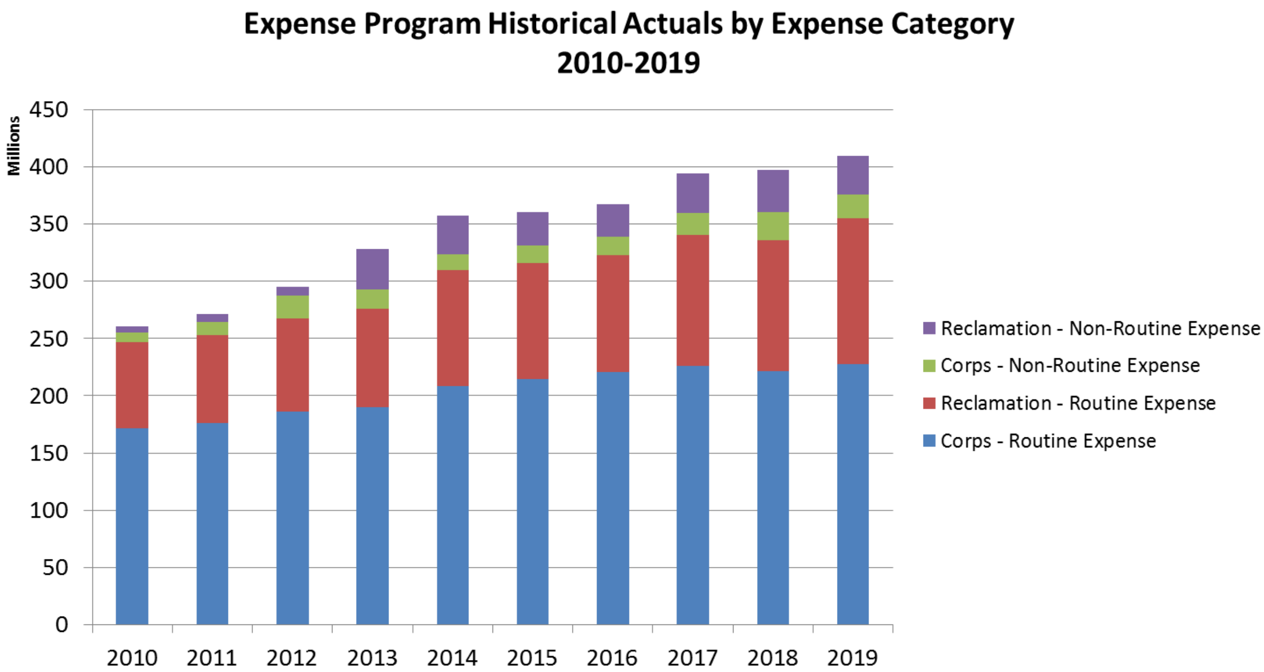
Figure 8.1-1 Historical Expenditures - Capital



The ability to ramp up the program relies on several large powertrain investments moving forward, specifically at Grand Coulee, McNary and Chief Joseph. These investments have taken longer to plan, design and execute than expected but are core to the business case for a higher level of investment. Advancing projects to fill in the gaps caused by delays in large investments is not always possible or optimal. A critical piece of the FCRPS investment strategy is optimizing the timing of investment. Investments are moved forward if analysis shows that it is both optimal and logistically possible. If the investment has higher value at a later date, it will not be moved forward to fill a gap.

Investment in powertrain components declined in the second half of the decade with more investment devoted to Station Power and Infrastructure. Many of these investments were made in anticipation of major powertrain investments in the 2020s. As powertrain investments reach the execution phase at Grand Coulee, McNary and Chief Joseph in the next 10 years, it is expected that the share of investment dedicated to powertrain equipment will rise.

Figure 8.1-2 Historical Expenditures - Expense



The expense program averaged a 5% increase per year, outpacing inflation and leading the FCRPS to seek ways to "bend the curve." Increases in the routine expense program reflect mandated increases in wage rates as well as increased regulatory and mitigation requirements. One anomaly is the increase in non-routine expense for Reclamation starting in 2013 reflecting the mechanical overhauls on units G22-24 in the Third Powerplant at Grand Coulee.

Table 8.1-1 Historical Spend

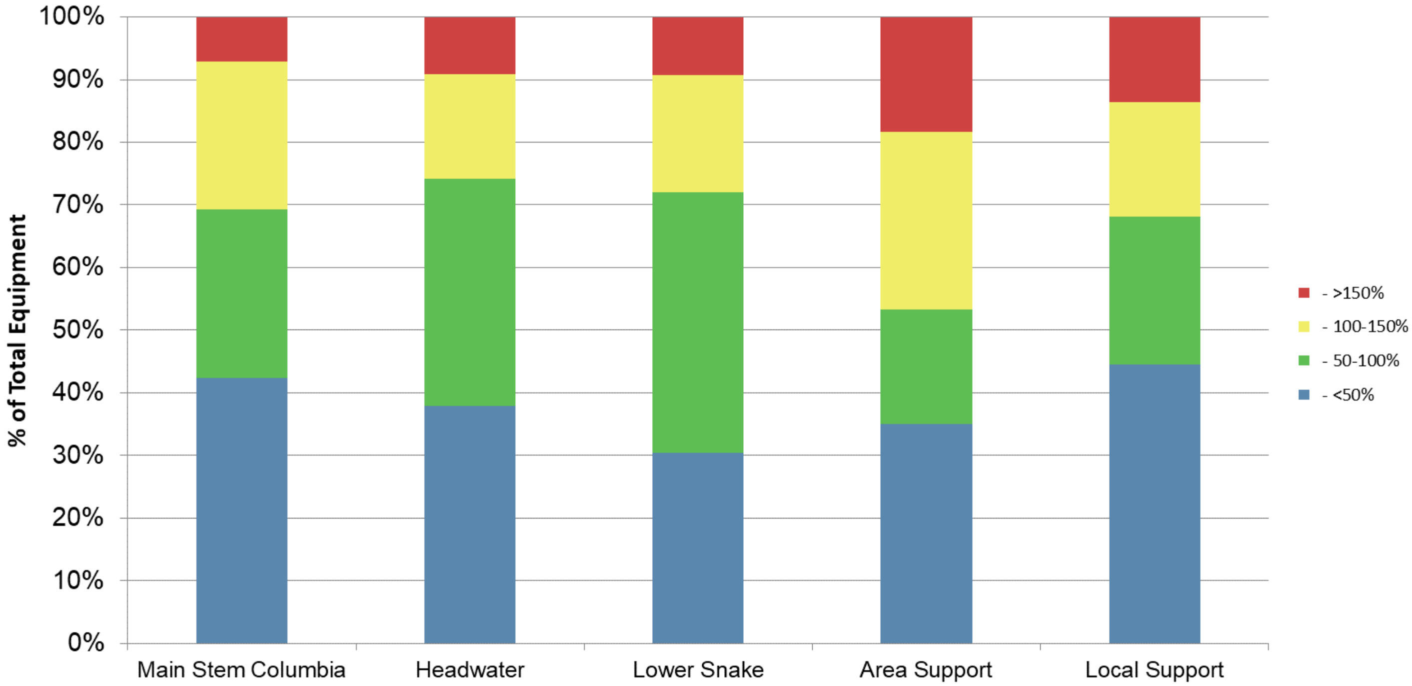
Program	Historical Spend (in thousands) With Current Rate Case						
Capital Expand (CapEx)	2015	2016	2017	2018	2019	2020	2021
Corps of Engineers							
Bureau of Reclamation							
Total Capital Expand							
Capital Sustain							
Corps of Engineers	131,692	143,838	160,377	157,145	150,409	170,971	206,895
Bureau of Reclamation	27,644	34,660	35,958	28,975	35,421	37,500	26,855
Total Capital Sustain	159,336	178,498	196,359	186,639	186,505	208,471	233,750
Expense (OpEx)							
Corps of Engineers	230,058	237,508	245,029	245,029	248,720	252,557	252,557
Bureau of Reclamation	130,291	130,208	149,658	152,105	161,124	153,609	151,623
Total Expense	360,349	367,716	394,687	397,693	409,844	406,166	404,180

8.2 Asset Condition and Trends

For the FCRPS, the average unit is over 50 years old with many components still in service from original construction. For Main Stem Columbia, Headwater, Lower Snake and Local Support asset classes, about 30% of assets have exceeded their design lives. For Area Support plants, closer to 50% have exceeded their design lives.

8.2.1 Asset Age

Figure 8.2-1, Current Asset Age by Classification



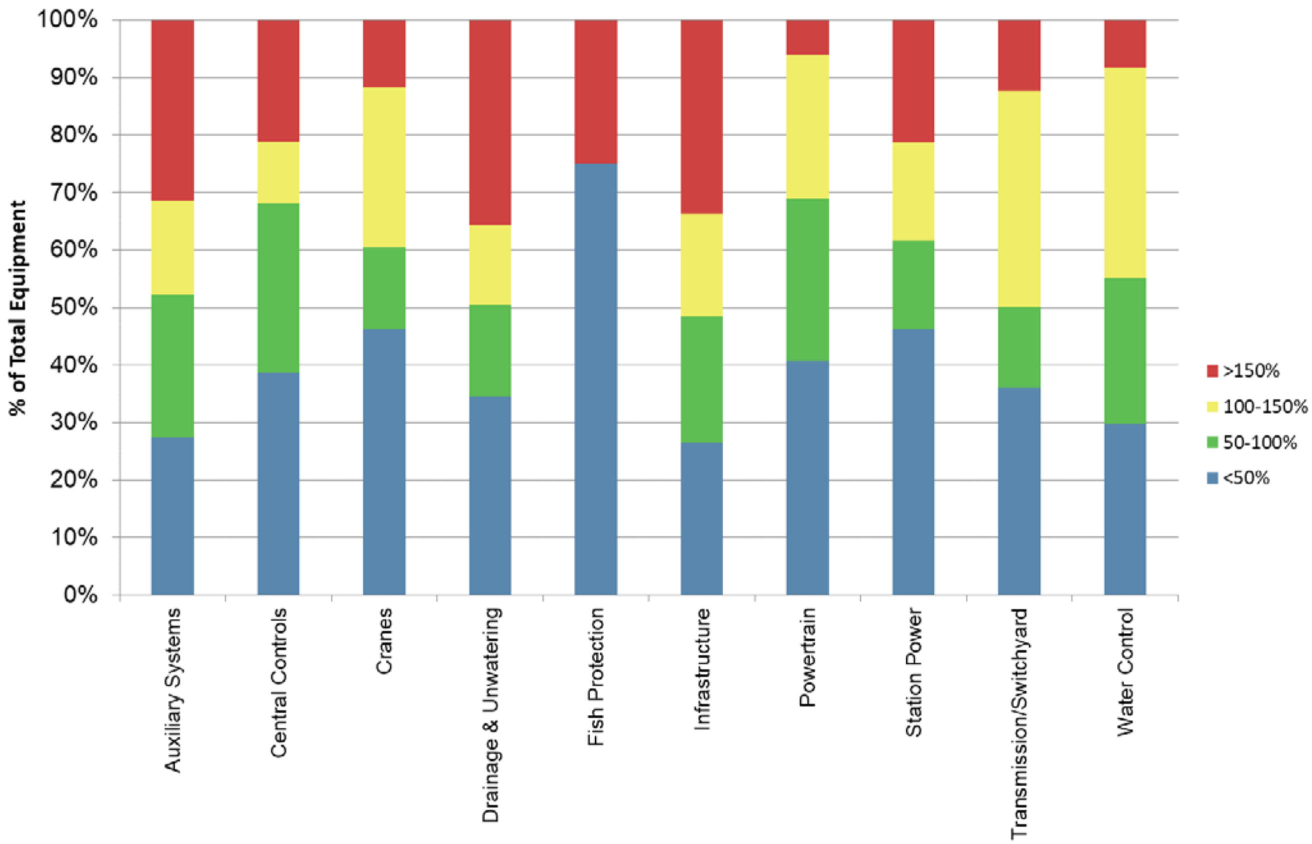
Although exceeding design life is not a cause for replacement, looking at the population demographics in aggregate provides useful information about potential near-term replacement need.

Assets in the Auxiliary System, Drainage and Unwatering, Infrastructure and Transmission/Switchyard categories tend to be pushed beyond their design lives than other equipment categories. Generally, these systems are built with fair amounts of redundancy or have more rigorous tests and inspections enabling them to stay in service for longer periods of time. In the next several years, many more assets in these categories will exceed their design lives with 63% exceeding their design life by the end of the decade.

Crane replacements have been a focus in recent years due to their criticality for powertrain replacement projects and during repairs that require unstacking. The percentage exceeding design life has decreased by 10% since the 2018 SAMP.

Much of the population of Powertrain and Central Controls equipment is nearing its design life. Without investment, the percentage exceeding design life would rise to 52% and 82%, respectively, by 2030.

Figure 8.2-2, Current Asset Age by Equipment Category



8.2.2 Asset Condition

FCRPS equipment condition is assessed using the hydroAMP condition assessment framework, a methodology used throughout the world for hydro asset condition assessment. In total, the condition of over 5,500 pieces of FCRPS equipment and equipment systems are tracked using the hydroAMP application. The hydroAMP Condition Assessment Guide contains specific instructions for the objective condition assessment of the power train and critically ancillary equipment. A more generic guide was created for the balance of plant assets to more subjectively assess the condition of more than eighty additional asset types.

Condition Assessment guides have been written collaboratively by subject matter expert teams with representation from Bonneville Power Administration, Army Corps of Engineers, Bureau of Reclamation, Chelan PUD, Seattle City Light and Hydro Quebec. Guides are periodically reviewed and revisited by the hydroAMP Steering Committee of which the above utilities are members. Development of the hydroAMP framework is supported by the 60+ member utilities of CEATI's Hydraulic Plant Life Interest Group (HPLIG).

Of the approximately 9,000 pieces of FCRPS equipment in hydroAMP, powertrain assets (Turbines, Generator Rotors and Stators, Governors, Excitation Systems, Transformers and Circuit Breakers) represent about a third. These assets are inventoried for each of the 31 plants in a consistent manner.

Remaining components are categorized as critical ancillary and balance of plant equipment, some of which have direct impacts on generation. The inventory of equipment in these categories is less consistent across the plants. Improvements in the consistency of asset identification throughout the FCRPS as well as improvements in how the condition assessments are collected and quality-controlled are being discussed as part of the Asset Investment Excellence Initiative.

Condition ratings for each asset 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**

Although the Main Stem Columbia, Headwater and Lower Snake facilities have similar age demographics, condition paints a different picture. At Headwater and Lower Snake plants, about 50% of the assets are in marginal or poor condition while about 30% Main Stem Columbia assets are in marginal or poor condition.

Figure 8.2-3, Current Asset Condition by Classification

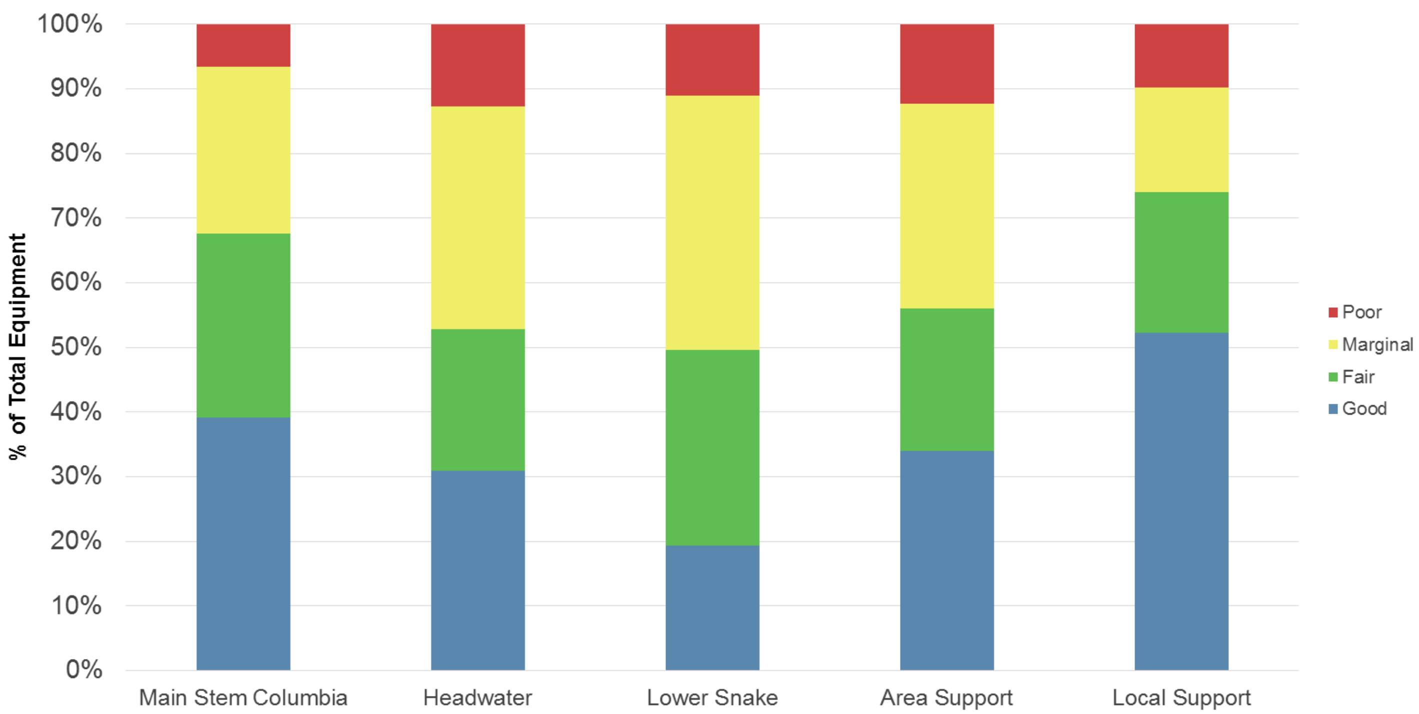
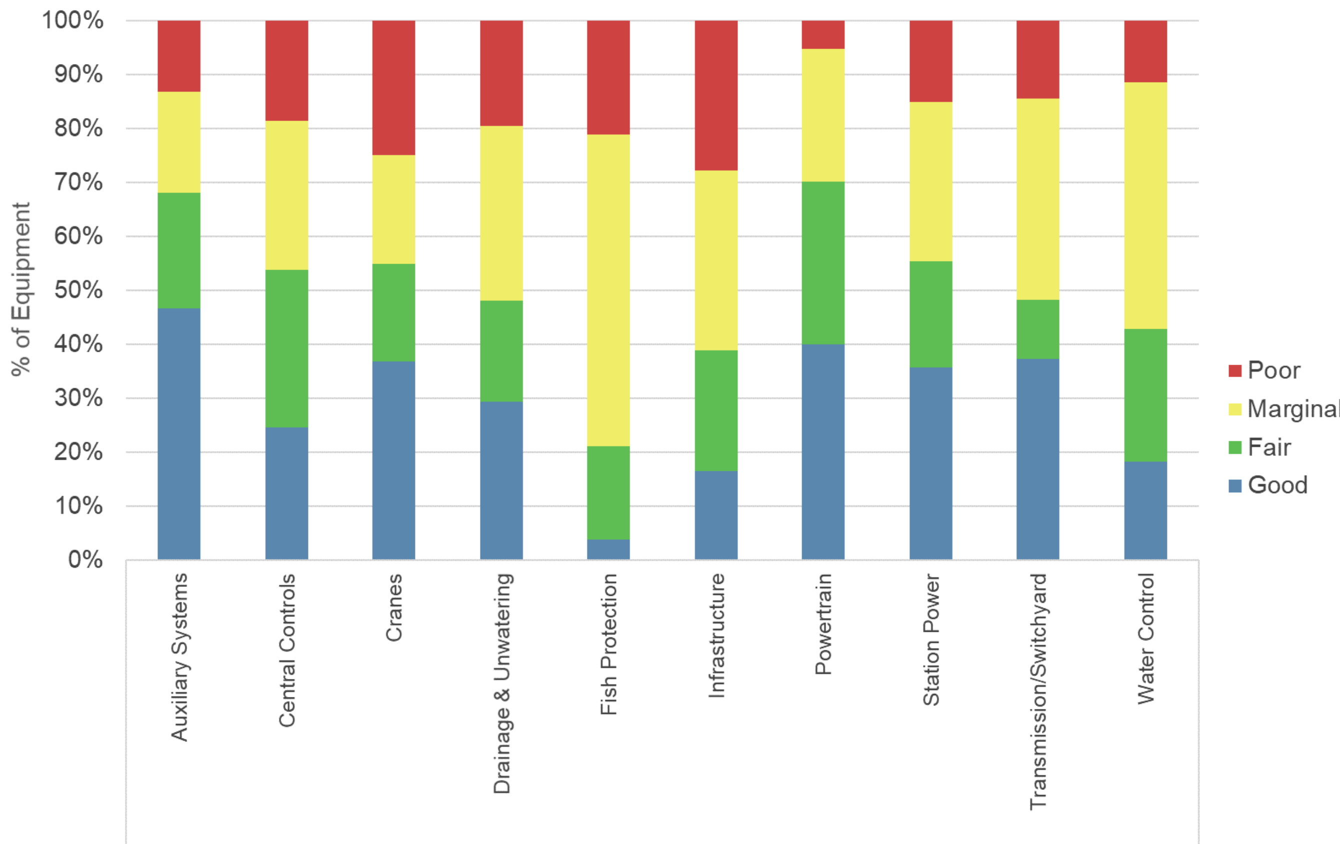


Figure 8.2-4, Current Asset Condition by Equipment Category



Auxiliary Systems: 32% are in marginal or poor condition. Fire Detection Systems and Compressed Air Systems are the primary drivers.

Central Controls: 45% are in marginal or poor condition. SCADA/GDACS, Station Control Boards, Main Consoles and Annunciation Systems are the primary drivers. Over 80% would be in marginal or poor condition in 10 years without investment.

Cranes: 40% are in marginal or poor condition. This has improved from 60% in the previous SAMP due to investments throughout the system.

Drainage and Unwatering: 52% are in marginal or poor condition. Pumps are the primary driver.

Emergency Closure Valves: 90% are in marginal condition. Only a small percentage would be expected to move into Poor condition in the next 10 years without investment.

Fish Protection: 79% are in marginal or poor condition. Fish screens are the primary driver. Over 90% would be in marginal or poor condition in the next 10 years without investment.

Infrastructure: 62% are in marginal or poor condition. Communications Hardware, Elevators and HVAC are the primary drivers.

Powertrain: 31% are in marginal or poor condition. Generator windings, Kaplan Turbine Runners and Components and Transformers are the primary drivers. This number rises to over 50% in the next 10 years without investment.

Station Power: 45% are in marginal or poor condition. Iso-Phase buses and switchgear are the primary drivers. This number rises to over 60% in the next 10 years without investment.

Transmission/Switchyard: 48% are in marginal or poor condition. Disconnects and Bus Work are the primary drivers.

Water Control: 58% are in marginal or poor condition. Emergency and Non-Emergency Closure gates are the primary drivers.

8.3 Asset Performance

Maintaining performance metrics is a requirement of the Corps and Reclamation's respective Direct Funding Agreements with BPA. The Performance Committee, a Three Agency subcommittee of the JOC, develops, revises, tracks and reports on performance metrics in accordance with the Direct Funding Agreements. Performance metrics, including their addition or removal, are reviewed and approved by the JOC and Executive Steering Committee on an annual basis. During the development of this SAMP, many changes to performance metrics were under consideration for FY20. For this SAMP, performance metrics are shown relative to the FY19 list of metrics and respective targets. Updates will be reflected in the 2022 SAMP when the suite of new and revised metrics has been solidified.

8.3.1 Safety

The FCRPS uses three metrics to track Safety Performance in the hydro business line. Days Away Restricted or Transferred (DART) has been the primary safety metric since 2015. Lost Time Accident Rates (LTAR) and Total Case Incident Rates (TCIR) are also tracked and compared to industry averages. Moving to DART in 2015 signaled a focus on FCRPS Safety performance, which has lagged behind industry average for a number of years.

FY 19 Safety Performance Targets

	DART	LTAR	TCIR
Stretch	1	0.5	2.3
Mid	1.5	0.95	3.7
Min	2.8	1.05	5.3

Days Away Restricted or Transferred per 200,000 person-hours

	2015	2016	2017	2018	2019
FCRPS	2.30	1.72	1.93	1.91	1.80
Industry Average	1.77	0.35	0.55		

Lost Time Accidents per 200,000 person-hours

	2015	2016	2017	2018	2019
FCRPS	1.48	0.81	0.82	0.74	1.41
Industry Average	0.73	0.27	0.36		

Total Case Incident Rate per 200,000 person-hours

	2015	2016	2017	2018	2019
FCRPS	4.44	4.26	3.39	4.99	3.33
Industry Average	2.76	1.95	1.28		

8.3.2 Reliability and Compliance

Reliability and Compliance metrics are managed by the Reliability Implementation & Technical Subcommittee (RITS). Reliability and Compliance for the FCRPS is primarily governed by the Western Electricity Coordinating Council (WECC) and the North American Electric Reliability Corporation (NERC). The RITS adopted two new metrics in 2017 to track Reliability and Compliance.

Indicator	Definition	Stretch	Mid	Min
Reliability: Standards Compliance	1) No WECC-identified alleged violations with a "high risk factor" violation and a "high" or "severe" severity level (level 3 or more), where "WECC-identified" means either discovered by WECC during an audit or formal WECC concurrence to a self-reported alleged violation. 2) 100 percent of submitted WECC-approved mitigation plans and at least 80% of related milestones are completed as scheduled, including self-reported violations. Note: Critical Infrastructure Protection Standards and Operational Standards are both included. Requirements with no Violation Risk Factors are not included.	100%	N/A	N/A
Reliability: Inherent Risk Assessments	Measures completion of each entity's initial or annual update to its Inherent Risk Assessment. This measures proactive compliance steps to align its compliance activities with NERC oversight goals to focus efforts on higher risk areas.	Com-plete	Started	Not Started

For FY19, the FCRPS met the Stretch target for the Standards Compliance metric and met the Mid target for completion of Inherent Risk Assessments. The last time the Standards and Compliance metric was not met was in 2014 due to a number of self-reported violations at Corps facilities.

8.3.3 Financial

The financial metrics that are currently tracked are related to budget execution and track the actual dollars spent relative to Start-of-Year budgets.

Indicator	Definition	Stretch	Mid	Min
Power Expense Expenditure Rate	Actual Routine power O&M expenses divided by planned O&M expenses for the latest revision of the Annual Power Budget.	95% - 100%		90% - 95%
Joint Expense Expenditure Rate	Actual Routine joint O&M expenses divided by planned O&M expenses for the latest revision of the Annual Power Budget.	95% - 100%		90% - 95%
NREX Expenditure Rate	Actual NREX expenditures divided by the total NREX funds available in the latest Annual Power Budget.	95% - 100%		90% - 95%
Capital Budget Expenditure Rate	Actual Capital expenditures divided by SOY budget, cumulative by month, large capital only.	95%	90%	85%

Historically, the Stretch targets have been difficult to meet at the FCRPS level for both capital and expense, however, Reclamation and the Corps have individually met their targets in a number of years. 2019 was the first year that all stretch targets were met since the current suite of metrics have been tracked.

Past and Current Year Performance										
Metric	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Power Expense Expenditure Rate	97.5%	97.6%	90.9%	94.0%	96.3%	94.3%	92.1%	97.2%	94.9%	98.4%
NREX Expenditure Rate					82.1%	78.5%	71.9%	89.4%	86.2%	98.7%
Large Capital Budget Expenditure Rate	96.1%	90.7%	94.5%	86.3%	89.6%	79.4%	93.2%	97.3%	102.5%	99.9%

The decline in the Capital Budget Expenditure Rate metric triggered a review of the capital investment program processes in 2014 that eventually resulted in the creation of the AIEI. Capital execution has improved as the AIEI has matured. However, not captured by the capital execution metric is that the SOY budget requests have not aligned with IPR requests. This means that there has been improvement on SOY forecasting and within year execution, but execution on long-term forecasts remain an issue.

8.3.4 Environmental/Trusted Stewardship

Fish screen reliability is critical for both safe fish passage and generation. The Corps is unable to operate a generating unit if it does not have fish screens in place at specific plants during the months of April through September in order to facilitate the safe passage of migrating fish. Outages associated with fish screens are tracked over this period and are compared, in aggregate for all plants with Fish Screens, to performance goals below.

Stretch	<= 250 hours
Mid	<= 350 hours
Min	>= 450 hours

Outage hours have grown significantly in recent years, reflecting the age and deteriorating condition of the fish screens themselves as well as their supporting equipment. Rehabilitation, replacement or removal strategies are being evaluated by the Corps and coordinated with plans for improved fish passage turbine replacement.

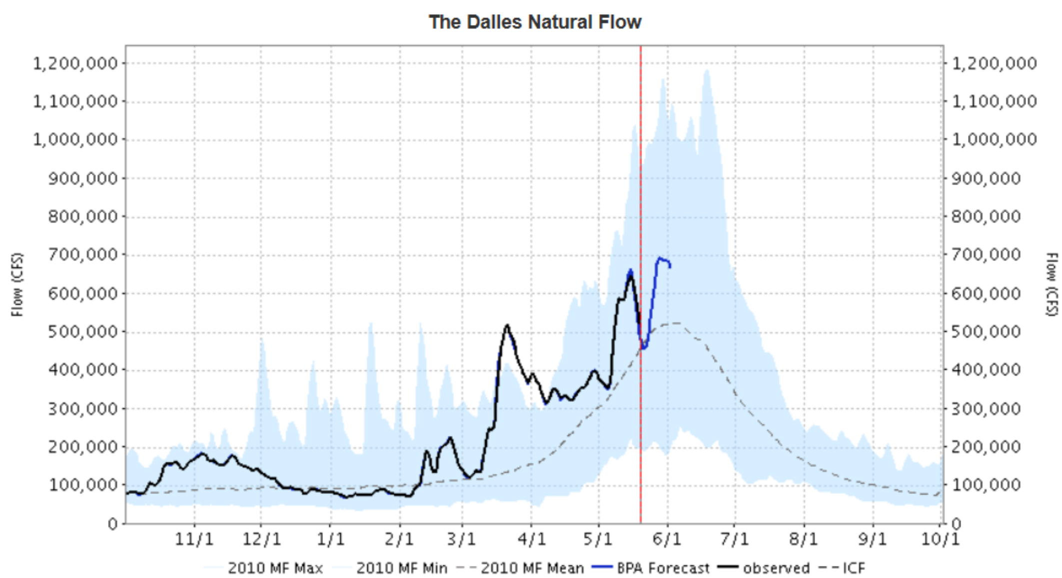
Performance Indicator Results: Fish Screen Reliability

Past and Current Year Performance								
Metric	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Fish Screen Reliability	197	274	211	509	655	2030	667	270

8.3.5 Availability

Availability metrics are the primary performance indicators used to measure the performance of electric generating equipment. Generally, higher availability equates to more generation and revenue. However, hydro resources differ from other generation resources due to the variability in their fuel source. Unlike more conventional dispatchable resources that can choose to produce when it is economic, hydro facilities are bound by the amount of water available for generation, which makes availability metrics a moving target. This is accentuated in the Columbia River Basin by the highly variable within-year and year-to-year flows. Between fall and summer, natural flows can change by up to a factor of 10 in wet years or by as little as a factor of 2 in dry years.

Annual Flow Uncertainty at The Dalles Dam



This highly variable water supply makes setting availability targets and comparing FCRPS availability to industry metrics challenging. Due to the unique configuration of each facility as well as the conditions in which they operate, the optimal level of availability will differ by plant, by month and by year. Currently, availability targets are informed by each plant's 5-year outage plan and are updated on an annual basis. Baseline forced outage targets are developed by blending industry average forced outage factors with a 5-year average of each plant's forced outage factor. The combination of forced outage factor estimates and each plants 5-year outage plan result in the availability targets shown in the table below.

FY19 Availability and Forced Outage Performance Targets

Forced Outage Factor

Plant	Stretch	Mid	Min
FCRPS	**2.2%**	**3.4%**	**4.4%**
Corps	**2.1%**	**3.6%**	**4.8%**
Chief Joseph	1.0%	1.7%	2.5%
Libby	1.0%	1.5%	2.5%
Albeni Falls	1.0%	1.5%	2.5%
NWS	**1.0%**	**1.7%**	**2.5%**
John Day	2.5%	4.3%	5.8%
The Dalles	2.5%	6.5%	7.7%
Bonneville	2.5%	3.8%	4.4%
Lookout Point	1.0%	2.5%	3.0%
Detroit	2.5%	3.0%	4.2%
Green Peter	1.0%	1.7%	2.5%
Lost Creek	1.0%	2.2%	2.7%
Hills Creek	2.5%	3.0%	3.5%
Cougar	2.5%	5.5%	7.0%
Big Cliff	2.2%	2.7%	3.5%
Foster	1.0%	1.5%	2.5%
Dexter	1.5%	2.5%	4.0%
NWP	**2.4%**	**4.8%**	**6.0%**
McNary	2.4%	2.9%	3.4%
Little Goose	2.5%	3.8%	4.3%
Lower Monumental	2.5%	3.8%	5.3%
Lower Granite	1.9%	2.4%	2.9%
Ice Harbor	2.5%	5.5%	12.0%
Dworshak	1.4%	2.2%	2.7%
NWW	**2.3%**	**3.4%**	**4.9%**
Reclamation	**2.4%**	**2.9%**	**3.4%**
Grand Coulee	2.5%	3.0%	3.5%
Hungry Horse	1.5%	2.1%	2.6%
Palisades	1.0%	1.5%	2.5%
Anderson Ranch	1.0%	1.5%	2.5%
Minidoka	1.6%	2.5%	7.0%
Green Springs	1.0%	1.5%	2.5%
Roza	1.0%	1.5%	2.5%
Chandler	1.0%	1.5%	2.5%
Black Canyon	1.0%	1.5%	2.5%
Boise Diversion	1.0%	1.5%	2.5%

Availability Factor

Plant	Stretch	Mid	Min
FCRPS	**80.6%**	**78.0%**	**76.9%**
Corps	**85.5%**	**83.5%**	**82.7%**
Chief Joseph	91.8%	90.7%	90.2%
Libby	86.9%	85.1%	84.3%
Albeni Falls	94.3%	93.5%	93.2%
NWS	**90.9%**	**89.7%**	**89.2%**
John Day	86.5%	84.6%	83.9%
The Dalles	78.8%	75.9%	74.6%
Bonneville	91.4%	90.2%	89.7%
Lookout Point	86.2%	84.3%	83.5%
Detroit	92.5%	91.5%	91.1%
Green Peter	94.5%	93.8%	93.4%
Lost Creek	92.4%	91.4%	91.0%
Hills Creek	94.1%	93.2%	92.9%
Cougar	92.4%	91.4%	90.9%
Big Cliff	92.7%	91.7%	91.3%
Foster	94.2%	93.5%	93.1%
Dexter	89.2%	87.7%	87.1%
NWP	**85.3%**	**83.3%**	**82.4%**
McNary	94.2%	93.4%	93.0%
Little Goose	79.7%	76.9%	75.7%
Lower Monumental	73.3%	69.6%	68.1%
Lower Granite	83.5%	81.3%	80.3%
Ice Harbor	74.1%	70.6%	69.1%
Dworshak	86.1%	84.2%	83.4%
NWW	**82.2%**	**79.8%**	**78.8%**
Reclamation	**71.1%**	**67.1%**	**65.5%**
Grand Coulee	69.3%	66.8%	65.8%
Hungry Horse	62.3%	59.2%	58.0%
Palisades	93.1%	92.5%	92.3%
Anderson Ranch	90.7%	89.9%	89.6%
Minidoka	40.6%	35.8%	33.9%
Green Springs	82.6%	81.2%	80.6%
Roza	84.9%	83.6%	83.1%
Chandler	92.5%	91.9%	91.7%
Black Canyon	92.9%	92.3%	92.1%
Boise Diversion	93.6%	93.1%	92.9%

Current year performance is shown in the table below. The past five years of performance are also shown relative to each year's respective performance targets.

Table 8.3-1 Historical Asset Performance Summary

Strategic Goal	Objective	Measure	Units	2015	2016	2017	2018	2019
Modernize assets	Power Reliability	Weighted Availability Factor	%	77.9%	76.5%	74.5%	78.4%	77.2%

	Forced Outage Performance					Availability Performance				
	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
Corps	**3.0%**	**4.2%**	**7.2%**	**6.6%**	**6.6%**	**82.4%**	**82.0%**	**79.8%**	**81.6%**	**82.2%**
Chief Joseph	0.0%	0.2%	2.0%	0.1%	0.1%	77.2%	84.5%	87.6%	90.6%	89.2%
Libby	0.7%	0.2%	0.0%	1.6%	1.6%	84.2%	82.1%	92.2%	93.4%	85.4%
Albeni Falls	0.2%	0.5%	0.0%	0.0%	0.0%	90.6%	90.7%	76.5%	86.4%	94.7%
Seattle District	**0.1%**	**0.2%**	**1.6%**	**0.4%**	**0.4%**	**78.7%**	**84.2%**	**88.2%**	**91.1%**	**88.6%**
John Day	10.0%	10.8%	9.8%	13.0%	13.0%	74.0%	75.7%	80.2%	75.3%	81.5%
The Dalles	0.3%	10.5%	13.8%	13.8%	13.8%	94.9%	86.6%	77.7%	76.6%	71.5%
Bonneville	2.7%	1.2%	4.8%	6.3%	6.3%	88.9%	77.7%	75.4%	84.6%	93.2%
Detroit	0.0%	19.9%	1.2%	0.1%	0.1%	94.2%	74.1%	89.4%	95.8%	90.9%
Big Cliff	1.0%	0.2%	7.2%	0.2%	0.2%	99.0%	88.0%	87.1%	95.5%	82.7%
Green Peter	0.2%	0.2%	0.9%	1.4%	1.4%	94.9%	93.9%	94.8%	95.9%	90.1%
Foster	0.3%	0.0%	0.0%	0.5%	0.5%	86.5%	84.3%	88.6%	95.9%	95.0%
Lookout Point	2.9%	0.4%	0.0%	0.0%	0.0%	90.6%	96.4%	93.2%	96.8%	93.3%
Dexter	0.0%	0.0%	0.0%	0.0%	0.0%	41.9%	88.6%	96.8%	96.9%	52.4%
Cougar	0.2%	37.1%	0.0%	10.9%	10.9%	85.9%	61.3%	43.4%	68.2%	84.0%
Hills Creek	3.7%	10.4%	0.1%	0.0%	0.0%	47.7%	51.3%	95.3%	93.3%	86.4%
Lost Creek	0.0%	0.6%	0.5%	0.0%	0.0%	93.7%	76.3%	15.3%	81.7%	92.7%
Portland District	**4.7%**	**8.5%**	**9.6%**	**11.2%**	**11.2%**	**84.9%**	**80.2%**	**78.3%**	**78.6%**	**80.9%**
Dworshak	0.2%	0.0%	0.0%	0.1%	0.1%	92.5%	82.9%	37.3%	52.9%	86.5%
Lower Granite	1.8%	0.3%	5.5%	1.8%	1.8%	77.3%	83.2%	71.4%	84.3%	84.4%
Little Goose	4.1%	2.6%	8.4%	1.5%	1.5%	80.1%	83.6%	83.0%	75.7%	72.1%
Lower Monumental	1.0%	0.2%	15.5%	13.4%	13.4%	77.9%	73.5%	58.9%	57.4%	69.3%
Ice Harbor	5.6%	4.9%	11.0%	13.6%	13.6%	78.3%	76.6%	62.1%	66.3%	66.5%
McNary	2.8%	0.6%	4.6%	0.2%	0.2%	87.1%	93.3%	89.7%	95.1%	91.5%
Walla Walla District	**2.7%**	**1.4%**	**8.1%**	**4.9%**	**4.9%**	**81.6%**	**82.8%**	**76.3%**	**79.0%**	**79.7%**
Reclamation	**4.1%**	**1.9%**	**3.2%**	**0.3%**	**0.3%**	**69.1%**	**65.6%**	**64.3%**	**72.2%**	**67.6%**
Grand Coulee	4.4%	2.1%				68.0%	64.5%			
Grand Coulee L/R	11.2%	4.5%	3.3%	0.3%	0.3%	72.2%	77.9%	63.0%	72.3%	67.2%
Grand Coulee TPP	1.1%	0.9%				65.9%	57.8%			
Hungry Horse	1.7%	0.3%	1.9%	0.2%	0.2%	81.4%	77.9%	80.2%	66.1%	62.7%
Palisades	0.0%	0.0%	0.0%	0.0%	0.0%	73.4%	69.5%	70.0%	79.6%	90.4%
Minidoka	0.7%	0.0%	29.8%	3.8%	3.8%	87.7%	58.2%	25.4%	23.4%	26.1%
Anderson Ranch	0.6%	2.0%	0.0%	0.2%	0.2%	94.6%	92.0%	77.5%	91.0%	87.3%
Boise Diversion	0.8%	1.4%	0.3%	1.0%	1.0%	59.4%	56.1%	95.2%	92.4%	99.6%
Black Canyon	0.1%	0.0%	0.0%	0.0%	0.0%	95.1%	95.1%	94.3%	94.7%	95.6%
Chandler	0.0%	0.2%	0.2%	0.0%	0.0%	40.6%	62.2%	81.8%	88.1%	81.1%
Roza	0.0%	0.0%	0.0%	0.0%	0.0%	64.3%	74.8%	86.1%	85.9%	85.4%
Green Springs	1.1%	2.9%	0.0%	0.1%	0.1%	83.7%	70.6%	88.4%	92.9%	83.7%

8.3.6 Cost of Power

BPA Power and Finance recently developed an agreed upon methodology to calculate the cost of generation and fully allocated cost of FCRPS plants. Both metrics will be trended over time and potential targets will be investigated. Some tweaks to allocation methodologies may still be made as this process matures. The definitions of each metric are below.

Table 8.3.6-1 – 3-year Average Cost of Power Metrics (FY17-FY19)

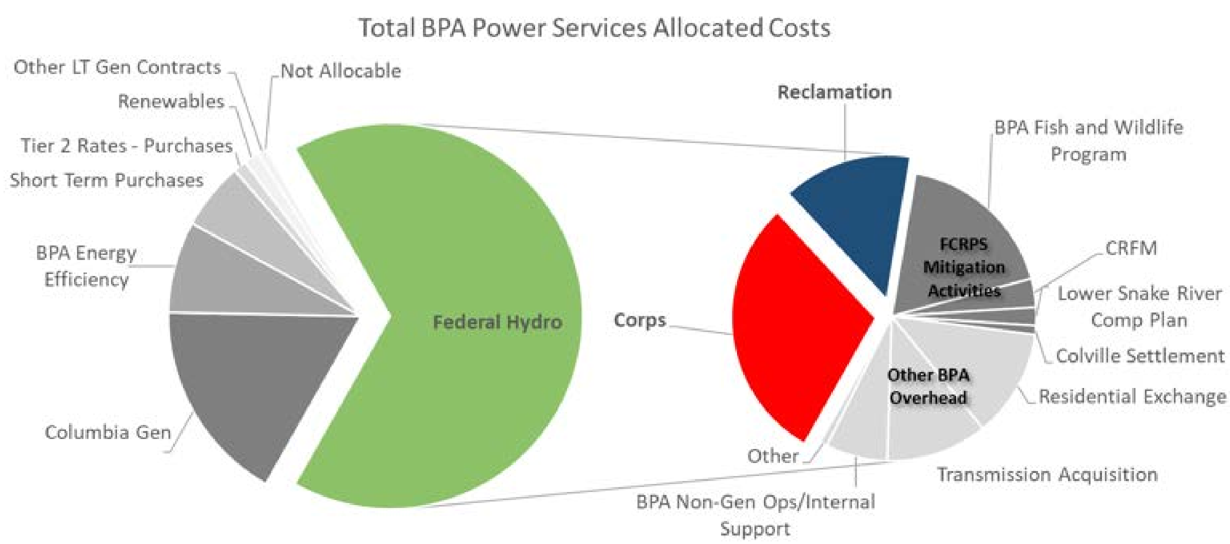
Resource	Cost of Generation ($/MWh)	Fully Loaded Cost $/MWh
Main Stem Columbia	7.52	18.19
Lower Snake	9.86	26.85
Headwater	12.49	23.06
Area Support	23.41	40.08
Local Support	29.56	40.11
FCRPS Hydro	**8.89**	**20.51**

Cost of Generation: The direct cost and administrative overheads of producing power at a plant. Includes operations, maintenance, administrative and capital related costs (interest expense).

Fully Loaded Cost: All costs of doing business associated with the hydro plant operations, power marketing and delivery. Includes all costs from the costs of generation plus all other allocable costs to the hydro system such as BPA's Fish and Wildlife program, Residential Exchange, transmission acquisition and other obligations.

The 3-year average cost of power metrics for FY17-FY19 are shown in Table 8.3.6-1. Average costs are compared to average annual generation. The FCRPS hydro cost of generation of $8.89/MWh shows that the system as a whole is a very cost of effective resource when looking at the direct costs of power production. This measure is the most comparable to spot market prices, which are more closely tied to the marginal cost of power production. The fully loaded cost of the system was $20.51/MWh, which itself is in the competitive range with recent Mid-Columbia spot market prices.

Costs allocated to Federal Hydro accounted for about 66% of Power Services total costs. Of the costs allocated to Federal Hydro, the Corps and Reclamation accounted for 44% while BPA's Fish and Wildlife Program, Residential Exchange, Transmission Acquisition and support costs accounted for an equivalent amount.

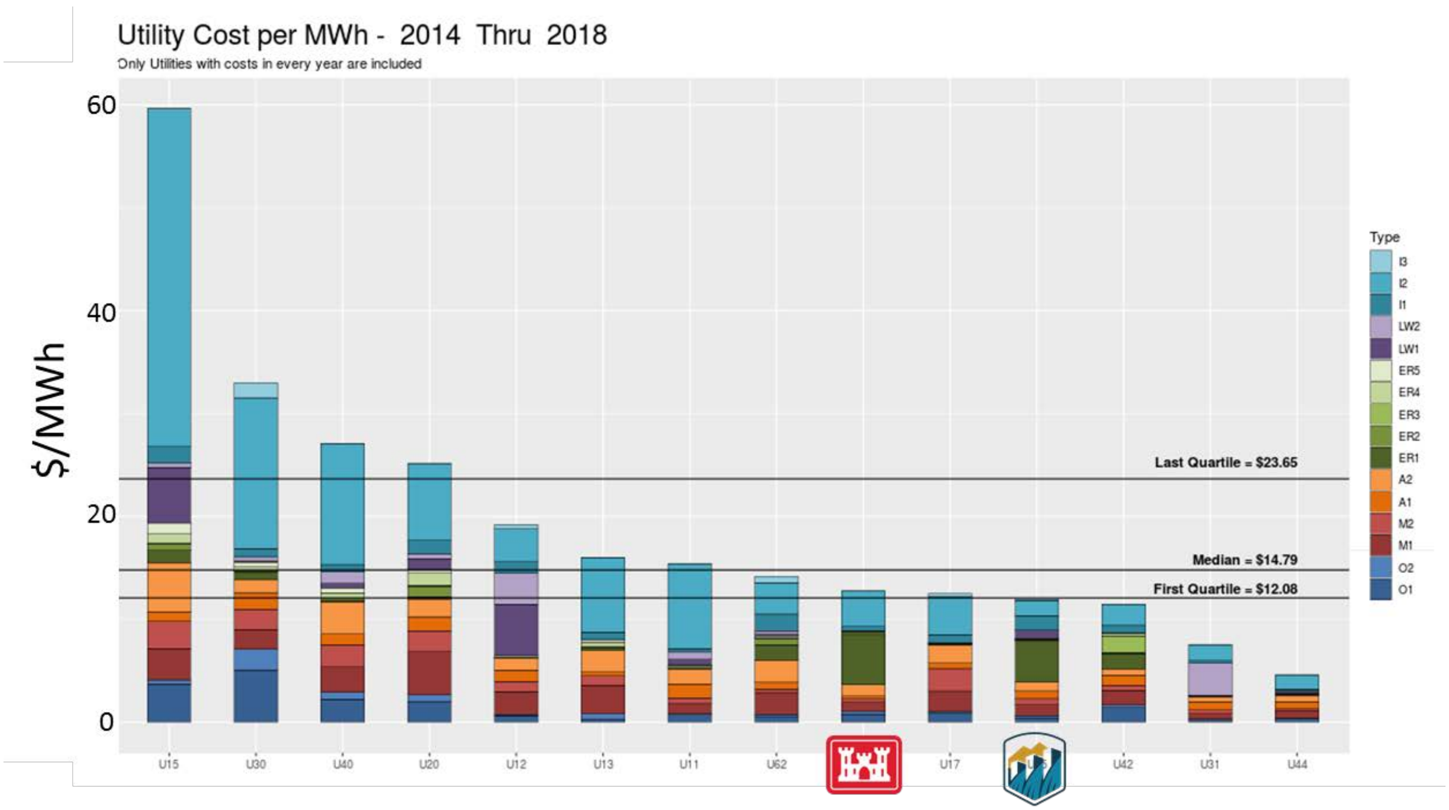


8.4 Performance and Practices Benchmarking

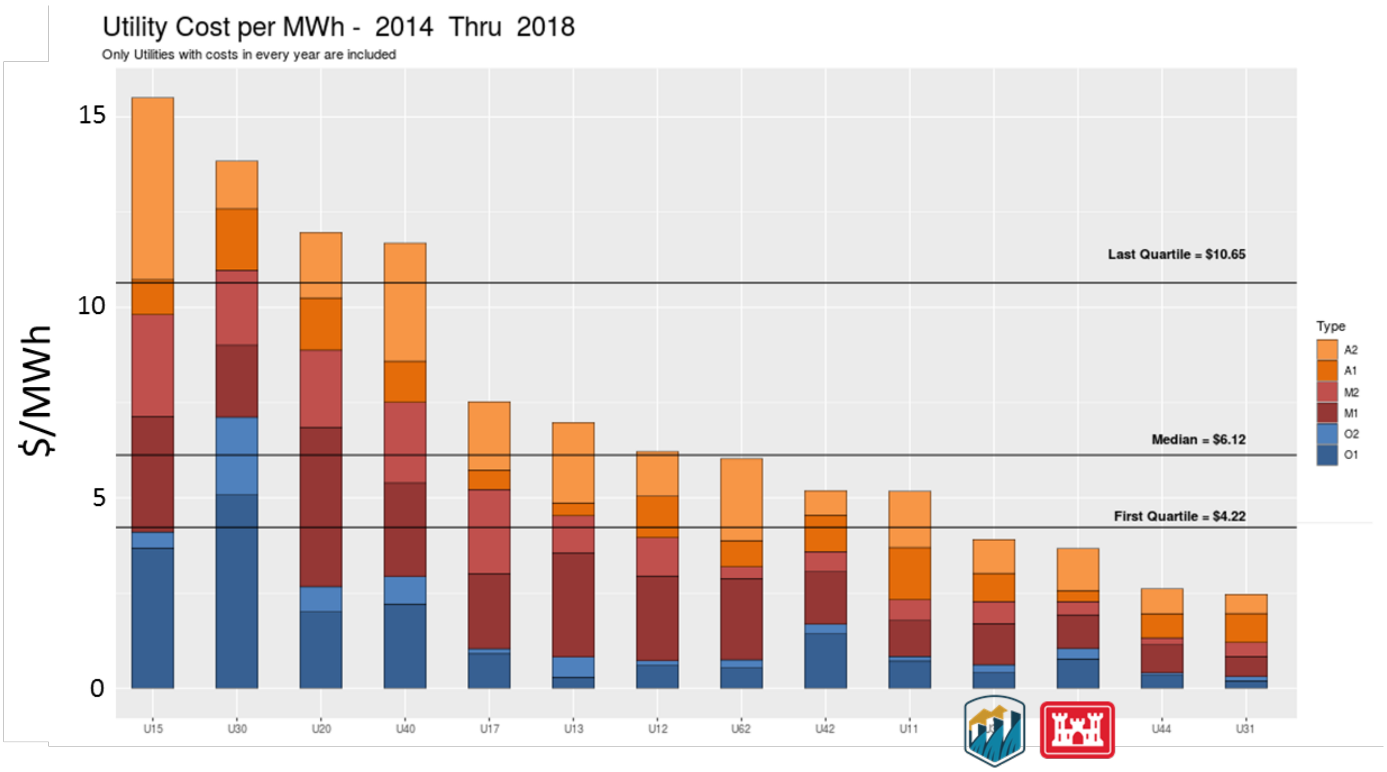
The FCRPS benchmarks its plants in the Hydro Productivity Committee (HPC) of the Electric Utility Cost Group (EUCG). As of 2019, there are 17 utilities in the HPC benchmarking 428 plants that represent 44% of the total installed hydro capacity in North America. The HPC maintains a data guide that provides instructions on what costs should be included, excluded and recommendations for cost allocations. The following cost categories are used to compare costs between utilities within EUCG:

- Operations (O – blues) includes facility operations and all operations planning
- Maintenance (M – reds) includes all facility maintenance
- Administration (A – oranges) includes IT, Finance, HR, Telecom, Asset Management, and more
- Environmental/Regulatory (ER – greens) includes Fish & Wildlife, Recreation, and Cultural Resources
- Land and Water Fees (LW – purples) includes rentals or fees for use of land or water
- Investment (I – cyan) includes non-routine expense

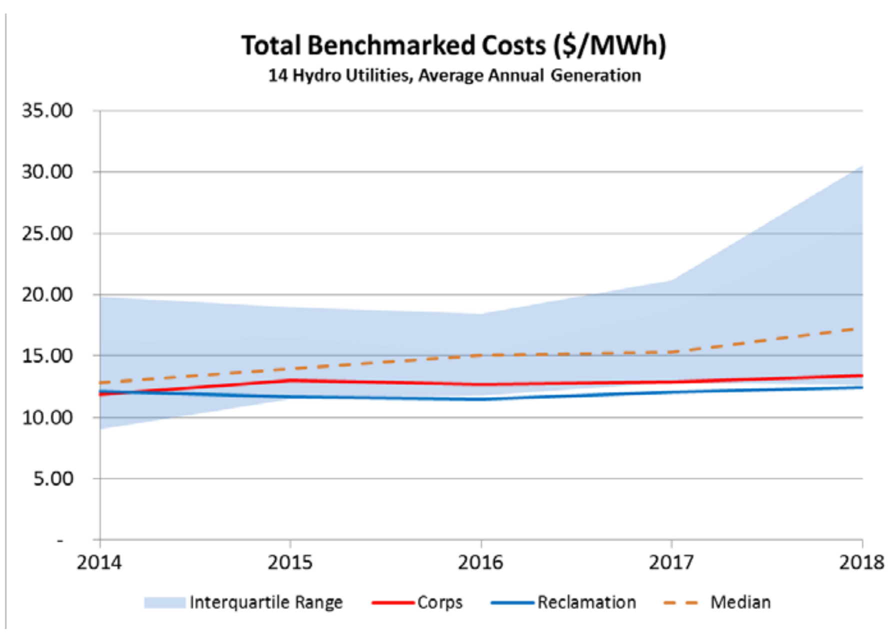
Note that the benchmarked costs and resulting the $/MWh will differ from BPA's cost of generation and fully allocated cost numbers. There are two major differences in the formulation of these numbers: (1) Benchmarked costs look at a 5-year average while the cost of generation and fully allocated cost look at and single fiscal year, and (2) interest expense is not included in benchmarked costs, rather, actual capital costs are recognized in the year in which they are incurred.



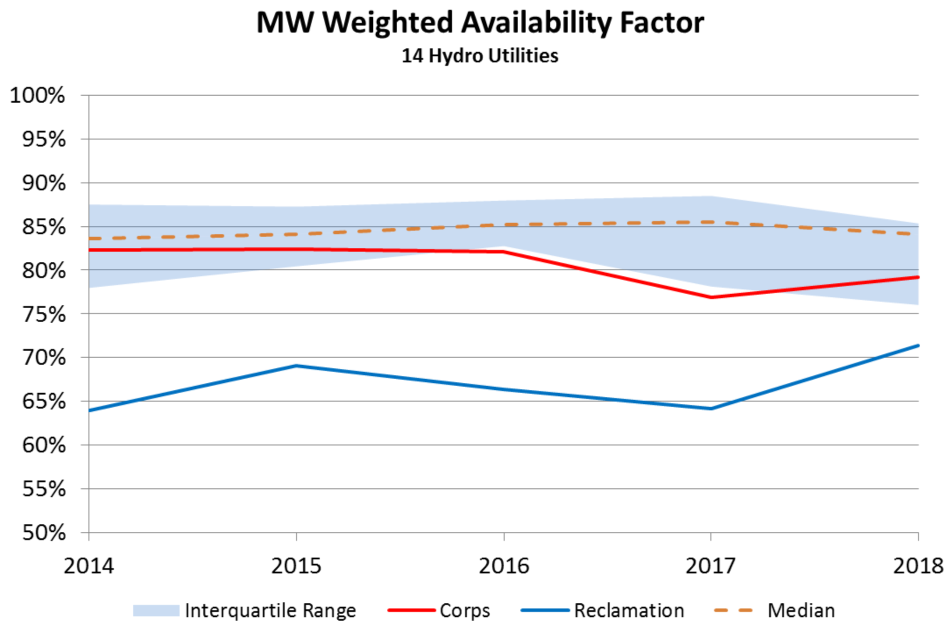
Over the 2014 to 2018 period, the Corps and Reclamation were at the dividing line between first and second quartile for lowest total benchmarked costs per MWh. Compared to other hydro utilities, the Corps and Reclamation have much larger facilities that benefit from economies of scale. Due to these economies of scale, it is expected that the Corps and Reclamation will benchmark well against other utilities. Efforts to bend the cost curve in recent years will further improve their standing.



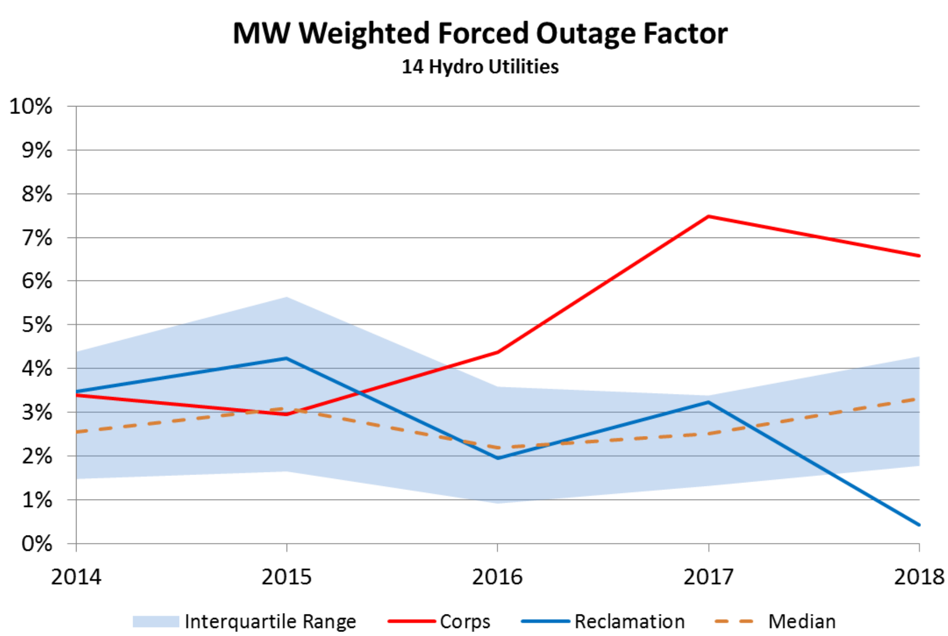
Corps and Reclamation total benchmarked costs increased by an average of 3% and 1% per year, respectively, between 2014 and 2018. This is considerably less than the industry trend which saw the first quartile, median and third quartile grow by an average of 9%, 8% and 13%, respectively.



Availability has consistently been below the industry median. The Corps has tended to be at the lowest quartile of availability while Reclamation has been far below the interquartile range.



For Reclamation, the primary driver has been scheduled outages in the Third Powerplant at Grand Coulee. For the Corps, forced outages have been a major contributor to unavailability since 2016 and have been far higher the rest of the industry. Due to their unplanned nature, these outages often prove to be costlier than scheduled outages as they can occur in times when unit availability is critical and mitigation efforts are difficult to implement on short notice. With tightening expense budgets, the FCRPS strategy is to rely on ramping up the capital program to reduce forced outages in the long-term. John Day, The Dalles, McNary and Ice Harbor have been major contributors to the high forced outage factor in recent years. At the Dalles and Ice Harbor, capital investments are currently underway on equipment responsible for forced outages. Investments in the 2020s and 2030s at McNary and John Day will also address reliability concerns.



9.0 RISK ASSESSMENT

Safety Risk

Figure 9.0-1, Risk Assessment, Safety

Likelihood	Insignificant	Minor	Moderate	Major	Extreme
Almost Certain	155	23	21	15	3
Likely	194	31	19	38	1
Possible	1173	120	116	96	40
Unlikely	1671	83	120	80	135
Rare	3879	391	276	292	149
	Consequence				

Equipment Category	# of Assets
Auxiliary Systems	13
Cranes	1
Infrastructure	48
Powertrain (incl.Main, SS, & Fish)	6
Transmission/Switchyard	1
Water Control	9
Total	**78**

The number of assets posing a high safety risk declined from 103 in the 2018 SAMP to 78. The previous SAMP actually forecasted the number to rise to 112. Changes to hydroAMP asset types, asset replacements and slower than expected condition degradation contributed to the difference from expectations.

39 of the 78 assets currently have investments identified to mitigate their safety risk. Risk is mitigated with operational procedures for assets that do not have an investment identified. Typically, investments are identified when operational procedures are excessively costly or do not effectively mitigated the risk.

Reliability Risk

Unit reliability is captured through lost generation and direct cost risks. It is believed that the failure of any individual asset poses only a low risk to overall system reliability. Future SAMPs could consider the sufficiency of current levels of redundancy with respect to the services that the hydro system provides such as grid stability and black start capability. Reliability and compliance are overseen by a Three Agency team known as the Reliability Implementation & Technical Subcommittee (RITS).

Financial Risk

Figure 9.0-3-1 Lost Generation Risk

Likelihood	Insignificant	Minor	Moderate	Major	Extreme
Almost Certain	8	10	51	14	2
Likely	4	15	89	54	7
Possible	64	135	459	546	31
Unlikely	57	205	777	724	29
Rare	165	600	1755	1501	122
	Consequence				

Lost Generation Risk by Equipment Category

Equipment Category	# of Assets
Central Controls	4
Cranes	5
Powertrain (incl.Main, SS, & Fish)	69
Station Power	42
Transmission/Switchyard	8
Grand Total	**128**

There are currently 128 assets in the high risk category for lost generation risk and 238 assets in the high risk category for direct cost risk. Between lost generation risk and direct cost risk, there are 275 unique assets currently posing a high financial risk as some assets are in the high risk category for both matrices. Currently, there are planned investments to address 139 of these high risk assets.

Figure 9.0-3-2 Direct Cost Risk

Likelihood	Insignificant	Minor	Moderate	Major	Extreme
Almost Certain	5	65	122	25	
Likely	2	47	143	88	3
Possible	16	297	974	256	2
Unlikely	13	528	1356	181	11
Rare	79	1248	2965	687	8
	Consequence				

Direct Cost Risk by Equipment Category

Equipment Category	# of Assets
Auxiliary Systems	48
Central Controls	10
Cranes	7
Drainage & Unwatering	1
Infrastructure	23
Powertrain (incl.Main, SS, & Fish)	107
Station Power	38
Water Control	4
Grand Total	**238**

In the previous SAMP, 369 assets were reported in the high risk category. The delineation between lost generation risk and direct cost risk was not produced at the time and assets that posed both a high lost generation and direct cost risk were double-counted in the total. A more accurate description would have been that there were 369 unique high risks posed by the assets. To compare to today, that number has gone down to 366 (128 high lost generation + 238 high direct cost). The previous SAMP forecasted 384 high risk assets in 2020. Future SAMPs will report on the number of unique assets between the two risk matrices.

Environmental Risk

Figure 9.0-4, Risk Assessment, Environment/Trusted Stewardship

Likelihood \ Consequence	Insignificant	Minor	Moderate	Major	Extreme
Almost Certain	197	3	13	4	
Likely	235	14	26	8	
Possible	1016	174	304	48	3
Unlikely	1596	172	179	140	2
Rare	3706	666	453	159	3

Equipment Category	# of Assets
Cranes	1
Drainage & Unwatering	7
Powertrain (incl.Main, SS, & Fish)	7
Water Control	11
Grand Total	**26**

There are currently 26 assets in the high environmental risk category. Changes to the environmental risk assessments for a number of asset types reduced this number significantly from 95 in the previous SAMP. The majority of the changes in evaluation shifted consequences from extreme to moderate. These assets can once again reach the high risk category, but only once their likelihood of occurrence raises to either likely or almost certain. Investments are identified for 8 of the high risk assets.

Compliance

No individual assets have risen above a low risk to NERC/WECC compliance due to their condition and likelihood of failure. Some assets could pose higher risks with respect to environmental compliance, but these risks are primarily captured under the environmental risk matrix. FCRPS reliability and compliance SMEs will continue to evaluate asset compliance risk and fully develop risk matrices if necessary.

10.0 STRATEGY AND FUTURE STATE

10.1 Future State Asset Performance

Future asset performance requirements are a combination of meeting Three Agency obligations and economic decisions to maximize the value of assets. Before effective performance objectives can be set, the tradeoffs between cost, risk and performance need to be analyzed. Minimizing lifecycle cost and maximizing investment portfolio value are currently the goals of the FCRPS investment strategy rather than meeting specific performance objectives. The demand analysis conducted by the Three agencies in 2020 and 2021 will inform the minimum level of service required to meet each agencies obligations. These will translate into minimum availability targets for each plant during different periods of the year. Targeting levels of availability above these minimum targets will continue to be an economic decision based on the incremental costs and benefits of achieving those targets.

Current plant availability targets are presented below but are primarily based on historical performance and future outage expectations. Targets in the 2022 SAMP will incorporate results of the demand analysis and will better align with business needs. The Three agencies will also investigate if other performance measures tied to risk mitigation better communicate the goals and objectives of the FCRPS asset strategy.

Table 10.1-1 Future Asset Performance Objectives

Objective	Plant	This Year	Year +1	2	3	4	5	6	7	8	9	10
Weighted Availability Factor	Grand Coulee	73%	69%	68%	69%	69%	69%	69%	69%	69%	69%	69%
Weighted Availability Factor	Chief Joseph	92%	95%	94%	95%	95%	95%	95%	95%	95%	95%	95%
Weighted Availability Factor	John Day	90%	89%	89%	90%	89%	89%	89%	89%	89%	89%	89%
Weighted Availability Factor	The Dalles	79%	83%	89%	89%	87%	87%	87%	87%	87%	87%	87%
Weighted Availability Factor	Bonneville	90%	89%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Weighted Availability Factor	McNary	94%	91%	93%	95%	79%	79%	79%	79%	79%	79%	79%
Weighted Availability Factor	Little Goose	85%	89%	91%	87%	91%	91%	91%	91%	91%	91%	91%
Weighted Availability Factor	Lower Monumental	86%	89%	89%	91%	89%	89%	89%	89%	89%	89%	89%
Weighted Availability Factor	Lower Granite	91%	90%	89%	90%	90%	90%	90%	90%	90%	90%	90%
Weighted Availability Factor	Ice Harbor	77%	76%	89%	89%	89%	89%	89%	89%	89%	89%	89%
Weighted Availability Factor	Libby	89%	89%	90%	87%	87%	87%	87%	87%	87%	87%	87%
Weighted Availability Factor	Dworshak	83%	86%	92%	94%	94%	94%	94%	94%	94%	94%	94%
Weighted Availability Factor	Hungry Horse	63%	62%	73%	69%	69%	69%	69%	69%	69%	69%	69%
Weighted Availability Factor	Palisades	93%	93%	93%	97%	93%	93%	93%	93%	93%	93%	93%
Weighted Availability Factor	Lookout Point	93%	94%	82%	94%	82%	82%	82%	82%	82%	82%	82%
Weighted Availability Factor	Detroit	95%	81%	0%	0%	95%	95%	95%	95%	95%	95%	95%
Weighted Availability Factor	Green Peter	91%	87%	95%	47%	49%	49%	49%	49%	49%	49%	49%
Weighted Availability Factor	Lost Creek	91%	93%	92%	94%	94%	94%	94%	94%	94%	94%	94%
Weighted Availability Factor	Albeni Falls	85%	96%	88%	84%	88%	88%	88%	88%	88%	88%	88%
Weighted Availability Factor	Anderson Ranch	93%	93%	93%	93%	93%	93%	93%	93%	93%	93%	93%
Weighted Availability Factor	Hills Creek	94%	94%	84%	94%	83%	83%	83%	83%	83%	83%	83%
Weighted Availability Factor	Cougar	91%	76%	82%	91%	91%	91%	91%	91%	91%	91%	91%
Weighted Availability Factor	Minidoka	78%	84%	83%	91%	91%	91%	91%	91%	91%	91%	91%
Weighted Availability Factor	Big Cliff	94%	94%	90%	94%	90%	90%	90%	90%	90%	90%	90%
Weighted Availability Factor	Foster	94%	85%	82%	70%	70%	70%	70%	70%	70%	70%	70%
Weighted Availability Factor	Green Springs	95%	90%	90%	95%	95%	95%	95%	95%	95%	95%	95%
Weighted Availability Factor	Dexter	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%
Weighted Availability Factor	Roza	75%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%
Weighted Availability Factor	Chandler	92%	91%	91%	91%	91%	91%	91%	91%	91%	91%	91%
Weighted Availability Factor	Black Canyon	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
Weighted Availability Factor	Boise Diversion	93%	93%	93%	94%	94%	94%	94%	94%	94%	94%	94%
Weighted Availability Factor	**FCRPS**	**78%**	**83%**	**82%**	**83%**	**83%**	**83%**	**83%**	**83%**	**83%**	**83%**	**83%**

10.2 Strategy

The FCRPS long term strategy is to make coordinated operations, maintenance and investment decisions that maximize the value of FCRPS assets by reducing costs, mitigating risk, improving efficiency and/or producing incremental value. A cornerstone of the strategy is decision making that is risk informed and considers asset condition, probability of failure and the impacts to each of the three agency's missions. These factors already drive the capital investment program and expanding a similar process into operations and maintenance decision making is a key initiative.

A key component in building the FCRPS strategy and identifying recommended funding levels is determining the optimal time to reinvest in FCRPS assets. FCRPS staff use Copperleaf's C55, an Asset Investment Planning and Management tool, to develop the capital investment strategy and plan. C55 tracks the benefits, costs and assets associated with investments and provides tools for future investment identification as well as investment decision optimization. Using asset condition, failure characteristics and investment information, C55 can calculate the optimal time to invest in an asset, optimize the timing of investments in an investment portfolio and illustrate the costs and benefits of different investment strategies or funding levels. There are two primary capabilities leveraged by FCRPS staff to develop investment strategies and plans:

Predictive Analytics: Identifies the optimal replacement date for each asset in the FCRPS asset registry by minimizing lifecycle cost and mitigating high safety and environmental risks within budget constraints. The optimal replacement dates produced by Predictive Analytics are intended to be directional and form the basis for investment identification and long-term funding levels.

Value Framework and Investment Decision Optimization: Optimizes the timing and alternatives of investments in a portfolio to maximize value within constraints. Projects identified to address the recommendations of Predictive Analytics as well as projects proposed by the plants are created in C55 and added to an investment portfolio. The benefits and costs of each project are assessed and the optimization tools are used to develop the Asset Plan.

10.2.1 Predictive Analytics

A risk-based approach is taken to identifying the optimal timing for investment. C55 Predictive Analytics calculate optimal replacement dates by:

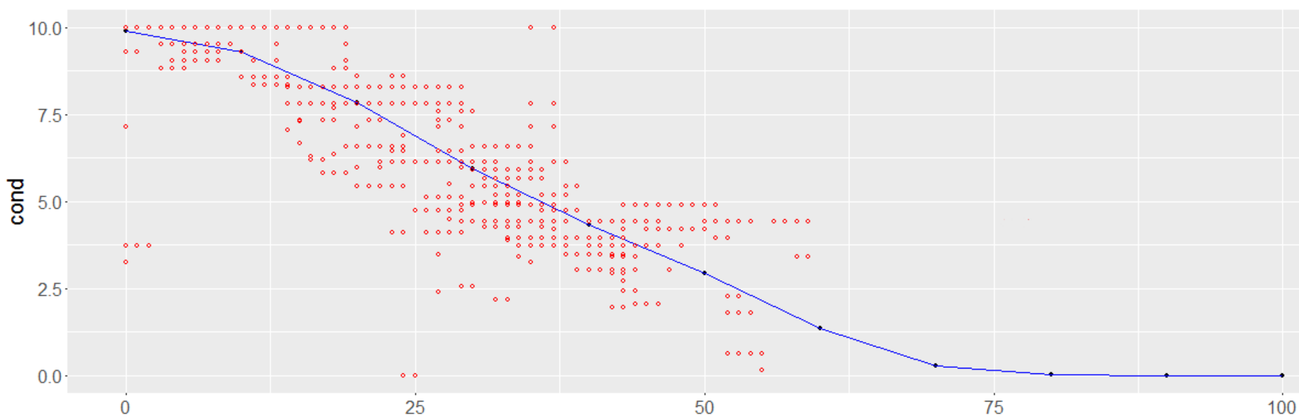
- Assessing current condition and forecasting how it changes over time;
- Relating asset condition to an effective age and probability of failure for each asset type;
- Multiplying the consequence of failure by the probability of failure for each respective asset to determine the risk it poses in a given year; and
- Minimizing the sum of the present value risk costs and replacement cost.

<u>Condition</u>

Historically, the Corps and Reclamation assessed equipment condition for powertrain and critical auxiliary components annually and balance of plant equipment semiannually. With the expansion of the asset registry in 2019, the FCRPS is evaluating assessment intervals to maximize the value of time spent on condition assessment. Equipment Condition is assessed using the hydroAMP Condition Assessment framework, described in detail in Section 8.2.2.

Future condition is forecast using expected degradation rates developed using regression analyses on hydroAMP condition data relating equipment condition to equipment age. The analysis groups condition scores into eleven buckets, rounding conditions scores to 0 through 10. Probit regressions then give the probability that a piece of equipment falls into each of the 11 buckets at a given age. The expected condition decay curve is built up from these regressions, which are the expected values at each age.

Example Equipment Condition Degradation Curve



The chart above illustrates an expected degradation curve with each individual point representing a condition assessment at a specific equipment age.

Probability of Failure

Failure Curves for powertrain and critical auxiliary equipment were updated in 2016 using an Expert Opinion Elicitation processes facilitated by the Army Corps of Engineers' Risk Management Center. The curves were developed for twenty-eight major hydropower assets using the opinion of Subject Matter Experts from the Corps, including the Hydroelectric Design Center, Bonneville Power Administration, US Bureau of Reclamation, Tennessee Valley Authority, Chelan Power and Western Area Power Administration. The Corps plans to update these curves with actual failures as data is collected in the coming years.

This task was initiated to replace existing failure curves that relied on empirical data containing both equipment replacements and retirements. Since the existing failure curves included retirement data that did not necessarily result from equipment failure, the curves likely overstated probability of failure and understated reliability as assets age.

Failure curves for all other components were updated for the 2020 SAMP using the Corps' Balance of Plant Weibull curves used nationally by their navigation and flood control lines of business.

Risks and Costs

Lost Generation Risk (LGR): Equipment failure may also result in longer outages and, thus, more lost generation than if replaced on a planned basis. LGR also increases as equipment condition degrades over time.

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

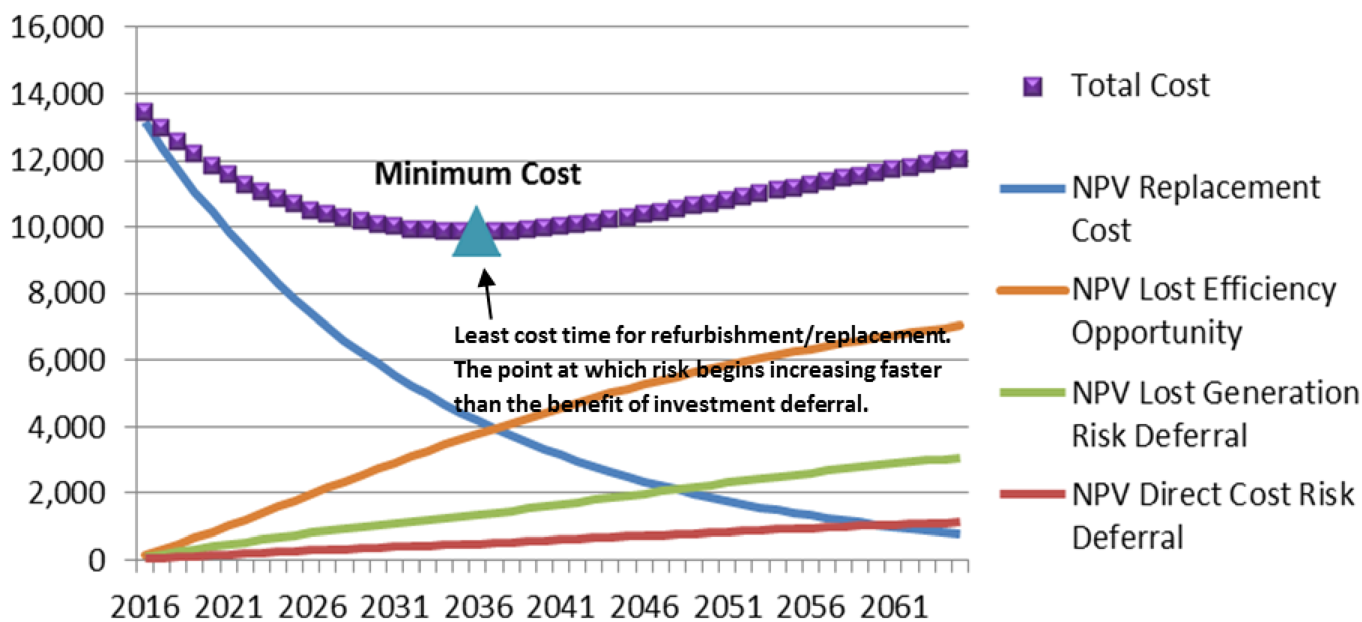
Lost Efficiency Opportunity (LEO): Some equipment replacements (turbine runners, transformers and generator windings) reduce efficiency losses. Deferring replacement results in a lost opportunity to capture increased generation from higher efficiency equipment.

Project Cost: The cost of the replacement or refurbishment activity.

Lifecycle Cost Minimization

To determine the optimal timing for replacement, each equipment component is evaluated in yearly time steps. In each year, the present value of accumulated financial risk cost is added to the present value cost of replacing the equipment in that year. The sum of these present value costs is the Total Cost related to a decision to delay equipment replacement until that year. This algorithm is described graphically below.

FCRPS Equipment Lifecycle Cost Minimization Methodology



The optimal time to plan on equipment replacement is at the low point (cost minimum) of the Total Cost curve. The cost minimum is the point in time at which the sum of financial risk costs and potential lost efficiency opportunity begin growing faster than the benefit of deferring the investment. Up until that time the value of investment deferral is greater than the expected increase in financial risk and lost efficiency opportunity costs, so it makes financial sense to continue deferring equipment replacement.

When a constraint is introduced, Predictive Analytics prioritizes all assets at or passed their respective optimal replacement dates based on their cost of deferral. Assets are chosen for replacement ranked by their respective deferral cost until there is no longer room within the budget. The analytics will then seek to replace the next highest deferral cost asset that remains within the budget constraint until either the constraint is reached in full or no further assets can be selected while remaining within constraints.

10.2.2 Value Framework

After optimal replacement dates are established, the Asset Planning Team, in coordination with other Corps and Reclamation planning functions, develop projects to address the risks identified by Predictive Analytics. These projects, along with other needs identified by the plants, are entered into the Portfolio Management module of C55 with a forecast for their annual spend and a preliminary assessment of their risks and benefits.

Benefits and risks associated with investment activities are evaluated using the Value Framework component of C55. The establishment of the FCRPS Value Framework was one of the first outcomes of the Asset Investment Excellence Initiative. The value measures upon which investments are assessed are summarized in the table below.

FCRPS Value Framework

Value Measure Categories	Value Measures	Organizational Goals
Financial	Financial Benefits	Maximize cost savings and increase efficiency to ensure low cost power Maintain ability to reliably supply energy to the grid
	Generation Efficiency Benefits	
	Direct Cost Risk	
	Lost Generation Risk	
Trusted Stewardship	Compliance Risk	Reduce Safety, Environmental and Compliance risks to as low as reasonably practicable. Ensure employee and public safety Maintain mandate to operate
	Environmental Risk	
	Productive Workplace Benefit	
Safety	Safety Risk	
Community	Public Perception Risk	

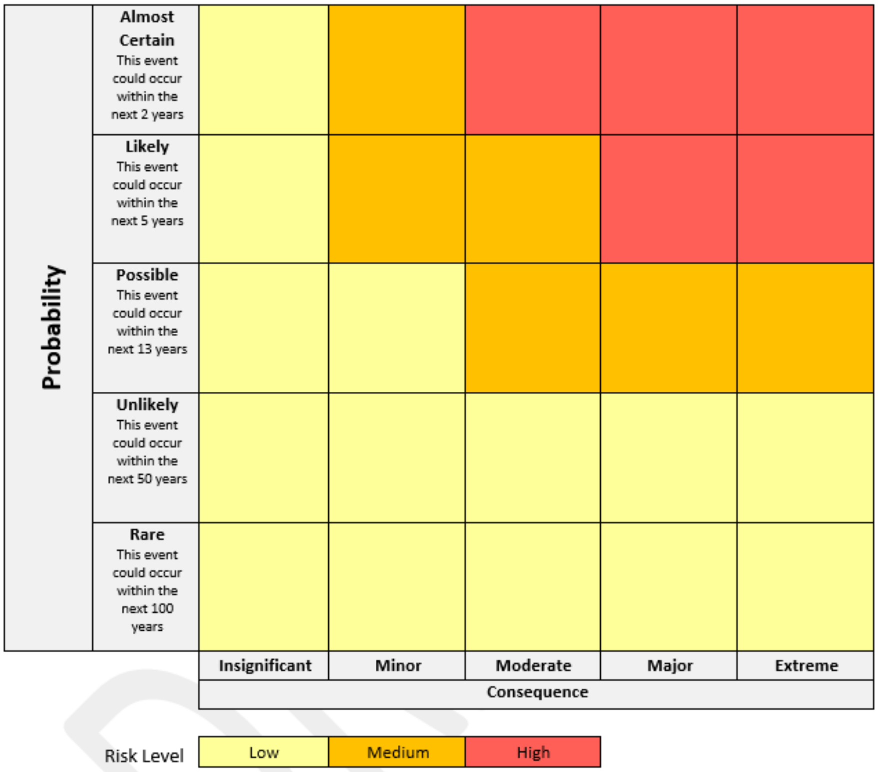
As described in Section 7.1, financial risks are assessed in dollars while trusted stewardship, safety and community value measures are assessed qualitatively. These qualitative measures are assessed using a 5 by 5 risk matrix that aligns the consequence scales of the qualitative measures to the quantified financial risks and benefits. This creates a method of assigning value to qualitative benefits and risks. For optimization purposes, safety and environmental risk receive weightings of 2.0 and 1.5 respectively. This means that Safety risks are weighted twice as heavily as an equivalent lost generation risk and environmental risks are weighted 1.5 times as heavily as an equivalent lost generation risk.

FCRPS Risk Matrix Consequence Descriptions

Consequence	Insignificant	Minor	Moderate	Major	Extreme
Financial Risk	<$10k	$10k - $100k	$100k - $1M	$1M - $10M	>$10M
Lost Generation Risk	< 280 MWh	280 MWh - 2,800 MWh	2,800 MWh - 28,000 MWh	28,000 MWh - 280,000 MWh	> 280,000 MWh
Compliance Risk	No or insignificant effect on operations or administrative flexibility or annual mandated costs < $10k	Change in operations or administrative flexibility or inability or annual mandated costs < $100k	Adverse impact on beneficial legal principles or precedents; project operations noticeably affected for compliance; inability to maintain system frequency or voltage or annual mandated costs < $1M	Adverse effect on existing beneficial legal principles or precedents; substantial changes needed in project operations or administration or annual mandated costs < $10M	Extremely difficult to meet fundamental statutory obligations; extremely unreliable system; extreme changes needed in project operations or administration or annual mandated costs > $10M
Environmental Risk	No impact	Impact to on-site environment (simple remediation) or where the remediation costs < $100k	Limited impact off-site (localized remediation required) or where the remediation costs < $1M	Detrimental impact on- or off-site (long-term remediation required) or where the remediation costs < $10M	Detrimental or catastrophic impact off-site (mitigation impossible) or or where the remediation costs > $10M
Safety Risk	No or minor injury, first aid	Treatment by medical professional	Lost time accident - temporary disability	Permanent disability	Fatality
Public Perception Risk	No or isolated internal complaints	Local media attention; widespread internal complaints; some public embarrassment	Transitory local media / federal / customer attention and criticism; some damage control; congressional enquiry; short duration loss of power to islanded community	Ongoing media / federal / customer attention; major damage control; significant impact on staff morale; congressional enquiry; extended duration loss of power to islanded community	Adverse and ongoing media / federal / customer attention, criticism and agency intervention; extreme damage control; parliamentary secretary called to congress; permanent duration loss of power to islanded community

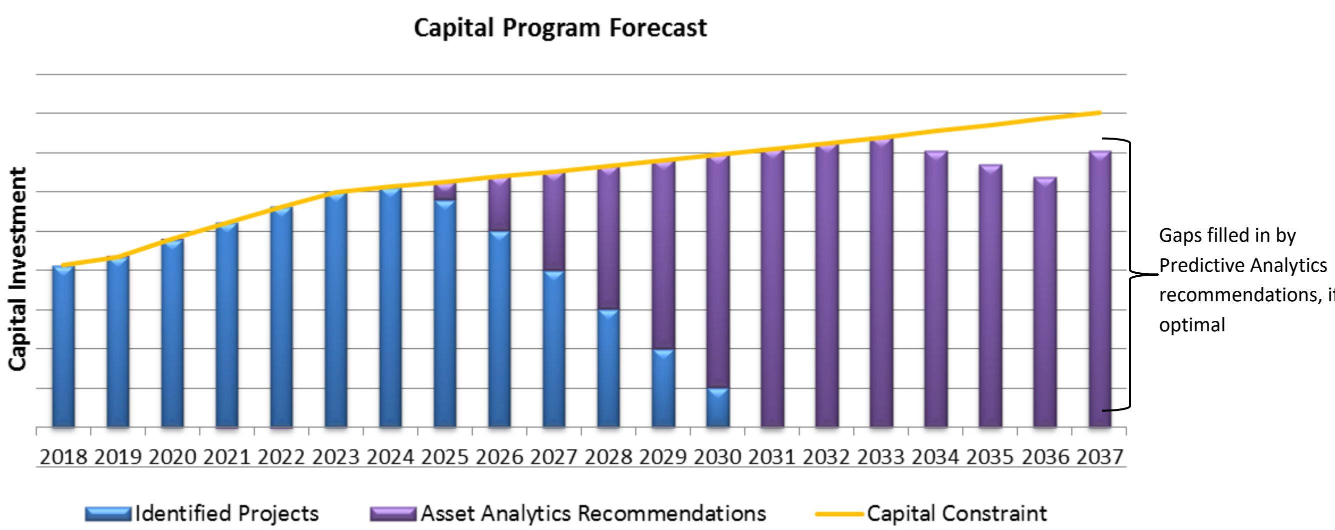
Lost Generation Risk and Direct Cost Risk (captured by "Financial Risk" above) are automatically calculated for assets that are attached to investments using the same analysis performed in Predictive Analytics described above. Investment impact dates and resulting condition scores from replacement or refurbishment are forecast and the mitigated Lost Generation and Direct Cost risks are calculated between the baseline and investment scenarios. For the remaining Value Measures, risk is calculated by multiplying the consequences selected from the matrix above by the assessed probability of occurrence. Mitigated risk is the difference between the assessed probabilities of occurrence with and without an investment as well as any change in future consequence that may result from an investment alternative. The risk matrix below displays the interaction of probability and consequence scales.

FCRPS Risk Matrix

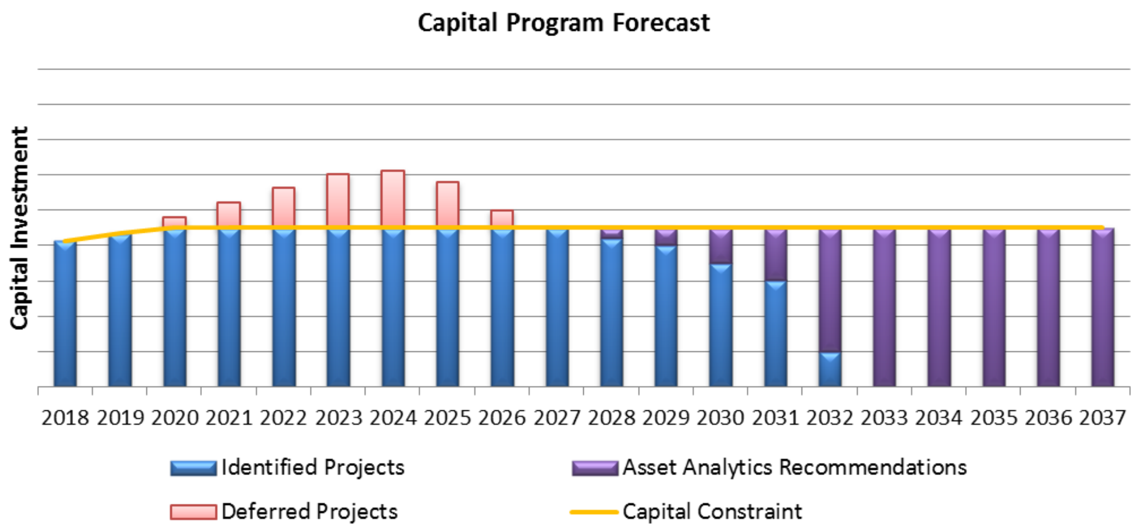


The Asset Plan is constructed through iterative optimizations of the FCRPS capital investment portfolio. For development of the SAMP, planned investments from the Asset Plan are optimized under the planning levels identified in each respective Strategy Alternative. If identified projects exceed the planning levels identified in the strategy alternatives, the optimization will defer investments in order to maximize the value of available capital funding. In future years in which the Asset Plan is not fully programmed up to the budget constraint, Predictive Analytics will identify assets for which it is optimal to plan a replacement but a project has yet to be identified. However, if there are no assets at or passed their optimal replacement dates, Predictive Analytics is not required to spend all available funds. The strategy presented in Section 10.2 is a result of these iterative analytics. The example below illustrates how optimization defers projects to stay within constraints.

The chart below shows hypothetical capital investment for planned projects in blue, which represent mature investments tracked in C55. As the capital forecast associated with planned projects declines, Predictive Analytics fills in gaps by selecting assets to replace, if optimal. In some cases, it may not be optimal to spend the entire budget.



With a more constrained budget, the existing portfolio of identified investments is optimized resulting in a number of projects moving to a later date. The forecast associated with deferred investment is highlighted in red in the example below. A lower constraint results in planned projects lasting farther into the future before Predictive Analytics is required to fill in gaps in the long term plan.



These processes are used to develop the sustainment and expansion strategies and plans are formulated using the methodologies described above.

10.2.3 Sustainment Strategy

The Three agencies aspire to develop sustainment strategies that combine maintenance, reinvestment, and operational strategies in order to maximize the value of FCRPS assets. Integration of these strategies is currently ad hoc and the maturity varies from plant-to-plant. As the OMOI progresses and the AIEI continues to mature over the next decade, integration and tradeoffs between capital and expense will be better understood. At present, the sustainment strategies for the capital and expense programs can be described as follows:

10.2.3.1 Capital Investment Strategy:

- Identify the level of investment associated with minimizing asset lifecycle cost at each plant while meeting the respective missions of the Three Agencies
- Develop projects that incorporate the results from this analysis while considering logistical requirements and potential efficiencies such as combining work into a single outage window
- During the scoping of major plant-wide powertrain replacements, evaluate unit efficiency and capacity improvements as well as the optimal number of units to fully replace
- Optimize the investment portfolio on an annual basis to maximize the value of the portfolio within constraints
- Reserve a portion of the capital budget for joint assets that will be optimized separately from power assets

10.2.3.2 Expense Strategy:

- Hold operations and maintenance costs flat for the BP22 rate period and then at-or-below the rate of inflation for future years
- Incorporate asset criticality into decision making to optimize use of constrained operations and maintenance budgets

10.2.4 Growth (Expand) Strategy

At present, BPA is not looking to expand FCRPS capacity from a resource adequacy perspective. However, there are incremental benefits and risk reductions that can be achieved from unit upgrades or additions. The primary source of incremental generation capability is actually a derivative of the sustainment program. Unit uprates and efficiency improvements are evaluated in conjunction with unit reliability improvements and can typically be achieved at minimal incremental cost. Both improvements are factored into business case alternatives analyses and are selected if they deliver the best value.

Dworshak and Libby Dams have been identified as powerhouses that are undersized relative to water availability. Both plants were originally designed to have more units than were ultimately completed. As a result, unplanned outages pose high financial and environmental risks, especially if they occur while other units are already out of service. To reduce these risks during planned replacements in the next decade, completing an additional unit at the two plants by leveraging existing infrastructure and components is under consideration. The Corps and BPA recently completed extensive analyses to determine if an additional unit is a cost-effective risk mitigation measure at either plant. A summary of the two projects are provided below:

10.2.4.1 Libby Unit 6

A total of 8 units were originally authorized by congress at Libby Dam but only 5 were fully constructed. Original plans called for a reregulation dam downstream of Libby, however, these plans were abandoned following a legal injunction in the 1980s. Absent the reregulation dam, units 6 through 8 were seen as unnecessary and construction was halted after the turbine components were installed. Remaining components for those units were put into a long-term storage condition, where they now remain.

Upcoming outages on Units 1-5 for capital investments raised the need for financial, operational and environmental review. A study was kicked off in 2017 to determine the cost of completing one of the unfinished units and evaluate whether it would be a cost-effective risk mitigation measure during the long-term capital outages. In addition to risk mitigation, some incremental generation could be realized during times of year when forebay elevations limit the capacity of the existing units. The total plant maximum output will not be increased though due to transmission limitations between Libby and Hungry Horse.

An economic analysis was performed on 12 different scenarios that assessed replacement timings on Units 1-5 with and without completing Unit 6. All scenarios that included Unit 6 had higher Net Present Values and Benefit Cost Ratios than scenarios in which Unit 6 was not completed. The scenario with the highest Net Present Value included building Unit 6 and completing capital improvements on all 5 existing units while the scenario with the highest Benefit Cost Ratio included building Unit 6 and completing capital improvements on 4 units. These results suggest building Unit 6 provides a cost effective mitigation measure and the leaves the option open to reduce the scope of future capital improvements.

The total cost to complete Unit 6 is $23 million dollars and it would be expected to produce a Net Present Value of $80 million over its lifetime. Proceeding with this project remains under consideration by BPA executives.

10.2.4.2 Dworshak Unit 4

Dworshak Dam was originally planned to have 6 units but only 3 were constructed. Unlike at Libby, only skeleton bays and intake structures exist for the remaining 3 units. No equipment was installed in those bays and the powerhouse structure only encloses the first 3 bays. Dworshak has one of the highest marginal outage costs in the FCRPS, as demonstrated in Figure 7.1-1. This is a result of Dworshak's unique configuration of two 103 MW units and one 259 MW. When the larger unit is out of service, the smaller units are not adequate to pass flows during much of the year which results in large generation losses as well as environmental impacts from spill. Unit 3, the larger unit, is critical for water quality and water management. Units 1 and 2 also have a fairly high marginal outage costs as there are times of the year where outflows exceed powerplant capacity even when all units are available. Unlike other plants in the system, these high marginal outage costs are not a result of reduced unit reliability but powerplant design. Units 1 and 2 are expected to be out of service for capital improvements in the next 10 years and Unit 3's recent extended outage is estimated to have cost more than $20 million per year.

The Corps and BPA studied the economics of installing a 4th unit to determine if it could be a cost effective risk mitigation measure for future unit outages in addition to providing some incremental generation. Unit sizes ranging from 150 to 300 MW were studied to determine what would be the most cost effective. A 300 MW unit produced the highest Net Present Value and Benefit Cost Ratio of $80 million and 1.52 respectively and is expected to cost $235 million. An expansion project of this magnitude would have large implications on the capital investment program during the construction phase. In addition to representing a large portion of the capital budget while being constructed, it is also thought to carry more execution risk than other projects in the capital investment portfolio. Further analysis will determine the best time to potentially build Dworshak Unit 4 in the broader context of upcoming reliability improvement needs on Units 1-3. The costs, risks and benefits then need to be weighed against the other reliability improvement projects in the capital portfolio. Given the number of upcoming large reliability improvement projects (e.g. at Grand Coulee, Chief Joseph, McNary and John Day), the ability to sustain and execute upon the capital program levels identified in the IPR is critical for this project to move forward. Proceeding with this project remains under consideration by BPA executives.

10.2.4.3 Other Expansion Projects

The addition of a third unit was also considered at Reclamation's Black Canyon in the past but has been on hold as there is not currently a financial justification or resource need to proceed with the project.

10.2.5 Strategy for Managing Technological Change and Resiliency

Power Services engages in many areas that serve to promote and integrate technological changes. Collaboration and knowledge sharing is an important strategy to adapt to these changes. Key collaborations enable BPA to keep abreast of the latest technological changes affecting the industry. They provide forums for addressing upcoming challenges and opportunities associated with new technologies. Power Services collaborates with CEATI interest groups, USBR Research and Development Group, USACE Hydroelectric Design Center, DOE Water Power Technologies office, and EPRI. BPA's Technology Innovation office has aided Power Services to develop roadmaps for technology innovation. These roadmaps steer our efforts toward the most beneficial innovations. They include three main categories pertinent to hydro assets:

10.2.5.1 Hydropower Reliability and Life Extension

Examples of focus areas include:

1. Machine condition monitoring, aimed at improving asset condition information to avoid damaging operations and to extend equipment life.
2. Oil analysis advancements, aimed at improving oil testing technologies to provide better information about the condition of oil filled equipment.

3. Predictive analytics, aimed at integrating machine condition monitoring and other operational information into software systems that predict when failures might occur, when maintenance or repair interventions will be necessary, and the type of intervention. This information could be used to extend equipment life, reduce routine maintenance outages, and reduce routine maintenance costs. It would enable an informed transition to condition based maintenance.
4. Repair and life extension technology improvements. One example is the development of cold-spray technology to allow longer lasting repairs of water passageway surfaces that have been damaged by cavitation.

10.2.5.2 Hydropower Equipment Environmental Risk Reduction

1. Oil-less Kaplan turbine technology, aimed at reducing oil leaks into the river that result from leaky oil filled Kaplan turbines while assuring good asset life.
2. Environmentally acceptable lubricants, aimed at developing and more environmentally acceptable lubricants that are suited or tailored to various hydropower applications.
3. Improved fish passage turbine and associated testing technology development, aimed at reducing fish mortality through turbines and more effectively testing improvements.
4. Hydropower Facility Optimization, aimed at maximizing plant generation efficiency within operational constraints and providing actionable information to operators to assure non-damaging turbine operations. This ties in with the Grid Mod Federal Data Modernization project.

10.2.5.3 Technological Change

A long developing issue within the hydro industry is the adoption of digital control systems to replace analog control systems. This technological change has resulted in new equipment that offers advantages over the old, but is expected to have a shorter life. Asset management tools are being adapted to properly reflect expected replacement cycles and build them into the plans. Since condition scores are integral to the asset management process, Power Services and CEATI collaborate to improve the hydroAMP condition assessment methodology to differentiate between analog and digital equipment. Examples include:

1) Development of the hydroAMP Generic Equipment List which defines design lives for different assets, with attention paid to digital vs. analog asset types.
2) Modifications to the guides for Governors and Miscellaneous Electrical equipment to improve condition assessment of digital equipment.
3) Improvements to the hydroAMP condition assessment tools will continue into the foreseeable future, to assure they reflect current technologies as shown in the example above.

Data acquisition and control systems, known as SCADA or DACS, have been prone to short life expectancies. The USACE has developed a Generic Data Acquisition and Control System (GDACS) that is intended to extend the life expectancy of this asset type by incorporating components that use industry standard protocols and design (i.e. generic) and therefore could be replaced in the future without full system replacement. GDACS systems have been implemented in the FCRPS for over a decade with success, and their deployment will continue at facilities with aging SCADA systems. Deployment is expanding to USBR facilities as well.

Turbine replacements with improved fish passage turbines have been identified as important improvements to the Lower Columbia and Snake facilities because of their fish passage and efficiency benefits. These projects have been studied at the system level in the Turbine Replacement Strategy, with the recommendation to prioritize these projects and to perform refined studies for each facility to determine optimal investment design. Refined studies have been performed for McNary and John Day and others are on the horizon. These studies result in better identification of costs and benefits and facilitate planning and programming of turbine replacements.

10.2.5.4 Resiliency

Resiliency is managed in an ad-hoc manner and strategies are not formally defined. IDIQ MATOC (Indefinite Delivery Indefinite Quantity Multiple Award Task Order Contracts) are in place to allow more rapid response to equipment failures. Active contracts of this type are currently limited to cranes but contracts for turbines and generators have existed in the past. Development of additional MATOCs are being considered for other long lead-time powertrain and structural components.

Station service equipment serves an important function to keep equipment running during normal operations and allow it to operate during a grid outage. The FCRPS has developed a station service equipment design philosophy that aims to provide sufficient redundancy which has led to an overall increase in redundancy at the plants to which it has been applied. As station service equipment replacements continue, each system will be evaluated and likely improved.

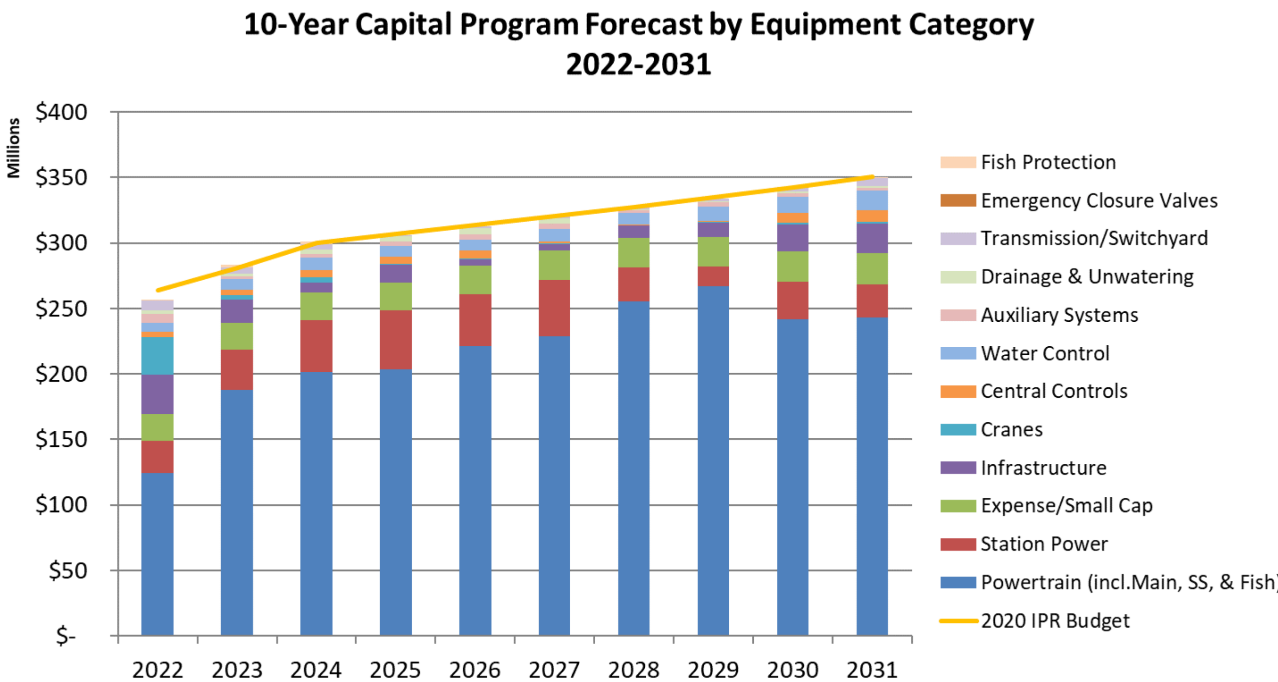
10.3 Planned Future Investments/Spend Levels

Capital investment levels are derived from the methodology described in 10.2. Capital investment associated with the expansion projects described above are not included in planned future investment levels as approval to proceed is pending. If either project is approved, capital investment forecasts will not increase and the capital investment portfolio will be reoptimized under the same budget. The recommended capital investment strategy ramps up to a $300 million budget by 2024 and then increases at the rate of inflation. Future fiscal year expense levels are projections assuming budgets escalate at the rate of inflation following the BP22 rate period and that modernization work on G19-21 at Grand Coulee is predominantly capital. These forecasts will be refined in future IPRs.

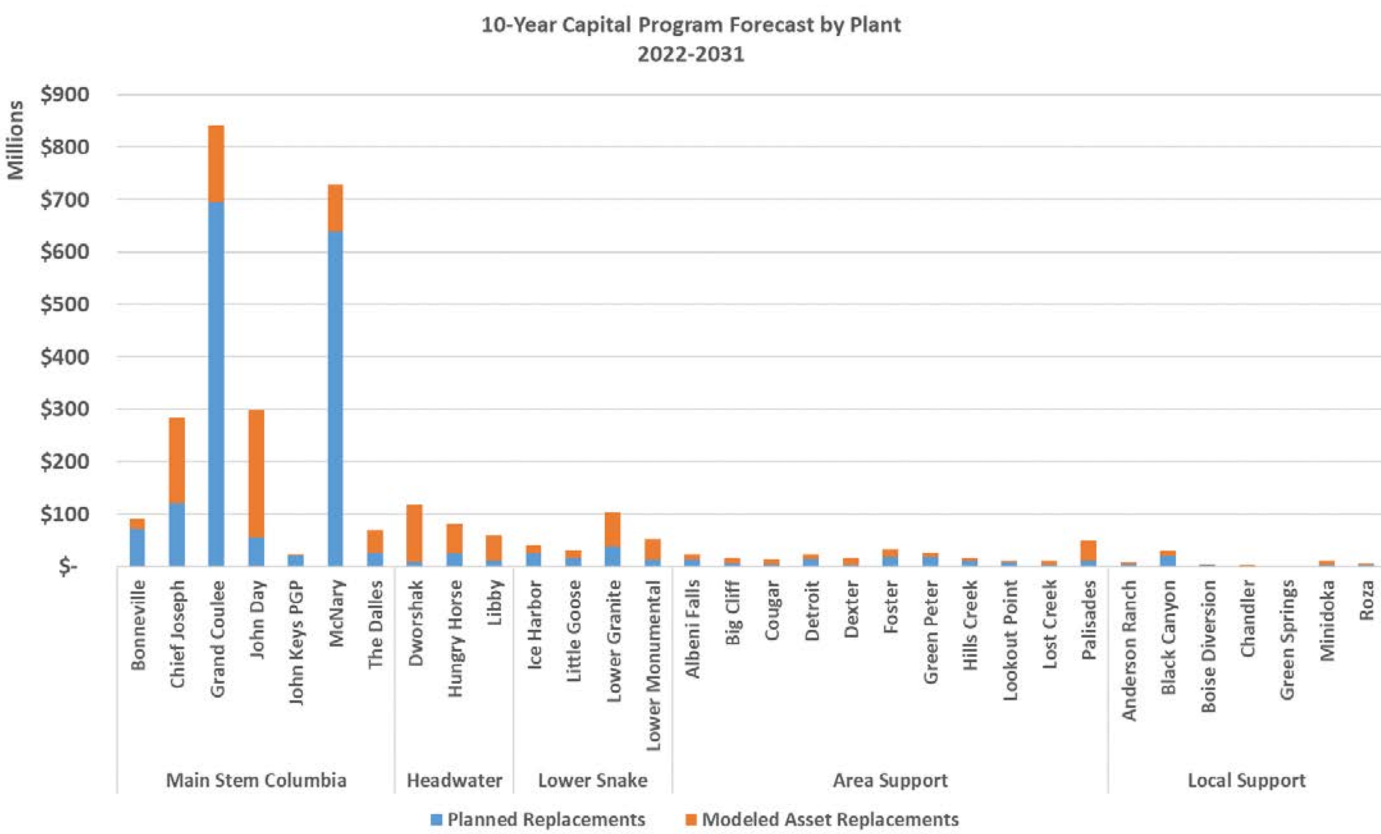
Table 10.3-1 Future Expenditures (in thousands)

Program	Rate Case FY's		Future Fiscal Years							
Capital Expand (CapEx)	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Corps of Engineers										
Bureau of Reclamation										
Total Capital Expand										
Capital Sustain										
Corps of Engineers	216,296	229,286	256,656	269,006	269,926	273,102	234,960	196,496	231,379	240,702
Bureau of Reclamation	47,824	51,974	43,344	37,844	43,721	47,364	92,578	138,379	111,056	109,590
Total Capital Sustain	264,120	281,260	300,000	306,850	313,647	320,466	327,538	334,875	342,435	350,292
Expense (OpEx)										
Corps of Engineers	252,557	252,557	258,953	262,029	266,596	270,293	274,489	278,562	282,849	287,032
Bureau of Reclamation	152,616	152,616	156,481	158,340	161,100	163,334	165,869	168,330	170,921	173,449
Total Expense	405,173	405,173	415,434	420,369	427,696	433,627	440,359	446,892	453,711	460,480

Investment in powertrain components is expected to increase substantially in the next 10 years as several major powertrain replacement projects ramp up. Grand Coulee G19-21 modernization, McNary turbine runner replacements and Chief Joseph generator rewinds account for the majority of the increases.

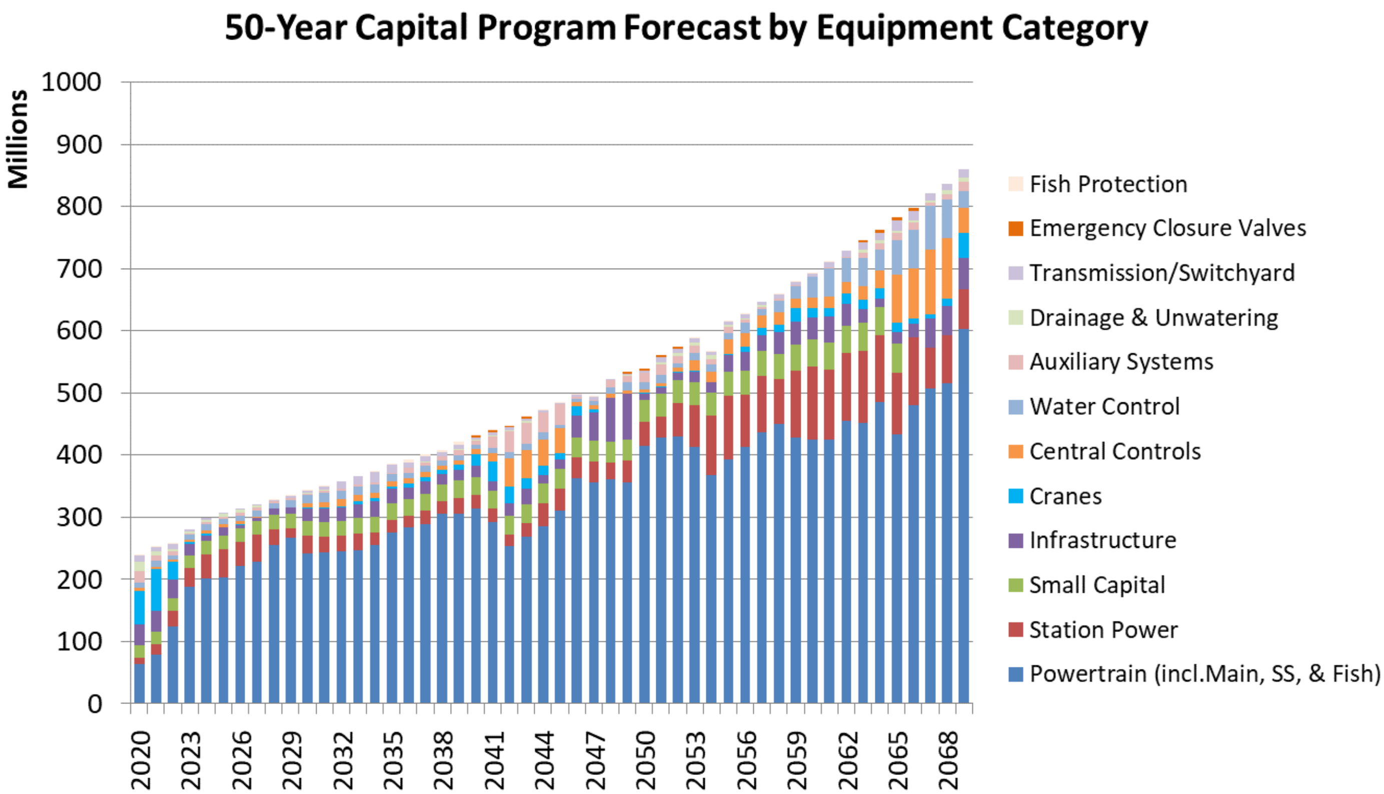


The chart below shows the total capital investment forecast at each plant. Blue bars represent planned projects that are either in design or construction. Orange bars represent forecasts associated with modeled asset replacements based on asset condition and risk for which a project is still in scoping or is yet to be identified. The timing and costs for modeled asset replacements are uncertain and tend to shift as projects are identified.



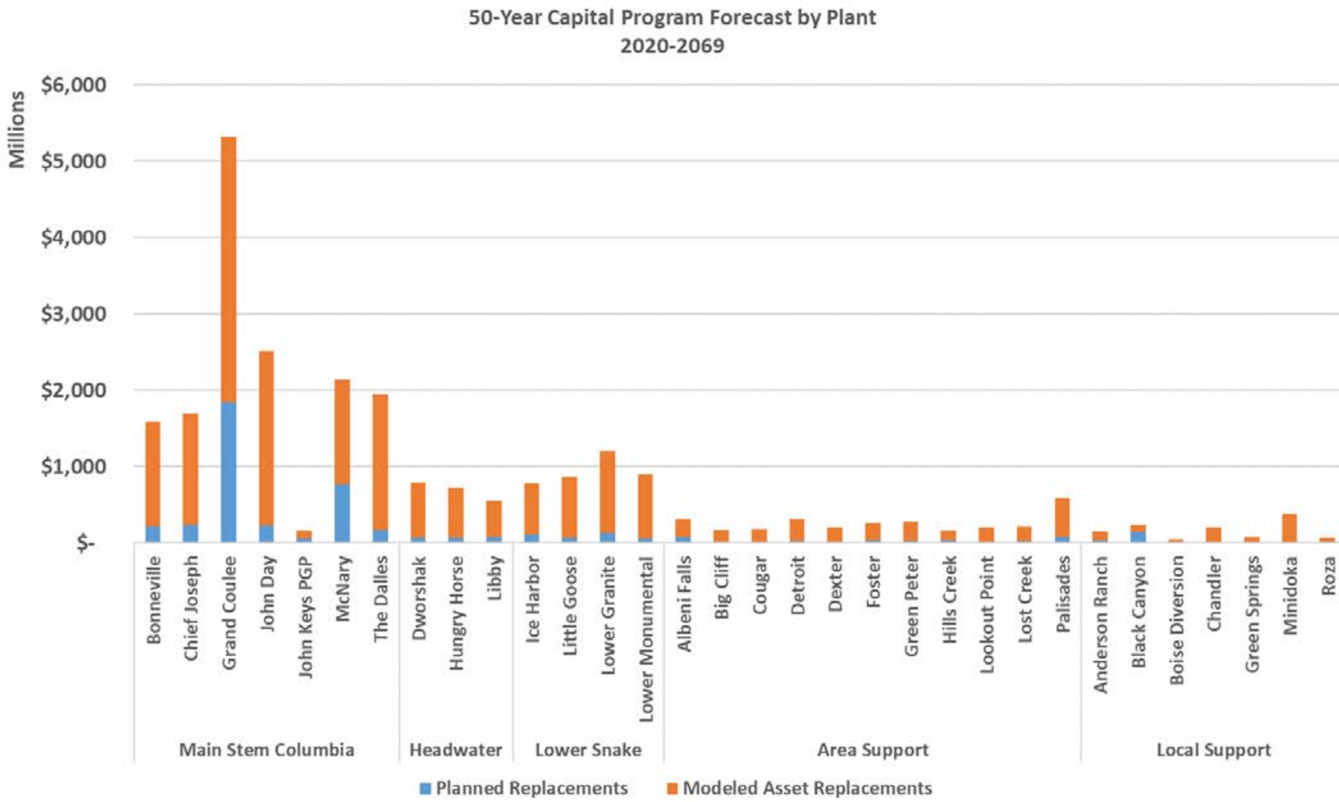
10.3.1 Long-term Capital Outlook

Beginning in the mid-2020s, investment in powertrain components will represent the vast majority of capital investments for about 20 years. In the 2040s, investment in cranes, central controls, infrastructure and auxiliary systems is expected to increase once again as powertrain investment levels off. Also of note is that the Predictive Analytics analysis finds it optimal to identify investments up to the budget constraint in nearly every year in the 50-year study period. At higher budget levels, Predictive Analytics does not find it optimal to use the full budget in future years. This is elaborated upon in Section 10.6.5



The level of investment by strategic class over the 50-year study period is highly correlated with the amount of generation provided by each strategic class. Main Stem Columbia plants are planned to receive the vast majority of investment, consistent with their importance to the FCPRS. Investment in the Area Support plants is high relative to their contribution to the FCRPS generation portfolio, however, less investment is targeted at powertrain equipment. Only 50% of the total investments in Area Support facilities address powertrain components compared to about 70% for other strategic classes. Much of the investment in these facilities support their multiple authorized purposes.

Strategic Class	% of Average Annual Generation	% of 50-Year Capital Forecast
Main Stem Columbia	77%	61%
Lower Snake	12%	15%
Headwater	6%	8%
Area Support	4%	11%
Local Support	1%	5%



10.4 Implementation Risks

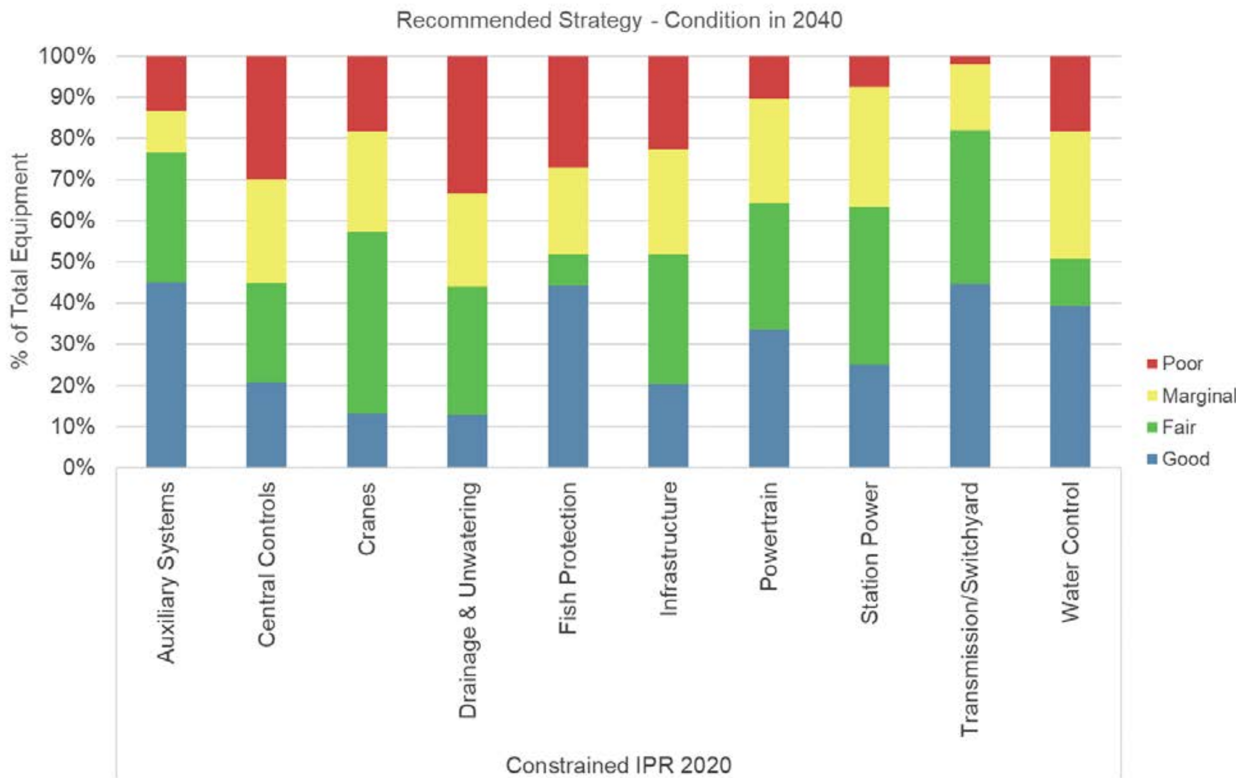
Table 10.4-1, Implementation Risks

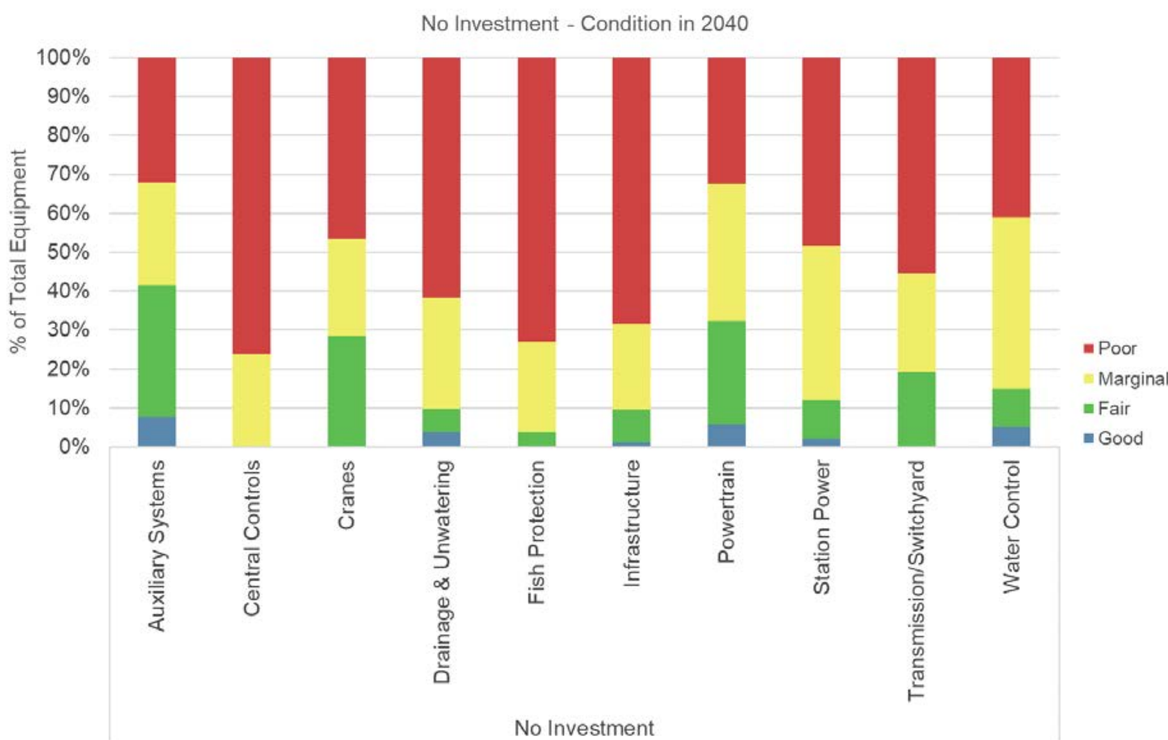
Risk	Impact	Mitigation Plan
Decisions on Dworshak Unit 4 and Libby Unit 6 are not made in a timely-manner causing delays to other investments	The construction of Dworshak Unit 4 and the completion of Libby Unit 6 represent significant portions of the Walla Walla and Seattle district investment programs. The optimal timing of investments in existing units at those facilities are impacted by these decisions. Investments will need to be reoptimized if these projects proceed. Dworshak Unit 4, with a significantly higher cost than Libby Unit 6, poses the highest risk.	Thorough analysis has been produced to provide decision makers with information on these two investments. Follow up analyses are currently being performed based on the initial review. Both investments are far enough out in time that the program can adjust, however, targeting a final decision on proceeding with design on either or both projects in 2020 will reduce risk of impacting planning.
Annual reoptimization of Asset Plan results in shifting resource requirements for Corps districts and Reclamation from year-to-year	Any perceived or real uncertainty in work ramping up or down at a given district or plant makes it difficult for the districts to adjust and plan resources. This is especially true at more remote facilities.	The Asset Plan Team will take the level of investment and number of projects by district into account when developing the System Asset Plan. More modest changes overtime are easier to resource and plan for than having large shifts from district-to-district. Earlier collaboration between the agencies on business cases will result in improved alignment and streamlined approval of projects. This will lend more certainty to future investments and less shifting in each revision of the plan.

Risk	Impact	Mitigation Plan
Bids received are higher than government estimates causing reevaluation of priorities	Higher than expected bids can result in the need to reevaluate the timing and merits of project. Some changes may result in deferring projects if the business case is severely impacted. The additional time to review can impact budget execution. Delays are compounded if bids received for joint assets require requesting additional federal appropriations.	Walla Walla district is the center of expertise for cost estimation at the Corps. For major projects, a cost and schedule risk analysis is employed to produce a risk-informed estimate for the cost and schedule of a project. The Corps is looking to adapt this more projects as the majority are single point estimates.
Optimistic project schedules result in under-execution of capital budget	Projects could take longer to execute than expected due to as-found conditions, contractor performance, outage scheduling or other factors. Without "shelf-ready" projects that resources can be shifted to, budget execution will be impacted.	Corps and Reclamation capital program managers provide 3-point estimates by project for the current year and the next fiscal year. A Monte Carlo simulation is run to produce a distribution of potential outcomes. Corps and Reclamation SOY budget requests are based on the results of this analysis. Although this captures some risk for near term budgets, a mitigation strategy still needs to be developed for the long-term portfolio.
Project complexity results in longer scoping and study than anticipated	Project schedules can be impacted when more studies or scoping are required than anticipated. Project justification for complex projects has taken more time than expected as our analyses and requirements evolve. This can also arise from disagreements in priorities or recommended project alternatives between BPA, the Corps and Reclamation.	The Business Process Improvement Taskforce developed a project lifecycle map that outlines the process from project identification to approval and the requirements to pass each stage gate. Early collaboration during the scoping of a project between the agencies reduces disagreements and ensures requirements for approval are agreed upon early in the process.
Regional strategies currently in process are not accepted by the FCRPS leadership or the Capital Workgroup causing disagreements in priorities	Regional strategies and design philosophies for non-powertrain equipment are under development. These strategies are meant to improve alignment between the agencies on investments where benefits have been difficult to quantify and FCRPS-wide priorities have not been clear. If there is not Three Agency alignment on the completed strategies, timing and scope of related investments identified by the plants and districts will remain uncertain.	Regional strategy teams have representation from each agency to ensure that coordination happens during development.

10.5 Asset Condition and Trends

Condition over the next 20 years is expected to remain relatively stable under the recommended strategy compared to today. Investments made across the system are expected to prevent significant declines in availability that would be seen absent investment. By 2040, the vast majority of FCRPS assets would be expected to be in marginal or poor condition without investment, including almost 70% of the powertrain assets.


Recommended Strategy - Condition in 2040
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% of Total Equipment
Auxiliary Systems
Central Controls
Cranes
Drainage & Unwatering
Fish Protection
Infrastructure
Powertrain
Station Power
Transmission/Switchyard
Water Control
Constrained IPR 2020
Poor
Marginal
Fair
Good


No Investment - Condition in 2040
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% of Total Equipment
Auxiliary Systems
Central Controls
Cranes
Drainage & Unwatering
Fish Protection
Infrastructure
Powertrain
Station Power
Transmission/Switchyard
Water Control
No Investment
Poor
Marginal
Fair
Good

10.6 Performance and Risk Impact

Over time, the recommended plan will reduce the number of high-risk assets in all categories relative to today. It is not expected that high-risk assets will be reduced to zero, nor is it the strategy. In some cases, the optimal intervention timing results in an asset remaining in the high-risk category for a number of years. Overall, assets that enter the high-risk category remain in the high-risk category for an average of 9 years in the recommended plan.

The following risk maps compare risk in 2040 under the recommended plan versus a no investment scenario.

10.6.1 Safety Risk

In 20 years, the number of high safety risk assets is expected to fall from 78 to 46. Without investment, the number would rise to 231. Assets that pass into the high safety risk category remain for an average of 10 years before replacement. In practice, operational procedures reduce these risks until the equipment is replaced.

Recommended Investment Strategy - FY2040 Safety Risk Matrix

Likelihood \ Consequence	Insignificant	Minor	Moderate	Major	Extreme
Almost Certain	170	40	2	3	
Likely	376	41	24	41	
Possible	1580	141	65	162	128
Unlikely	1331	193	83	182	74
Rare	3615	233	378	133	126

No Investment - FY2040 Safety Risk Matrix

Likelihood \ Consequence	Insignificant	Minor	Moderate	Major	Extreme
Almost Certain	684	85	47	100	6
Likely	904	80	91	62	16
Possible	2386	239	182	158	156
Unlikely	1380	160	94	170	73
Rare	1718	84	139	33	77

10.6.2 Financial Risk

In 20 years, the number of high lost generation risk assets is expected to fall from 128 to 104. Without investment, the number would rise to 867. Assets that pass into the high lost generation risk category remain for an average of 7 years before replacement.

Recommended Investment Strategy - FY2040 Lost Generation Risk Matrix

Likelihood	Insignificant	Minor	Moderate	Major	Extreme
Almost Certain	8	6	19	14	
Likely	16	81	144	71	
Possible	34	275	692	598	21
Unlikely	75	232	623	506	53
Rare	23	231	1299	1963	193

Consequence

No Investment - FY2040 Lost Generation Risk Matrix

Likelihood	Insignificant	Minor	Moderate	Major	Extreme
Almost Certain	12	29	239	190	11
Likely	19	106	366	404	23
Possible	38	283	915	1250	91
Unlikely	75	222	652	550	68
Rare	12	185	606	759	74

Consequence

10.6.3 Direct Cost Risk

In 20 years, the number of high direct cost risk assets is expected to fall from 238 to 222. Without investment, the number would rise to 876. Assets that pass into the high direct cost risk category remain for an average of 11 years before replacement.

Recommended Investment Strategy - FY2040 Direct Cost Risk Matrix

Likelihood	Insignificant	Minor	Moderate	Major	Extreme
Almost Certain	12	42	129	32	
Likely	14	76	331	60	1
Possible	26	322	1509	215	4
Unlikely	27	300	1307	223	6
Rare	54	630	2928	809	64

Consequence

No Investment - FY2040 Direct Cost Risk Matrix

Likelihood	Insignificant	Minor	Moderate	Major	Extreme
Almost Certain	28	193	535	151	12
Likely	15	189	771	166	12
Possible	35	402	2287	366	22
Unlikely	26	288	1313	240	11
Rare	29	298	1300	417	18

Consequence

10.6.4 Environmental Risk

In 20 years, the number of high environmental risk assets is expected to fall from 25 to 12. Without investment, the number would rise to 82. Assets that pass into the high environmental risk category remain for an average of 9 years before replacement.

Recommended Investment Strategy - FY2040 Environmental Risk Matrix

Likelihood \ Consequence	Insignificant	Minor	Moderate	Major	Extreme
Almost Certain	198	8	9		
Likely	345	64	70	3	
Possible	1431	280	218	145	2
Unlikely	1357	263	162	80	1
Rare	3419	414	516	131	5

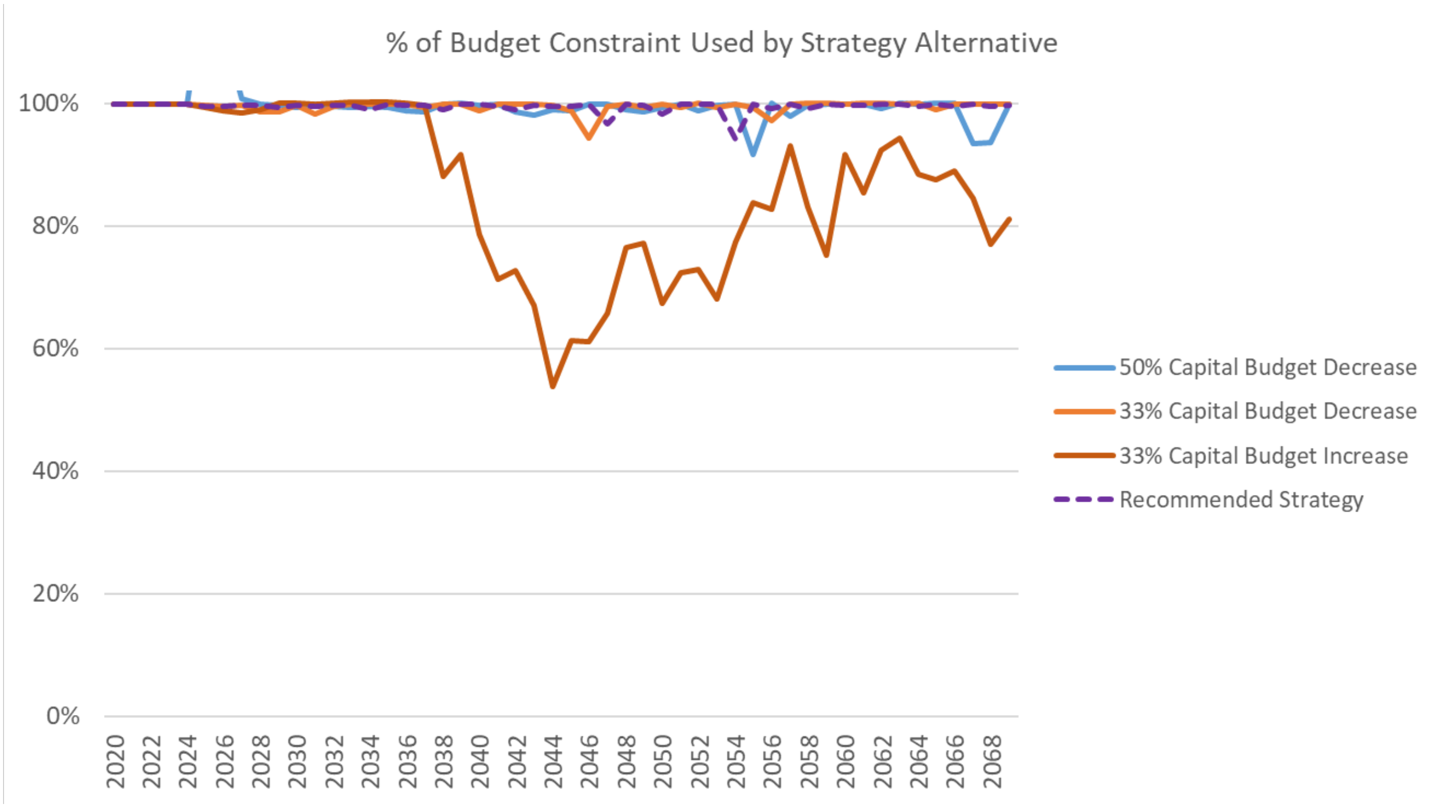
No Investment - FY2040 Environmental Risk Matrix

Likelihood \ Consequence	Insignificant	Minor	Moderate	Major	Extreme
Almost Certain	834	26	48	14	
Likely	842	113	178	18	2
Possible	2171	429	347	171	3
Unlikely	1312	313	165	85	2
Rare	1592	149	238	71	1

10.6.5 Economics of the Strategy

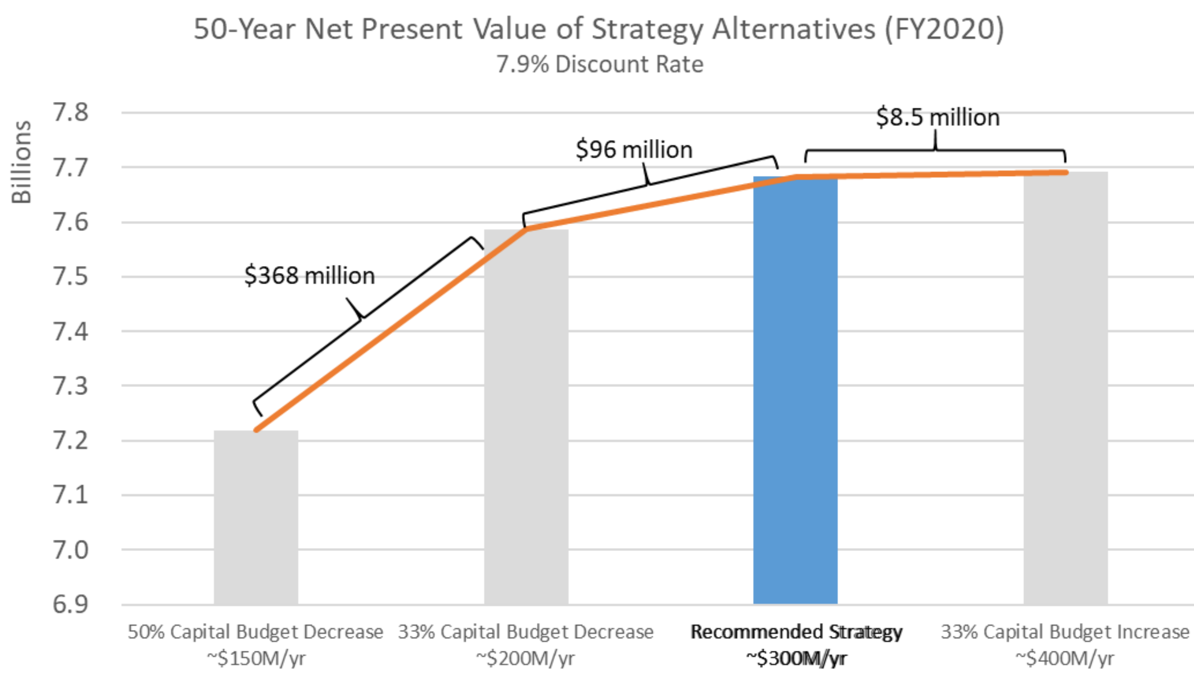
Arriving at a recommended investment level involves performing sensitivity analysis to understand the cost and risk tradeoffs of different levels of capital investment. In addition to the recommended strategy, a 33% higher, 33% lower and 50% lower capital budget constraint were modeled. In each alternative, the model identifies investments in assets in order to minimize lifecycle cost up to the budget constraint. The model will not identify investments up to the budget constraint if it is not optimal to do so.

At the recommended budget level and reduced budget levels, the model found it optimal to use the entire budget in nearly every year in the study period. At the higher budget level, the model forecasts that investments are able to catch up with optimal replacements by the late 2030s. Investment then falls to as low as 60% of the available budget in the 2040s before increasing, on average, for the remainder of the study period.



10.6.5.1 Net Present Value of Investment

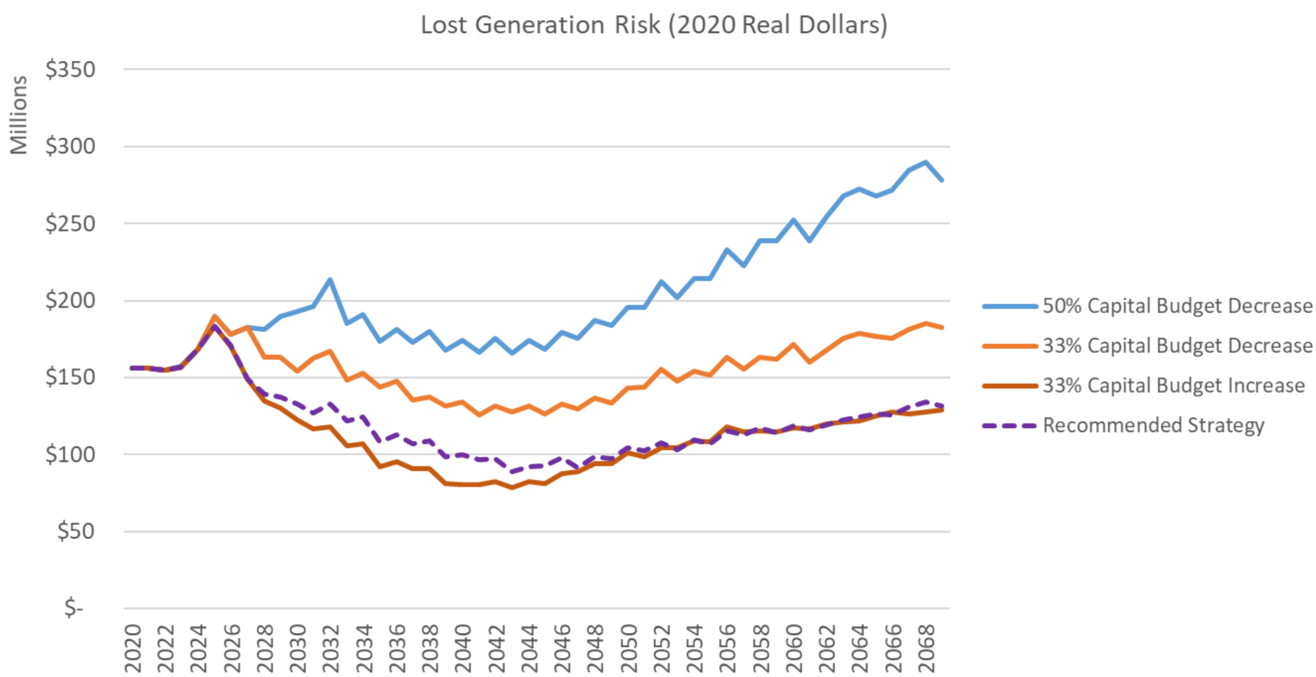
Compared to a no investment alternative, all budget levels analyzed produce a Net Present Value between $7.2 and $7.7 billion through risk mitigation and efficiency benefits. Higher levels of investment over the recommended strategy produce only minor incremental benefits. Lower levels of investment become increasingly costlier. A 33% reduction in investment reduces the NPV by $96 million and a 50% reduction in investment reduces the NPV by $368 million.



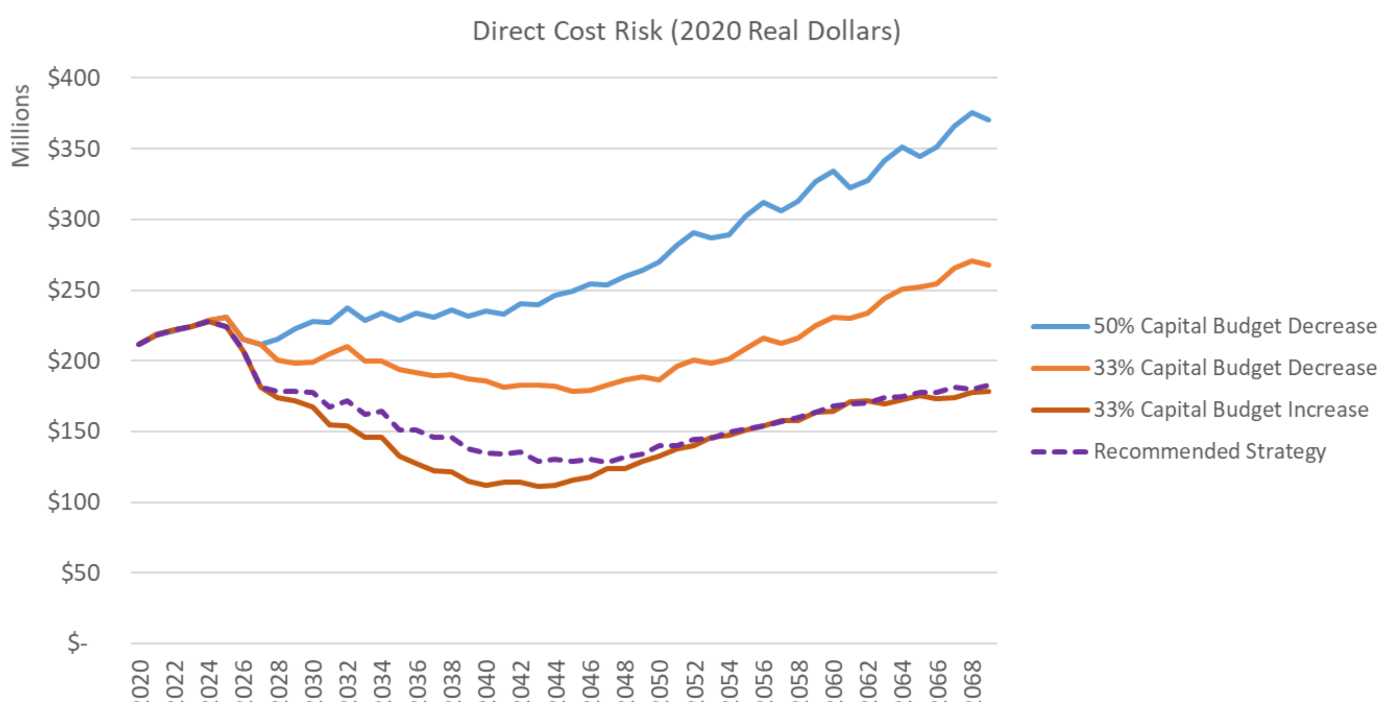
10.6.5.2 Long-term Risk Profiles

The following charts illustrate the risk profiles and efficiencies benefits for each strategy alternative. Differences in funding levels begin in 2021 and reach their stated target by 2024. It is assumed that, on average, it takes four years from the start of a project before the construction phase begins. This means that the first year in which impacts of the different budget levels can be seen is 2025.

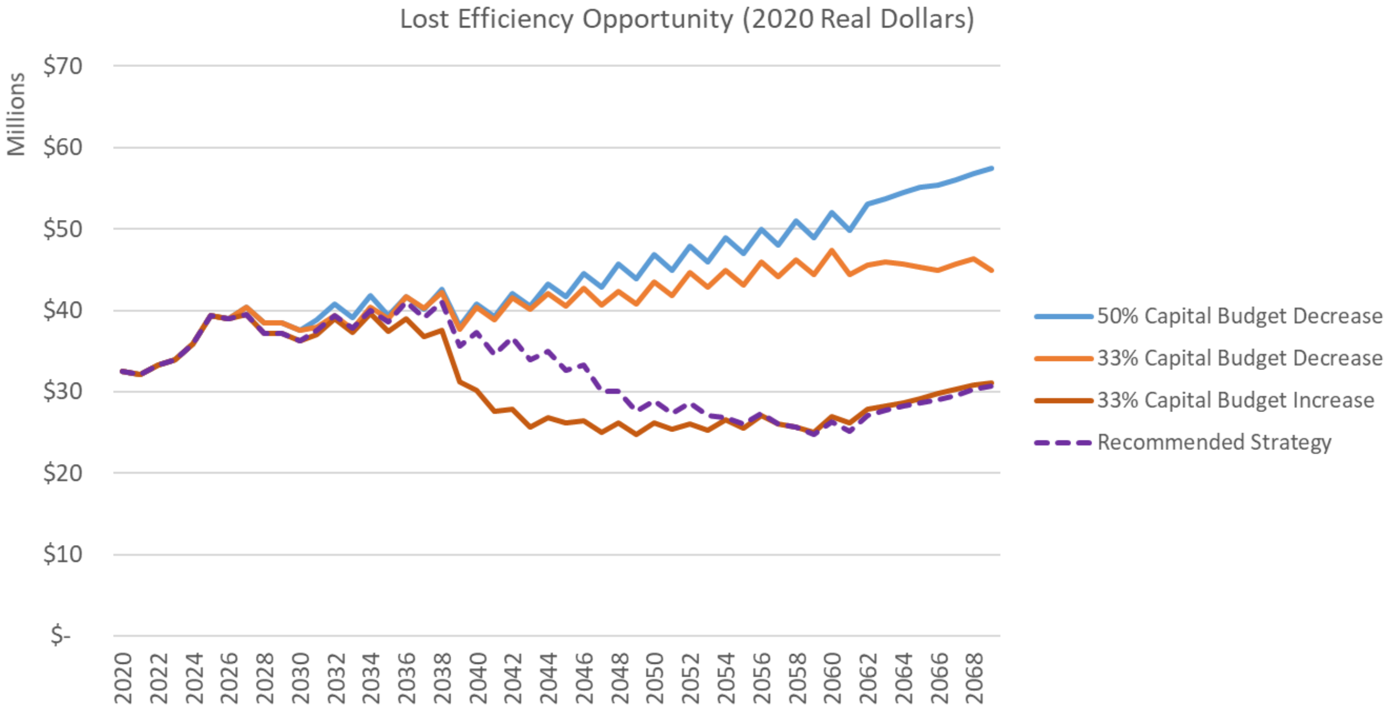
10.6.5.3 Lost Generation Risk



10.6.5.4 Direct Cost Risk

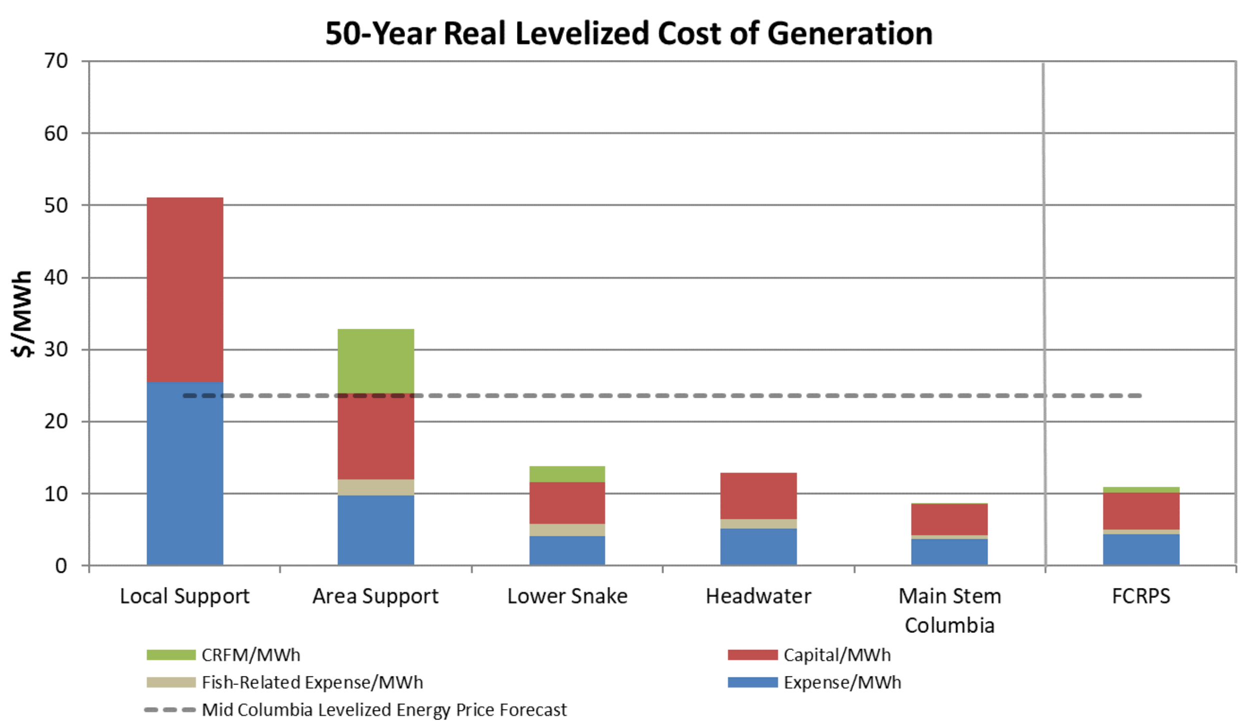


10.6.5.5 Lost Efficiency Opportunity



10.6.5.6 Real Levelized Cost of Generation

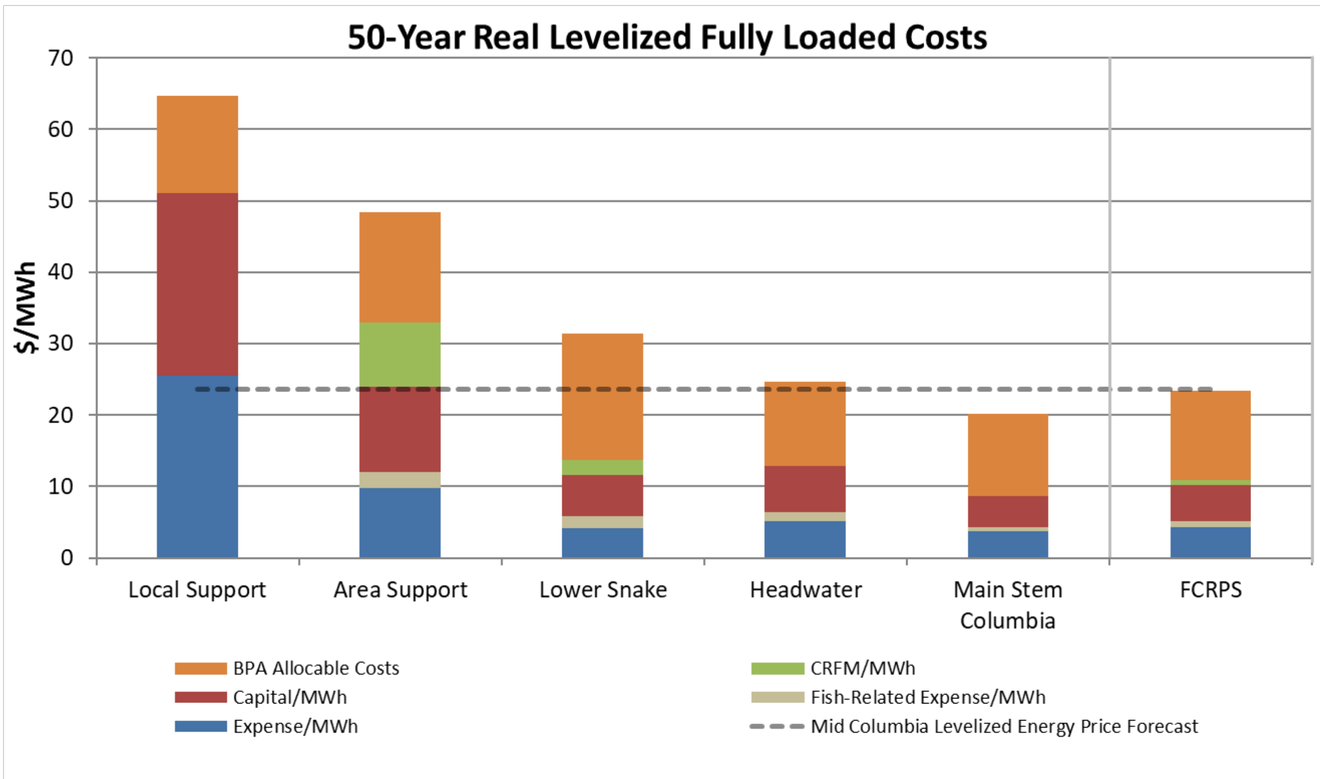
The Levelized Cost of Generation is a forward look at the Cost of Generation metric described in Section 0. It takes the capital and expense programs outlined in the recommended strategy and levelizes them over a 50-year period to give a representative annual capital and expense value. Plant generation is also modified based on the changes in the lost generation risk profiles to recognize difference from current conditions. For purposes of this analysis, financing is not considered for capital expenditures.



As a whole, the FCRPS has a 50-Year Real Levelized Cost of Generation of $9.56/MWh compared to a real levelized energy price forecast of $23.58/MWh for the Mid-Columbia. All plants in the Main Stem Columbia, Headwater and Lower Snake strategic classes are expected to produce power at or below the real levelized energy price. This means that 84% of the capital investment program over the next 50 years is targeted at plants producing power at a cost below the expected spot market energy price. Note that, like the Cost of Generation metric, this is not an "all-in" cost and only considers the incremental costs of generation.

10.6.5.7 Real Levelized Fully Loaded Cost

The Real Levelized Fully Loaded Cost includes allocations for all costs that can be attributed to the FCRPS. This includes BPA's Fish and Wildlife Program, Residential Exchange and other BPA overheads. Future BPA allocable costs are assumed to increase at the rate of inflation for the purpose of this analysis. The strategy outlined in this SAMP is expected to result in a Real Levelized Fully Loaded Cost of $22.00/MWh for the 50-year study period. Thus, planned investments over the next 50 years are forecasted to result in only a minor increase over the system's current Fully Loaded Cost of $20.51/MWh shown in Table 8.3.6-1 over FY17-FY19.



10.6.5.8 Summary of Results

To summarize, over 60% of the capital and expense programs in this SAMP are targeted at the Main Stem Columbia, which have a 50-year incremental cost of generation of $7.54/MWh and a fully loaded cost of $19.04/MWh. Budgets for the Lower Snake and Headwater strategic classes are proportional to the amount of generation they contribute to the system. Multipurpose activities represent a larger portion of the budgets for Area Support and Local Support facilities, resulting in budgets proportionately higher than the amount of FCRPS generation they represent.

Strategic Class	% of FCRPS Average Annual Generation	% of 50-Year Capital Forecast	% of 50-Year Expense Forecast	50-Year Cost of Generation ($/MWh)	50-Year Fully Loaded Cost ($/MWh)
Main Stem Columbia	77%	61%	64%	$7.54	$19.04
Lower Snake	12%	15%	14%	$12.13	$29.80
Headwater	6%	8%	8%	$11.76	$23.56
Area Support	4%	11%	10%	$30.07	$45.52
Local Support	1%	5%	4%	$42.48	$56.06
FCRPS	100%	100%	100%	$9.56	$22.00

11.0 Addressing Barriers to Achieving Optimal Performance

Due to the nature of having three separate government agencies collectively act as a single hydropower utility, there are inherent challenges to achieving optimal performance.

Despite being the *largest* producer of hydropower in the United States, the Corps is part of a military organization whose priorities, processes and procedures focus on multiple mission requirements that extend beyond hydropower asset management. As a result, the FCRPS agencies, including the Corps at the Division level, at times have minimal influence over some of these priorities and processes as they relate to our shared hydropower mission.

Despite being the *second largest* producer of hydropower in the United States, Reclamation's primary mission is on water management as the largest wholesaler of water in the country. As with the Corps, Reclamation's regional priorities, processes and procedures are also required to align with their fundamental mission requirements that extend beyond hydropower asset management.

The three FCRPS agencies continue to develop methods to improve on the processes and procedures within their control.

Hydropower acquisition is an understood challenge within the FCRPS. With hydro equipment having so many unique and complex aspects, it is a regional priority to build more effective, efficient and optimal acquisition strategies and processes. Several steps are underway accomplish this. For example, an interactive Hydro Acquisition Workshop is under development that will share expertise and promote acquisition best practices among the people executing complex hydropower projects. This FCRPS workshop scheduled in May 2020 will include folks from project management, operations, contracting, engineering, and construction. Overall, the FCRPS has identified multiple focus areas for acquisition improvement and has prioritized developing necessary courses of action to continue growth in hydropower acquisition.

Having three separate agencies means having three reporting structures, three front offices and potentially three strategic directions. This results in additional complexities in the review, approval and reporting of projects and budgets. For example, the Corps and Reclamation are required to seek approval from and report to both their own agency and BPA. This can lead to an iterative alignment process, as projects of strategic importance in one organization may not initially be important in another organization. The Three Agency Asset Management Commitment in Section 2.1.1 lays the groundwork for bringing the agencies together during the decision-making process. Ensuring the agencies share a common FCRPS Asset Management mission, vision and understanding of all sources of value is critical to achieving optimal performance.

Historically, BPA Power products and services have been developed based on the capabilities and limitations of the existing assets. With major powerplant modernization projects on the horizon, there is now an opportunity to shape the design of the assets around future needs and opportunities. Increased collaboration between BPA operations, the trading floor and FCRPS asset management is critical to ensure these opportunities are realized.

12.0 DEFINITIONS

Asset Investment Excellence Initiative (AIEI): A Federal Columbia River Power System initiative to improve long term capital investment planning capabilities and processes.

Asset Planning Team (APT): Federal Columbia River Power System long term planning team tasked with development of the System Asset Plan.

Bonneville Power Administration (BPA): Power Marketing Authority in the Pacific Northwest under the Department of Energy.

C55: Asset Investment Planning and Management Tool used by Federal Columbia River Power System long term planning staff.

Capital Workgroup (CWG): Federal Columbia River Power System technical and economic Capital Investment review team tasked with review and approval of all Large Capital investments.

CEATI: User-driven organization that facilitates electric utility information sharing and technical projects for its participants.

Columbia River Fish Mitigation (CRFM): A program to mitigate the impacts to fish posed by the dams primarily on the lower Columbia and lower Snake Rivers.

Days Away Restricted or Transferred (DART): The number of recordable non-fatal injuries and work-related illnesses resulting in lost time or days on restricted or transferred duty per 100 full-time workers.

Direct Cost Risk (DCR): A risk calculated in Asset Analytics reflecting the incremental cost of equipment failure compared to planned replacement (not including lost generation).

Direct Funding Agreements: Memoranda of Agreement that establish the ability for BPA to directly fund the Capital and Operations & Maintenance programs of the Corps and Reclamation.

Executive Steering Committee (ESC): A Three Agency leadership team team that develops long term goals and strategies for the FCRPS and provides guidance to the Joint Operating Committees.

Expenditure: Term used by the Capital Investment program to describe an investment activity.

EUCG: Member-based trade association comprised of professionals from utility companies that meets semi-annually to provide a forum and tools to exchange information, share lessons learned, and find solutions to industry issues.

Federal Columbia River Power System (FCRPS): The Three Agency partnership comprised of the United States Army Corps of Engineers, United States Bureau of Reclamation and Bonneville Power Administration tasked with delivering on the multipurpose missions of the 31 federal hydroelectric facilities in the Pacific Northwest.

Hydraulic Plant Life Interest Group (HPLIG): A CEATI interest group focused on hydropower technology, asset management, operations & maintenance and best practices sharing.

hydroAMP: Hydro industry equipment condition assessment framework.

Integrated Program Review (IPR): A BPA financial public process in which capital and expense programs are reviewed with customers, stakeholders and other interested parties.

ISO 55000: A series of three international standards for Asset Management.

Joint Operating Committee (JOC): A committee tasked with overseeing the implementation of the direct funding agreements.

Lost Efficiency Opportunity (LEO): An opportunity cost calculated in Asset Analytics that is associated with deferral of investment in more efficient equipment.

Lost Generation Risk (LGR): A risk calculated in Asset Analytics reflecting the incremental loss of generation resulting from forced outages due to equipment failure.

Lost Time Accident Rate (LTAR): The number of recordable non-fatal injuries and work-related illnesses resulting in lost time per 100 full-time workers. Restricted to hydro-related incidents and only counts hydropower labor hours. Calculated on a 365-day rolling window to provide an annual rate, using 100 FTE = 200,000 man-hours.

North American Electric Reliability Corporation (NERC): Nonprofit corporation that develops standards for power system operation, monitors and enforces compliance, assesses resource adequacy and provides power system operation education and training resources.

North American Electric Reliability Corporation Critical Infrastructure Protection (NERC CIP): A set of Cyber and Physical Security requirements designed to secure the assets required for operating North America's bulk electric system.

Non-Routine Expense (NREX): Investment projects or large, maintenance activities that are not regularly re-occurring and are not classified as a capital expenditure.

Operations and Maintenance (O&M): The routine activities performed by the Corps and Reclamation as owners and operators of the 31 hydroelectric facilities.

Operations and Maintenance Optimization Initiative (OMOI): The Corps' initiative to improve O&M decision making through a better understanding of value and risk to all missions at the facilities.

PAS 55: The predecessor to ISO 55000 and the first publicly available specification for optimized management of physical assets.

Predictive Analytics (PA): C55 asset lifecycle cost minimization module.

United States Army Corps of Engineers (Corps): Owner and Operator of 21 Federal Columbia River Power System plants under the Department of the Army.

United States Bureau of Reclamation (Reclamation): Owner and Operator of 10 Federal Columbia River Power System plants under the Department of the Interior.

Reliability Implementation & Technical Subcommittee (RITS): Subcommittee of the Joint Operating Committee that is tasked with providing direction to the FCRPS regarding matters dealing with reliability and compliance issues, managing changes in Bulk Electric System Reliability Standards and requirements and managing interagency power generation/transmission technical issues.

Strategic Asset Management Plan (SAMP): A document specifying a long-term optimized approach to asset management, derived from, and consistent with, the organizational strategic plan and asset management policy.

System Asset Plan (SAP): A document specifying the projects, resources and timescales associated with achieving the goals described in the Strategic Asset Management Plan. Sometimes referred to as the “Asset Plan.”

Three Agency: Refers to the partnership between Bonneville Power Administration, the United States Army Corps of Engineers and the United States Bureau of Reclamation.

Total Case Incident Rate (TCIR): The sum of all recordable non-fatal injuries and work-related illnesses per year per 200,000 labor hours.

Total Dissolved Gas (TDG): A measure of the concentration of dissolved gasses in water downstream of spillways resulting from spilled water at dams.

Value Framework: A module in C55 that allows for the comparison and optimization of an investment portfolio.

Western Electricity Coordinating Council (WECC): The Regional Entity responsible for compliance monitoring and enforcement applicable to the Pacific Northwest.