Summary Report

Environmental Flows Workshop for the Middle Fork and Coast Fork of the Willamette River, Oregon

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Middle and Coast Forks Willamette River
Environmental Flows Workshop
16 – 17 January 2007

Workshop Agenda & Purpose

The Nature Conservancy (TNC) and the U. S. Army Corps of Engineers (USACE) have collaborated on the Sustainable Rivers Project (SRP). This effort identifies opportunities to manage Corps Dam operations to achieve more ecologically sustainable flows, while maintaining or enhancing dam benefits. The Willamette River Flow Project is one of nine ongoing SRP projects nationally and is being conducted in conjunction with the USACE Willamette Floodplain Restoration Feasibility Study. Both projects have focused on the Coast and Middle Forks of the Willamette River (Fig 1). These two subbasins contain 6 of the 13 dams in the Willamette River system. Their operation affects downstream reaches and has implications for the operation of the other dams in the river network. The goal is to use the Coast and Middle Forks and the mainstem Willamette immediately downstream of these tributaries as a pilot study that can be replicated in the rest of the Willamette River system.

The process of producing recommended flows began in February 2006 with a workshop attended by 86 people from 34 entities including state and federal government, universities and non-governmental organizations. The initial workshop identified sources and experts for a review of the available literature and datasets pertaining to flow requirements for species and ecological processes of the Middle and Coast Forks of the Willamette River. The literature review was compiled by the Institute for Water and Watersheds at Oregon State University with personnel from OSU's Department of Fisheries and Wildlife (Gregory, Ashkenas, Campana 2007). This summary formed the basis for a second workshop held in Salem, Oregon on January 16-17, 2007. The final outcomes of these meetings are summarized in this report.

Participants in the second workshop included 43 people from 14 government and non-governmental organizations. The original agenda (see Appendix A) was modified due to last-minute weather constraints which prevented some participants from attending. The original agenda was to have provided an overview of the summary report by its' authors, Stan Gregory and Linda Ashkenas, followed by presentations pertaining to the hydrologic data by Jeff Opperman (TNC) and John Hickey (USACE). The attendees (Appendix B) were then to break into four groups to discuss and determine environmental flows for (1) channel morphology and water quality, (2) riparian and floodplain systems, (3) non-salmonid animal species (4) salmonid fish. Due to the weather delays, the first day consisted of presentations on the hydrologic data and a general discussion of the flow requirements of key species and communities. The review of the summary report was presented in abbreviated format on the second day of the workshop. In addition, workshop participants were divided into two groups rather than four; one focused on channel/floodplain processes and riparian vegetation and the other focused on aquatic species.

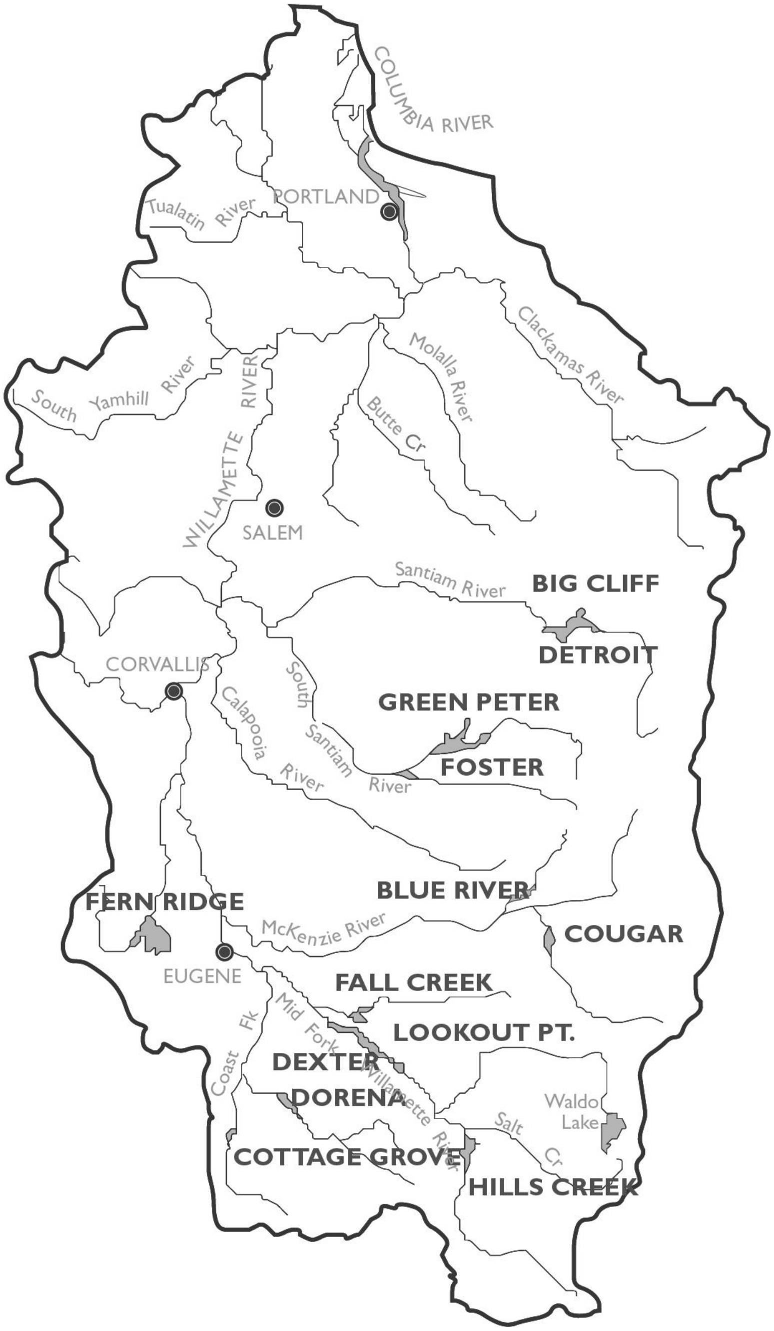
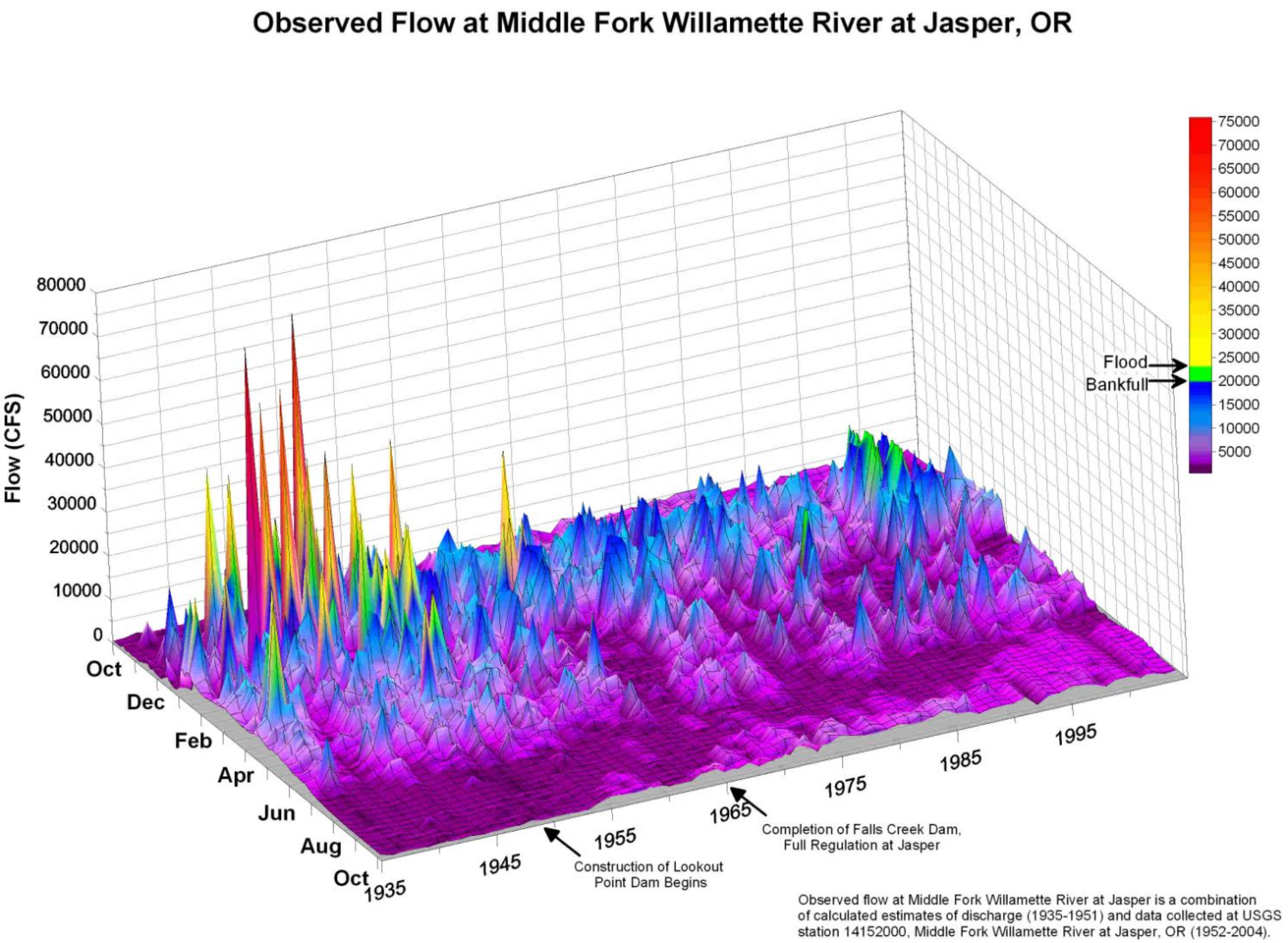


Figure 1. Map of the Willamette River basin showing major tributaries and the locations of the thirteen USACE flood control projects (USACE, 2000).

Each working group was charged with developing recommended flow regimes that would meet the ecological flow requirements or flow relationships for their assigned riverine processes, habitats, or target species. At the outset, it was determined that an average hydrograph would be used as a baseline, and that the working groups would not attempt to define flow targets for wet, dry or critically dry water years. Each group was to address both low (base) flows and high flows. High flows were further divided into three categories: 1) high flow pulses (up to bankfull, less than 2-yr return interval), 2) small floods (overbank, approximately 2 – 10-yr return interval), and 3) large floods (floodplain maintenance, greater than 10-yr return interval). The breakout groups discussed the timing, magnitude, duration and rate of change of flows in these four flow categories. Each group worked with a facilitator, two recorders and two operators of Regime Prescription Tool (RPT) software. RPT was developed jointly by TNC and USACE to provide a graphical interface to view hydrologic information easily and to draft flow recommendations (http://www.hec.usace.army.mil/software/hec-rpt/). Both groups spent the majority of their time working on their respective flow proposals and convened in a final synthesis session to integrate their proposed flow regimes. The independently developed flow regimes of the two groups were notably similar and the two proposals were easily integrated.

The RPT software provided an effective tool for rapidly illustrating hydrologic regimes and for comparing recommended flows with existing regulated or unregulated flows. It served as a common framework for discussing flow requirements and recording narrative information, numerical flow attributes, and graphical hydrologic information. The graphical results of the two working groups were integrated in less than 15 minutes, which then provided a framework for resolving minor differences between the groups.

The literature and data review provided several critical syntheses of flow information. To aid their discussions and recommendations, workshop participants were able to view hydrologic data for regulated and unregulated flows in the Middle Fork of the Willamette River, Coast Fork, mainstem Willamette River below confluence, and mainstem Willamette River in Albany, Oregon. The major hydrologic graphs were 1) 3-D representation of long-term hydrograph, 2) annual means of maximum, average, and minimum flows, 3) regulated and unregulated flow history, 4) flood frequency, 5) flow duration curves, and 6) duration at bankfull flow. Graphs for the Middle Fork are illustrated in Figures 2 – 7.



Observed Flow at Middle Fork Willamette River at Jasper, OR

Flood

Bankfull

Construction of Lookout Point Dam Begins

Completion of Falls Creek Dam, Full Regulation at Jasper

Observed flow at Middle Fork Willamette River at Jasper is a combination of calculated estimates of discharge (1935-1951) and data collected at USGS station 14152000, Middle Fork Willamette River at Jasper, OR (1952-2004).

Figure 2. Observed flows at the Jasper gage, Middle Fork Willamette River, 1936 – 2004. Months run from left to right to highlight summer low flows. Figure created by Chris Nygaard, USACE, Portland, OR.

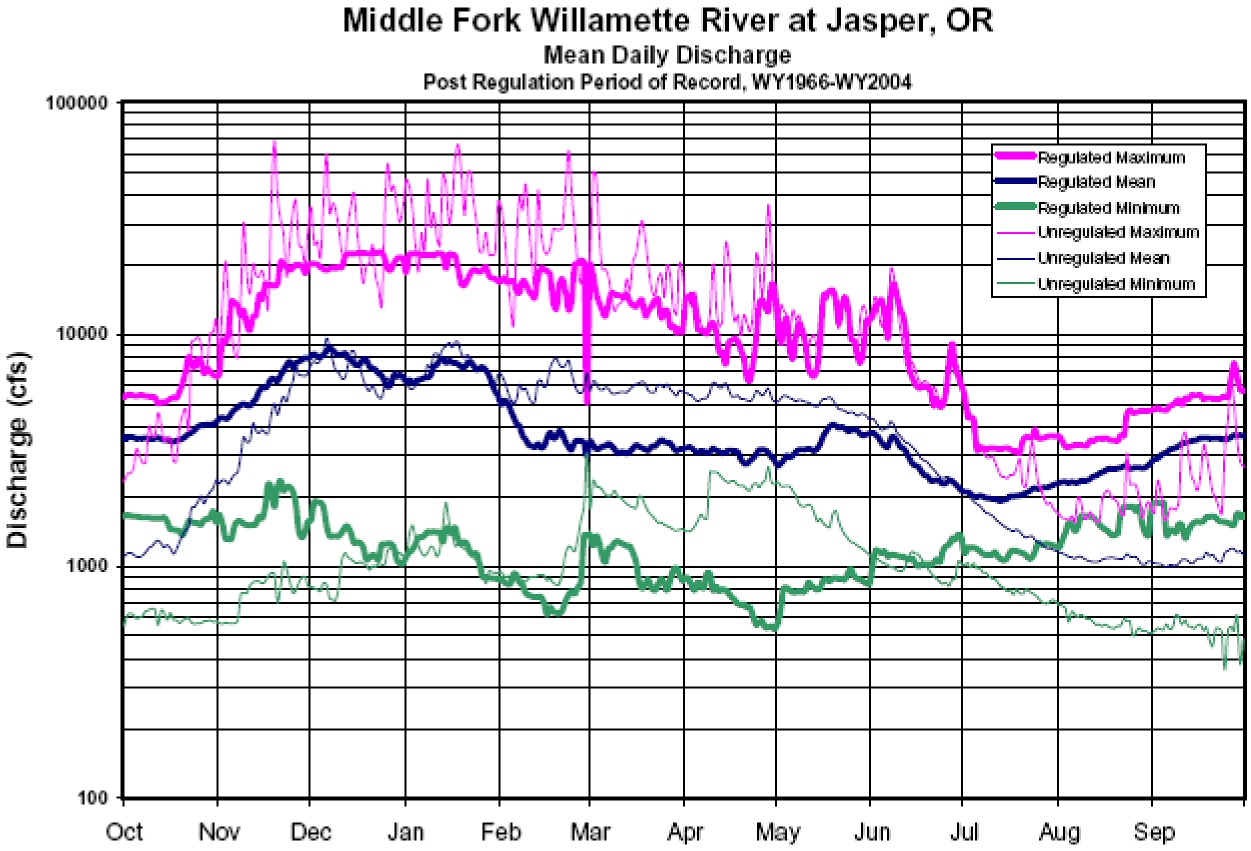


Figure 3. Mean daily discharges (maxima, minima and averages) at the Jasper gage, Middle Fork Willamette River for period of post-dam completion (1966-2004). Regulated flows are those observed at the gage; unregulated flows are derived from USACE models. Figure created by Chris Nygaard, USACE, Portland, OR.

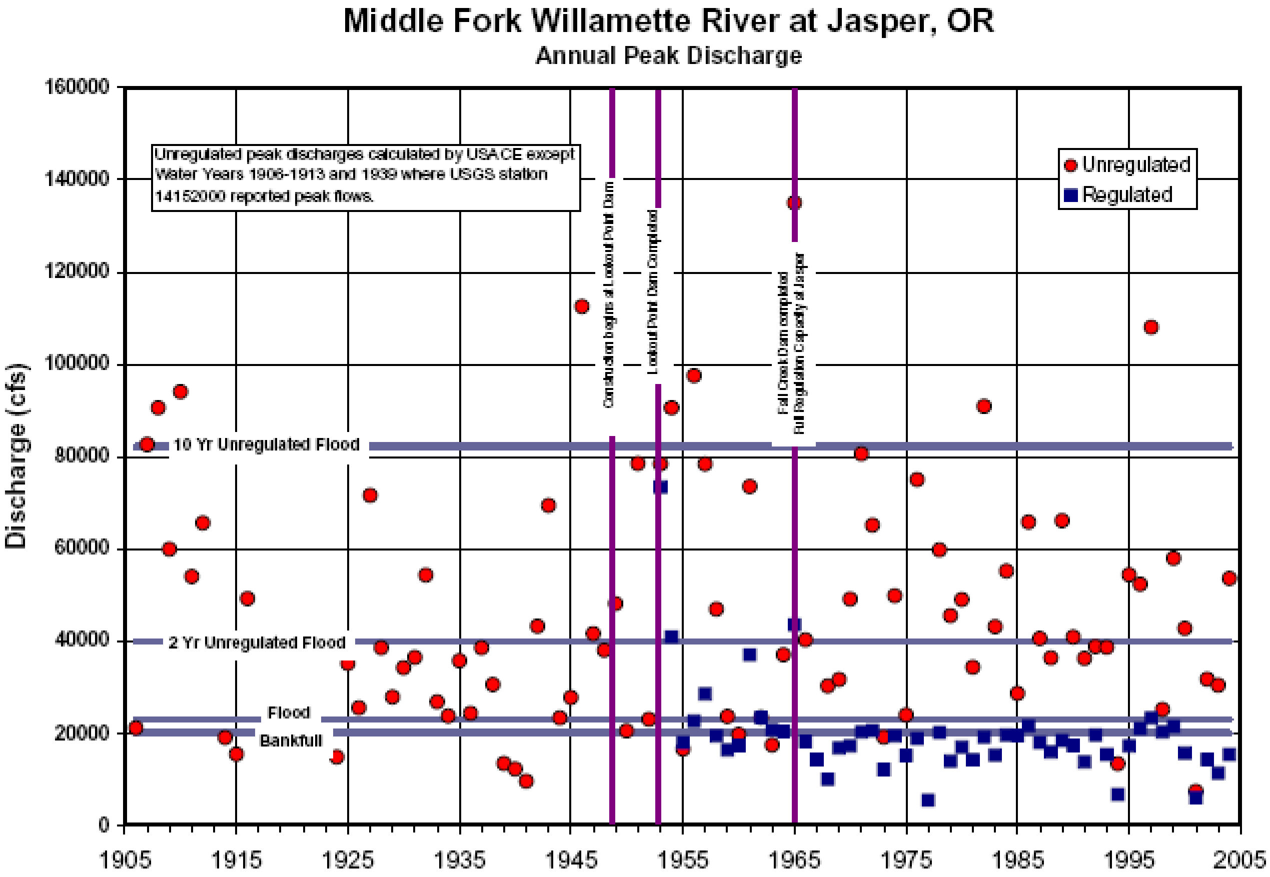
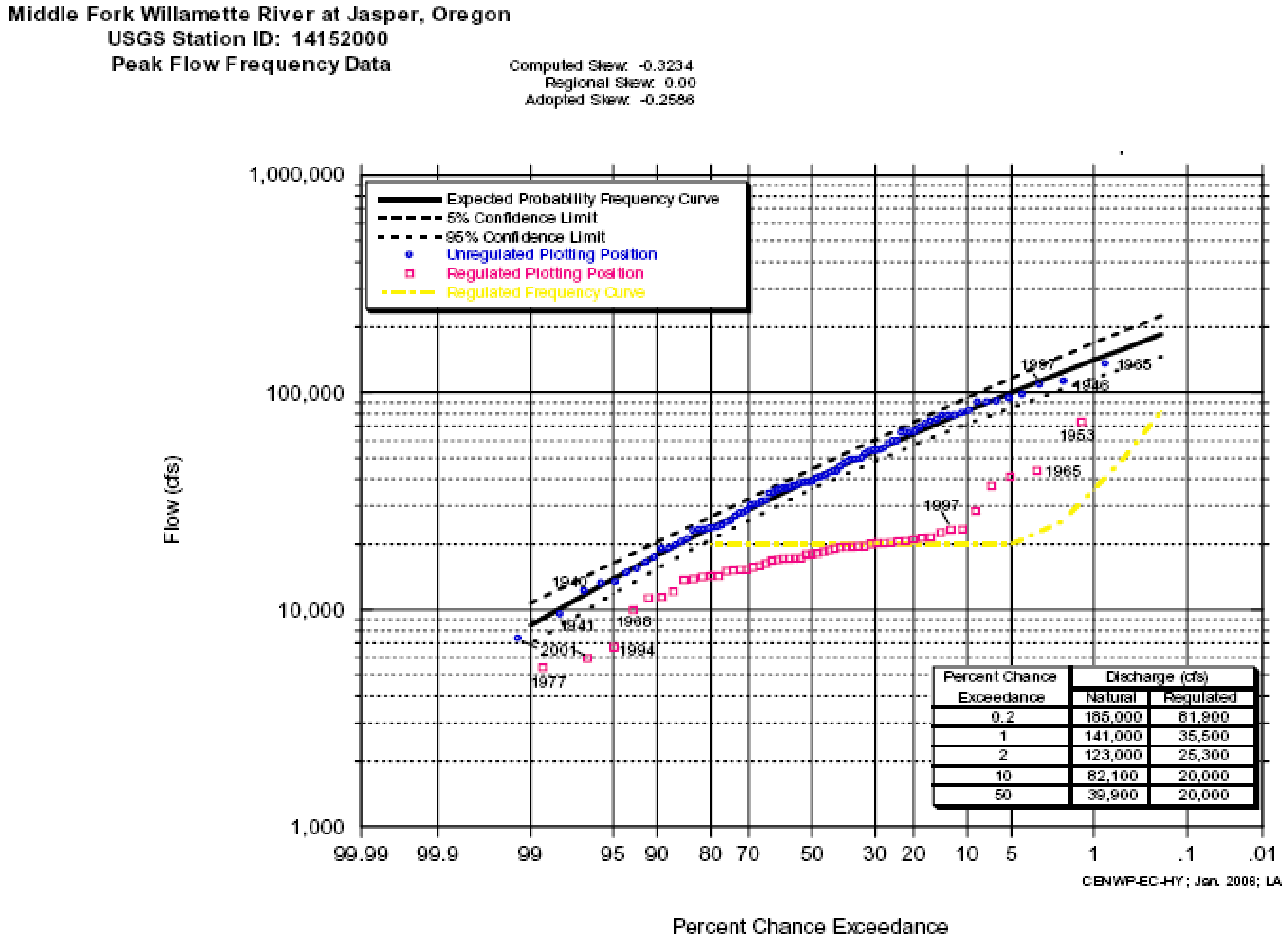


Figure 4. Annual peak discharges at the Jasper gage, Middle Fork of the Willamette River. Blue bars indicate the four environmental flow levels. Figure created by Chris Nygaard, USACE, Portland, OR.



Percent Chance Exceedance	Discharge (cfs)	
	Natural	Regulated
0.2	185,000	81,900
1	141,000	35,500
2	123,000	25,300
10	82,100	20,000
50	39,900	20,000

Figure 5. Flood frequency (probability of exceedence) for the Middle Fork Willamette River at Jasper. Figure created by Chris Nygaard, USACE, Portland, OR.

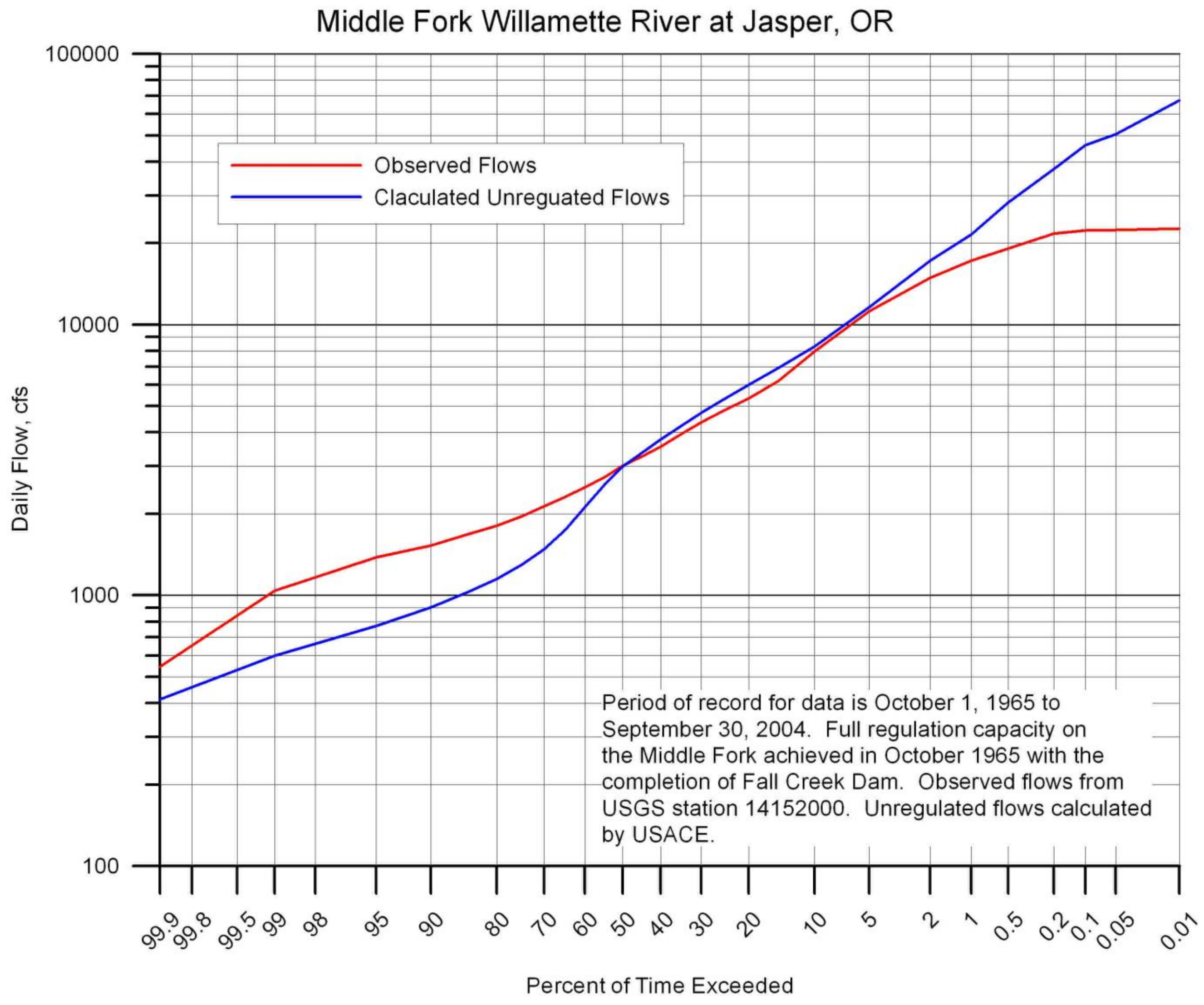


Figure 6. Flow duration curve for the Middle Fork Willamette River at Jasper. Figure created by Chris Nygaard, USACE, Portland, OR.

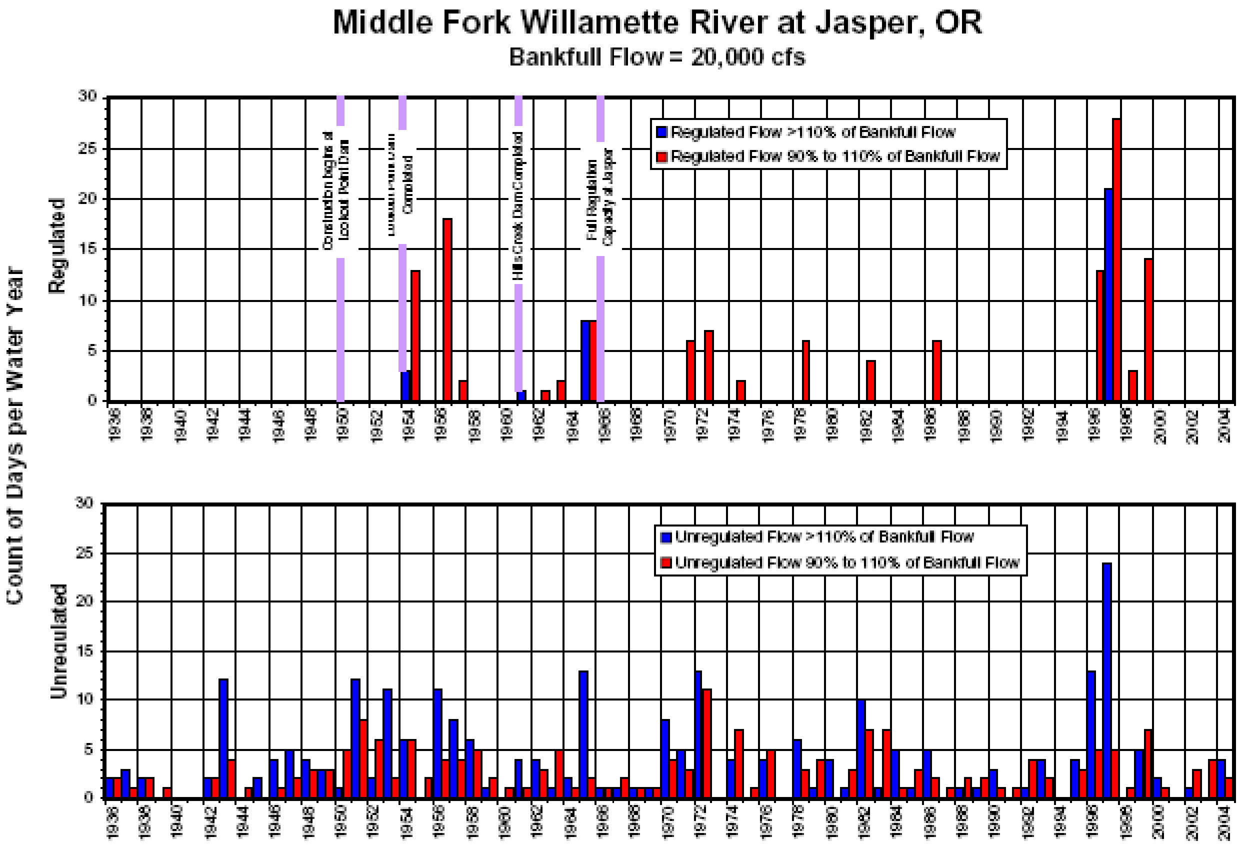


Figure 7. Number of days that discharges are at bankfull levels for the Middle Fork of the Willamette River at Jasper. Comparison of regulated and unregulated flows by water year. Figure created by Chris Nygaard, USACE, Portland, OR.

Workshop Results

Flow recommendations focused primarily on the Middle Fork below Dexter dam and the mainstem Willamette above Springfield. Neither working group developed specific recommendations for operations/reaches on the Middle Fork below Fall Creek and Hills Creek dams. Groups did not develop specific flow recommendations for the Coast Fork Willamette, but noted that flow management does not alter flows in the Coast Fork to the degree observed in the Middle Fork. Relationships between flows and water quality issues, particularly temperature, did not receive as much attention as the groups and organizers felt warranted.

Middle Fork Willamette River

The results of the two working groups were integrated into a single hydrograph, which is referred to as the "unified ecosystem flow recommendation" in this report. Critical components of the ecosystem flow recommendations include 1) small fall pulses, 2) winter bankfull flows, 3) small floods above current bankfull flows (2-yr to 10-yr regulated flows), 4) larger floods (2-yr to 10-yr unregulated flows), 5) spring pulse flows, 6) spring to summer transition flows, and 7) summer low flows. The components are identified in the hydrograph illustrated in Figure 8 and explained in greater detail below. Differences between the recommendations of the two groups, where they exist, are highlighted. Graphs from RPT are used to illustrate the ecosystem flow components.

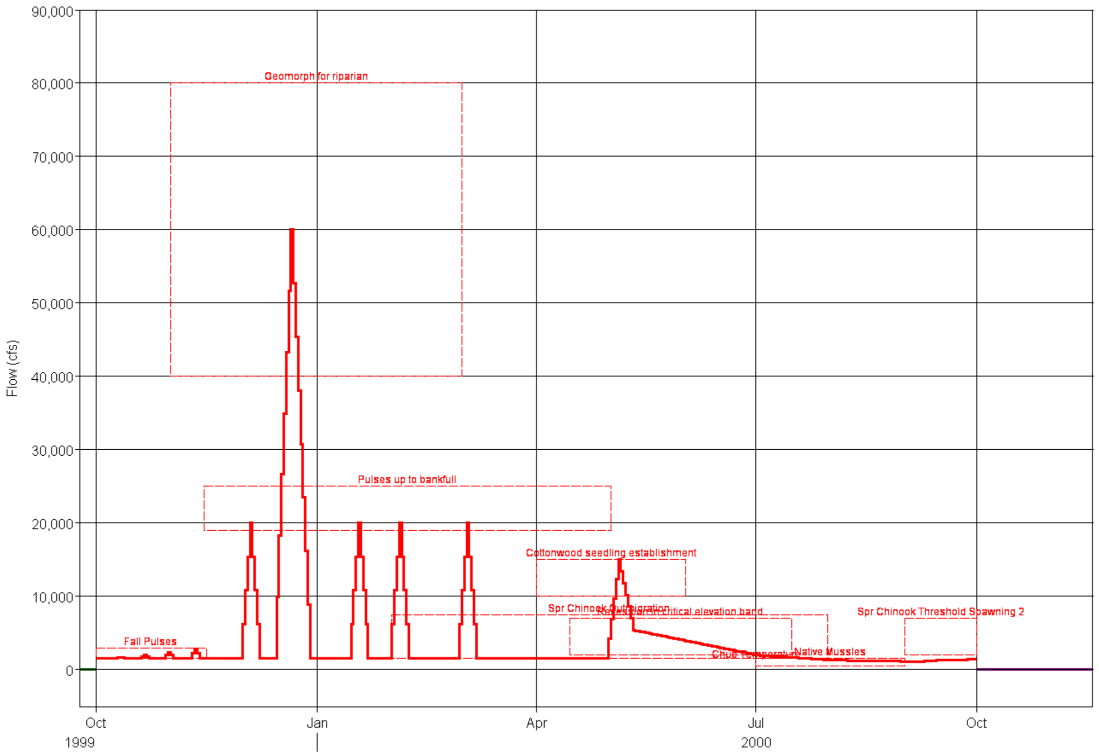


Figure 8. Unified Ecosystem Flow Recommendations for the Middle Fork Willamette River.

Fall Transition Flows and Small Fall Pulses

General recommendations

During fall, reservoir operations require pools to be drawn down to provide for flood storage. Both groups recommended that reservoirs should be drawn down without causing sharp transitions of increased flow and temperatures in the fall season (Fig. 9). Abrupt transitions during these events can strand fish and create substantial and artificial changes in temperature because of reservoir releases. During this time, several early fall storms would cause small flow pulses, similar to historical unregulated fall pulses (Fig. 10; see Fig. 2 for historical trends). The magnitude of these pulses would increase going into the late fall/winter base flow transition.

Fall Transition Flows

Recommendation:

Time period: September 1 – October 1
Magnitude range: < 1500 cfs
Duration: <5 days based on unregulated record

Related ecosystem functions:

Avoid rapid flushing of warm water from reservoir
Initiate increase fall flows for fish passage

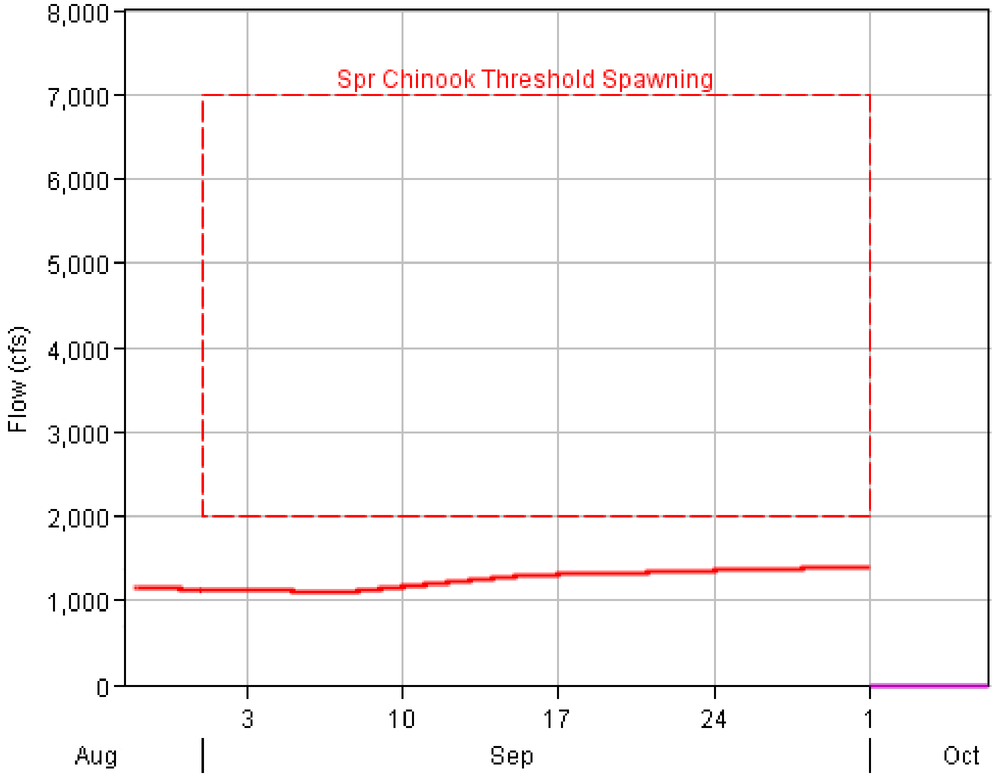


Figure 9. Hydrograph of fall flows required for Chinook salmon spawning.

Small Fall Pulses

Recommendation:

Time period: October 1 – November 15
Number of events: 1-4 based on precipitation events
Magnitude range: 1500 - 3000 cfs
Duration: <5 days based on unregulated record

Related ecosystem functions:

Avoid flushing of warm water from reservoir
Passage for fish
Avoid stranding

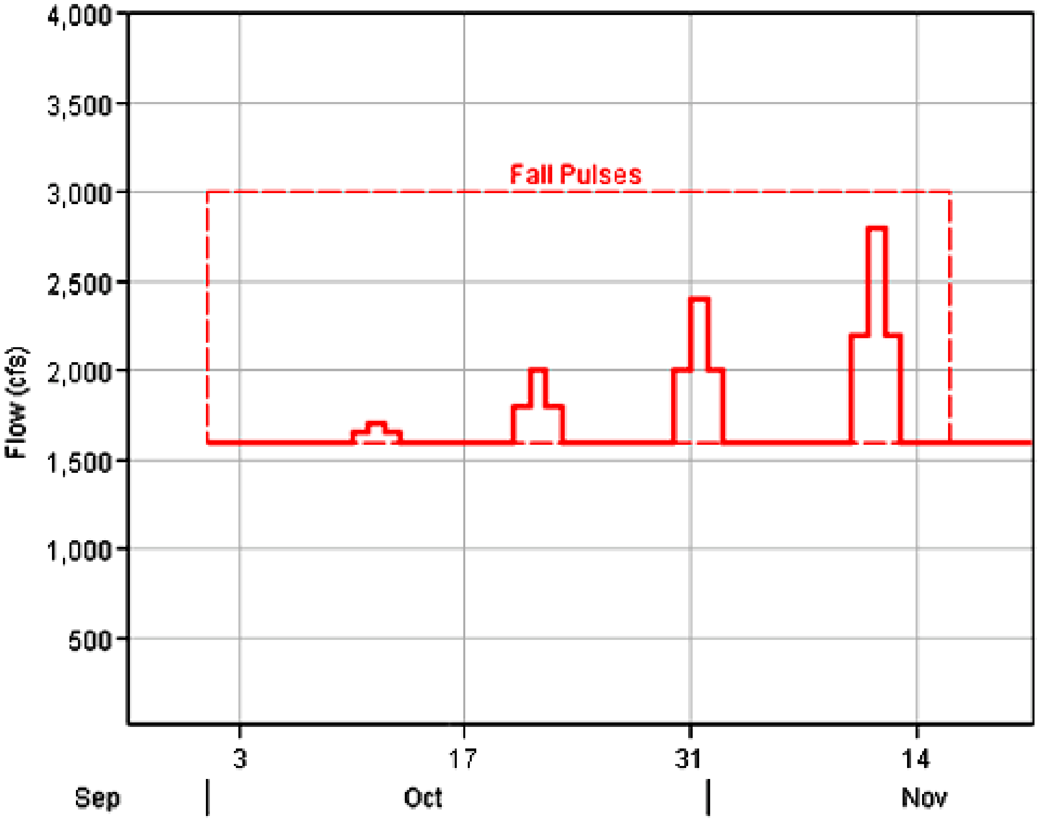


Figure 10. Hydrograph of representative fall pulses.

<u>Aquatic species group</u>

Spring Chinook salmon spawn from September 1 through October 15 (Fig. 11). Flows during and following this time (incubation flows) must be at or above spawning flows to prevent dewatering and stranding of young. In an average water year, 1800 cfs is a minimum, 2000 cfs is optimal, and 2500 cfs is maximal below Dexter Reservoir. One option suggested by the group is to set incubation flows as a function of spawning flows (i.e., incubation flows must equal or exceed spawning flows to avoid stranding of redds or emerging fry). Temperature and gravel availability at this season and flows are also critical for salmon survival and production.

Small flow pulses can occur roughly 1 to 3 times over the fall season. Upstream unregulated gaging stations may be used to determine design criteria. Some suggested that the 50-75% exceedence based on inflows to the reservoirs might be a useful criterion, but others felt that the 90% exceedence was more appropriate at this season (exceedence is the probability that a flow of a given magnitude will be exceeded based on the history of recorded flows). Temperature monitoring and planning are essential for flow management because of the tendency of the reservoirs to release warmer water than would normally occur at this season. The recession rate is a critical flow property of small floods in the fall. These flows typically are short duration and natural pulse timing should be mimicked as closely as possible.

Floodplain/plant group

The group recommended early fall pulses to provide passage for migrating fish (i.e., Chinook salmon), but the biological basis for these flows was the primary topic for the other work group. A possible physical basis for these flows is the historical fall discharges. Recommended flows for small flow pulses during this season would range from 1700 to 2800 cfs. Early fall pulses could be operationally maintained within 150% of historical magnitude for fall pulses.

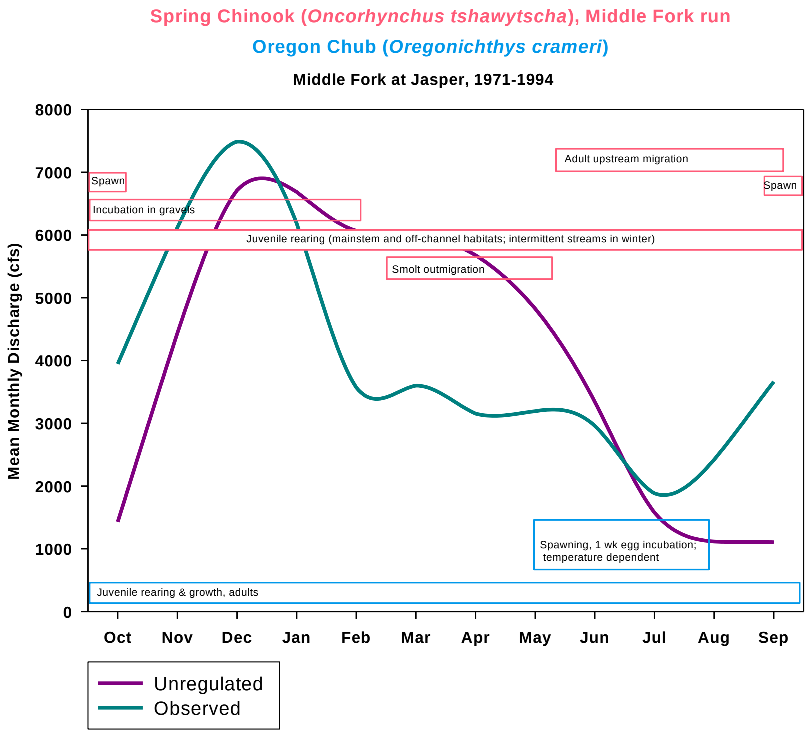


Figure 11. Life history of two native fish species, one anadromous (Chinook) and one resident (chub) in relation to discharge regime (observed vs. unregulated).

Winter Bankfull Flow Pulses

General recommendations

Bankfull flows typically occur from mid-November to early March (Fig. 12). Both groups extensively discussed the definition of “bankfull” flow. Most considered the pre-regulation bankfull flows to be the hydrological process that shaped much of the modern channel and floodplain and the most important geomorphic context for maintenance of channel morphology. However most recent determinations of bankfull flows are based on post-regulation hydrographs. An additional, important point is that bankfull flows in the Willamette River System are defined by the National Weather Service based on perceived risk of flood damage rather than a hydrologic analysis of return intervals for flows that fill the active channel. Bankfull flow is a hydrologic concept and the group recommended that its determination be based on hydrologic analysis by either the U.S. Army Corps of Engineers or the U.S. Geological Survey. There was a consensus that bankfull flow in the Middle Fork is at least 19,000 - 20,000 cfs, and most felt that it was probably greater (e.g., 25,000 cfs). Bankfull flows tend to occur over longer duration under current flow regulation, but these events do not occur as frequently as they would without regulation.

Winter Bankfull Flow Pulses

Recommendation:

Time period: November 15 – March 15
Number of events: 1-5 based on precipitation events
Magnitude range: 19,000 – 25,000 cfs
Duration: Mimic duration of unregulated events

Related ecosystem functions:

Provide flows for downstream migration of juvenile salmon and smolts
Create lateral habitats on floodplain margin
Transport sediment and create new pools and riffles
Create new floodplain surfaces through bar development
Smooth transitions after winter high flow events are required for aquatic communities to move between lateral refuges

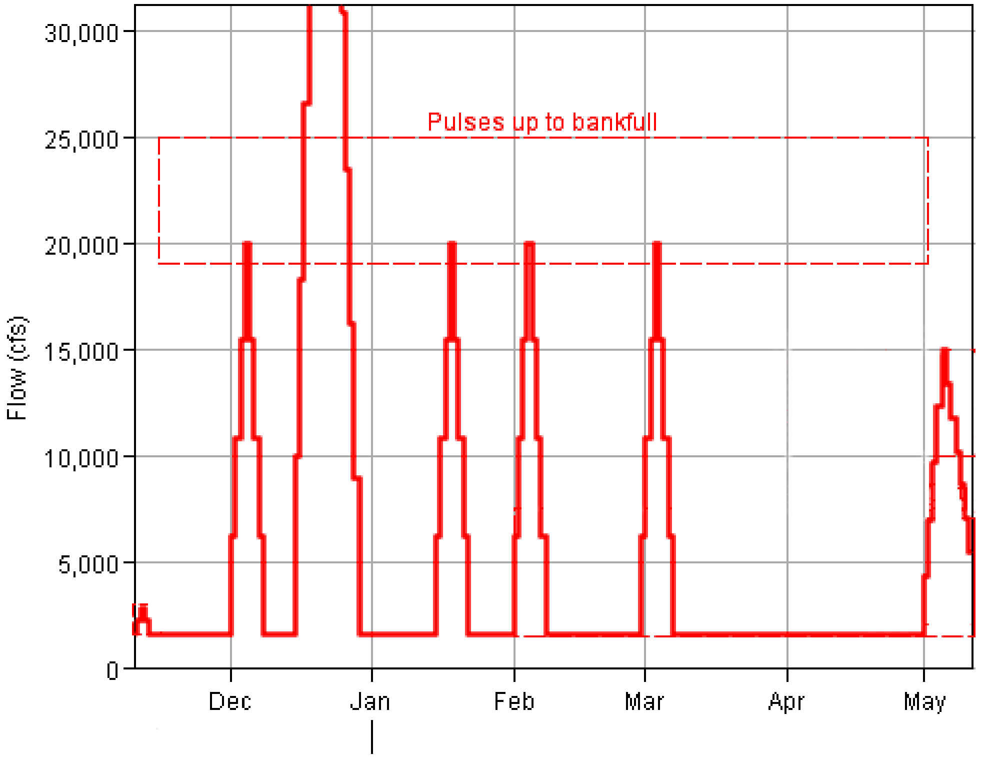


Figure 12. Hydrograph of representative flows that approach or slightly exceed bankfull flow.

<u>Aquatic species group</u>

Most of the biological flow recommendations during this late fall/winter season focus on outmigrating Chinook salmon and other anadromous species and center around achieving flows that approach bankfull. These bankfull flows are also important for opening and maintaining side channel and backwater habitat for a number of species, including Chinook salmon, lamprey, and chub. The group estimated that these near-bankfull flows ranged from 20,000 cfs to 25,000 cfs. Temperature may also be a factor, especially during late winter bankfull pulses if reservoirs store water and alter the temperature downstream with large volumes of water at temperatures different than the river would normally exhibit.

Flows of this magnitude correspond to a “high winter flow event” and sometimes are referred to as flushing flows. These flows create ephemeral habitats. At first, some participants hypothesized that these flows might “cleanse” the system of disease. A fish pathologist attended on the second day and doubted that there was adequate data from the Willamette River to support this idea.

Thorough knowledge of geomorphic relationships is necessary to design bankfull flows. Mapping of floodplain elevations (or topography) is necessary to understand the extent and timing of inundation. The sharp rise and slow recession are important for aquatic species with eggs attached to submerged/emergent vegetation (e.g., insects, frogs, fish). A smoother and concave-shaped recession limb is important to provide continual access to low velocity refuges (especially floodplain margins) and to minimize stranding. Historical hydrographs (pre-regulation) provide a model for designing the duration and recession rates for these events. Interannual variability of these flows is ecologically important and should be related to natural flow conditions upstream of the dams and in unregulated tributaries. Floodplain restoration is also critical for these flow events to be ecologically effective.

Oregon chub are positively and negatively affected by these floods. The floods create new habitat and redistribute chub populations, but they also can introduce exotic species into areas from which they are presently excluded. Chub may be negatively affected at flows above 19,000 cfs. Several participants were concerned that maintenance of artificial flows to limit the distribution of exotic species was not ecologically consistent and would be unlikely to be successful in preventing introduction of exotic species over the long term.

Floodplain/plant group

The group considered bankfull flows to be extremely important in shaping the active channel and floodplain. Such floodplain and bar formation is critical for development of surfaces for regeneration of cottonwood and other riparian plants. The range of flows recommended for bankfull discharge was 19,000 cfs to 25,000 cfs. Implementation of such flows would be tied to natural flood events. Flow managers would need to develop criteria for conditions under which these pulses would be implemented. The timing, duration, and recession patterns of these flows would need to mimic unregulated flows to the extent possible. The group emphasized that such flows were extremely frequent prior to flood regulation, and current estimates of bankfull flows are probably underestimates. Such flows do not need to be above 20,000 each year but should vary within the window of natural hydrologic variability.

Some suggested that a larger pulse may be necessary to have these smaller pulses succeed in their ecological/geomorphic objectives by mobilizing sources of sediment from adjacent floodplains to be redistributed by lower flows. In wet years, managers should consider pulsing to bankfull flows for no more than 3 days, then reducing to lower discharge for a few days, then pulsing back to bankfull flows for no more than 3 days to reflect small flood durations under unregulated conditions. This pulsed flow may develop sediment availability for gravel bar formation, channel migration, and riffle and pool development in a meandering river. Hydrologic records should be analyzed to statistically determine the number and appropriate duration of these pulses that occurred in unregulated conditions. The group recommended use of IHA to help determine number of these small spikes per year or the number of days they are at 110% of bankfull.

The group discussed possible test sites, such as the reach below Hills Creek Reservoir. Implementation would require river managers to work with communities and agencies to maintain and restore locations where bankfull and slightly higher floods can occur to provide ecological benefits.

Small Floods Above Bankfull (Bankfull to 2-yr unregulated floods)

General recommendations

The floodplain/plant group discussed the geomorphic and ecological roles of small floods that are slightly higher than bankfull flows, specifically 25,000 to 40,000 cfs. These would be floods of less than 2-yr recurrence intervals under unregulated flow regimes, but now would range from 2-yr to 100-yr recurrence flows under existing flow regulation because of the flattening of the flood frequency through flow management (Fig. 4). These floods typically would occur during November through February. It is likely that small floods above bankfull historically influenced channel form and perhaps cause more reshaping of floodplains than the flows less than bankfull. The group did not reach consensus on recommendations for flow management for these flows, therefore the RPT plots do not have any representation of these flows. The aquatic group supported the ecological significance of such flows in the final integration discussion but they did not discuss these types of flow events within their working group sessions. Both groups noted that small floods above bankfull discharge would benefit cottonwood and early successional stages of floodplain plant communities by creating bare surfaces.

Much of the discussion above applies here as well concerning habitat creation for juvenile rearing, ephemeral habitat, concerns due to stranding, important of recession curve shape, duration etc.

Small Floods Above Bankfull Flow

Recommendation:

No consensus recommendation
Time period: November 15 – March 15
Magnitude range: 25,000 – 40,000 cfs

Related ecosystem functions:

Transport sediment and create new pools and riffles
Create new floodplain surfaces through overbank erosion and deposition
Create new floodplain surfaces through bar development
Creates surfaces for regeneration of cottonwood and other riparian trees

Large Winter Flood (2-yr to 10-yr unregulated flow)

General recommendations

The floodplain/riparian plant group also discussed the geomorphic role of floods that historically recurred every 2 to 10 years but now have been reduced in frequency to once every 100 to 200 years (Fig. 13; also see Fig. 4). These flows typically occurred in December through early February and the magnitudes ranged from 40,000 cfs to 80,000 cfs on the Middle Fork. These larger floods were more likely to be major influences on floodplain structure and processes under unregulated, historical flow regimes. Under present conditions, they undoubtedly would modify channels and floodplains, create new channels, mobilize sediment deposits in the valley, and cause extensive deposition of sediments on floodplains. While these processes have geomorphic and ecological relevance, it was also noted that they would cause damage to infrastructure built within the historical floodplain. Managing flow to permit more frequent occurrence of these historically common floods presents many challenges. While the group was charged with identifying the physical and ecological importance of different flow regimes, it also noted that intentional management to allow these flows may not be feasible and at the very least would require extensive preparation with communities along the river to prepare for such flow events. These flows were discussed primarily by the floodplain/plant group, though the aquatic species group cautiously supported the ecological relevance of such flows in the integration session. The implications and feasibility of such flows can be studied further within the Corps' floodplain study.

Large Winter Floods

Recommendation:

No consensus recommendation
Time period: November 15 – March 15
Magnitude range: 40,000 – 80,000 cfs

Related ecosystem functions:

Create new floodplain surfaces through overbank erosion and deposition
Create new floodplain surfaces and channel complexity through channel avulsion
Create new floodplain surfaces through bar development
Creates surfaces for regeneration of cottonwood and

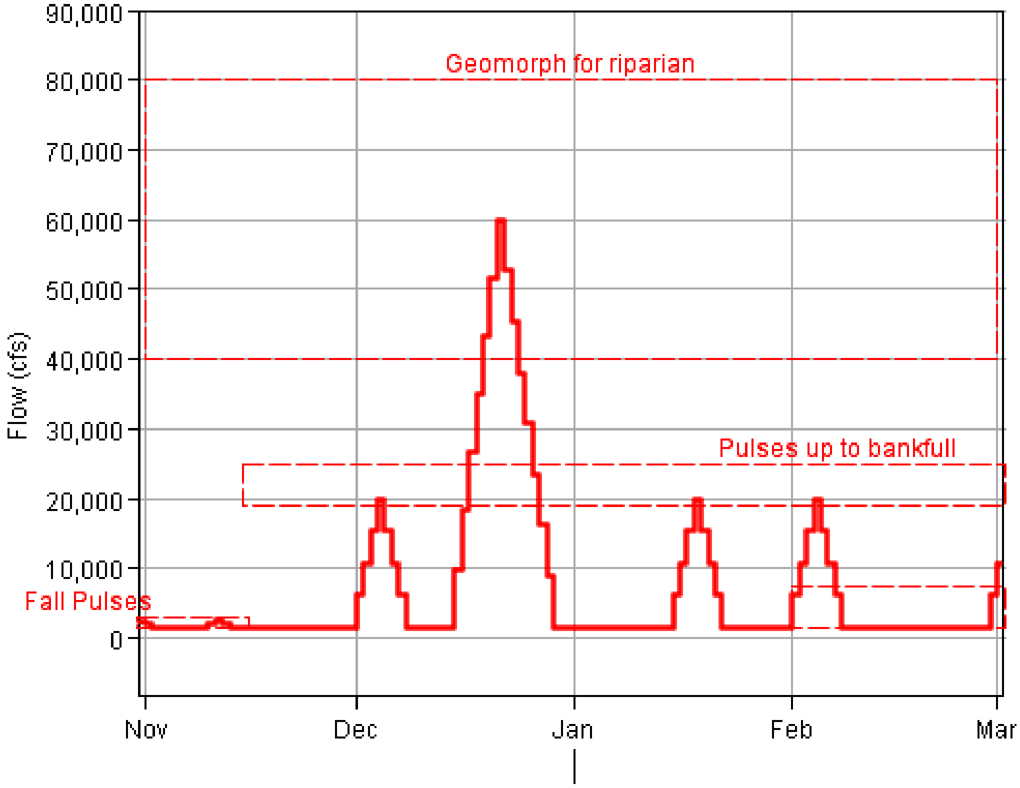


Fig. 13. Hydrograph of representative small flood (2-yr to 10-yr unregulated flow).

Spring Pulse Flow

General recommendations

Both groups independently identified the ecological importance of the spring transition period between winter base flow and summer low flow. In addition to spring flow pulses, the rate of recession in spring is an extremely critical hydrologic influence on many aquatic and terrestrial species.

Spring Flow Pulses

Recommendation:

Time period: March 1 – July 1
Number of events: 1-5 based on precipitation events
Magnitude range: 4,000 – 15,000 cfs
Duration: Mimic duration of unregulated events

Related ecosystem functions:

Provide flows for downstream migration of juvenile salmon and smolts
Create lateral habitats on floodplain margin
Disperse seeds and establish cottonwood seedlings
Smooth transitions after winter high flows are required for aquatic species to move between lateral refuges

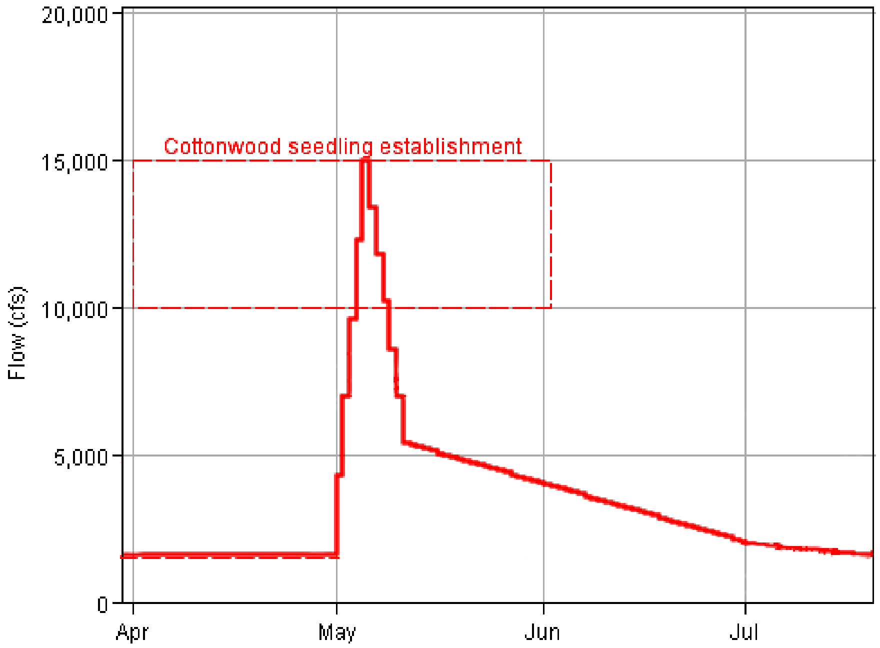


Fig. 14. Hydrograph of representative spring pulse.

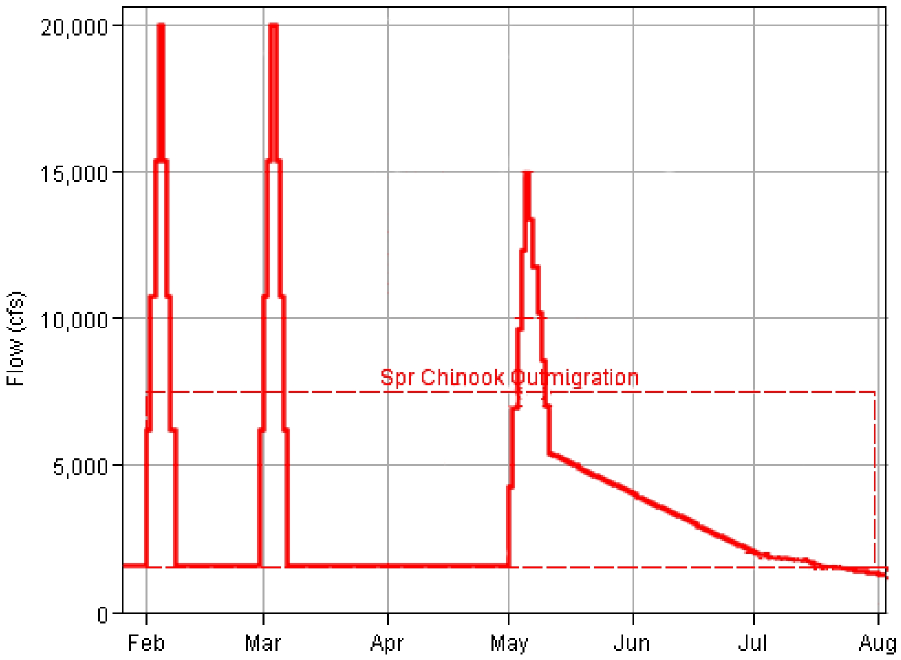


Fig. 15. Hydrograph of flows required for migration of juvenile Chinook salmon and smolts in spring.

Aquatic species group

Spring pulse flows occur from late February through early July and include the spring-to-summer transition period (see transition discussion below). The magnitude of spring pulses was not specified but the group suggested using historical flow records and estimates of current unregulated flow as a basis for designing these flow regimes (Fig 14 and 15). These flows are important keys for outmigration of juvenile Chinook salmon from early spring to June/July. These pulses also increased the availability of side channel and alcove habitats for migrating fish species. Cooler temperatures associated with these spring pulses will benefit native species but not introduced non-native species. The group noted that spring pulses could adversely affect Oregon chub populations by disturbing chub populations during spring spawning and introducing non-native predators (Fig. 11). Status of Oregon chub has been exacerbated by elimination of extensive floodplain forests and introduction of non-native predators. Oregon chub require low velocity habitats with extensive vegetation. Dispersal along floodplains may be hindered if chub must disperse through exposed open-water habitats.

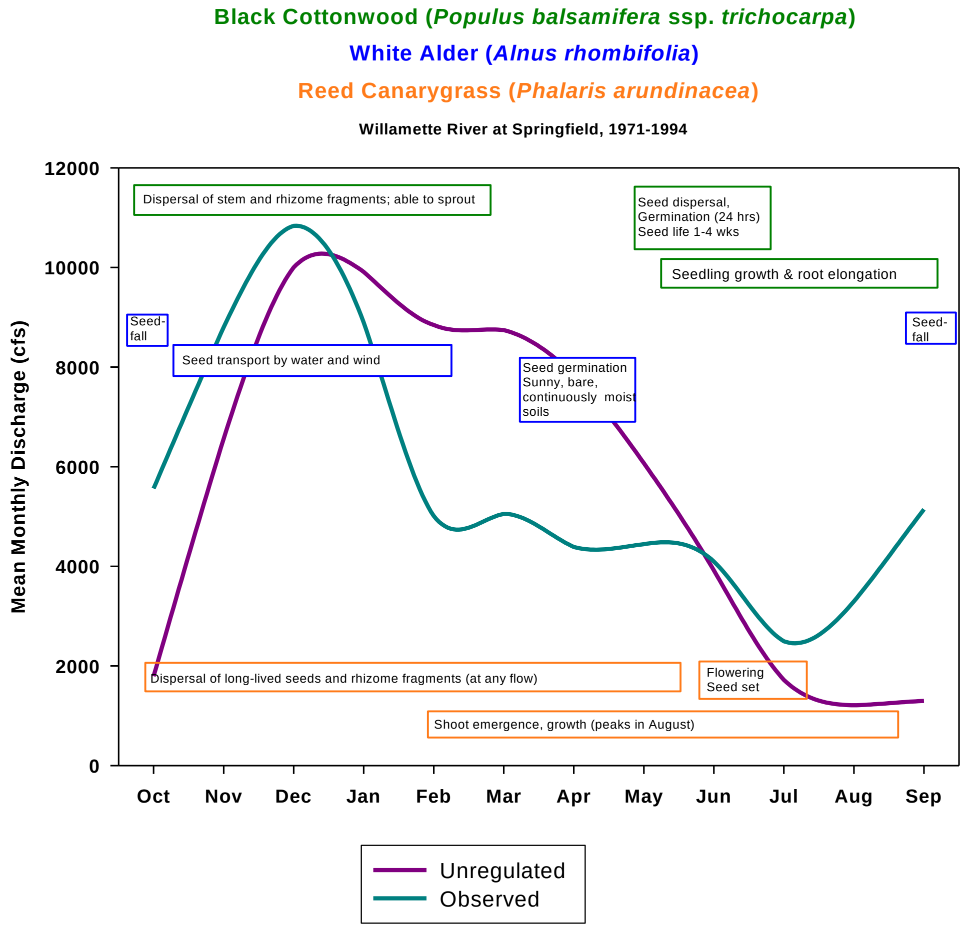


Figure 16. Life history stages and timing of three floodplain plant species (two trees and one grass) in relation to discharge (observed and unregulated).

Floodplain/plant group

The group agreed that spring pulses were important for establishment of cottonwood seedlings and other native floodplain trees such as Oregon ash, Pacific willow, and white alder (Fig. 16). Such flows would approach 10,000 to 15,000 cfs. The pulse generally occurs between April and May and precedes the gradual recession from May through July. Spring pulses are not required every year for cottonwood but should occur at least every few years.

Spring to Summer Transition

General recommendations

Timing and rate of seasonal transitions between high flow and low flow (or vice versa) are extremely critical for aquatic ecosystems and riparian communities (Fig. 16 and 17). Abrupt decreases in discharge strand organisms, alter the survival of seedlings, expose fish to predators, and displace native species from their habitats. This property of hydrologic regimes is simpler to manage effectively than more unpredictable and powerful high flows.

Spring to Summer Transition Flow

Recommendation:

Time period: March 1 – July 1
Magnitude range: 5,000 down to 1,500 cfs

Related ecosystem functions:

Rate of drawdown in spring is critical for seed dispersal and cottonwood seedling establishment
Smooth transitions after winter high flows are required for aquatic species to move between lateral refuges
Use of floodplains and near channel environments for wildlife reproduction requires gradual recession rates

Aquatic species group

The timing and rate of flow recession are critical to minimize stranding of juvenile fish of both out-migrating and resident species. Historical unregulated flows in this season did not exhibit abrupt decreases in flows, but such abrupt changes now occur as reservoirs begin to fill in early summer. The group recommended smoother, longer transitions to summer low flow. The group also noted that flow management in this season should be closely tied to floodplain restoration because of past loss of available wetted area, simplification of edges for rearing and holding, and loss of riparian forest and plant cover. Both flow and habitat interact to create important low velocity areas.

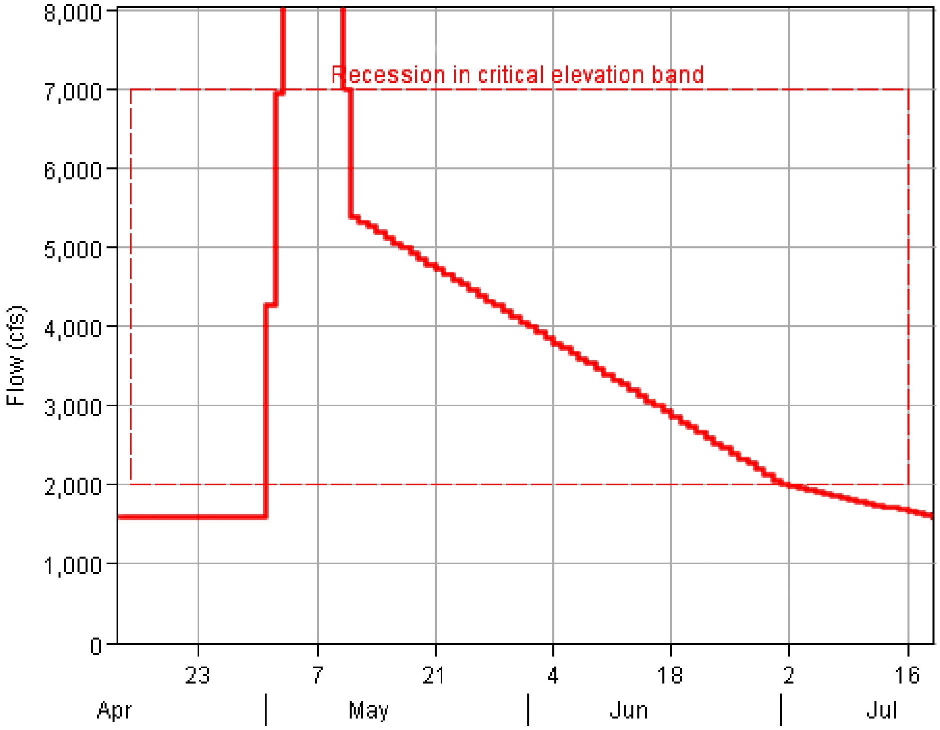


Fig. 17. Hydrograph of spring recession from winter base flow.

The timing of this flow includes the 1 May to 1 July period when returning adult Chinook migrate upstream. State fisheries agencies have recommended flows of 4,000 cfs on 1 May in the Middle Fork. Flow regimes at his time of year also have major consequences for water temperature. In addition to meeting these general flow targets, the group felt that gradual rates of recession were critical.

Chub spawning from 1 June to end of July is most successful at a temperature range of 15˚C to 18˚C. Colder water associated with high flows decreases spawning success, however higher temperatures promote earlier bass spawning leading to increased predation on chub. Flows between 1,000 cfs to 19,000 cfs are suitable for Oregon chub in this season.

Most of the flow management in this season focuses on in-channel species. Some concerns were raised about high flows in spring and early summer. Western Pond Turtle can become isolated if flows stay too high. Nests are constructed in June and July, but high flows hinder migration movement to nest sites away from the main channel.

Floodplain/plant group

The flow magnitude in the transitional season from winter base flow to summer low flow is critical for the distribution of seeds of cottonwood and other riparian plants (e.g., Oregon ash, Pacific willow, white alder, bigleaf maple) and the rate of recession from high flow to low flow is a critical determinant of seedling survival. Discharge should be gradually decreased, allowing roots to keep up with the dropping water levels in the floodplain and riparian soils. Most studies have occurred on other rivers and a better understanding of the flow requirements of dominant floodplain species in the Willamette River is needed.

Summer Base Flows – Transition from late spring to end of summer

General recommendations

Summer low flows have been artificially augmented by reservoir releases to meet navigation requirements and dilute pollutants to maintain water quality (e.g., dissolved oxygen, temperature). Current operations decrease flows to a minimum in June and then increase flows to two to three times higher than historical flows by August or September. Both groups felt that this low flow alteration is likely to be ecologically detrimental. The degree to which the hydrograph can be shifted toward historical summer base flows is a complex issue and will require attention by several agencies and affected communities. Better understanding of these impacts and appropriate analytical tools are needed to determine ecologically effective low flows. Both groups agreed that river management should at least follow the overall pattern of pre-dam hydrograph, if not its magnitude (Fig. 18). The groups also felt that flows in non-regulated tributaries could serve as a guide for rates of flow decline.

Summer Base Flow

Recommendation:

Time period: June 1 – October 1
Magnitude range: 1,000 – 2,000 cfs

Related ecosystem functions:

Increases in summer low flows after drawdown may negatively affect terrestrial and aquatic species with critical habitats close to the river margin
Riparian plant seedlings near channel margins may be eliminated by inundation in late summer
Nesting shorebird species may have nests inundated by rising river levels

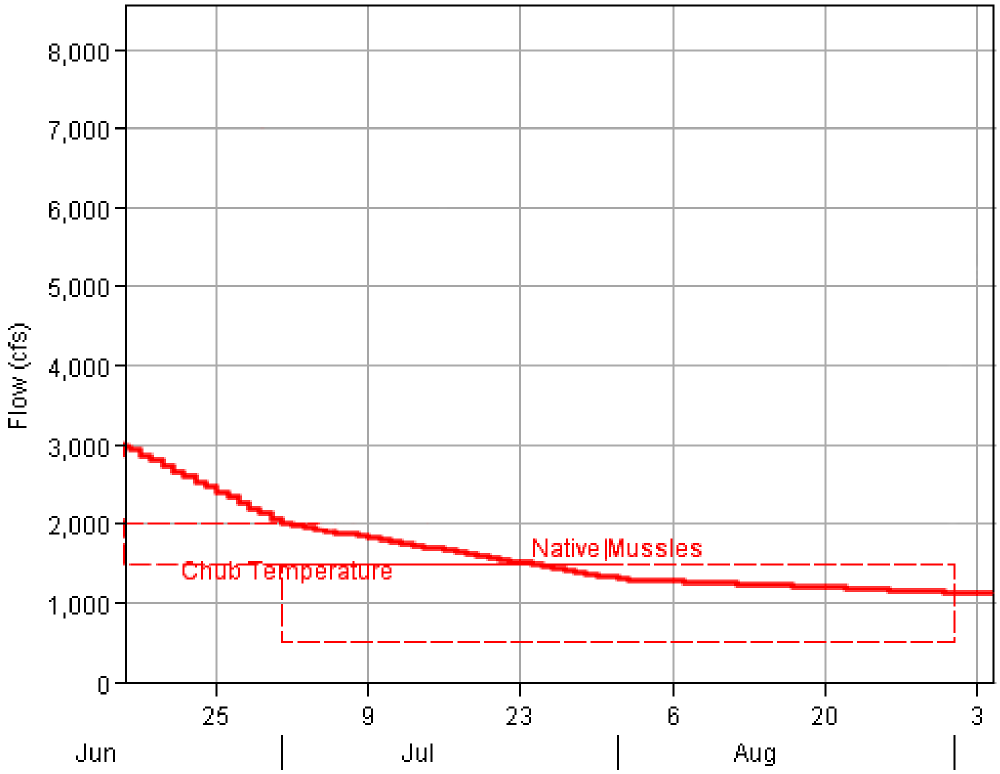


Fig. 18. Hydrograph of summer base flow.

<u>Aquatic species group</u>

Summer base flows are critical to numerous aquatic species. Adult spring Chinook will be holding in the river during summer. These fish are adapted to the historical summer base flow conditions, generally less than 2000 cfs. Freshwater mussels require flows of approximately 1,000 cfs for settlement. Flows also must be adequate for movement of coastal cutthroat trout, in part because trout serve as important intermediate hosts for mussels. Flows for Oregon chub should be between 1,200 cfs and 4,000 cfs during this season, with no ramping, spikes or abrupt decreases.

Flows required by Western Pond Turtles will be similar to flows required by adult salmon. Western Pond Turtle can become isolated if flows stay too high; high fast flows preclude migration movement. Slow gradual flows allow movement and successful reproduction of turtles. Numerous species lay eggs on emergent vegetation (e.g., invertebrates, frogs) and shifting flows can detrimentally affect aquatic communities. Augmented summer flows and stairstep ramps and decreases are likely to negatively affect aquatic ecosystems.

Loss of cold water refuges may be important in the Willamette. Higher summer base flows may be pushing organisms away from historic sites. Bacterial pathogens are also a major concern for fish communities in late summer. High summer flows also may alter the temperature regimes of the off-channel habitats. Better understanding of the thermal dynamics is needed.

Floodplain/plant group

Nearshore survival of riparian species and vegetation may be adapted to these lower summer discharges, and present augmentation may be detrimental. Studies of floodplain plant communities during the spring and summer are badly needed. The lowering of flows and then increasing two to three fold may harm nesting birds along the shorelines. On the other hand, current flows that are two to three times higher than historical flows may deter expansion and recruitment of invasive species, such as reed canarygrass and knotweeds. Again, studies of the Willamette River are needed.

Temperature management is complex in summer. Low flows may protect cold habitats at this time of year. Higher releases from the dams may create greater mixing and loss of cold water habitat. Current low flow augmentation may inundate areas that would otherwise have extensive hyporheic interactions. Substrate composition is now also different from historical conditions. More research is need on the dynamics of cold water habitats.

The group recommended gradual decreases over summer rather than a stairstep shape and that once a minimum flow is reached (at whatever level is chosen), river management should strive to maintain a relatively stable flow rather than increasing flows throughout the summer. The summer base flow of 1,000 cfs could serve as an initial target based on historical hydrograph.

Summary Hydrograph – Illustration of flow requirements for Middle Fork Willamette River

The working groups in the Environmental Flow Workshop identified several critical flow requirements for aquatic ecosystems of the Middle Fork of the Willamette River. The changes that would be required for the regulated flows are illustrated in Fig. 19 and 20. A hydrograph that would meet the recommendations of the Middle Fork Willamette flow workshop was developed based on USGS gauging station data for water year 2003. The modeled unimpaired hydrograph is compared to the 2003 regulated hydrograph. The portion that contributes to the recommended hydrograph and would not require major modification from current operations is illustrated as a solid red line. The portion of the recommended hydrograph that would require modification from the regulated hydrograph is illustrated as a solid green line. Periods that would require modification to meet the recommendations are illustrated as a dashed red line.

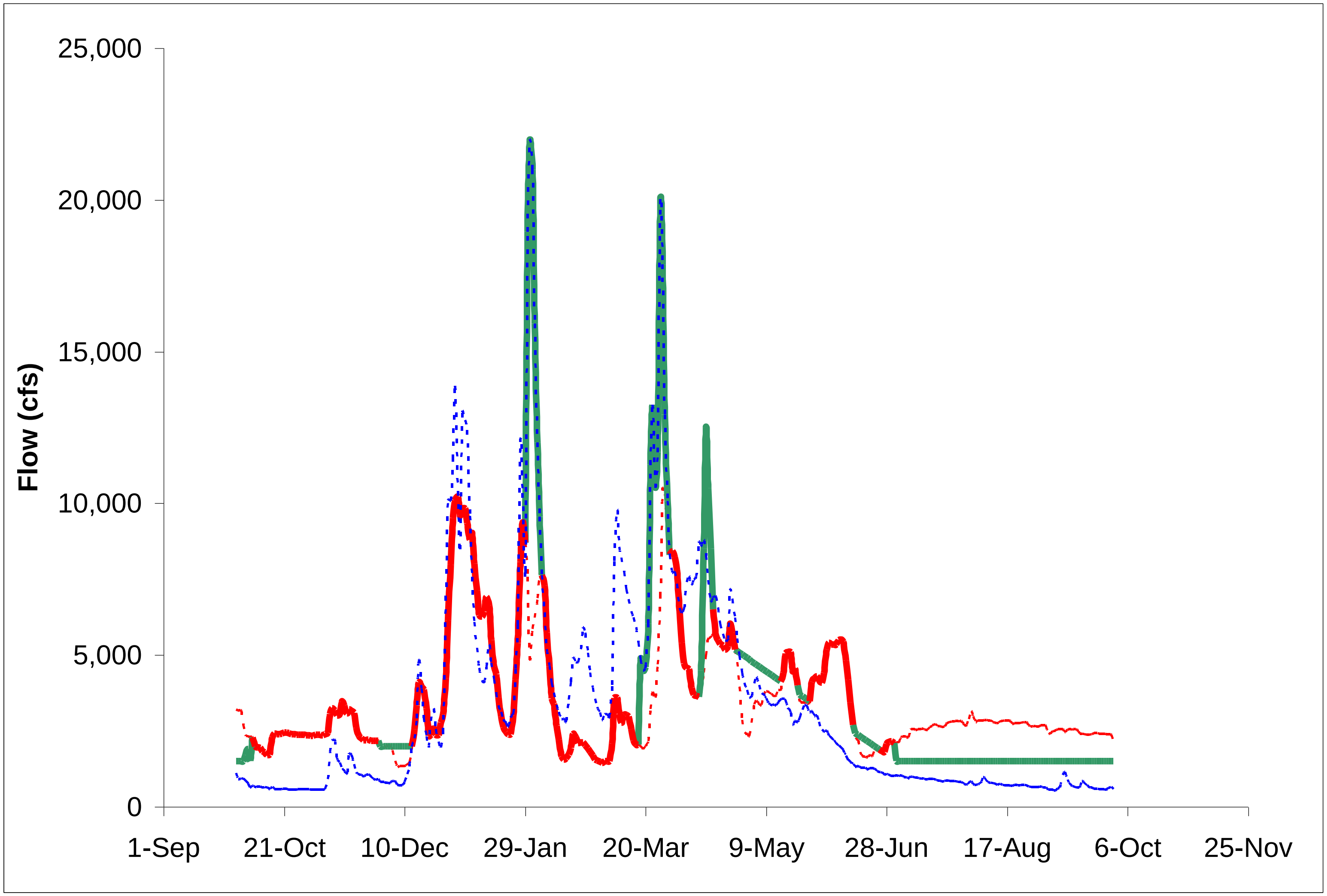


Fig. 19. A hydrograph that would meet the recommendations of the Middle Fork Willamette flow workshop (based on water year 2003 for the Middle Fork of the Willamette). Dashed blue line is the modeled unimpaired hydrograph. Solid red line is the portion of the 2003 regulated hydrograph that contributes to the recommended hydrograph. Solid green line is the portion of the recommended hydrograph that would require modification from the regulated hydrograph. The dashed red line shows the regulated hydrograph during those periods when it would require modification to meet the recommendations.

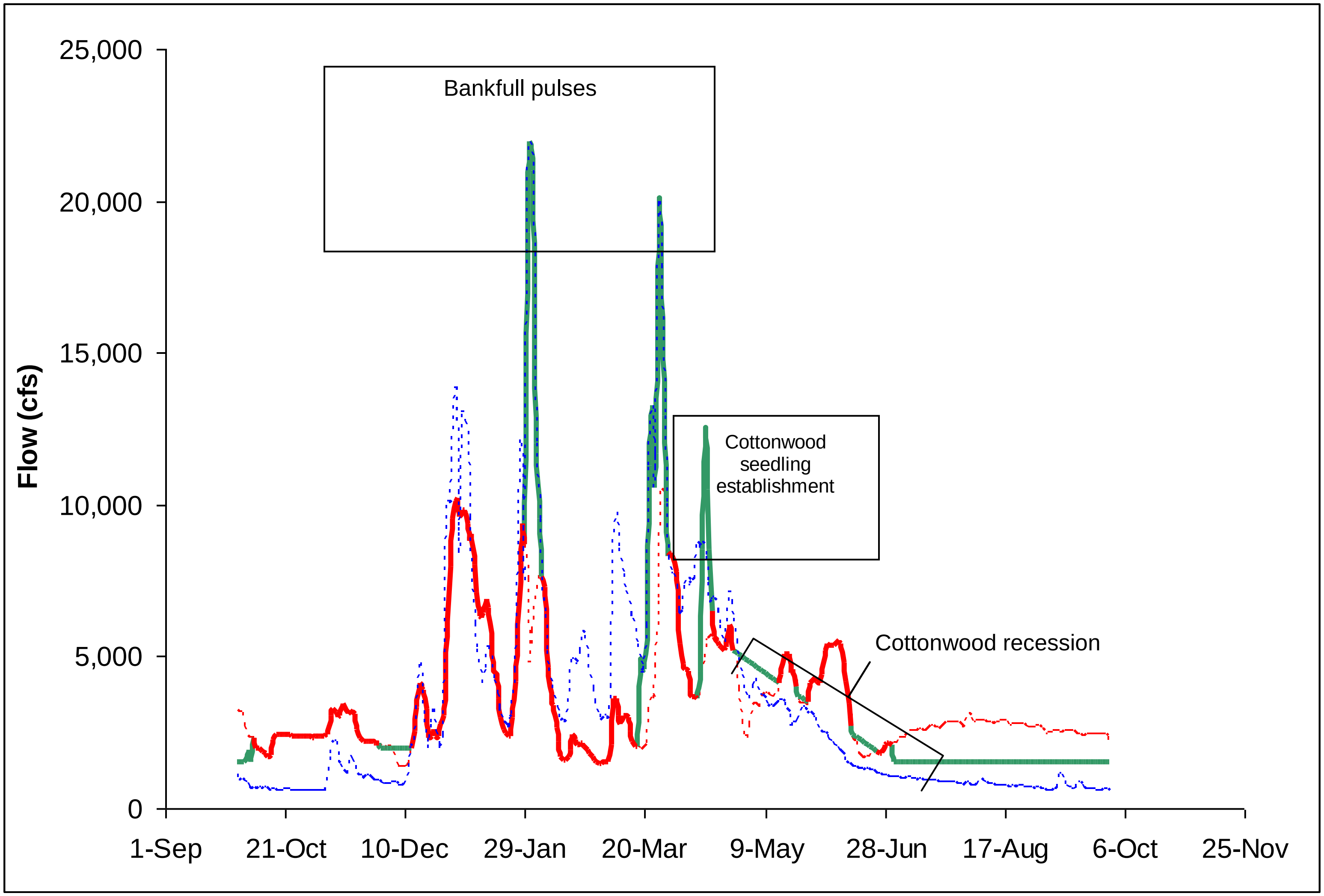


Fig. 20. Illustration of selected periods of ecological flow requirements for the hydrograph for water year 2003 that would meet the recommendations of the Middle Fork Willamette flow workshop (from Fig. 20).

Coast Fork Willamette River

The groups did not have adequate time to discuss management of the Coast Fork. Several participants suggested that the flow regimes in the Coast Fork have not been modified as extensively as flows in the Middle Fork and that flow management issues were not as critical in the Coast Fork. Several participants from the Coast Fork watershed did not agree and indicated that more focused attention should be devoted to flow management in the Coast Fork.

Uncertainties, Data Gaps and Research Needs

Influences of bankfull flows and small floods on floodplain maintenance and development

One of the most critical questions to emerge from the workshop was the relative importance of bankfull flows (19,000 to 25,000 cfs) compared to small winter floods (higher than bankfull; 40,000 cfs to 80,000 cfs) for creating and maintaining the floodplain. There is no doubt that bankfull flows can reshape the active channel on a frequent basis. But the geomorphic literature indicates that both bankfull flows and small floods have to potential to shape floodplains. The extensive erosion, avulsion, and deposition of sediments during small floods have sufficient power to create large floodplains. On the other hand, bar formation and development, followed by depositional events, can create floodplain surfaces on the inner bank of meanders during flows that approach or slightly exceed bankfull conditions. There are no definitive studies of the historical or current relative importance of these two processes in the Willamette River. Studies of floodplain surfaces and stratigraphy could answer the historical question and serve as a context for flow management decisions. On-going monitoring could quantify and map the development of floodplains through bankfull flow processes. The goals of the flow management recommendations are more readily achievable if the bankfull flow processes are sufficient to effectively create and maintain floodplain surfaces and features such as side channels, bars, and alluvial deposits for regeneration of riparian trees.

Technical basis for determination of bankfull flow

A second important question raised in the workshop was the technical basis and operational procedure for determining the magnitude of bankfull flows as a basis for flow management. Currently, bankfull flows in the Willamette River System are defined by the National Weather Service based on perceived risk of flood damage. The participants recommended the U.S. Army Corps of Engineers to develop a hydrologically-based analysis of return intervals for flows that fill the active channel (possibly in collaboration with the U.S. Geological Survey). Most participants also felt that the current estimate of bankfull flow in the Middle Fork is likely to be an underestimate based on hydrologic record and current channel morphology. Integration of hydrologic and geomorphic factors could better establish appropriate criteria for this critical hydrological characteristic. This is an important design criterion for flow management in the entire Willamette River system.

Another issue that needs additional information is the regeneration, establishment, and survival of floodplain plant communities. Most available studies indicate that flow levels during all seasons and rates of transition between high flow and low flow are critical for reproduction, growth, and survival. But studies of the species in the Willamette River and its floodplain sediments and flows are almost non-existent. This is a critical resource that could be jeopardized by continued alteration of hydrologic regimes in the Willamette River.

Responses of aquatic and terrestrial biota to flow in the Willamette River

Several species of concern (Chinook salmon, Oregon chub, Western Pond Turtle) may have requirements for critical habitats, water quality, access and movement, and refuge from disease. Very little specific flow information is available for these species. As flow operations are modified, well-designed experiment and observations about the responses of these species could demonstrate the effectiveness of flow modifications and inform future flow management decisions.

Flow management must also be coordinated with programs to restore the simplified floodplains and severely diminished extent of native floodplain plant communities. Flow management is inherently integrated with the structure of the floodplain and nature of the riparian forest communities. Studies of the efficacy of restoration approaches will increase the likelihood that modified flows will have the desired improvements in aquatic and terrestrial ecosystems.

Timeframes for potential uncertainty

Following the workshop, the authors of this report attempted to illustrate the times within the flow regime when the consequences of flow modification or the uncertainties about ecological responses to altered flow regimes may be greater. This illustration is provided to stimulate discussion of management options, but was not part of the working group discussions in the flow workshop.

The following graphical illustration of uncertainty is based on the assumption that the potential for adverse ecological effects increases proportionally with change from the long-term averages for either maximum, mean, or minimum flows (Fig. 21). Additionally, it assumes that these effects or uncertainties are additive and are based on proportional change in either low flow, mean flow, or maximum flow (in contrast to absolute differences in flow). We calculated the proportional change in maximums, means, and minimums for mean daily flow (Fig. 3) based on the difference between the unregulated flow regime and the regulated flow regime. The stacked graph illustrates the additive proportional change in the flow regime based on the sum of the proportional changes for maximum, mean, and minimum flow. Fundamentally, this graph illustrates the extent of modification of the major components of the natural flow regime----low flow, mean flow, and maximum flow.

Two periods of the water year exhibit regulated flows that do not greatly differ from the unregulated hydrograph—winter base flow (mid-December through late January) and spring transition flow (early June through mid-July). The late summer through late fall flows have been modified the most on a proportional basis. These flows primarily reflect the effect of flow augmentation, especially for mean and minimum flow (Fig. 3). Late winter flow also exhibit substantial flow modification through flood storage and reduction in discharge relative to the unregulated hydrograph.

This analysis of proportional changes in the maxima, means, and minima for mean daily flows over the water year identifies the times of the year during which flows in the Middle Fork of the Willamette River are similar to unregulated flows and the time during which the flows are proportionally greater or lower than unregulated flows. These times of substantial change are related to ecological processes identified in the Environmental Flows Workshop and described in the previous section of this report. This analysis does not identify the magnitude of changes or ecological impacts.

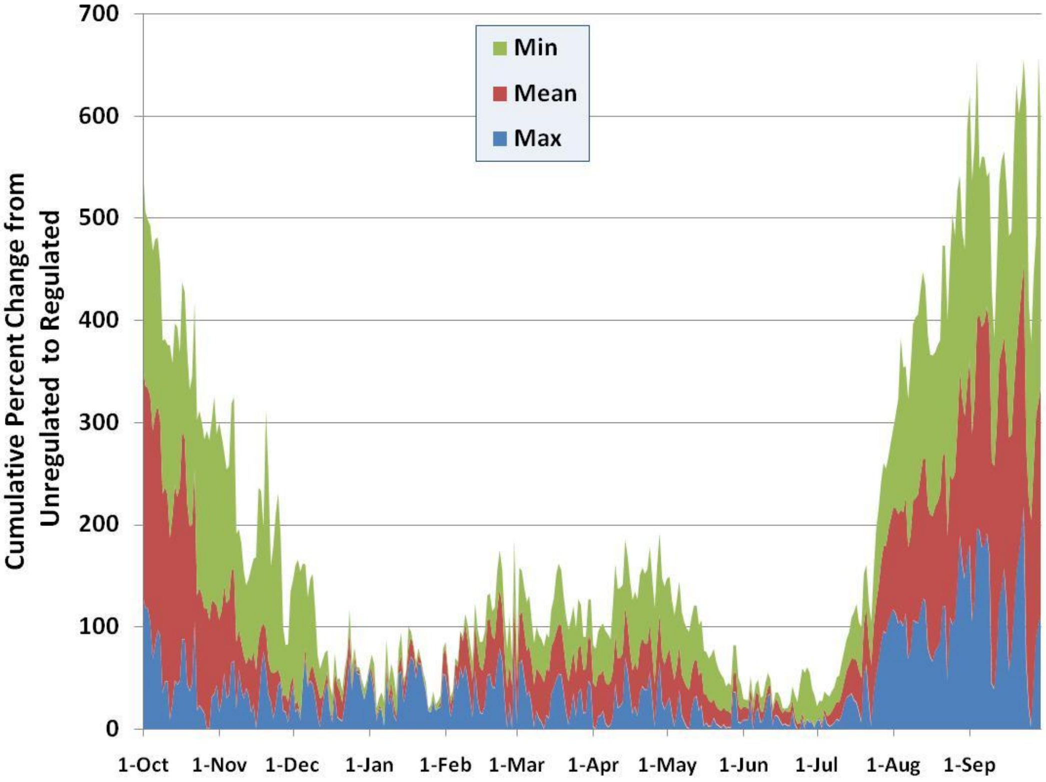


Fig. 21. Proportional changes in the maxima, means, and minima for mean daily flows over the water year in the Middle Fork of the Willamette River (comparison of mean daily flows for regulated and unregulated hydrographs).

Willamette Environmental Flows Workshop Attendees
January 16-17, 2007

First	Last	Organization	Working Group
Amman*	Julie	U.S. Army Corps of Engineers	Channel, riparian, floodplains
Ashkenas	Linda	Oregon State University	Aquatic species
Bach***	Leslie	The Nature Conservancy	Aquatic species
Bass	Art	Willamette Riverkeepers	Aquatic species
Bartholomew	Jerri	Oregon State University	Aquatic species
Bauer	John	The Nature Conservancy	Aquatic species
Beal	Kat	U.S. Army Corps of Engineers	Aquatic species
Beechie	Tim	NOAA Fisheries	Channel, riparian, floodplains
Bernstein	Laurie	U.S. Forest Service	Channel, riparian, floodplains
Blazer	Jason	Friends of Buford Park	Channel, riparian, floodplains
Burchfield	Stephanie	NOAA Fisheries	Aquatic species
Cerra	Josh	David Evans and Associates	Channel, riparian, floodplains
Domingue	Rich	NOAA Fisheries	Channel, riparian, floodplains
Duffe*	Bruce	U.S. Army Corps of Engineers	Aquatic species
Dykaar	Bruce	Ecohydrology Northwest	Channel, riparian, floodplains
Ferber	Bill	OR Water Resources Department	Aquatic species
Fitzhugh	Tom	The Nature Conservancy	Channel, riparian, floodplains
Gagnon*	Paula	The Nature Conservancy	Aquatic species
Garletts	Doug	U.S. Army Corps of Engineers	Aquatic species
Gramlich	Nancy	OR Dept of Environmental Quality	Channel, riparian, floodplains
Gregory	Stan	Oregon State University	Channel, riparian, floodplains
Hickey**	John	U.S. Army Corps of Engineers	Channel, riparian, floodplains
Kanbergs*	Karl	U.S. Army Corps of Engineers	Channel, riparian, floodplains
McConnaha	Chip	Jones and Stokes	Aquatic species
Montanaro	Eve	Middle Fork Willamette Watershed Council	Channel, riparian, floodplains
Mullan	Anne	NOAA Fisheries	Aquatic species
Opperman**	Jeff	The Nature Conservancy	Aquatic species
Ott*	Mike	U.S. Army Corps of Engineers	Channel, riparian, floodplains
Petersen	Erik	U.S. Army Corps of Engineers	Channel, riparian, floodplains
Pope	Michael	OR Dept of Fish and Wildlife	Channel, riparian, floodplains
Rea***	Matt	U.S. Army Corps of Engineers	Channel, riparian, floodplains
Reber*	Pam	Coast Fork Watershed Council	Channel, riparian, floodplains
Reis	Kelly	OR Dept of Fish and Wildlife	Aquatic species
Scheerer	Paul	OR Dept of Fish and Wildlife	Aquatic species
Scullion**	Mary Karen	U.S. Army Corps of Engineers	Aquatic species
Seymour	Kim	David Evans and Associates	Channel, riparian, floodplains
Simmons	Mindy	U.S. Army Corps of Engineers	Channel, riparian, floodplains
Skold*	Jason	The Nature Conservancy	Aquatic species
Soll	Jonathan	The Nature Conservancy	Channel, riparian, floodplains
Taylor	Greg	U.S. Army Corps of Engineers	Aquatic species
Tullos	Desiree	Oregon State University	Channel, riparian, floodplains
Wright	Pamela	OR Dept of Environmental Quality	Aquatic species
Ziller	Jeff	OR Dept of Fish and Wildlife	Channel, riparian, floodplains

* Recorder
** RPT Modeler
*** Facilitator

Middle and Coast Forks Willamette River
Environmental Flows Workshop

January 16-17, 2007

AGENDA

January 16, 2007

8:30 Welcome and introductions, review of process, discussion of meeting outcomes - Matt Rea, Leslie Bach

9:30 Overview and Discussion of literature review and flow/ecological analysis - Stan Gregory, Linda Ashkenas, Michael Campana
- Overview of the flow regimes in the Middle and Coast Forks
- Water quality and ecological components of the Middle and Coast Forks

10:15 Discussion

10:45 Summary of synthesis elements, environmental flow components - Stan Gregory, Linda Ashkenas, Michael Campana
- Discussion of differences between Middle and Coast Forks
- Indicators of Hydrologic Alteration analysis
- Regime Prescription Tool

11:30 Discussion

12:00 Lunch (provided)

12:30 Instructions for breakout groups

1:00 Break out groups
Break out groups will be organized around four different ecological aspects: fish and aquatic systems; riparian and floodplain systems; hydrogeomorphology; and water quality. Each group will develop recommended flows based on specific Environmental Flow Components (low flows, flood pulses, small floods and large floods), and will identify significant knowledge and information gaps. Groups will separately address the Middle and Coast Forks.

4:30 Adjourn

January 17, 2007

8:30 Break-out groups complete work

10:30 Presentations by break-out groups

12:00 Lunch (provided)

1:00 Integrate flow recommendations from break-out groups into a single unified set of flow recommendations for the Middle and Coast Forks.

3:00 Meet with Colonel O'Donovan, Corps of Engineer's Portland District Commander, to present flow recommendations

4:30 Adjourn