ASOTIN CREEK INTENSIVELY MONITORED WATERSHED: FINAL PROGRESS REPORT - OCTOBER 15, 2019

Closing of Recreation and Conservation Office Contract 15-1443

South Fork Asotin Creek treatment reach 2019

Prepared for:

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EXECUTIVE SUMMARY

The Asotin Creek Intensively Monitored Watershed project was implemented in 2008. The focal species are naturally reproducing summer steelhead. Based on previous habitat assessments and preliminary IMW monitoring, it was decided that riparian function and instream habitat complexity were impaired. The **long-term** restoration goals are to implement fencing, native plant revegetation, and weed control to enhance riparian function. The **short-term** restoration goals are to add large woody debris (LWD) to increase habitat diversity and promote a more dynamic channel (e.g., increase sediment sorting, pool frequency, and floodplain connection). The IMW is testing the effectiveness of the short-term goals at increasing steelhead production and productivity in Charley, North Fork, and South Fork Asotin Creeks. We implemented the IMW using a staircase experimental design where a different study creek was restored in different years starting in 2012 and ending in 2016. Each stream is divided into three 4 km long sections and one or more sections has been restored in each stream with the remaining sections acting as controls. We have built 654 large woody debris structures at an average density of 4.7 structures per 100 m in the treatment sections. A total of 14 km has been restored (~39% of the study area) and 22 km remains as controls (61% of the study area). We have continued to add LWD to treatment sections as needed based on our adaptive management plan informed by annual habitat survey results. The purpose of adding more wood is to keep the density of wood high in treatment sections compared to control areas to mimic, promote and eventually sustain processes of wood accumulation, creation of habitat complexity and floodplain connection. We are using extensive habitat sampling and fish PIT tagging and resighting to estimate changes in habitat and juvenile steelhead abundance, growth, survival, movement, production, and productivity in each experimental section. There are five passive transponder tag (PIT) interrogation sites within Asotin Creek that are used to monitor adult and juvenile PIT tag steelhead movement in Asotin Creek watershed – three of these sites (ACM, ACB, AFC) were upgraded with new equipment in 2018.

The primary purpose of this progress report is to 1) summarize the work performed as part of the Asotin Creek Intensively Monitored Watershed (IMW), RCO 15-1443 for the period October 1, 2018 to September 30, 2019, 2) update the status of the IMW, 3) describe the intended "path to completion" and future needs of the IMW (including challenges and opportunities), and 4) update the list of outreach and publications generated from the IMW.

Work Performed

- Outreach and knowledge transfer
    - published the low-tech process-based restoration manual
    - presented low-tech process-based restoration manual at the Salmon Recovery Conference in Tacoma, WA
    - presented IMW results and status to the Snake River Salmon Recovery Board Regional Technical Team
    - Led a group of landowners on a tour of the Asotin IMW restoration sites and explained the process and goals of low-tech process-based restoration and post-assisted log structures
    - Co-lead a group of NRCS biologists and engineers on tour of post-assisted log structures to explain restoration method and IMW results
    - Developed preliminary outline for a life history manuscript for Asotin summer steelhead
    - Developed preliminary outline for a life cycle model for Asotin summer steelhead
- Project Management
    - Provided budgets and statements of work for IMW contracts
    - Developed, submitted, revised, and presented proposals to the Salmon Recovery Funding Board to secure restoration funding for increasing wood density in treatment areas in 2020
    - Coordinated with RCO, WDFW, SRSRB, and NOAA on project logistics, funding, implementation, and reporting
    - Coordinated with NOAA and WDFW for fish sampling and stream restoration permits

    - Coordinated with WDFW regarding securing permission to fell trees and thin forest stands and use the wood for building wood structures
- Data Management and Analysis
    - Developed a new fish capture database based on the Columbia Basin PIT Tag Information System's (PTAGIS) P4 data collection application including queries to import and QAQC field data
    - Summarized habitat data and wood structure surveys completed in 2018
    - Downloaded temperature loggers and PIT tag array data, collected discharge measurements, uploaded data and relayed array status to PTAGIS (WDFW lead)
- Monitoring Equipment and Infrastructure Maintenance and Repair
    - Repaired the Cloverland Bridge (ACB) PIT Tag array antennas that were damaged during the 2019 spring flows (WDFW lead)
    - Ordered new fish monitoring supplies and repaired survey equipment
- Monitoring and Data Collection
    - Completed mark-recapture surveys and PIT tagging of juvenile steelhead during summer and fall survey periods
    - Completed habitat surveys using a rapid habitat assessment protocol for 6km of the study area (all fish sites)
    - Completed structure surveys of 14 km of the study site documenting ~750 post-assisted log structures and log jams.

IMW Status and Key Findings To Date

- Experimental design and monitoring infrastructure developed and implementing 12th year of monitoring
- Restoration implemented and adaptive management plan being used to evaluate and adjust the monitoring and/or restoration as needed
- Positive habitat and fish responses to restoration treatments compared to controls
- Streams with larger annual high flows and more available floodplain are responding more than streams with streams with smaller annual flows and less available floodplain
- Responses appear to be flow and stream dependent and changes to instream complexity may result in smaller fish and habitat responses compared to changes due to floodplain connection
- Proposing to add more wood to force greater over-bank flows and increased floodplain connection

Future Needs, Challenges, and Opportunities

- Complete monitoring of at least two life history cycles (by 2020 we will have completed one full life cycle)
- Maintain high contrast between wood density in treatment and control sections (i.e., implement adaptive management plan)
- Challenges are to maintain high quality data stream and complete timely analyses with unpredictable budgets
- Opportunities to partner with University and research funding such as National Science Foundation and other sources to allow continued monitoring
- Asotin IMW presents a valuable opportunity to inform restoration actions across tens of thousands of miles of wadeable streams in US that can help greatly improve riparian extent and conditions, promote recovery of sediment and hydrologic processes that create and maintain habitat complexity and diversity, and increase the production and productivity of ESA listed salmon and steelhead. This IMW also has profound implications related to mitigating climate change impacts due to the potential to cost-effectively limit the impacts of climate change on the flow regime of headwater and wadeable streams

ACKNOWLEDGMENTS

The Asotin Intensively Monitored Watershed (IMW) is a collaborative multi-agency initiative sponsored by the Snake River Salmon Recovery Board (SRSRB). The SRSRB provides oversight and technical review of all the Asotin Creek IMW activities through support from the Regional Technical Team (RTT) and National Oceanic and Atmospheric Administration (NOAA) staff. The majority of the IMW takes place on the Asotin Wildlife Area managed by the Clarkston office of the Washington Department of Fish and Wildlife (WDFW) with portions of monitoring also occurring on land managed by the US Forest Service (USFS) in the Pomeroy Ranger District on

Umatilla National Forest managed by the land. Both the WDFW and USFS have supported the development and implementation of the Asotin IMW since its inception. Steve Martin (former director) and John Foltz (current director) of the Snake River Salmon Recovery Board have been supporters of the IMW and worked continually to help secure monitoring and restoration funds and coordinate between all the stakeholders – the IMW could not have been implemented without their commitment to the project. Keith Dublanica of the Washington State Recreation and Conservation Office (RCO) made sure contracts and funds were always secured to continue this long-term and complex project. Funding for the primary monitoring and reporting components of the IMW are from the NOAA Pacific Coastal Salmon Recovery Fund (PCSRF) and the National Marine Fisheries Service (NMFS) Interior Columbia Basin Office's Federal Columbia River Power System. Funding for restoration activities comes from PCSRF through the State of Washington's Salmon Recovery Funding Board (SRFB), BPA, Conservation Commission, USFS, and WDFW.

We are also grateful for support we receive from Ethan Crawford of WDFW in the form of field staff and data on fish-in fish-out from the Clarkston office to assist the IMW project, and Bonneville Power Administration (BPA) which supports WDFW's efforts to collect fish-in fish-out data in Asotin Creek. Bob Dice, the manager of the Clarkston Wildlife Office, has also provided the IMW with accommodation, transportation, and access since the start of the project. Megan Stewart of the Asotin County Conservation District, Brad Johnson of the Palouse Conservation District, and Dave Karl of the WDFW have also been an indispensable part of the IMW team, working with the local landowners and agencies to help secure access, operating permits, local support, and acting as sponsors for IMW funding. The Asotin County Public Utility Department has provided us with office space and storage for field gear. Del Groat (now retired) and Bill Dowdy of the USFS have provided generous donations of time and large wood for the restoration treatments and Billy Bowles, also with USFS, has helped with safety training for field crews. We also wish to thank the Koch and Thornton families for graciously providing us access to private property along Charley Creek to conduct monitoring and restoration (these properties have since been purchased by WDFW). Bruce Heiner, WDFW Habitat Engineer and Barry Sutherland, USDA Natural Resources Conservation Service (NRCS) Fluvial Geomorphologist provided comments on the earlier versions of the restoration plan. The following groups have provided direct support to the IMW in either goods or services and we wish to thank them for their help with this important fisheries conservation project: Avista Power, Clearwater Power, Collier Electric, Inland Metals Electric, TDS Telecom, WDFW, and USFS.

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1 INTRODUCTION AND SETTING

In 2008, Asotin Creek was chosen as a location to implement an Intensively Monitored Watersheds (IMW) project in southeast Washington (Figure 1 and 2). We are implementing the IMW experiment within an adaptive management framework and have revised aspects of the experimental design, restoration plan, and monitoring based on the iterative evaluation process of adaptive management (Wheaton et al. 2012, Bouwes et al. 2016). An experimental study design has been developed and refined for the Asotin Creek IMW that includes treatment and control sections within the Asotin Creek tributaries of Charley Creek, North Fork Asotin Creek (North Fork), and South Fork Asotin Creek (South Fork; hereafter referred to together as “study creeks”). The study creeks generally exhibit homogenized and degraded habitats, with poor-moderate riparian function and floodplain connection, and low frequencies of large woody debris (LWD) accumulations and pool habitat, which are thought to be limiting salmonid production (SRSRB 2011). A detailed Restoration Plan was developed that proposed long-term riparian enhancement and short-term LWD additions as restoration treatments in the Asotin Creek IMW (Wheaton et al. 2012). The restoration plan was updated based on extensive modeling to determine the optimum experimental design (Loughin et al. 2018) and we continue to add more LWD to maintain high densities of LWD in the treatment compared to control sections as part of our adaptive management plan (Bennett et al. 2015, Wheaton et al. 2012, Bouwes et al. 2016).

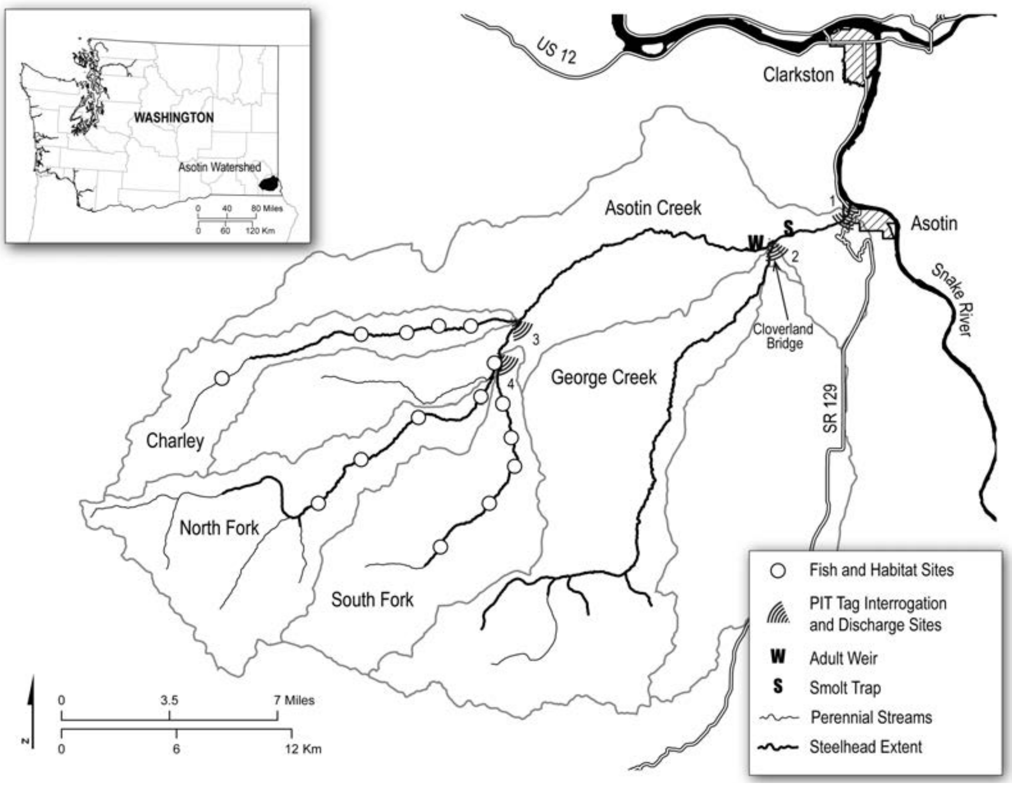

Figure 1. Location of Asotin Creek within Washington, the Asotin Creek Intensively Monitored Watershed study creeks, and monitoring infrastructure including fish and habitat sites in Charley Creek, North Fork, and South Fork Creek, discharge gauges, passive integrated transponder (PIT) tag interrogation sites, and the WDFW adult weir and smolt trap for fish-in fish-out monitoring. Water temperature is monitored at each fish and habitat site. PTAGIS PIT tag interrogation sites are: ACM – mouth of Asotin Creek, ACB – Asotin Creek mainstem at Cloverland Bridge, AFC – confluence of North Fork and South Fork Asotin Creek, and CCA – near mouth of Charley Creek.

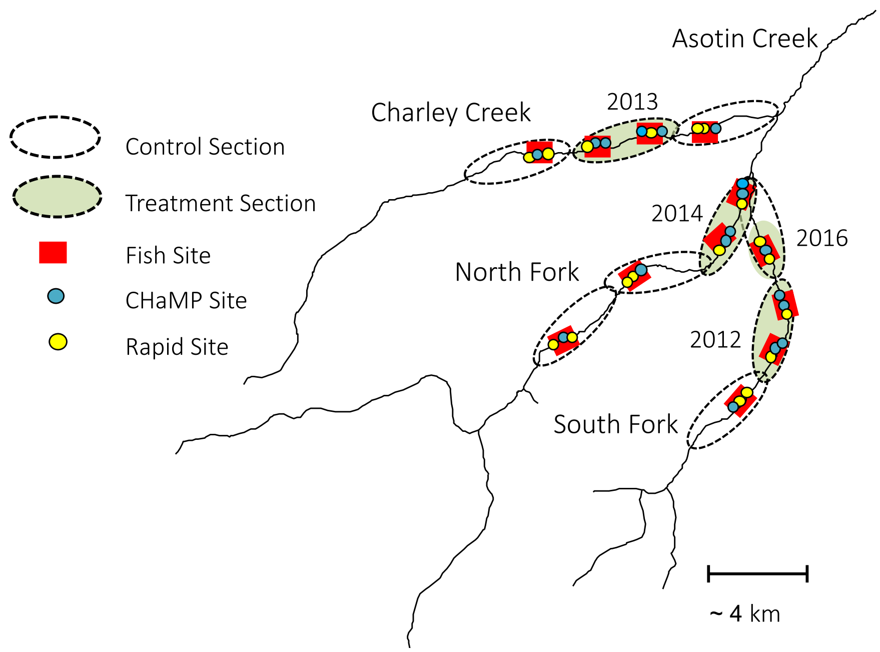

Figure 2. Experimental design and sample sites for juvenile PIT tagging and habitat surveys for the Asotin Creek Intensively Monitored Watershed project. Each study stream has three 4 km long sections. One section in each stream has been restored using post-assisted log structures (shaded green): South Fork (2012), Charley Creek (2013), and North Fork (2014). Additional section was restored in South Fork (lower section) in 2016 at part of the adaptive management plan. All other sections not colored are controls. Fish sites and habitat survey sites are nested within each section. CHaMP = Columbia Habitat Monitoring Protocol, Rapid = custom rapid habitat survey.

The primary purpose of this progress report is to summarize 1) the work performed as part of the Asotin Creek Intensively Monitored Watershed (IMW) between October 1, 2018 and September 30, 2019, 2) the status of the IMW, 3) future needs of the IMW (including challenges and opportunities) and proposed "path to completion", and 4) update the list of outreach and publications generated from the IMW (Appendix A).

2 WORK PERFORMED: OCTOBER 1, 2018 – SEPTEMBER 30, 2019

2.1 Outreach and knowledge transfer

- Published the low-tech process-based restoration manual
    - As a result of the IMW restoration development and testing, we published a manual on low-tech process-based restoration that details the principles and methodology of adding structural elements (beaver dams and large woody debris) to streams (Wheaton et al. 2019, lowtechpbr.restoration.usu.edu). Although the manual focuses on wadeable streams, the principles are applicable to all streams where beaver or wood play a role in riverscape processes. Monitoring and lessons learned from the Asotin Creek and Bridge Creek IMWs played a significant role in the manual's conception and development. Funding for the manual was provided by Utah State University and the USDA Natural Resources Conservation Service
- Presented at the Salmon Recovery Conference in Tacoma, WA
    - Gave a presentation on the potential benefits and cost-effectiveness of low-tech process-based stream restoration based on the results of the Asotin and Bridge IMWs and the publication of the low-tech process-based restoration manual
- Presented at the Snake River Salmon Recovery Board monthly Regional Technical Team meeting
    - Gave a presentation on the results and status of the IMW up to December 31, 2018 at the regular SRSRFB monthly technical meetings

    - Presented a restoration proposal to the Salmon Recovery Funding Board (local and state) in April, May, and June for adding wood to the existing restoration sections as part of the IMW adaptive management plan
- Landowner tour of the Asotin IMW restoration sites
    - Co-led a tour with Asotin County Conservation District to show local landowners restoration structures in the Asotin IMW and explain the process and goals of low-tech process-based restoration using post-assisted log structures (PALS). The intent of the tour was to increase awareness and generate interest in implementing more restoration on private land using lessons learned from the IMW
- NRCS Tour of post-assisted log structures
    - Co-led a group of NRCS biologists and engineers on tour of PALS to explain restoration method, IMW results, and discuss permitting and risk/benefits associated with the low-tech restoration approach developed in the Asotin IMW
- Life history manuscript for Asotin summer steelhead
    - Developed preliminary outline and coordinated with WDFW for writing a manuscript that describes the life history variability of summer steelhead in Asotin Creek. The manuscript would be a foundational paper on which to understand the effectiveness of restoration actions
- Life cycle model for Asotin summer steelhead
    - Began to outline the steps and data needs for developing a summer steelhead life cycle model that could be populated with IMW and WDFW fish-in fish -out data. The model would be used to develop and assess restoration scenarios based on the approach of McHugh et al. (2018) and Weber et al. (2019)

2.2 Project Management

- Provided budgets and statements of work for IMW contracts
    - Worked with ACCD, SRSRB, and RCO to develop statement of work, budgets, and contracts with Eco Logical Research, Inc. and WDFW to support monitoring, analysis, reporting, and outreach.
- Developed, submitted, revised, and presented proposals to the Salmon Recovery Funding Board
    - As part of our adaptive management plan we developed proposals and presented the proposals to SRFB (local and state) to secure restoration funding to add wood to treatment areas in 2020 to maintain high contrasts between treatment and control areas and force more floodplain connection.
- Coordinated with stakeholders
    - Kept in regular contact with RCO, WDFW, SRSRB, and NOAA to discuss project logistics, funding, implementation, and reporting
    - Coordinated with WDFW to secure permission to fell trees and thin forest stands and use the wood for building wood structures
- Coordinated with NOAA and WDFW on permitting
    - Worked with NOAA and WDFW to secure permits for fish sampling and stream restoration

2.3 Data Collection, Management, and Analysis

- Data collection
    - Downloaded temperature loggers, PIT tag array data, and game cameras, and collected discharge measurements
- Completed 2018 fall mark-recapture surveys, and majority of 2019 mark-recapture surveys (summer and fall) and as of Oct 3, 2019 have captured and PIT tagged 51,085 juvenile steelhead since 2008
- Completed rapid habitat surveys of geomorphic units and LWD in all 12 fish sites totalling 6 km of surveys (3km of control and 3km of treatment)
- Database management

  - Developed a new fish capture database based on the Columbia Basin PIT Tag Information System's (PTAGIS) P4 data collection application including queries to import and QAQC field data (archived Roving Fish database developed by ISEMP because the database is no longer supported)
  - Imported 2018 fish capture data into the database
  - Worked on QAQC and synthesis of temperature, discharge, and habitat databases including management of photos of structure effectiveness
- Data Analysis and Management
  - Summarized habitat data and wood structure surveys completed in 2019
  - WDFW determined ages of fish captured in 2018 by reading of scales and we used custom R code to estimate the age of all PIT tagged fish up to the end of 2018 based on the length – scale age relationship determined by the scale ages.
  - Calculated and updated the abundance of juvenile steelhead at all 12 fish monitoring sites from 2008-2019 for summer and fall mark-recapture surveys
  - Calculated growth rate for juvenile steelhead at all 12 fish monitoring sites from 2008-2019 for all capture data for summer-fall and fall-summer growth periods

2.4 Monitoring Equipment, Infrastructure Maintenance/Repair, and Training

- WDFW repaired PIT Tag array antennas
  - the Cloverland Bridge (ACB) array was repaired after damage during the 2019 spring flows
- Equipment maintenance and repair
  - Ordered new fish monitoring supplies and repaired survey equipment in preparation for summer fish surveys in July
  - Attended PIT tag training session conducted by Biomark at the Priest Rapids fish hatchery
  - Replaced several temperature loggers throughout the study site and updated the discharge monitoring sites

3 ASOTIN IMW STATUS SUMMARY AND KEY FINDINGS

3.1 Status Summary

Location: Asotin Creek, river left tributary to the Snake River at rKM 522.234

Restoration Type: Large woody debris in short-term, riparian protection and enhancement in long-term

Focal Species: Wild, summer run, steelhead (*Oncorhynchus mykiss*); Major Spawning Area

Project Start Date: 2008

Project Costs:
Monitoring 2008-2018 = ~3.5 million, to complete to 2023 = ~ 1.0 million: Total Monitoring = 4.5 million.
Restoration 2008-2019 = ~ 550,000, to complete to 2023 = ~ 100,000: Total Restoration = 0.65 million.
TOTAL PROJECT = 5.15 million to inform stream restoration on over 150,000-200,000 miles of wadeable stream in Western US.

Restoration Dates: 2012-214, 2016

Restoration Size: ~ 750 post-assisted log structures (PALS) and wood accumulations promoted by PALS, almost 9 miles of stream treated at a cost of ~$550,000. Approximately 39% of the study area has now been treated with high-densities of large woody debris.

Monitoring: Pit tagging 3,000-5,000 + juvenile steelhead a year, CHaMP monitoring 18 sites (2011-2017 and thereafter as needed), extensive PIT tag array system to monitor emigration and immigration, discharge and temperature throughout study area, fish abundance, growth, movement, survival, production, and productivity

Goals: to test the effectiveness of large wood additions at increasing juvenile steelhead production and productivity in wadeable streams. Provide recommendations for wadeable and headwater stream restoration using wood treatments throughout the Columbia River basin. Provide assessment of low-tech process-based restoration method to improve cost-effectiveness of wood restoration in small streams. Provide guidance for buffering climate change impacts on small streams, across a broad range of stream types from snow dominated flow regimes to more rain dominated and intermittent flow regimes.

Approach: Developed a ***low-tech process-based riverscape*** **(**lowtechpbr.restoration.usu.edu) approach to adding wood to wadeable streams that provides structure for the stream to kick of processes of erosion, deposition, and overbank flow to increase complexity and improve riparian and floodplain conditions. This approach is different than more traditional engineering approaches because it focuses on "letting the system do the work" rather than trying to impose form on the stream.

Timeline (Figure 3): completed design, setting up monitoring infrastructure, monitoring pre-treatment period, implementing all the restoration, preliminary analysis and implementing an adaptive management plan. **TO BE COMEPLTED – monitor at least two complete life cycles of steelhead or approximately 10 years of post-treatment monitoring. Synthesize the monitoring efforts and complete final report. Funding from NOAA expected to be available to 2023 but it is unclear if funding is available to complete the project.**

Adaptive Management Actions: We have developed and published an adaptive management plan (Bouwes et al. 2016) and are currently implementing the portion of adaptive management that suggests if wood density decreases in the treatment areas, we will add more wood/structures to promote further recovery of the channel and floodplain.

Lessons to date: Low-tech process-based restoration is effective at increasing complexity of steelhead habitat, increasing in pools, bar development, side-channels, tree recruitment, and floodplain connection, and juvenile abundance survival is increasing in treatment areas. However, habitats are improving in the three streams at different rates. We hypothesize that the greatest fish abundance increases will be realized when the restoration promotes "complete floodplain reconnection" and are poised to demonstrate this in the coming years. The results from this IMW will have broad applications to wadeable streams across western North America that make up the majority of stream miles in a watershed and help to promote cost-effective and science-based approaches to stream restoration and recovery of ESA listed salmon and steelhead.

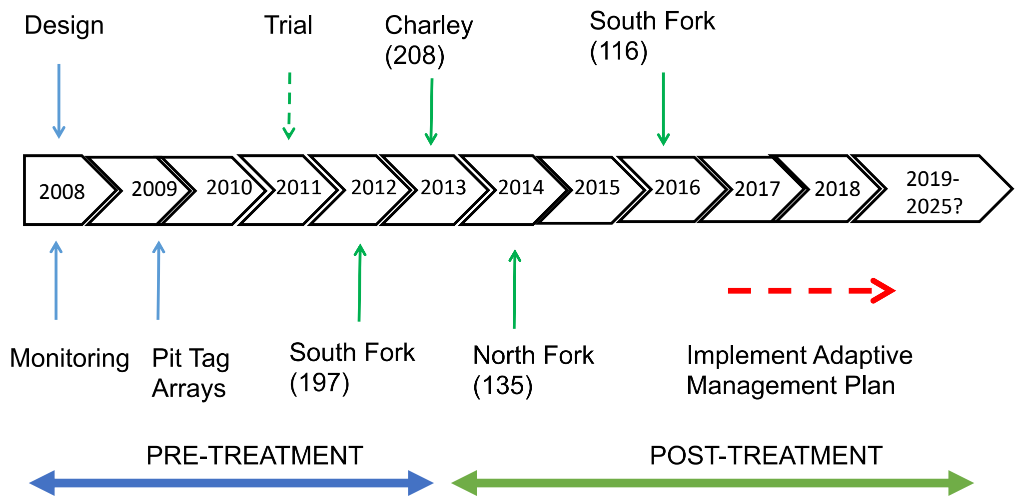

Figure 3. Timeline of Asotin Creek Intensively Monitored Watershed. The project is currently in the "Implement the adaptive management phase" which includes continued monitoring, evaluation, and adjustments of the restoration actions or monitoring as outlined in Wheaton et al. 2012.

3.2 Key Findings To Date

We have documented significant changes in hydraulic and geomorphic conditions in treatment versus control sections. However, changes differ across streams. Streams with larger spring flows and more available floodplain (e.g., North Fork) are responding more than streams with smaller spring flows and less available floodplain (e.g., Charley and South Fork). Habitat changes are more significant in the active channel compared to the floodplain. This is likely because we focused on building structures to increase instream habitat complexity and flows have been relatively small during the post-restoration period (Figure 4). Specifically, we have demonstrated that post-assisted log structures (PALS) and unsecured wood accumulations:

Habitat Responses within the active channel

- have increased hydraulic diversity,
- increased hydraulic diversity has led to greater sediment sorting and increased formation of bars,
- geomorphic change detection has demonstrated active scour and sediment deposition around post-assisted log structures (PALS) and wood accumulations,
- the number, depth, and area of pool habitat has increased,
- the number of geomorphic units around structures has increased,
- bank erosion and increased meandering are evident near some structures, but banks are generally armored and resistant to rapid change

Habitat Responses within the active floodplain

- overbank flow has increased but does not occur over large areas of treatment sections (i.e., limited to areas with low banks and high densities of channel spanning structures)
- some-side channels have been reconnected, expanded (in length, branching, or width), and/or created,
- much of the "riparian area" and active floodplain still support upland plant species, indicating full floodplain connection has not been attained.

Fish Responses in treatment areas relative to control areas

- juvenile fish movement between sections within the same stream and between streams is very limited and our instream arrays have high detection efficiency (>90%) which is ideal for assessing the effect of wood treatments on fish abundance, growth, survival, and production/productivity,

- juvenile steelhead abundance, survival, and net rate of energy intake (NREI) estimates show positive increases after treatment,
- growth rates appear to be slightly density dependent; differences between control and treatment sections have not been fully assessed,
- production/productivity has been calculated for 2009-2017 but because juvenile fish range from 0-4 years old, complete productivity measures are only available for 2010-2016 and do not provide enough data to assess restoration effectiveness at this time,
- adult escapement peaked prior to the restoration treatments and averaged 720 adults from 2008-2012 compared to 495 from 2013-2018 (2008-2018 average adult escapement = 629; Figure 5).

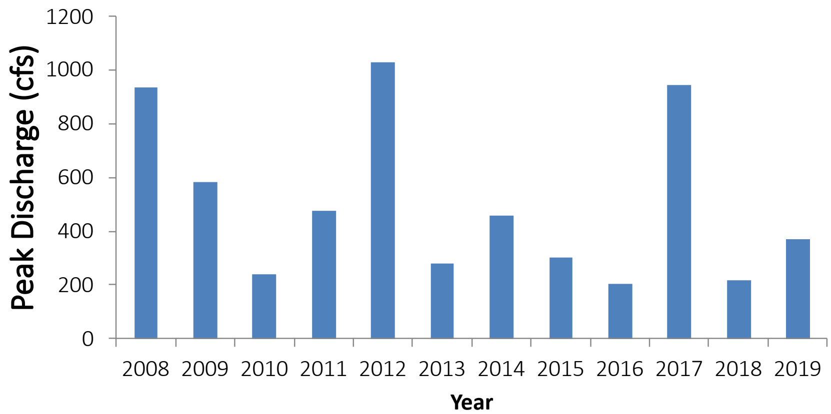

Figure 4. Asotin Creek mainstem peak discharge by year. Discharge data compiled from USGS gauge #13334550. Restoration began in 2012.

Figure 5. Adult steelhead escapement in Asotin Creek mainstem as determined by WDFW fish-in fish-out adult weir captures and PIT tagging: 2008-2018 (Herr et al. 2018). Note – 2019 adult escapement likely to be well below 200.

4 FUTURE NEEDS, CHALLENGES, AND OPPORTUNITIES

The Asotin Creek IMW is poised to provide a wealth of information to support restoration planning in wadeable streams and provide guidance on low-tech process-based restoration methods which can greatly increase the cost-effectiveness of restoration actions. The staircase design we have implemented provides increased power to detect treatment responses compared to traditional BACI designs (Loughin et al. 2018) and will allow us to assess treatment effectiveness in three distinct stream types (small - large streams with limited to more extensive contemporary floodplain, and flow regimes from relatively stable spring fed to highly flashy and unstable). These IMW attributes will enable us to extrapolate the results to a wider range of streams and settings, making the IMW even more cost-effective. It is also apparent that lessons learned from this IMW will be particularly relevant to increasing negative impacts of climate change on the hydrologic regime of many Pacific Northwest streams. With snowpack extent expected to decrease by over 30% in the next few decades, low-tech process-based restoration may be able to mitigate some climate change effects by improving floodplain connection, groundwater storage, and flood attenuation (Hafen 2018).

4.1 Future Needs

We require continued support from Pacific States Marine Fisheries Commission (NOAA-PSMFC), Washington State Recreation and Conservation Office (RCO), Salmon Recovery Funding Board (SRFB), Snake River Salmon Recovery Funding Board (SRSRFB), and other sources including donations from Eco Logical Research, Inc. (ELR), National Science Foundation (NSF), in-kind donations, graduate student studies, and other ongoing research (e.g., WDFW fish-in and fish-out project). Some indication from funding agencies on how many years will be supported would allow us to determine when we need to terminate monitoring activities and dedicate remaining funds to data analyses and reporting. We anticipate requiring at least one additional year of funding to assess the data after the suspension of monitoring (based on our current funding levels). We are initiating proposals with NSF to try and make the Asotin a long-term monitoring/research site because of the investment in infrastructure and data collection and the potential to learn much more about restoration effectiveness in the future.

4.2 Challenges and Opportunities

We have used a broad array of tools and analyses to assess the Asotin IMW experiment to date and many of these tools were developed or supported by work conducted by the Integrated Status and Effectiveness Monitoring Program (ISEMP) and the Columbia River Habitat Monitoring Protocol (CHaMP; e.g., NREI, geomorphic change detection, geomorphic unit delineation). Many of these approaches are complex and require extensive modeling and GIS, or assessment of large amounts of detection data. Unfortunately, since ISEMP and CHaMP have been discontinued the Asotin IMW is no longer supported by these programs and the tools must be run independently. We are currently reviewing these data streams to determine how and if we will use them in the future. A main challenge now is to maintain the data stream necessary to complete our assessment of the experiment, conduct considerable QAQC of our methods and model outputs, and continue to develop and refine our databases to be able to update analysis as new data comes in.

We may also develop a life cycle model based on approaches we have already developed for other watersheds (McHugh et al. 2017, Weber et al. 2018). Using a LCM would help synthesize the data collected in the IMW and WDFW studies, help assess the potential summer steelhead production benefits of different restoration scenarios, and has been recommended in reviews of the IMW program (Hillman, T. Pers. Comm.). We are currently synthesizing the data required as inputs into a LCM for summer steelhead in Asotin Creek.

We are currently implementing our adaptive management plan (Bouwes et al. 2016, Wheaton et al. 2012) and see it as a great opportunity to increase the effectiveness of the restoration community as a whole (Figure 6). We hypothesized in our restoration plan (Wheaton et al. 2012) and describe in the low-tech process-based restoration manual (Wheaton et al. 2019), it may require multiple restoration treatments to create self-sustaining riverscapes (i.e., fully functioning channels, floodplains, and riparian areas). Our annual surveys of restoration structures (Figure 7) indicate that as predicted, some PALS moved, got smaller or grew in size, and new wood accumulations (i.e., log jams) developed within the restoration treatment areas. The new wood accumulations are developing as a result of redistribution of wood from PALS and recruitment from the riparian forest (mainly alder) as the PALS force bank erosion and meandering (Figure 8). However, the pace of wood recruitment is not matching the pace of wood movement through the system and floodplain connection is only happening is small areas of the treatment sections. Therefore, we have secured SRFB funding to add more wood to the treatment areas in 2020 as a second restoration "phase" to continue to mimic and promote wood accumulations to increase hydraulic diversity, geomorphic diversity, overbank flow, and floodplain reconnection. This approach of using an explicit adaptive management plan and evaluating habitat and fish responses annually to determine when further management actions (i.e., restoration) are necessary has been recommended for decades, but rarely implemented. It is also a fundamental recognition that a single restoration treatment is unlikely to reverse a century or more of stream degradation and could provide the template for a new more phased approach to restoration that is consistent with the stream evolution model proposed by Cluer and Thorne (2014).

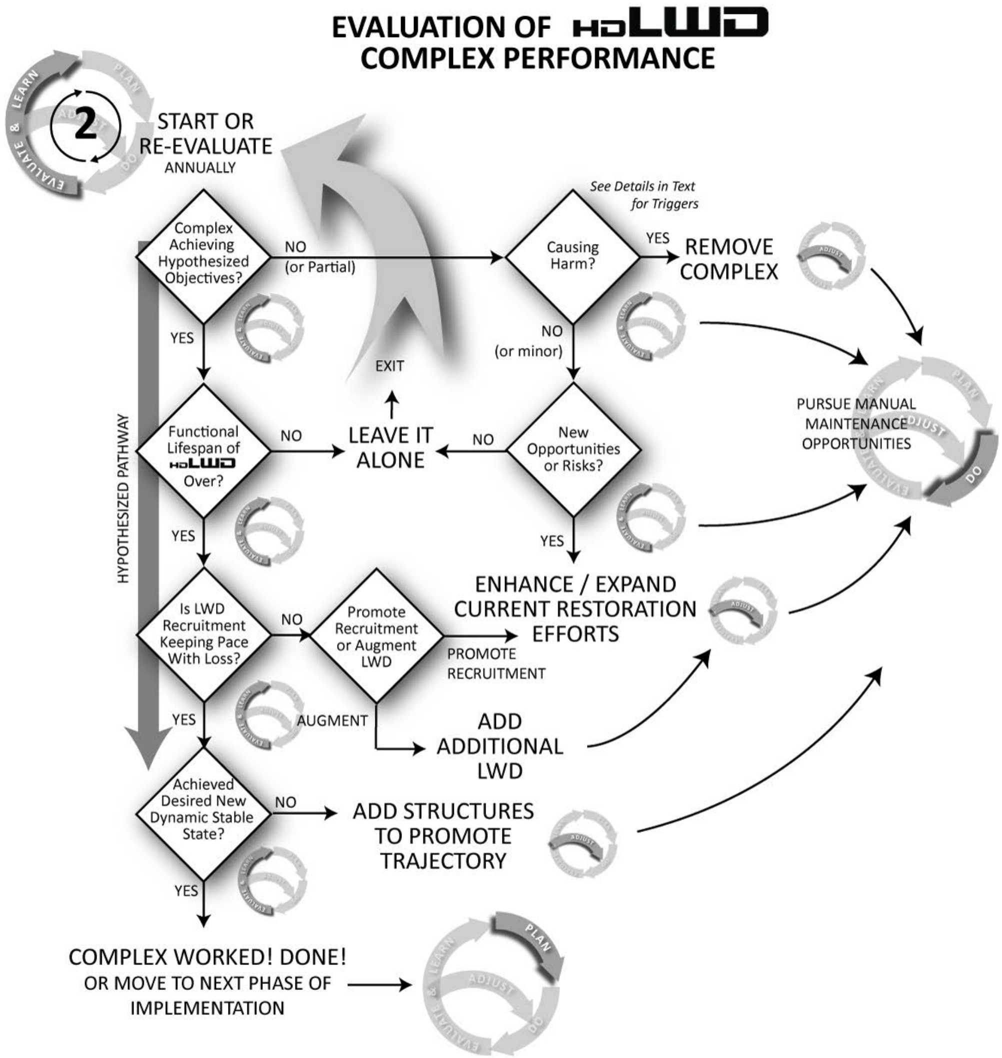

Figure 6. Asotin Creek IMW Adaptive Management loop for evaluating the restoration treatment scale (150-200 post-assisted log structures built over 4 km). From our structure surveys (see figure 7) we can see that the group of structures (high-density LWD) are still functioning; however, as some structures move or become less functional, the recruitment of new wood is not keeping pace with wood decomposition or loss. Therefore, our adaptive management decision is to continue promoting wood recruitment and add more wood.

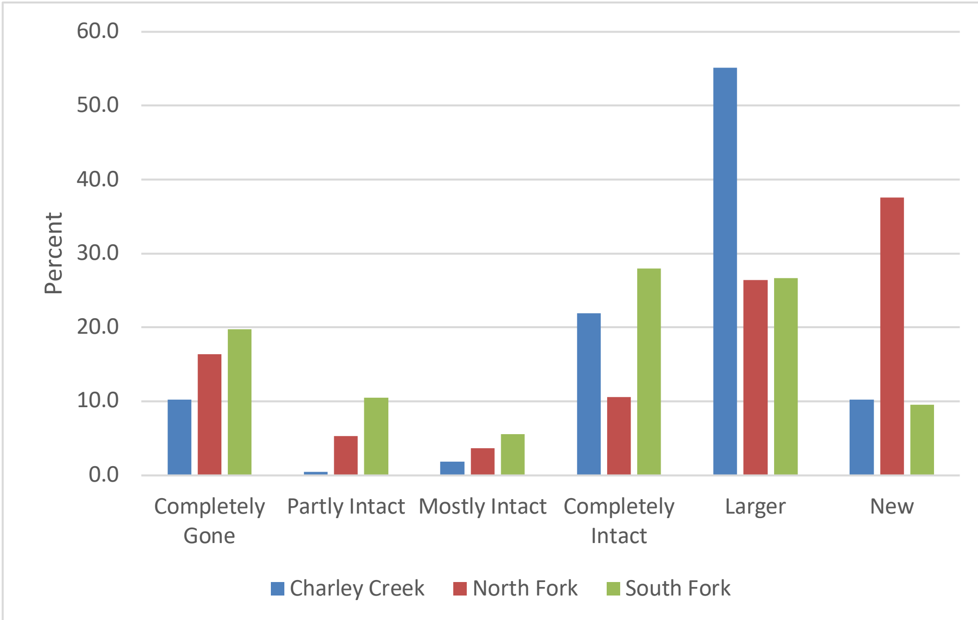

Figure 7. Results of a structure survey in August-September 2019 showing the percent of structures in different conditions by stream. The condition of structures ranged from gone (structure no longer where it was built) to completely intact. "Larger" refers to structures that were at least 25% larger than when they were originally built due to small and/or large woody debris accumulation on the structure. "New" refers to structures (wood accumulations aka log jams) in areas where they did not exist prior to restoration due a combination of natural wood and structure wood that moved and accumulated in a new location. Structures were built in South Fork in 2012 (196 structures) and 2016 (118 structures), Charley in 2013 (208 structures), and North Fork in 2014 (135 structures) – total 654.

Figure 8. Group of alder trees that have bene recruited into North Fork Asotin Creek as a result of a river left bank-attached post-assisted log structure (PALS) directing flow against the river right bank.

5 LITERATURE CITED

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APPENDIX A. SUMMARY OF KEY OUTREACH AND REPORTING

Outreach

We coordinate and receive input from the Snake River Salmon Recovery Board (SRSRB), the SRSRB Regional Technical Team (RTT), Washington State Recreation and Conservation Office (RCO), Salmon Recovery Funding Board (SRFB), SRFB Monitoring Panel, and Pacific States Marine Fisheries Commission. We also collaborate with the US Forest Service and Washington Department of Fish and Wildlife for monitoring and restoration efforts. We meet and present to these groups and other interested parties in southeast Washington multiple times a year at the SRSRB RTT meetings in Dayton, WA. To date we have presented at least 35 times on the Asotin IMW to the SRSRB and its partners. We have received valuable feedback from local groups, provided updates on the IMW progress, and sought funding when necessary to make the Asotin IMW a success. The following partial list outlines other venues where we have presented Asotin IMW designs, methods, restoration approaches, results, and lessons learned. **Bold** outreach items below were completed during the performance period of this report (Jan 01, 2019 – June 30, 2019).

Bouwes, et al. 2009. Presentation. Oregon Chapter of the American Fisheries Society. Bend OR. Evaluating Cormac-Jolly-Seber and Barker mark-resight models when passive instream antennae are used to collect resight data.

Bouwes et al., 2010. Presentation. American Fisheries Society 2010 Western Division. Overcoming challenges to estimating survival, movement and habitat use of fickle salmonids that may choose to emigrate, immigrate or stay at home.

Bouwes, et al. 2010. Presentation. Advances in the population ecology of stream salmonids symposium. Luarca, Spain. Large-scale stream restoration experiments: investigating what fish need in an uncertain environment.

Loughin et al. 2011. Presentation. American Fisheries Society 2011 Western Division - Development of the Asotin Creek Intensively Monitored Watershed Project with specific emphasis on experimental design and implementation considerations

Bennett et al. 2011. Presentation. American Fisheries Society 2011 Western Division - Characterizing juvenile steelhead abundance, growth, and survival at multiple spatial and temporal scales during the pre-treatment period of large restoration experiment: Asotin Creek Intensively Monitored Watershed.

Bouwes, et al. 2011. Presentation. Spring Runoff Symposium. Logan, UT. Watershed restoration experiments: maximizing learning while trying to recover endangered species.

Bouwes, et al. 2011. Presentation. Pacific States Marine Fisheries Council PIT Tag Workshop. Stevenson WA. Using mobile and passive antennas to improve estimates of survival, tracking of movement, and habitat use of salmonids.

Camp et al. 2011. Presentation. American Fisheries Society 2011 Western Division - Rapid assessment of reach scale movement and habitat associations of juvenile steelhead using portable pit-tag antennas and low cost geographic positioning system

Wall et al. 2011. Presentation. American Fisheries Society Annual Meeting. Seattle, WA - September 4-8, 2011. Giving fish more energy without giving them more food: Can streambed topography influence a fish's net rate of energy intake?

Wall and Bouwes. 2011. Presentation. Utah State University Water Initiative Spring Runoff Conference, Logan, UT. Can we give fish more energy without giving them more food?

Bennett et al. 2012. Presentation. Asotin County Annual Meeting. Asotin Creek Intensively Monitored Watershed: Updates and insights into restoration effectiveness.

Bennett et al. 2013. Presentation. Pacific Northwest Aquatic Monitoring Partnership, Portland, OR. Intensively Monitored Watersheds Coordination Workshop. Asotin Creek Intensively Monitored Watershed, southeast Washington: summary of approach, design, and preliminary findings.

Wall et al. 2013. Presentation. American Fisheries Society Western Division Annual Meeting. Boise, ID. Assessing the predictive ability of a process-based net rate of energy intake model for drift-feeding salmonids.

Bennett et al. 2014. Presentation. Washington State University, Pullman, WA. Does stream restoration work? How the Asotin Creek Intensively Monitored Watershed Project intends to find out.

Bennett et al. 2014. Presentation. Joint Aquatic Sciences Conference, Portland, OR. Restoration of wadeable streams with high-density large woody debris (HDLWD).

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Bennett et al, 2015. Presentation. Snake River Salmon Recovery Data Symposium, Dayton, WA. Asotin Creek Intensively Monitored Watershed Snake River Data Symposium Update

Bennett et al. 2015. Presentation. Asotin County Annual Meeting. Asotin Creek Intensively Monitored Watershed: Updates and insights into restoration effectiveness.

Bennett et al. 2015. Presentation. Salmon Recovery Conference, Vancouver, Washington. Intensively Monitored Watersheds: An approach towards determining restoration effectiveness

Camp, et al. 2015. Presentation. American Fisheries Society, Portland, OR. Presentation. Asotin Creek Intensively Monitored Watershed: Lessons Learned from Three Years of Restoration.

Camp, et al. 2015. Presentation. Rapid Assessment Monitoring Strategies. Snake River Salmon Recovery Board Data Symposium, Walla Wall, WA.

Wall et al. 2015. Presentation. American Fisheries Society Annual Meeting. Portland, OR. Using large-scale application of a foraging model in the interior Columbia River Basin to help understand patterns of habitat use in salmonids.

Bennett et al. 2016. Presentation. Pacific Northwest Aquatic Monitoring Partnership, Portland, OR. Intensively Monitored Watersheds Coordination Workshop. Intensively Monitored Watersheds: ideal elements, implementation challenges, and progress towards determining restoration effectiveness.

Bennett et al. 2017. Presentation. Asotin County Annual Meeting. Asotin Creek Intensively Monitored Watershed: Updates and insights into restoration effectiveness.

Bennett et al. 2017. Presentation. Salmon Recovery Conference, Wenatchee, Washington. Asotin Creek Intensively Monitored Watershed: An emerging story of restoration effectiveness

Bennett, Wheaton, and Camp. 2017. Workshop. Snake River Salmon Recovery Board Cheap and Cheerful Restoration Workshop, Dayton, WA. Sharing lessons learned and providing hands on experience in constructing post-assisted log structures (PALS) and beaver dam analogs (BDAs) developed in Asotin Creek and Bridge Creek Intensively Monitored Watersheds.

Bennett et al. 2018. Presentation. Upper Columbia Science Symposium, Wenatchee, WA. January 24-25, 2018. Can we stretch restoration funds to address the wood deficit? A high-density large woody debris case study.

Bennett et al. 2018. Presentations. Pacific Northwest Aquatic Monitoring Partnership, Portland, OR. Intensively Monitored Watersheds Coordination Workshop. 1) Progress and challenges on testing the effectiveness of process-based low-tech restoration: Asotin Creek IMW and 2) Beaver Dam Analogs Galore! Implications of Bridge Creek IMW Accomplishments and Potential for Further Learning.

Bennett et al. 2019. Presentation. Salmon Recovery Conference, Tacoma, WA. April 8-9, 2019. Low-tech process-based restoration to treat structurally starved riverscapes.

Bennett, et al. 2019. Presentation. American Fisheries and Wildlife Society Conference, Reno, NV. Sept 30-Oct 3, 2019. Low-tech process-based restoration to treat structurally starved riverscapes.

Bennett, et al. 2019. Presentation. Snake River Salmon Recovery Board, Regional Technical Meeting, Clarkston, WA. November 20, 2019. Update and overview of Low-tech process-based restoration to treat structurally starved riverscapes and Update on Asotin IMW.

Reports and Publications

We have produced a wide variety of reports and publications to support the development of the IMW and share the results of our monitoring and research. Many methods and publications were co-developed by CHaMP and ISEMP using Asotin IMW data and staff time. These efforts have expanded the available tools and analyses options for the Asotin. **Bold** reports or publications items were completed during the performance period of this report (Jan 01, 2019 – Sept 30, 2019).

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