

Draft Technical Memorandum

Date: 31 September 2013

Project Number: 1937.01

To: Kimball Storedahl

From: Catherine Morello/Eric Jeanes/Dudley Reiser – R2 Resource Consultants

Subject: Ridgefield Pit, Daybreak Mine

cc: Randy Sweet

Background

Storedahl Property L.L.C. owns and J.L. Storedahl & Sons, Inc. (Storedahl) operates a gravel processing plant in rural Clark County, Washington, near the East Fork Lewis River (EFLR). This site is known as the Daybreak Mine. The existing structural setting for the Daybreak Mine dates from 1968 and possibly earlier. In April 2004 Storedahl completed a multi-species Habitat Conservation Plan (HCP) covering the (then) proposed expansion of Daybreak Gravel Mine and its existing operations. The plan was designed to ameliorate potential effects of river channel shift into the gravel mining pits and ponds. Conservation Measures (CMs) were established in the HCP to contribute to regional conservation efforts to protect the local species and their habitats. In particular, CM-10 is the “Study of the Ridgefield Pits and East Fork Lewis River”, it reads as follows:

“A study will be initiated to investigate water temperature, DO, fish use, and geomorphology associated with the nearby Ridgefield Pits to:

- assess the influence of pools on fish habitat and fish use;
- assess the influence of pools on EFLR water temperatures and DO;
- assess pool volume, channel shape, and sediment infill rates; and
- provide information to refine the contingency plan to minimize negative effects of potential future avulsions into the Daybreak site.”

This Technical Memorandum (TM) describes the results of fish sampling surveys completed by R2 Resource Consultants, Inc. (R2) of the Ridgefield Pits during summer 2013. R2 performed the following activities as outlined in CM-10 in the HCP (Sweet et al. 2004):

- fish habitat surveys of the East Fork Lewis River between RM 6 and RM 13;
- observations of fish use in the E. Fk. Lewis River between RM 6 and RM 13;
- and monitoring of temperature and DO in the avulsed reach.

EXISTING CONDITIONS

Historically, the East Fork Lewis River (EFLR) has been an actively migrating channel. In 1996, the channel migrated into pits formed by previous gravel mining operations on the west bank of the river across from the Daybreak Mine operations. This channel avulsion took place in the area termed the Ridgefield Pits (Pits) (Figure 1). Over the following decades, the Pits have been disconnected and reconnected to the mainstem river several times depending on channel location and river flow level. As of summer 2013, Pits 6 thorough 9 did not have an inlet connection to the main channel at lower flow levels (Figure 2). Pits 7 and 9 were connected through an outlet channel in Pit 7. Pits 6 and 9 were isolated from the mainstem at the time of the survey. However, Pit 9 had a small outlet channel that flowed into Pit 8.

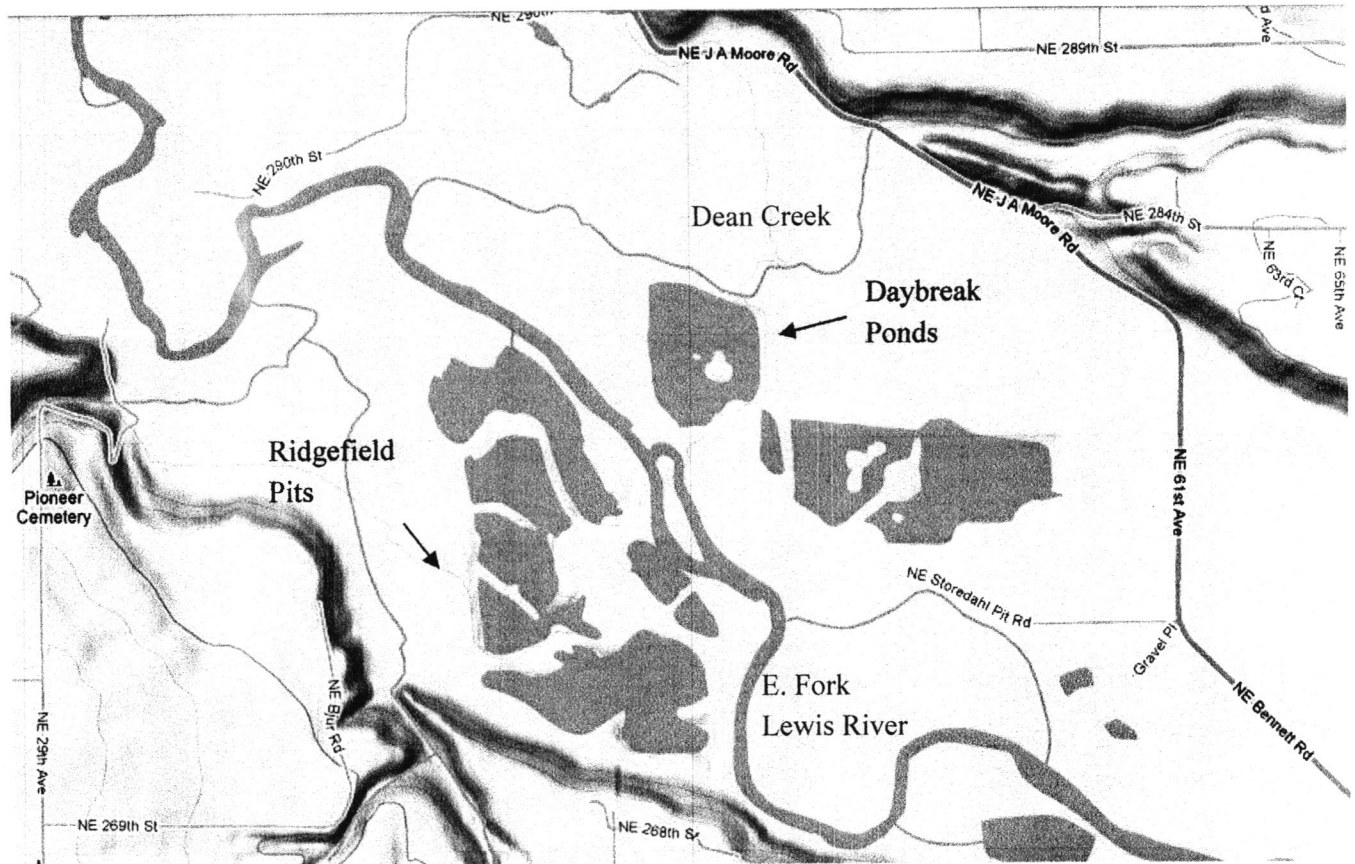


Figure 1. Map of the Daybreak Mine site and Ridgefield Pits near La Center, Washington.
Prepared with Google Maps.

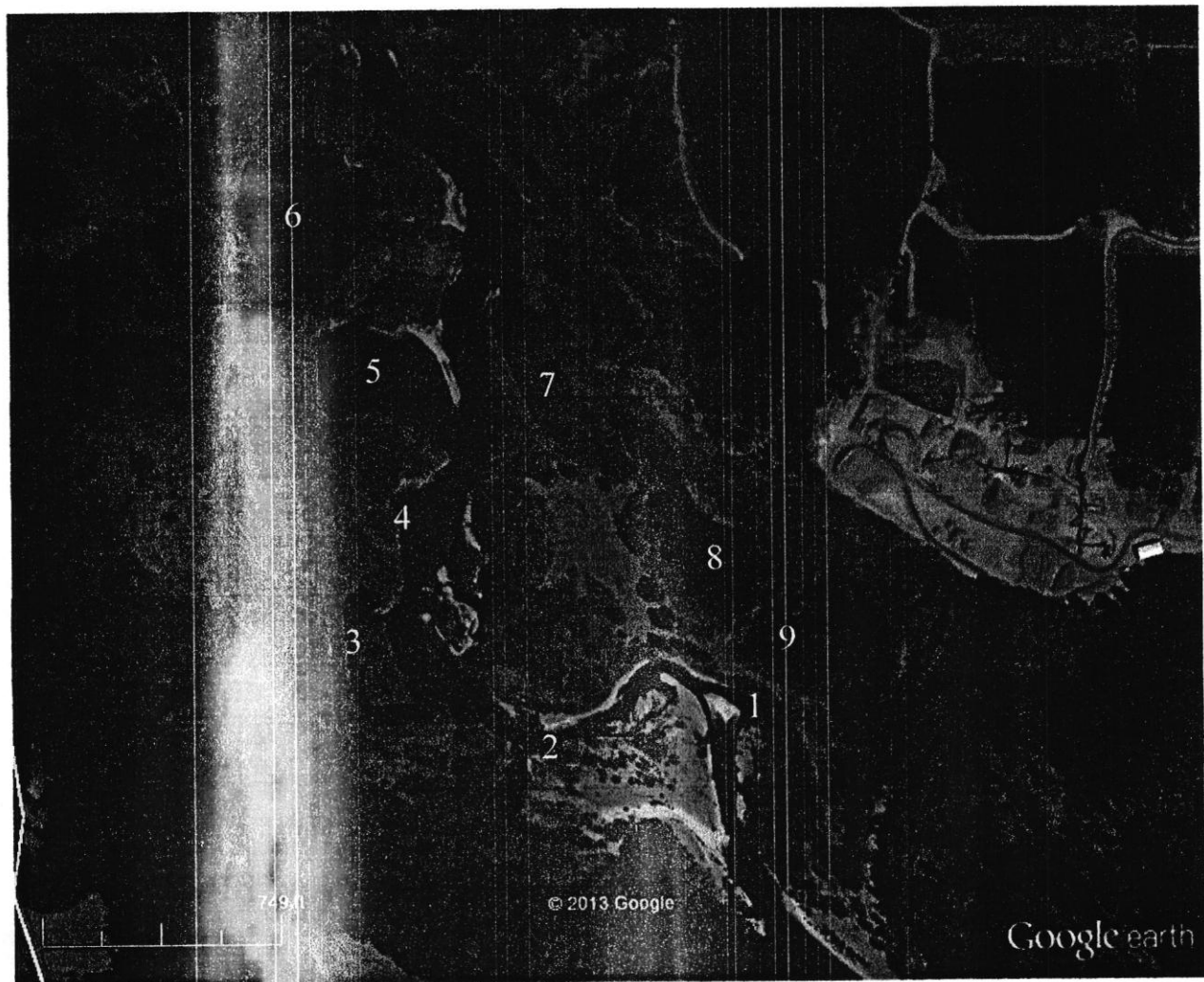


Figure 2. August 2012 aerial photo of the Ridgefield Pits with original Ridgefield Pit locations numbered according to the HCP (Sweet et. al 2004), EFLR, Washington.

The mainstem EFLR supports five anadromous salmonid fish species, including: Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*) and chum (*O. keta*) salmon; steelhead (*O. mykiss*) and sea-run cutthroat trout (*O. clarkii*). Bull trout are also present in the Lewis River, but are not believed to be present in the EFLR (Sweet et al. 2004). Several of these species are currently federally protected under the Endangered Species Act (Table 1).

Table 1. List and status of salmonid species protected under the Endangered Species Act in the East Fork Lewis River, Washington.

Name	Latin Name	Federal Status
Steelhead (Rainbow trout)	<i>Oncorhynchus mykiss</i>	Threatened
Bull trout	<i>Salvelinus confluentus</i>	Threatened
Chum salmon	<i>Oncorhynchus keta</i>	Threatened
Chinook salmon	<i>Oncorhynchus tshawytscha</i>	Threatened
Coho salmon	<i>Oncorhynchus kisutch</i>	Threatened

Previous fish surveys in the nearby avulsed channel regions indicated a variety of native fish present that included rainbow trout (*Oncorhynchus mykiss*), northern pikeminnow (*Ptychocheilus oregonensis*), largescale sucker (*Catostomus macrocheilus*), sculpin, threespine stickleback (*Gasterosteus aculeatus*), and four non-native species, which included largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), and brown bullhead (*Ameiurus nebulosus*) (R2 Resource Consultants unpublished data).

METHODS

An initial site reconnaissance was made to the Ridgefield Pits on May 23, 2013. A comprehensive site visit was made over the two day period extending from July 30 to July 31, 2013. Sampling for both trips included minnow trap and snorkeling surveys. In addition, water quality profile measurements including temperature, dissolved oxygen and pH, were taken within each area sampled. A visual approximation was made as to the level of connectivity of each of the Pits to the mainstem EFLR. Representative site and fish photographs are included in the attached appendices.

Minnow Traps

Gee-type minnow traps were set in the Ridgefield Pits in order to document fish presence in the Pits and nearby mainstem EFLR. The traps were distributed throughout all of the Pit areas and along the adjacent mainstem channel. The traps were constructed of 1/4" (6.4 mm) square galvanized wire mesh. They measured 16 inches (42 cm) long and 9 inches (23 cm) wide with a 1 inch (25 mm) entrance hole. These traps were generally set in water depths ranging from 1.0

to 4.0 ft. The traps were baited with a commercial salmon egg mixture prior to deployment. Trap locations were marked with GPS. The traps were left to soak several hours or overnight, and checked the following day. Three minnow traps (A-C) were set on 23 May on the east side of the EFLR (Figure 3).

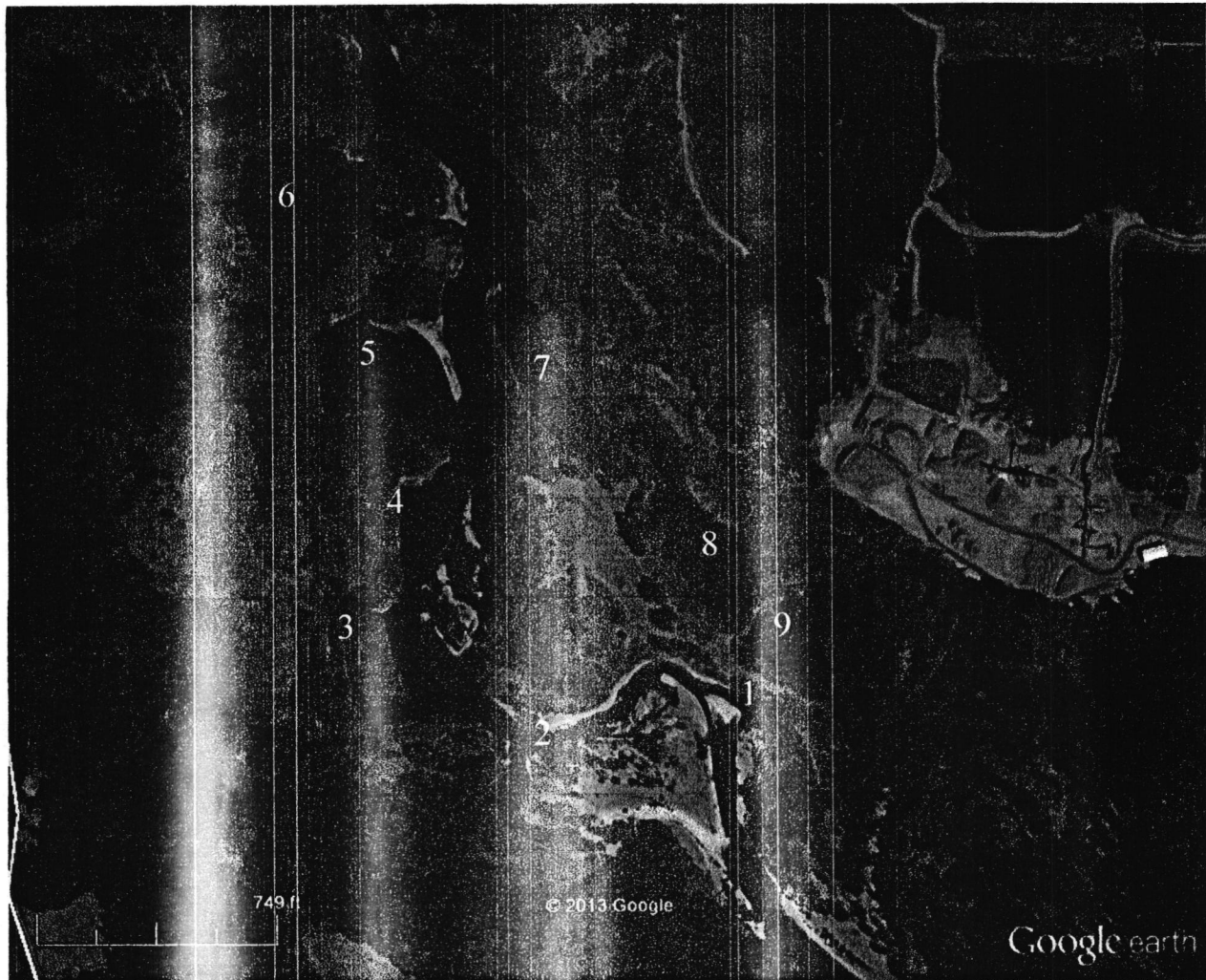


Figure 3. Pit number (yellow) and location of initial minnow trap deployments (red star) 23 May, 2013, E. Fk. Lewis River, Washington.

Twenty-three minnow traps were set in July, 2013. The majority of the traps were located in Pit 6, the largest isolated Pit and along the adjacent mainstem (Figure 4).

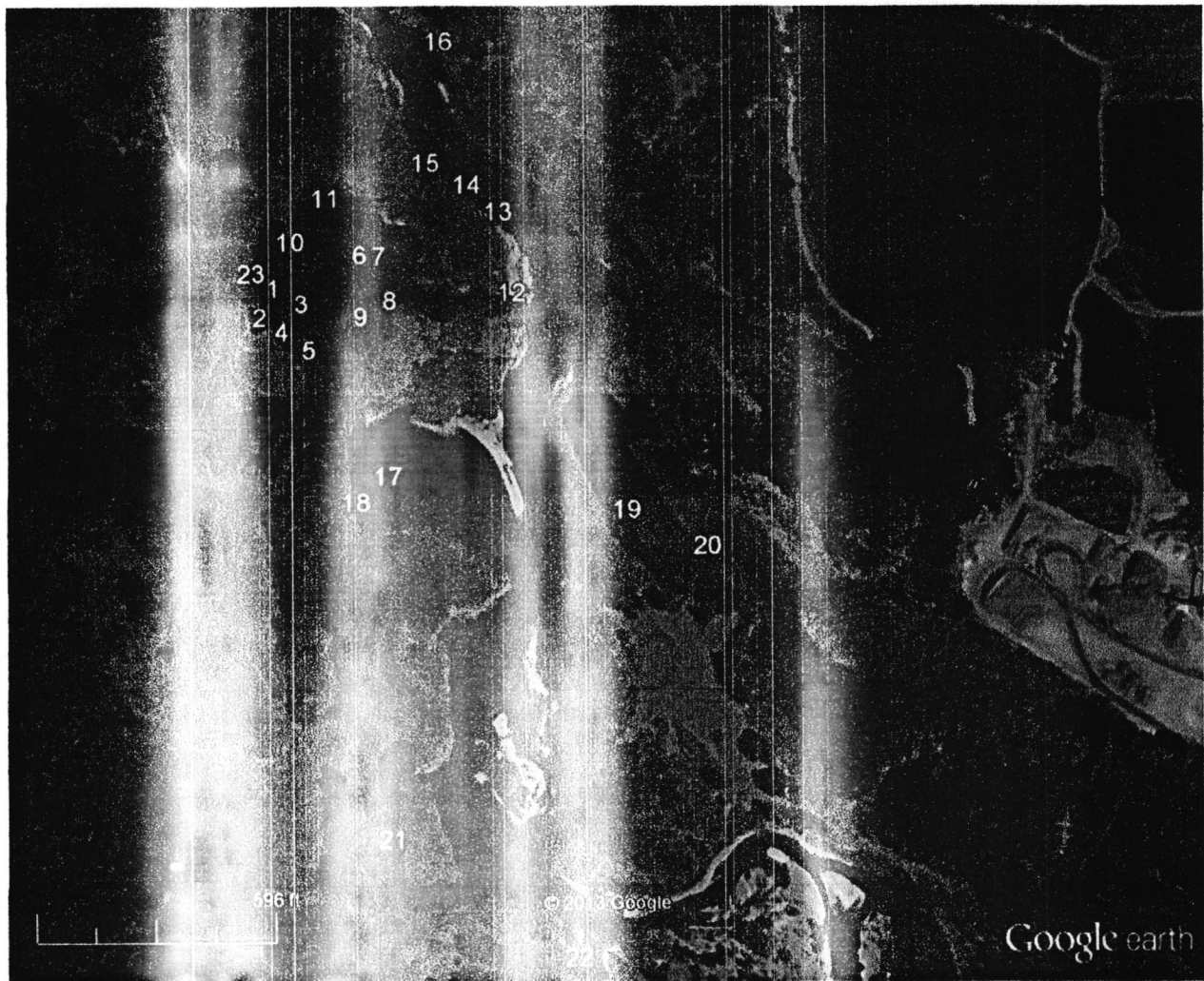


Figure 4. Minnow trap locations in the Ridgefield Pits , July 2013, E. Fk. Lewis River, Washington.

Snorkel Survey

Pits 8 and 9 on the east side of the EFLR were snorkeled in May 2013. Visual snorkel surveys were conducted at all Pit locations and along the adjacent mainstem areas in July 2013. Snorkel surveys were conducted by one snorkeler and one observer moving generally in an upstream direction. Visibility was estimated for each site.

Fish Handling

After capture, all fish were placed into a darkened recovery unit (live car) until they were processed in groups. Fish were removed from the live car and placed in an anesthetic bath with tricaine methanesulfonate (70 mg/l), identified to species and measured to the nearest mm total length. Fish were then allowed to recover in fresh water and released within the same survey site area in which they were captured. No immediate injuries or mortalities of fish were observed.

Water quality

Water quality parameters including temperature, pH and dissolved oxygen were measured with a calibrated Hydrolab Quanta backpack style water quality meter. Measurements were taken in conjunction with the minnow trap sets. Measurements were generally taken at the surface, mid water column and near the bottom of each sample location.

RESULTS

Minnow Trap

No fish were captured during minnow trapping (n=3 traps) activities at the initial site reconnaissance in May, 2013.

Twenty-three minnow traps were deployed and recovered in July 2013, capturing a total of 115 fish (Figure 4; Table 1). Five species were captured in the minnow traps: banded killifish (*Fundulus diaphanous*), largemouth bass (*Micropterus salmoides*), N. pikeminnow (*Ptychocheilus oregonensis*), threespine stickleback (*Gasterosteus aculeatus*) and misc. sculpin species (Table 1). Threespine stickleback were the most numerous species captured (n=39) followed by juvenile largemouth bass (n=33). All of the traps with the exception of trap #11 captured at least one fish. Trap #12 in the mainstem EFLR captured the most fish (n=18), predominantly sculpin species. The dominant sculpin species captured was the slimy sculpin (*Cottus cognatus*), however not all sculpins were identified to species level. Four banded killifish were captured in Pit 6 in trap #8. This trap was set in the shallow weedy area favored by killifish (Wydoski and Whitney 2003).

Table 1. Number of fish captured in each minnow trap during July 2013 sampling in the Ridgefield Pits and EFLR, Washington.

Pond #	Trap #	Killifish	Largemouth Bass	Northern Pike minnow	Sculpin sp.	Threespine Stickleback	Total
6	1		1	1			2
6	2		3				3
6	3		2				2
6	4		3				3
6	5		5				5
6	6		1	1			2
6	7			1			1
6	8	4	3				7
6	9		5				5
6	10		3				3
6	11						0
MS	12			2	13	3	18
MS	13			5		1	6
MS	14				3	5	8
MS	15					2	2
MS	16				1		1
5	17					7	7
5	18					4	4
7	19		5	2		2	9
8	20		2			3	5
3	21				5	12	17
2	22				4		4
6	23			1			1
Total		4	33	13	26	39	115

MS= mainstem

Fish captured in the minnow traps ranged in length from 15 to 103mm in length (Table 2). The largest fish captured was a N. pikeminnow, the smallest were threespine stickleback (Table 2).

Table 2. Minimum, average and maximum length of fish captured in minnow traps, Ridgefield Pits and EFLR, Washington.

	Min	Ave	Max
Killifish	72	75.3	80
Largemouth bass	30	37.6	51
N. pikeminnow	50	66.8	103
Sculpin sp.	20	62.5	78
Threespine stickleback	15	38.2	75

Snorkeling

During the May 2013 sampling, four largemouth bass were observed during the snorkel survey of Pit 9, ranging from 100 to 300 mm in length. No other fish species were observed in May. Visibility was approximately 3-4 feet in Pits 8 and 9.

All nine Pit areas were snorkeled in July, 2013. The results of the surveys are provided for each Pit area in the description below.

Pit 1

This pit has become part of the mainstem river in a wide braided gravel bar floodplain area. This section of the study area had defined riffle habitat and overall contained less warm water species than areas downstream. One juvenile Chinook salmon (*O. tshawytscha*) was observed holding in a mainstem riffle.

Pit 2

Pit 2 is part of a large off-channel area with pooled water. The channel is fed by groundwater inflow and did not have a defined inlet channel at the time of the summer low flow survey. This pit had a deep shaded pool along the south bank that contained an estimated 500 yearling coho 80-100 mm in length. Many juvenile rainbow trout (*O. mykiss*) and stickleback were also observed, but the large quantities of minnows present in other downstream pits were noticeably absent. There is a woody debris jam at the outlet to the side channel.

Pit 3

Pit 3 is similar to Pit 2 in that it is a large off channel meander. The deepest area of this pit is adjacent to the mainstem at the upstream end and contained several large adult suckers,

whitefish, and pikeminnow. There was a sizeable woody debris jam at the outlet to the side channel.

Pit 4

Pit 4 was a deep, wide slow area of the mainstem river. No fish were observed in this area.

Pit 5

Pit 5 is a large side slough with a wide shallow connection to the mainstem river. This slough had a fish assemblage similar to the mainstem along Pit 6, including clouds of minnow species, sculpin, dace, threespine and sucker. One mosquitofish (*Gambusia affinis*) was observed during the snorkel survey. This slough contained dense aquatic vegetation, particularly in the center of the slough.

Pit 6

Pit 6 was one of two pits (also pit 9) completely isolated from the mainstem channel at summer low flow. However, only a couple feet of elevation separated this pit from the mainstem river. This pit had a mixed warm water species composition dominated by largemouth bass. Amphibian eggs were present on almost every piece of wetted woody debris in this pond.

The left bank mainstem along Pit 6 was a slow moving run containing a large assemblage of many fish species. The left bank is a gentle slope with thick aquatic vegetation and silty substrate. The most numerous fish were clouds of thousands of minnow species under 30 mm including sucker and pikeminnow fry; sculpin, dace, stickleback and bass were also present in large quantities. No juvenile salmonids were observed in this area. The right bank mainstem channel was faster flowing, with a more gravel/cobble substrate.

Pit 7

Pit 7 was a shallow pond with low visibility and contained a large amount of aquatic vegetation. No fish were observed.

Pit 8

Pit 8 was a nearly isolated pond with a slight connection downstream to Pit 7 and upstream to Pit 9. Habitat conditions in Pit 8 were similar to Pit 7 with a large amount of aquatic vegetation and low visibility. One largemouth bass (200mm) was the only fish observed.

Pit 9

Pit 9 was one of the two pits (also Pit 6) that were completely isolated from the mainstem channel at the time of the summer survey. Pit 9 had a small downstream connection flowing directly into Pit 8. Several adult largemouth bass, bluegill (*Lepomis macrochirus*) and suckers were observed in this pit. The water was clearer in this pit than in Pits 7 and 8.

Water Quality

Water quality measurements including temperature, conductivity, dissolved oxygen and pH were taken in Pits 6 through 9 (Table 3). In addition, water visibility was measured with a secchi disk.

Table 3. Water quality parameters measured at the Ridgefield Pits and the EFLR, July 2013.

Location	Depth (m)	Temp (°C)	Cond. (ms/L)	DO (mg/L)	pH	Secchi (ft)
Pit 6	0.5	22.9	0.056	6.13	7.66	5.0
	1.5	22.8	0.550	2.43	7.65	
	3.0	22.4	0.057	1.22	7.65	
Mainstem at Pit 5 outlet	0.5	18.6	0.055	9.02	8.07	5.5
	0.7	18.4	0.055	9.41	8.14	
	1.3	18.3	0.055	11.09	8.23	
Pit 5	0.5	19.9	0.055	8.43	7.79	6.0
	1.0	19.4	0.056	7.73	7.79	
	2.0	18.9	0.055	8.56	7.79	
Pit 7	0.5	19.9	0.063	8.10	7.65	5.0
	1.0	19.1	0.057	8.36	7.72	
	2.0	19.0	0.058	8.47	7.69	
Pit 8	0.5	21.1	0.059	6.73	7.50	3.5
	0.8	20.1	0.059	3.63	7.53	
	1.5	17.4	0.095	2.09	7.51	
Pit 9	0.5	20.0	0.043	10.66	7.54	5.0
	1.0	19.6	0.043	9.19	7.44	
	2.0	19.1	0.044	9.85	7.40	
Mainstem at Pit 6	0.5	18.7	0.056	8.61	7.46	6.0
	1.0	18.7	0.056	8.61	7.45	
	2.0	18.7	0.056	8.48	7.46	
	3.0	18.7	0.056	8.45	7.45	
	4.5	18.6	0.056	8.50	7.40	

CONCLUSIONS

The fish species assemblage of the EFLR has been affected by the avulsion of the river into the Ridgefield Pits. Currently, the mainstem river adjacent to Pits 5 and 6 contains a greater number of warm water species than other areas of the mainstem upstream and downstream of the pit 5 and 6 area. At times when the pits, particularly Pit 6, have a direct connection to the mainstem river it is likely fish move or are flushed out into the mainstem margin. These fish may remain and rear in this area. The mainstem margin adjacent to Pit 6 contains fine substrate material and heavy aquatic vegetation.

Pit 6 had higher water temperatures and lower dissolved oxygen levels than the adjacent mainstem. Outflow from this pit at higher river level may influence water quality conditions of the mainstem channel. This pit currently provides good rearing habitat for several warm water species, but is not suitable for most salmonids.

The upstream pits, 1-4, have become part of the mainstem channel, and contain residual deep holes and backwater areas that provide juvenile fish rearing habitat but has also increased predation opportunity, particularly by large adult pikeminnow. These upstream areas are less utilized by juvenile warm water species than areas downstream near Pit 6, and contain more salmonid species. Habitat in this section of the river is a riffle pool sequence with mineral (gravel or cobble) substrates.

Pits 7, 8 and 9 are off channel ponds that do not currently appear to be contributing fish production to the mainstem fisheries populations. However, these ponds do have higher water temperatures and lower dissolved oxygen levels that might affect the water quality of the mainstem downstream of the pits at certain flow levels.

REFERENCES

- Sweet, R. H. and 7 coauthors. 2004. Daybreak Mine Expansion and Habitat Enhancement Project, Habitat Conservation Plan. J.L. Storedahl and Sons, Inc.
- Wydoski, R.S. and R.R. Whitney. 2003. Inland Fishes of Washington. American Fisheries Society, Bethesda, Maryland.

APPENDIX

FISH CAPTURE TABLE

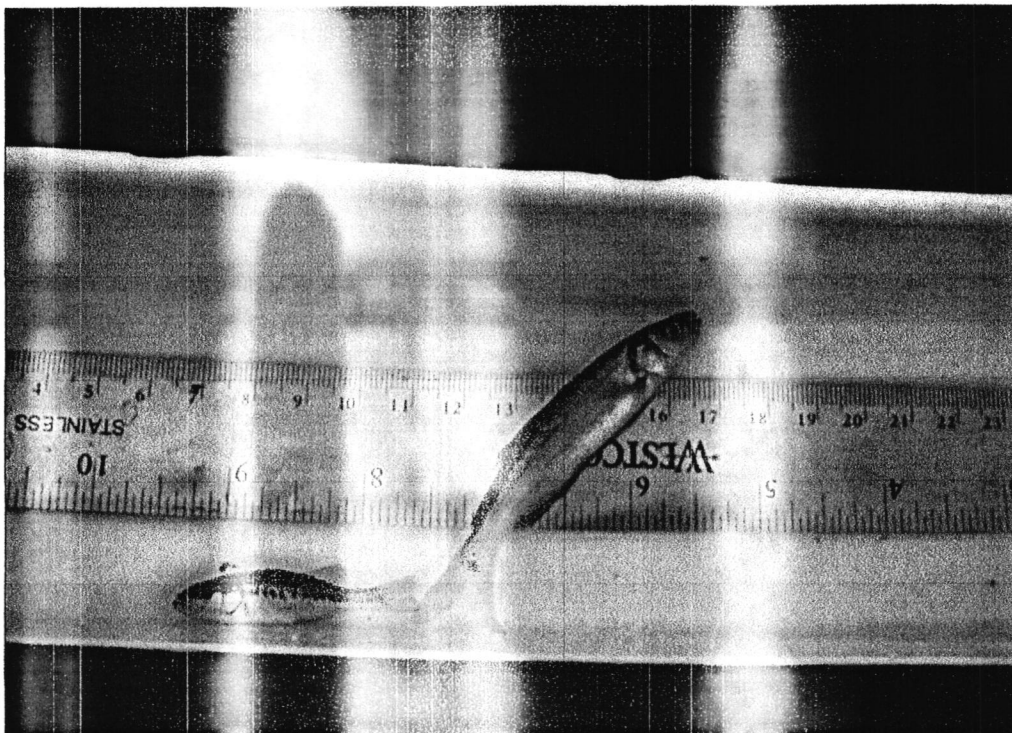
Pond	Trap #	Fish	Length (mm)	Pond	Trap #	Fish	Length (mm)
6	23	pikeminnow	65	mainstem	12	slimy sculpin	78
6	10	largemouth bass	35	mainstem	12	slimy sculpin	75
6	10	largemouth bass	36	mainstem	12	slimy sculpin	62
6	10	largemouth bass	37	mainstem	12	slimy sculpin	60
6	11	none		mainstem	12	slimy sculpin	64
6	6	pikeminnow	60	mainstem	12	slimy sculpin	66
6	6	largemouth bass	32	mainstem	12	slimy sculpin	65
6	9	largemouth bass	32	mainstem	12	slimy sculpin	40
6	9	largemouth bass	35	mainstem	12	slimy sculpin	63
6	9	largemouth bass	37	mainstem	12	slimy sculpin	61
6	9	largemouth bass	41	mainstem	12	slimy sculpin	71
6	9	largemouth bass	42	mainstem	12	slimy sculpin	73
6	5	largemouth bass	31	mainstem	12	slimy sculpin	72
6	5	largemouth bass	36	mainstem	12	stickleback	40
6	5	largemouth bass	42	mainstem	12	stickleback	15
6	5	largemouth bass	44	mainstem	12	stickleback	25
6	5	largemouth bass	33	mainstem	12	pikeminnow	50
6	4	largemouth bass	32	mainstem	12	pikeminnow	54
6	4	largemouth bass	30	mainstem	13	pikeminnow	65
6	4	largemouth bass	31	mainstem	13	pikeminnow	60
6	2	largemouth bass	36	mainstem	13	pikeminnow	70
6	2	largemouth bass	34	mainstem	13	pikeminnow	72
6	2	largemouth bass	39	mainstem	13	pikeminnow	75
6	3	largemouth bass	38	mainstem	13	stickleback	40
6	3	largemouth bass	37	mainstem	14	slimy sculpin	72
6	1	largemouth bass	39	mainstem	14	slimy sculpin	75
6	1	pikeminnow	68	mainstem	14	slimy sculpin	20
6	7	pikeminnow	103	mainstem	14	stickleback	62
6	8	killifish	75	mainstem	14	stickleback	75
6	8	killifish	80	mainstem	14	stickleback	60
6	8	killifish	72	mainstem	14	stickleback	62
6	8	killifish	74	mainstem	14	stickleback	54
6	8	largemouth bass	35	mainstem	15	stickleback	35
6	8	largemouth bass	37	mainstem	15	stickleback	35
6	8	largemouth bass	40	mainstem	15	crayfish	80
				mainstem	16	slimy sculpin	60

Pond	Trap #	Fish	Length (mm)	Pond	Trap #	Fish	Length (mm)
5	17	stickleback	30	3	21	stickleback	35
5	17	stickleback	31	2	22	slimy sculpin	60
5	17	stickleback	30	2	22	slimy sculpin	62
5	17	stickleback	32	2	22	slimy sculpin	68
5	17	stickleback	33	2	22	slimy sculpin	70
5	17	stickleback	37	5	18	stickleback	41
5	17	stickleback	31	5	18	stickleback	47
7	19	largemouth bass	39	5	18	stickleback	42
7	19	largemouth bass	41	5	18	stickleback	39
7	19	largemouth bass	47	5	18	crayfish	80
7	19	largemouth bass	51				
7	19	largemouth bass	50				
7	19	stickleback	31				
7	19	stickleback	33				
7	19	pikeminnow	65				
7	19	pikeminnow	62				
8	20	largemouth bass	35				
8	20	largemouth bass	36				
8	20	stickleback	35				
8	20	stickleback	36				
8	20	stickleback	39				
3	21	slimy sculpin	50				
3	21	slimy sculpin	65				
3	21	slimy sculpin	56				
3	21	slimy sculpin	58				
3	21	slimy sculpin	60				
3	21	stickleback	30				
3	21	stickleback	31				
3	21	stickleback	32				
3	21	stickleback	33				
3	21	stickleback	34				
3	21	stickleback	35				
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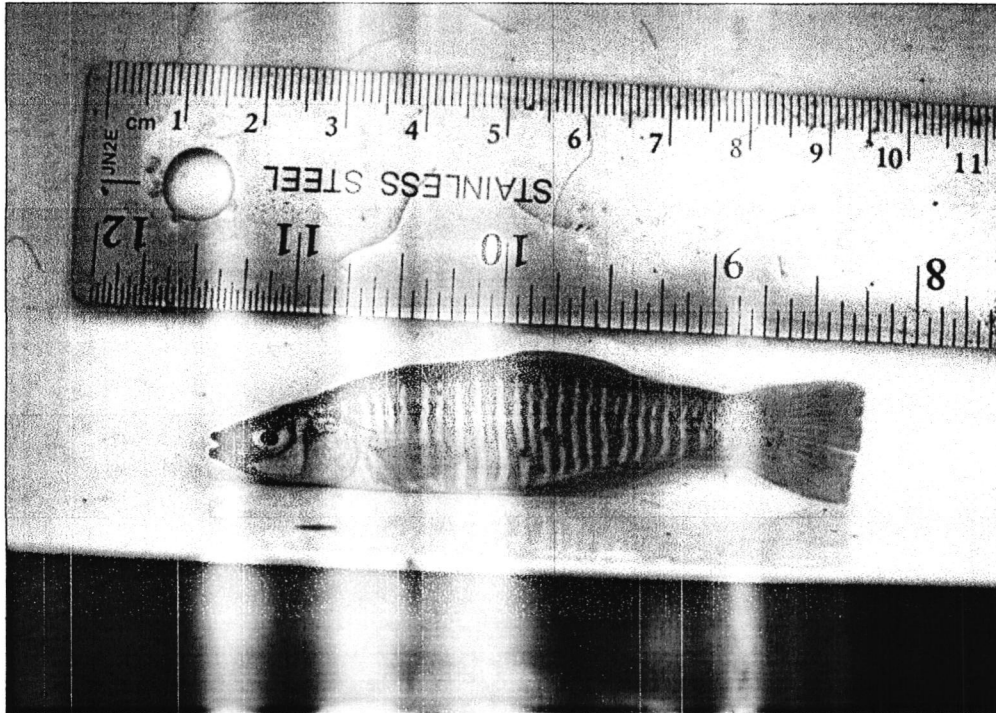
PHOTOGRAPHS



Ridgefield Pit 6 facing west near the EFLR, Washington.



Representative *N. pikeminnow* and largemouth bass captured in a minnow trap in Pit 6, EFLR, Washington.



Representative banded killifish captured in a minnow trap in Pit 6, EFLR, Washington.

Technical Memo

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Date: October 28, 2013
From: Thomas Grindeland, P.E.
Subject: CM-10 Monitoring Report – Ridgefield Pits Bathymetric Survey



Introduction

WEST Consultants Inc. (WEST) conducted a bathymetric survey and developed an estimate of sediment infill rates for the Ridgefield Gravel Pits located along the East Fork Lewis River. The periodic survey and infill rate estimate are required under Conservation Measure 10 (CM-10) of the Habitat Conservation Plan (HCP). The location of the Ridgefield Pits is shown on Figure 1 (Appendix A).

The East Fork Lewis River avulsed into the abandoned Ridgefield Pits in 1996. Figure 2 shows the path of the avulsion from aerial photography taken in November 1996. Because the river has the potential to avulse into the off-channel Daybreak Pits, the HCP requires an estimate of the amount of time that would be required for geomorphic recovery. Geomorphic recovery of the East Fork Lewis River channel within the Ridgefield Pits will occur when the geometry and hydraulics of the channel return to conditions similar to those that existed prior to the 1996 avulsion. This is assumed to occur when the channel has returned to an elevation similar to the pre-avulsion channel. The avulsion into the Ridgefield Pits that occurred in 1996 provides an opportunity to estimate recovery time.

The geomorphic recovery of the Ridgefield Pits is also important in the discussion of the potential for avulsion into the Daybreak Pits. It was determined that the potential for the river to avulse into the downstream end of the existing Daybreak Pits is greatly reduced due to the river's current location within the Ridgefield Pits (WEST, 2001). Once geomorphic recovery occurs within the reach of the Ridgefield Pits, the river may have an increased potential for migration in the lateral direction. Lateral migration could allow the channel to move back to a location near the Existing Daybreak Pits.

Methodology

WEST conducted a bathymetric survey of the Ridgefield Gravel Pits 1 – 7 along the East Fork Lewis River. The survey was completed on August 27, 2013. The survey included the active channel, back channel areas, gravel/sand bars, and the overbank areas below ordinary high water within the boundaries of Ridgefield Pits 1 through 7. Pit 8, Pit 9, and an isolated portion of Pit 3 located along the eastern boundary were not included in the survey. The vertical datum for the survey is NGVD 29.

Survey control was established using a Trimble RTK GPS system. To establish control, a Washington State Department of Transportation benchmark (monument ID: 4880) was used. Control was verified using other benchmarks in the vicinity of the project site (National Geodetic Survey benchmark RD4104 and Clark County benchmark 1267). Control was established along the entire project reach in order to complete shallow water and ground portions of the survey. For the areas which were too deep for conventional survey equipment, a survey grade SONAR instrument, integrated with the RTK GPS system, was used to collect bathymetric data.

In order to estimate the sediment infill rates from the survey results, a digital terrain model (DTM) of the project area was developed using Arc-GIS. Overbank areas not included in the survey were supplemented with available LiDAR (USACE, 2010). The resulting DTM of the 2013 survey is shown in Figure 3.

A contour map of the bathymetric survey performed in September 1999 (Chase Jones, 1999) of Ridgefield Pits 1 through 7 was also available for this analysis. The map provided only below water surface contours of 1999 pit conditions. Unfortunately, the contour map of the 1999 survey contained only a few overbank elevation points. The 1999 contours were recreated in Arc-GIS and a DTM was created from the 1999 bathymetry. The DTM of the 1999 bathymetry was supplemented with overbank contour data developed from LiDAR flown in 2004 (USACE, 2004). The DTM of the 1999 survey is shown in Figure 4.

A boundary for each pit was developed to conduct sediment infill calculations. The boundary extends beyond both the historic and current pit area in order to capture potential channel migration. The boundaries for each pit are shown in Figure 5. The volume of the Ridgefield Pits for 1999 and 2013 surveys were estimated using Arc-GIS. The same top elevations were used in the calculation of remaining pit volumes.

Sediment Infill Rate

The average depths of the Ridgefield Pits before the avulsion occurred were estimated by a former gravel mine operator at the Ridgefield Pits. The pre-avulsion pit volumes are shown in Table 1 (WEST, 2001). The estimated pit volumes from the 1999 and 2013 bathymetric surveys are also shown Table 1.

Table 1: Estimated Changes in Volume of the Ridgefield Pits since the 1996 avulsion.

Pit	Pre-1996 Pit Volume (2001 study)	Pre-1996 Pit Depth (2001 study)	Pit Top Elevation (2001 study)	1999		2013	
				Volume	Volume Change	Volume	Volume Change
	(yd ³)	(ft)	(ft)	(yd ³)	%	(yd ³)	%
1	157,700	12	35	118,583	-25%	21,958	-86%
2	102,900	12	34	130,131	26%	54,185	-47%
3	108,500	20	33	124,203	14%	76,290	-30%
4	143,500	20	32	105,176	-27%	51,000	-64%
5	164,800	20	31	160,661	-3%	88,955	-46%
6	204,900	30	31	128,119	-37%	66,211	-68%
7	186,900	20	30	178,981	-4%	96,299	-48%
total	1,069,200			945,854	-12%	454,897	-57%

According to the results listed in Table 1, the reduction in total volume for Pits 1 – 7 averaged approximately 3-percent per year for the period of 1996 – 1999. For the period of 1999 – 2013, the reduction in total pit volume averaged approximately 3.2-percent per year. For the period of 1996 -1999, the volume of Pit 2 and Pit 3 increased 26-percent and 14-percent, respectively. The noted volume increase in these pits is attributed to several factors: 1) Localized erosion from lateral channel migration may have increased the pit volumes and transported the material downstream; 2) The geomorphic boundaries (Figure 5) established for this study may have increased the pit volume because it includes areas which were excluded in the previous study; 3) The pre-1996 pit volumes may have been under-estimated.

The predicted recovery period developed from the recent survey is approximately 30 years from time of the initial avulsion (1996). This suggests that the Ridgefield Pits will fill by 2026. Figure 6 summarizes the observed and predicted infill rate for the Ridgefield Pits. This information corresponds very favorably to the prediction of 25 – 30 years originally published in the Habitat Conservation Plan (WEST, 2001).

Geomorphic Observations

A site reconnaissance of the Ridgefield Pits site was conducted by Thomas R. Grindeland P.E. and Rick Shimota P.E. on August 30, 2013. Observations of the channel and overbank areas were made to determine the extent and characteristics of sediment infilling. A photographic log of site reconnaissance observations is provided in Appendix B.

The material deposited in Pits 1 and 2 was observed to be sands, gravels and, cobbles with a median diameter (D_{50}) of approximately 2.5 inches. The general characteristic of Pit 1 was riverine in nature and characteristics of a former gravel pit were not evident. The eastern portion of Pit 2 has a geomorphic character similar to Pit 1. The western portion of Pit 2 is more similar

to a back channel environment, with fine sands being the predominant sediment. Historic aerial photography shows the channel was located in this area in 2007 and coarser material may have been deposited under the current sand deposits. Portions of the channel in Pit 3 were observed to have a gravel and cobble substrate, with a D_{50} of approximately 2.5 inches. Again, the sediment deposits observed in the backwater areas of Pit 3 are primarily sand. Predominantly, sediment deposits in Pits 4 through 7 were observed to be sand.

Native material or "leave strips" were noted to have separated each of the gravel pits. The 1996 avulsion and subsequent floods have eroded away transportable material in the area of where leave strips had been breached, leaving behind gravels and cobbles, which have formed short riffles connecting Pit 3 to Pit 4, Pit 4 to Pit 5, and Pit 5 to Pit 7.

A review of historic aerial photography for the Ridgefield Pits was performed to evaluate lateral channel migration conditions. Aerial photography of the site was available for years 1990, 2000, 2002, 2004, 2007, 2011 and 2012. A channel centerline for each available year was developed and overlain as shown in Figure 7.

The most significant migration of the channel centerline was observed to have occurred in Pit 2. The channel centerline in the vicinity of Pit 2 moved laterally approximately 350 feet between years the 2007 and 2011. The centerline switched from the western edge of Pit 2 to the eastern edge of Pit 1. The channel migrated eastward a further 80 feet from 2011 to 2012. If the lateral channel migration continues eastward, the channel could move into the eastern portion of Ridgefield Pit 3 or into Ridgefield Pit 9. Potential migration paths are shown in Figure 7.

If the channel migrates into Pit 3, portions of Pit 2 and Pit 3 may be bypassed, lengthening the recovery time of those pits. If the channel migrates into Pit 9, then Pits 2, 3, 4, and 5 will be bypassed, which may lengthen the recovery time of the bypassed pits. However, it is likely that the channel will still be contained within the Ridgefield Site even if the channel shifts to Pit 3 or Pit 9.

Conclusion

The recent bathymetric survey conducted in 2013 suggests that the pits are on a trajectory to fill by 2026, with a predicted recovery period of 30 years from the time of the initial avulsion. Figure 6 summarizes the observed and predicted infill rate of the Ridgefield Pits. The observed rate corresponds well with the prediction of 25 – 30 years originally published in the Habitat Conservation Plan (WEST, 2001). It is recognized that if lateral channel migration bypasses the pits, recover times may be significantly longer. However, it is likely that the East Fork Lewis River channel will remain in the Ridgefield Pits Site for an extended period into the future.

Since the observed infill rates are approximately the same as the original 2001 prediction, and the risk of the channel shifting out of the Ridgefield site has not changed significantly, no change to the Avulsion Contingency Plan (CM-09) associated with the HCP is recommended.

References

U.S. Army Corps of Engineers, LiDAR data, 2010.

WEST Consultants, Geomorphic Analysis of the East Fork Lewis River in the Vicinity of the Daybreak Mine Expansion and Habitat Enhancement Project, May 18, 2001.

Appendix A: Figures

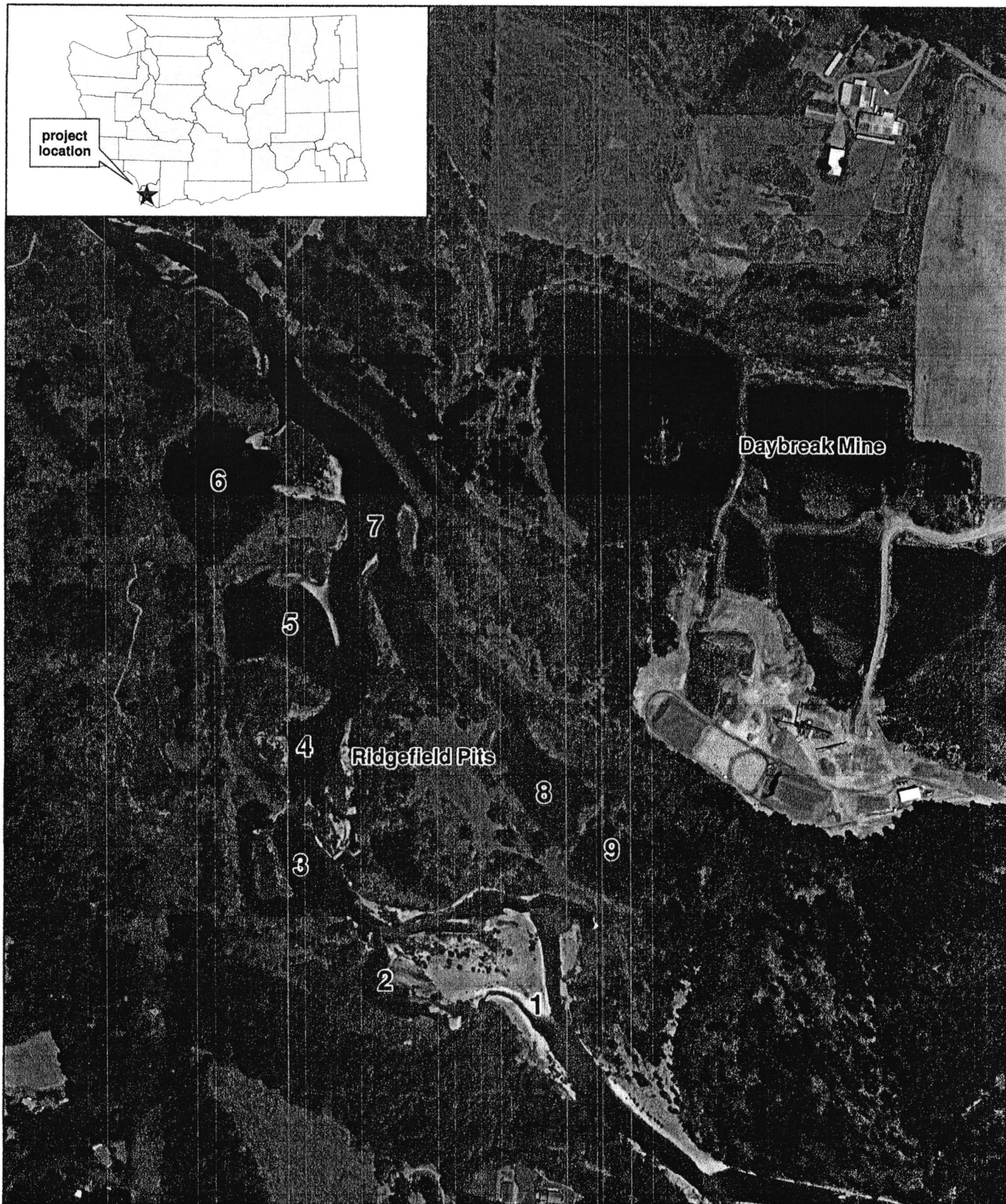


Figure 1
Project Location
Ridgefield Pits - EF Lewis River



0 250 500 1,000 Feet

Ortho Imagery - 1996

Figure 2
Ridgefield Pits - EF Lewis River
November 1996



Figure 3
2013 Survey DTM
Ridgefield Pits - EF Lewis River

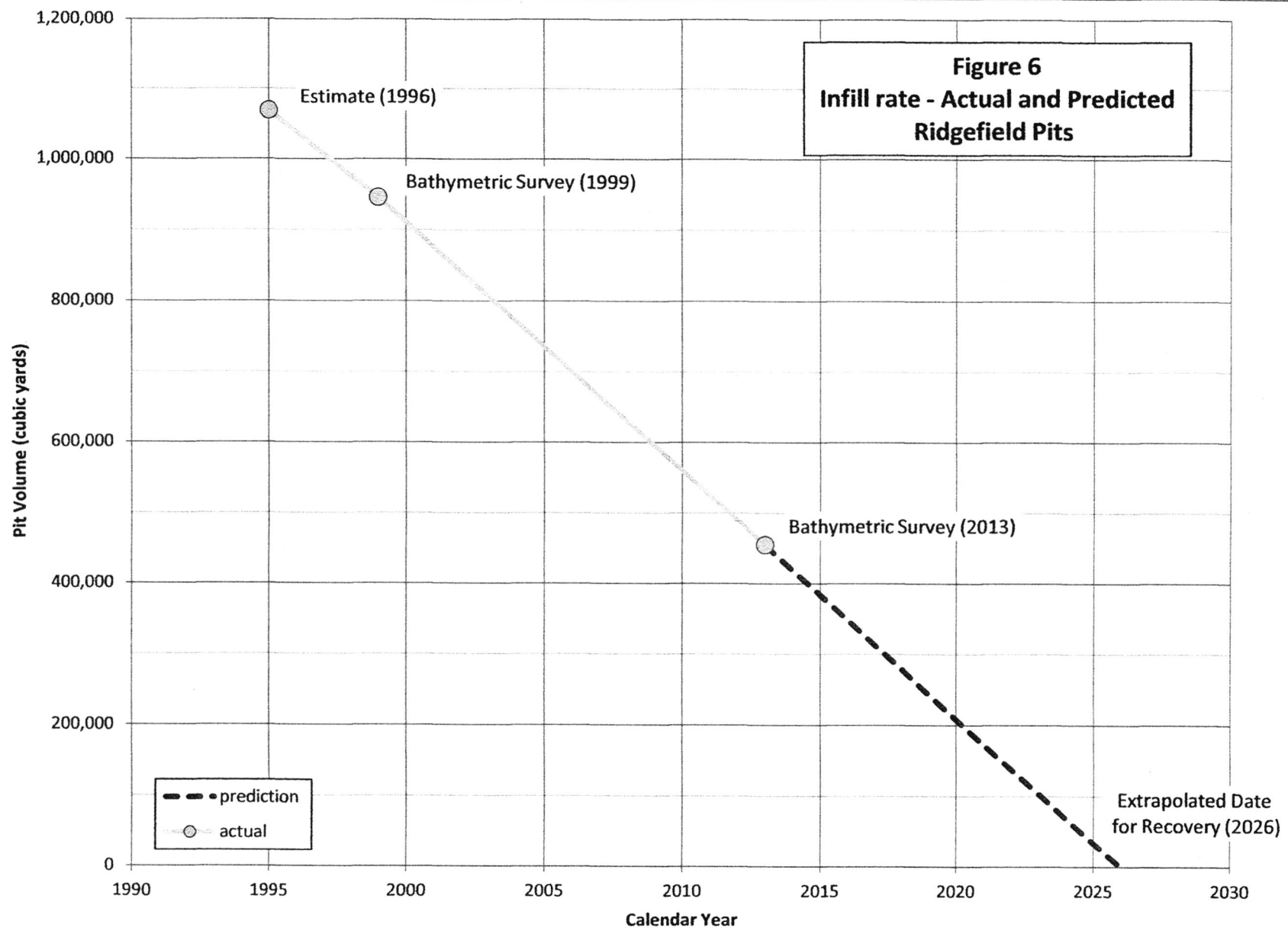


Figure 4
1999 Survey DTM
Ridgefield Pits - EF Lewis River



0 100 200 400
Feet
Ortho Imagery - 2011

Figure 5
Pit Analysis Boundaries
Ridgefield Pits - EF Lewis River



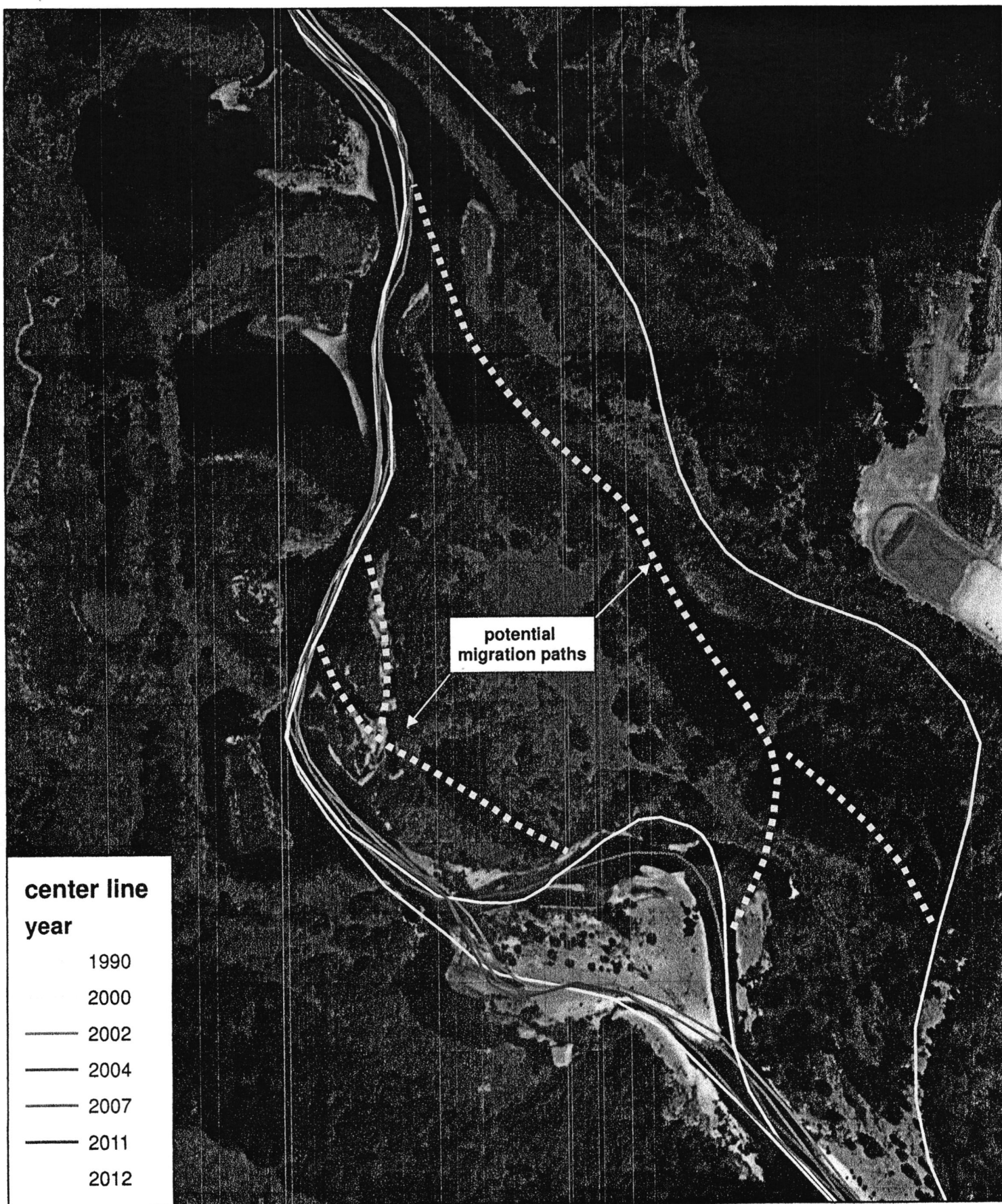


Figure 7
Comparison of Historic Stream Centerlines
EF Lewis River - Ridgefield Pits

Appendix B. Photographic Log

**Ridgefield Pits Site Reconnaissance
East Fork Lewis River - 08/30/13**



Photo 2: Looking downstream (north) at eastern portion of Pit 1.

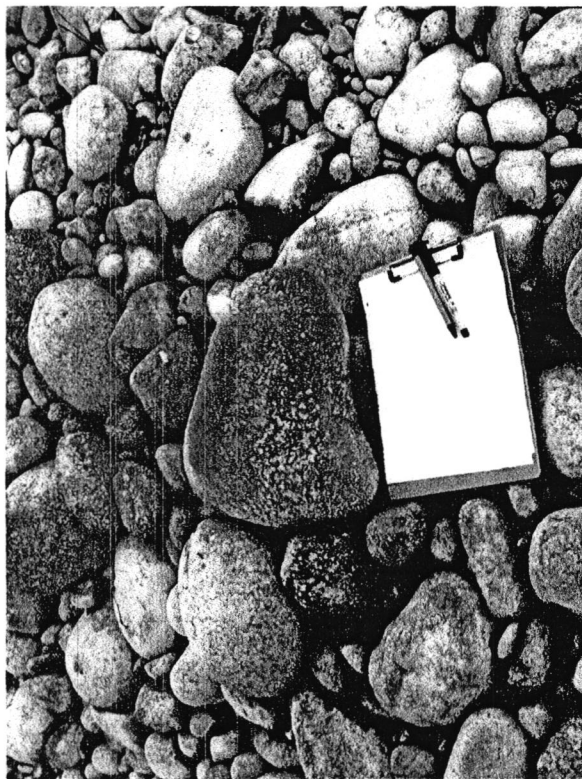


Photo 4: Streambed material, left bank of Pit 1.



Photo 1: Looking northeast at the southern extent of Pit 1.



Photo 3: Looking west towards Pit 2, near western boundary of Pit 1.



Photo 5: Looking east from Pit 1, towards Pit 9.



Photo 6: Looking downstream (west) towards downstream extent of Pit 2.



Photo 7: Streambed material, left bank of Pit 2.



Photo 8: Looking north, western edge of Pit 2. Note gravel delta deposition on right of photo. Sand deposition is predominant left of the gravel delta.

**Ridgefield Pits Site Reconnaissance
East Fork Lewis River - 08/30/13**



Photo 10: Looking downstream towards entrance of Pit 3.



Photo 12: Looking north, western edge of Pit 3.

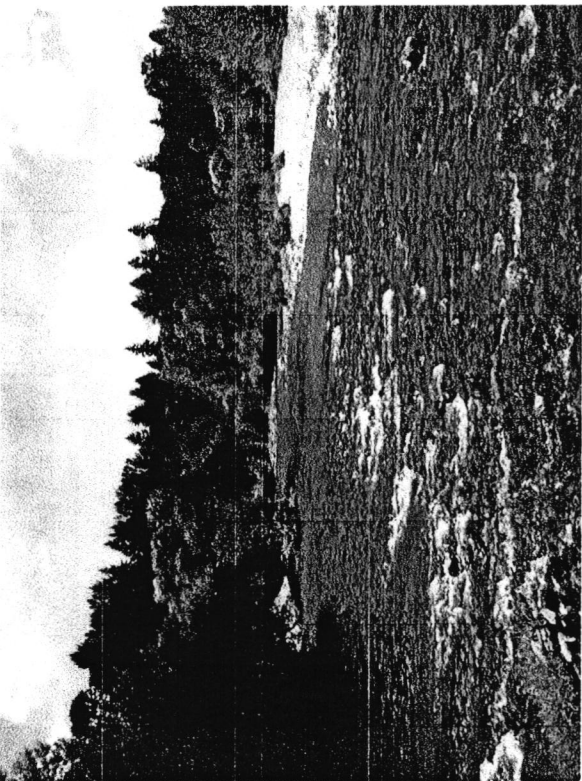


Photo 9: Looking downstream towards Pit 3 from exit of Pit 2.

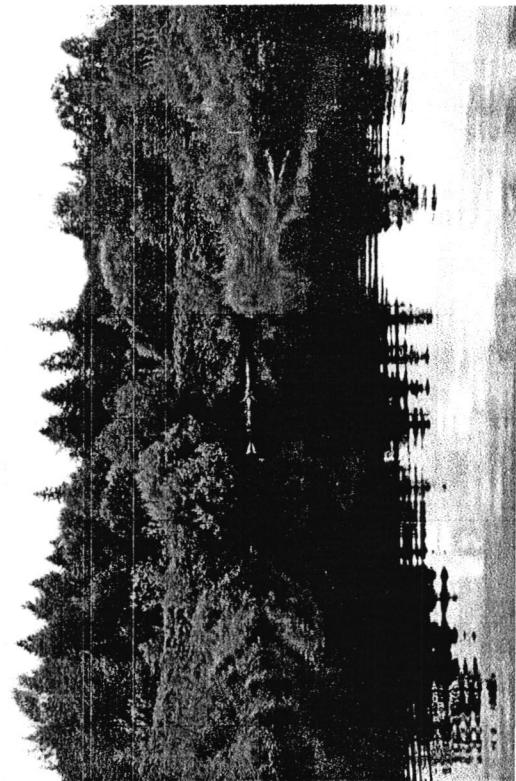


Photo 11: Looking west from mid section of Pit 3.



Photo 13: Looking upstream (south) at exit of Pit 3.



Photo 14: Looking north at the downstream extent of Pit 3. Note the formation of apex log jam on west side of the channel.



Photo 15: Looking upstream (south) at entrance of Pit 4. Note apex jam on right.



Photo 16: Looking downstream from entrance of Pit 4. Note the formation of a second apex log jam on west side of the channel near the exit.



Photo 17: Looking southeast (upstream) from the right bank of Pit 4.



Photo 18: Looking upstream at Pit 4 from Pit 5.



Photo 19: Looking northeast from entrance of Pit 5. Note sandbar formation which separates main channel from the backwater area of Pit 5.



Photo 20: Looking northwest at backwater area of Pit 5.



Photo 21: Looking southwest at southern boundary of Pit 6.



Photo 22: Looking west at Pit 6. Note that Pit 6 is currently cut off from the active channel of the EF Lewis River.



Photo 23: Looking north at Pit 6 from eastern boundary.

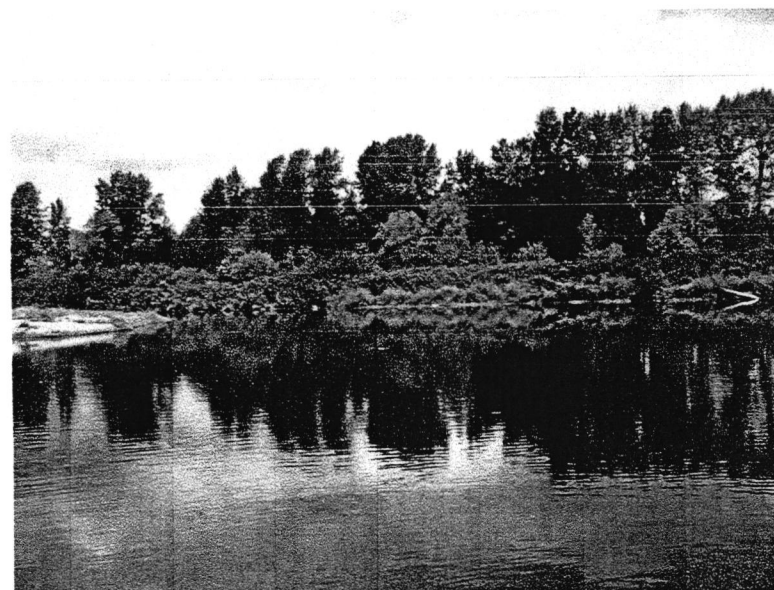


Photo 24: Looking downstream toward the mid section of Pit 7. Note this section is active channel.



Photo 25: Looking upstream from entrance of Pit 7 towards Pit 5.



Photo 26: Looking south at the backwater section of Pit 7.



Photo 27: Looking upstream at entrance to backwater section of Pit 7.

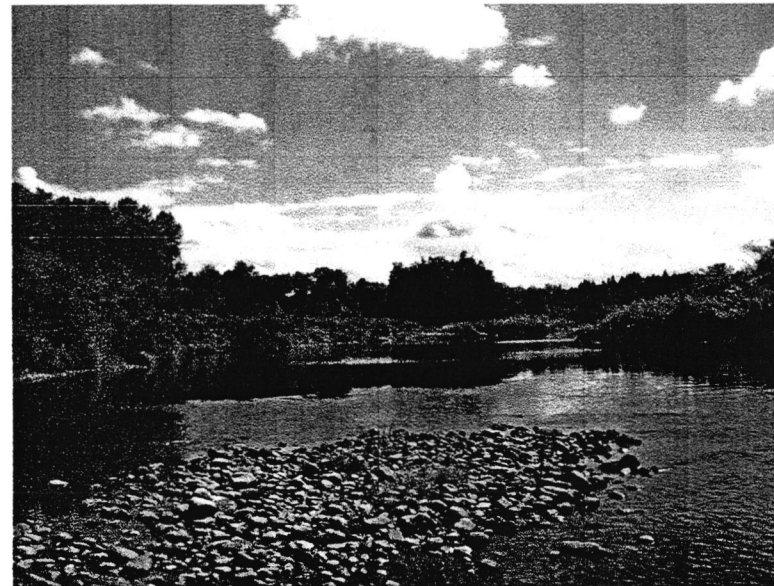


Photo 28: Looking upstream at the downstream extent of Pit 7.