Handouts

Klamath Basin Collaborative Monitoring Plan Workshop

May 14 -15, 2025

Ashland Springs Hotel, Ashland Oregon

2.1 Guiding Principles for Process-Based Restoration

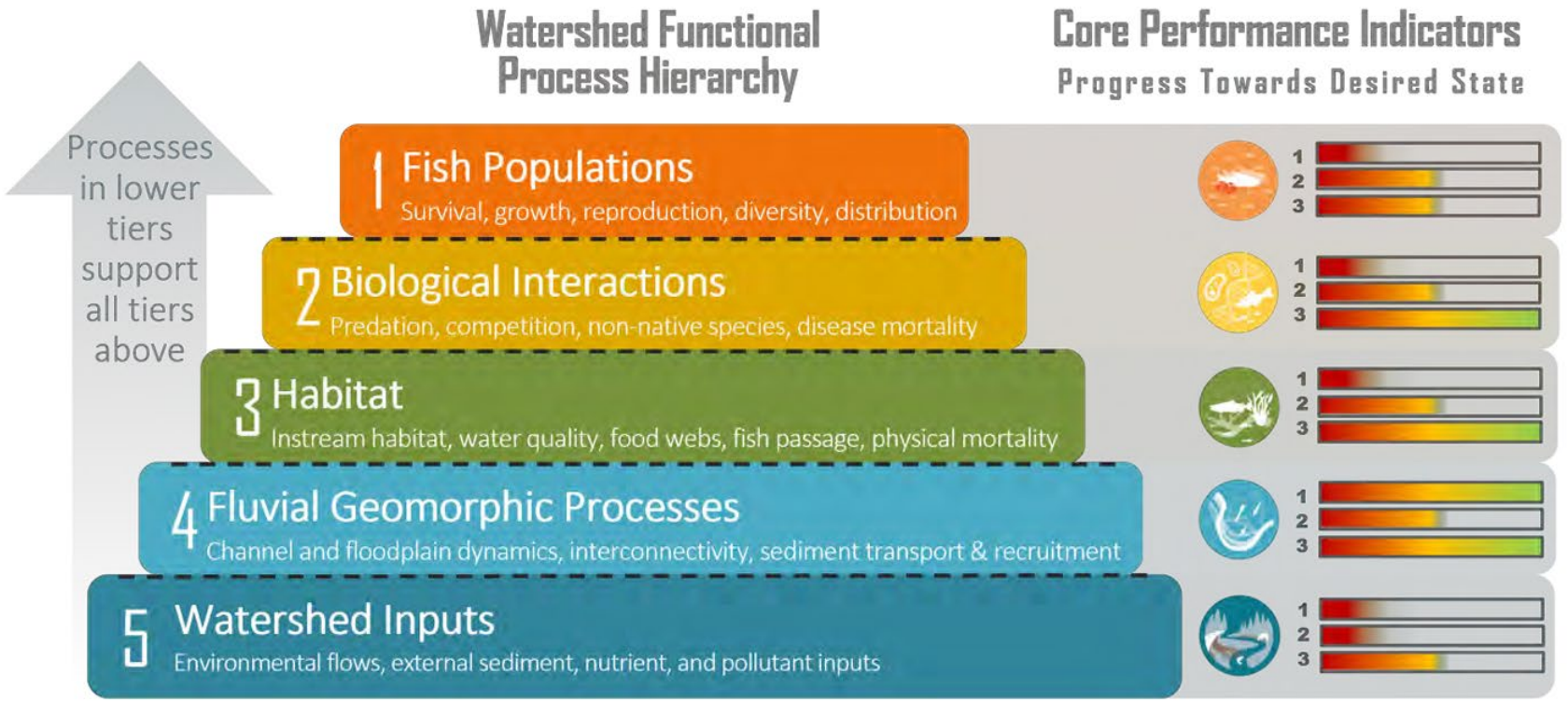

Figure 2-1. Diagram illustrating the concept of bottom-up restoration by tier of watershed processes, where practitioners should focus first on addressing the underlying causes at the base of the hierarchy before carrying out restoration in other tiers that rely on this foundation (after Roni and Beechie 2013, Harman et al. e2012). The stylistic heat-map colored bars underneath "Core Performance Indicators" represent different metrics that have been selected to measure the status of conditions within the different biophysical tiers and are used to track progress towards achieving the desired state.

IFRMP Plan Document 2023, Section 2.1, Page 30, https://ifrmp.org/wp-content/uploads/2023/02/KlamathIFRMP_PlanDocument_20230212_FINAL2.pdf

Klamath IFRMP Goals and Objectives Hierarchy

Whole-Basin Nested Goals	Nested Objectives
Fish Populations (FP) 1. Achieve naturally self-sustaining native fish populations	1.1 Increase juvenile production
	1.2 Increase juvenile survival and recruitment to spawning populations
	1.3 Increase overall population abundance and productivity, particularly in areas of high existing abundance or potential future abundance or in special or unique populations
	1.4 Maintain or increase life history and genetic diversities
	1.5 Maintain or increase spatial distributions as necessary
Fisheries Actions (FA) 2. Regulate harvest to support self-sustaining populations.	[9] 2.1 Improve management and regulations/enforcement of harvest, bycatch and poaching of naturally produced fish such that populations do not decline and can recover. **While essential for recovery of fish populations, this objective and objective 3.1 are outside the scope of the IFRMP and falls under the responsibility of federal and state agencies with jurisdiction over harvest management.*
Biological Interactions (BI) 3. Reduce biotic interactions that could have negative effects on native fish populations	[9] 3.1 Do not generate adverse competitive or genetic consequences for native fish when carrying out hatchery, production, or conservation actions
	3.2 Minimize disease-related mortality by reducing vectors and factors known to lead to fish disease outbreaks
	3.3 Reduce impacts of non-native plant and animal species on native fish
Habitat (H) 4. Improve freshwater habitat access and suitability for fish and the quality and quantity of habitat used by all freshwater life stages	4.1 Restore fish passage and re-establish channel and other habitat connectivity, particularly in high-value habitats (e.g., thermal refugia)
	4.2 Improve water quantity and quality for fish growth and survival
	4.3 Enhance, maintain community and food web diversity supporting native fish
	4.4 Reduce fish mortality due to entrainment, scour, stranding
	4.5 Enhance and maintain estuary, mainstem, tributary, lake, wetland, and refuge habitats for all freshwater life stages and life histories of fish
Fluvial Geomorphic Processes (FG) 5. Create and maintain spatially connected and diverse channel and floodplain morphologies	5.1 Improve and maintain productive sediment delivery, storage, sorting, and transport dynamics
	5.2 Increase channel and floodplain dynamics and interconnectivity
	5.3 Promote and expand establishment of diverse riparian and wetland vegetation that contributes to complex channel and floodplain morphologies
Watershed Inputs (WI) 6. Improve water quality, quantity, and ecological flow regimes	6.1 Improve instream ecological flow regimes year-round for the Klamath River mainstem and its tributaries in all sub-basins
	6.2 Reduce anthropogenic sediment inputs while maintaining natural and beneficial sediment inputs
	6.3 Reduce external nutrient and pollutant inputs that contribute to detrimental bio-stimulatory conditions

[9] **Note: Under the direction of the IFRMP Federal Coordination Group, fishery management actions, and related fish population monitoring is relevant to the Plan but considered 'already in place' and thus out of scope of IFRMP. However, we are integrating with new monitoring undertaken by ODFW, CDFW, and other agencies.**

IFRMP Plan Document, 2032, Table 2-1, Page 32
https://ifrmp.org/wp-content/uploads/2023/02/KlamathIFRMP_PlanDocument_20230212_FINAL2.pdf

Table 2-2: IFRMP Core Performance Indicators (CPIs) selected by Working Group participants across goals and relevant objectives and associated CPI proxies used currently within the Klamath IFRMP Restoration Prioritization Tool. The hyperlinks in this table direct users to later parts of this plan addressing monitoring strategies for these CPIs. Underlined text in the CPI column links to the relevant section of the IFRMP Monitoring Recommendations.

Goal	Objectives	CPIs	CPI proxies
 **Fish Populations (FP)** **1. Achieve naturally self-sustaining native fish populations.**	FP1: Maintain or increase spatial distributions	• Focal species presence/absence • % of historical habitat occupied	• Mapped current distributions of focal fish species in the Basin • Mapped current distributions of focal fish species in the Basin vs. mapped known historical distributions of focal fish species
	FP2: Increase juvenile production	• Presence of spawning • Presence of rearing • Productivity	None identified
	FP3: Increase juvenile survival and recruitment to spawning populations	• Recruitment	None identified
	FP4: Increase overall population abundance and productivity, particularly in areas of high existing abundance or potential future abundance or in special or unique populations	• Abundance	None identified
	FP5: Maintain or increase life history and genetic diversities	• Life history diversity • Age structure/demographics • Genetic diversity	None identified
 **Biological Interactions (BI)** **3. Reduce biotic interactions that could have negative effects on native fish pops.**	BI1: Do not generate adverse competitive or genetic consequences for native fish when carrying out conservation-oriented hatchery supplementation as needed **[Outside scope of IFRMP, included here for completeness]**	NA	NA
	BI2: Minimize disease-related mortality by reducing vectors and factors known to lead to fish disease outbreaks	• Prevalence of disease pathogens • Prevalence of disease-related mortality	None identified
	BI3: Reduce impacts of non-native plant and animal species on native fish	• Presence of invasive aquatic species	• Trout Unlimited - Number of aquatic invasive species per subwatershed
 **Habitat (H)** **4. Improve freshwater habitat access and suitability for fish and the quality and quantity of habitat used by all freshwater life stages**	H1: Restore fish passage and re-establish channel and other habitat connectivity, particularly in high-value habitats (e.g., thermal refugia)	• See FP 1	• EPA - Density Road-Stream Crossing • Trout Unlimited - Ratio current max. stream network connectivity to historical (inland)
	H2: Improve water temperatures and other local water quality conditions and processes for fish growth and survival	• Thermal refugia • Water temperature • Water chemistry • Turbidity • Nutrients	• NorWeST Mean Aug Stream Temperatures – 2040s

IFRMP Plan Document, 2023, Table 2-2, Page 35 https://ifrmp.org/wp-content/uploads/2023/02/KlamathIFRMP_PlanDocument_20230212_FINAL2.pdf

Goal	Objectives	CPIs	CPI proxies
		• Chlorophyll-a • Nuisance phytoplankton & cyanotoxins	
	H3: Enhance, maintain community and food web diversity supporting native fish	• None brought forward as priority to support	None identified
	H4: Reduce fish mor tality due to entrainment, scour, stranding	• None brought forward as priority to support	None identified
	H5: Enhance and maintain estuary, mainstem, tributary, lake and wetland habitats for all freshwater life stages and life histories of resident and anadromous fish	• Riparian condition • Stream habitat condition (physical)	• EPA - % Potentially Restorable Wetlands
 **Fluvial Geomorphic Processes (FG)** **5. Create and maintain spatially connected and diverse channel and floodplain morphologies**	FG1: Increase and maintain coarse sediment recruitment and transport	• Sediment transport	None identified
	FG2: Increase channel and floodplain dynamics and interconnectivity	• Geomorphic flushing flows • Channel complexity • Floodplain connectivity	• EPA - % Developed, High Intensity in HCZ (Hydrologically Connected Zone); • Net river-floodplain exchange in unconfined reaches
	FG3: Promote and expand establishment of diverse riparian and wetland vegetation that contributes to complex channel and floodplain morphologies	• Large wood recruitment and retention	• EPA - % Developed, High Intensity in RZ (riparian zone) • EPA - Density all roads in RZ (riparian zone)
 **Watershed Inputs (WI)** **6. Improve water quality, quantity, and ecological flow regimes**	WI1: Improve instream ecological flow regimes year-round for the Klamath River mainstem and tributary streams	• Instream flows	• Trout Unlimited - Water Quantity Sub-Index, • Trout Unlimited - Flow volume change risk II (base flow)
	WI2: Reduce anthropogenic fine sediment inputs while maintaining natural and beneficial fine sediment inputs	• Fine sediment loads	• USGS - Count of past placer mines in sub-watershed • EPA - PHWA Wildfire Vuln. Sub-index • EPA - Density all roads in Watershed
	WI3: Reduce external nutrient and pollutant inputs that contribute to bio-stimulatory conditions	• Nutrient loads	• Trout Unlimited - # Diversions per stream mile • EPA - % Agriculture in Watershed

IFRMP Plan Document, 2023, Table 2-2, Page 36 https://ifrmp.org/wp-content/uploads/2023/02/KlamathIFRMP_PlanDocument_20230212_FINAL2.pdf

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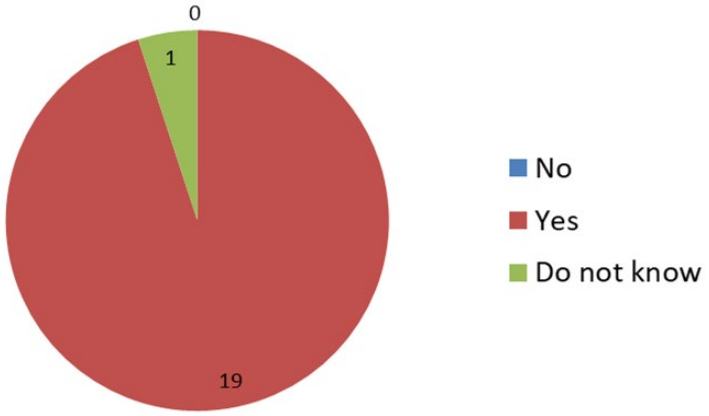
May 5-9, 2025
Monitoring Survey Results

Resource for group discussion

Monitoring gaps that should be addressed over the next five years



Biotic Interaction
- Prevalence of trematodes in the upper basin
- Prevalence, severity and distribution of disease in the above damn reaches / tributaries post anadromy

Fish Abundance/Recruitment/Production
- Spawning surveys and out-migrant trapping in key tributaries
- Estimate reach-specific, population-specific production (e.g., smolt trapping in Shasta River, Scott River, and mid-Klamath)

Fish Distribution/Habitat Use
- Access to private lands to understand where fish are going
- Temporal and spatial distributions and movements of fish across life stages
- Temporal and spatial distributions and movements of hatchery suckers
- Thermal refugia usage moving to the upper basin
- Mapping and understanding of thermal refugia

Fish Models
- Habitat based production models

Fish Repopulation
- Repopulation monitoring and fish passage, at reach-scale

Fish Use of Diversions
- Sucker and salmonid use of diversions in the Klamath Project to inform the need for screening of diversions in the Keno impoundment stretch
- Diversions in Shasta and Scott basins

Fluvial Geomorphology
- Bathymetric surveys
- Streambed characterization of tributaries, especially in reservoir reach
- Benthic monitoring throughout the basin
- Understanding effects of large wood on geomorphology

Water Quality
- Water temperature frequency/resolution
- Upslope land use and soil loss
- Riparian recovery
- Upper basin long-term tributary nutrient, sediment, turbidity
- Wetland/agriculture nutrients
- Assessment of progress towards TMDL goals
- Sediment and nutrients levels in the lower river and estuary through multiple years
- Relationship of nutrients to algal blooms

Watershed Inputs
- Hydrologic effects of fire
- Upper Klamath real-time sonde data
- Hydro-flow of springs in the Shasta River
- Upper basin tributary discharge

Misc Fish Monitoring
- Review and report the camera/trash rack data
- *O. mykiss* broadly
- Upper basin spring Chinook monitoring

Most Important Existing Monitoring that should continue to occur over next 5 years

Biotic Interaction
- Avian predation on suckers and salmonids based on PIT tags recovered from the upper basin rookeries
- Fish health monitoring for *C. shasta* and Ich

Fish Abundance, Recruitment, Productivity,
- -Monitoring endangered suckers (adults and juveniles) and shortnose sucker populations in the upper Klamath, Lost River, and Clear Lake
- Redband and steelhead base information and how it impacts mainstem flows
- Salmon juveniles-per-spawner to inform productivity

Fish Migration
- Scott and Shasta long term monitoring sites for adult migration and smolt outmigration
- Sonar at Iron Gate to detect adult migration upstream
- Smolt outmigration trapping in mainstem Klamath
- Timing of river entry, movement and habitat used from ocean to spawning grounds by adults including use of habitat/tributaries not used for spawning (e.g., temperature refugia)

Fish Spatial Structure, Age Structure, Diversity,
- Spatial structure and diversity of each species
- Age distribution of adults
- Spatial and diversity issues for juveniles and smolts from redds to rearing, to over-summering, to over-wintering

Fish Use of Diversion
- Diversion monitoring

Fluvial Geomorphology
- Bathymetry
- Accretion

Monitoring Infrastructure
- Maintain existing PIT tag infrastructure around the Upper Basin (e.g., Williamson River, Link River ladder, Pelican Bay, Shoreline Springs, and Hagelstein)

Water Quality
- Long-term water quality monitoring going including temperature, turbidity, pH, oxygen, and make it available in real-time
- Algal biomass
- Habitat monitoring (transition to benthic in addition to planktonic monitoring)
- Sediment concentration
- River reach metabolism studies in the mid and lower Klamath
- Temperature stratification in pools
- Toxins
- Add BGA and chlorophyll to sondes

Water Quantity/Flow
- Flow (discharge) gages
- Water deliveries to Reclamations Project and how it impacts mainstem flows

Watershed Inputs
- Nutrients throughout the basin
- Inflow/outflow nutrient throughout the basin
- Fire associated water quality
- Post-fire effects/recovery
- Sondes data
- Groundwater monitoring

Most important <u>new</u> monitoring that should occur over next 5 years

<u>Biotic Interaction</u>
- Monitor trematodes, a parasite of suckers, their snail hosts, in upper Klamath Lake and other waterbodies in the upper basin
- Disease monitoring and fish health in the upper basin

<u>Fish Abundance/Recruitment/Productivity</u>
- Tributary-, population-, and mainstem reach-specific smolt production
- Spawning surveys upstream of Iron Gate
- Tributary-, population-, and mainstem reach-specific spawning ground survey to inform escapement

<u>Fish Distribution/Habitat Use</u>
- Adult movement and numbers from ocean to confluence (TR and KR), confluence to spawning habitat
- Fish passage and connectivity
- Out-migrant trapping in key tributaries and reaches on the Klamath including around Copco
- Thermal refugia
- Fish passage at Link and Keno to understand how fish attempt to pass and the challenges

<u>Fish Use of Diversions</u>
- Diversion monitoring

<u>Fish Life History</u>
- Chinook life history monitoring (juvenile outmigration timing, size and survival and adult return timing and abundance, specific to each tributary)
- Coho life history monitoring
- Redband trout population and life history monitoring

<u>Fluvial Geomorphology</u>
- Increased resolution of accretion monitoring
- Bathymetry
- Understanding floodplain hydrology in reservoir footprints
- Classifying streams (intermittent/hydrology)
- Which streams are most resilient to drought and how to improve that

<u>Sucker Monitoring</u>
- Monitoring focused on Klamath Largescale suckers in the upper Klamath Basin
- Endangered sucker population monitoring (especially juveniles and larvae), identify cause of sucker recruitment problems
- Monitor the fate of hatchery-reared suckers when released into the wild
- Monitor existing sucker populations in Gerber Reservoir and other local water bodies (e.g., Lower Klamath Lake, Tule Lake, and Lost River)
- Use acoustic telemetry to monitor suckers in Clear Lake, Gerber, and other local water bodies with suckers

<u>Water Quality</u>
- Mainstem habitat monitoring post-dam removal (disease, sediment transport, water quality).
- Water quality around Keno and Lake Ewauna to understand potential migration barriers associated with warm temps and low DO
- Water temperature and quality monitoring
- Benthic monitoring
- SSC/turbidity curves
- Sediment characterization
- Riparian recovery
- Increase in spatial extent of sediment and nutrient monitoring in upper basin tributaries and wetlands.
- Monitor floodplain and riparian vegetation response to restoration
- Turbidity monitoring at key locations
- BGA and chlorophyll

Most important other monitoring that should be considered

Biotic Interaction
- Number and foraging habits of avian predators in the upper basin
- Invasive species detection and assessments including predation effects

Climate
- Climate patterns
- Snowmelt and groundwater dynamics relative to runoff

Fish Abundance/Recruitment/Productivity
- - Status and recovery of spring Chinook

Fish Distribution/Habitat Use
- Salmonid usage of upper Klamath and wetlands
- Habitat monitoring in Shasta and Trinity

Fish Spatial Structure / Age Structure / Diversity
- Basin-wide genetic evaluation

Fish Use of Diversion
- Stream diversion and use

Food Web
- Food web studies

Monitoring Infrastructure/Technology
- Telemetry and data collection above anadromy
- Expand LiDAR in tributaries

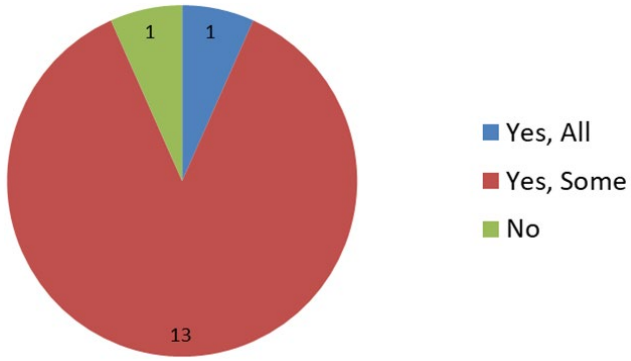
Sucker Monitoring
- Track suckers from year-1 to year-2, to year-3 to identify recruitment bottleneck

Water Quality
- Understand pHOS through the development of ocean fishery monitoring, SGS, smolt-production, and population-specific and cohort-specific
- Invertebrate
- Macroinvertebrate surveys
- Algal toxin
- Expand time frame into later season (e.g., cyanotoxins)

Watershed Inputs
- Nutrient changes in riparian and terrestrial parts of the basin, stable isotopes in terrestrial habitats
- Soil and water sampling at rain-on-fire and major landslide events
- Drone surveys as indicator for soil stability impacted by land management practices
- Soil moisture probes to inform connectivity duration of tributaries and groundwater levels
- Wood/riparian surveys
- Beaver surveys
- Landscape scale analyses using satellite data
- Gravel recruitment in former reservoir reaches
- Shade/vegetation mapping using first returns from LiDAR to understand impacts on surface water.
- Groundwater temp/level monitoring

May 2025 Survey Results
(small set of KBMP/KBFC respondents so not representative of our larger group)

Current Monitoring Activities: Would you modify any?



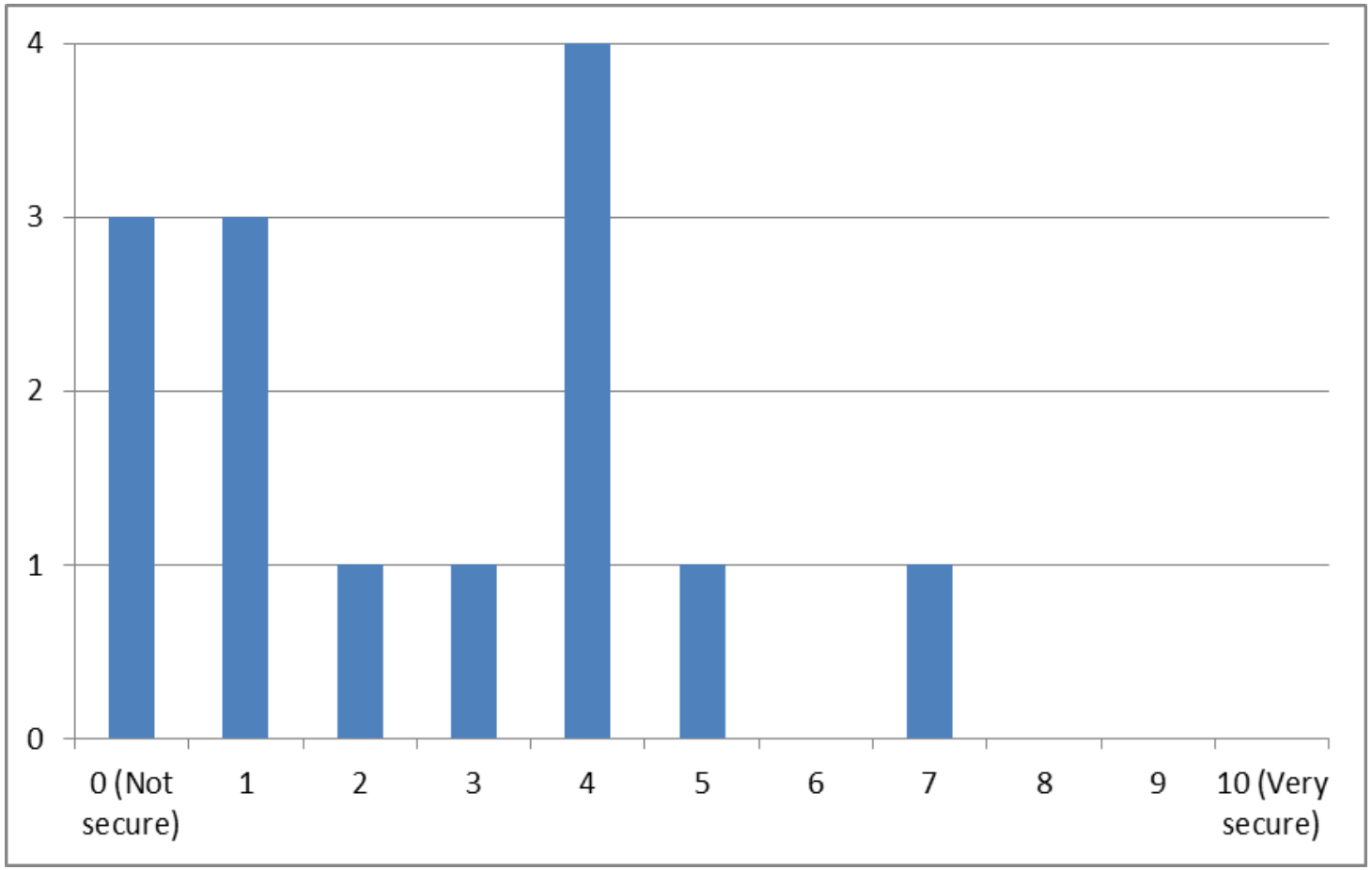
- Maintain existing monitoring while adding new objectives based on post-dam removal condition and fish repopulation upstream
- Design a monitoring plan based on hypothesized outcomes
- Assess monitoring needs for policy decisions
- Additional ARIS cameras for enumeration, complete bathymetric and accretion surveys
- Improve processes and support for QA/QC, managing, and sharing data, including coordinated interagency project site exchange to and learn from the efforts of others
- Increase community involvement, citizen science, education, and landowner relations to benefit access
- Expanded spatial distribution and temporal coverage
- Mainstem RST near CA/OR
- Additional PIT tagging and snorkel/redd surveys to focus water quality monitoring efforts
- Annual synthesis and timely reporting
- Additional benthic habitat monitoring
- Review/compare programs to ensure parameters, frequency, and methods align/differ

Any other information to share?

- Cannot rely on legacy data (i.e., prior to dam removal) to interpret current observations or inform forecasts
- Visit study areas
- Need for upper and lower basin communication with an ability to work across political borders and maintain information sharing to be adaptive
- Need accretion and bathymetry surveys
- Utilize new technologies to inform basin-scale management, while streamlining all protocols to facilitate comparisons

  Refine Scott/Shasta TMDLs to inform restoration, while identifying the proportion of TMDL objectives tied to contributing factors

Is current monitoring funding secure?



2 2024 IFRMP Monitoring Recommendations

Resource for group discussion

Watershed Inputs – Instream Flow

IFRMP Section 5.0: Recommended Monitoring Actions & Costs

Recommendations

- Expand network of streamflow gaging stations
- Track groundwater levels at monitoring wells

Existing Monitoring

- Streamflow gages provide spatial coverage across the basin
- Groundwater monitoring throughout the basin

Gaps/Needs

- Streamflow monitoring at tributary mouths and within fish population areas
- Real-time, publicly accessible, flow data
- Systematic/comprehensive groundwater monitoring

Recommendation	1-Year Cost	10-Year Cost
Streamflow stations (top priority sites)	$298,000	$3,091,000
Streamflow station (second priority sites)	$305,000	$2,774,000
Groundwater stations	$85,000	$192,000

Watershed Inputs - Nutrient Loads

IFRMP Section 5.0: Recommended Monitoring Actions & Costs

Recommendations

- Expand streamflow gaging stations
- Track groundwater levels at monitoring wells

Existing Monitoring

- Broad spatial coverage in the tributaries of the Upper Klamath River subbasins and the mainstem
- Focused locations in Scott, Shasta, and Trinity subbasins
- Nutrient concentration at individual sites assessed up to 12 times per year

Gaps/Needs

- Lack of data to understand how large precipitation events or flow management changes contribute nutrients to the system

Recommendation	1-Year Cost	10-Year Cost
Water samplers (top priority sites)	$685,000	$5,326,000
Water samplers (second priority sites)	$847,000	$5,395,000

Watershed Inputs - Fine Sediment Loads and Turbidity

IFRMP Section 5.0: Recommended Monitoring Actions & Costs

Recommendations

- Expand/maintain network of continuous sondes with real-time data transmission
- Standardize data collection and sharing across organizations

Existing Monitoring

- Longitudinal monitoring network from Keno to the estuary

Gaps/Needs

- Limited information in tributaries (e.g., Scott River, Sprague River, and Wood River)
- Event-based monitoring to better understand how large precipitation events contribute fine sediment to the system

Recommendation	1-Year Cost	10-Year Cost
Continuous sondes (top priority sites)	$594,000	$3,812,000
Continuous sondes (second priority sites)	$839,000	$3,571,000
Standardized data practices	Workshop (TBD)	Workshop (TBD)

(same recommendations as **Habitat - Water Temperature**)

Fluvial Geomorphology - Large Wood Recruitment and Retention

IFRMP Section 5.0: Recommended Monitoring Actions & Costs

Recommendations

- Measure current large wood concentrations with LiDAR
- Assess potential large wood supple with LiDAR tree height recommendations

Existing Monitoring

- Wood inventories associated with site-specific habitat assessments or individual restoration effectiveness monitoring

Gaps/Needs

- Consistent basin-wide monitoring approach is lacking
- Inventories need to be standardized
- Process-focused assessments
- Better understanding of natural and/or historic wood metrics

Recommendation	1-Year Cost	10-Year Cost
Measure current large wood concentrations	$1,161,000	$3,565,000
Assess potential large wood supply	$1,149,000	$3,539,000

Fluvial Geomorphology - Geomorphic Flushing/Scouring Flows
IFRMP Section 5.0: Recommended Monitoring Actions & Costs

Recommendations

- Characterize flushing flows with gage data and transport measurement calibrations

Existing Monitoring

- None identified

Gaps/Needs

- Build on existing work and expand flow monitoring stations

Recommendation	1-Year Cost	10-Year Cost
Characterize flushing flows with gage data	$7,000	$1,009,000

Fluvial Geomorphology - Floodplain Connectivity/Inundation

IFRMP Section 5.0: Recommended Monitoring Actions & Costs

Recommendations

- Map alluvial valleys with floodplains
- Monitor timing and duration of overbank flows from gage sites
- Map floodplain inundation extent from satellite imagery

Existing Monitoring

- Floodplain connectivity addressed through geomorphic studies of channel changes

Gaps/Needs

- Not monitored on a basin-wide scale
- Metrics that address the interface between channels and floodplains

Recommendation	1-Year Cost	10-Year Cost
Map alluvial valleys	$952,000	$1,189,000
Monitor timing of overbank flows	$20,000	$141,000
Map floodplain inundation extent	$26,000	$81,000

Fluvial Geomorphology - Channel Complexity

IFRMP Section 5.0: Recommended Monitoring Actions & Costs

Recommendations

- Assess basin-wide planform complexity from imagery
- Assess detailed topographic complexity in larger streams

Existing Monitoring

- None identified

Gaps/Needs

- Not monitored on a basin-wide scale
- Transferrable metrics to track adjustments to channel complexity over broad spatial and temporal scales

Recommendation	1-Year Cost	10-Year Cost
Assess basin-wide planform complexity	$32,000	$72,000
Assess topographic complexity in larger streams	$3,907,000	$12,197,000

Fluvial Geomorphology - Sediment Distributions

IFRMP Section 5.0: Recommended Monitoring Actions & Costs

Recommendations

- Map substrate sizes with air photos or bathymetric LiDAR

Existing Monitoring

- None identified

Gaps/Needs

- Standardized broad-scale sediment transport monitoring

Recommendation	1-Year Cost	10-Year Cost
Map substrate sizes (air photos method)	$423,000	$1,319,000
Map substrate sizes (bathymetric LiDAR method)	$3,915,000	$12,224,000

Habitat - Water Temperature

IFRMP Section 5.0: Recommended Monitoring Actions & Costs

Recommendations

- Maintain/expand the network of continuous sondes with real-time data transmission
- Standardize data collection and sharing across organizations

Existing Monitoring

- Over 100 monitoring sites located in all subbasins

Gaps/Needs

- Real-time assessments
- Better coordination regarding how data is collected, reported, and shared

Recommendation	1-Year Cost	10-Year Cost
Continuous sondes (top priority sites)	$594,000	$3,812,000
Continuous sondes (second priority sites)	$839,000	$3,571,000
Standardized data practices	Workshop (TBD)	Workshop (TBD)

(same recommendations as **Watershed Inputs - Fine Sediment Loads and Turbidity**)

Habitat - Water Chemistry (DO, pH, conductivity)

Recommended Monitoring Actions & Costs

Recommendations

- Maintain/expand the network of continuous sondes with real-time data transmission
- Standardize data collection and sharing across organizations

Existing Monitoring

- Most subbasins have a few monitoring sites
- Samples collected 1-12 times per year, except for the Scott River and Shasta River subbasins which have extensive monitoring

Gaps/Needs

- Continuous data and if possible real-time data to evaluate effects associated with events such as floods
- Better coordination among agencies collecting, reporting, and sharing data

Recommendation	1-Year Cost	10-Year Cost
Continuous sondes (top priority sites)	$594,000	$3,812,000
Continuous sondes (second priority sites)	$839,000	$3,571,000
Standardized data practices	Workshop (TBD)	Workshop (TBD)

Habitat - Thermal Refugia

Recommended Monitoring Actions & Costs

Recommendations

- Identify and map refugia across the basin
- Detailed monitoring of a subset of thermal refugia
- Assess utilization of thermal refugia
- Evaluate the relative proportion of flow and effects on mixing

Existing Monitoring

- Groundwater wells monitored in the Upper Klamath Basin

Gaps/Needs

- No coordinated basin-wide assessment
- Identify, classify, and map refugia at the basin scale
- Identify refugia on private lands
- Monitoring of a subset of refugia to better understand the seasonal variability and utilization of the refugia

Recommendation	1-Year Cost	10-Year Cost
Map basin-wide thermal refugia	$511,000	$1,595,000
Monitor subset of thermal refugia	$6,000	$68,000
Assess utilization of thermal refugia	$21,000	$256,000
Evaluate flow/mixing with hydraulic modeling	TBD	TBD

Habitat - Nuisance Phytoplankton and Associated Algal Toxins
Recommended Monitoring Actions & Costs

Recommendations

- Maintain/expand the existing monitoring network for evaluating levels of nuisance phytoplankton and associated algal toxins in the basin

Existing Monitoring

- Occurs throughout the basin
- Chlorophyll-a monitoring efforts implemented by the USGS in the Upper Klamath Lake
- Monitoring exists in the Trinity River and Lake Shastina

Gaps/Needs

- None identified

Recommendation	1-Year Cost	10-Year Cost
Indirect phytoplankton monitoring	$35,000	$1,431,000
Direct phytoplankton and toxin monitoring	$227,000	$2,198,000

Habitat - Stream Habitat Condition

Recommended Monitoring Actions & Costs

Recommendations

- Assess basin-wide stream habitat diversity from imagery, supplemented in key areas with detailed field-surveys
- Monitor aquatic invertebrate abundance and species composition

Existing Monitoring

- None identified

Gaps/Needs

- Broad-based assessment of the status of physical habitat structure and diversity

Recommendation	1-Year Cost	10-Year Cost
Assess basin-wide planform complexity	$32,000	$72,000
Assess topographic complexity in larger streams	$3,907,000	$12,197,000
Supplemental field surveys	$5,000	$64,000
Monitor aquatic invertebrates	Workshop (TBD)	Workshop (TBD)

Habitat - Riparian Condition

Recommended Monitoring Actions & Costs

Recommendations

- Implement remorse sensed methods for undertaking broad-scale evaluations of riparian structure and condition

Existing Monitoring

- Riparian condition is assessed for many fish habitat restoration projects across the basin as part of localized project effectiveness monitoring efforts
- Rate at which riparian vegetation complexity is being recovered at restored sites is assessed indirectly via Klamath Bird Observatory

Gaps/Needs

- No program/protocol to broadly assess riparian habitats across the basin

Recommendation	1-Year Cost	10-Year Cost
Topographic LiDAR assessment of vegetation	$1,166,000	$3,575,000
Supplemental field surveys	$5,000	$64,000
Imagery-based NDVI assessment of vegetation	$51,000	$161,000

Biotic Interactions - Disease
Recommended Monitoring Actions & Costs

Recommendations

- Expand existing monitoring network for *Ceratoonova shasta* and *Parvicapsula minibornis*
- Expand existing monitoring network for *Ichthyopthierius multifiliis* (Ich) and *Flavobacterium columnarae* (Columnaris)
- Develop approach for monitoring disease pathogens/parasites affecting endangered suckers

Existing Monitoring

- Collaborative monitoring *C. Shasta* and *P. minibicomis*

Gaps/Needs

- Gaps in monitoring coverage
- Current methods can be insensitive to early or light infections of Ich
- Direct evaluation of disease condition in suckers is logistically difficult

Recommendation	1-Year Cost	10-Year Cost
None provided		

Biotic Interactions - Invasive Aquatic Species

Recommended Monitoring Actions & Costs

Recommendations

- Establish eDNA sampling network for monitoring invasives

Existing Monitoring

- Localized surveys for invasive species, often research focused, and some incidental reporting derived from inadvertent captures of invasives during other fish monitoring efforts

Gaps/Needs

- No directed, systematic monitoring efforts that could provide information on changing distributions and/or abundance of invasive species across the basin

Recommendation	1-Year Cost	10-Year Cost
Establish eDNA network for invasives	$275,000	N/A

Fish Populations - Focal Species Population Indicators

Recommended Monitoring Actions & Costs

Recommendations

- Establish eDNA sampling network for monitoring distribution of focal species
- Support current initiatives in the basin focused on integrating and sharing information related to fish population indicators
- Support ongoing fish population monitoring efforts throughout the basin

Existing Monitoring

- Monitoring across basin by numerous entities
- Spatial and temporal distribution, presence of spawning and rearing

Gaps/Needs

- Ensure monitoring can track changes
- Sharing data across monitoring agencies at the basin-wide scale
- Chinook fishery management (e.g., age-structure escapement estimates)
- Establish a life-cycle monitoring site in the lower Klamath River mainstem

Recommendation	1-Year Cost	10-Year Cost
Establish eDNA network for focal species	$275,00	N/A
Support initiatives on fish population information sharing (PIT Tag Detection)	$8,589,000	$51,024,000
Support ongoing fish population monitoring efforts	$14,094,000	$180,426,000
Fill existing or upcoming gaps on life-cycle monitoring	Workshop (TBD)	Workshop (TBD)