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SUMMARY REPORT:

Environmental Flow Recommendations Workshop for the McKenzie River, Oregon

November 2010

MCKENZIE RIVER © LESLIE BACH/TNC

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Cover: The lower McKenzie River (Photograph by Leslie Bach, The Nature Conservancy)

Summary Report: Environmental Flows Workshop for the McKenzie River, Oregon

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Contents

Figures

Tables

Summary Report: Environmental Flows Workshop for the McKenzie River, Oregon

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Introduction

Background

The Sustainable Rivers Project (SRP) began in 2002 as a partnership between The Nature Conservancy (the Conservancy) and the U.S. Army Corps of Engineers (USACE) aimed at developing, implementing, and refining a framework of environmental flows downstream of dams. The goal of the Sustainable Rivers Project is to identify opportunities to change dam operations to provide more ecologically sustainable flows, while at the same time meeting human needs and congressionally authorized purposes. The environmental flow framework is often developed through an iterative process that includes scientific assessment and expert input to develop the flow recommendations. These flow recommendations are then evaluated by dam operators for feasibility, implemented where possible, and monitored by scientists to evaluate their effect on the river ecosystem and dam operations. (Tharne, 2003; Acreman and Dunbar, 2004; Richter et al., 2006; The Nature Conservancy, 2009). Because the initial flow recommendations are often based on incomplete knowledge of the key flow–ecology relationships, the recommendations are implemented on a trial basis to test hypotheses and reduce uncertainties. Monitoring and adaptive management is a critical aspect of the environmental flow recommendations framework.

In 2006, The Nature Conservancy and USACE launched the Willamette Sustainable Rivers Project. A summary report on the flow requirements of key Willamette species and communities was completed in 2007 (Gregory et al., 2007a), followed by a flow recommendations workshop focusing on the Coast and Middle Forks of the Willamette River. The outcome of the workshop was a set of environmental flow recommendations for the Middle Fork Willamette River below Lookout Point/Dexter dams (Gregory et al., 2007b), with initial implementation of the recommendations occurring in 2008 through 2010. In 2008 the Conservancy, USACE, the Eugene Water & Electric Board (EWEB) and the U.S. Geological Survey (USGS) began an environmental flow study for the McKenzie River, a major tributary of the Willamette with both USACE and EWEB dams.

McKenzie River

There are several water management projects on the McKenzie River (fig. 1), including EWEB’s Carmen-Smith-Trail Bridge hydropower dams, USACE’s Blue River and Cougar multipurpose dams, and EWEB’s Leaburg and Walterville power diversions and canals. To assist scientists in developing environmental flow recommendations, the USGS completed a summary report on the hydrology, geomorphology, and ecology in the McKenzie River basin (Risley et al., 2010). The report also evaluated how the streamflow and geomorphology of the river have been altered by USACE and EWEB dams and canals over the past 50 years and described the types of flows that are needed to sustain key ecosystem processes.

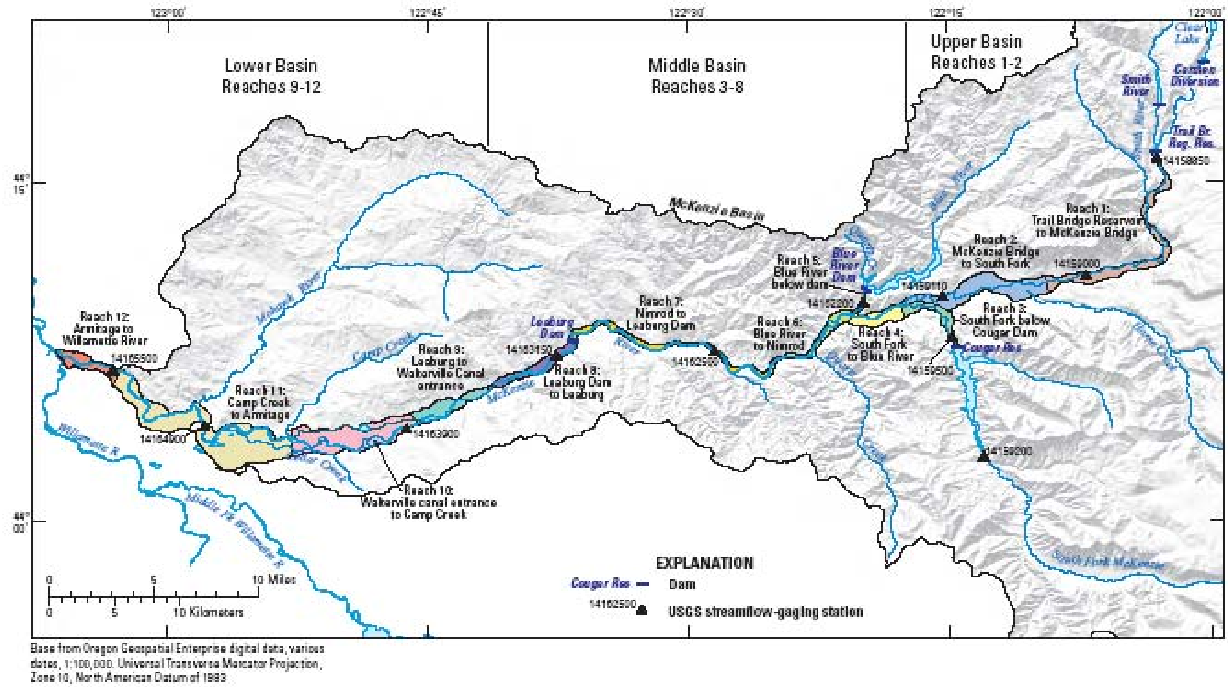

Figure 1. Map of the McKenzie River basin, showing study reaches.

For the study, the McKenzie River study area was divided into 12 reaches based on geomorphic homogeneity between Trail Bridge Dam and the Willamette River confluence (fig. 1). Reaches 3 and 5 are the portions of the South Fork McKenzie and Blue Rivers below the Cougar and Blue River dams, respectively.

Workshop

Agenda

After McKenzie River stakeholders reviewed the USGS report (Risley et al., 2010), the Conservancy held a flow recommendations workshop (March 10–11, 2010) at EWEB headquarters in Eugene, Oregon (Appendix A). Over 50 persons, from universities, State, Federal, and local government agencies, attended (Appendix B). For the workshop, the 12 reaches were aggregated into 4 main sections: South Fork McKenzie River (reach 3), Middle McKenzie River (reaches 4–7), McKenzie River through EWEB canal reaches (reaches 8–10), and Lower McKenzie River (reaches 11–12). Flow recommendations for the upper McKenzie River, above the South Fork McKenzie River, were not covered in the workshop, as flows have not significantly changed from historic conditions in this reach. After introductions and technical presentations from the USGS, the attendees were broken into four breakout groups. The groups were formed from a mix of experts representing all major disciplines, including fisheries and aquatic biota, hydrology, geomorphology and riparian/floodplain ecology. Each group was assigned a reach and asked to develop a full range of flow recommendations that could meet the needs of aquatic species, channel morphology, and riparian and floodplain processes (table 1). If time permitted, the groups were also asked to develop flow recommendations for additional reaches. The breakout groups met on both days. However, because there were fewer attendees on the second day, group 1 was merged with group 4.

Table 1. River reach assignments for the workshop breakout groups.

Group	March 10, 2010	March 11, 2010
1	South Fork McKenzie River (Reach 3)	(merged with group 4)
2	Middle McKenzie River (Reaches 4–7)	EWEB canal reaches (Reaches 8–10) South Fork McKenzie River (Reach 3)
3	EWEB canal reaches (Reaches 8–10)	Middle McKenzie River (Reaches 4–7) Lower McKenzie River (Reaches 11–12)
4	Lower McKenzie River (Reaches 11–12) South Fork McKenzie River (Reach 3)	South Fork McKenzie River (Reach 3)

Each breakout group was provided with a facilitator, a note keeper, and a person who operated a visual computer software program called the Regime Prescription Tool (RPT). Developed by USACE and the Conservancy, RPT allows a workshop audience to easily view hydrologic information and create flow recommendations during discussions (*http://www.hec.usace.army.mil/software/hec-rpt/*) . As a visual tool, RPT can create a synthetic annual hydrograph for a reach. Individual flow recommendations can be added (or deleted), and their magnitudes and durations can also be easily adjusted.

To provide the breakout groups with a range of potential streamflows that could be expected at a reach location, estimated and observed regulated and unregulated daily-mean streamflow data for the period from 1936 to 2004 (Risley et al., 2010), for all 12 study river reaches were loaded into RPT prior to the workshop. Each water year in the time series was also predefined as wet, average, dry, critical, or none based on an analysis of the streamflow record from the USGS gage near Vida, Oregon. The groups were also given a table of streamflow statistics specific to the four workshop reaches (table 2). These statistics included bankfull flow, small and large floods, annual 7-day 10-year (7Q10) low flow, and the average September and October flows. The statistics are based on estimated and observed unregulated daily-mean streamflow data (1936–2004) collected at USGS streamflow gages located within of each workshop reach. With the exception of bankfull flows, the statistics were computed using the Nature Conservancy's Indicator of Hydrologic Alteration (IHA) software. It should be noted that the flood statistics in table 2 were not computed using annual peak flow data since the IHA software only used daily-mean streamflow data. Annual peak flow data would have yielded higher flood statistic values.

Table 2. McKenzie River streamflow statistics for the four workshop study reaches based on estimated and observed unregulated daily-mean streamflow data from 1936 to 2004.

[Bankfull flow estimates are from table 7 in Risley et al., 2010. Other statistics were computed using the Nature Conservancy's Indicator of Hydrologic Alteration software and streamflow data compiled in Risley et al. (2010). Flood estimates in this table are based on daily streamflow data and are different from flood estimates in table 12 of Risley et al. (2010) which are based on annual peak flow data and different time periods.]

Workshop reach	USGS streamflow station	Bank-full flow (cfs)	1.5-year return period (cfs)	2-year return period (cfs)	10-year return period (cfs)	Low flow 7Q10 (cfs)	Mean Sept (cfs)	Mean Oct. (cfs)
South Fork McKenzie River (Reach 3)	14159500	5,000	6,189	7,131	12,940	240	259	276
Middle McKenzie River (Reaches 4–7)	14162500	20,000	24,640	28,090	45,910	1,555	1,710	1,753
EWEB canal reaches (Reaches 8–10)	14163150	22,500	27,460	31,640	52,480	1,745	1,928	1,975
	14163900	22,500	28,320	32,620	54,110	1,799	1,988	2,036
Lower McKenzie River (Reaches 11–12)	14165500	25,000	34,420	39,660	65,770	2,187	2,416	2,475

Following the workgroup sessions on the second day, all attendees participated in a plenary session. Using the RPT software, the flow recommendations from groups that worked on similar study reaches were then unified into a single set of recommendations for each reach. For this report some additional refinements were made to the recommendations to reduce redundancy within a reach. The timing of recommended flow events that were common in all the reaches was also synchronized.

Results

South Fork McKenzie River

The South Fork McKenzie River reach extends 4.5 miles from Cougar Dam to the McKenzie River confluence. The steep and narrow reach has stable pool–riffle morphology, except near the confluence with the McKenzie, which was historically dynamic. Flow recommendations and ecology linkages for this reach are shown in figures 2 and 3 and described below.

Fall flows for channel habitat maintenance and fish outmigration

Recommendation:

Period:	October 15 to November 30
Events per year:	2 to 3
Magnitude range:	1,500 to 4,700 cfs
Duration:	<5 days
Frequency:	Annually for smaller flows, once every 3 years for near bankfull flow

Ecosystem objective:

Fall flows are needed to wet side channels and maintain habitat for aquatic species. These flows will also allow for the regular evacuation of water from Cougar Reservoir in a manner that will minimize dewatering and stranding of juvenile fish. The flows will mimic moderate flow events that naturally occurred early in the rainy season. Chinook juveniles that spend the summer in the reach will be assisted by these flows in their downstream migration to the ocean. The magnitude of smaller flows should be at or above spawning flows yet below bankfull flow to avoid scouring and destroying redds. The magnitude of the larger flow should still be below bankfull. All the fall flow events should have a gradual ramped decrease. It will be necessary to closely monitor the flows to determine impacts and benefits to both redds and juvenile fish and to adjust their magnitude and duration accordingly.

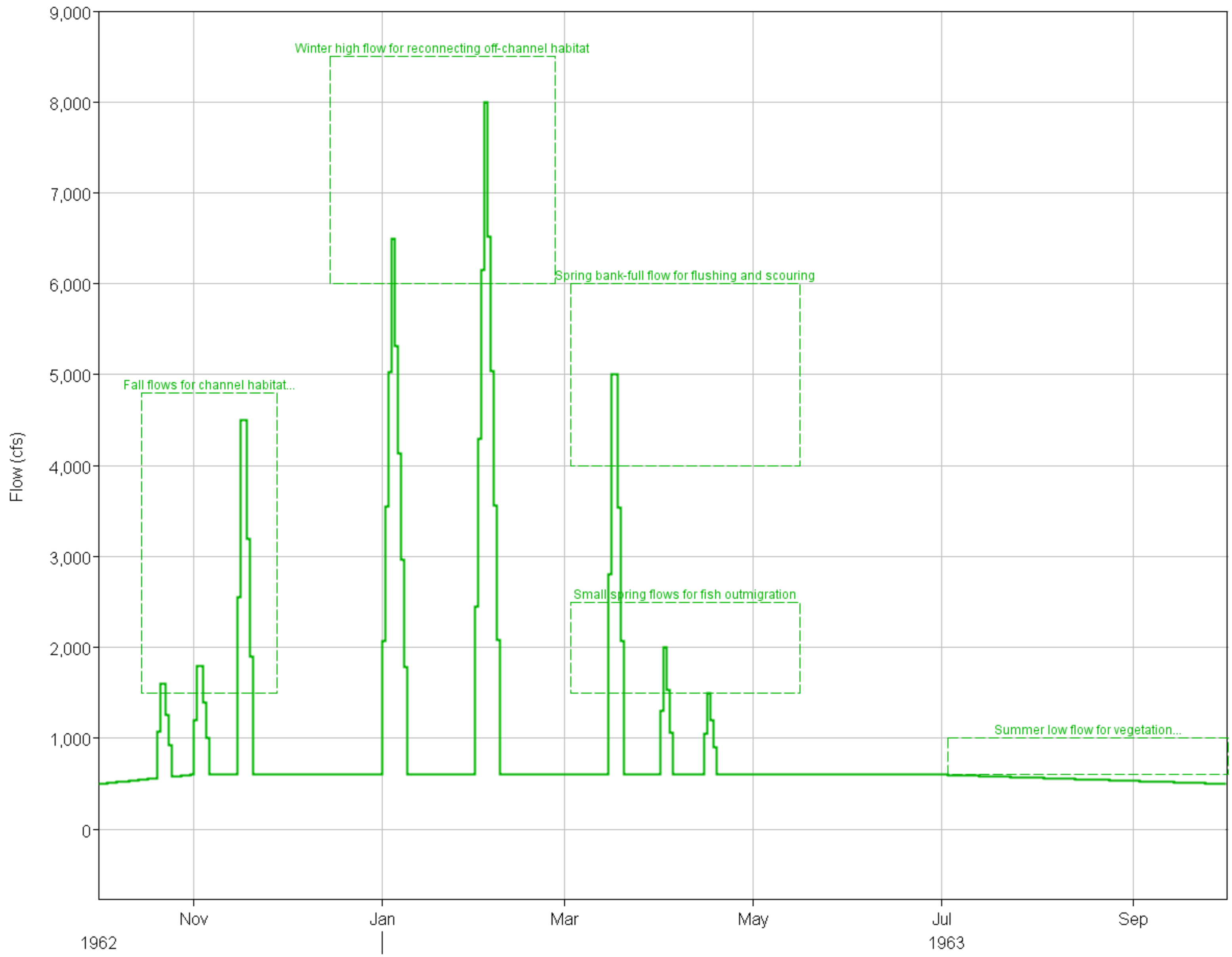

Figure 2. RPT generated plot of flow recommendations for the South Fork McKenzie River (Reach 3).

Winter high flow for reconnecting off-channel habitat

Recommendation:

Time period:	December 15 to February 28
Events per year:	1
Magnitude range:	6,000 to 8,000 cfs
Duration:	<5 days
Frequency:	Once every 2 years or less frequently

Ecosystem objective:

Small floods have been eliminated from the ecosystem in the post-dam period. These floods are important for connecting and wetting side channels, opening up new habitat, gravel movement, and flushing sediment and wood into side channels. Newly connected side channels will provide spawning and rearing habitat for spring Chinook. Resident trout, macroinvertebrates, and other species will also benefit by increased habitat diversity and clean, unarmored substrates. These high flows should be planned in conjunction with possible gravel augmentation efforts to maximize benefits. Although winter high flows can result in some impacts to fish, these flows were part of the natural system. The recommended frequency for these flows is once every 2 years or longer, to minimize impacts to the population.

Small spring flows for fish outmigration

Recommendation:

Time period:	March 1 to May 15
Events per year:	1 to 2
Magnitude range:	1,500 to 2,000 cfs
Duration:	< 5 days
Frequency:	Annually

Ecosystem objective:

These below bankfull spring flows will provide flows for the downstream migration of juvenile salmon and smolts. These flows will also make side-channel and alcove habitats available to fish during the migration period.

Spring bankfull flow for flushing and scouring

Recommendation:

Time period:	March 1 to May 15
Events per year:	1
Magnitude range:	4,000 to 6,000 cfs
Duration:	<5 days
Frequency:	Once every 3 years

Ecosystem objective:

In addition to assisting fish outmigration, a spring bankfull flow is needed (in the lower reaches more than in reach 3) once every 3 years for flushing, gravel sorting, and gravel bar development. Cleansing gravel beds of fine sediments is needed for spawning. This flow will also disperse cottonwood seeds and establish seedlings. The recommended frequency is based on the historic hydrograph and professional knowledge.

Summer low flow for vegetation development and fish rearing

Recommendation:

Time period:	July 1 to October 31
Magnitude range:	500 to 600 cfs
Duration:	Gradual decrease from July 1 to September 30 Ramped increase from October 1 to October 31
Frequency:	Annually

Ecosystem objective:

Gradual recession in the summer is needed to facilitate cottonwood and alder root growth development. Minimum flow in the summer is also essential for spring Chinook rearing. During October, flows should be gradually ramped up during and after spawning.

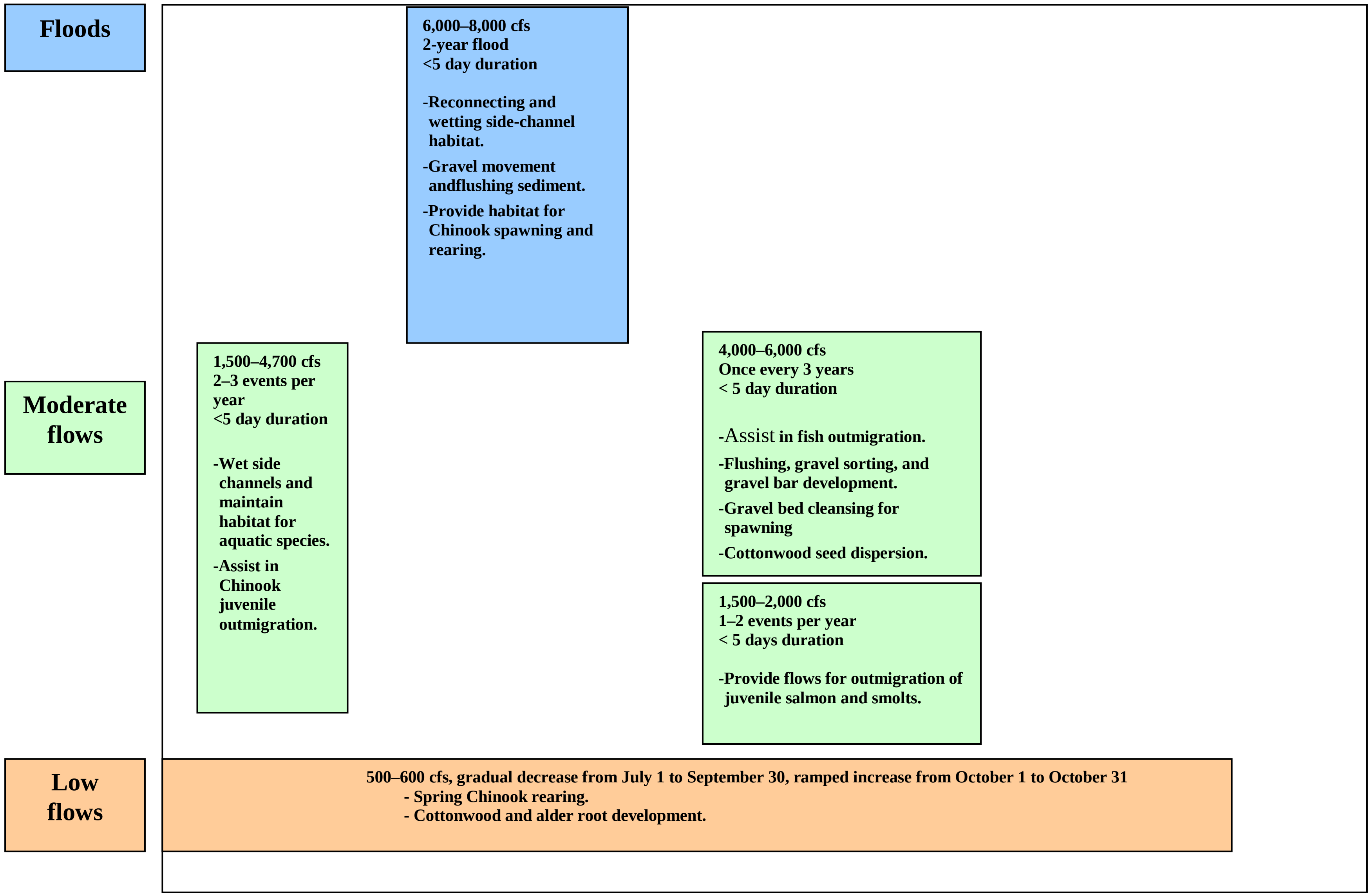

Figure 3. Dam flow release and ecology linkages for the South Fork McKenzie River (Reach 3)

Middle McKenzie River

The Middle McKenzie River reach extends 22 miles from the South Fork confluence to the Leaburg canal diversion dam. Much of this section, though not all of it, is characterized by highly confined channels with few gravel bars or side channels. Flow recommendations and ecology linkages for this reach are shown in figures 4 and 5 and described below.

Fall flows to protect Chinook redds and benefit fish outmigration

Recommendation:

Time period:	October 15 to November 30
Events per year:	2 to 3
Magnitude range:	5,500 to 19,000 cfs, should follow the natural hydrograph
Duration:	<5 days
Frequency:	Annually for smaller flows, once every 3 years for the larger near bankfull flow.

Ecosystem objective:

After the spring Chinook salmon spawning period (from approximately September 1 to October 15), sufficient flows are needed to prevent dewatering and stranding of redds. A near bankfull flow is needed in the fall once every 3 years for channel flushing, gravel movement and sorting, and vegetation scouring. The flows will mimic the magnitude and frequency of moderate flow events that naturally occurred early in the rainy season. Chinook juveniles that spend the summer in the reach will be assisted by these flows in their downstream migration to the ocean. The magnitude of smaller flows should be at or above spawning flows yet below bankfull flow to avoid scouring and destroying redds. The magnitude of the larger flow should still be below bankfull. All the fall flow events should have a gradual ramped decrease. Due to reservoir operation and potential harm to redds, flow releases will need to be initially monitored and adjusted before they become a permanent recommendation.

Winter bankfull flow for off-channel habitat maintenance and fish outmigration

Recommendation:

Time period:	Dec 15 to March 31
Events per year:	1
Magnitude range:	19,000 to 21,000 cfs
Duration:	<5 days
Frequency:	Once every year

Ecosystem objective:

This flow will assist in fish outmigration, as well as provide for flushing, gravel sorting, and gravel bar development. Cleansing gravel beds of fine sediments is needed for spawning. Bankfull flows will reconnect side-channel and floodplain habitat and provide off-channel rearing for juvenile salmonids.

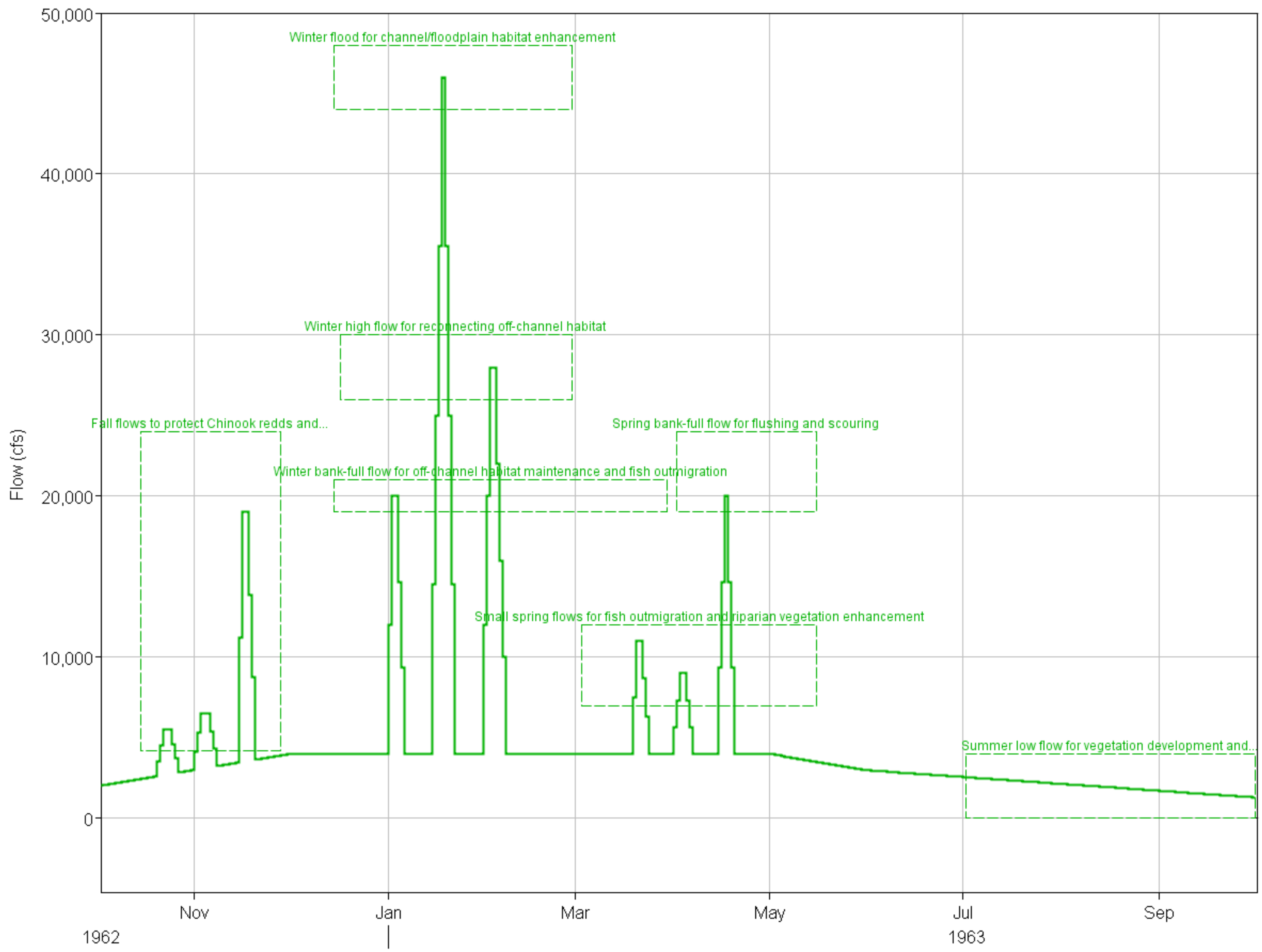

Figure 4. RPT generated plot of flow recommendations for the Middle McKenzie River (Reaches 4–7)

Winter high flow for reconnecting off-channel habitat

Recommendation:

Time period:	December 15 to February 28
Events per year:	1
Magnitude range:	26,000 to 30,000 cfs
Duration:	<5 days
Frequency:	Once every 5 years

Ecosystem objective:

Small floods have been lost from the ecosystem in the post-dam period. These floods are important for connecting and wetting side channels, opening up new habitat, creating channel complexity, moving gravel, and flushing sediment and wood into side channels. Newly connected side channels will provide spawning and rearing habitat for spring Chinook. Resident trout, macroinvertebrates, and other species will also benefit by increased habitat diversity and clean, unarmored substrates.

Winter flood for channel/floodplain habitat enhancement

Recommendation:

Time period:	December 15 to February 28
Events per year:	1
Magnitude range:	46,000 cfs or greater
Duration:	Based on upstream inflow conditions
Frequency:	Once every 10 years

Ecosystem objective:

A large flood every 10 years will increase channel complexity by enhancing pool and off-channel development. It will also help in large woody debris recruitment and gravel movement. Although a 10-year flood will typically not alter the floodplain, flood waters will spill over into the floodplain and rejuvenate it with fresh sediment deposits. This magnitude flow will also reconnect low elevation side channels.

Small spring flows for juvenile fish outmigration and riparian vegetation enhancement

Recommendation:

Time period:	March 1 to May 15
Events per year:	1 to 2
Magnitude range:	9,000 to 11,000 cfs
Duration:	<5 days
Frequency:	Annually

Ecosystem objective:

These below bankfull spring flows will provide flows for the downstream migration of juvenile salmon and smolts. These flows will also make side-channel and alcove habitats available to fish during the migration period. Recession rates should be designed to enhance riparian vegetation establishment.

Spring bankfull flow for flushing and scouring

Recommendation:

Time period:	April 1 to May 15
Events per year:	1
Magnitude range:	19,000 to 21,000 cfs
Duration:	<5 days
Frequency:	Once every 3 years

Ecosystem objective:

In addition to assisting fish outmigration, a spring bankfull flow is needed once every 3 years for flushing, gravel sorting, and gravel bar development. Cleansing gravel beds of fine sediments is needed for spawning. This flow will also disperse cottonwood seeds and establish seedlings.

Summer low flow for vegetation development and fish rearing

Recommendation:

Time period:	July 1 to October 31
Magnitude range:	2,000 to 3,000 cfs
Duration:	Gradual decrease from June 1 to September 30 Ramped increase from October 1 to October 31
Frequency:	Annually

Ecosystem objective:

Gradual recession in the summer is needed to facilitate cottonwood and alder root growth development. Minimum flow in the summer is also essential for spring Chinook rearing. During October, flows should be gradually ramped up during and after spawning.

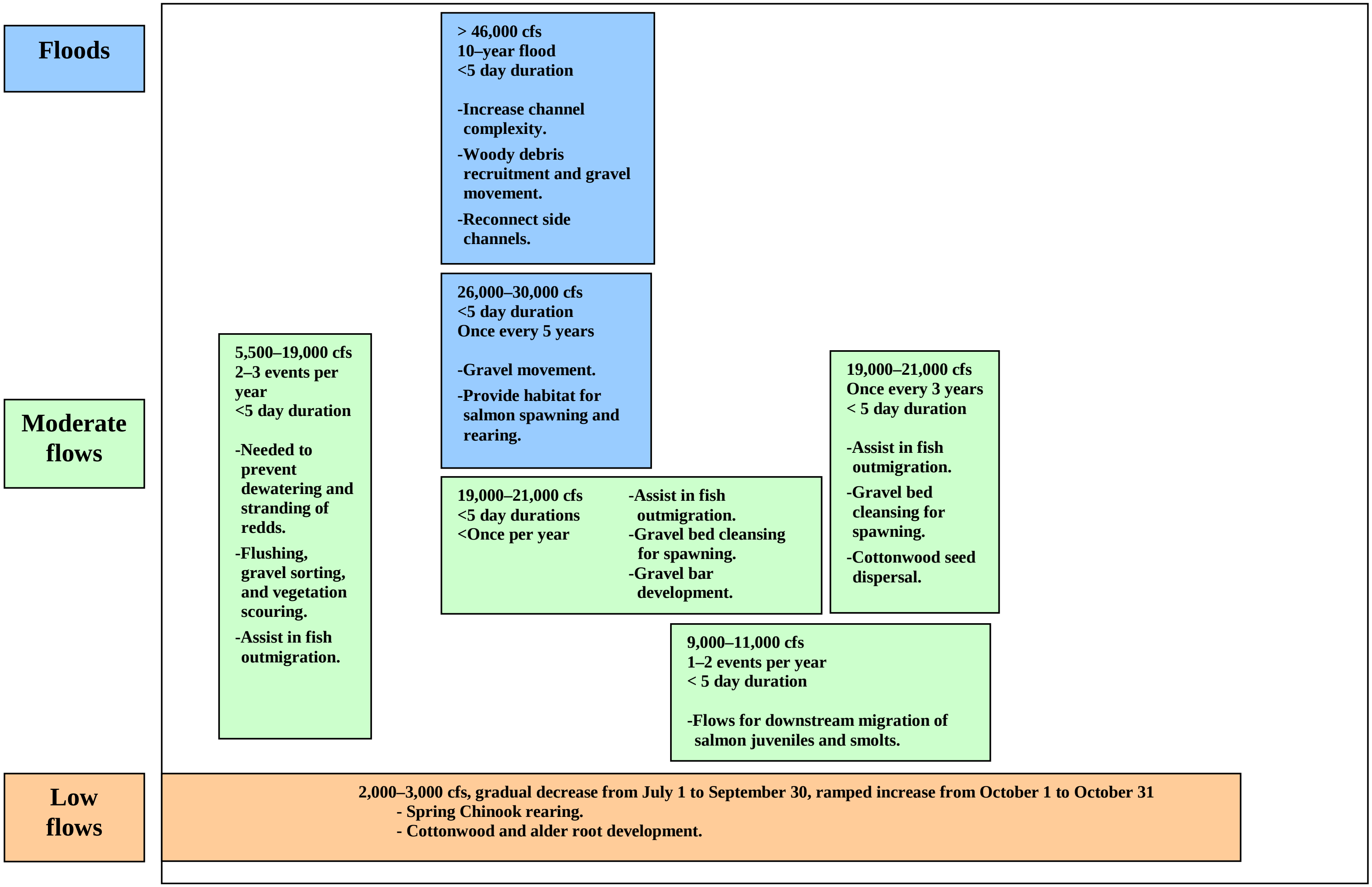

Figure 5. Dam flow release and ecology linkages for the Middle McKenzie River (Reaches 4–7)

McKenzie River through EWEB canal reaches

The EWEB canal reaches extend for 18.3 miles from Leaburg diversion dam to the Camp Creek confluence. The Leaburg Canal portion has narrow confined channel with stable pool–riffle morphology. However, the Walterville Canal portion opens to a wide unconfined floodplain with numerous multithread bends and gravel bars. Flow recommendations and ecology linkages for this reach are shown in figures 6 and 7 and described below.

Fall flows to protect Chinook redds and benefit fish outmigration

Recommendation:

Time period:	October 15 to November 30
Events per year:	2 to 3
Magnitude range:	6,000 to 20,000 cfs
Duration:	<5 days
Frequency:	Annually for smaller flows, once every 3 years for the larger near bankfull flow flow.

Ecosystem objective:

After the spring Chinook salmon spawning period (from approximately September 1 to October 15), below bankfull flows are needed to prevent dewatering and stranding of redds. A near bankfull flow is needed in the fall once every 3 years for channel flushing, gravel movement and sorting, and vegetation scouring. The flows will mimic moderate flow events that naturally occurred early in the rainy season. Chinook juveniles that spend the summer in the reach will be assisted by these flows in their downstream migration to the ocean. The magnitude of smaller flows should be at or above spawning flows yet below bankfull flow to avoid scouring and destroying redds. The magnitude of the larger flow should still be below bankfull. All the fall flow events should have a gradual ramped decrease. Due to reservoir operation and potential harm to redds, flow releases will need to be initially monitored and adjusted before they become a permanent recommendation.

Winter bankfull flow for gravel movement

Recommendation:

Time period:	December 15 to March 31
Events per year:	1
Magnitude range:	22,000 to 24,000 cfs, should follow the natural hydrograph
Duration:	<5 days
Frequency:	Once every year

Ecosystem objective:

This flow is needed to mobilize gravels and flush out fine sediments. This will provide bare surfaces and areas of silt deposition which is beneficial for lamprey. It is possible that this flow recommendation could be created by closing the Leaburg and Walterville canal entrances during a winter storm event. That way this event could be created without making specific Blue River and Cougar Dam flow releases. A flow of this magnitude will also inundate low elevation side channels.

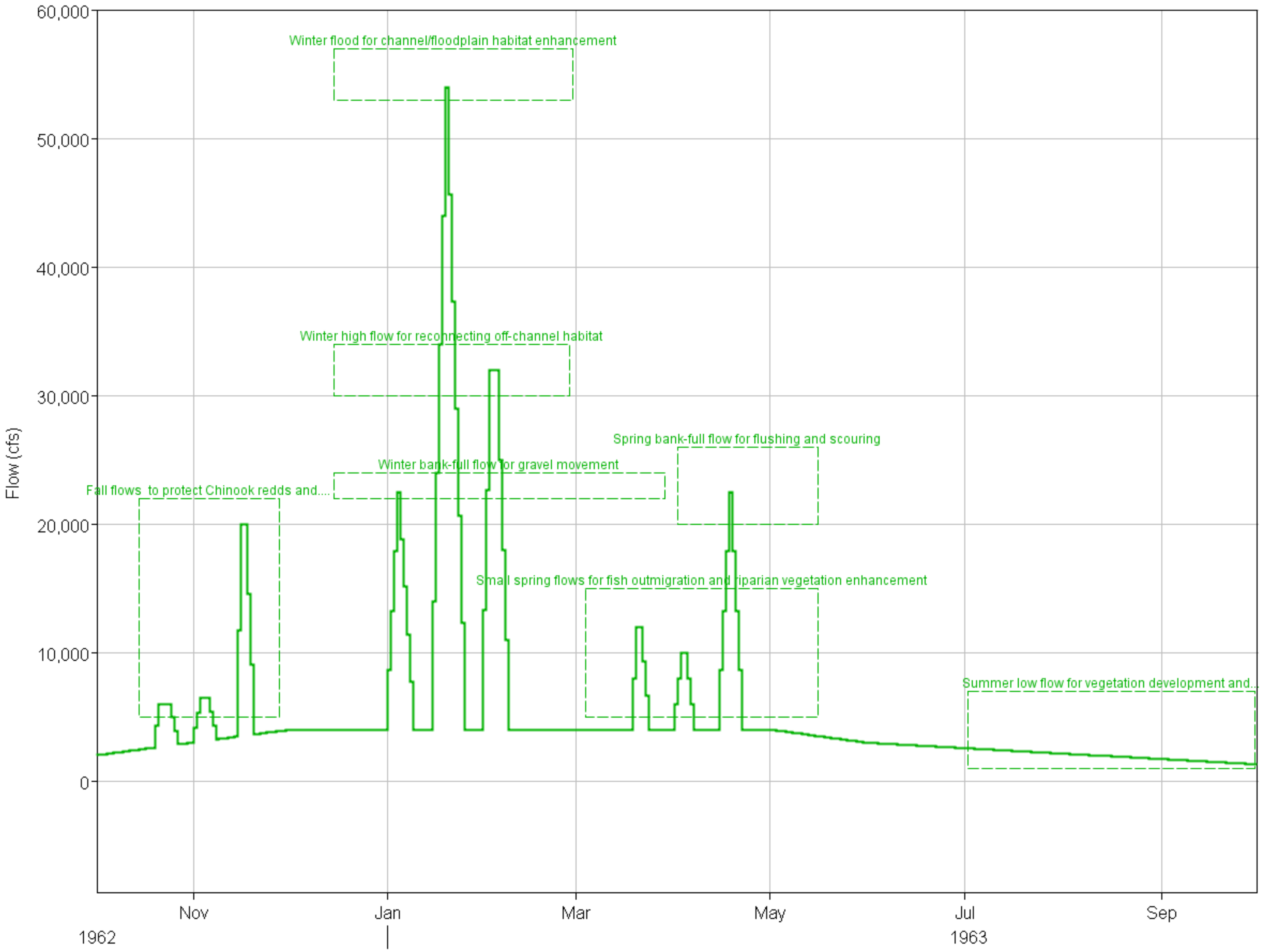

Figure 6. RPT generated plot of flow recommendations for the EWEB canal reaches (Reaches 8–10)

Winter high flow for reconnecting off-channel habitat

Recommendation:

Time period:	December 15 to February 28
Events per year:	1
Magnitude range:	30,000 to 34,000 cfs
Duration:	<5 days
Frequency:	Once every 5 years

Ecosystem objective:

Small floods have been lost from the ecosystem in the post-dam period. These floods are important for connecting and wetting side channels, opening up new habitat, gravel movement, and flushing sediment and wood into side channels. Newly connected side channels will provide spawning and rearing habitat for spring Chinook. Resident trout, macroinvertebrates, and other species will also benefit by increased habitat diversity and clean, unarmored substrates. This flow is also needed to mobilize gravels and flush out fine sediments. This will provide bare surfaces and silt bar formation which is beneficial for lamprey. A flow of this magnitude will also inundate low elevation side channels. Although specific flow releases from Blue River and Cougar Dam would be needed to create this flow on a 1 to 3 year interval, a 5,000 cfs portion of the flow could be provided by closing the Leaburg and Walterville canal entrances during the event.

Winter flood for channel/floodplain habitat enhancement

Recommendation:

Time period:	December 15 to February 28
Events per year:	1
Magnitude range:	54,000 cfs or greater
Duration:	Based on upstream inflow conditions
Frequency:	Once every 10 years

Ecosystem objective:

A large flood every 10 years will increase channel complexity by enhancing pool and off-channel development. It will also help in large woody debris recruitment and gravel movement as bank erosion will introduce new wood and gravel to the system. Although a 10-year flood will typically not alter the floodplain, flood waters will spill over into the floodplain and rejuvenate it with fresh sediment deposits.

Small spring flows for fish outmigration and riparian vegetation enhancement

Recommendation:

Time period:	March 1 to May 15
Events per year:	1 to 2
Magnitude range:	10,000 to 12,000 cfs
Duration:	<5 days
Frequency:	Annually

Ecosystem objective:

These below bankfull spring flows will provide flows for the downstream migration of juvenile salmon and smolts. These flows will also make side-channel and alcove habitats available to fish during the migration period.

Spring bankfull flow for flushing and scouring

Recommendation:

Time period:	April 1 to May 15
Events per year:	1
Magnitude range:	22,000 to 24,000 cfs
Duration:	<5 days
Frequency:	Once every 3 years

Ecosystem objective:

In addition to assisting fish outmigration, a spring bankfull flow is needed once every 3 years for flushing, gravel sorting, and gravel bar development. Cleansing gravel beds of fine sediments is needed for spawning. This flow will also disperse cottonwood seeds and establish seedlings.

Summer low flow for vegetation development and fish rearing

Recommendation:

Minimum flow in the river:	1,500 cfs
Time period:	July 1 to September 30

Ecosystem objective:

A minimum flow during the summer is also essential for spring Chinook rearing and cottonwood and alder root growth development. Under the current Federal Energy Regulatory Commission (FERC) license, EWEB is permitted to divert up to 2,500 cfs into the Leaburg and Walterville canals as long as a minimum of 1,000 cfs of flow is kept in the river. However, under more natural flow conditions (without the canals and upstream reservoirs) the minimum summer flows in Reaches 8–10 would be higher than 1,000 cfs as seen in figures 16 and 17 in Risley et al. (2010). In this flow recommendation the minimum flow in the river will be raised to 1,500 cfs during the summer months. However, the maximum diversion limit will remain at 2,500 cfs.

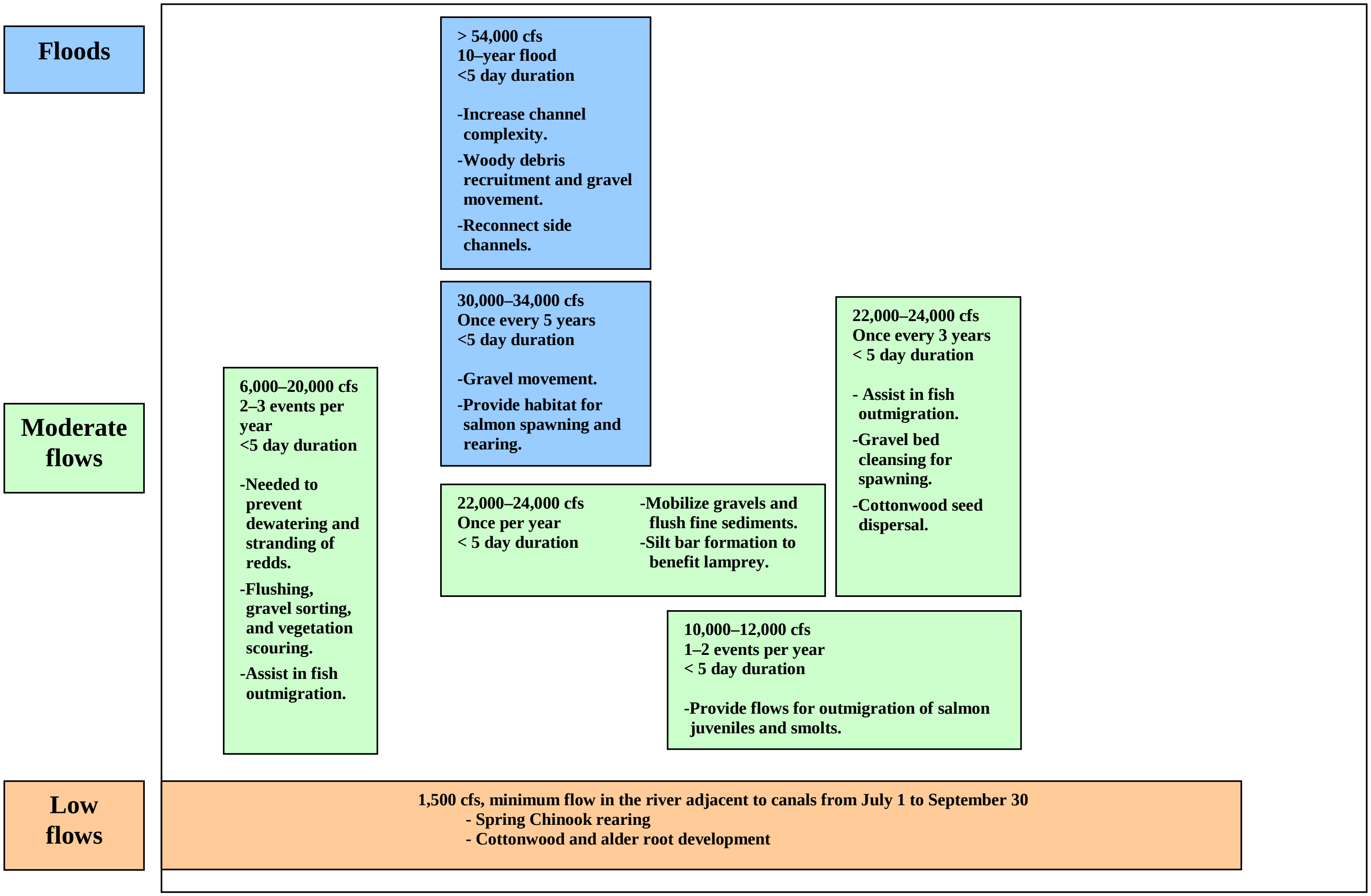

Figure 7. Dam flow release and ecology linkages for the EWEB canal reaches (Reaches 8–10)

Lower McKenzie River

The lower McKenzie River reach extends from Camp Creek 20.7 miles to the Willamette River confluence. This section is of the river is characterized as wide unconfined floodplain, which becomes more alluvial near the Willamette River confluence. Flow recommendations and ecology linkages for this reach are shown in figures 8 and 9 and described below.

Fall flows to protect Chinook redds and benefit fish outmigration

Recommendation:

Time period:	October 15 to November 30
Events per year:	2 to 3
Magnitude range:	7,500 to 24,000 cfs
Duration:	<5 days
Frequency:	Annually for smaller flows, once every 3 years for the larger near bankfull flow.

Ecosystem objective:

After the spring Chinook salmon spawning period (from approximately September 1 to October 15), below bankfull flows are needed to prevent dewatering and stranding of redds and emerging fry. A near bankfull flow is needed in the fall once every 3 years for channel flushing, gravel movement and sorting, and vegetation scouring. The flows will mimic moderate flow events that naturally occurred early in the rainy season. Chinook juveniles that spend the summer in the reach will be assisted by these flows in their downstream migration to the ocean. The magnitude of smaller flows should be at or above spawning flows yet below bankfull flow to avoid scouring and destroying redds. The magnitude of the larger flow should still be below bankfull. All the fall flow events should have a gradual ramped decrease. Due to reservoir operation and potential harm to redds, flow releases will need to be initially monitored and adjusted before they become a permanent recommendation.

Winter bankfull flow

Recommendation:

Time period:	December 15 to March 31
Events per year:	1
Magnitude range:	24,000 to 26,000 cfs
Duration:	<5 days
Frequency:	Once every year

Ecosystem objective:

This flow is needed to mobilize gravels and flush out fine sediments. This will provide bare surfaces and silt bar formation which is beneficial for lamprey. It is possible that this flow recommendation could be created by closing the Leaburg and Walterville canal entrances during a winter storm event. That way this event could be created without making specific Blue River and Cougar Dam flow releases. A flow of this magnitude will also inundate low elevation side channels.

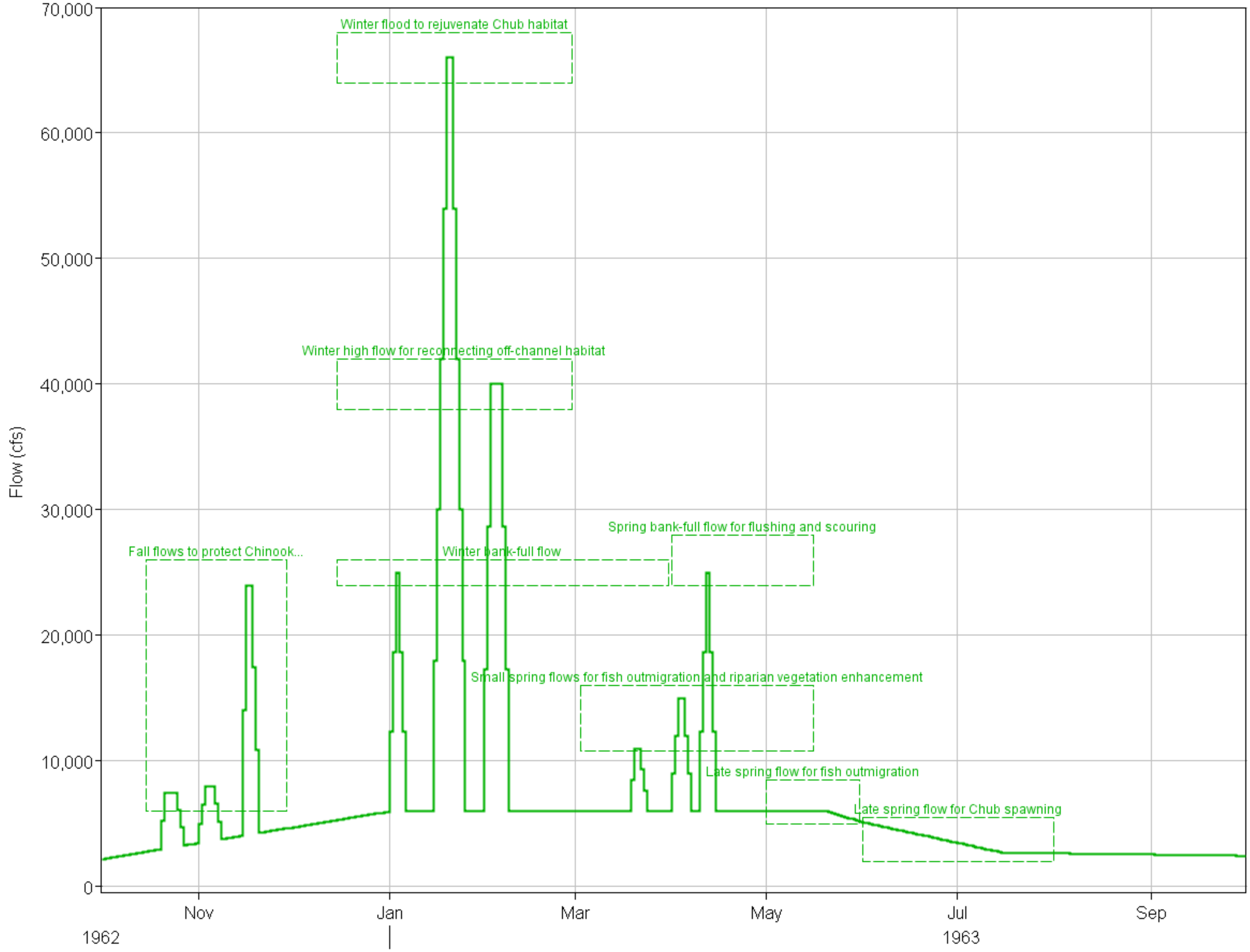

Figure 8. RPT generated plot of flow recommendations for the lower McKenzie River (Reaches 11–12)

Winter high flow for reconnecting off-channel habitat

Recommendation:

Time period:	December 15 to February 28
Events per year:	1
Magnitude range:	38,000 to 42,000 cfs
Duration:	<5 days
Frequency:	Once every 5 years

Ecosystem objective:

Small floods have been lost from the ecosystem in the post-dam period. These floods are important for connecting and wetting side channels, opening up new habitat, gravel movement, and flushing sediment and wood into side channels. Newly connected side channels will provide spawning and rearing habitat for spring Chinook. Resident trout, macroinvertebrates, and other species will also benefit by increased habitat diversity and clean, unarmored substrates.

Winter flood to rejuvenate Oregon chub habitat

Recommendation:

Time period:	December 15 to February 28
Events per year:	1
Magnitude range:	66,000 or greater cfs
Duration:	Based on upstream inflow conditions
Frequency:	Once every 10 years

Ecosystem objective:

A large flood every 10 years will provide regeneration of Oregon chub habitat in off-channel locations. A large flood will also increase channel complexity by enhancing pool and off-channel development. It will also help in large woody debris recruitment and gravel movement. Although a 10-year flood will typically not alter the floodplain, flood waters will spill over into the floodplain and rejuvenate it with fresh sediment deposits.

Small spring flows for fish outmigration and riparian vegetation enhancement

Recommendation:

Time period:	March 1 to May 15
Events per year:	1 to 2
Magnitude range:	11,000 to 15,000 cfs
Duration:	<5 days
Frequency:	Annually

Ecosystem objective:

These below bankfull spring flows will provide flows for the downstream migration of juvenile salmon and smolts. These flows will also make side-channel and alcove habitats available to fish during the migration period and will provide inundation of gravel bars to encourage seed germination.

Spring bankfull flow for flushing and scouring

Recommendation:

Time period:	April 1 to May 15
Events per year:	1
Magnitude range:	24,000 to 26,000 cfs
Duration:	<5 days
Frequency:	Once every 3 years

Ecosystem objective:

In addition to assisting fish outmigration, a spring bankfull flow is needed once every 3 years for flushing, gravel sorting, and gravel bar development. Cleansing gravel beds of fine sediments is needed for salmon spawning and for regenerating Oregon chub habitat. This flow will also disperse cottonwood seeds and establish seedlings.

Late spring flow for fish outmigration

Recommendation:

Time period:	May 1 to May 31
Magnitude range:	5,000 to 7,000 cfs
Frequency:	Annually

Ecosystem objective:

Juvenile spring Chinook salmon need approximately 6,000 cfs for outmigration during this period.

Late spring flow for Oregon chub spawning

Recommendation:

Time period:	June 1 to July 31
Magnitude range:	2,500 to 3,000 cfs
Frequency:	Annually

Ecosystem objective:

Flows in the lower McKenzie River reaches need to be kept at the current mean post-dam flow levels from May through July for successful Oregon chub spawning. If flows are too high during this period, water temperatures may be too cool. If flows are too low there may insufficient aquatic or submerged riparian vegetation available for spawning.

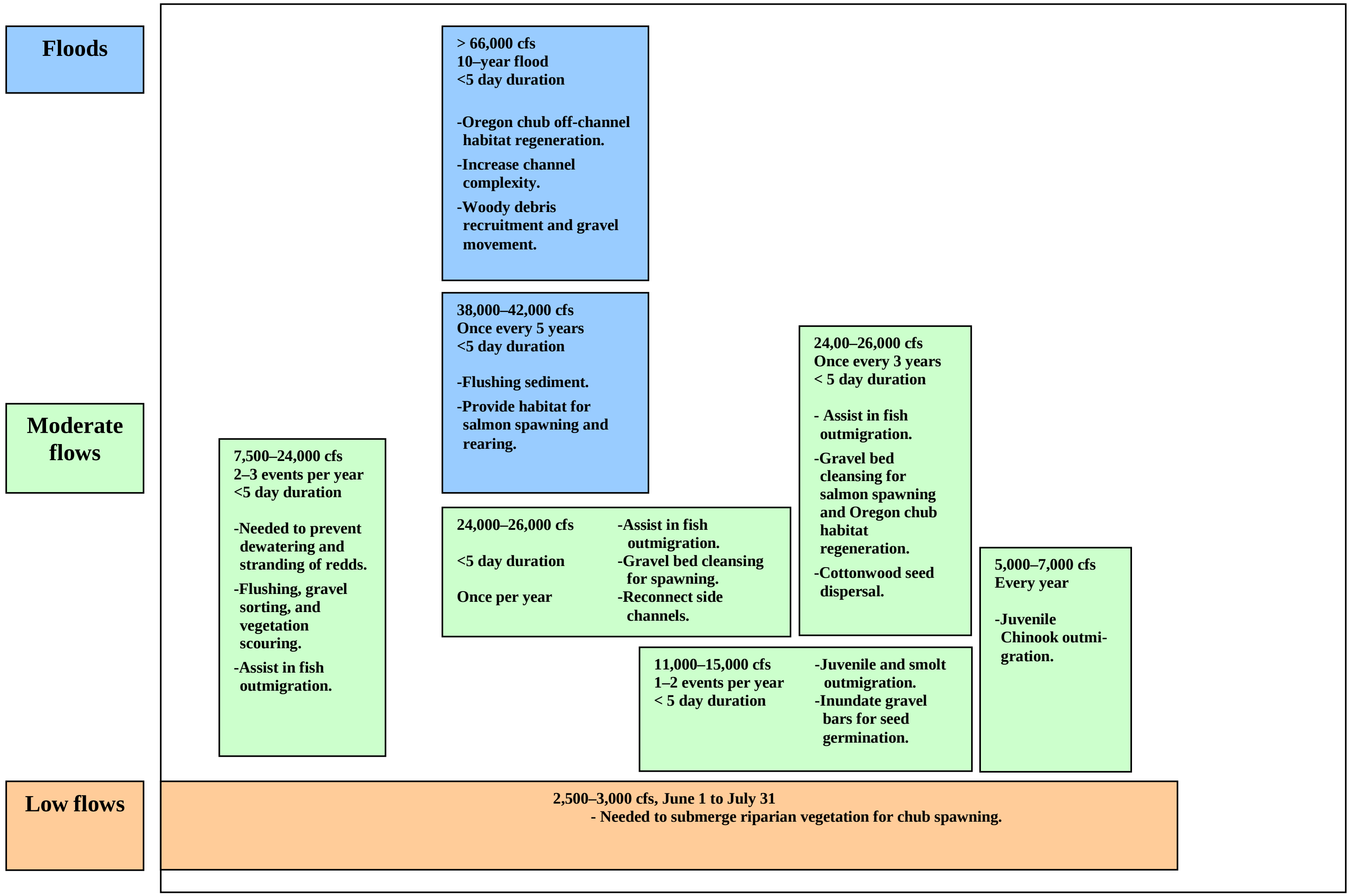

Figure 9. Dam flow release and ecology linkages for the Lower McKenzie River (Reaches 11–12)

Recommendations for future monitoring and evaluation

As the environmental flow recommendations are implemented for the McKenzie River their effectiveness in achieving geomorphic and ecosystem objectives will need to be evaluated. Development of a comprehensive monitoring plan was outside the scope of the workshop, but several recommendations can be made based on discussions at the workshop and expert knowledge. Recommendations focus on monitoring activities that evaluate the effects of flow management on off-channel habitat, gravel bar conditions and changes, riparian vegetation, and aquatic biology. Knowledge gained through the monitoring process will be used to refine the objectives and flow targets of the environmental flow program.

Off-Channel Habitat

In each of the four study reaches, specific prescribed bankfull and flood events are intended to improve off-channel habitat. The desired goal is maintaining and creating a diverse array of side-channels, sloughs, and alcoves ranging in size and character from small, rarely inundated floodplain channels, to large side channels that are inundated during modest flows. Monitoring and assessment recommendations include:

(1) Pre-implementation assessment of off-channel habitat conditions.

- Create a database of off-channel features using available LIDAR and aerial photographs that identify features in each reach.
- Stratify the off-channel features according to the level of discharge (below bankfull, bankfull, small flood, and large flood) required for inundation.
- Verify off-channel conditions during site visits including:
    - Off-channel feature cover (bare or vegetated).
    - Aquatic and adjacent terrestrial native vegetation—type, condition, and density.
    - Off-channel substrate (filled with fine sediment or cobble bed).
    - Anthropogenic obstacles hindering habitat connectivity and quality (revetment, dike across inlet, invasive vegetation, etc).
    - Presence, length, and diameter of large woody debris.
    - Bank height.
    - Condition of off-channel head and mouth.
    - Presence, frequency, and duration of off-channel flow.
    - Water quality-DO, pH, and water temperature.

(2) Example metrics to measure during the implementation of environmental flows:

- Channel length and complexity: Measurements every 5 years (or following large flow event) of the centerline length based on LIDAR or aerial photographs.
- Inundation: Y/N response to determine if each off-channel feature was actually wetted during flow events at the mouth and access points.
- Scour: Y/N response to determine if off-channel scoured during flow events.

- Significant erosion: Y/N response to flag newly created off-channels or off-channels that were substantially modified after a flow event.

(3) Additional suggestions for monitoring off-channel habitat:

- Focus monitoring effort on the lower McKenzie River where off-channel features are most abundant.
- Establish photo points at key sites. These sites should be locations accessible during winter/high flow conditions.
- Establish a manually operated staff gage or automated water height recorder at photo points for the purpose of documenting maximum water depth for each flow event.
- Visit key sites during and after high flow events to photograph and document scour, bank erosion, accumulation of large wood debris, and other changes.
- Install a water quality logger network in off-channel habitats to document conditions pre and post flow implementation and to assess habitat suitability for exemplar species.

Gravel Bars and other Alluvial Features

Another major objective of environmental flows is the rejuvenation of gravel bars and other alluvial features. In addition to increasing the number and size of active gravel bars, this involves creating island and floodplain bars that encompass a diverse range of elevations, sizes and vegetation classes. Monitoring and assessment recommendations include:

(1) Pre-implementation assessment of gravel bar conditions:

- Create an inventory of existing gravel bars, keeping track of vegetation density, bar height, and bar area. Map the bars using aerial photographs and LIDAR imaging. The LIDAR-derived topography can be used to determine bar elevation.
- Use field observations to validate trends detected through mapping.
- Collect sediment particle size data (Wolman pebble counts at key sites).

(2) Example metrics to measure during the implementation of environmental flows (can be determined from future aerial photograph mapping and LIDAR imaging).

- Bar area
- Vegetation density
    - Bare: 0–10% vegetative cover
    - Moderate: 10–60% cover
    - Dense: 60–100% cover
- Bar type
    - Floodplain bar: Bar is connected to floodplain
    - Island bar: Bar is completely surrounded by water
- Bar elevation

    - As detected from LIDAR, elevation changes can be used to infer deposition or erosion. Bar elevation could be measured infrequently (for example, every 5 years or after a large magnitude flow event).

(3) Additional suggestions for monitoring gravel bars:

- Focus on the lower McKenzie where gravel bars and alluvial features have been historically most abundant.
- Identify 3 to 4 key sites for more intense monitoring. After conducting an initial assessment, select several characteristic bars that include at least one densely vegetated bar and a bare active bar.
- Establish photopoints at the key sites so that repeat photographs can be taken throughout the low and high flow seasons.
- Conduct Wolman pebble counts at the key sites to evaluate changes in the surface texture of bars over time.
- Evaluate bar armoring at key sites by sampling the bar substrate at the same locations where Wolman pebble counts are conducted. Bar substrate can be evaluated through field or laboratory sieving. Additionally, photograph-based textural analyses are becoming increasingly used in Oregon and Washington streams and may facilitate the sediment sampling process (see Buscombe and others, 2010).
- Monitor gravel transport using painted tracer rocks, which are placed on the bar during the low flow season and then re-mapped the following summer. Their movement, or absence, will provide information on flows needed to inundate and transport gravel at different bars.
- Monitor the depth of scour and deposition using scour chains.

Riparian Vegetation

Environmental flows that will promote and enhance riparian vegetation include spring high flows to support cottonwood seed dispersion and germination, and summer low flows to facilitate cottonwood and alder root growth and development. Monitoring and assessment recommendations include:

(1) Pre-implementation assessment of riparian vegetation conditions:

- Map the riparian vegetation using aerial photographs and LIDAR imaging.
- Use field observations to validate trends detected through mapping.

(2) Example metrics to measure during the implementation of environmental flows.

- Seedling density
    - Bare: 0–10% vegetative cover
    - Moderate: 10–60% cover
    - Dense: 60–100% cover

(3) Additional suggestions for monitoring riparian vegetation:

- The USGS Fort Collins Science Center in Fort Collins, Colorado has considerable expertise in riparian vegetation dynamics and could provide guidance during the monitoring phase.

Aquatic Biology

Many of the prescribed environmental flows are designed to protect and enhance of McKenzie River Basin fish populations at various life stages. Exemplar fish species in the basin, described in Risley et al. (2010), include spring Chinook, bull trout, Pacific lamprey, and Oregon chub. Although the environmental flows did not specifically address other aquatic species such as red-legged frogs and western pond turtles, also described in (Risley et al., 2010), these and other off-channel species will benefit from overall improvements to off-channel habitats. Monitoring and assessment recommendations include:

(1) Pre-implementation assessment of existing aquatic biological conditions:

- Assemble recent fish surveys and reports from EWEB, USACE, and the Oregon Department of Fish and Wildlife (ODFW).
- Consult with fish biologists from these agencies who are familiar with the river basin to coordinate with ongoing fish monitoring and assessment efforts.
- Conduct detailed studies of habitat availability and connectivity--documenting pool depth, cover, large wood accumulations, spawning beds and other key features.

(2) Example conditions to inventory during the implementation of environmental flows.

- Monitor Chinook redds and juveniles to ensure they are not stranded after the implementation of fall bankfull flows.
- Determine if large winter flood events can rejuvenate Oregon chub habitat in the Lower McKenzie River reaches by documenting chub presence, habitat type, and location.
- Determine if Chinook outmigration is assisted by fall, winter, spring, and late spring environmental flows. This should be coordinated with ongoing tagging efforts by ODFW and other agencies.
- Determine if late spring flows in the lower reach will enhance Oregon chub spawning.
- Determine if summer low flows in the EWEB canal reaches are sufficient for spring Chinook rearing.
- Evaluate off-channel use of habitat by fish.

(3) Additional suggestions for monitoring aquatic conditions:

- Monitoring aquatic species will rely on extensive coordination with other ongoing efforts
- by State and Federal agencies and academia.
- Establish specific key sites for fish surveys, which can be revisited on a regular basis.
- Different key sites will need to be established for different fish species and different fish life stages. These should include off-channels habitats to monitor for Oregon chub and juvenile salmonids, silt bars for lamprey, and large mainstem pools for salmonids, adult lamprey, and other species.
- Consult with the USGS Forest Research Ecosystem Science Center (FRESC) in Corvallis, Oregon, in regards to monitoring exemplar amphibian species (red-legged frogs and western pond turtles).

Recommendations for Future Studies

Future studies are recommended to fill in data gaps and develop a better understanding of McKenzie River Basin ecosystem processes. These potential studies could focus on channel morphology, streambed incision, sediment budgeting, and geomorphic mapping.

Channel Morphology and Streamflow

The relationships between streamflow and channel morphology shown in table 21 of Risley et al. (2010) are conceptual. Flow targets for specific habitat objectives need to be better defined. For example, for each reach, what is the range of discharge levels necessary to inundate, maintain and create off-channel habitat? Further refinement of these relationships, based on hydraulic modeling combined with field observations, would provide a stronger basis for environmental flow guidelines.

Streambed Incision

The extent of streambed incision along the lower McKenzie River needs to be assessed in more detail. Previous studies by Klingeman (1971) and Risley et al. (2010) show nearly 8 feet of incision at the USGS streamflow gage near Coburg, Oregon. Anecdotal accounts indicate other areas along the lower McKenzie River may have also experienced incision. The magnitude and extent of streambed degradation should be determined in order to better assess the effect of environmental flow releases on channel morphology. The vertical stability of the streambed could be evaluated through comparison of modern and historical survey data, in combination with a field campaign aimed at detecting evidence of bed degradation.

Sediment Budget

A bed material sediment budget in the McKenzie River Basin could be used to assess spatial patterns of gravel supply and transport capacity. A sediment budget would also identify and quantify sources of sediment from tributaries and channel erosion, while accounting for the effects of geology, dams, revetments and other factors. Information gained from the sediment budget would be helpful for identifying trends in channel morphology. For example, are some reaches likely candidates for incision or gravel bar recruitment? A sediment budget could also help managers to set more realistic goals for restoration and environmental flows. For example, if very little bed sediment is currently delivered to the lower McKenzie River, then environmental flows designed for the purpose of increasing gravel bar area could be redesigned to activate existing vegetated bars while minimizing the net export of these gravels.

Geomorphic Assessment and Mapping

A comprehensive geomorphic assessment would help identify other obstacles to creating and maintaining channel complexity along the lower reaches of the McKenzie River. Information on bank materials and their potential for erodiblity would inform discussions of channel migration and help set reasonable goals for future channel change. Detailed mapping of bank materials and channel bed substrate, combined with a longitudinal survey, could be used to identify intrinsic controls (such as bedrock outcrops) on channel change. This mapping could also incorporate revetments and other artificial bank hardening. Currently detailed maps of bank protection are only available for USACE revetments.

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Appendix A. Workshop agenda

McKenzie River

Environmental Flows Workshop

March 10-11, 2010

Eugene Water and Electric Board

500 East 4th Avenue Eugene, Oregon

AGENDA

March 10, 2010

10:00 Welcome and introductions – Eugene Water and Electric Board, Corps of Engineers, The Nature Conservancy

10:15 Review of process, discussion of meeting outcomes – Leslie Bach, The Nature Conservancy

10:30 Overview, Questions and Answers and Discussion of McKenzie River system, hydrologic analysis and flow/ecology relationships as background for developing environmental flow recommendations – John Risley, Rose Wallick and Ian Waite, U.S. Geological Survey

11:30 Overview of Regime Prescription Tool software that will be used in Working Groups – John Hickey, Corps of Engineers

11:45 Instructions for Working Groups and Discussion – Leslie Bach

12:15 Lunch (provided)

1:00 Working groups

Working groups will be organized with a mix of expertise and will address four different reaches of the McKenzie River. Each group will develop recommended flows for the 4 reaches based on specific Environmental Flow Components (low flows, flood flows, small floods and large floods), considering a range of species, communities and ecological processes including fish and other aquatic species, riparian and floodplain systems, channel morphology and water quality. Groups will also identify significant knowledge and information gaps and potential monitoring elements.

4:00 Adjourn

March 11, 2010

8:30 Working Groups complete work

10:30 Presentations by Working Groups and discussion of flow recommendations for each reach. Integration of flow recommendations from Working Groups into a single unified set of flow recommendations for each reach.

11:30	Lunch (provided)
12:30	Continuation of presentations by Working Groups and discussion of flow recommendations for each reach. Integration of flow recommendations from Working Groups into a single unified set of flow recommendations for each reach.
2:30	Summary of results and discussion of next steps
3:00	Adjourn

Appendix B. List of workshop attendees

Coordinator	Leslie	Bach	The Nature Conservancy
RPT coordinator	John	Hickey	U.S. Army Corps of Engineers
Group 1			
Facilitator	Allison	Aldous	The Nature Conservancy
RPT operator	Krista	Jones	United States Geological Survey
RPT operator	Julie	Amman	U.S. Army Corps of Engineers
	Doug	Gartletz	U.S. Army Corps of Engineers
	Gordon	Grant	USFS - PNW Research Station
	Suzanne	Walther	University of Oregon
	Anne	Mullan	NOAA Fisheries
	Ronald	Costello	Bonneville Power Administration
	Kelly	Reis	Oregon Department of Fish and Wildlife
	Dan	Bell	The Nature Conservancy
	Nancy	Toth	Eugene Water and Electric Board
	Brian	Bangs	Oregon Dept. of Fish & Wildlife
	Chris	Vogel	McKenzie River Trust
	Bill	Ferber	Oregon Water Resources Department
Group 2			
Facilitator	Valerie	Kelly	United States Geological Survey
RPT operator	Adam	Stonewall	United States Geological Survey
RPT operator	Laurie	Rice	U.S. Army Corps of Engineers
	Greg	Taylor	U.S. Army Corps of Engineers
	Stephanie	Burchfield	NOAA Fisheries
	Bonny	Hammons	US Forest Service
	Trish	Carroll	U.S. Forest Service

	Cris	Mateaus	Oregon State University
	Patricia F.	McDowell	University of Oregon
	Kara	Di Francesco	Oregon State University
	Rosemary	Mazaika	Bonneville Power Administration
	Andrew	Talabere	Eugene Water and Electric Board
	Chris	Budai	U.S. Army Corps of Engineers
	Jeffrey J.	McDonnell	Oregon State University

Group 3

Facilitator	Terrence	Conlon	United States Geological Survey
RPT operator	Mary Karen	Scullion	U.S. Army Corps of Engineers
	Larry	Six	McKenzie River Watershed Council
	Rich	Piaskowski	U.S. Army Corps of Engineers
	Ray	Rivera	U.S. Forest Service
	Karl	Morgenstern	Eugene Water and Electric Board
	Rose	Wallick	United States Geological Survey
	Bruce	Duffe	U.S. Army Corps of Engineers
	Steve	Liebhardt	Bureau of Land Management
	Michael	Mattick	Oregon Water Resources Dept.
	Jeffrey	Ziller	Oregon Dept. of Fish & Wildlife
	Mindy	Simmons	U.S. Army Corps of Engineers
	Sharon	Schulz	U.S. Army Corps of Engineers
	Dave	Donahue	Eugene Water and Electric Board
	Sherri	Johnson	Oregon State University/PNW

Group 4

Facilitator	Dustin	Bengtson	U.S. Army Corps of Engineers
RPT operator	John	Risley	United States Geological Survey
	Tim	Hardin	Oregon Dept. of Fish and Wildlife
	Paul	Scheerer	Oregon Dept. of Fish and Wildlife
	Desiree	Tullos	Oregon State University
	Ian	Waite	United States Geological Survey
	Robert	Annear	DHI
	Kirk	Schroeder	Oregon Dept. of Fish and Wildlife
	Chad	Helms	U.S. Army Corps of Engineers
	David	Hulse	University of Oregon
	Brad	Taylor	Eugene Water and Electric Board

Jason	Karnezis	Bonneville Power Administration
Travis	Roth	Oregon State University
Jim	O'Connor	United States Geological Survey
Ian	Chane	U.S. Army Corps of Engineers