Aquatic Inventory Project (AIP) Habitat Surveys: Morton Creek – 2008 & 2012

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Introduction

In 2009 the Curry Soil and Water Conservation District (District), the South Coast Watershed Council (Council), and their partners, undertook a channel relocation project on lower Morton Creek that replaced 0.5 miles of ditched stream channel with 0.6 miles of newly constructed, designed stream channel. To evaluate the effectiveness of the project the District and Council conducted pre and post stream habitat surveys using the Oregon Department of Fish and Wildlife's (ODFW) Aquatic Inventory Project (AIP) protocol. This report is a comparison of the results of those surveys.

Background

Morton Creek is a tributary to New River, which is located in northern Curry and southern Coos counties, on the southern Oregon coast. The creek originates in the foothills and low mountains to the north and east of the town of Langlois. Multiple intermittent and perennial headwater streams drain a mix of hillslope pasture and non-industrial forestland, and a small, hard rock upland quarry is operating in the middle watershed. Approximately 0.5 miles east of Highway 101 Morton Creek transitions from a hillslope confined, moderately steep channel into a terrace confined, relatively low gradient channel. Approximately 1 mile to the west of the highway the channel transitions again into an unconfined, low gradient stream that flows across the New River coastal plain for approximately 1.5 miles; at which point it merges with a large wetland on the south side of New Lake.

The New River coastal plain is a matrix of wetlands, small coastal lakes, stream channels, ditches, pastures, and estuarine habitat, that supports a highly productive coho fishery. In the late 19th century settlers began to manipulate the location and morphology of the lower New River tributary channels in order to create large, contiguous pastureland for sheep, dairy cows, and cattle. By the early 1960's lower Morton Creek had been channelized in a ditch that ran approximately 0.5 miles westward along a property line, where it emptied into a large ditch called Bono Ditch that was dug to drain New Lake south into New River. The Morton Creek ditch channel was maintained ("cleaned out") periodically through the late 1990's, but when Oregon coastal coho were listed under the Endangered Species Act (ESA), maintenance ceased because the landowners were concerned that the ESA listing would make such maintenance illegal without a permit.

By the mid-2000's the lower end of the Morton Creek ditch channel had filled with sediment and the stream was fanning out in multiple directions across the adjacent pastureland. This led to two problems: (1) prolonged saturation of the adjacent pasture was causing the vegetation to convert from grasses back into wetland forbes and willows; and (2) Morton Creek lost a low flow fluvial connection to Bono Ditch. As a result of these problems, valuable sub-irrigated summer pasture was being lost, and returning salmonids were impeded from reaching the spawning grounds and outmigrating juveniles were trapped in the ditch channel --- a channel that was plagued by low quality habitat and near lethal summer water temperature.

In 2007 the majority owner of the ditch channel approached the District and Council with a proposal to abandon the ditch and realign Morton Creek through lower elevation topography that included herbaceous and shrub dominated wetlands. This led the District

to apply for an OWEB technical assistance grant (#208-2031), for funding to develop and design a new Morton Creek stream channel. In the spring of 2008 the District solicited design proposals from five stream restoration firms. The contract was awarded to Graham Matthews and Associates (GMA), of Weaverville, California. Between April and June GMA surveyed the site, conducted a hydrologic-hydraulic-sediment transport analysis, and developed a preliminary project design (~60% completion); at which point the District's Project Manager applied for a removal-fill permit to implement the project. After an initial review the US Army Corps of Engineers and NOAA Fisheries determined the project would require individual consultation, so implementation was postponed for a year.

Project construction started the first week of August, 2009, and lasted through early October. ODFW and District staff conducted an aquatic salvage on the ditch channel prior to construction, which yielded a surprising number of coho pre-smolts (~940), along with a wide variety of other aquatic organisms (see appendix for Aquatic Salvage table). Nearly 0.6 miles of new stream channel were built, and 0.5 miles of ditch channel were decommissioned. The downstream end of the new channel was routed into a remnant segment of Bono Ditch that flows north into New Lake, thus creating a fluvial connection to New Lake and New River. Near the upstream end of the new channel an inline pond was excavated to trap incoming bedload, so sediment could be removed from a "sacrifice area" to prevent the downstream channel from over-aggrading. It was designed to hold an average year's bedload, which was estimated at ~400 cubic yards, but due to construction challenges the actual size of the pond was closer to 300 cubic yards. Within the new channel 16 log structures were built, using approximately 50 whole trees and logs that averaged 45 ft in length x 18 inches in diameter. Upstream of the new channel narrow, inset floodplain terraces were excavated and streambanks were sloped along ~650 feet of Morton Creek to provide fish hydraulic relief where the stream was incised due to past channelization. Following construction Morton Creek was fenced from livestock, beginning at Rivermile 0.2 and extending upstream through the inset terrace construction (herein referred to as the 'modified segment of channel'); downstream of RM 0.2 the creek wasn't fenced because seasonal flooding would require a burdensome amount of maintenance. Planting began in the spring of 2010, but the lion's share was deferred to 2011 because the project's Conservation Reserve Enhancement Program (CREP) contract was delayed; the site was then interplanted from 2012 through 2015.

During the first winter post-implementation the inline pond filled with bedload after high flows in November and December, and a headcut developed near RM 0.46 because of modifications to the design that shortened the channel, which subsequently increased the slope. In summer 2010 approximately 200 cubic yards of sediment were removed from the inline pond, which indirectly aggravated the headcut by depriving the downstream channel of bedload. No sediment was removed in the summer of 2011 (nor any year since), and log weirs were built for grade control to arrest and reverse the headcut. The channel responded quickly during the winter of 2011-12, and by summer 2012 the headcut was no longer noticeable.

For further information on the project design and implementation contact the District for a copy of the OWEB technical assistance Final Report and the federal Permit Compliance Report.

Project Effectiveness Monitoring

District staff conducted stream habitat surveys in 2008 and 2012 using ODFW's AIP protocol, to evaluate pre and post conditions, respectively. The results of the 2008 survey were presented in a report prepared by the District, dated August 25, 2010. The results of the 2012 survey, and a comparison of pre and post conditions, are presented below.

Methods

Data characterizing instream habitat conditions were collected by District staff using ODFW's Aquatic Inventory Project (AIP) protocol (Moore, et al., 2008 & 2012). The newest version of the AIP protocol was used in each year, with the following modification: all unit widths and lengths were measured, rather than estimated, to decrease surveyor bias. In 2008 Morton Creek was divided into 5 reaches, totaling 3,836 meters of primary stream channel. Reach 1 spans the ditched Morton Creek channel that was replaced with the constructed channel; Reach 2 and approximately 15% of Reach 3 span the 'modified segment of channel' where inset terraces and bank sloping were implemented; the remainder of Reach 3, as well as Reaches 4 & 5, were surveyed to develop a better understanding of instream conditions within the remainder of low gradient mainstem channel; and to act as potential control reaches for future comparison. In 2012 the new Morton Creek channel, the modified segment of channel, and the remainder of Reach 3 from the 2008 survey (ending at Highway 101), were re-inventoried; Reaches 4 & 5 from the 2008 survey were not due to funding constraints. In the 2012 survey the new channel was divided into two reaches to capture changes in the valley and channel morphology. As a result, reach breaks do not correlate between the two survey years; instead, Reach 1 from the 2008 survey compares to Reaches 1 & 2 from the 2012 survey, and Reaches 2 & 3 from the 2008 survey compare to Reach 3 from the 2012 survey. For the purpose of evaluating the effectiveness of the relocation project, the data sets do allow for a direct comparison of the abandoned segment of ditched channel with the newly constructed stream channel, but not for the modified segment of channel.

The 2008 and 2012 data were entered into the AIP database and analyzed according to the AIP analysis protocol (versions MARCROPRO097 and MACROPRO-2012, respectively). The analysis generated reach summaries that provided means, ranges and an expression of variables on a *per primary channel length* basis. The reach summaries were compared to ODFW's benchmark indicators (after Flitcroft et al., 2002) to evaluate the overall quality of instream habitat, and to compare the new channel to the abandoned ditch channel. Data summaries and benchmark status are presented in Table 1. Reaches are grouped by comparison, such that Reach 1 from the 2008 survey is followed by Reaches 1 & 2 from the 2012 survey, etc.; Reaches 4 & 5 from the 2008 survey are also included. See attached maps for clarification.

Table 1. Morton Creek 2008 & 2012 AIP Reach Summaries and Benchmark Indicators

NOTE: Reach 1 from the 2008 survey should be compared to Reaches 1&2 from the 2012 survey; and Reaches 2&3 from the 2008 survey should be compared to Reach 3 from the 2012 survey.

Stream/Reach	Year	Grad-ient	Primary Length (m)	Total Length (m)	Reach Area (m^2)	% Pri-mary	W:D Ratio	ACW (m)
Project Area								
Morton Reach 1	2008	0.2%	769	862	2397	93.8%	8.6	5.3
Morton Reach 1	2012	0.0%	401	418	1943	98.1%	8.4	6.3
Morton Reach 2	2012	0.7%	719	746	2352	98.6%	8.4	6.0
Morton Reach 2	2008	0.4%	109	117	338	97.9%	8.2	4.1
Morton Reach 3	2008	0.9%	948	1027	2552	95.3%	9.5	5.0
Morton Reach 3	2012	1.1%	1222	1272	3372	97.2%	9.2	4.8
Control Area								
Morton Reach 4	2008	1.0%	1305	1382	3686	97.9%	15.4	6.0
Morton Reach 5	2008	2.2%	705	768	1827	96.7%	14.5	5.3

Desirable
Between
Undesirable

	Pools					**Riffles (.5-2.0%)**		**Shade**	**Large Wood**		
Stream/Reach	# of Pools	% Area	Pool Freq	Residual Depth	# of Com-plex Pools	% gr	% s/o & snd	Avg %	#/ 100m	vol/ 100m	key/ 100m
Project Area											
Reach 1 (2008)	35	23.2%	4.6	0.34	0.0	62	18	6	0.4	0.1	0.0
Reach 1 (2012)	4	20.4%	16.6	0.63	0.0	NA	NA	47	0.5	1.5	0.2
Reach 2 (2012)	30	71.2%	4.1	0.50	14.0	94	5	23	16.0	20.0	1.1
Reach 2 (2008)	7	27.6%	4.1	0.34	0.0	78	23	78	2.7	1.3	0.0
Reach 3 (2008)	60	63.6%	3.4	0.48	3.0	73	24	69	3.7	1.9	0.1
Reach 3 (2012)	65	65.3%	4.0	.53	4.0	79	8	78	4.2	2.8	0.0
Control Area											
Reach 4 (2008)	61	59.2%	3.8	0.52	1.0	62	8	69	1.3	0.5	2.0
Reach 5 (2008)	17	35.2%	8.5	0.71	1.0	45	13	95	5.0	2.1	0.1

Findings

Construction of the new channel added 351 meters of primary channel to Morton Creek in comparison to the abandoned ditch channel, which resulted in a net increase of 1,898 m^2 of instream habitat. From the end of the new channel upstream to Highway 101 Morton Creek added 165 meters of primary channel, which resulted in a net increase of 482 m^2 of instream habitat; possibly a result of the modifications that were made to approximately 15% of this reach. The new Morton Creek channel was 0.7-1.0 meters wider than the abandoned ditch channel (based on active channel width), but the two channels had similar width to depth ratios. The number of pools remained nearly constant between the new channel and the abandoned channel, but residual pool depth and the number of complex pools increased significantly in the new channel. Instream wood parameters also increased significantly in the new channel, but they fell short of the

desirable benchmarks. From the end of the new channel upstream to the highway the number of pools remained nearly constant, but residual pool depth and the number of complex pools increased in 2012; though not significantly.

Discussion

The Morton Creek ditch channel (Reach 1 in the 2008 survey) was a straight, perched channel that was dominated by Reed Canary grass, lacked woody riparian vegetation and instream wood, and was regularly grazed by livestock. Visually it appeared to be a highly simplified, inhospitable environment for salmonids; the 2008 AIP reach data seemed to confirm this: the channel had relatively small, shallow, simplified pool habitat and virtually no riparian shade and instream wood. Considering this assessment, we were surprised to find an abundance of coho, tremendous numbers of lamprey ammocetes (5,000 – 10,000), and a diversity of other aquatic organisms rearing in the ditch when it was salvaged in August 2009. We concluded this discrepancy, between the quality of instream habitat and the salvage catch, is an indication that our observations and the AIP metrics had underestimated instream complexity in the ditch channel; and that the Reed Canary grass was owed the credit because, by forming dense root mats along the channel margins and isolated clumps within the active channel, the grass had created extensive undercut bank habitat and resting areas during high flows.

This observation is worth sharing because it highlights the fact that, although the ditch channel lacked most characteristics associated with quality instream habitat, it was still a functioning ecosystem; and so even though the project design was based on fluvial geomorphic principals and the new channel was constructed with intact habitat, [we assume] the project will still have a negative impact on the aquatic ecosystem until the new stream channel matures. And the extent and magnitude of the impact will, in many ways, depend on the quality of the design and implementation, and the pace and character of the revegetation.

In the case of Morton Creek the geomorphic indicators from the 2012 AIP survey suggest that by Year 3 the new channel was already outperforming the 2008 ditch channel (Note: this statement does not account for underrepresented habitat associated with the Reed Canary grass). Specifically, the new channel had significantly more pool area, depth, and number of complex pools, which is probably the result of (1) the geometry of the excavated channel, (2) the channel's sinuosity is promoting and maintaining lateral scour pools, (3) the instream log placements are generating scour and providing cover, and (4) stream flow is concentrating in the active channel and constructed floodway instead of sheet flowing across the adjacent pastureland, as was the case with the ditch channel. The new channel also added 1,898 m^2 of additional habitat to the stream network, which by default suggests the new channel will have more carrying capacity.

Upstream of the new channel the AIP metrics indicate that instream conditions improved slightly in the reach that extends up to Highway 101 (Reaches 2 & 3 in 2008; Reach 3 in 2012), but those changes are not significant; nor can they be specifically tied to the terracing and bank sloping that occurred in the reach. What's more interesting, though, is that the AIP metrics characterize this reach as moderately good habitat, but visual observations suggest otherwise.

Conclusion
The results of the 2008 and 2012 AIP surveys suggest that the 'Morton Creek Channel Relocation' project significantly improved instream conditions over the abandoned ditch channel by Year 3 post-implementation, in part by adding 1,898 m^2 of habitat to the stream network. The new channel is still severely deficient in shade (as was to be expected), and the project did fall short of the 'desirable' instream wood benchmarks. The 'desirable' benchmark for shade should be achieved in a relatively short timeframe (10-20 years) because the site is being aggressively revegetated through a CREP contract. The shortage of instream wood, however, will take longer to reconcile unless additional logs are added to the system.

In contrast to the AIP survey, the magnitude and diversity of the aquatic salvage raised the question whether the Reed Canary grass was actually creating more quality habitat, such as undercut banks, than was captured in the AIP metrics. The results of the salvage were also a telling reminder that even a seemingly lousy stretch of low gradient, coastal stream can still sustain a relatively intact aquatic ecosystem; so channel abandonment – reconstruction projects need to aggressively establish quality instream and riparian habitat in order to minimize the disruption and strain that these projects have on those ecosystems.

References

Moore, K.M.S, K.K. Jones, and J.M. Dambacher. 2008. Methods for Stream Habitat Surveys: Aquatic Inventories Project. Information Report 2007-01, Oregon Department of Fish & Wildlife, Corvallis. 67p

Moore, K., K. Jones, J. Dambacher, et al. 2012. Aquatic Inventories Project Methods for Stream Habitat Surveys. Conservation and Recovery Program Oregon Department of Fish & Wildlife, Corvallis. 73p

Flitcroft, R.L., K.K. Jones, K.E.M. Reis and B.A. Thom. 2002. Stream Habitat Conditions in Western Oregon, 2000. Monitoring Program Report Number OPSW-ODFW-2001-05, Oregon Department of Fish and Wildlife, Salem, Oregon

Appendix

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Morton Creek Fish Salvage Operation - Channel Abandonment Phase

prepared by ODFW - Gold Beach District Office

All fish were salvaged with electroshocking backpack and transported in a live tank under compressed oxygen and aeration.
Fish were relocated into new channel appox. 0.5 miles from old site on Rick McKenzie property. This was a collective effort with ODFW, the land owner and the Curry County Soil and Water Conservation District.

NOTE:

Numerous rough skinned newts were salvaged during this project.
Hundreds of redlegged frogs were present, but not salvaged.
Juvenile Pacific Giant Salamanders were also present and salvaged to the best ability of personnel.
Possibly 2-3 different species of Crayfish were noted during this salvage, unknown species as of salvage dates.
Curry SWCD staff continued to salvage the ditch channel as the isolated pools dried up, which led to the salvage of thousands of lamprey ammocetes.

Date	Pool	Length (ft)	Width (ft)	Area	Volt-age	pulse width	pulse rate	Coho 0+	coho mort-ality	Steel head 1+	Cut-throat 1+	trout 0-90mm	amo-cetes	stickle back	cray-fish	cot-tids	amphibs (rough skinned newts)	personel	hours shocked
This area was the initial work zone where digging was to take place. Fish left in the channel most likely followed the new channel after the diversion. This area was never reshocked, however the area below this work site was salvaged on later dates.																			
9/10/2009	1	300	8	2400	400	p	11 - 12	132	2	1	2	0	4	47	0	0	4	Tane, Battleson, Siegal	2
9/10/2009	2	150	8	1200	400	p	11 - 12	58	0	3	0	0	1	51	0	2	2	Tane, Battleson, Siegal	1
								190	2	4	2	0	5	98	0	2	6		
Channel had been dewatered and diversion to new channel was in place. The old channel was beginning to have isolated pools, so this area below was deemed most important for salvage. Entire length of area affected by dewatering was approximately 0.4 miles long with an average width of 4-5 feet. Further down, the channel was highly grown over with grass.																			
9/15/2009	1	20	5	100	400	p	11	20	3	0	0	0	5	15	0	0	1	Tane, Battleson	
9/15/2009	2&3	2	5	10	400	p	11	5	0	0	0	0	3	4	0	2	2	Tane, Battleson	
9/15/2009	4	3	4	12	400	p	12	2	0	0	0	0	10	2	0	0	0	Tane, Battleson	
9/15/2009	5	8	4	32	400	p	12	5	0	0	0	0	4	10	0	0	0	Tane, Battleson	
9/15/2009	6	10	4	40	400	I	11	11	0	0	0	0	11	1	1	0	0	Tane, Battleson	
9/15/2009	7	50	5	250	400	I	11	39	1	0	0	0	3	114	1	0	0	Tane, Battleson	
9/15/2009	8	120	4	480	400	I	11	36	0	0	0	0	4	35	1	1	0	Tane, Battleson	
9/15/2009	9	120	4	480	400	I	11	41	0	1	0	0	5	43	0	1	2	Tane, Battleson	
9/15/2009	10	80	5	400	400	I	11	49	0	0	0	0	17	63	0	0	2	Tane, Battleson	
9/15/2009	11	25	4	100	400	I	11	19	0	0	0	0	2	4	0	0	0	Tane, Battleson	
9/15/2009	12	150	5	750	400	I	11	104	6	0	1	0	0	90	0	0	7	Tane, Battleson	
9/15/2009	13	4	4	16	400	I	11	5	0	0	0	0	1	2	0	0	0	Tane, Battleson	
								336	10	1	1	0	65	383	3	4	14		5
Dewatering beginning to leave pools dry causing mortalities. Hundreds of amocetes left high and dry, plenty of predator presence (egrets, king fishers)																			

Date	Pool	Length (ft)	Width (ft)	Area	Volt-age	pulse width	pulse rate	Coho 0+	coho mort-ality	Steel head 1+	Cut-throat 1+	trout 0-90mm	amo-cetes	stickle back	cray-fish	cot-tids	amphibs (rough skinned newts)	personel	hours shocked
9/17/2009	1	25	4	100	400	I	11	4	8	0	0	0	3	11	0	0	0	Tane, Battleson, Minster (SWCD)	
9/17/2009	2	4	2	8	400	I	11	0	0	0	0	0	75	20	0	0	1	Tane, Battleson, Minster (SWCD)	
9/17/2009	3	20	3	60	400	I	11	52	0	0	0	0	18	72	3	0	3	Tane, Battleson, Minster (SWCD)	
9/17/2009	4	100	4	400	400	I	11	42	0	2	0	0	14	206	3	5	11	Tane, Battleson, Minster (SWCD)	
9/17/2009	5	80	3	240	400	I	11	43	0	0	0	0	5	106	0	1	7	Tane, Battleson, Minster (SWCD)	
9/17/2009	6	25	2	50	400	I	11	45	0	0	0	0	4	130	1	1	6	Tane, Battleson, Minster (SWCD)	
9/17/2009	7	15	4	60	400	I	11	32	0	0	1	0	4	28	0	3	0	Tane, Battleson, Minster (SWCD)	
9/17/2009	8	15	4	60	400	I	11	17	0	0	0	0	1	44	1	0	6	Tane, Battleson, Minster (SWCD)	
9/17/2009	9	20	3	60	400	I	11	9	0	0	0	0	10	24	0	0	0	Tane, Battleson, Minster (SWCD)	
9/17/2009	10	40	4	160	400	I	11	26	2	0	0	0	6	21	0	0	3	Tane, Battleson, Minster (SWCD)	
								270	10	2	1	0	140	662	8	10	37		5
These pools had already been sampled so area measurements would be measured twice and thus not included, particularly since pools were drying up and less area would artificially enhance densities.																			
9/22/2009	1				400	I	11	18	0	0	0	0	4	60	1	0	3	Battleson, Siegal	
9/22/2009	2				400	I	11	32	0	0	0	0	15	120	0	0	1	Battleson, Siegal	
9/22/2009	3				400	I	11	21	0	1	0	0	16	85	0	0	8	Battleson, Siegal	
9/22/2009	4				400	I	11	20	0	0	0	0	12	225	2	0	3	Battleson, Siegal	
9/22/2009	5				400	I	11	13	1	0	1	0	11	31	0	0	6	Battleson, Siegal	
9/22/2009	6,7,8				400	I	11	39	2	0	0	0	4	243	0	1	2	Battleson, Siegal	
9/22/2009	9				400	I	11	0	1	0	0	0	1	25	0	0	0	Battleson, Siegal	
								143	4	1	1	0	63	789	3	1			3
Totals				**7468**				**939**	**26**	**8**	**5**	**0**	**273**	**1932**	**14**	**17**	**57**		

Morton Creek Habitat Surveys

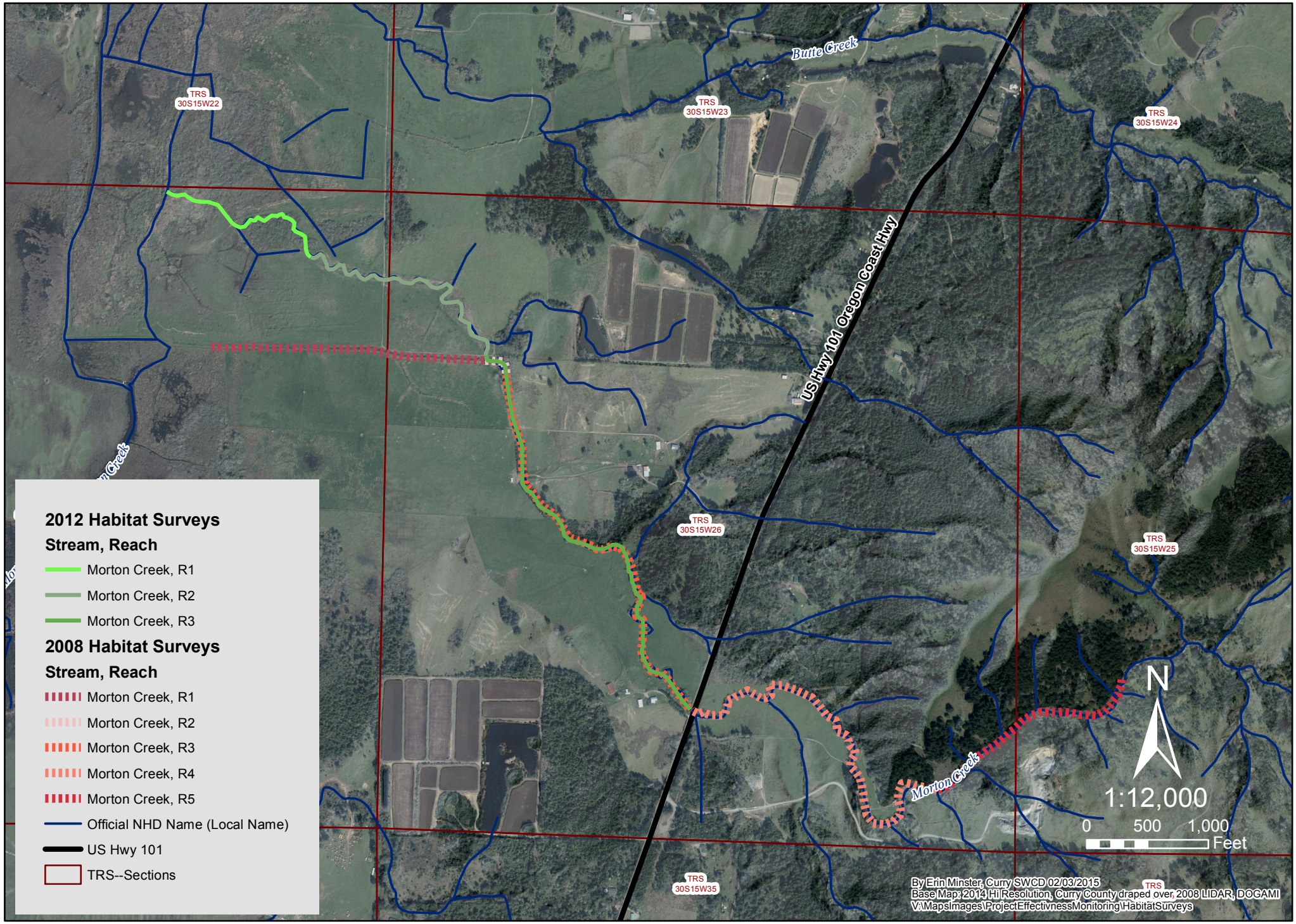

Figure 1

2008—Start of AIP survey on the ditch channel; which had not been “cleaned out” in more than a decade, and had subsequently filled with sediment by 2008.

Figure 2

2012—Start of AIP survey on the new Morton Creek channel.

Figure 3

2008—Reach 1, units 20-26: Looking upstream where deposition had filled the ditch channel and was forcing the stream to fan out across the adjacent pastureland.

Figure 4

2012—Reach 1, unit 2: Looking downstream at the lower end of the new channel, which is being backwatered by New Lake via an abandoned segment of the original Bono Ditch channel.

Figure 5

2008—Start of Reach 2, unit 82: Looking upstream.

Figure 6

2012—Near the start of Reach 2, unit 15: Looking upstream on the new channel at a lateral scour pool and log structure.

Figure 7

2012—Reach 2, unit 15: Coho were abundant in pool habitat on the new channel.

Figure 8

2012—Reach 2, unit 53: Looking upstream at the in-line sediment retention pond that was designed as a "sacrifice area" where incoming bedload could be removed to prevent the downstream channel from filling with sediment. In Year 1 ~200 cubic yards were removed, but no material has been removed since because USACE erroneously omitted bedload removal from the removal-fill permit authorization.

Figure 9

2008—Reach 2, unit 87: Looking upstream at a segment of incised channel that was modified in 2009 through the construction of inset floodplain terraces and bank sloping.

Figure 10

2012—Reach 2, unit 65: Looking downstream at the "cutoff" where the old channel was abandoned and filled — the log and rocks were used to seal off the old channel.

Figure 11

April 2014—Looking downstream at the new channel near the break between Reach 1 & 2, where the gradient decreases and the stream transforms into a “meadow-trench” channel.

Figure 12

April 2014—Looking upstream at a lateral scour pool in Reach 2. Notice the point bar development and the colonization of riparian vegetation, including sedge.

Figure 13

April 2014—Looking upstream at one of three log weirs constructed in 2011 for grade control to arrest and reverse the upstream migration of a headcut.

Figure 14

April 2014—Looking upstream at the new Morton Creek channel in Reach 2, where log structures and channel sinuosity have formed “complex pools”.

Figure 15

April 2014—Reach 2 on the new channel was enrolled in CREP to fence livestock from the stream and revegetation the area with native trees and shrubs.

Figure 16

April 2014—The earliest plantings were free-to-grow as of spring 2014, but the project continued to be interplanted and maintained in order to reach a desirable stocking density.