



East Fork Lewis River - Ridgefield Pits Geomorphology

06/27/19



Purpose of Geomorphology Analysis

Update estimates of pit filling rates

Is a project to address the pits worth it?

Understand lower river geomorphology

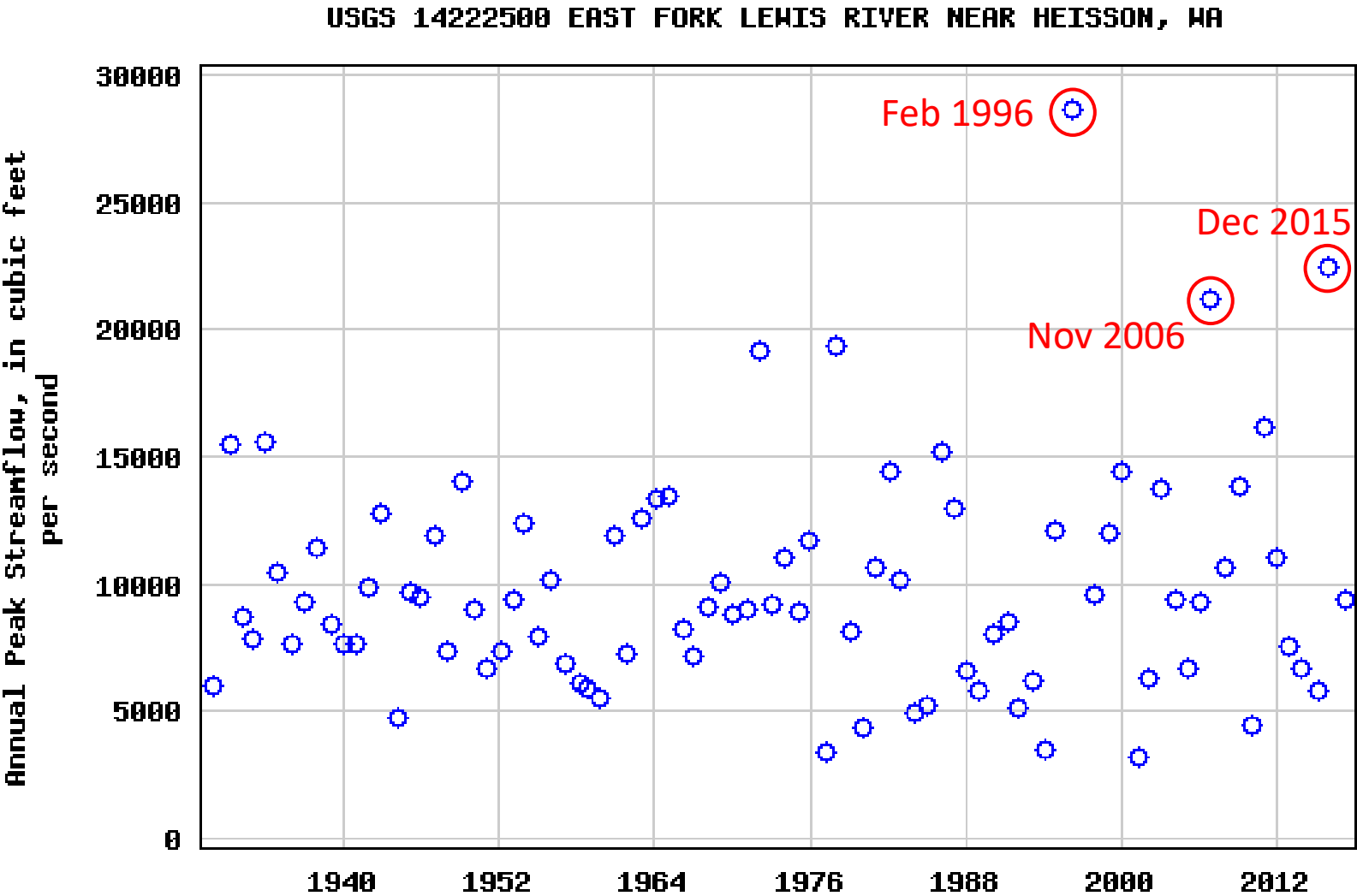
What restoration actions are appropriate given the geomorphic context?

How might future changes affect or interact with restoration actions?

Past Relevant Geomorphology Studies

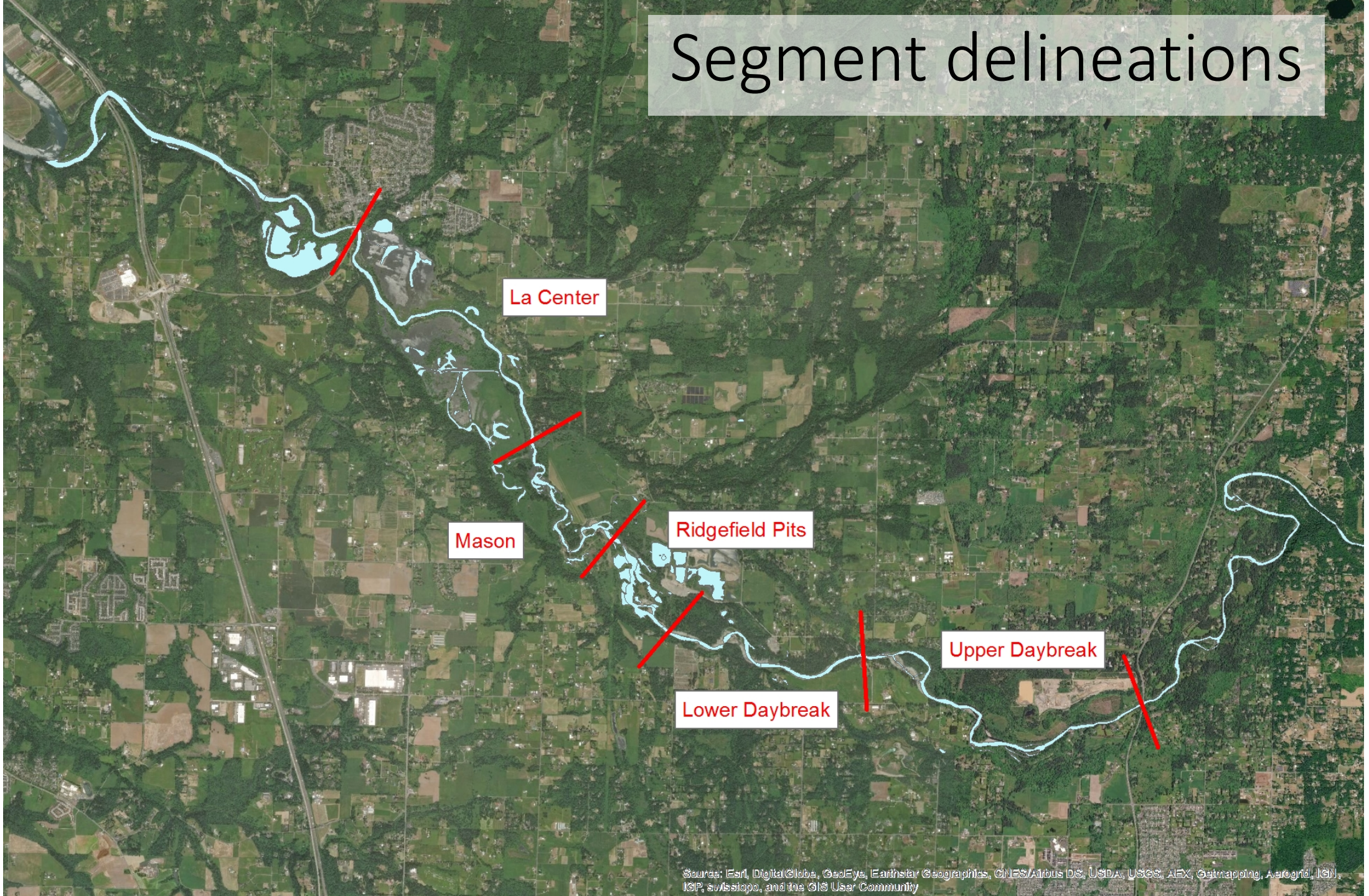
- Daybreak Mine Expansion HCP (Storedahl & Sons 2003).
Geomorphology and restoration info provided by: R2 Resources, WEST, and Ecological Land Services.
 - Conceptual Restoration Plan for Ridgefield Pits (R2 Resource Consultants 1999) – Appendix B of HCP
 - Geomorphic Analysis of the East Fork Lewis River (WEST Consultants 2001) – Appendix C of HCP
 - Daybreak Ponds Avulsion Mitigation (WEST Consultants 2001 and Ecological Land Services) – Addendum 1 to Appendix C of HCP
- Assessment and Strategic Plan for East Fork Lewis River (Dover Habitat Restoration for Friends of the East Fork 2003)
- East Fork Lewis River (RM 13 to RM 6), Including West Daybreak Park Project Reach – Fluvial Geomorphology and Erosion and Sediment Evaluation (Frank Reckendorf 2010).
- The Lower East Fork Lewis River Subbasin: A Summary of Habitat Conditions, Salmonid Distribution, and Smolt Production (WDFW 2001)
- East Fork Lewis River Basin – Habitat Assessment (SP Cramer & Associates 2005)
- Lower East Fork Lewis River Habitat Restoration Plan (Inter-Fluve and Cramer Fish Sciences, for LCFRB 2009)

Flood History



Flood Recurrence Interval	Discharge (CFS)
2-Year	9,160
5-Year	12,900
10-Year	15,400
25-Year	18,500
50-Year	20,800
100-Year	23,100
200-Year	25,300
500-Year	28,300

Segment delineations



Government Land Office (GLO) surveys

1854-1858

“Low rich bottom subject to inundation”

Upland forest:

“... mostly burnt and dead, & partly fallen with thick undergrowth”



GLO surveys

Braided or anastomosing
channel pattern through pits
and in lower Daybreak
segments

Highly sinuous meandering downstream

Meandering/wandering stream types above

Numerous side channels
and wetland areas
throughout valley bottom





Lower Daybreak

Upper Daybreak

Daybreak Bridge

Lewisville Bridge

1858

Lower Daybreak

Upper Daybreak

Daybreak Bridge

Lewisville Bridge

1910

Lower Daybreak

Upper Daybreak

Daybreak Bridge

Lewisville Bridge

1935

Lower Daybreak

Upper Daybreak

Daybreak Bridge

Lewisville Bridge

1939

Lower Daybreak

Upper Daybreak

Daybreak Bridge

Lewisville Bridge

1948

Lower Daybreak

Upper Daybreak

Daybreak Bridge

Lewisville Bridge

1955

Lower Daybreak

Upper Daybreak

Daybreak Bridge

Lewisville Bridge

1970

Lower Daybreak

Upper Daybreak

Daybreak Bridge

Lewisville Bridge

1975

Lower Daybreak

Upper Daybreak

Daybreak Bridge

Lewisville Bridge

1990

Lower Daybreak

Upper Daybreak

Daybreak Bridge

Lewisville Bridge

2005

Lower Daybreak

Upper Daybreak

Daybreak Bridge

Lewisville Bridge



2018

Lower Daybreak

Upper Daybreak

Daybreak Bridge

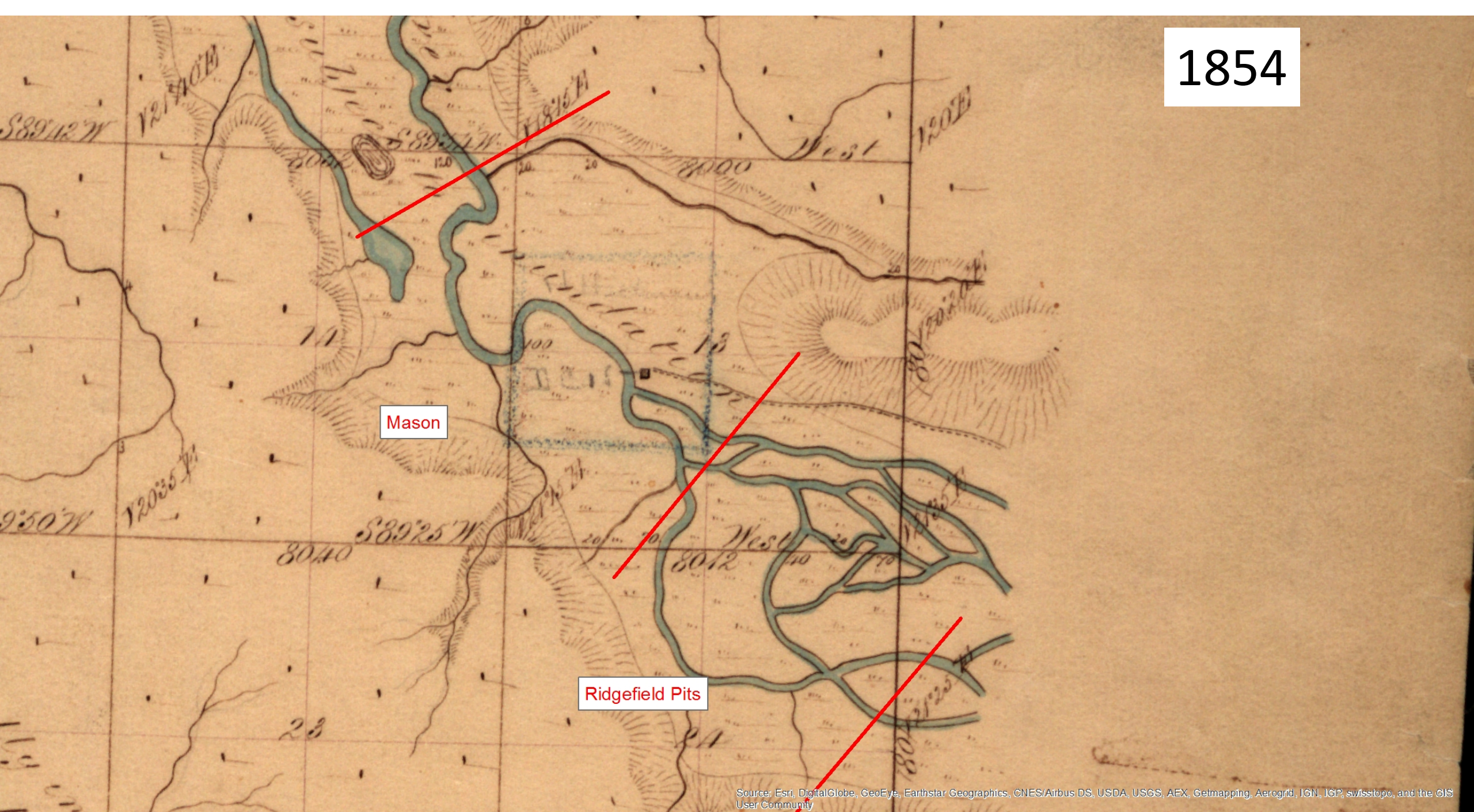
Lewisville Bridge



Mason

Ridgefield Pits

1854



1910

Mason

Ridgefield Pits

1935

Mason

Ridgefield Pits

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

1939

Mason

Ridgefield Pits

1951

Mason

Ridgefield Pits

1955

Mason

Ridgefield Pits

1960

Mason

Ridgefield Pits

1970

Mason

Ridgefield Pits

1975

Mason

Ridgefield Pits

1990

Mason

Untitled Map
Where this data layer is from

Ridgefield Pits

2005

Mason

Untitled Map
No text description for this map.

Ridgefield Pits

2018

Mason

Ridgefield Pits

Take Home Messages from Geomorphic History

Historical Conditions

- Anastomosing in pits reach and up- and downstream
- Highly sinuous meandering in Mason and Daybreak segments
- Likely abundant wood and large wood creating stable jams and forested island features
- Abundant side-channels
- Well-connected floodplains with abundant wetlands and abandoned oxbows
- Channel adjustment during large event (~5 YR recurrence or greater)

Take Home Messages from Geomorphic History

Primary Land Use Impacts

- Conversion of valley bottom forest to agriculture and rural residential
- Instream mining from 1930s to at least 1975
- Mainstem channel avulsions into gravel pits
- Dredging in lower reaches from late 1800s to 1920s
- Roads and bridges
- Channel bank armoring
- Floodplain fill

Take Home Messages from Geomorphic History

Current Conditions

- Meandering reaches with occasional side-channels
- Partially-to-fully disconnected floodplains and less floodplain wetlands
- Narrower channel migration zone
- Moderate large wood abundance but smaller and less stable. Smaller, more transient jams.
- Less large forest structure and hydraulic roughness
- Pit capture effects on Mason Reach?

Current Channel Dynamics

Channel change in some areas occurs seldomly or not at all due to confinement from bridges, armoring, fill, or pit capture

– Low habitat complexity



Current Channel Dynamics

Channel change in other areas occurs very frequently (~annually) due to loss of bank vegetation, loss of large forest structure, loss of large instream wood/jams, channel constrictions, or continued adjustment from past pit avulsions.

– High habitat complexity but possibly redd scour and burial issues



Implications for Restoration Actions

- Assume there will be continued channel changes, especially planform (lateral) dynamics.
**They have always occurred throughout the lower river even though processes, rates, and locations have changed.*
- Continued profile 'rebound' in lower Daybreak. Implications to side channel enhancement
- Effects of Daybreak Bridge constriction: Repeat cycles of sediment deposition then re-incision will continue to deliver sediment to downstream reaches
- Continued erosion of West Daybreak bank will continue to supply sediment to downstream. Pros and cons.
- Possible incision in Mason Segment due to bedload trapping in pits
- Pit avulsion into Daybreak Pits would cause significant impairment (important to prevent)
- Assume wood delivery will continue, but that it will be small and transient
- Areas of high channel complexity have less invasive species
- Design for resiliency and deformation, with channel alterations that retain quality habitat with fluctuating sediment supplies

Analysis of Ridgefield Pit Filling

Available Data and Limitations

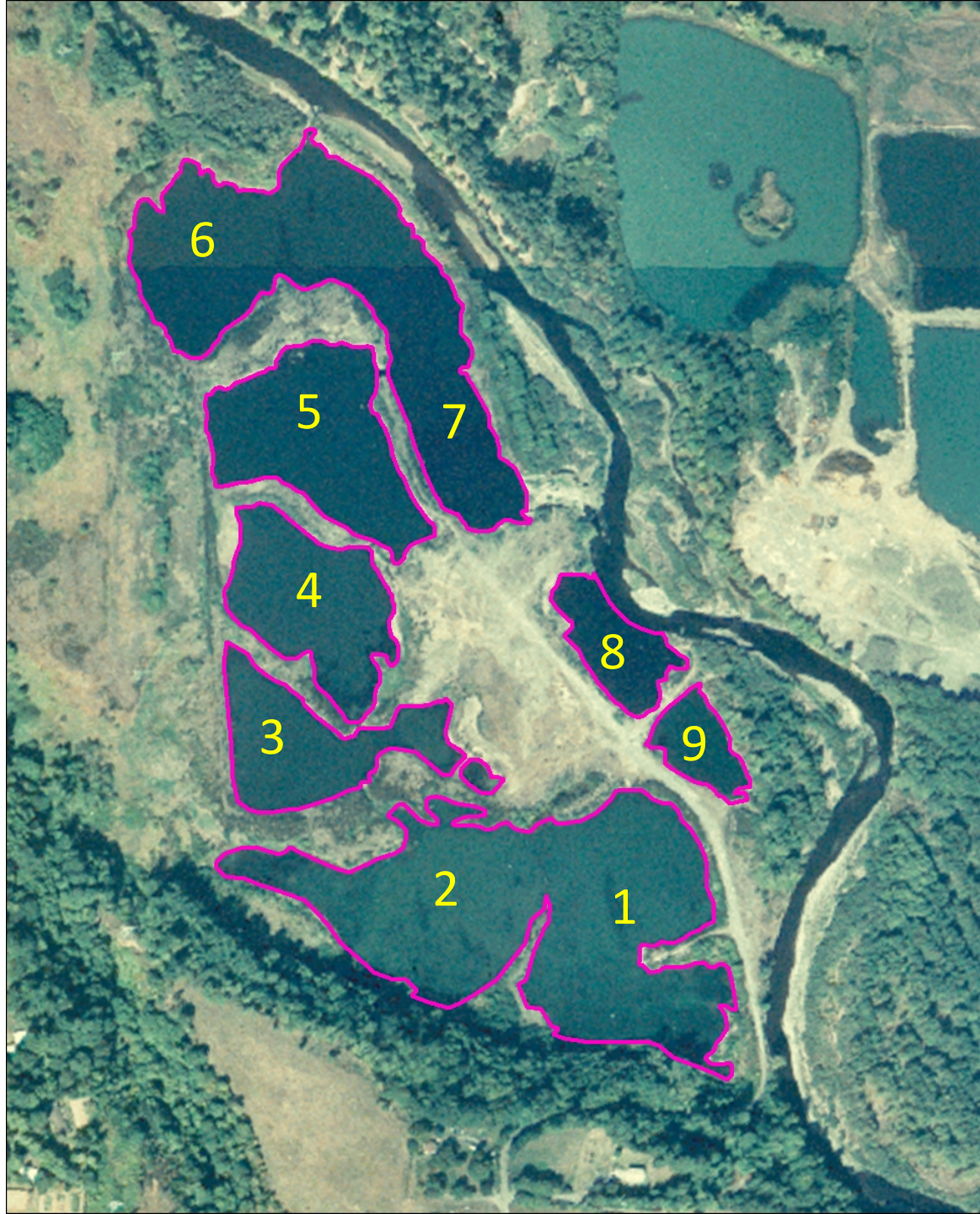
Pre-avulsion data – estimates from workers at the mine

1999 Study – WEST Consultants survey (Storedahl HCP Appendix C)

2013 Study – WEST Consultants survey (Tech Memo to Storedahl)

2018 Study – Estuary Partnership and Inter-Fluve survey

Pit Numbering



Avulsion History

Avulsion into Mile 9 Pit in November 1995





1990



1994



Feb 1996



Summer 1996

Nov/Dec 1996





1999

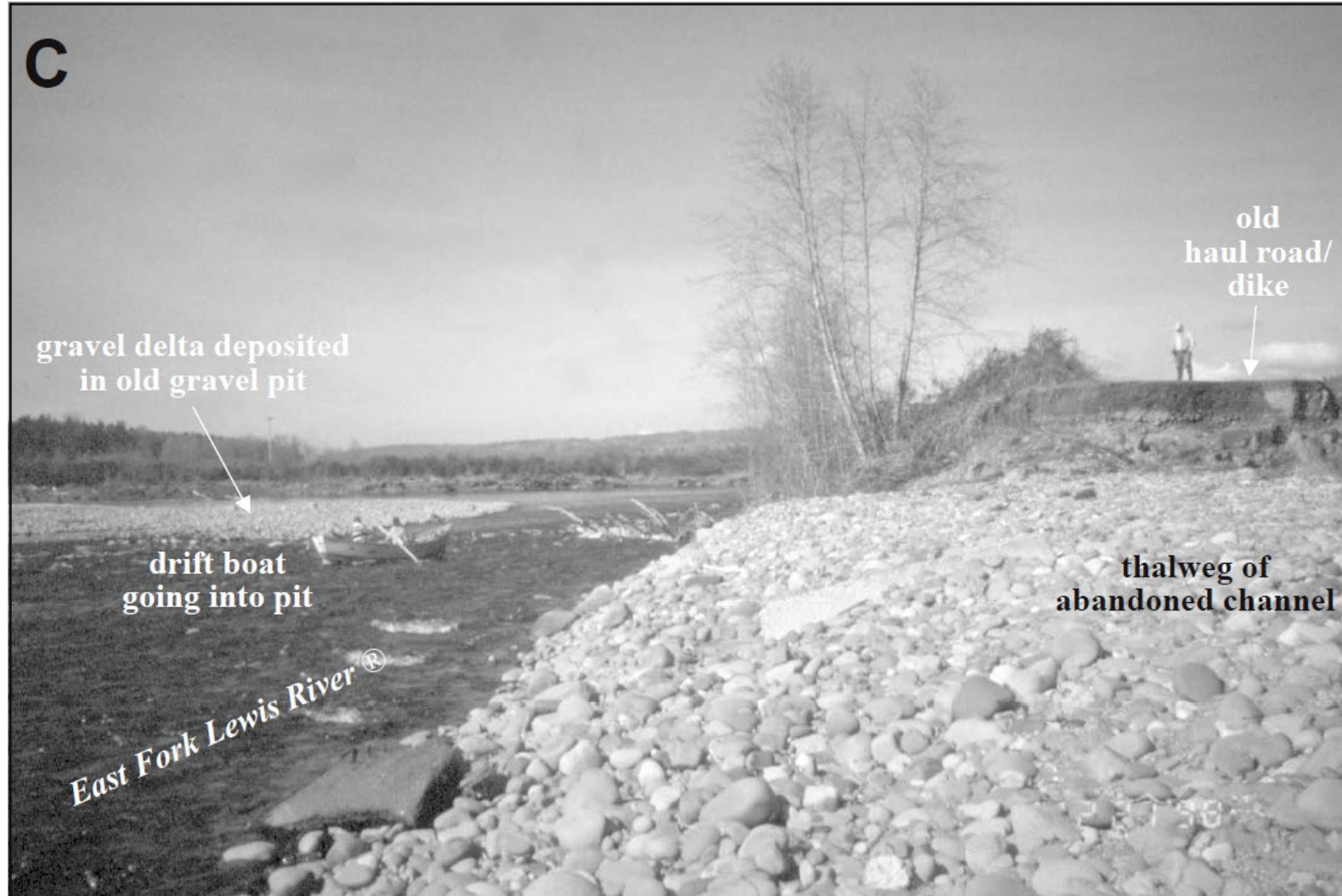
2019



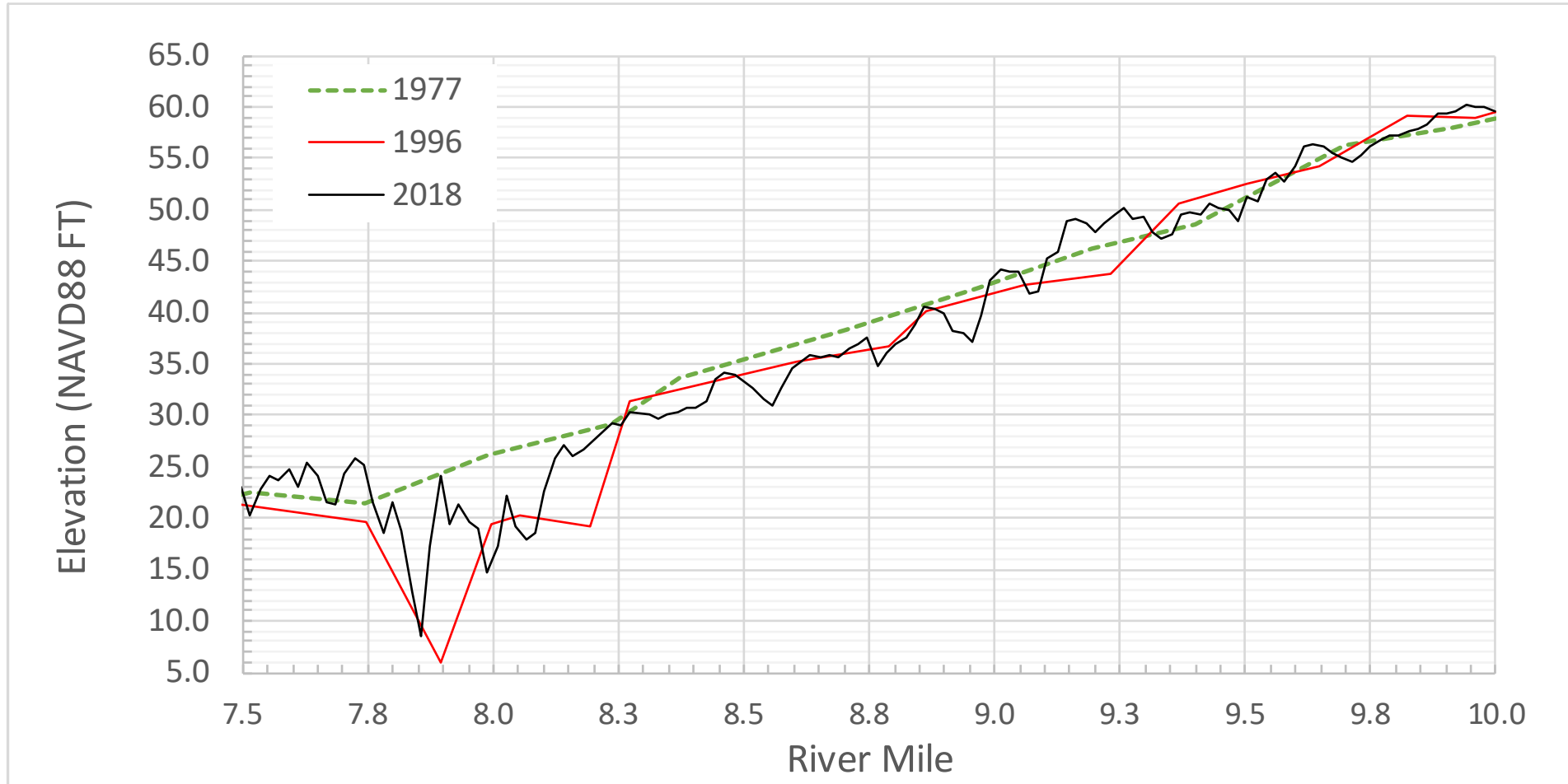
Geomorphic Effects of Pit Avulsion

Profile Response

- 5 ft lowering immediately upstream of the pit entrance 1 month following avulsion (WEST 1996 as cited in WEST HCP appendix)
- Slight increase in slope upstream of put avulsion noted by WEST (HCP appendix) immediately following avulsion
- 10 ft lowering immediately upstream of the pit entrance (Norman et al. 1998).

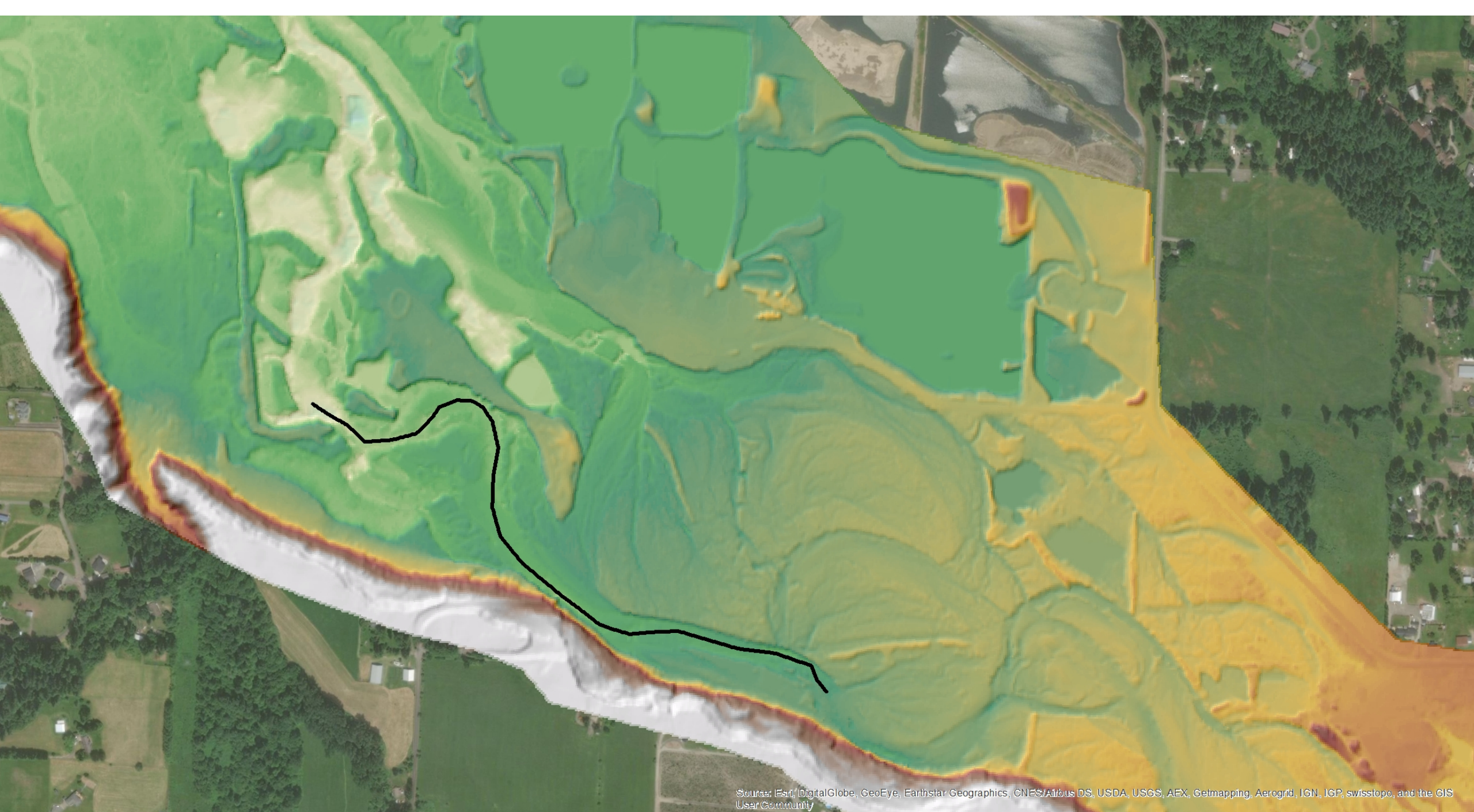


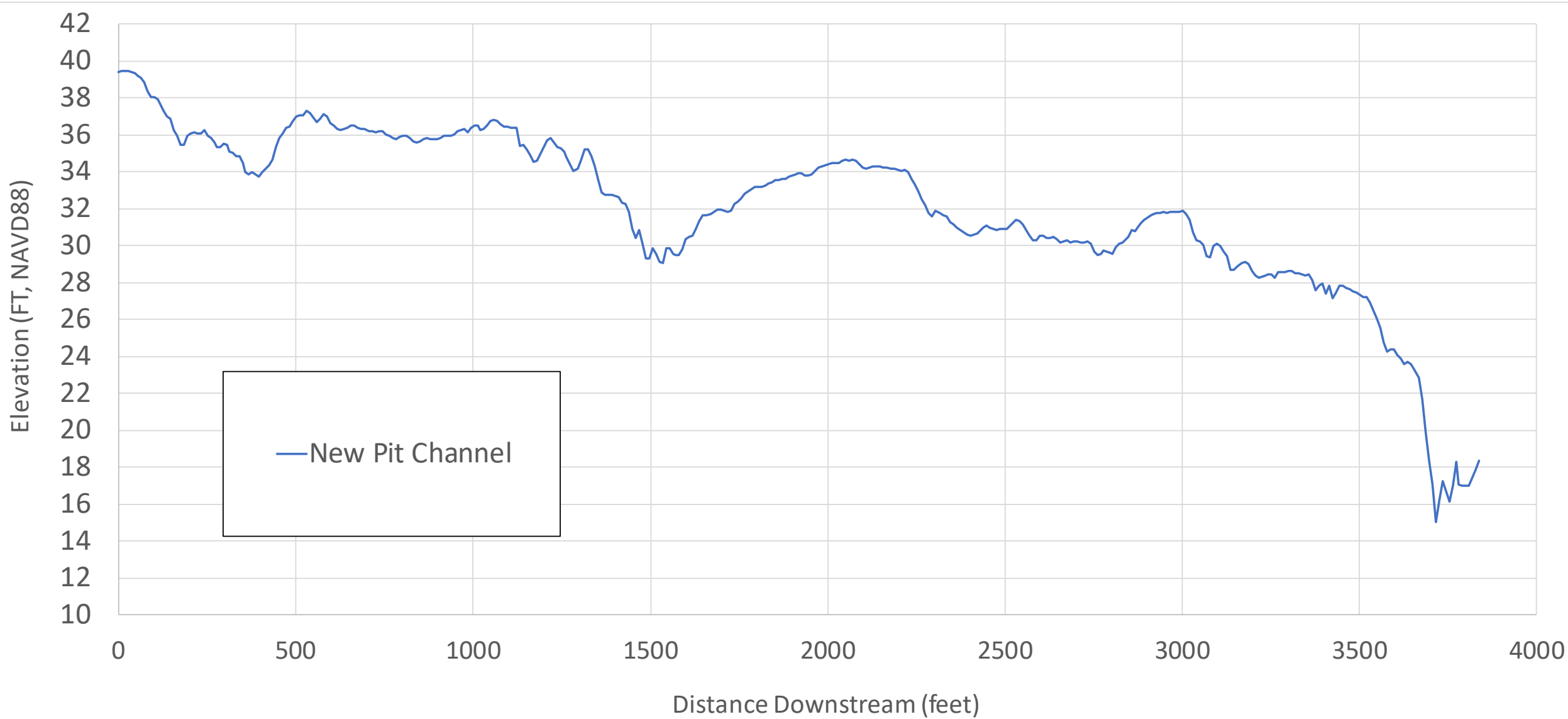
Geomorphic Effects of Pit Avulsion

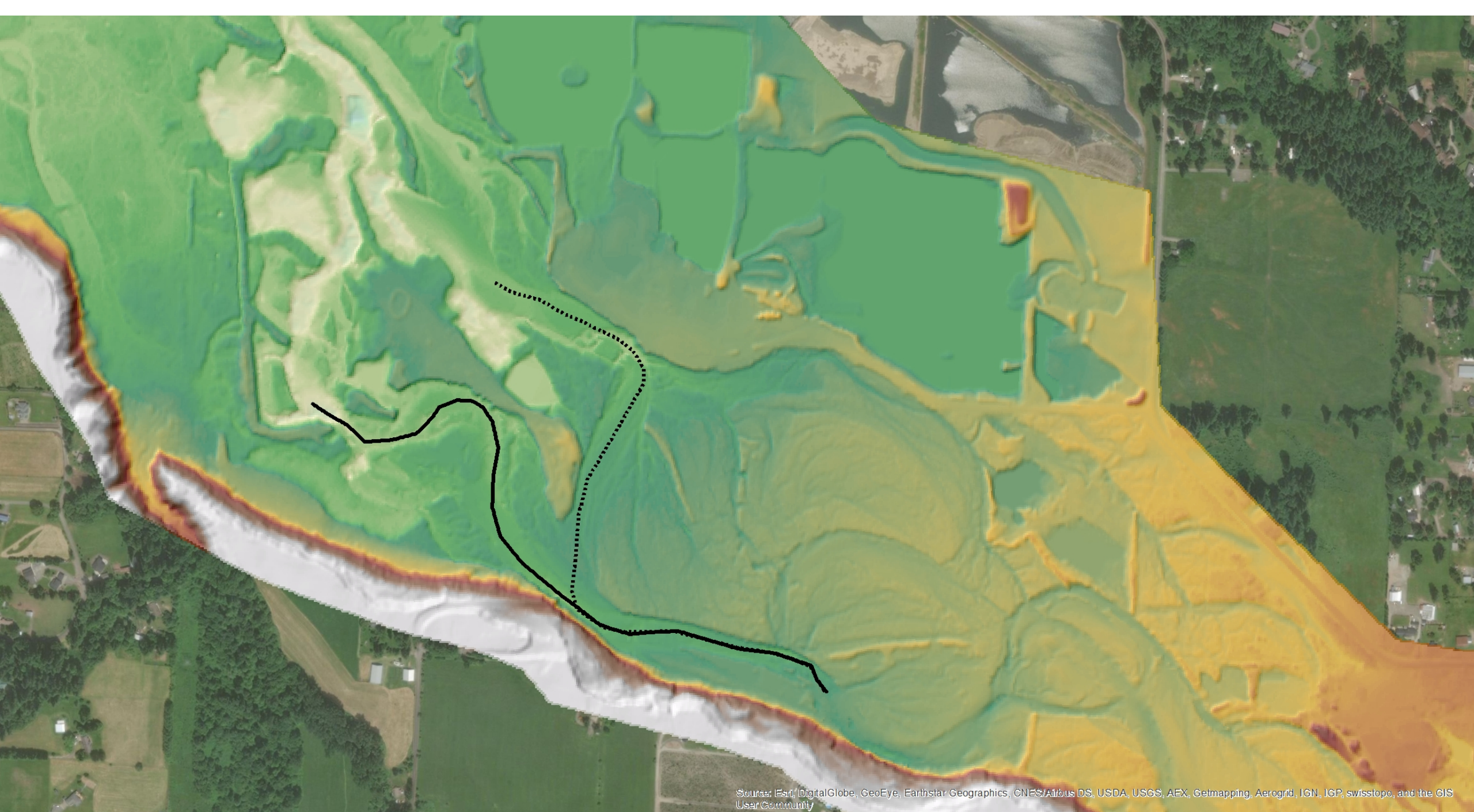


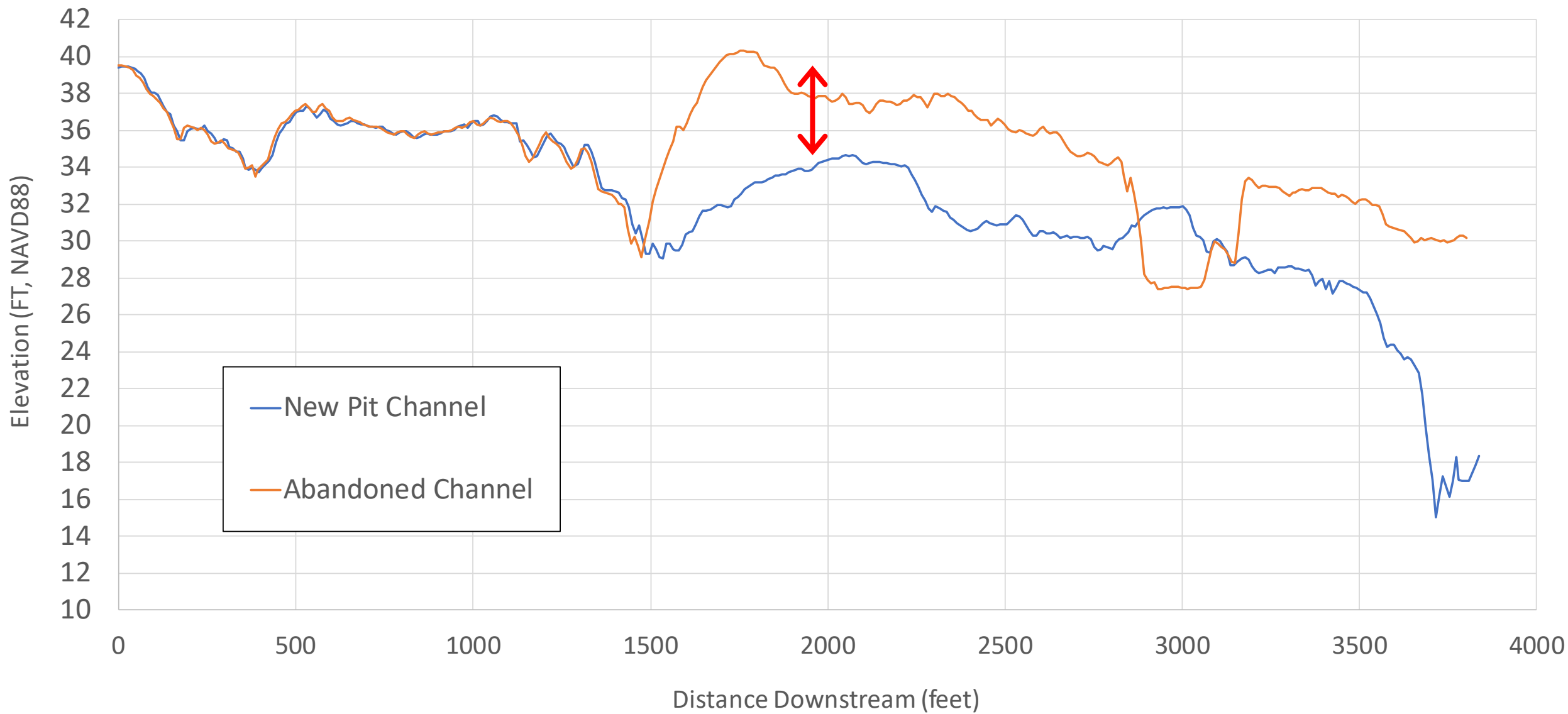


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community









WEST Sediment and Pit Recovery Study

- Performed to understand rate of recovery if river avulses into Daybreak Pits, and because once Ridgefield Pits have recovered, avulsion or erosion into the Daybreak Pits may be more likely.
- Original estimates from 2001 (in HCP) were developed based on sediment yield and transport analyses and assumptions of trap efficiency. Ranged from 25-30 years
 - Watershed sediment yield and bedload transport capacity estimate = 25 years
 - *However, it was noted it could be 75 years if Norman (1998) estimate of 2 million cubic yards is used*
 - Delta growth rate = 30 years
- 2013 Study of pit filling (WEST). Used volumetric calculation of pit filling to estimate rate and predict timeline. Again came up with 30 years.

West Sediment Study (cont'd)

- Performed bathymetric survey in 2013 to update infill rate estimate

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

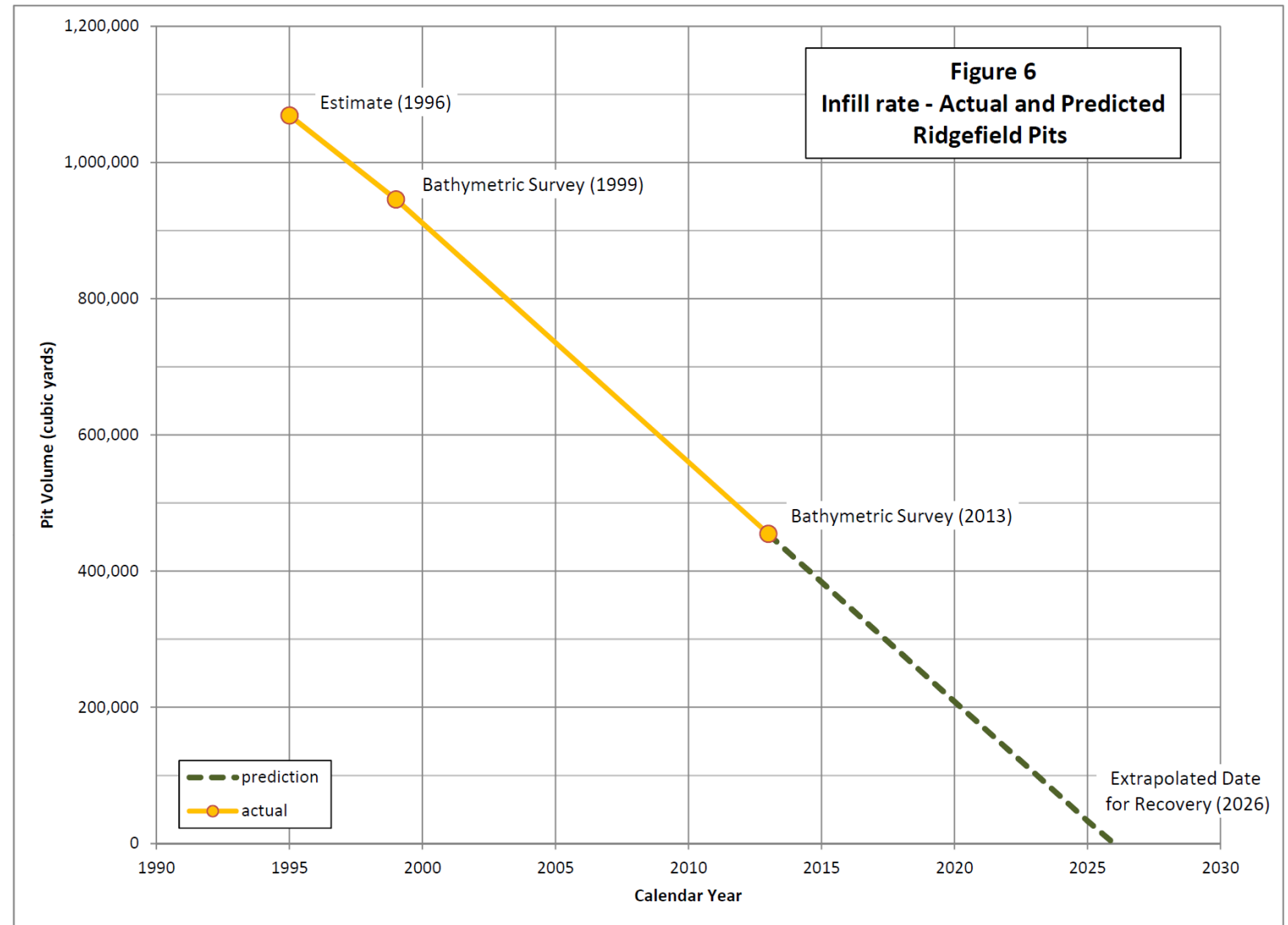
Pit	Pre-1996 Pit Volume (2001 study)	Pre-1996 Pit Depth (2001 study)	Pit Top Elevation (2001 study)	1999		2013	
				Volume	Volume Change	Volume	Volume Change
	(yd ³)	(ft)	(ft)	(yd ³)	%	(yd ³)	%
1	157,700	12	35	118,583	-25%	21,958	-86%
2	102,900	12	34	130,131	26%	54,185	-47%
3	108,500	20	33	124,203	14%	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%



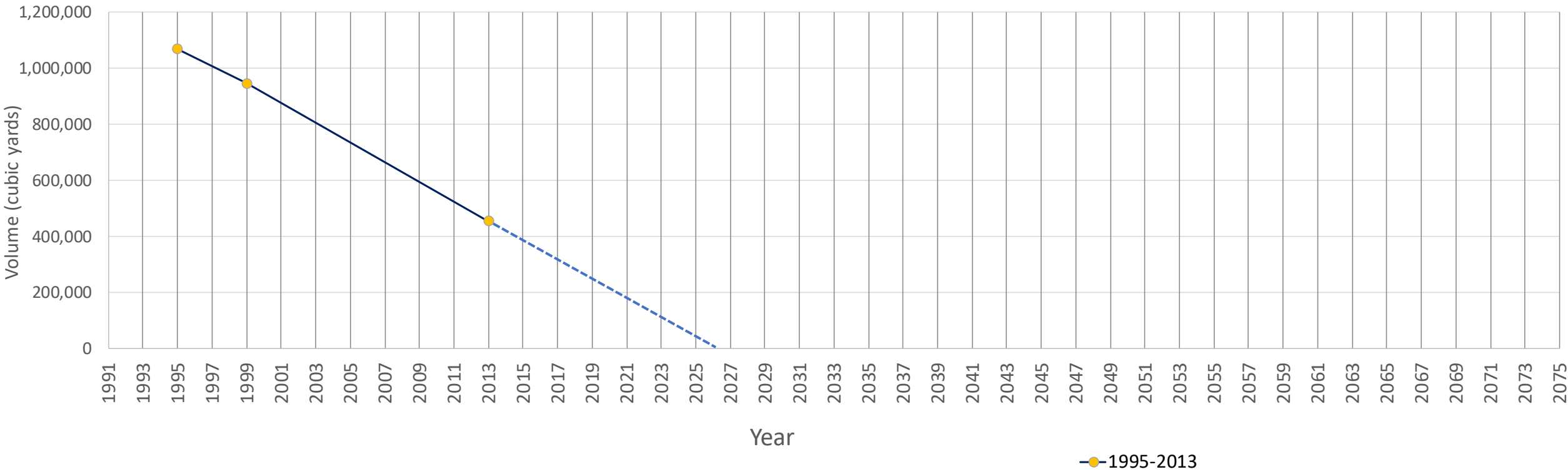
West Sediment Study (cont'd)

Estimate pits on a trajectory to fill by 2026

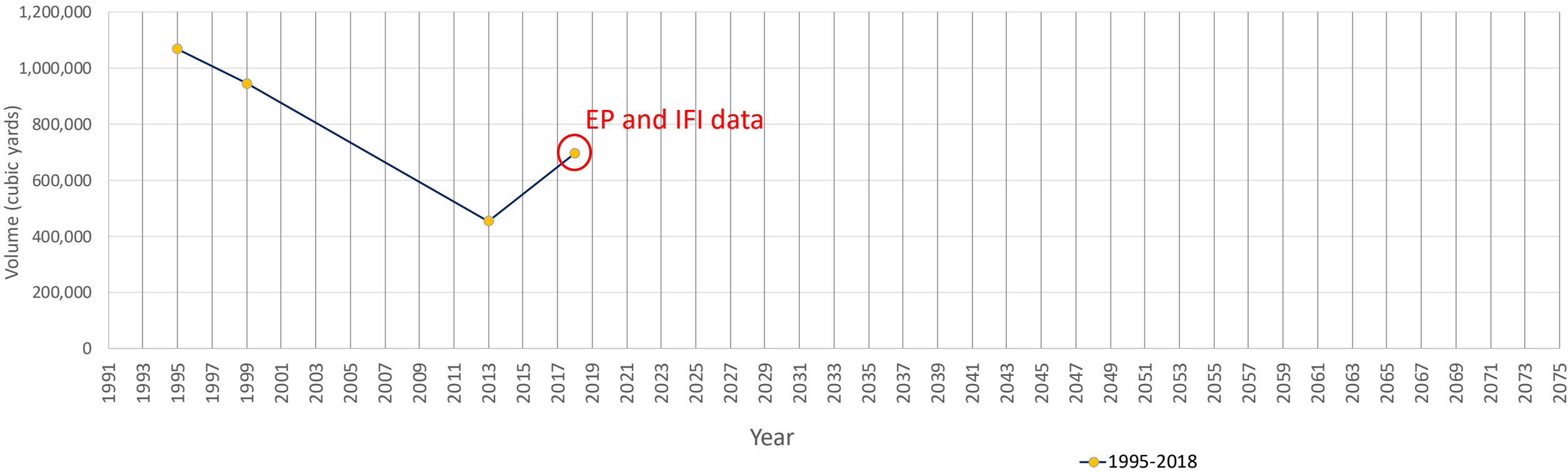
**they don't include Pits 7 & 8 in their filling estimates*



Total Pit Volume



Total Pit Volume



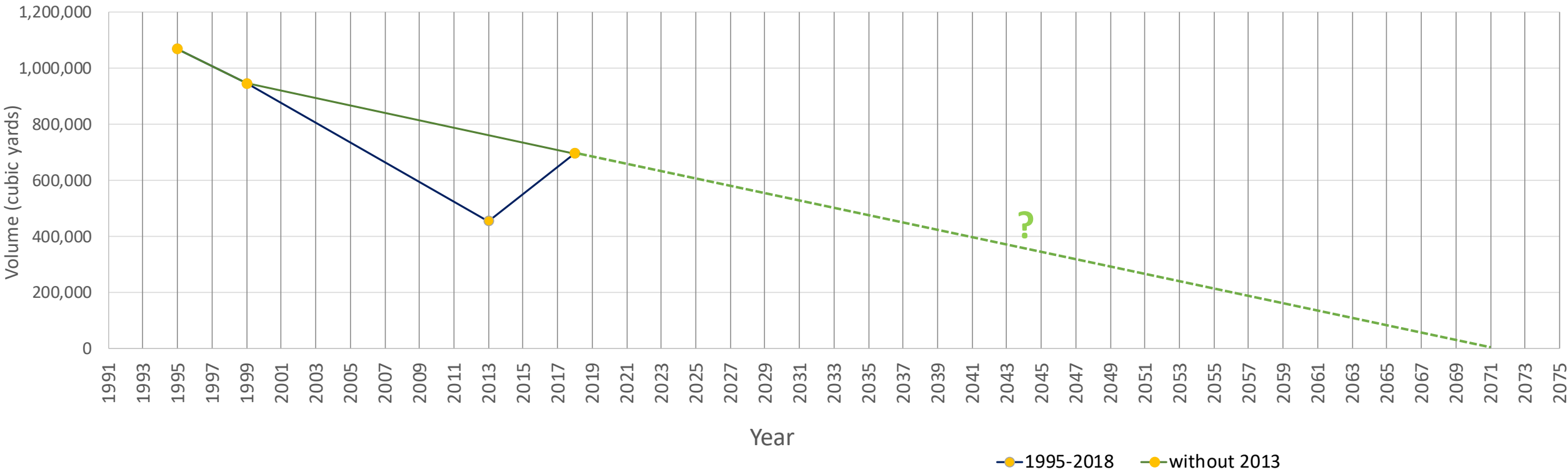
Pit boundaries used for
volumetric analysis
– from WEST (2014)



0 100 200 400
Feet
Ortho Imagery - 2011

Figure 5
Pit Analysis Boundaries
Ridgefield Pits - EF Lewis River

Total Pit Volume

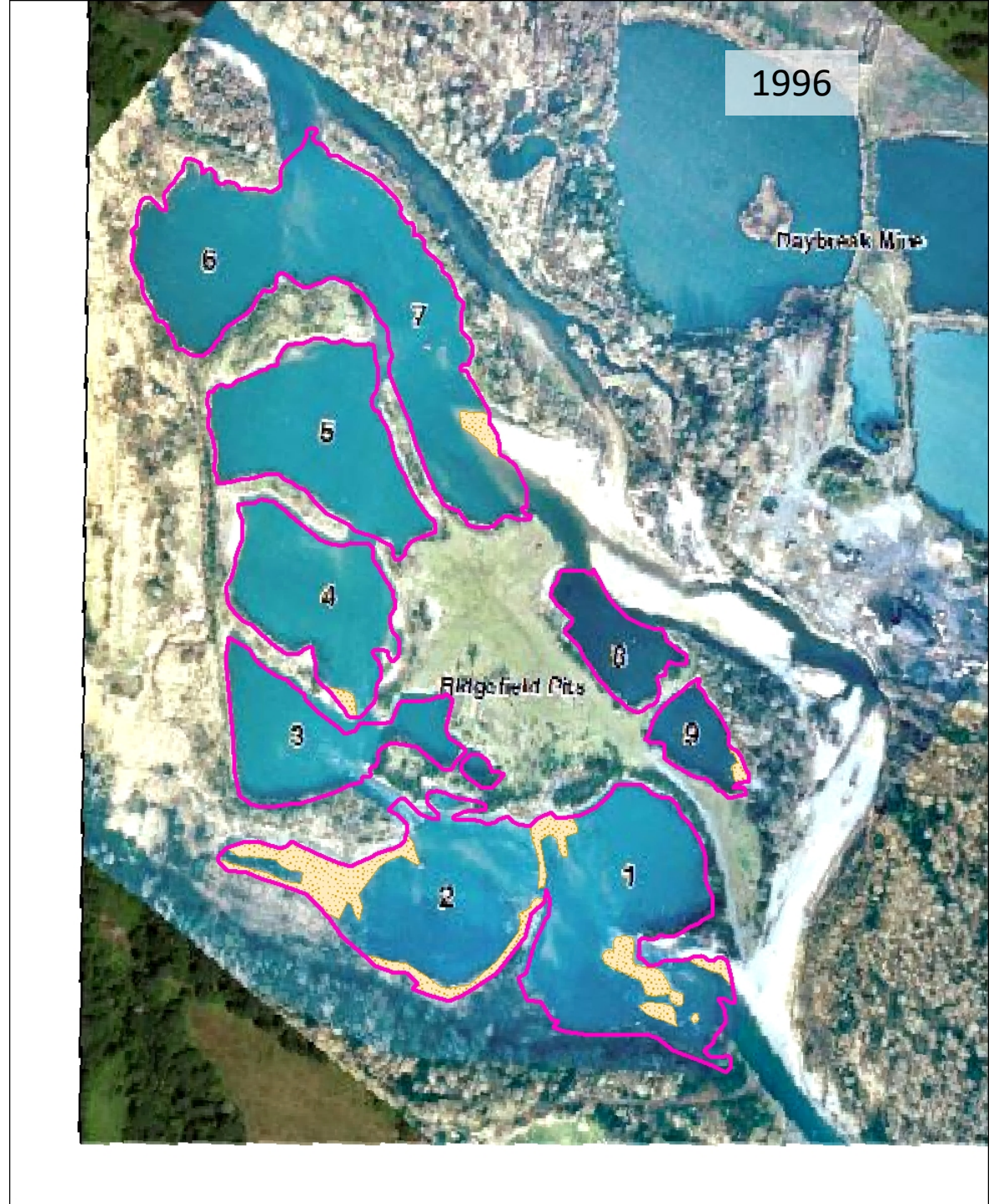


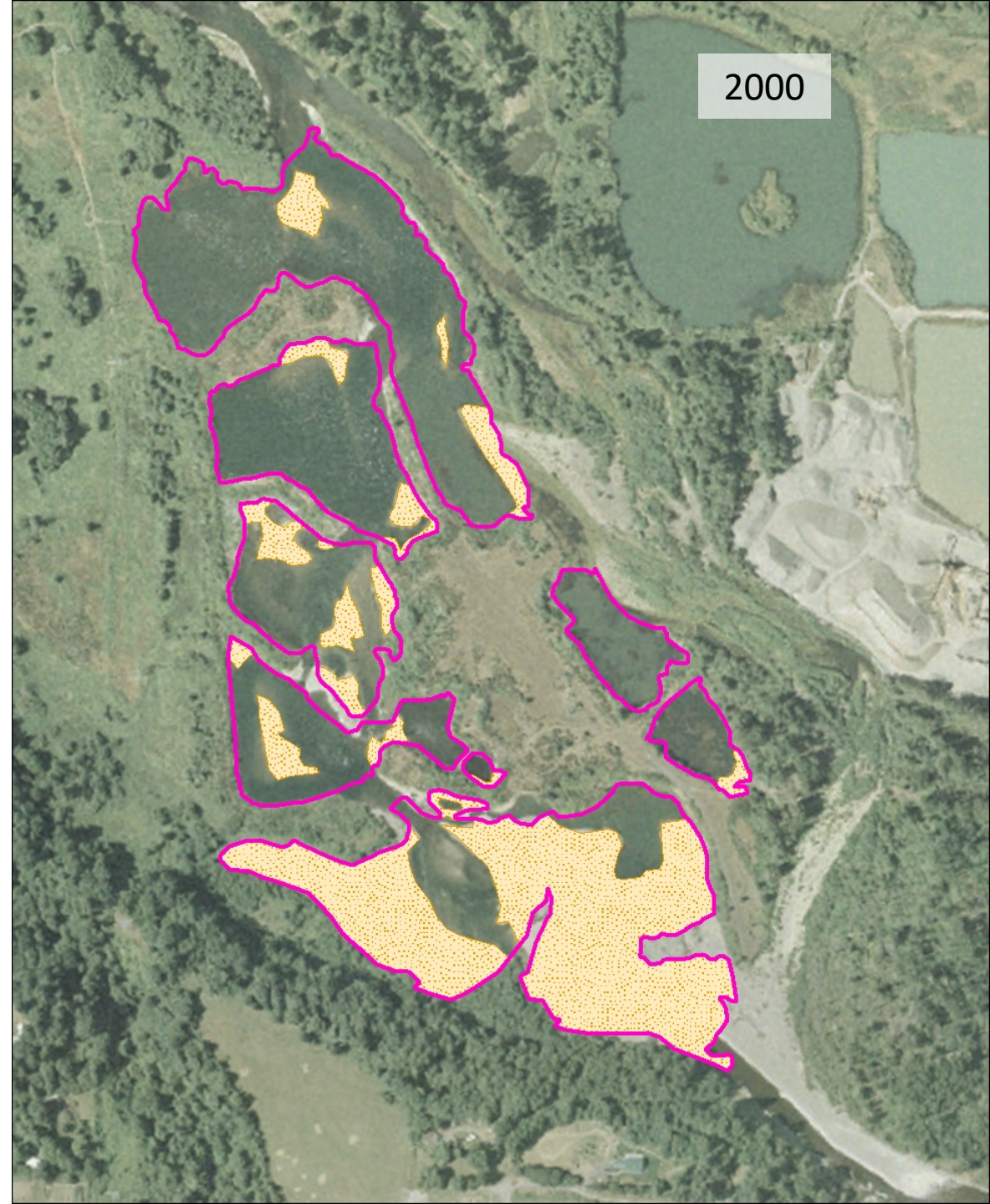
Analysis of Ridgefield Pit Filling

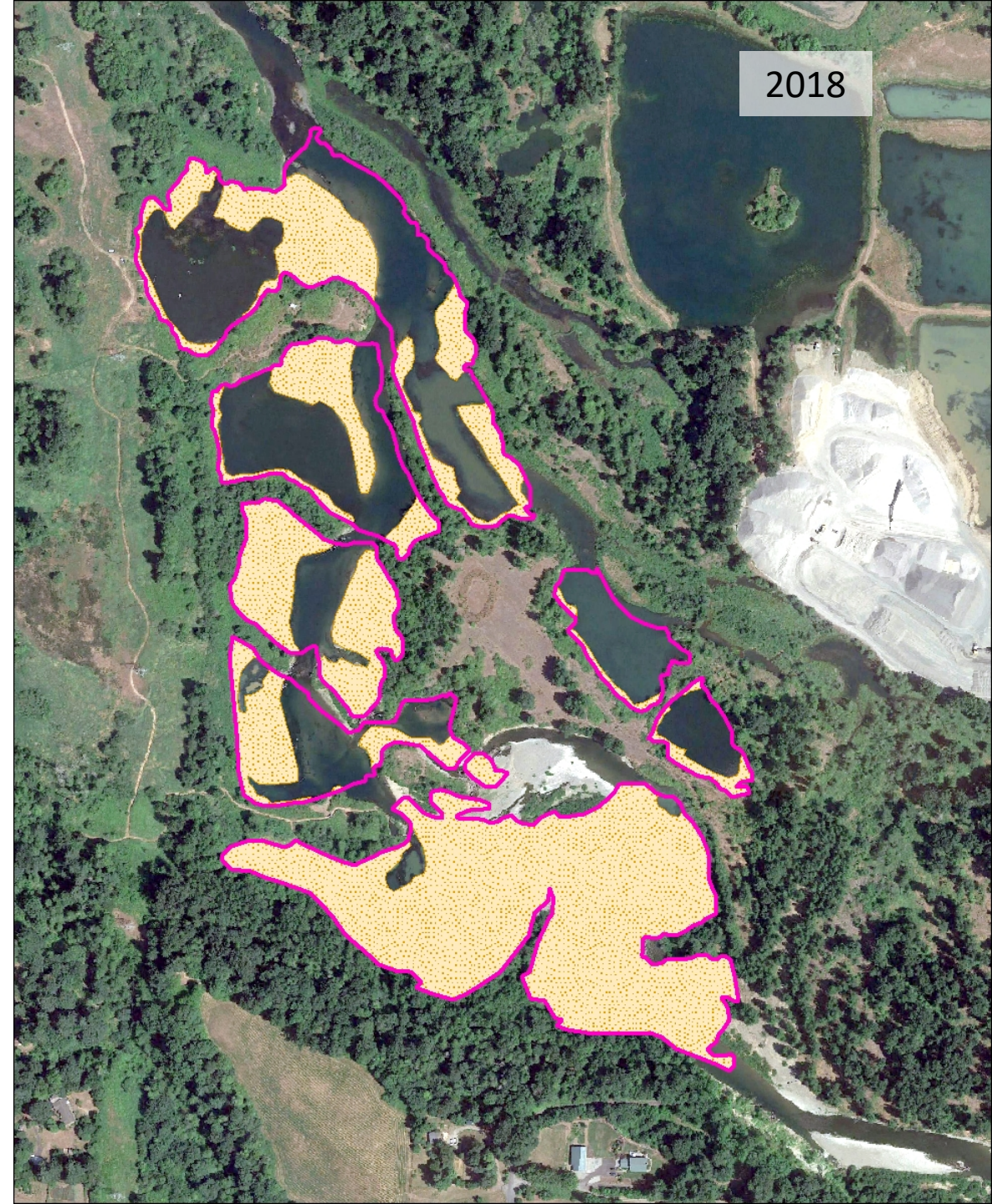
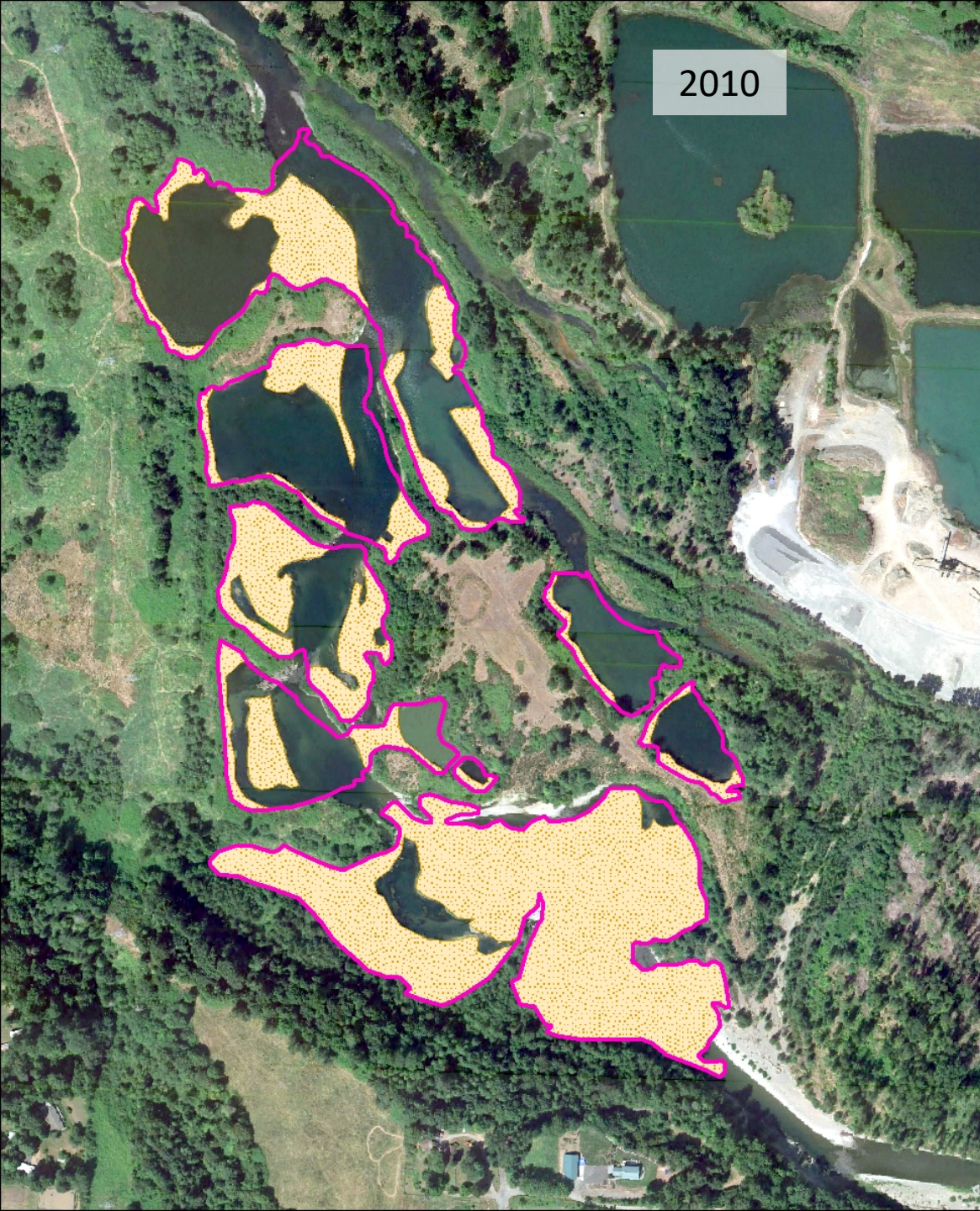
Planview Area of Pit Filling

Methods

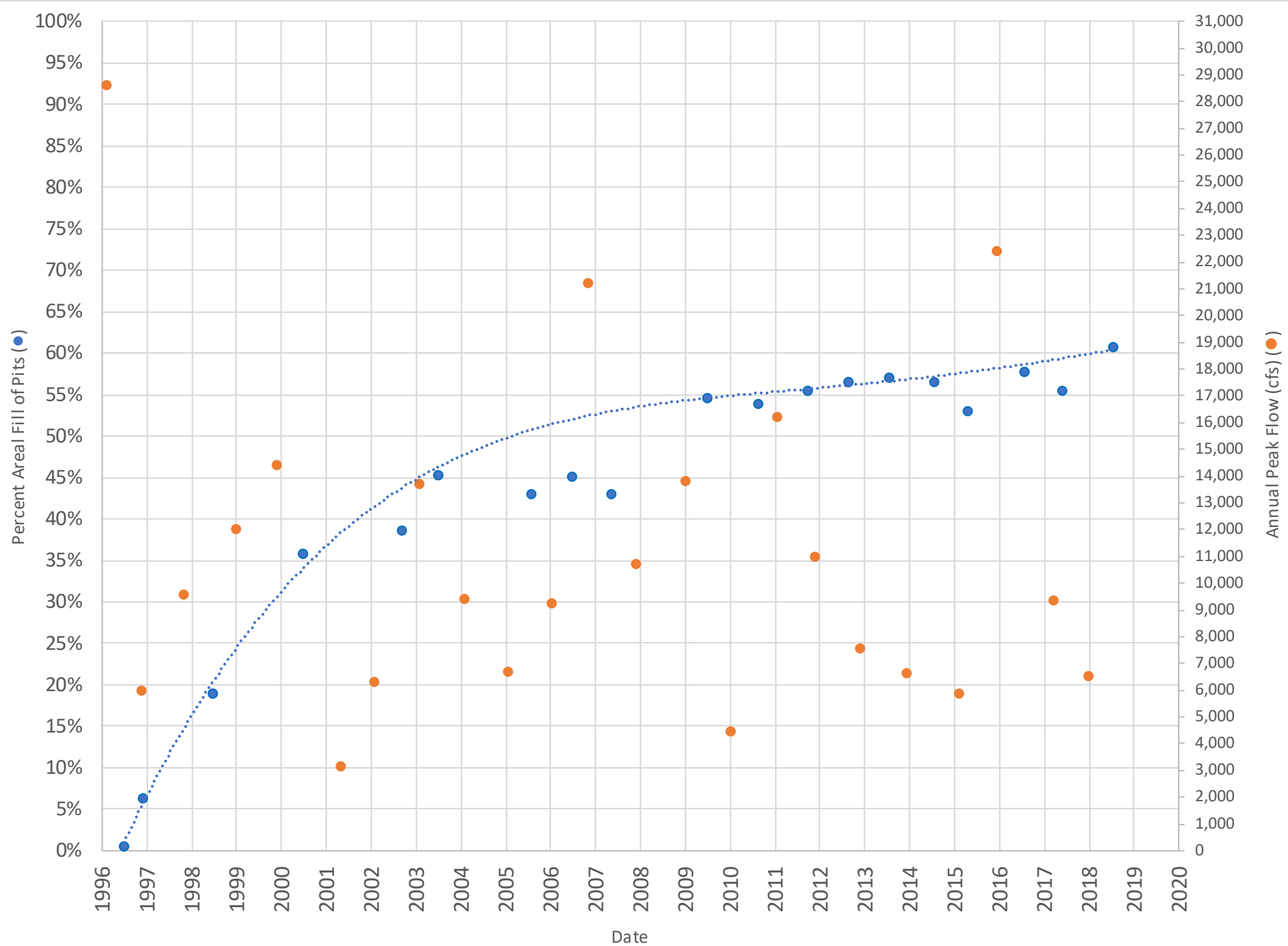
- Used Air photos from 1996 to 2018 (18 sets – almost every year)
- Began with pit outlines from pre-avulsion (1994)
- In a GIS, digitized planview area of recovered channel bed elevation visible from photos
- Calculated area of filling as a proportion of pre-avulsion pit outlines





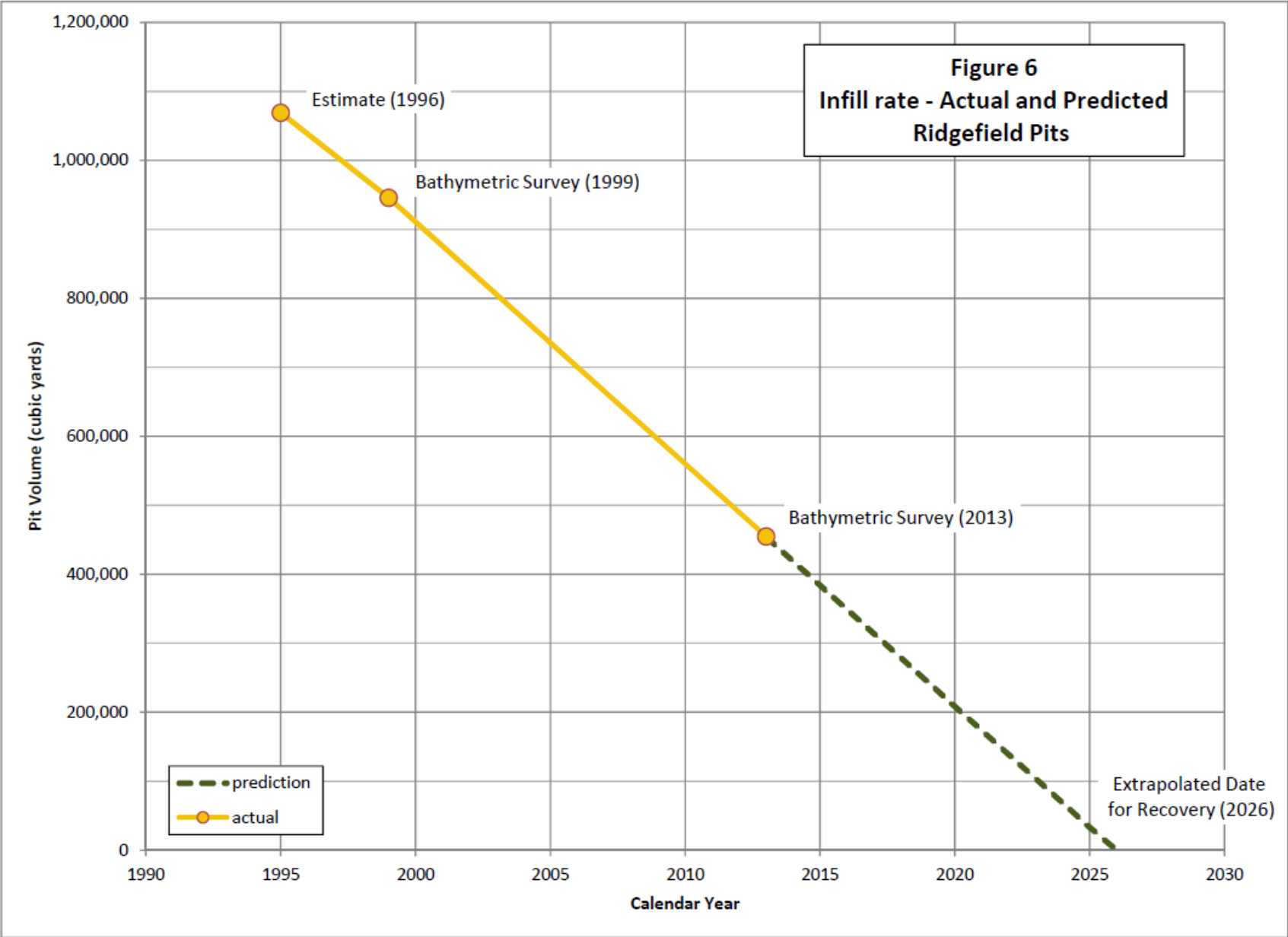


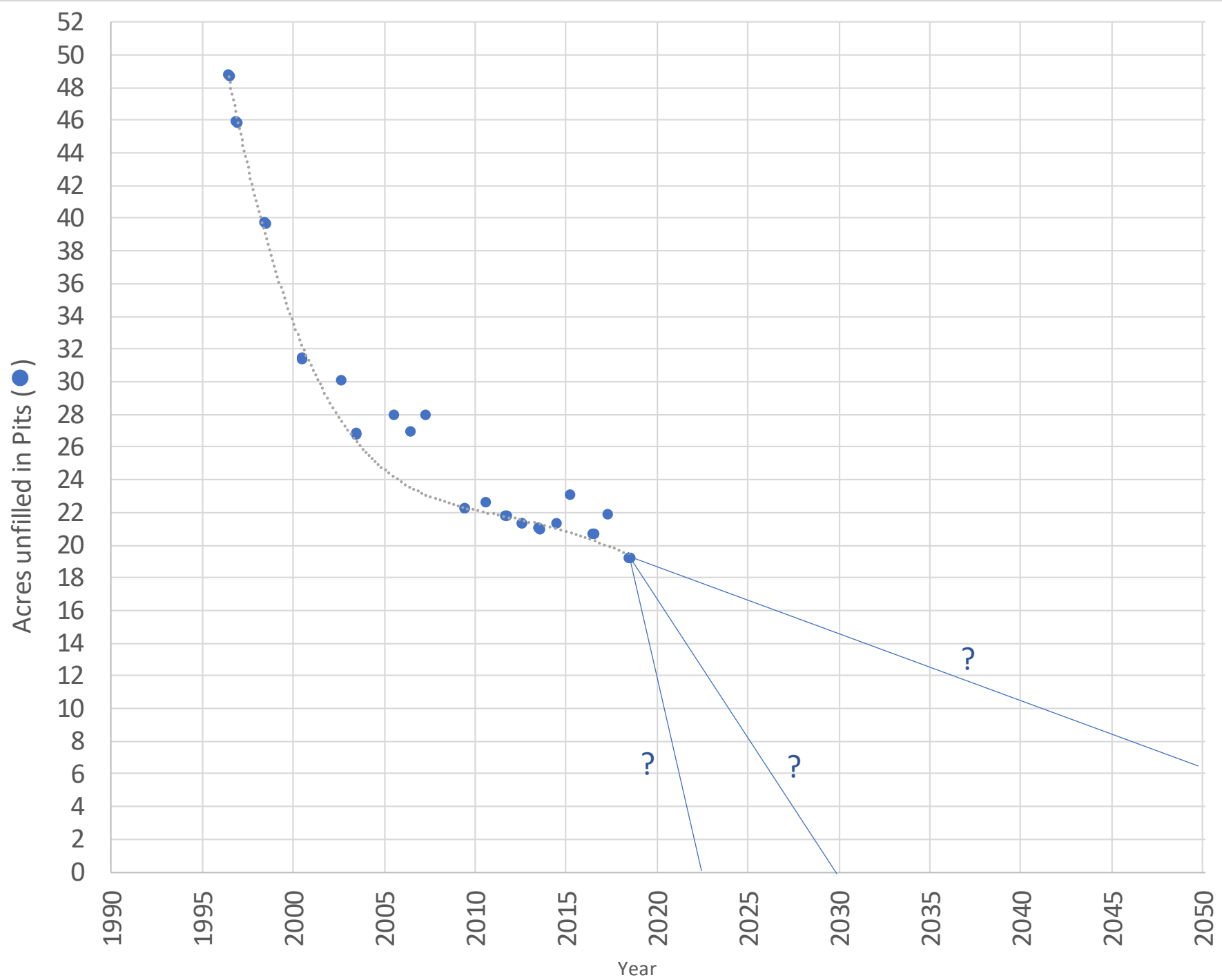
Air Photo Year	Pit Fill Area		Intervening annual peak events	
		Percent Fill	Flow (cfs)	Date
1996	0.27	0.55%	28,600	8-Feb-96
1996	3.13	6.38%	6,000	19-Nov-96
1998	9.31	18.98%	9,580	30-Oct-97
2000	17.59	35.85%	12,000	27-Dec-98
			14,400	25-Nov-99
2002	18.96	38.65%	3,170	30-Apr-01
			6,330	25-Jan-02
2003	22.2	45.25%	13,700	31-Jan-03
2005	21.09	42.99%	9,420	29-Jan-04
			6,690	18-Jan-05
2006	22.08	45.01%	9,270	10-Jan-06
2007	21.1	43.01%	21,200	7-Nov-06
2009	26.77	54.57%	10,700	3-Dec-07
			13,800	8-Jan-09
2010	26.4	53.81%	4,470	1-Jan-10
2011	27.24	55.52%	16,200	16-Jan-11
2012	27.7	56.46%	11,000	22-Nov-11
2013	28.02	57.11%	7,570	19-Nov-12
2014	27.74	56.54%	6,660	2-Dec-13
2015	26.01	53.02%	5,850	10-Feb-15
2016	28.34	57.77%	22,400	9-Dec-15
2017	27.18	55.40%	9,360	15-Mar-17
2018	29.82	60.78%	6,540	29-Dec-17

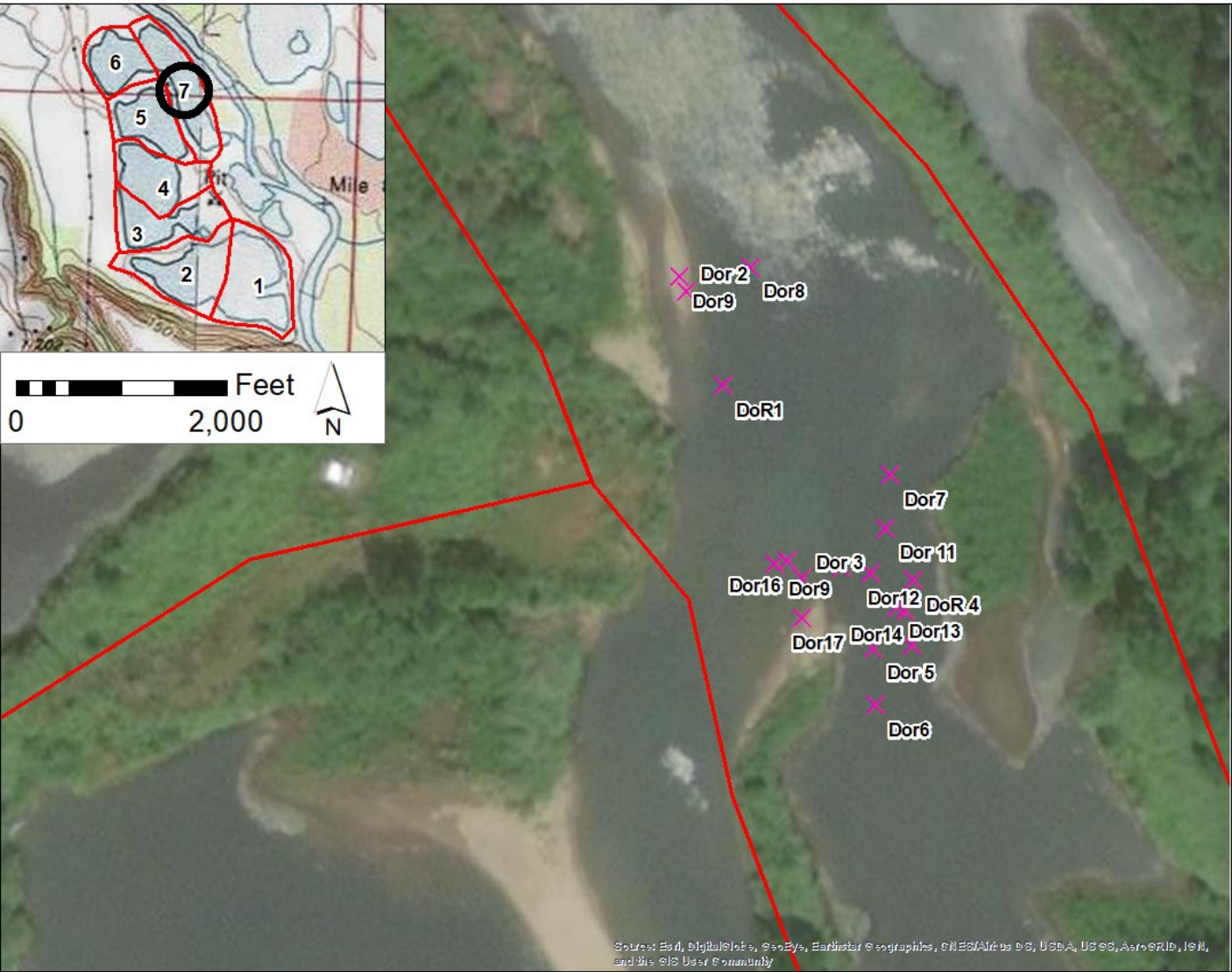


Analysis of Ridgefield Pit Filling

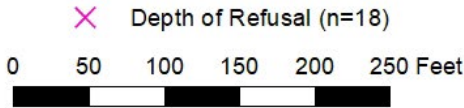
From WEST (2013)







EF Lewis Ridgefield Pits
Depth of Refusal
Created Oct 2018



DOR Location #	Depth (ft)	Depth of Refusal (ft)	Thickness (ft)
1	2.25	4.75	2.5
2	3.5	9.5	6
3	4.6	8	3.4
4	8.5	10	1.5
5	6.5	8.6	2.1
6	6.4	11.3	4.9
7	3.5	10.2	6.7
8	9.5	14	4.5
9	3.5	5.5	2
10	6.25	10	3.75
11	11.6	13	1.4
12	9	12.2	3.2
13	7.9	9.25	1.35
14	7.8	12.5	4.7
15	7.8	11.7	3.9
16	5	7	2
17	1.7	4.2	2.5
Averages	6.2	9.5	3.32

Average Thickness (ft)	3.32
Years	23
Avg feet per year	0.14
Avg inches per year	1.7
Range (inches)	0.7 – 3.5

