Appendix A
Stakeholder Meeting Materials

February 6, 2017

Lower South Platte Watershed Master Plan Stakeholder Kickoff Meeting
Morgan and Washington Counties

Name	Organization	Email
Jim Zwetzig	Morgan County	jzwetzig@co.morgan.co.us
Jeff Crane	CWCB	jeff@craneassociates.net
Michelle Covelli	Morgan County Finance	mcovelli@co.morgan.co.us
Laura D. Teague	Morgan County BOCC	lteague@co.morgan.co.us
Ken Bohl	Fort Morgan Irrigation Company	waterman80701@yahoo.com
Don and Joyce Werner		brizi@kei.net
John Rusch		jrruschit@flci.net
Don Amont	Platte River Recovery	d.amont@hotmail.com
Mark Turner	Sedgwick County	sedgwickcoem@yahoo.com
Don Schneider	Sedgwick County	dontam84@hotmail.com
Brad Curtis	City of Fort Morgan	bradley.curtis@cityoffortmorgan.com
Greg Eti	Department of Local Affairs	greg.eti@state.co.us
Dave Hampton		dhampton411@gmail.com
Jim Yahn	North Sterling and Prewitt Reservoirs/CWCB	jim@northsterling.org
Darlene Carpio	Senator Gardner's Office	Darlene_carpio@gardner.senate.gov
Greg Thomason	Morgan County Economic Development Corp	director@co.morgan.co.us
Joe Frank	Lower South Platte Water Conservancy District	jmfrank@lspwcd.org
Byron H Pelton	Logan County Commissioner	bpelton@logancountyco.gov
Tony Cappello	NCHO Director	tonyc@nchd.org
Darren Luft	Sterling Irrigation Company	dpluft@kci.net
Joe McBride	Logan County Commissioner	jmcbride@logancountyco.gov
Chuck Darchuk	The Sterling Irrigation Company #1	chuck@kci.net
Stephen Smith	Morgan Conservation District	stephen.smith.3708@gmail.com
Brent Schantz	CDWR	brent.schantz@state.co.us
Evan Snyder	CDWR	evan.snyder@state.co.us
Bruce Phillips	CDWR	bruce.phillips@state.co.us
Gene Manuello	NOI	gene44@q.com
Pam Cherry	Morgan County	pcherry@co.morgan.co.us
Connor Woodall	Morgan County	cmwoodall11@gmail.com
Dave Donaldson	Logan County	donaldson@logancountyco.gov

April 19, 2017

Lower South Platte Watershed Master Plan Stakeholder Meeting/Workshop
Morgan and Washington Counties

Name	Organization	Phone	Email
Brian Murphy	CDM Smith	303.345.7595	murphym@cdmsmith.com
Jeff Crane	CWCB	970.261.5043	jeff@craneassociates.net
Tim Stitzman	Landowner	970.768.5115	cowrya@gmail.com
CW Scott	USDA/NRCS Fort Morgan	970.867.8568	c.w.scott@co-usda.gov
Alllyn Wind	Lower Platte & Beaver	970.768.6049	alwind@centurylink.com
Jim Zwetzig	Morgan County	970.768.0819	jzwetzig@co.morgan.co.us
Brad Curtis	City of Fort Morgan	970.542.3901	bcurtis@cityoffortmorgan.com
Chuck Miller	Landowner	970.842.5575	cmiller@ama.auctions.com
Glenn Wilcox	Landowner	970.645.2518	sunskin686@aol.com
Ken Bohl	Jackson Lake Reservoir and Fort Morgan Irrigaiton	970.768.0705	waterman80701@yahoo.com
Evan Snyder	DWR	970.520.0497	evan.snyder@state.co.us
Joe Frank	LSPWCD	970.520.0628	jmfrank@lspwcd.org
LeaAnn Laybourn	Washington County Commissioner	970.l554.1538	llaybourn@co.washington.co.us
Bryant McCall	Washington County OEM	970.630.8662	oem@co.washington.co.us
Darrell Groth	Landowner	303.919.4884	darrell.tdg@gmail.com
Keving Houck	CWCB	303.866.3441 x3219	kevin.houk@state.co.us
Chris Pauley	Anderson Consulting	970.226.0120	chris.pauley@acewater.com
Andrea Harbin	CDM Smith	303.383.2408	harbina@cdmsmith.com

April 20, 2017

Lower South Platte Watershed Master Plan Stakeholder Meeting/Workshop
Logan and Sedgwick Counties

Name	Organization	Phone	Email
Brian Murphy	CDM Smith	303.345.7595	murphym@cdmsmith.com
Keving Houck	CWCB	303.866.3441 x3219	kevin.houk@state.co.us
Chris Pauley	Anderson Consulting	970.226.0120	chris.pauley@acewater.com
Andrea Harbin	CDM Smith	303.383.2408	harbina@cdmsmith.com
Dave Donaldson	Logan County	970.582.0888	donaldson@logancounty.co.gov
Darlene Carpio	Senator Gardner	970.630.6817	darlene_carpio@gardner.senate.gov
Rick Fleharty	Lower South Platte Water Conservation District	970.522.1378	rickfleharty@lspwcd.org
Bruce Phillips	Division of Water Resources	970.370.0296	bruce.philiips@state.co.us.org
Larry Frame	Julesburg Irrigation District	970.520.3347	supt.jid@pctelcum.oop
Mark Turner	Sedgwick County	970.580.6234	sedgwickcoem@yahoo.com
Joe McBride	Logan County	970.580.0285	jmcbride@logancounty.co.gov
George Good	City of Sterling	970.522.9700	good@sterlingcolo.com
Byron Pelton	Logan County	970.571.0608	bpeltion@logancounty.co.gov
Chloe Lewis	MSPRA	303.877.5581	middlesouthplatte@gmail.com
Forrest Leaf	Consulting Eng	522.119	forrestleaf@quest.net

April 19, 2017

Stakeholder Meeting
Morgan and Washington Counties

- All irrigators were invited
- Roads and bridges of Morgan County were highly impacted
- 100-yr flows increase upstream, near Weld co., and are reduced closer to the Nebraska state line
- What does "resiliency" mean for these stakeholders?
- Outreach to CPW – was unable to make today's meeting but is willing to participate
- Outreach to CDOT – no response, but we're hoping to engage their participation
- What might an Alliance do (how might a coalition help)?
    - Watershed coalitions become the day-to-day drivers of the master plan
    - Find funding
    - Represent a wide variety of stakeholders
    - Facilitate implementation of projects
    - Generally formed at the watershed level, which may not make sense for the South Platte, given its size
    - Adds weight to getting funding
    - Who might drive a coalition in the Lower South Platte?
        - Multiple irrigation districts
        - Private landowners
- Specific focus areas for Morgan and Washington Counties
    - North side of river didn't flood in 1965, but did in 2013 and 2015; When north side floods (and North Sterling Canal gets full), water is trapped, creating a health issue for those on septic (Daryl Grove)
        - Town of Messex has no way to get rid of water (Daryl Grove)
        - Concern of uncontrolled water coming into the ditch companies (Joe Frank)
        - Need to create avenues for water to return to river (Evan Snyder)
    - Sedimentation and trees (no channel) (Ken Bohl)
    - Vegetated islands (Allyn Wind)
    - Orchard Bridge

- Northline GIS in Breckenridge knows of post-flood aerials (continuous of whole lower South Platte)

April 20, 2017

Stakeholder Meeting
Logan and Sedgwick Counties

- Chloe Lewis is available as a resource to share lessons learned
    - Multiple stakeholders involved with multiple interests
        - Difficult to find compromise; education required
        - Multi-tiered funding collaboration – funding from many sources from federal, to state, to county, to city funds
        - Important to gain face time with people to understand different perspectives
- Logan county is looking for master plan to be an operational plan, including steps moving forward
- Rechannelization within the last few years; affecting infrastructure
    - Immense erosion on the south side of the river (near Julesburg); exposure of fiber optic lines and other infrastructure; may be caused by diversion further upstream?
- Need to look at ownership change of river from Fort Morgan downstream
    - Land being purchased by public entities; easements; etc.
        - CDM Smith will try to engage CPW and other entities
- Who is the authority to maintain the river?
    - Identify the difference between WOTUS and irrigation ditches for maintenance purposes
- Large sedimentation problem near Smith Anderson Ditch
- Sedimentation near any bridge within the study area
- Sedimentation combined with vegetation growth exacerbates the sediment problem
    - No cattle grazing near the river anymore to keep vegetation growth in check
- Issues of water quality
    - Increased eutrophication
        - Caused by effluent from Denver?
- Successes and Challenges of similar projects on Colorado River Basin
- County road 93 bridge needed to be replaced (wooden structure) overflow bridge is supposed to function when main bridge is closed, but this bridge ends up being closed during flooding anyway (eastern part of Logan County)
- Railroad trestles - near Pawnee
- Master Plan will help with identifying mitigation projects that can help with flooding
- Should look at Nebraska as an example because of similar geology, hydrology, etc.
- How will we integrate significant tributaries?
    - Beaver, Bijou, Pawnee, Kiowa, etc.
    - Funding for Master Plan is for the main stem of the South Platte
    - Master Plan can act as a spring board to drive focus towards tributaries for future plans
        - Can document issues with tributaries
        - May not be able to recommend projects on tributaries that don't have DIRECT impact on the South Platte
        - Identify funding for future studies for tributariess
        - Sets the stage for future studies
    - Master Plan will try to find opportunities to tie tributaries into study
- Problems with return flow when water gets trapped north of railroad
- Cooling pond near ethanol plant in sterling

- Flood stage water for 90 days in 2015
    - 2015 generally more devastating than 2013 due to longer duration of flood stage
- Tamarack Wildlife area
    - No river management
- Dune Ridge State Wildlife Area
    - No river management
    - Just upstream of Sterling
    - Headgate immediately downstream of area
    - Sterling #1 Ditch
    - Smith Henderson Ditch
- Scalva Farm (owned by City of Sterling)
- CPW will need to be a bigger player than originally thought
    - Much of the river immediately downstream of CPW owned land are areas of concern
- Would like to get federal agencies to attend May 12th meeting
    - NRCS
    - CPW
    - Army Corps
        - Regulatory
        - Flood Reduction
            - Possible funding source?
    - EPA?
    - DOLA
    - FEMA
    - US Fish and Wildlife?
    - CDOT?
    - People from the Nebraska project
        - Successes and challenges
        - Jerry Kenny (Executive Director of Headwaters Corporation)
    - Summarize these stakeholder meetings to establish agenda to forward to agencies to encourage participation
    - Maybe federal agencies will simply listen and then develop solutions that will or will not be accepted
        - Followed by a discussion with CDM Smith
- Bureau of Reclamation land ownership in lower South Platte?
    - BOR as a funding source?
- Krook Bridge
- Atwood Bridge

May 12, 2017

Lower South Platte Master Plan Agency Meeting
Morgan Community College

Name	Organization	Phone
Brian Murphy	CDM Smith	
Kevin Houck	CWCB	303-866-3441 x3219
Scott Gamcarz	WQCD	303-692-2374
Ken Kehmeier	CPW	970-972-4350
Kayla Eckert	US Army Corps of Engineers	402-659-4441
Tom Wiestail	Logan County Water Conservation Board	970-630-3748
George Good	City of Sterling	970-522-9700
Darlene Caprio	Senator Gardner	970-848-3095
Mark Turner	Sedgwick County Commissioner	970-580-6234
Dusty Johnson	Representative Buck	970-702-2136
Ken Bohl	Jackson Lake & Ft Morgan Reservoir	970-768-0705
Jeff Rice	Journal-Advocate Ft. Morgan Times	970-580-2857
Bob Erosky	Colorado Division of Water Reserources	970-380-9992
Evan Snyder	Colorado Division of Water Reserources	970-520-0497
Allyn Wind	Pioneer Water and Irrigation	970-768-0049
Don Chapman	Riverside	970-867-6586
Joe Frank	LSPWCD	970-522-1378
Mark Arndt	Morgan Commissioner	970-542-3500
Connor Woodall	Morgan Intern	215-534-6571
Pam Caerty	Morgan County Floodplain Administrator	970-542-3509
Kent Pflager	MCQWD	970-862-3054
Mark Kokes	Hwy 144 Ranchettes HOA	970-467-7780
Darrell Groth	59037 CR N Merino	303-919-4884
Bryant McCall	Washington County OEM	970-630-8662
Lea Ann Laybourn	Washington County Commissioner	970-554-1538
Dave Donaldson	Logan County Commissioner	970-522-0888 x225
Jim Zwetzig	Morgan County Commissioner	970-768-0819
Andrea Harbin	CDM Smith	303-383-2408
Solomon Abel	CDM Smith	515-708-5028
Chris Pauley	Anderson Consulting Engr.	970-226-0120

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Project Number	Page Of
CDM/CWCB [redacted]02	1 2

Owner-Project	By	Date
CDM/CWCB LSPR Master Plan	CSF	05/12/17

Subject	Checked By	Date
MTG. Workshop w/ Regulatory Agencies		

Ag AM grant @ Comm. College in Ft. Morgan

USACE Kayla Eckert Uptown — Civil Works CONSTRUCTION SIDE

Feasibility 50 - 50 cost share

Construction 65 - 35 " "

General Investigations

Sec 205 Fld Reduction

" 206 Eco System Restoration

" 14 StreamBank Eros to prot Pub Infrastruc

All Limit Max cost at $10 mil

COE takes care of 404 etc, permitting thru Reg. Branch

Scott - WRCD 404 IP would regr. State Lvl. 401 process for W.Q.
- Not involved in Reg. or Gen. 404s
- otherwise really get involved once construction starts

BM - will get COE - Reg. office staff at a Fut. Mtg.
- " " Platte R. Recovery Prog. Rep. at Fut. Mtg. under ESA

Ken Have scrape sand bars and banks
- 3 mi D/S Crook Bridge
- Pony Express SWA in Sedgwick City

Flesh
Graze to promote herbaceous growth to promote Sage grouse habitat
- partner w/ DU a lot
- fish species thought to have been harmed by 2013 & 2015 have rebounded greatly since Rd.
- partner w/ CDOT a lot

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Project Number CDM CO [redacted] 02	Page 2 Of 2	
Owner-Project LSPR Master Plan	By CJP	Date 5/12/17
Subject Mtg./Workshop w/ Regulatory Agencies	Checked By	Date

10:10 Also a participant in Platte River Recovery Plan will have construction presence in Brush

Local Dist. Wildlife Mangers along LSPR

Matt Budie – Explains Role & Area

Ken:
- on Tamarisk sites A pumps water up to trickle back into LSPR
- SHPO issues for modifying Irrig. Structures.

Kevin Houck – CWCB Explain Role

Jim O'Ewetzig – ask how irrig. entities control / participate in the study, processes, soln.?

Q what is an Alliance or a Coalition, Differences

KH – Grp of diverse stake holders that come together to promote a mutually agreeable soln.
Has a more powerful 'Hyk' for assist. / Kayla COI Agrees the same for COEs process

10:50 AM Break

11:05 Q & A Session

Quantified benefit LSPR???

Joe Frank – what defines a healthy stream when have competing interests, can you get funding from eco, flood, recreation

such as NCWCD.

Kayla –
2:00 Noon.
- IDEA & ID Makeup of coalition / stakeholders (none voting board members i.e. technical advisors)
- IDEA & Dev. Reg. Process – Defn.s – overlaps – Roadmap for success

CDM Smith

CLIENT _____ JOB NO. _____ COMPUTED BY _____

PROJECT Regulatory Agency Pipe Mtg @ MCC, Ft. Morgan DATE CHECKED _____ DATE 9/12/17

DETAIL _____ CHECKED BY _____ PAGE NO. 1A/

	NAME	ORGANIZATION	PHONE
(1)	BRIAN MURPHY	COM Smith	
A1	Kevin Hack	CWCB	303-866-3441 x3219
A2	Scott Gamcarz	WQCD – req. area is SPR	303-692-2374
A3	Ken Kehmeier	CPW	970-472-4350
A4	Kayla Eckert Uptmor	US Army Corps of Engineers	402. 659. 4441
A5	Matt Budie – FEMA RS		
1	TOM WESTHILL	Logan Co Water District Conservancy Board Flood Restoration on Pawnee Ck?? Bd 3-4 years	970-630-3748
2	George Good	City of Sterling PW Dir	970-522-9700
3	Darlene Cayia	Sen. Gardner	970-848-3095
4	Mark Turner	Sedgwick County Commissioner	970 580 6234
5	Dusty Johnson	Rep. Buck (CO-04)	970-702-2136
6	Ken Bohl	Jackson Lake & Ft. Morgan Reservoir	970-768-0705
7	JEFF RICE	JOURNAL-ADVOCATE FT. MGN TIMES	970-580-2857
8	Bob Erosky	Colorado Division Water Resources	970-380-7992
9	Evan Snyder	Colorado Division of Water Resources	970-520-0497
10	Allyn Wind	Pioneer Water + Irrigation	970-768-0049
11	DON Chapman	RIVERSIDE	970 867 6586
12	Joe Frank	LSPWCD	970-522-1378
13	Mark Arndt	Morgan Commissioner Board Briefed on SPR	970 542-3500
14	Connor Woodall	Morgan Intern	215-534-6571
15	Pam Cheney	Morgan County Floodplain	970-542-3509
16	Kent Peterson	MCDWD	970-867-3054
17	MARK KOKES	HWY 144 Ranchettes HOA	970-467-7780
18	Darrell Groth	59037 Cnty RD N Merino	303-919-4884
19	Bryant McCall	Washington County OEM	970-630-8662
20	Lea Ann Laybourn	Washington County Commissioner	970.554.1538
21	DAVE DONALDSON	LOGAN COUNTY COMMISSIONER	970-522-0888 x224
22	JIM ZWETZIG	MORGAN CO COMMISSIONER	970-768-0819
(E)	Andrea Harbin	COM Smith	303-383-2408
(E)	Solomon Abel	COM Smith	515-708-5028

July 17, 2017

Lower South Platte Watershed Master Plan Stakeholder Meeting

Presentation by Jerry Kenny: Platte River Recovery Implementation Program

Name	Organization	Phone	Email
Brian Murphy	CDM Smith	303.345.7595	murphym@cdmsmith.com
Andrea Harbin	CDM Smith	303.383.2408	harbina@cdmsmith.com
George Good	City of Sterling	970.522.9700	good@sterlingcolo.com
Lea Ann Laybourn	Washington County Commissioner	970.554.1538	llaybourn@co.washington.co.us
David Foy	Private Landowner	970.380.2516	foyfarms@hotmail.com
Darrell Groth	Private Landowner	303.919-4884	darrell.tdg@gmail.com
Dave Donaldson	Logan County Commissioner	970-522-0888	donaldson@logancountyco.gov
Mark Turner	Sedgwick County Commissioner	970.580.6234	sedgwickcoem@yahoo.com
Tim Katers	DOLA	303.864.7888	tim.katers@state.co.us
Jeff Crane	DOLA	970.261.5043	jeff@craneassociates.net
Dick Parachini	Interested Citizens	720.301.3620	rsparachini991@gmail.com
Bruce Phillips	DWR	970.370.0296	bruce.phillips@state.co.us
Brett Eckerchamp	Congressman Buck's Office	970.702.2136	dusty.johnson@mail.house.gov
Joe Frank	LSPWCD	970.520.0628	jmfrank@lspwcd.org
Kevin Houck	CWCB	303.866.3441 x3219	kevin.houck@state.co.us

Major takeaways from the May 2017 site visits:

- Sedimentation
- Uncontrolled water in canals/ditches
- Messex
- Hunting Land
- City of Sterling

Sedimentation

- A lot of sedimentation within the channel
- Sedimentation of ditches
- Vegetated sandbars

Uncontrolled water in Canals/Ditches

- Many instances of uncontrolled water flowing through ditches

Messex

- Railroad acted as a dam
  - Trapped water north of railroad tracks
- River crossed railroad and ran into Tetsel ditch
  - Tetsel has a return flow ditch, which could return flow in high flow situations to take pressure off Messex
- Water spilled from N. Sterling in 2013 flooding road to Messex
  - no water in ditch beyond that point

*1997: City of Sterling flooded from Pawnee Creek because water was trapped north of the railroad tracks

Hunting Lands

- Many parcels owned by CPW and private hunting clubs
  - These land owners generally let vegetation grow to provide habitat
  - This method of management has consequences on adjacent land

City of Sterling

- Henderson Smith Ditch Headgate
  - Washed out
  - Ditch is laden with sediment
  - City rebuilds ditch with sand periodically
  - Example of the direction in which many ditches within the project area may be headed

- Lowline Ditch often becomes the main South Platte channel
  - One example of the river periodically changing course within the project area
  - Threatens the ethanol plant in the City of Sterling

Henderson Smith Ditch
2013

Henderson Smith Ditch
2015

Henderson Smith Headgate

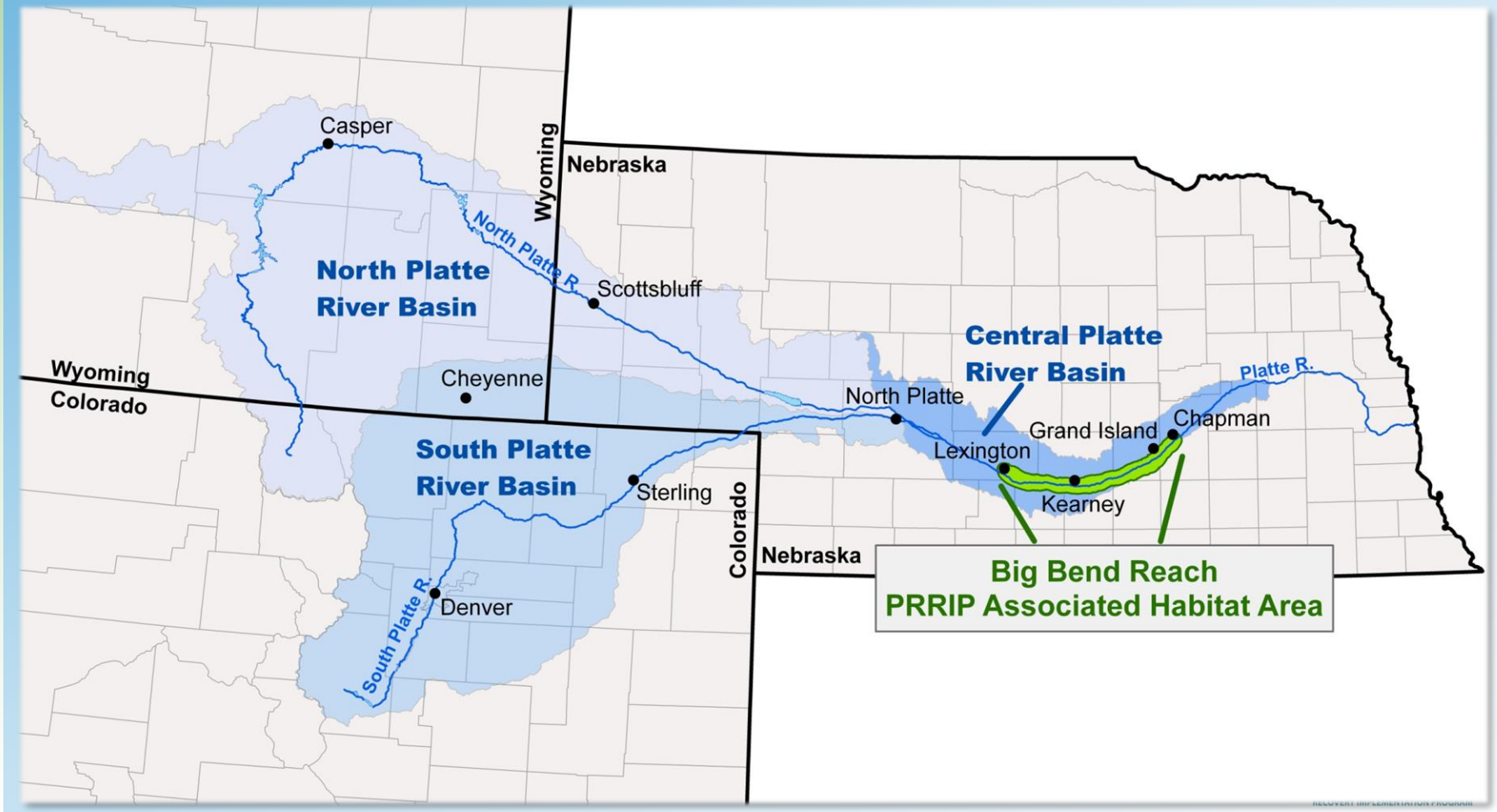
South Platte Stakeholders
Fort Morgan, CO
July 17, 2017

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Platte River Recovery Implementation Program -

Jerry F. Kenny, Ph.D., P.E. - Executive Director

Platte River Basin



Target Species on the Platte River

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

ESA coverage for water users

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Extent of Vegetation Expansion
&
Loss of Braided Nature of Platte River

Collaborative Program

Costs split:
$317M in 2005 dollars,
50/50 between States
&
Federal Government

Governance Structure:
Everyone at the table with a voice and a vote
&
Move forward by consensus

Independent Implementation:
-Executive Director's Office
(Honest Broker)
-Financial Management Entity
-Land Interest Holding Entity

Process Integrity:
Independent Science Advisory Committee
&
Peer Reviews

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Program Components

Adaptive Management

Land **Water**

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Program Mission

- Land Plan
  - Acquire, protect, and restore 10,000 acres of habitat for the three avian species
- Water Plan
  - Reduce deficits to FWS Target Flows by average annual of 130,000 to 150,000 AFY
- Adaptive Management Plan
  - Do the science necessary to make sure the land and water resources are providing benefit to the species

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Water Plan

- Reducing Deficits to FWS Target Flows by average annual of 130,000 to 150,000 AFY
  - 3 Initial Projects – Tamarack I (CO), Pathfinder Modification (WY), Lake McConaughy EA(NE)
  - New water conservation/supply projects

Target Flows

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Three State's Contributions

- Nebraska – EA storage in Lake McConaughy and 10% of non-irrigation season natural in flow
- Wyoming – Pathfinder Reservoir Modification and a portion of the yield from recovered storage
- Colorado – Tamarack I retiming project
- Total score 80,000 Acre-Feet Annually on average
  - 50,000 to 70,000 AFY to be developed

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Program Water Acquisition

- Potential Sources
  - Retime excesses
  - Acquire by lease or purchase
  - Water Management Incentives
    - Reduce CU and increase return flow
- Water in hand – 10,000 AFY

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

J2 Regulating Reservoir Concept

Platte River

CNPPID Diversion

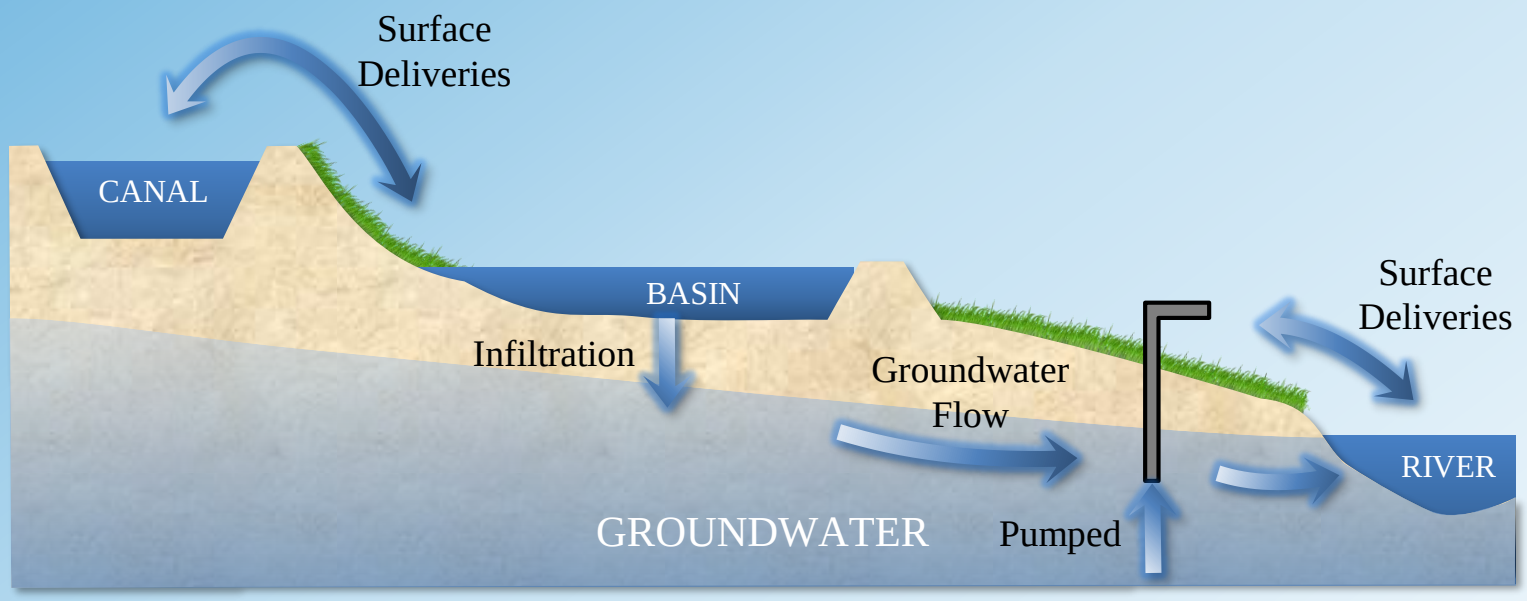
J2 Return

J2

J2 Regulating Reservoir

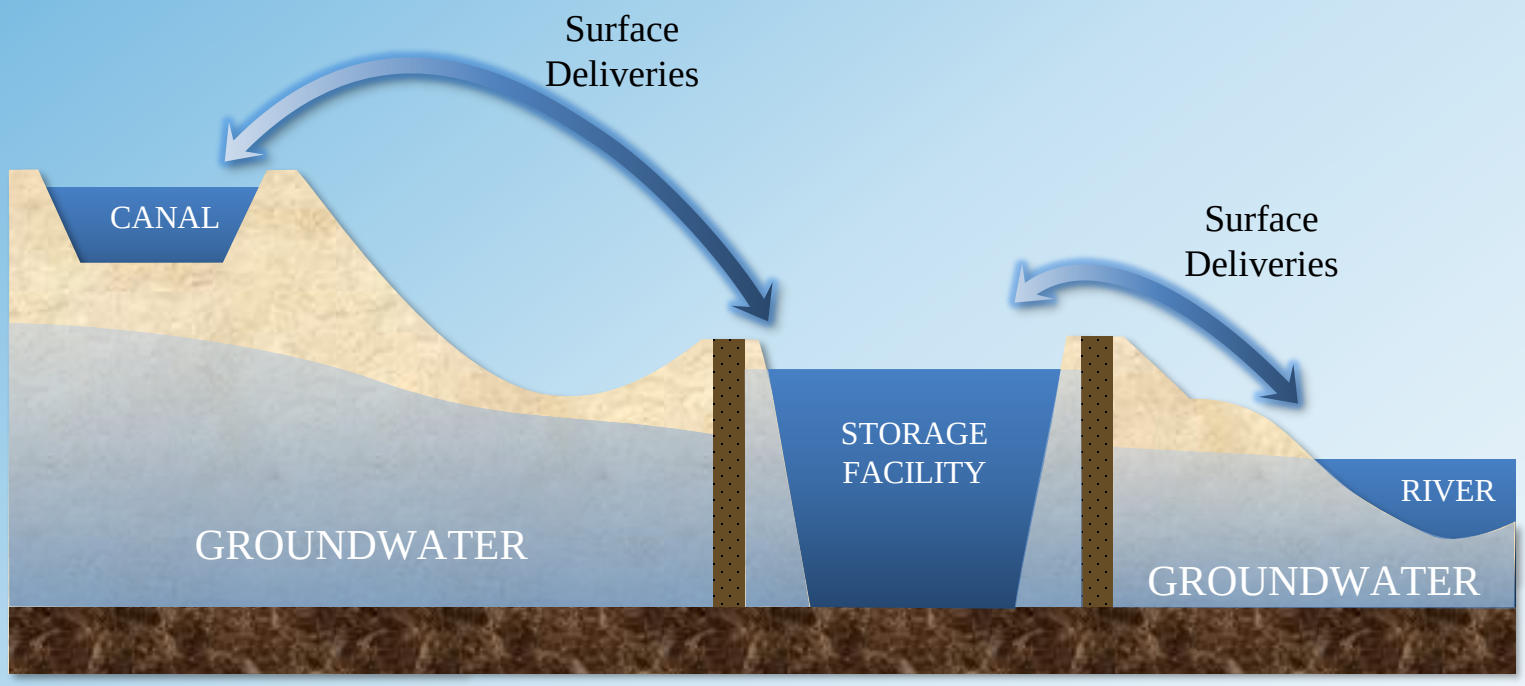
Phelps County Canal

General Concept Broad Scale Recharge



PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

General Concept Slurry Wall Storage



PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Water Sources

- Retiming – 25,000 to 30,000 AFY
  - Broad Scale Recharge
  - Slurry Wall Pit
- Leases – 10,000 to 12,500 AFY
  - Pathfinder Municipal (WY)
  - Central Platte NRD Canal/Ditch Companies
  - Central Nebraska Public Power and Irrigation District
  - Nebraska Public Power District
- Acquire and Retire – 2,500 AFY

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Land Plan

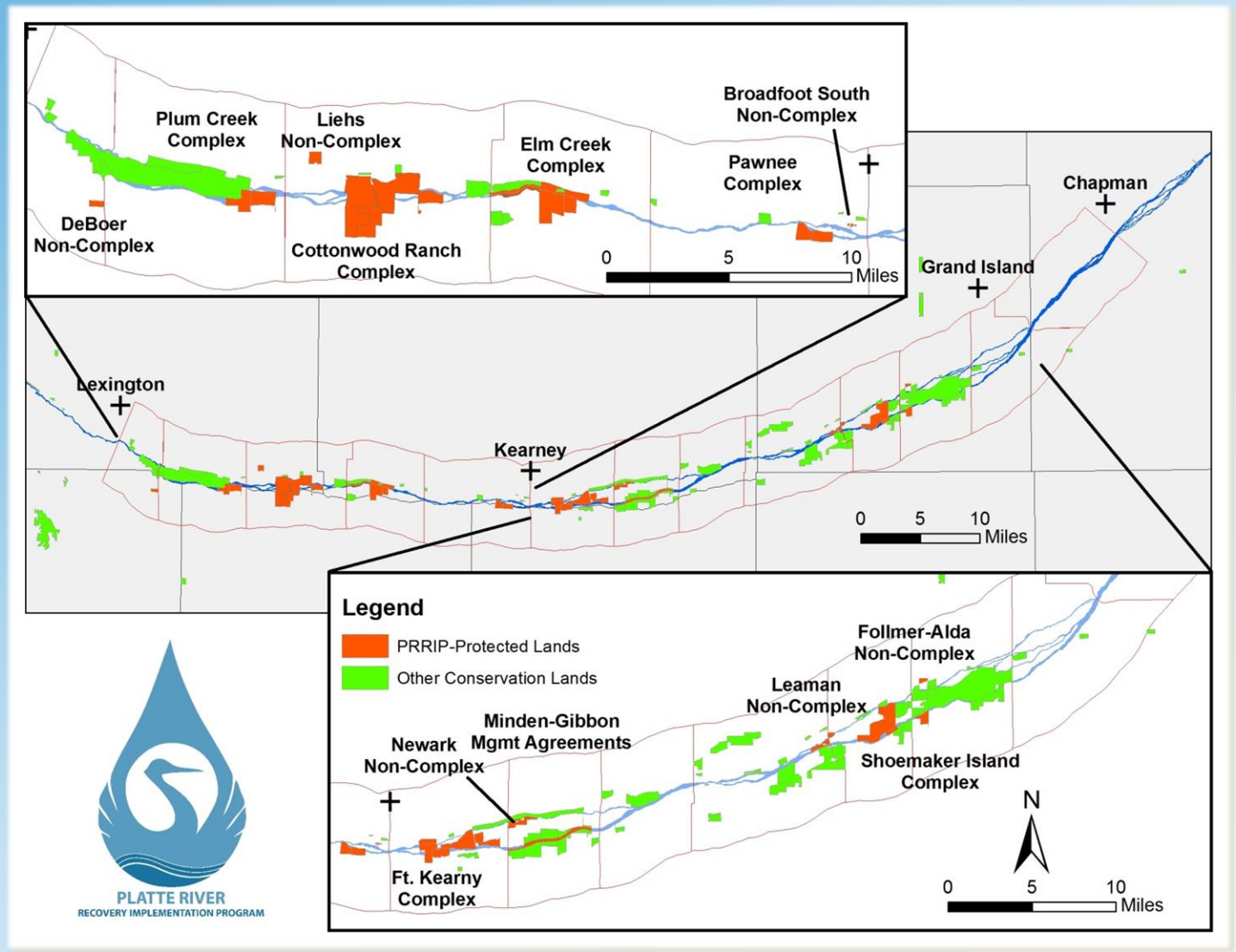
Acquisition, protection, and restoration of 10,000 acres of habitat for the three avian species – 12,000 acres protected

Land Plan – Guiding Principles

- Willing seller/willing buyer
- Pay property taxes
- Good Neighbor Policy
- Public Access for Recreation

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Conservation Lands



PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

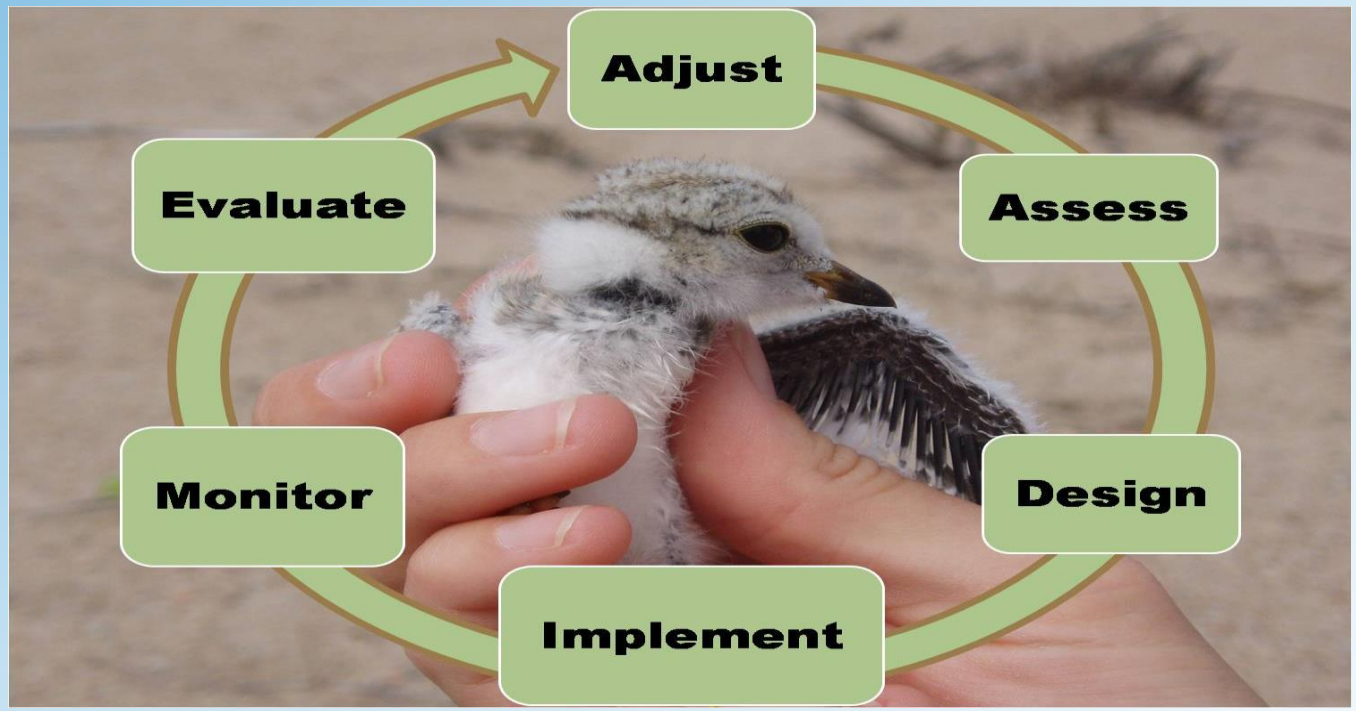
PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Adaptive Management Plan

- Improve production of least tern and piping plover from the central Platte River.
- Improve survival of whooping cranes during migration.
- Avoid adverse impact from Program actions on pallid sturgeon populations.
- Within overall objectives 1-3, provide benefits to non-target listed species and non-listed species of concern and reduce likelihood of future listings

Key Features of Adaptive Management Plan

- AM allows you to move forward in the face of uncertainty
  - Systematic, rigorous process to test hypotheses & apply information learned to improve management of land and water for benefit of species
  - Need to Know v. Nice to Know- (tied to management actions)



PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

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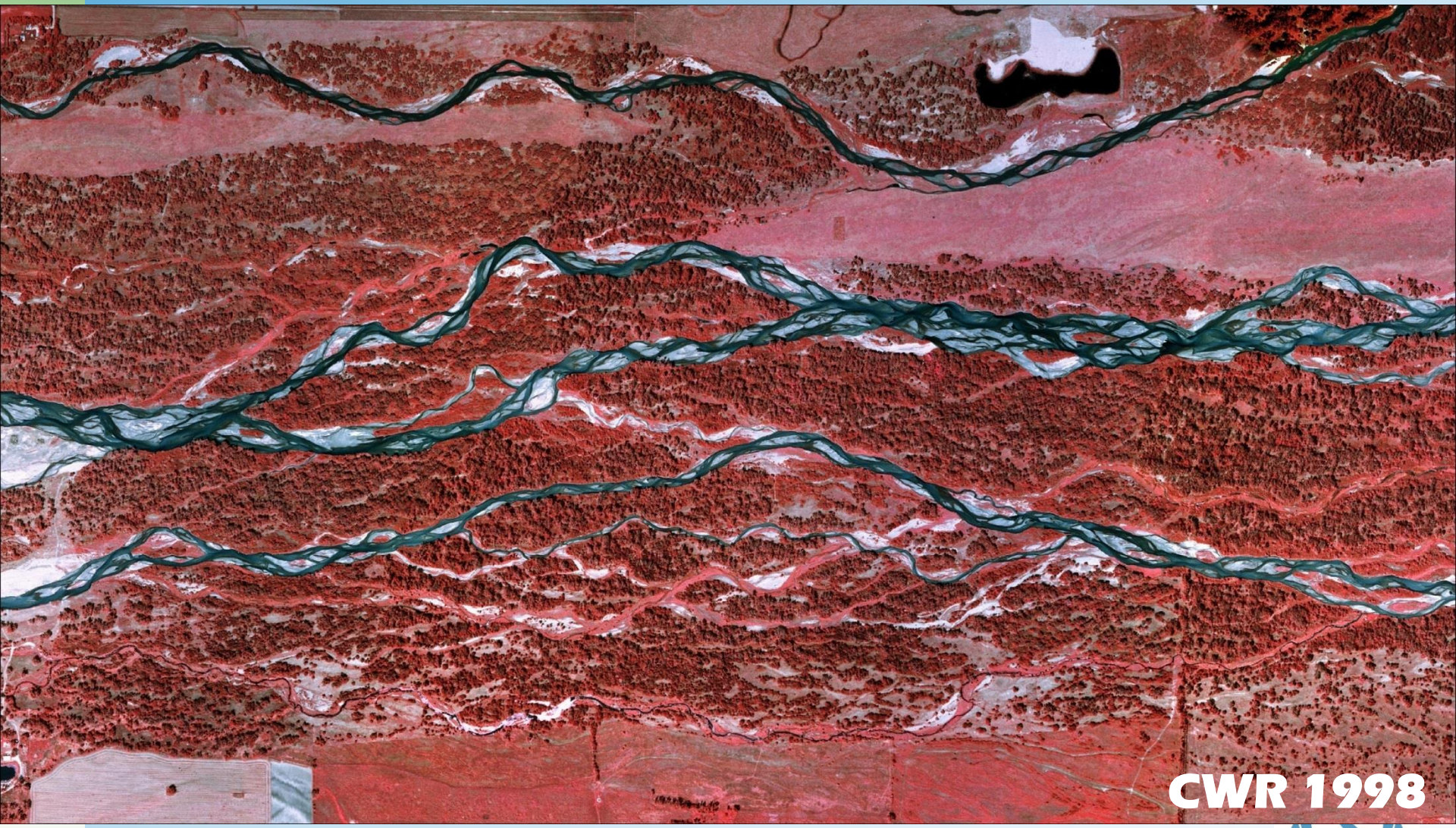

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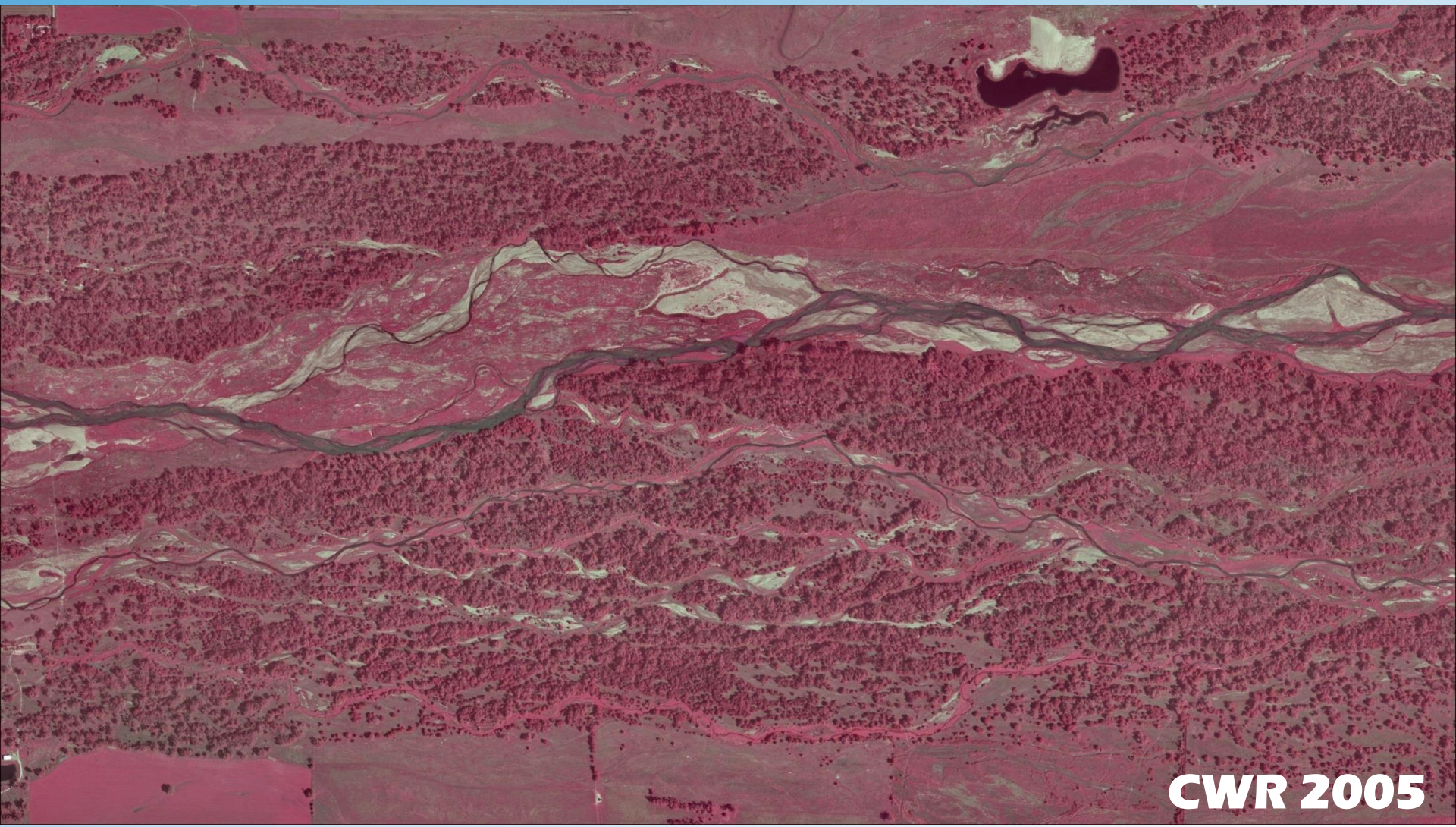
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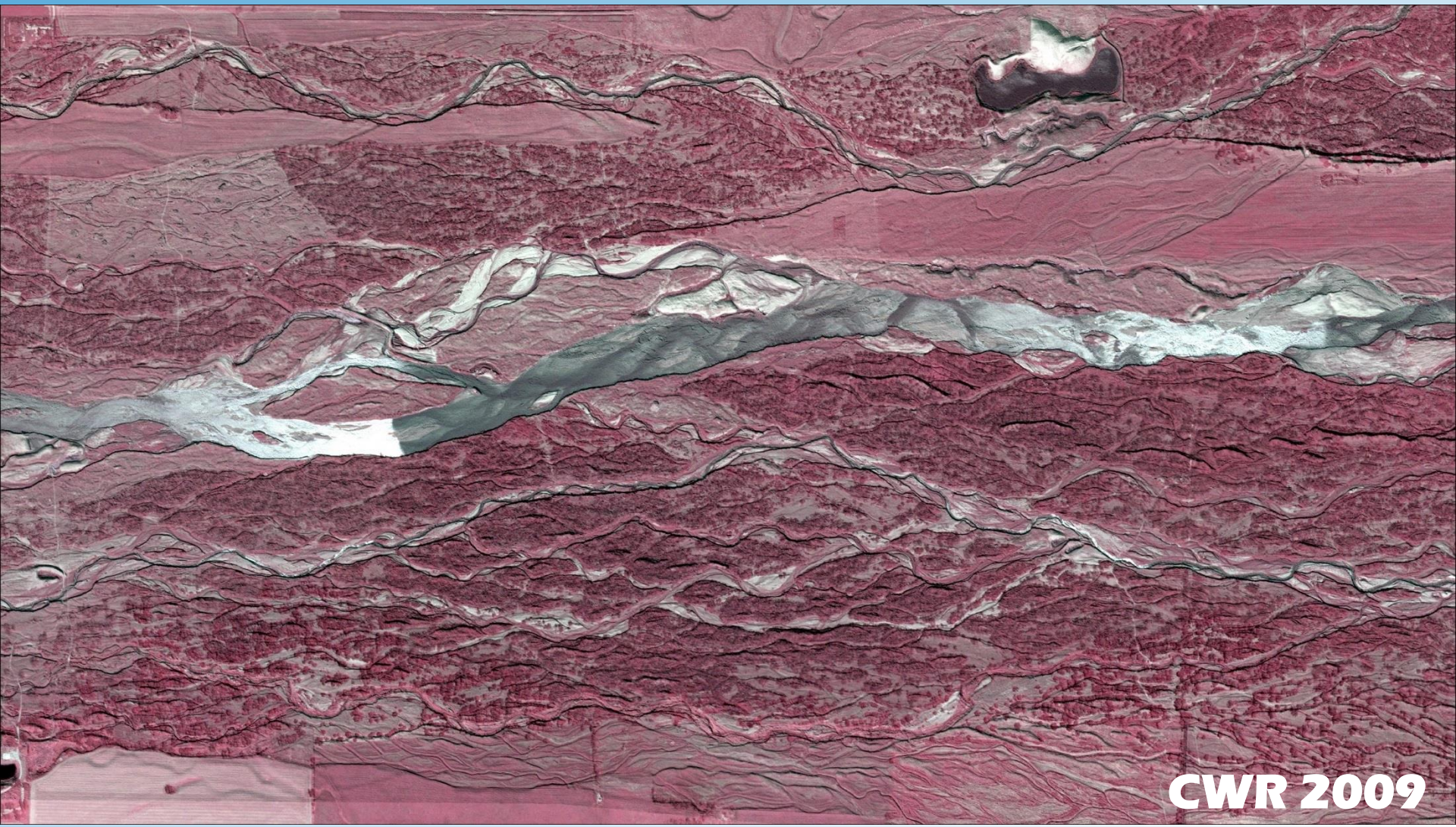
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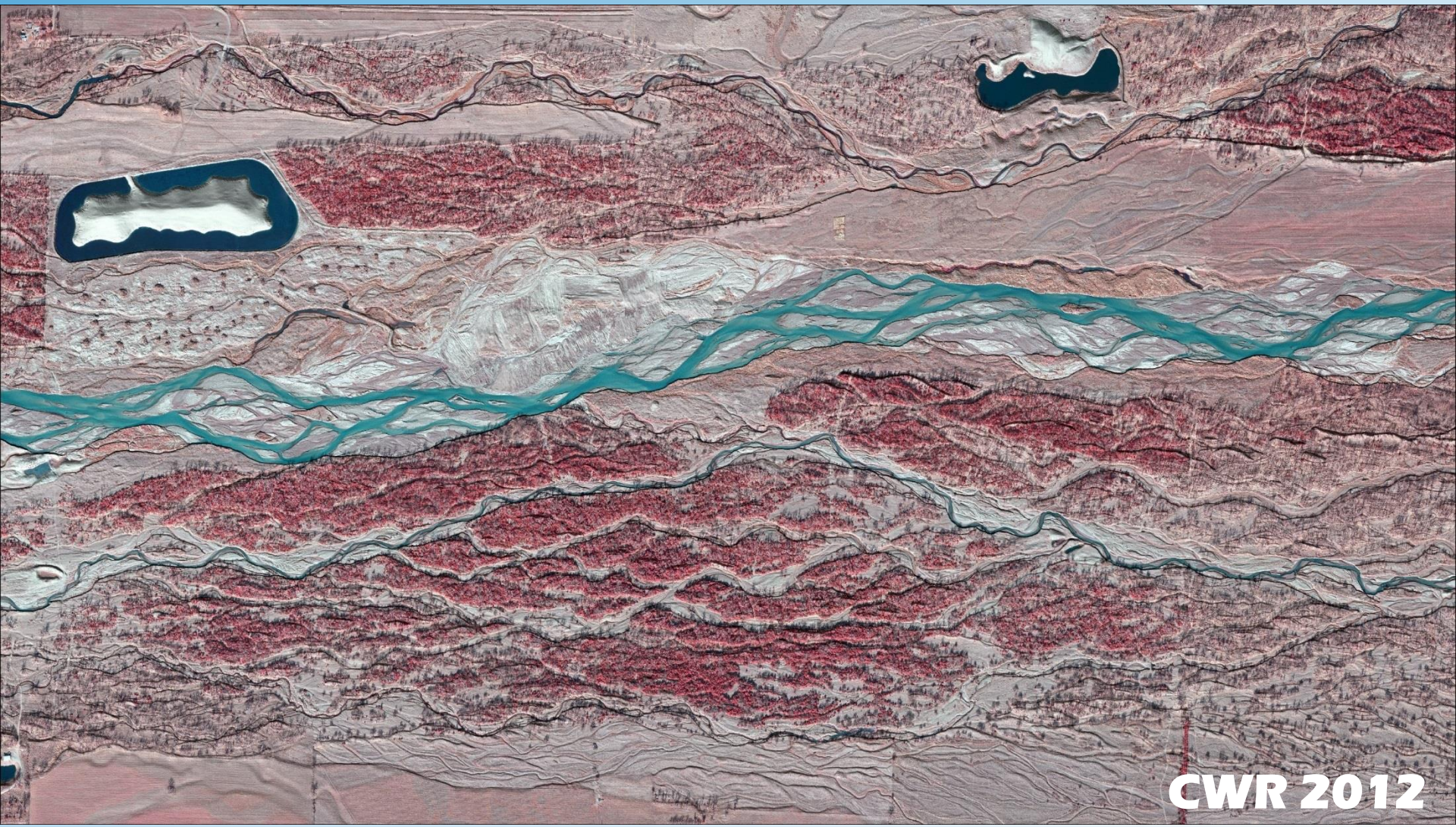
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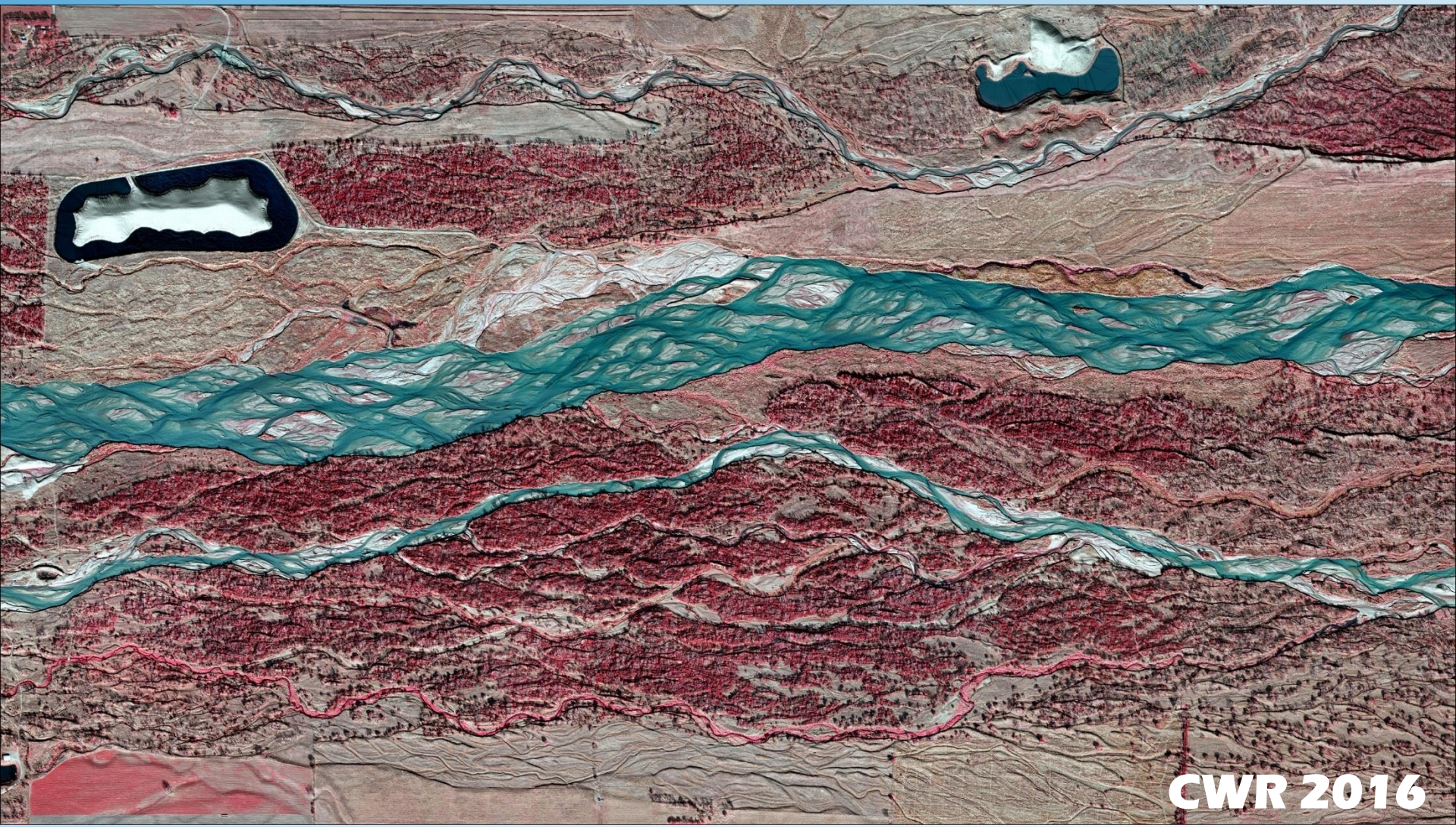
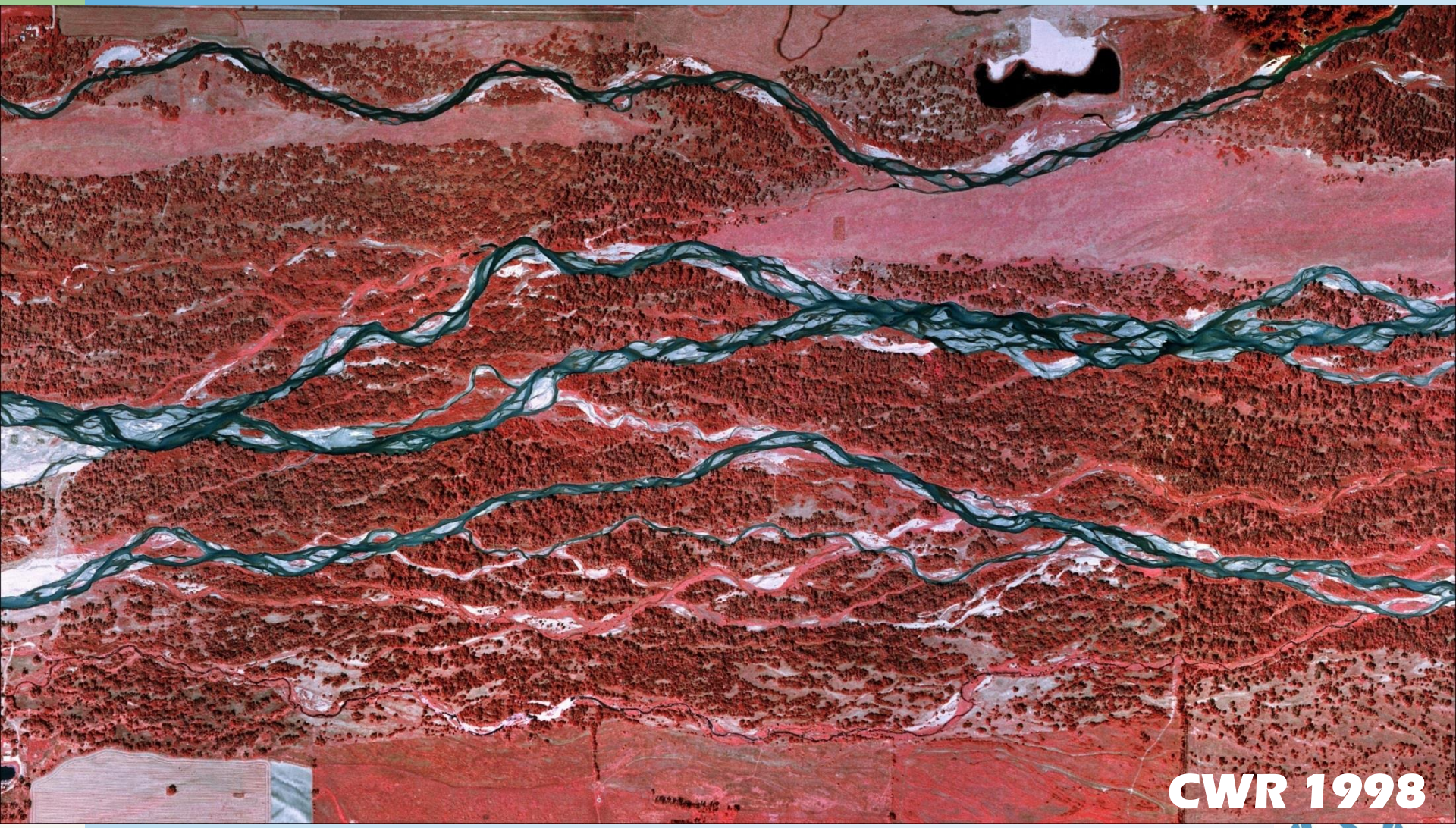

CWR 2016



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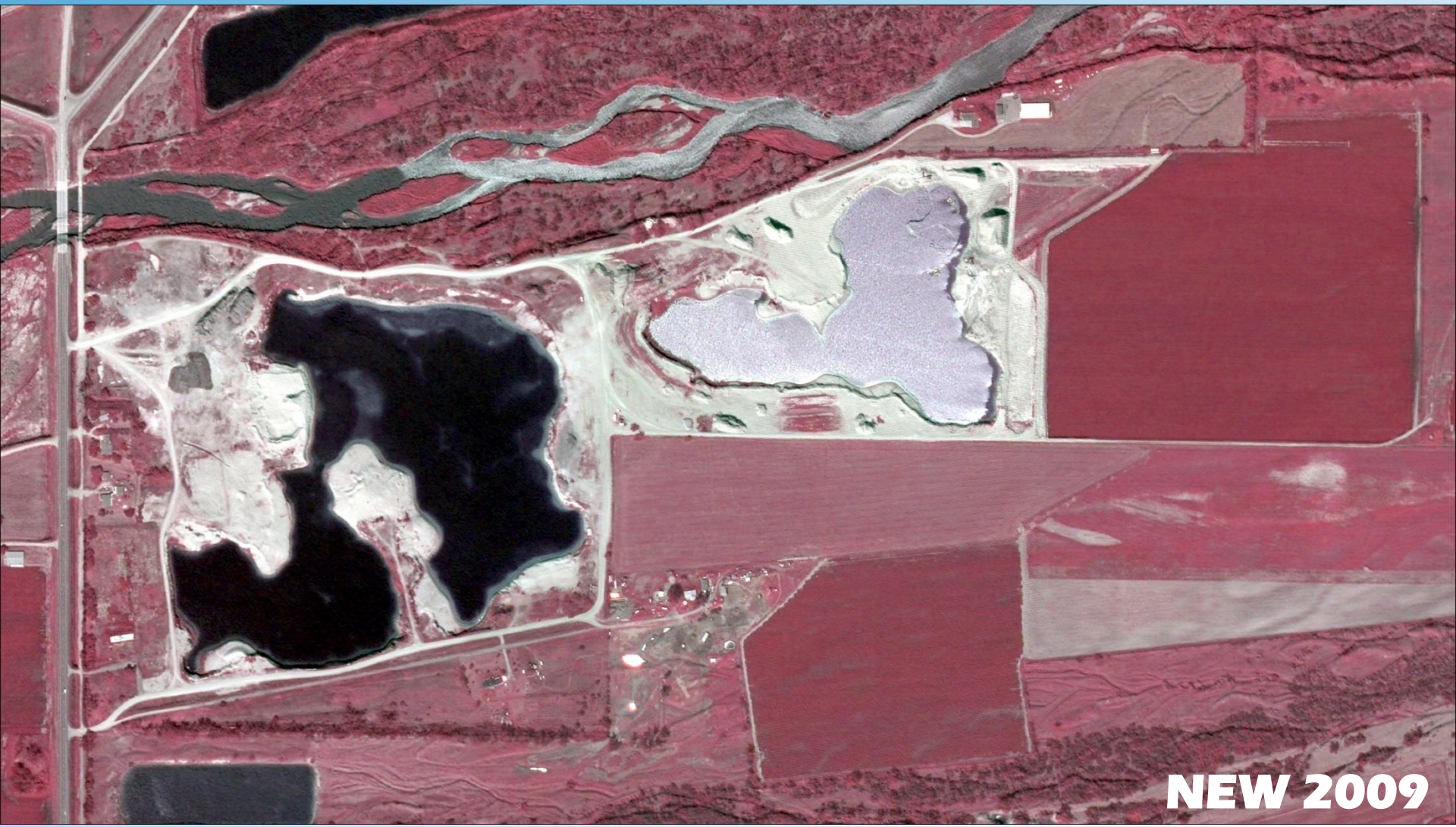
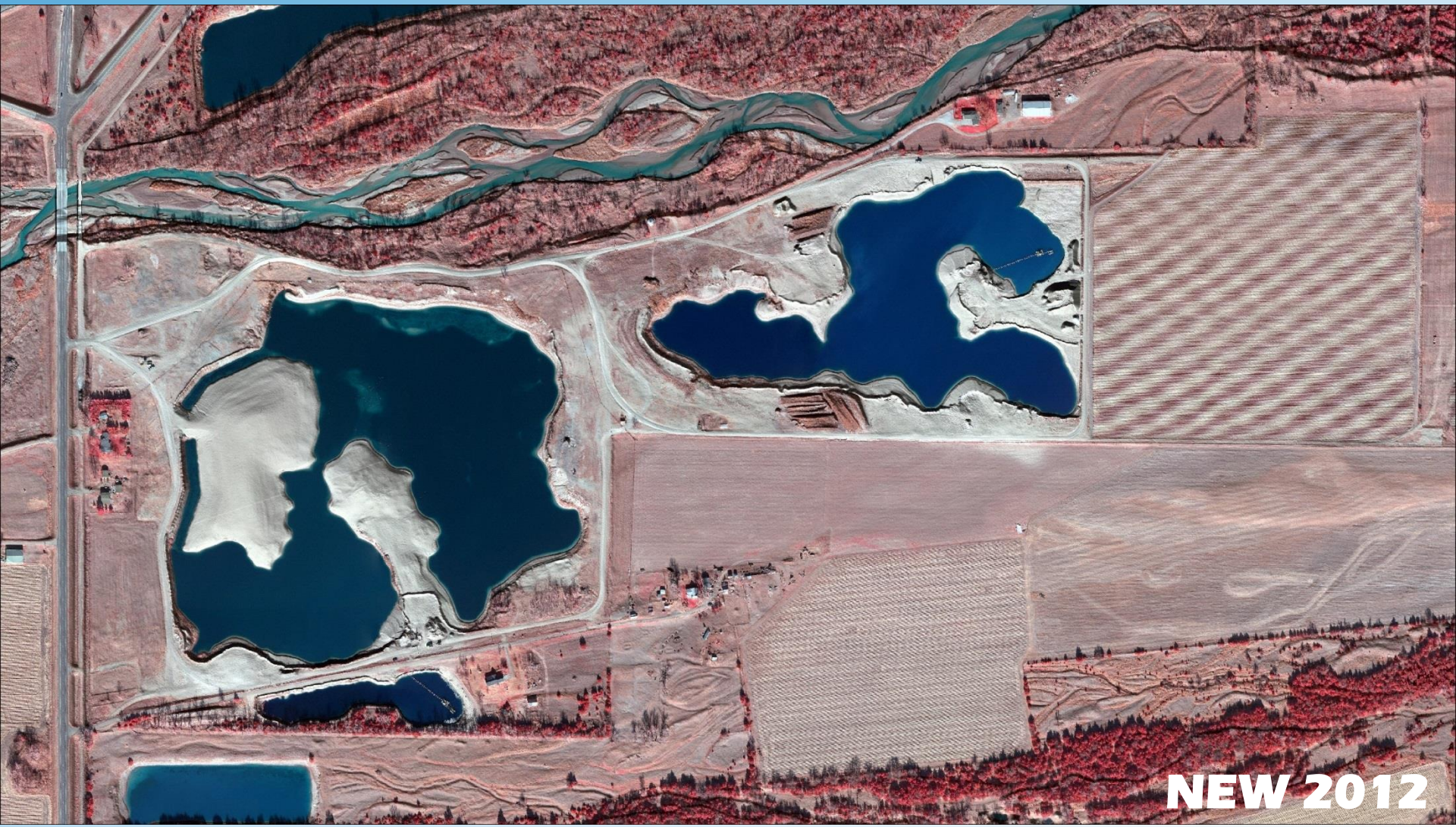
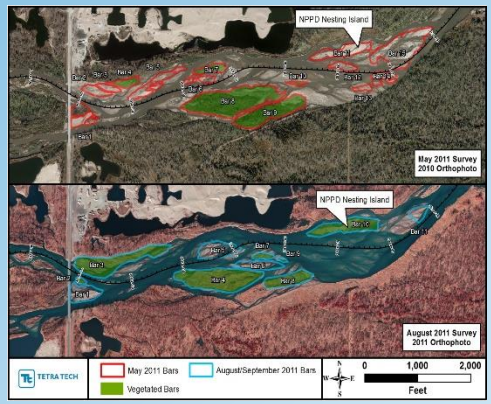

NEW 2009

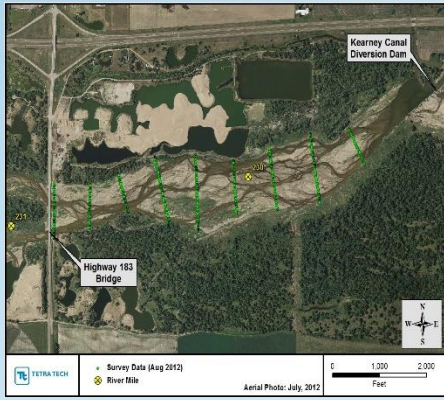

NEW 2012

NEW 2016

Monitoring Data

Effort	Frequency	Description
Least Tern and Piping Plover Use and Productivity Monitoring	Annual	Document species use, habitat variables and productivity in the AHR.
Least Tern and Piping Plover Habitat Availability Analysis	Annual	Document occurrence and amount of habitat in AHR meeting minimum species habitat suitability criteria.
Discharge Measurements	Real-time	Real-time Platte River discharge monitoring at six locations in the AHR. Stream gaging conducted in cooperation with the USGS and Nebraska Department of Natural Resources
June Color-Infrared Imagery	Annual	Document in-channel and off-channel habitat conditions during least tern and piping plover nest initiation period.
November Color-Infrared Imagery and Light Detection and Ranging	Annual	Document channel morphology and topography under leaf-off and low discharge conditions.
System-Scale Geomorphology and Vegetation Monitoring	Annual	Monitor sediment transport, channel morphology and in-channel vegetation throughout the AHR. Data include bed and suspended sediment load measurements, repeat channel transect surveys, bed and bank material sampling, and vegetation monitoring.
HEC-GeoRAS Hydraulic Model of AHR	As Necessary	Segment-scale hydraulic model for evaluation of channel hydraulics and development of water surface profiles across a range of discharges.





AM Step 1 – Assess

PRRIP "Big Questions"

PRRIP Big Questions = What we don't know but want to learn	Broad Hypotheses[1]	Priority Hypotheses[2]
Implementation – Program Management Actions and Habitat		
1. **Will implementation of SDHF[3] produce suitable[4] tern and plover riverine nesting habitat on an annual or near-annual basis?**	*PP-1a: Flows of 5,000 to 8,000 cfs magnitude in the habitat reach for a duration of three days at Overton on an annual or near-annual basis will build sandbars to an elevation suitable for least tern and piping plover habitat.*	Flow #1
2. **Will implementation of SDHF produce and/or maintain suitable whooping crane riverine roosting habitat on an annual or near-annual basis?**	*PP-1b: Flows of 5,000 to 8,000 cfs magnitude in the habitat reach for a duration of three days at Overton on an annual or near-annual basis will increase the average width of the vegetation-free channel.*	Flow #3, Flow #5
3. **Is sediment augmentation necessary for the creation and/or maintenance of suitable riverine tern, plover, and whooping crane habitat?**	*PP-2: Between Lexington and Chapman, eliminating the sediment imbalance of approximately 4000,000 tons annually in eroding reaches will reduce net erosion of the river bed, increase the sustainability of a braided river, contribute to channel widening, shift the river over time to a relatively stable condition, and reduce the potential for degradation in the north channel of Jeffrey Island resulting from headcuts.*	Sediment #1
4. **Are mechanical channel alterations (channel widening and flow consolidation) necessary for the creation and/or maintenance of suitable riverine tern, plover, and whooping crane habitat?**	*PP-3: Designed mechanical alterations of the channel at select locations can accelerate changes towards braided channel conditions and desired river habitat.*	Mechanical #2

Critical Uncertainties

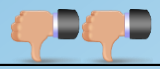
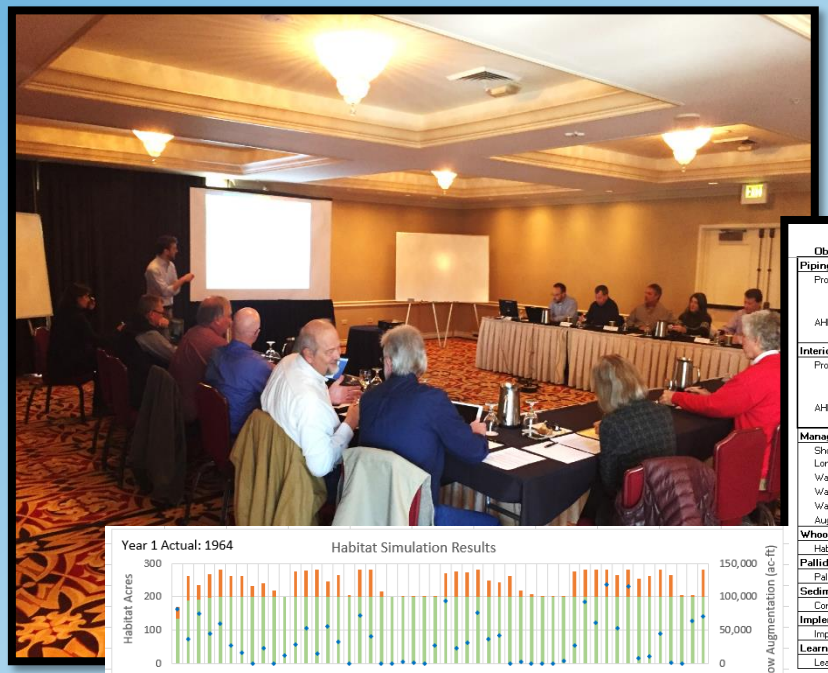
PRRIP Big Question	2014 Assessment	Basis for assessment
Implementation – Program Management Actions and Habitat		
1. Will implementation of SDHF produce suitable tern and plover riverine nesting habitat on an annual or near-annual basis?		Peer-reviewed Program synthesis concludes that SDHF will not produce suitable nesting sandbars.
2. Will implementation of SDHF produce and/or maintain suitable whooping crane riverine roosting habitat on an annual or near-annual basis?		Trending negative; Program synthesis chapters now in development will be discussed with the TAC and ISAC and peer reviewed in 2015; those synthesis chapters and published manuscripts related to the Program's vegetation and lateral erosion research will likely support a "two thumbs down" assessment in the 2015 State of the Platte Report.
3. Is sediment augmentation necessary for the creation and/or maintenance of suitable riverine tern, plover, and whooping crane habitat?		Trending positive; certainty about the sediment deficit; uncertainty about the role of that deficit in habitat creation and maintenance.
4. Are mechanical channel alterations (channel widening and flow consolidation) necessary for the creation and/or maintenance of suitable riverine tern, plover, and whooping crane habitat?		Trending positive; planform management manuscript now in development will be published and will likely support a "two thumbs up" assessment in the 2015 State of the Platte Report.
Effectiveness – Habitat and Target Species Response		
5. Do whooping cranes select suitable riverine roosting habitat in proportions equal to its availability?		A definitive assessment is expected by 2017 once peer review of data analyses (monitoring, telemetry, stopover study data, habitat availability assessments, IGERT research) is complete.
6. Does availability of suitable nesting habitat limit tern and plover use and reproductive success on the central Platte River?		Trending positive; three documents now in development will be peer reviewed and/or published and will likely support a "two thumbs up" assessment in the 2015 State of the Platte Report.
7. Are both suitable in-channel and off-channel nesting habitats required to maintain central Platte River tern and plover populations?		Trending negative; three documents now in development will be peer reviewed and/or published and will likely support a "two thumbs down" assessment in the 2015 State of the Platte Report.
8. Does forage availability limit tern and plover productivity on the central Platte River?		Trending negative; synthesis document related to tern forage (fish) will be peer reviewed that, in combination with the results of the Foraging Habits Study, will likely support a "two thumbs down" assessment in the 2015 State of the Platte Report.
9. Do Program flow management actions in the central Platte River avoid adverse impacts to pallid sturgeon in the lower Platte River?		Peer-reviewed Program stage change study concludes Program flow management actions will avoid adverse impacts.
Larger Scale Issues – Application of Learning		
10. Do Program management actions in the central Platte River contribute to least tern, piping plover, and whooping crane recovery?		By definition, implementation of the Program contributes to recovery of the target species. A definitive answer for this question can only be obtained by a broader analysis of the contribution of the central Platte to range-wide recovery.
11. What uncertainties exist at the end of the First Increment, and how might the Program address those uncertainties?		This question is a "parking lot" for uncertainties that could be addressed through adaptive management in an extended First Increment or new Second Increment.

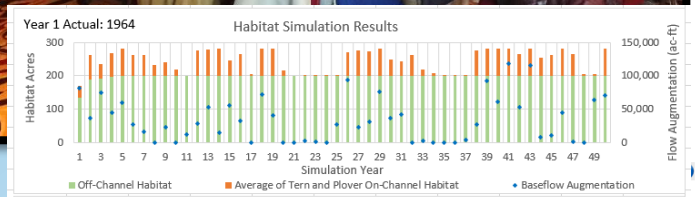
Table 2. 2014 Big Questions table.

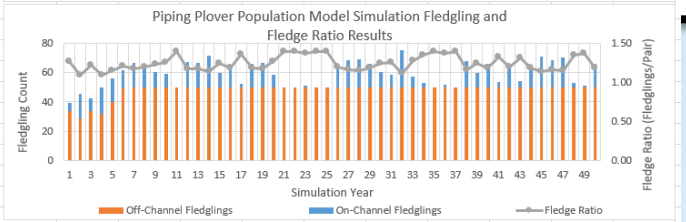
Structured Decision Making Process lead to First Policy Level Adjustment in June 2016

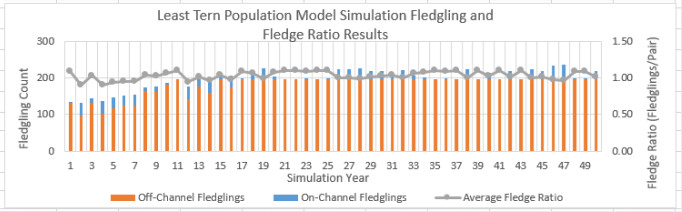


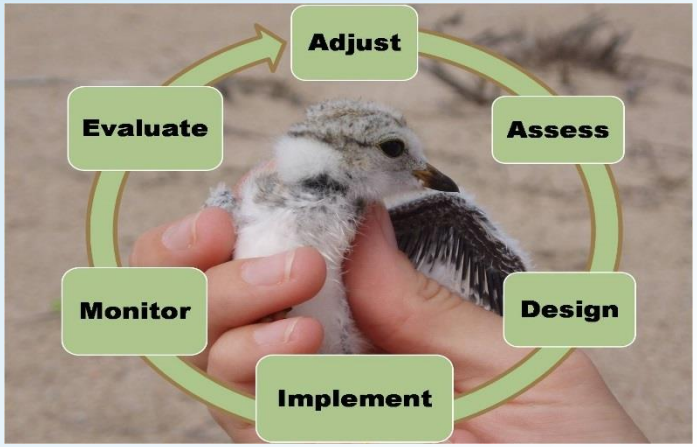
Objective	Performance Measure	Units	Dir	STC	A2	A3	A4	A5	A6	B1	B2	B3	B4
Piping Plovers													
Program Repro Success	Average Breeding Pair (BP)	#/year	H	22	34	28	29	29	27	48	49	50	43
	Average Fledge Ratio	#/year	H	1.30	1.27	1.37	1.34	1.34	1.40	1.40	1.38	1.37	1.40
	Total Fledglings over 50 yr	#	H	1,420	2,144	1,903	1,929	1,929	1,868	3,346	3,379	3,400	3,006
AHR Repro Success	Average Breeding Pair	#/year	H	30	42	35	37	37	35	55	57	58	51
	Average Fledge Ratio	#/year	H	1.33	1.30	1.37	1.36	1.36	1.40	1.40	1.38	1.37	1.40
Interior Least Terns													
Program Repro Success	Average Breeding Pair (BP)	#/year	H	97	141	104	106	105	102	225	226	226	215
	Average Fledge Ratio	#/year	H	1.07	1.06	1.09	1.08	1.09	1.10	1.10	1.09	1.09	1.10
	Total Fledglings over 50 yr	#	H	5,187	7,462	7,312	7,339	7,319	7,279	12,361	12,347	12,318	11,802
AHR Repro Success	Average Breeding Pair	#/year	H	140	182	176	177	176	174	263	264	264	256
	Average Fledge Ratio	#/year	H	1.08	1.07	1.09	1.09	1.09	1.10	1.10	1.09	1.09	1.10
Management Cost													
Short-term Management Co	1st Increment Cost (2017-2019)	1000$	L	$130	$1,220	$1,081	$1,081	$1,081	$1,056	$1,042	$1,068	$1,068	$44
Long-term Management Co	NPV (50 yrs)	1000$	L	$2,931	$6,225	$2,343	$2,343	$2,343	$1,658	$1,214	$2,810	$2,810	$996
Water Use - Wet Years	Proportion of Program water used	%	L	0%	0%	0%	9%	5%	0%	0%	0%	9%	0%
Water Use - Normal Years	Proportion of Program water used	%	L	0%	0%	0%	63%	44%	0%	0%	0%	63%	0%
Water Use - Dry Years	Proportion of Program water used	%	L	0%	0%	0%	77%	56%	0%	0%	0%	77%	0%
Augmented Volume	Avg. Volume Program water / yr	ac-ft/year	L	0	0	0	39,090	27,033	0	0	0	39,090	0
Whooping Crane													
Habitat Use	Habitat Suitability Scale	-3 to +3	H	0	-1	2	2	2	1	1	2	2	1
Pallid Sturgeon													
Pallid Sturgeon Risks	Presense of critical water diversions	Yes/No	L	No	No	No	No	No	No	No	No	No	No
Sediment													
Contribution to Sediment Si	Sediment Supply Scale	-2 to +2	H	0	1	2	2	2	0	0	2	2	0
Implementation Effort													
Implementation Costs/Risks	Implementation Scale	-4 to 0	H	0	-2	-3	-3	-3	0	-1	-3	-3	-1
Learning													
Learning Potential	Learning Potential Scale	0 to 3	H	1	2	1	1	1	0	0	1	1	0

Legend
Better than selected
Worse than selected
Selected

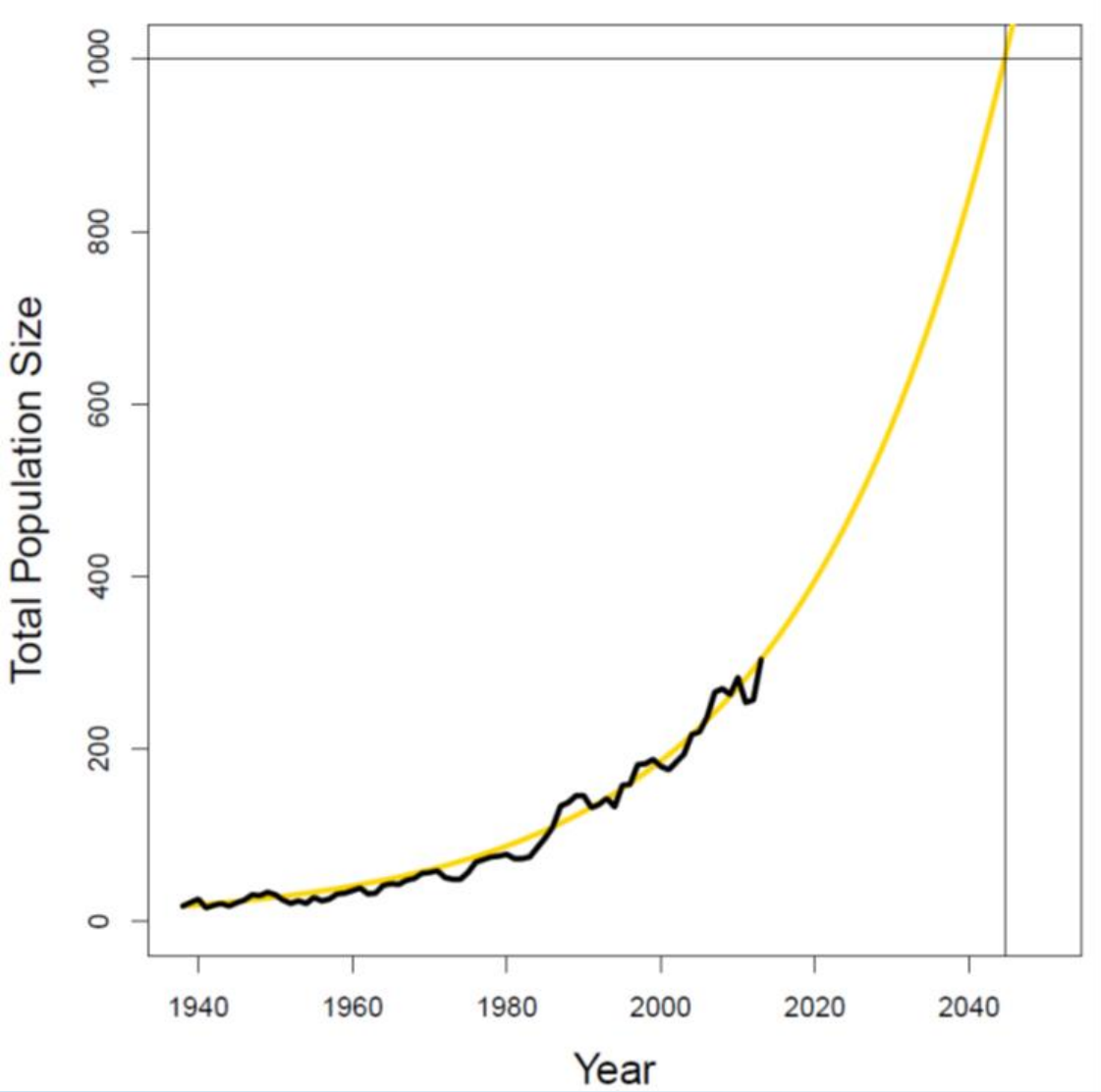








Whooping Crane Population – Migratory Flock



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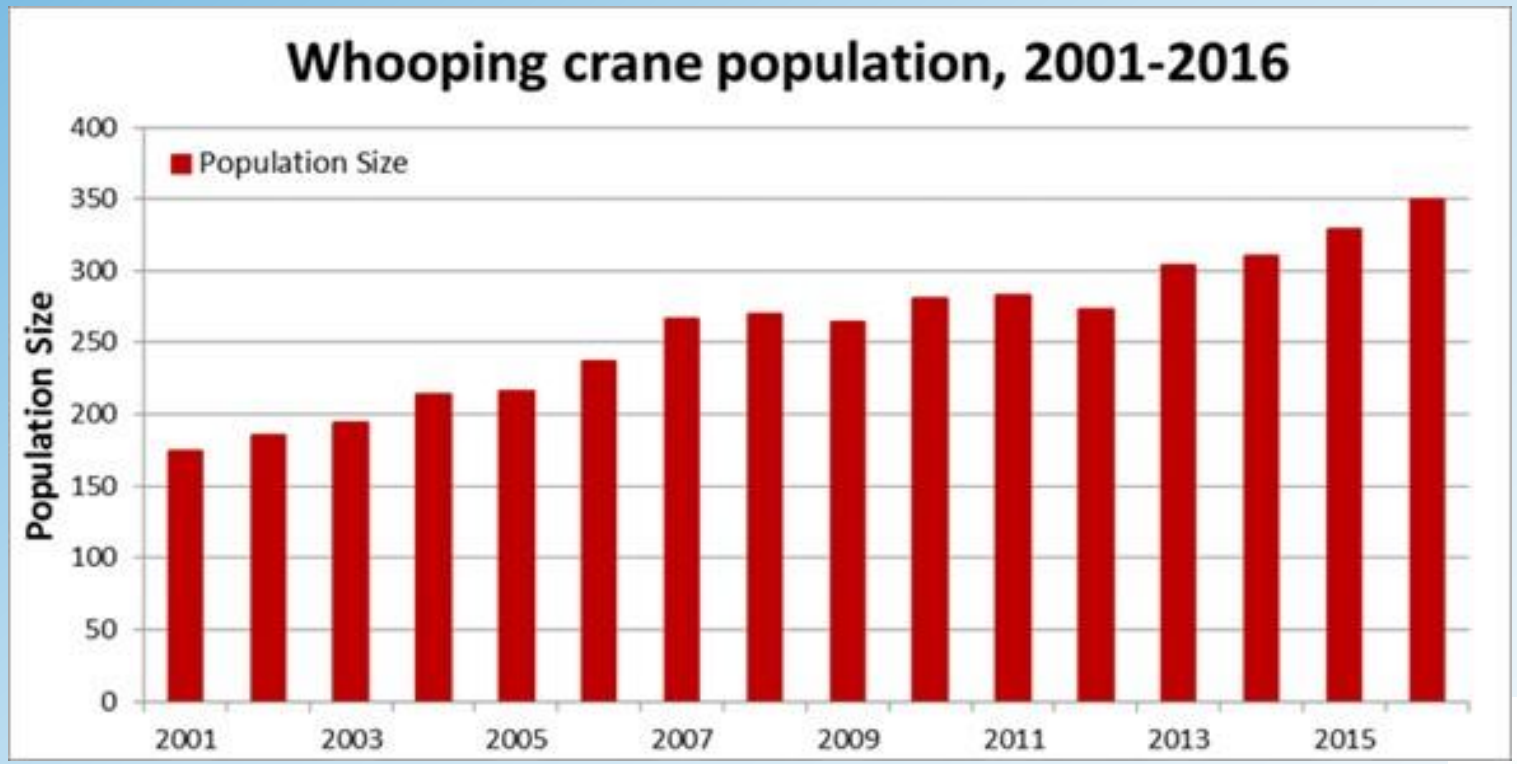
Whooping Crane Population - Migratory Flock



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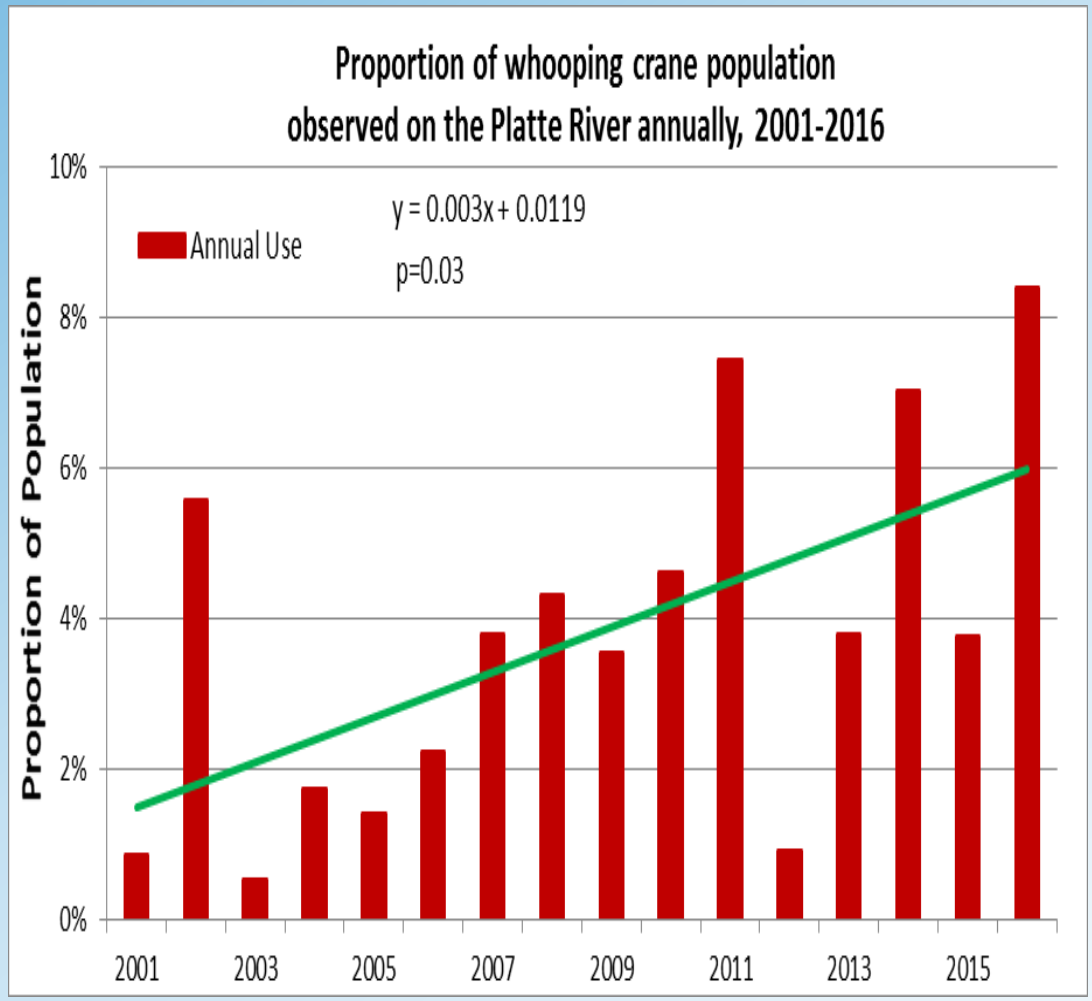
Whooping Crane Use of Platte River



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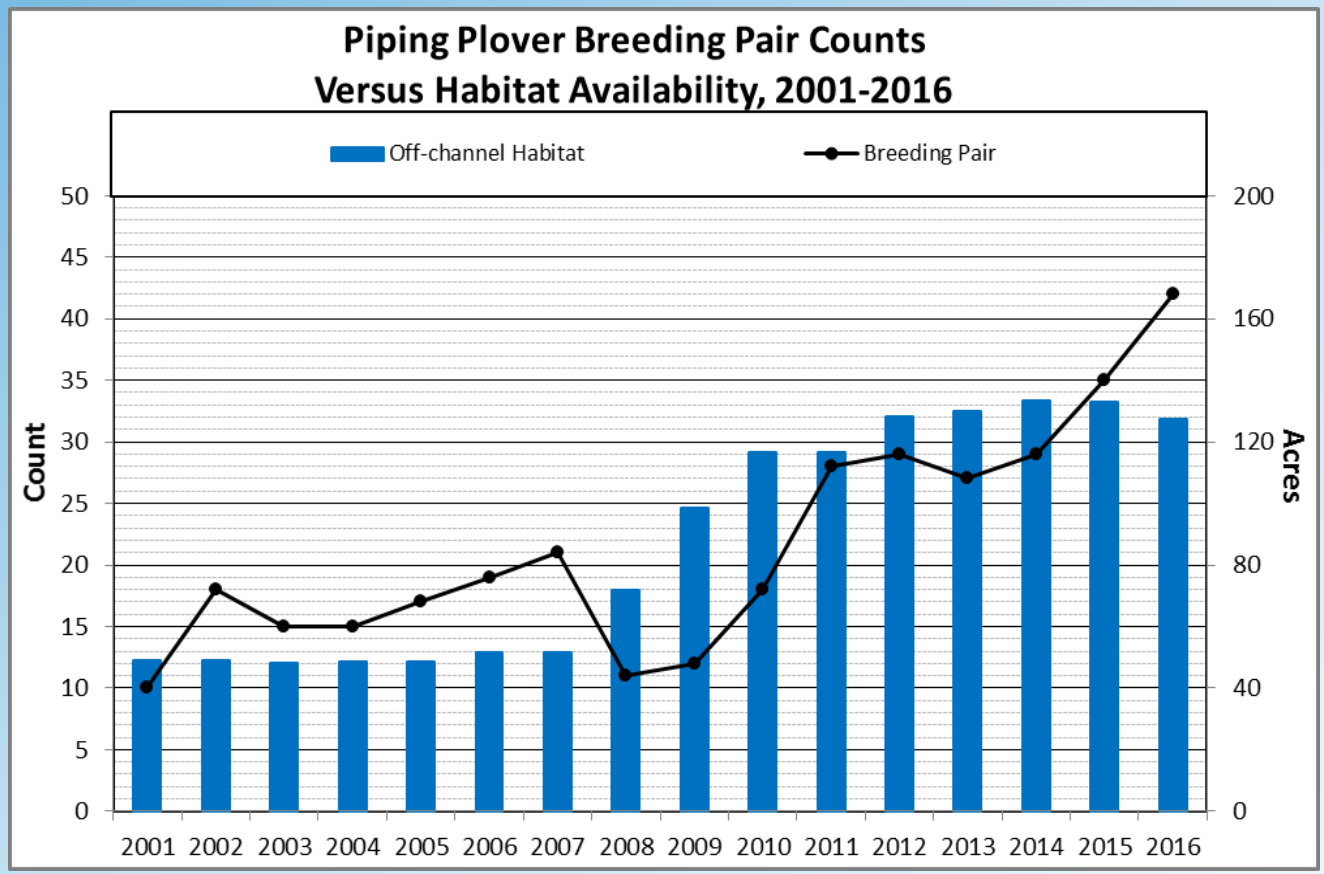

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RECOVERY IMPLEMENTATION PROGRAM

Permitting Processes

- Mitigation for mitigation
  - PRRIP actions done to mitigate past actions
  - These actions by PRRIP still require mitigation

Actions and Permitting Requirements

- Habitat Rehabilitation
  - Channel Tillage
  - Tree Clearing
- Island Building
- Off-Channel Sand and Water
- Sediment Augmentation
- Wetland Disturbance
  - Conveyance Project
  - Water Project

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RECOVERY IMPLEMENTATION PROGRAM

Restoration Approaches

- Two fundamental strategies
  - Flow –Sediment – Mechanical (FSM)
  - Mechanical Creation and Maintenance (MCM)

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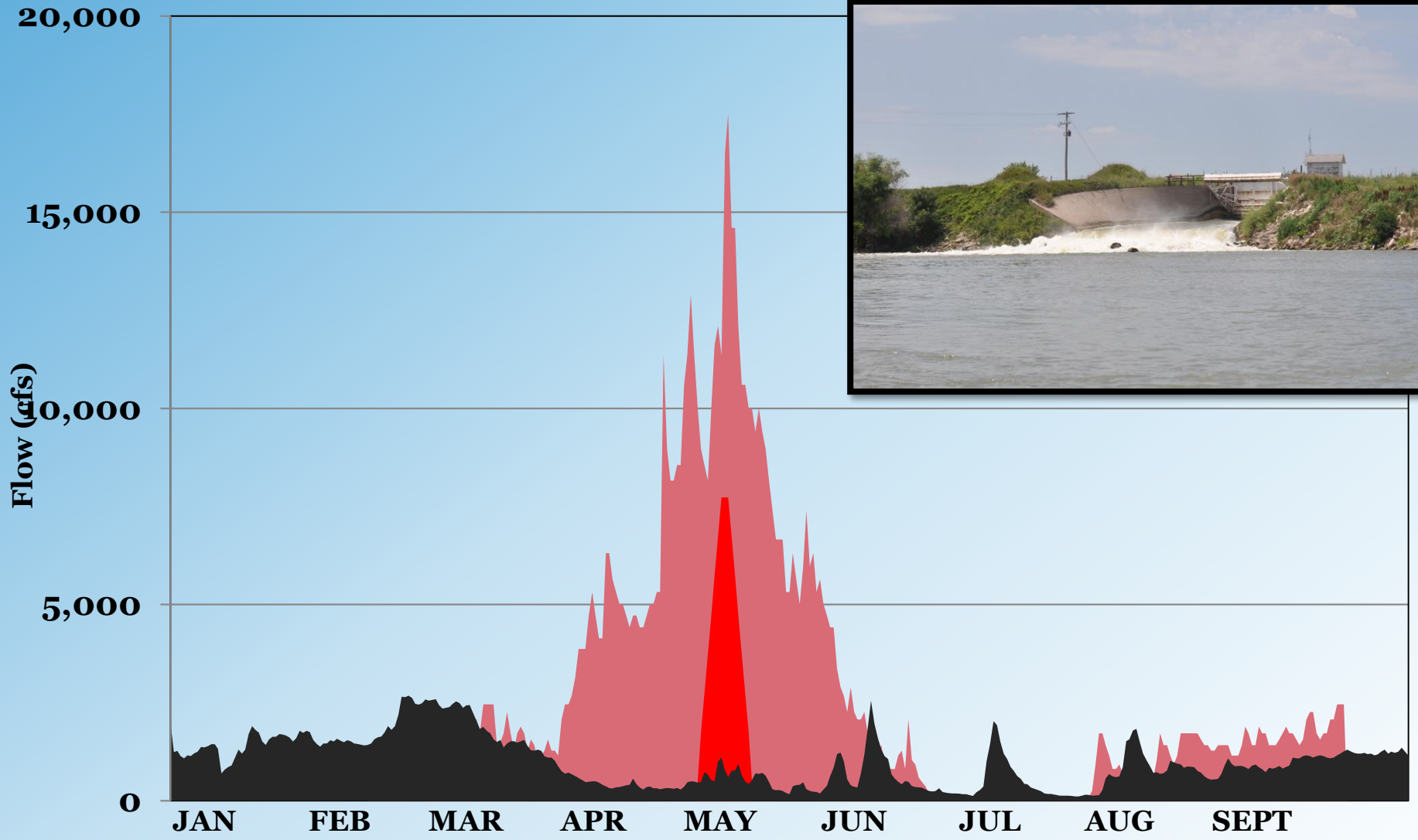
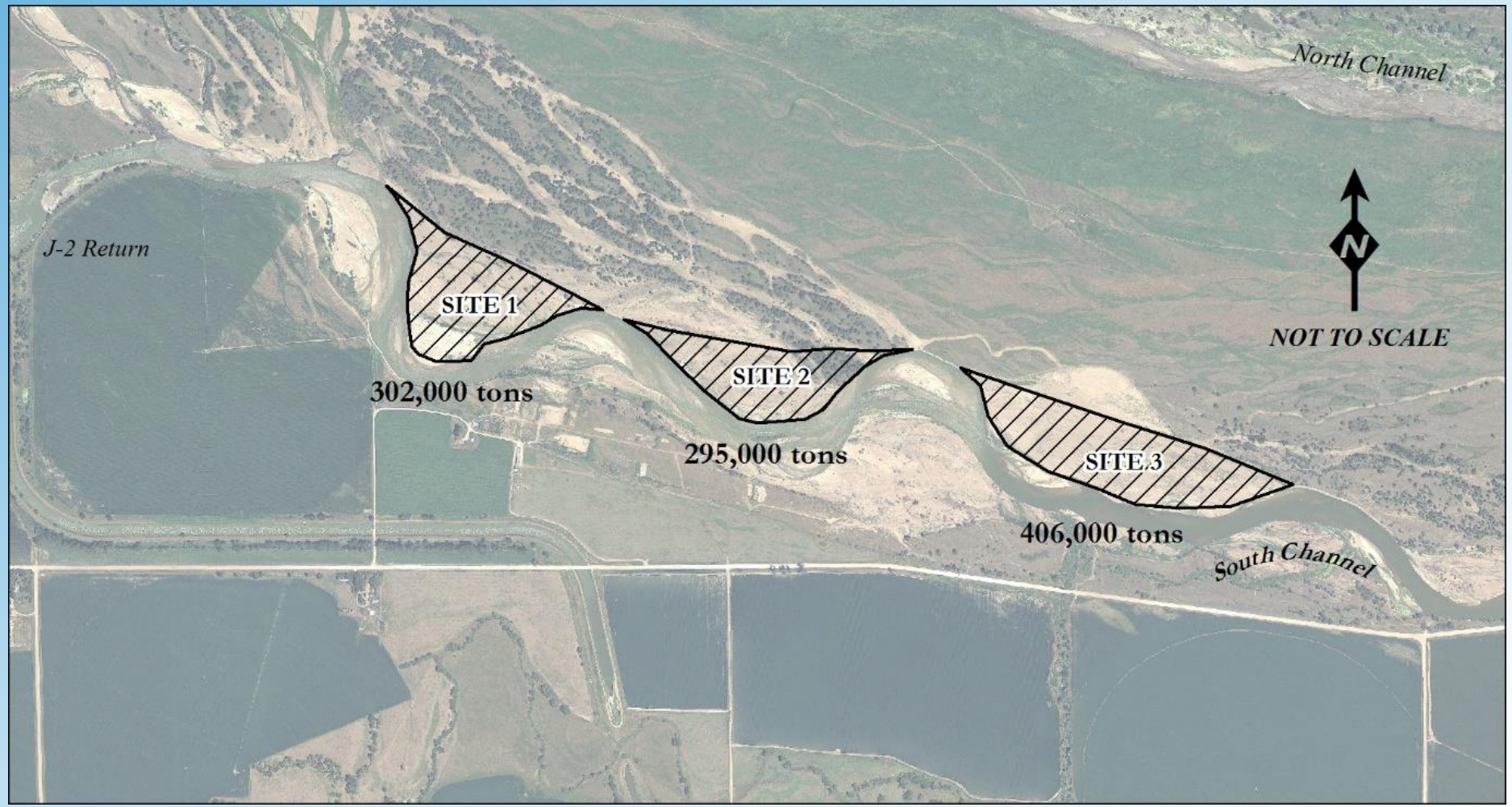
Flow – Sediment - Vegetation



Flow – Sediment - Vegetation

Flow – Sediment - Vegetation

Flow – Sediment - Vegetation



Flow – Sediment - Vegetation

Flow – Sediment - Vegetation

Flow – Sediment - Vegetation

Flow – Sediment - Vegetation

MCM

MCM

MCM
Flow

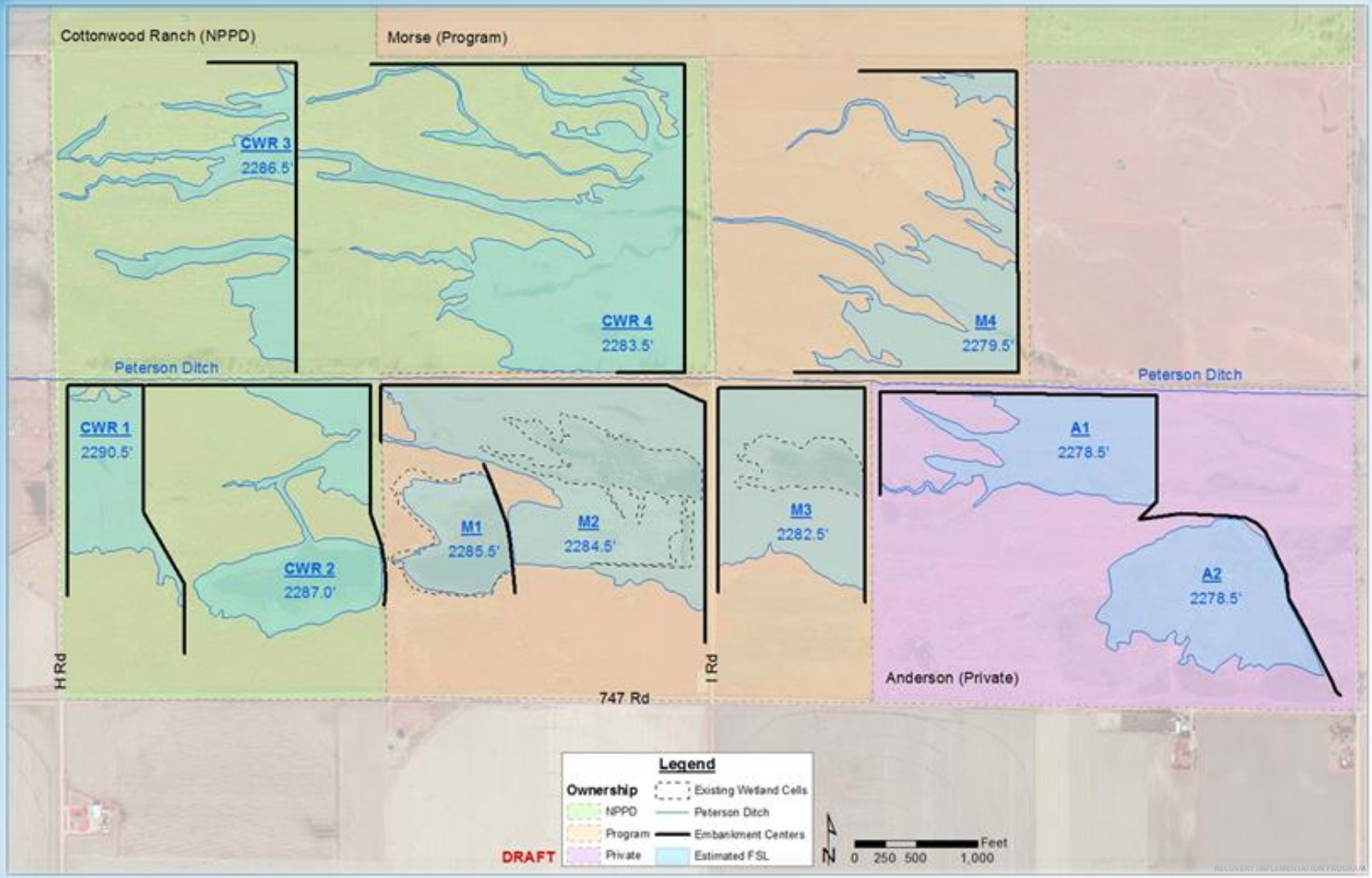
MCM

MCM

MCM

MCM

Broad Scale Recharge - Conceptual Design



General Thoughts on Permitting

1. We strive to avoid impacts
2. If we cant avoid, minimize impacts
3. If permit is necessary, we try for no compensatory mitigation as the PRRIP is mitigation
4. Permitting is hard and slow. An adversarial approach makes it harder and slower.

Path Forward

First Increment Extension

- Need to complete Water Plan and continue learning
  - Extension to 2032
  - Additional funds $106 million
  - Goal adjustments
    - +1,500 habitat acres
    - 120,000 AFY water target
  - Update Environmental Documents
  - Obtain authorizations

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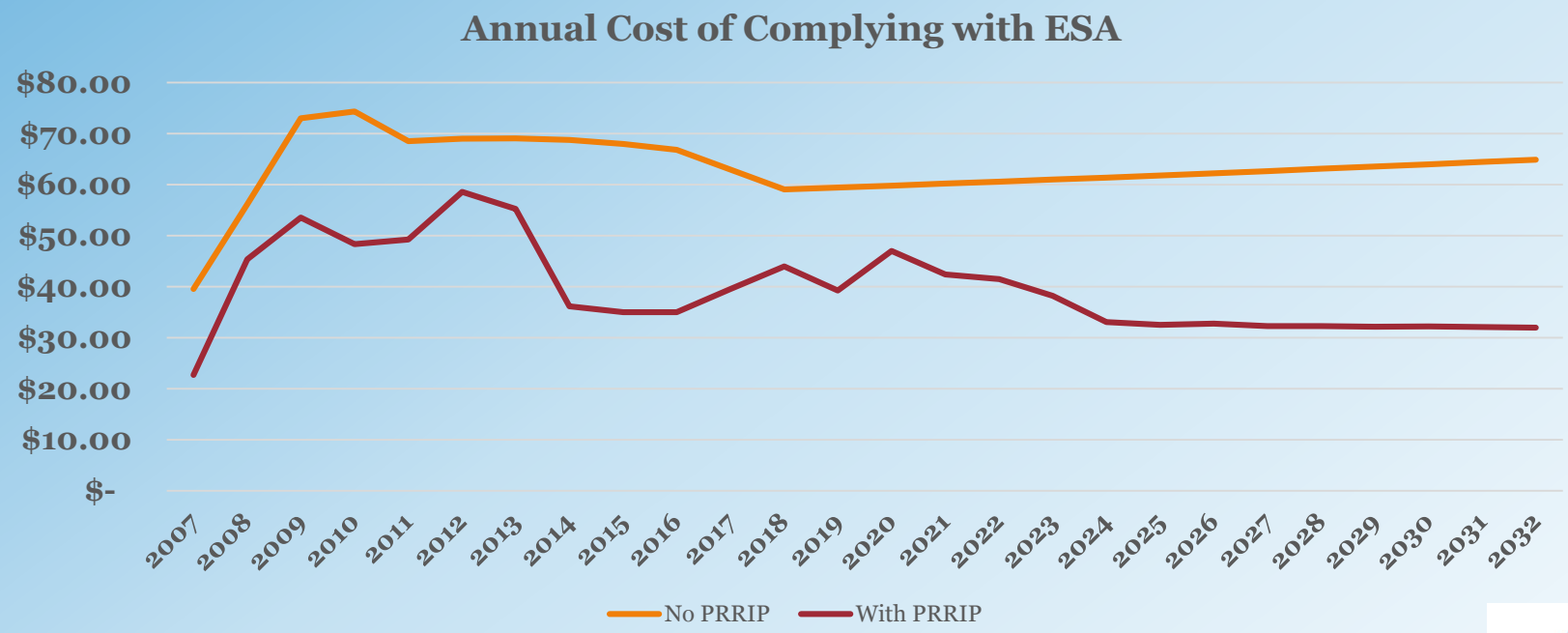
Cost of ESA Compliance
(Millions of Dollars Annually)



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www.platteriverprogram.org

Jerry F. Kenny
kennyj@headwaterscorp.com
308-237-5728

October 18, 2017

Lower South Platte River Meeting

Brush, CO Fairgrounds; 4-H Building

Presentation of background of risk analyses
- Started with infrastructure: bridges, diversions
- Points of constriction on river
- Geomorphic process
  - REM
  - Active channel, Flood hazard area, 100-year flood plain
  - Flood hazard area is not constrained by 100-year flood plain

Alliance
- Enables more funding
- Middle South Platte Alliance has the knowledge to be a resource
- Funding primarily comes from CWCB
- Need to know goals of State Water Plan
- Need to incorporate goals into grant writing

**No roster available*

Appendix B

Reaches and Property Data

N
W
E
S

0 0.5 1
Miles

USDA NAIP 2015

Headgate
Oil & Gas Well
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
Private Parcel
Private, Limited Management Parcel
Public Access Lands

South Platte River Master Plan

Figure B-1: Land Ownership

Reach: 1

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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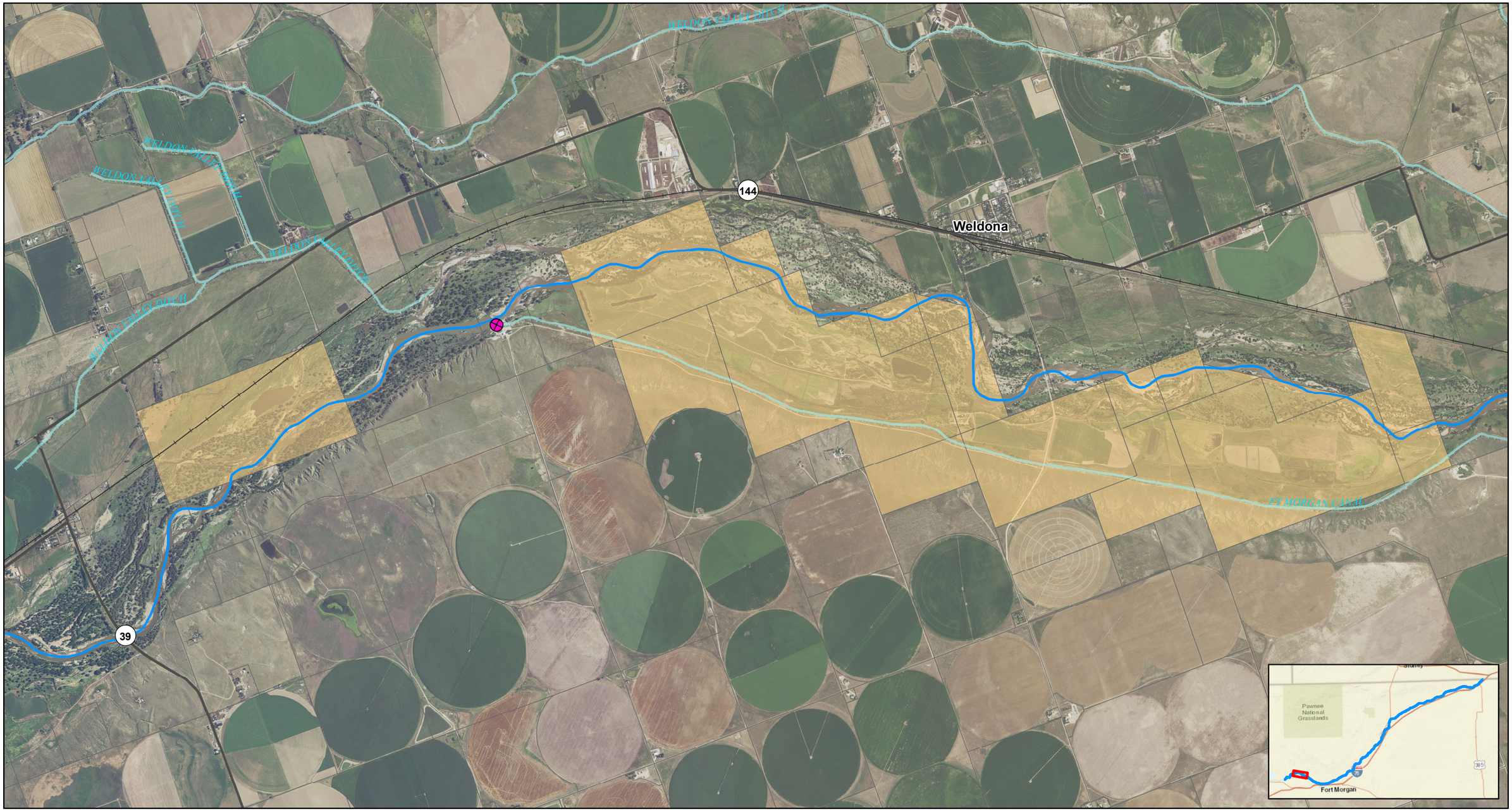

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USDA NAIP 2015

Headgate
Oil & Gas Well
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
Private Parcel
Private, Limited Management Parcel
Public Access Lands

South Platte River Master Plan

Figure B-2: Land Ownership

Reach: 2

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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Headgate
Oil & Gas Well
NPDES
South Platte River
Tributary
Canal
Interstate
Highway
Railroad
County Boundary
Private Parcel
Private, Limited Management Parcel
Public Access Lands

N E S W

0 0.5 1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure B-3: Land Ownership

Reach: 3

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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USDA NAIP 2015

Headgate
Oil & Gas Well
NPDES
South Platte River
Tributary
Canal
Interstate
Highway
Railroad
County Boundary
Private Parcel
Private, Limited Management Parcel
Public Access Lands

South Platte River Master Plan

Figure B-4: Land Ownership

Reach: 4

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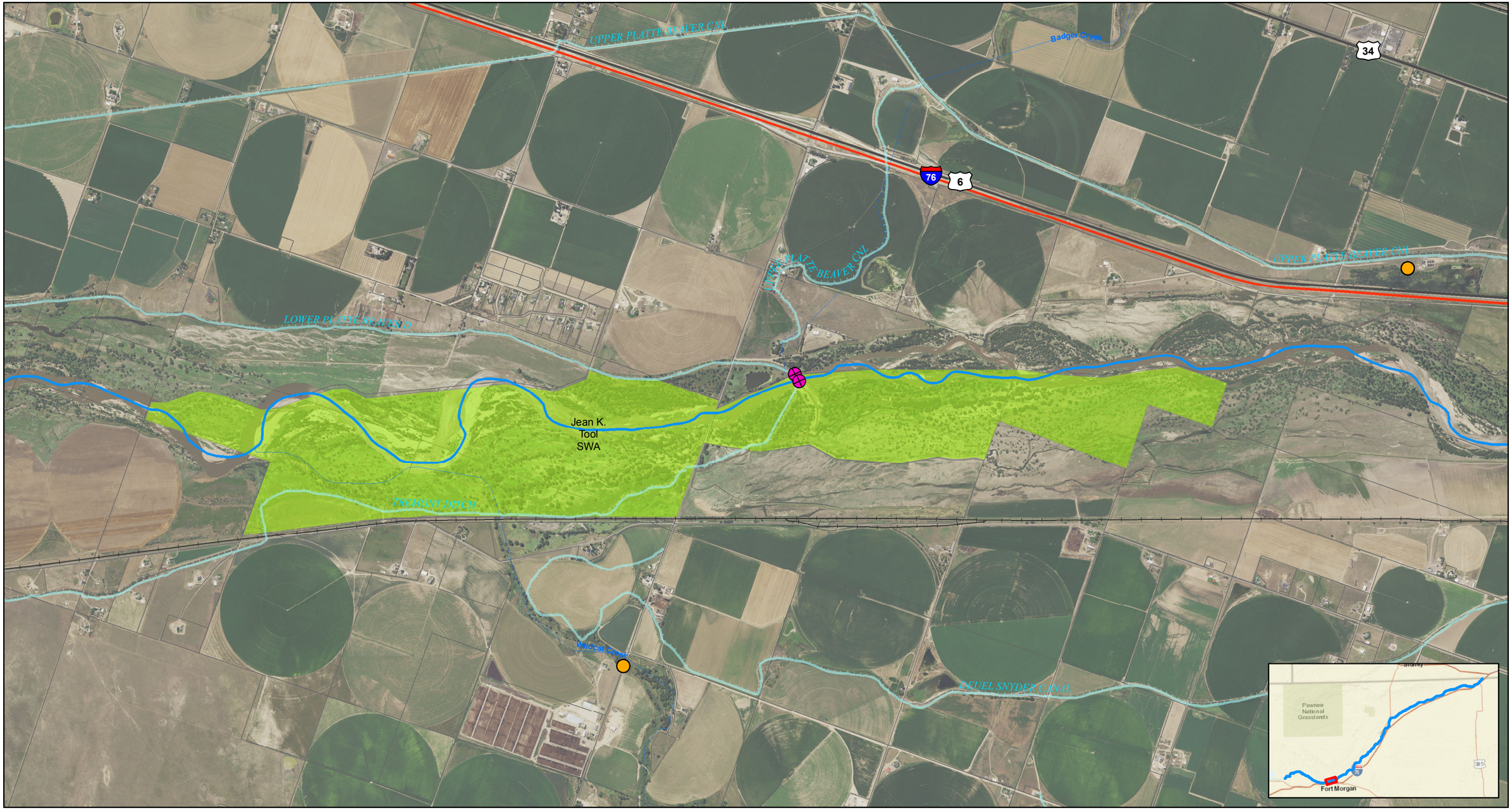

South Platte River Master Plan

Figure B-5: Land Ownership

Reach: 5

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Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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N
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0 0.5 1
Miles

USDA NAIP 2015

Headgate
Oil & Gas Well
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
Private Parcel
Private, Limited Management Parcel
Public Access Lands

South Platte River Master Plan

Figure B-6: Land Ownership

Reach: 6

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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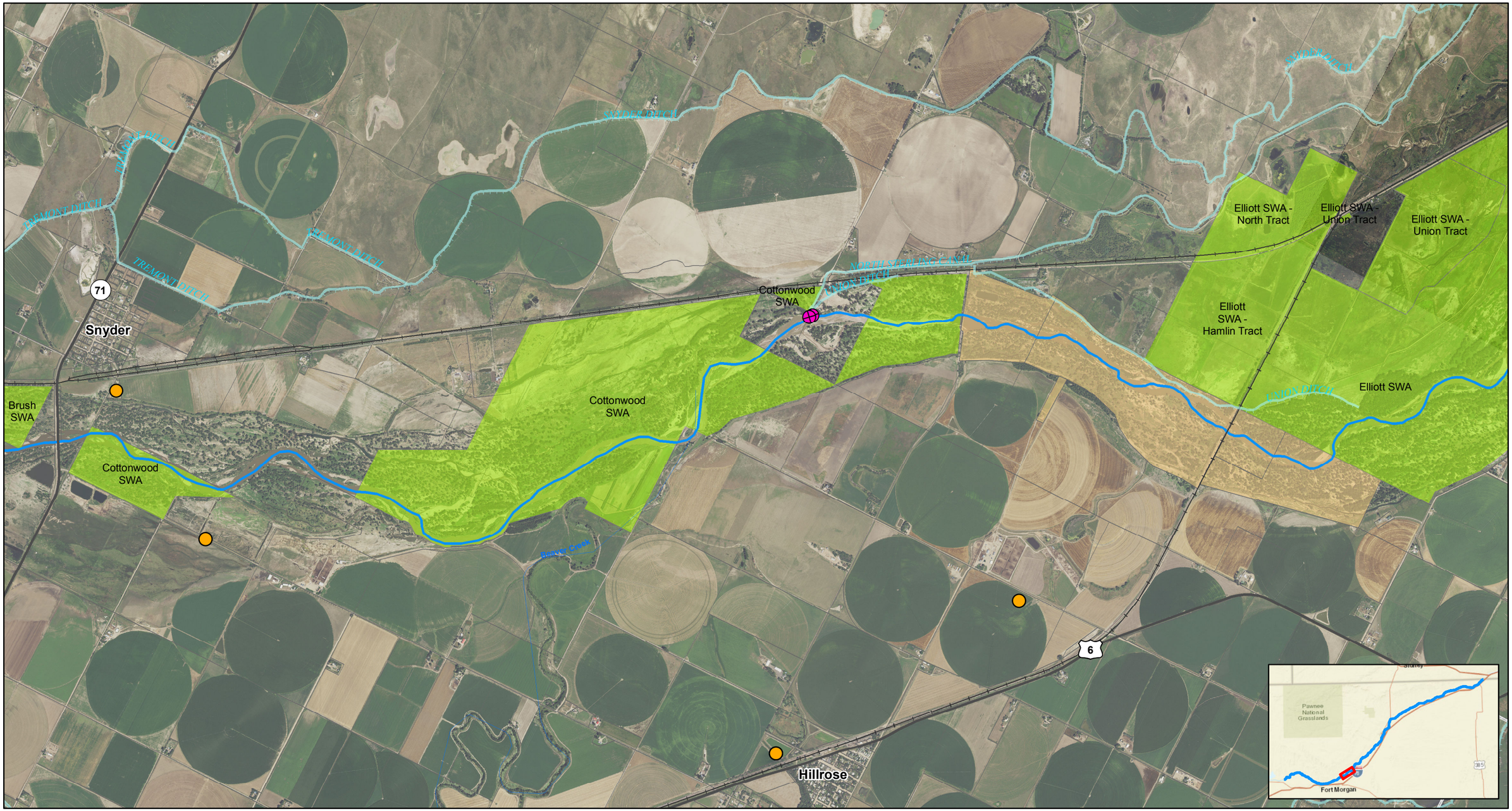

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Miles

USDA NAIP 2015

Headgate
Oil & Gas Well
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
Private Parcel
Private, Limited Management Parcel
Public Access Lands

South Platte River Master Plan

Figure B-7: Land Ownership

Reach: 7

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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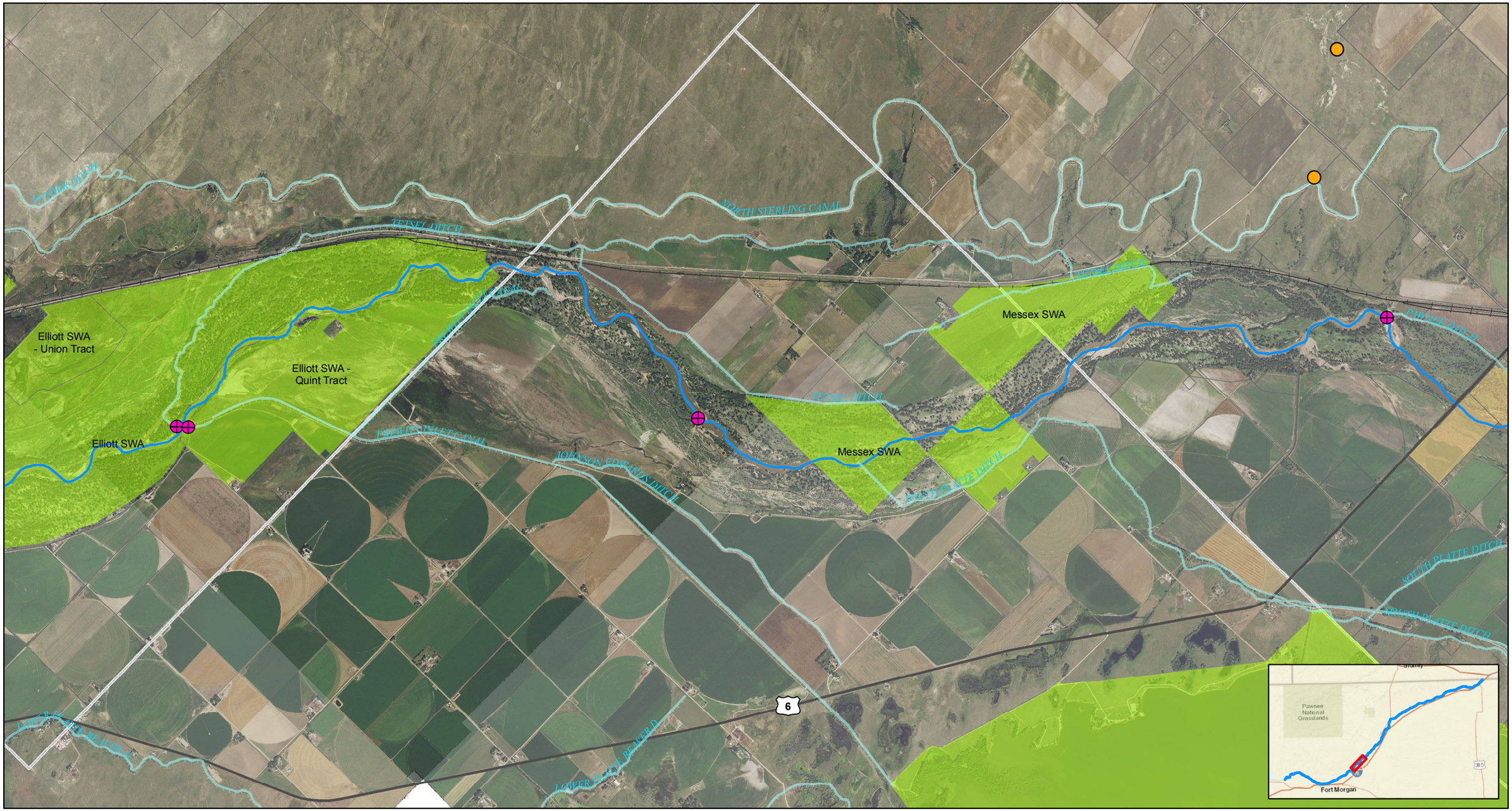

South Platte River Master Plan

Figure B-8: Land Ownership

Reach: 8

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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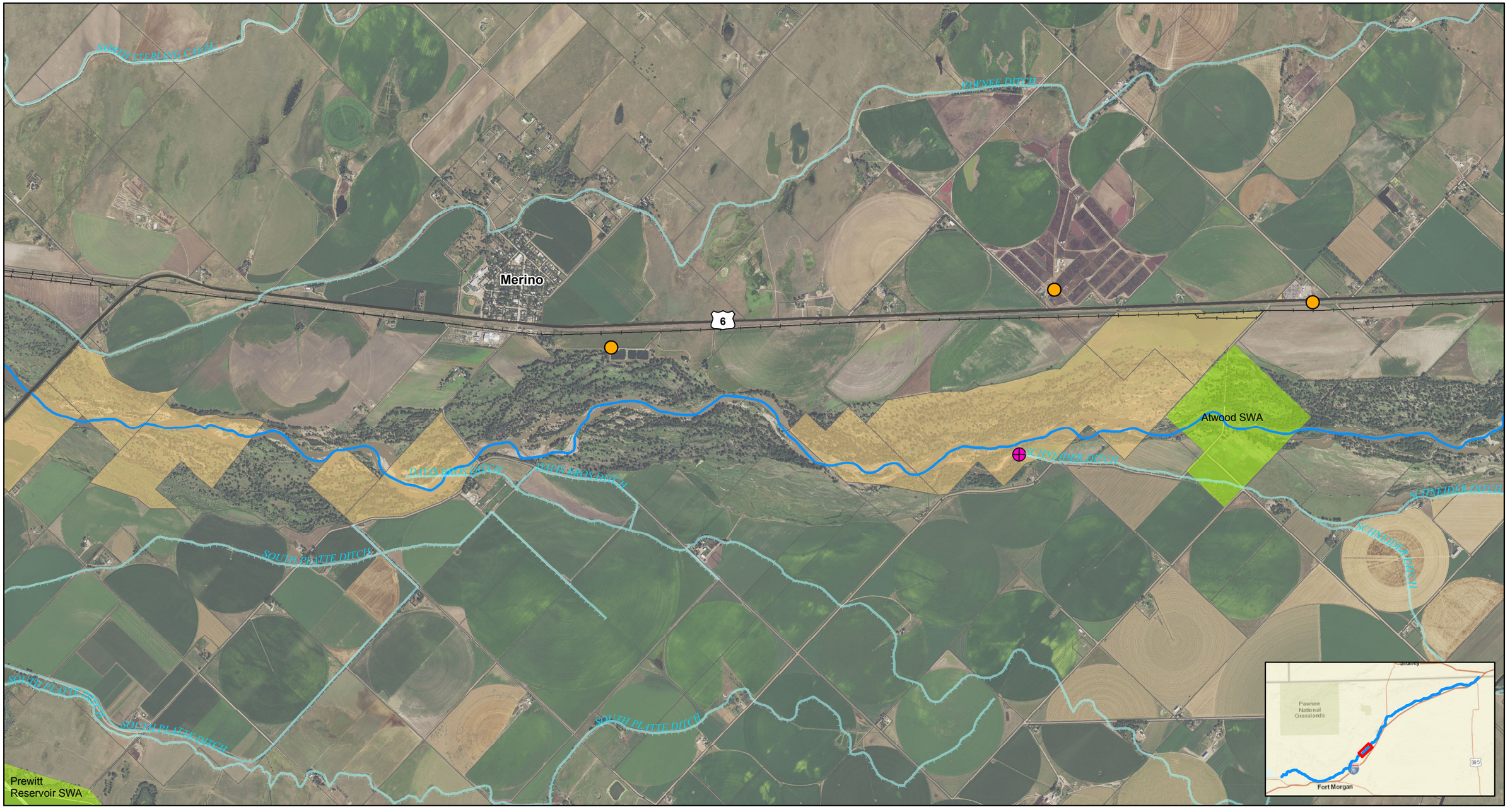

South Platte River Master Plan

Figure B-9: Land Ownership

Reach: 9

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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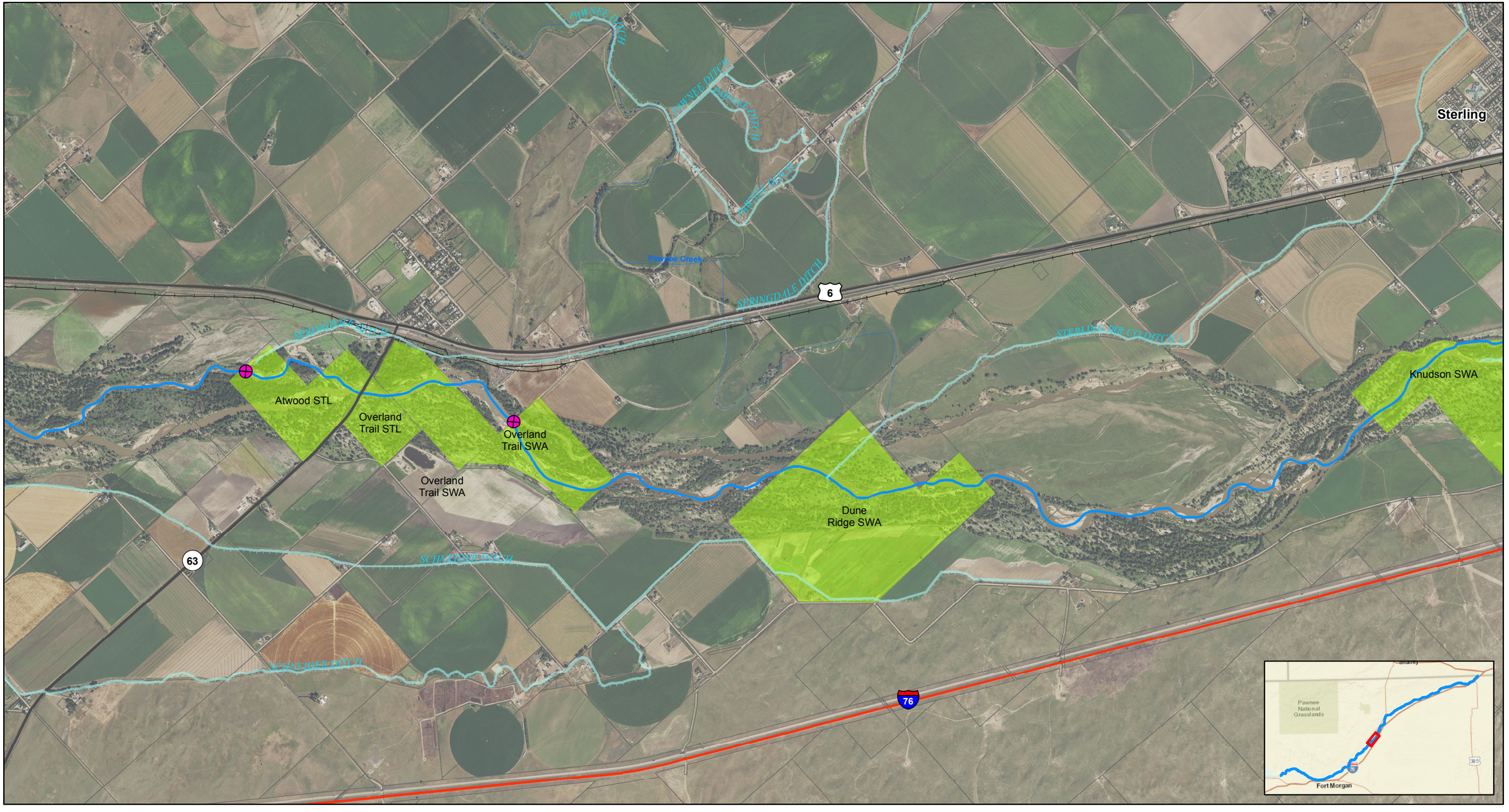

Headgate
Oil & Gas Well
NPDES
South Platte River
Tributary
Canal
Interstate
Highway
Railroad
County Boundary
Private Parcel
Private, Limited Management Parcel
Public Access Lands

0 0.5 1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure B-10: Land Ownership

Reach: 10

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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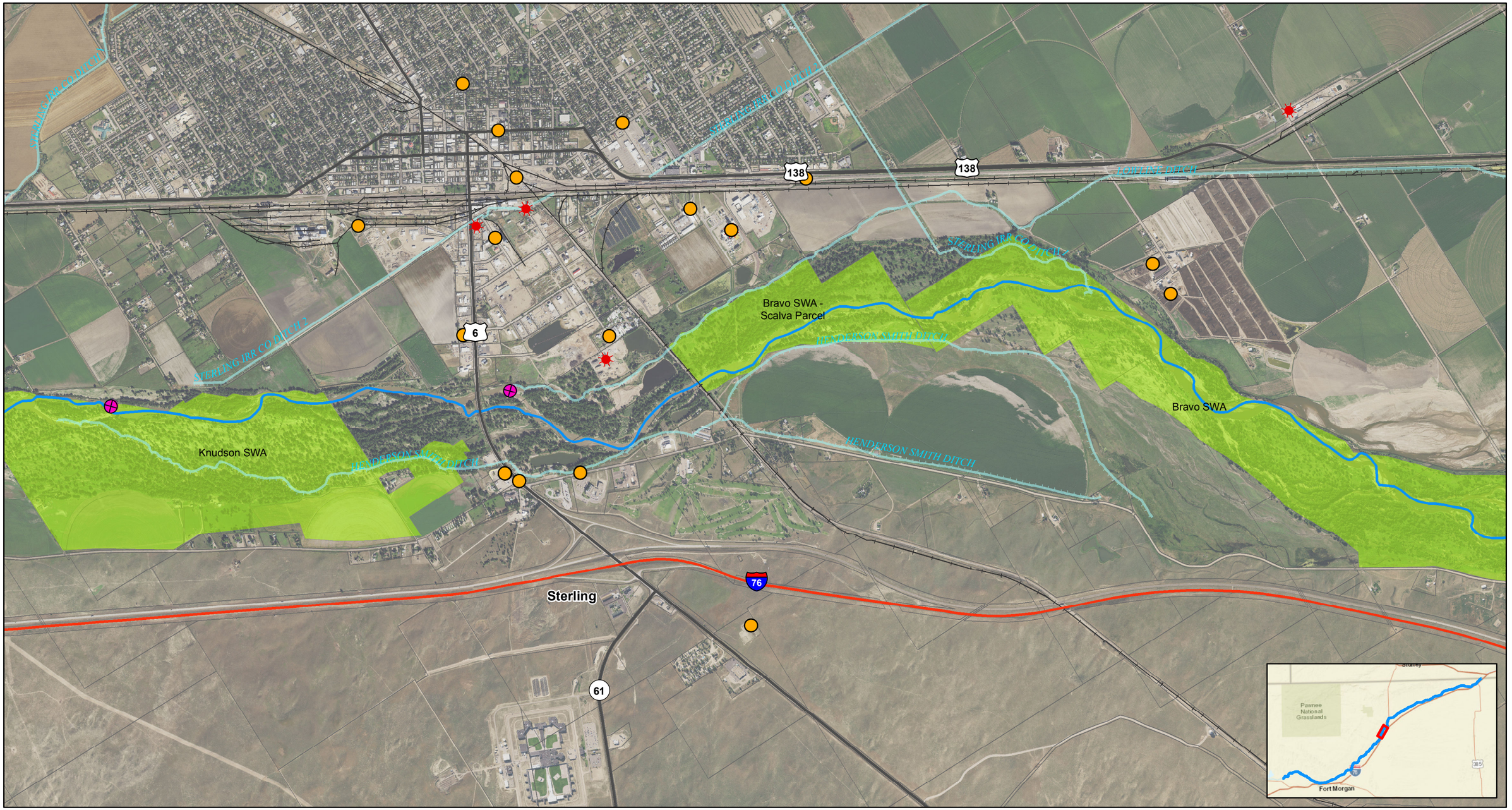

South Platte River Master Plan

Figure B-11: Land Ownership

Reach: 11

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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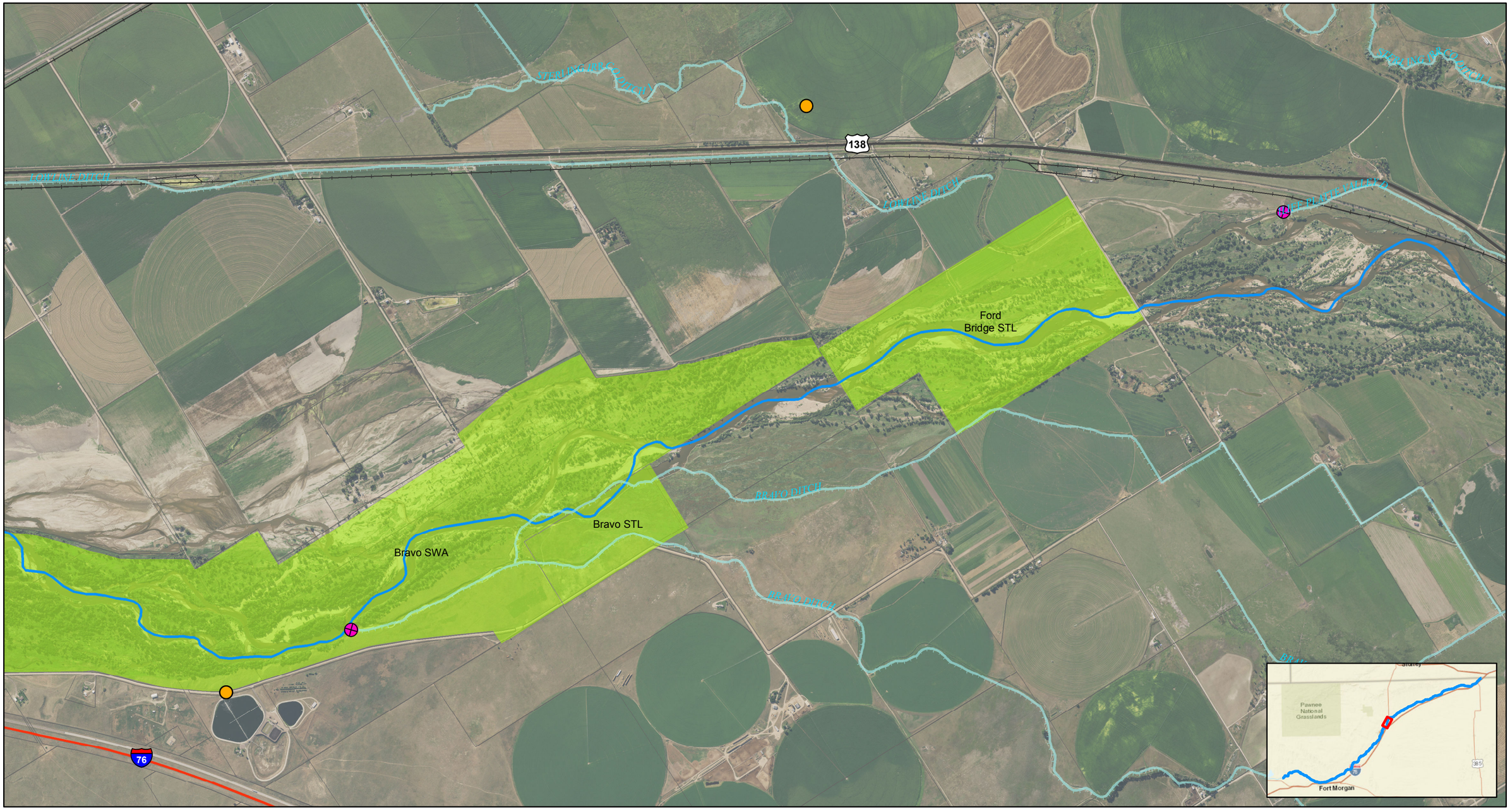

Headgate
Oil & Gas Well
NPDES
South Platte River
Tributary
Canal
Interstate
Highway
Railroad
County Boundary
Private Parcel
Private, Limited Management Parcel
Public Access Lands

0 0.5 1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure B-12: Land Ownership

Reach: 12

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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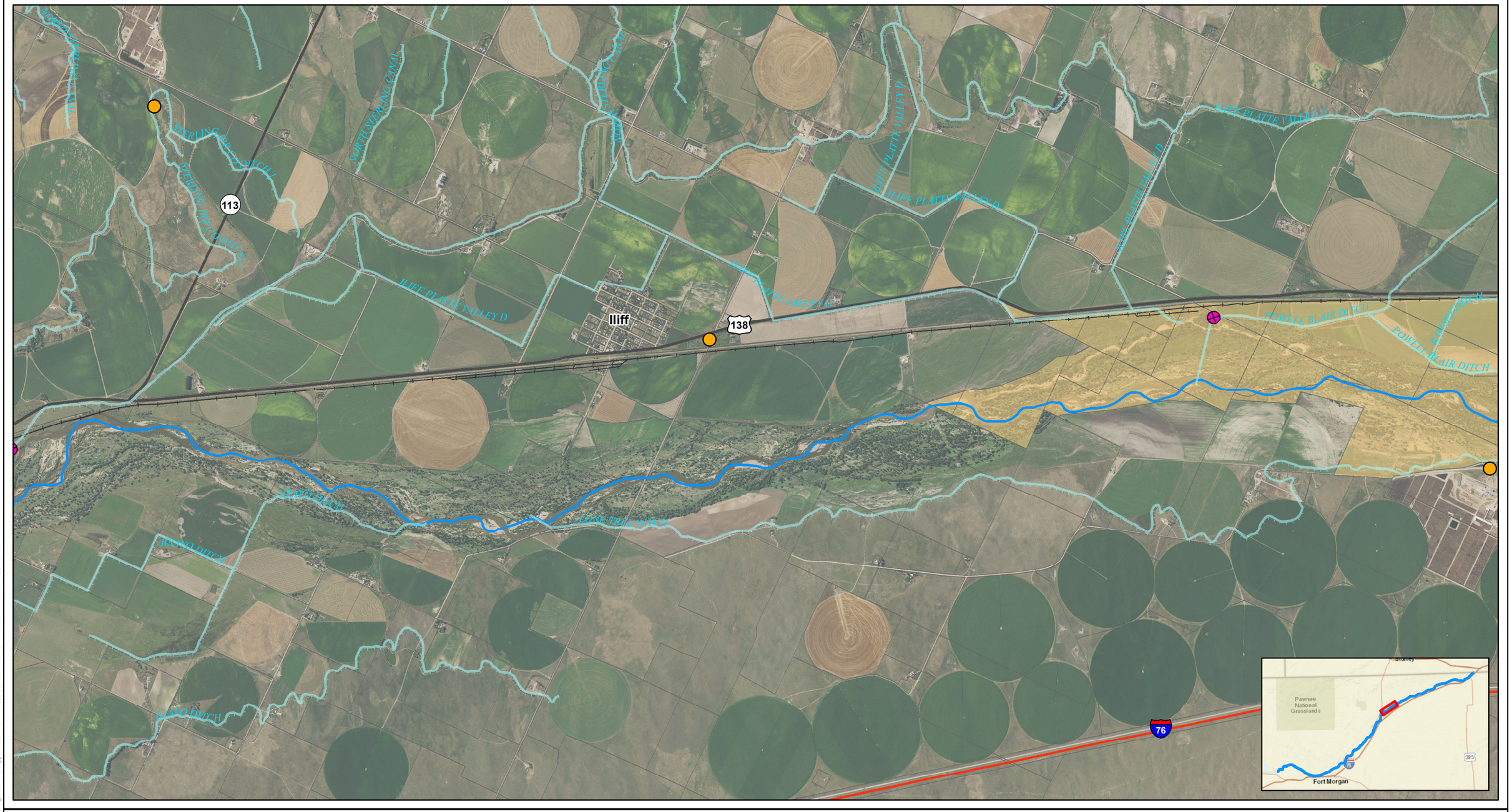

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USDA NAIP 2015

Headgate
Oil & Gas Well
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
Private Parcel
Private, Limited Management Parcel
Public Access Lands

South Platte River Master Plan

Figure B-13: Land Ownership

Reach: 13

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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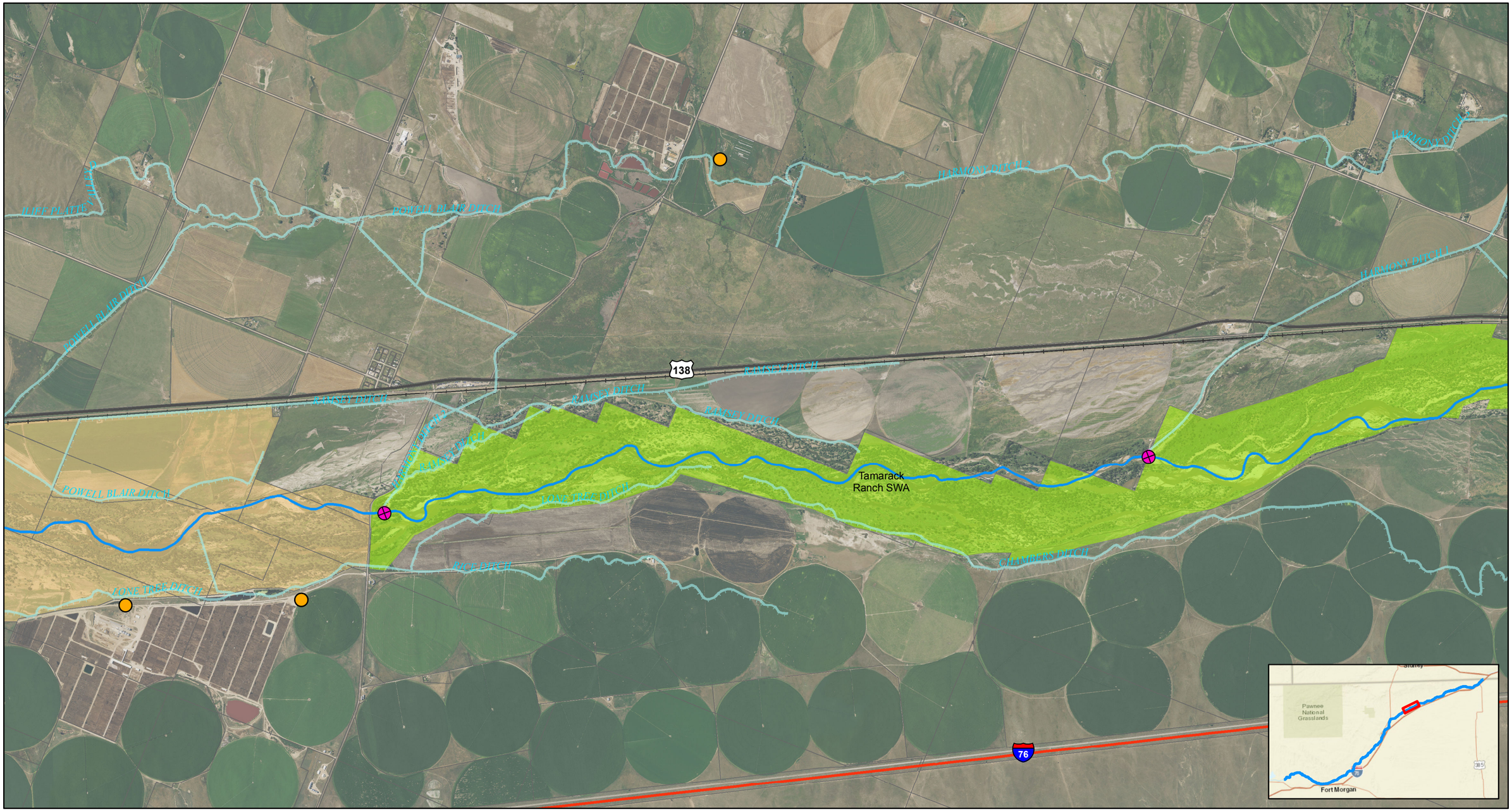

South Platte River Master Plan

Figure B-14: Land Ownership

Reach: 14

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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Duck Creek SWA

Duck Creek SWA

Duck Creek STL

HARMONY DITCH 2

HARMONY DITCH 1

HARMONY DITCH 1

HARMONY DITCH 1

HARMONY DITCH 1

HARMONY DITCH 1

HARMONY DITCH 1

HARMONY DITCH 1

Crook

138

LONG ISLAND DITCH

LONG ISLAND DITCH

Tamarack Ranch SWA

55

CHAMBERS DITCH

TAMARACK DITCH

Tamarack Ranch SWA

76

Tamarack Ranch SWA

Pawnee National Grasslands

Fort Morgan

385

N

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Miles

USDA NAIP 2015

Headgate

Oil & Gas Well

NPDES

South Platte River

Tributary

Canal

Interstate

Highway

Railroad

County Boundary

Private Parcel

Private, Limited Management Parcel

Public Access Lands

South Platte River Master Plan

Figure B-15: Land Ownership

Reach: 15

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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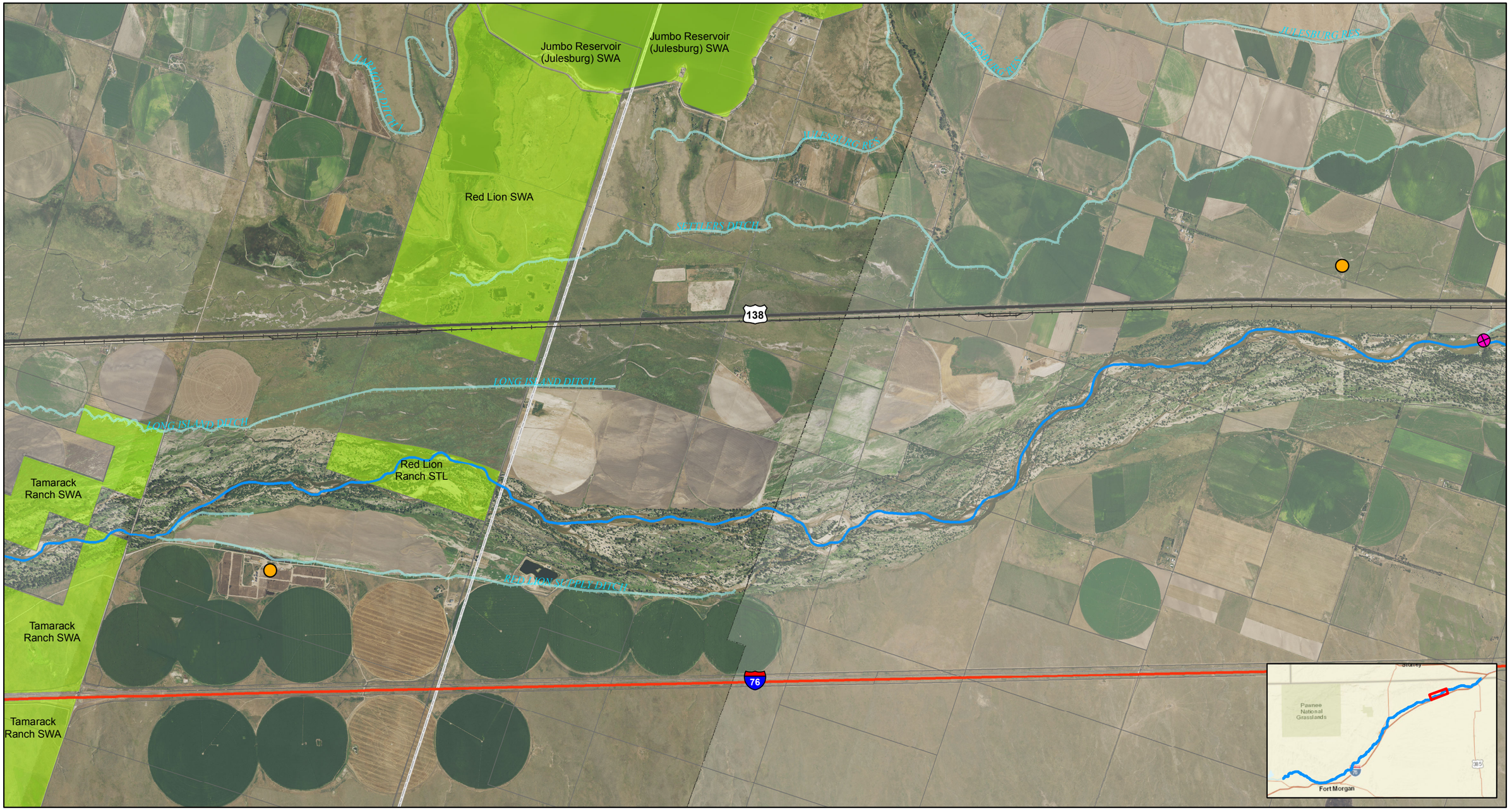

South Platte River Master Plan

Figure B-16: Land Ownership

Reach: 16

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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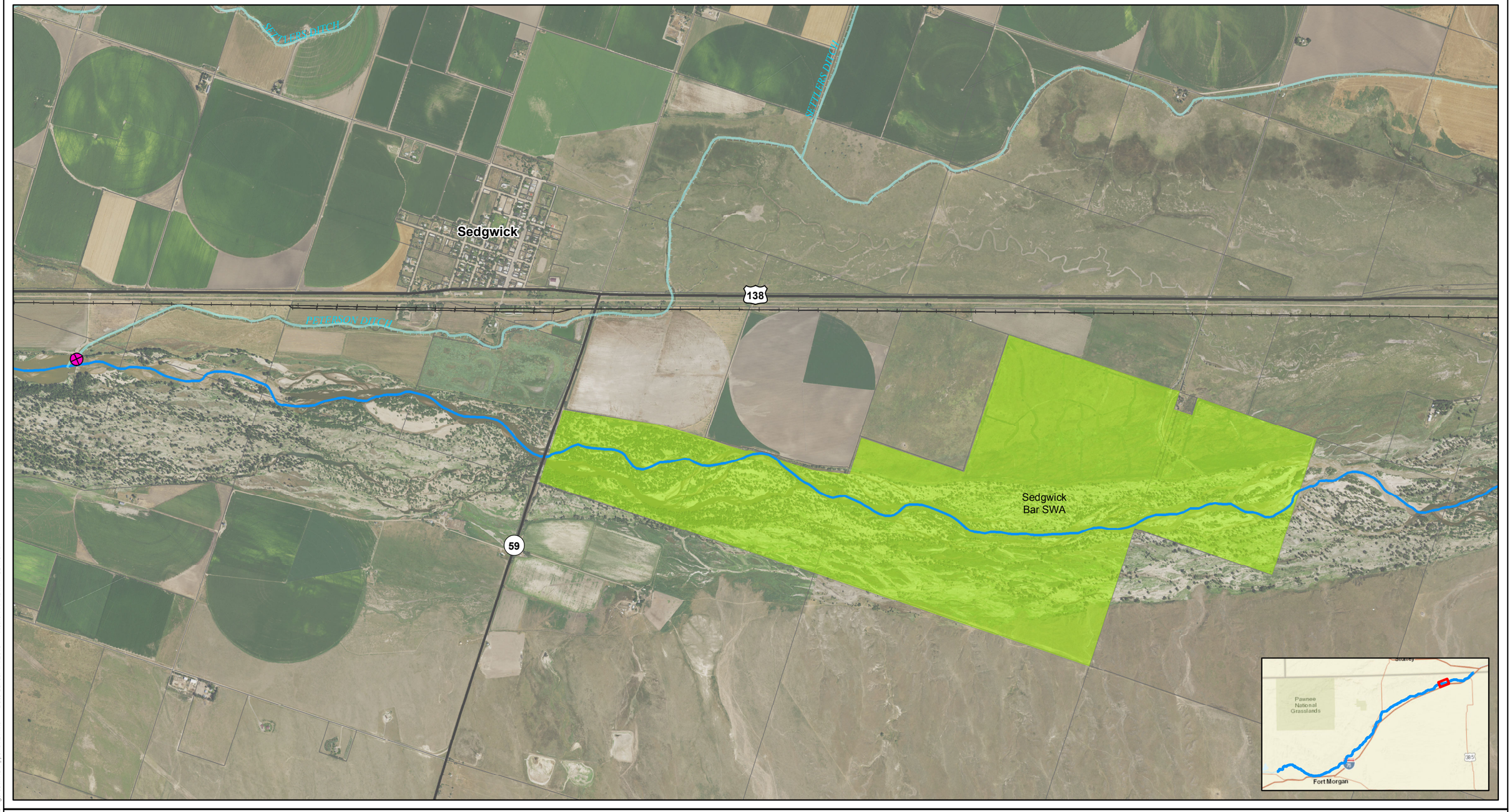

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Miles

USDA NAIP 2015

Headgate
Oil & Gas Well
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
Private Parcel
Private, Limited Management Parcel
Public Access Lands

South Platte River Master Plan

Figure B-17: Land Ownership

Reach: 17

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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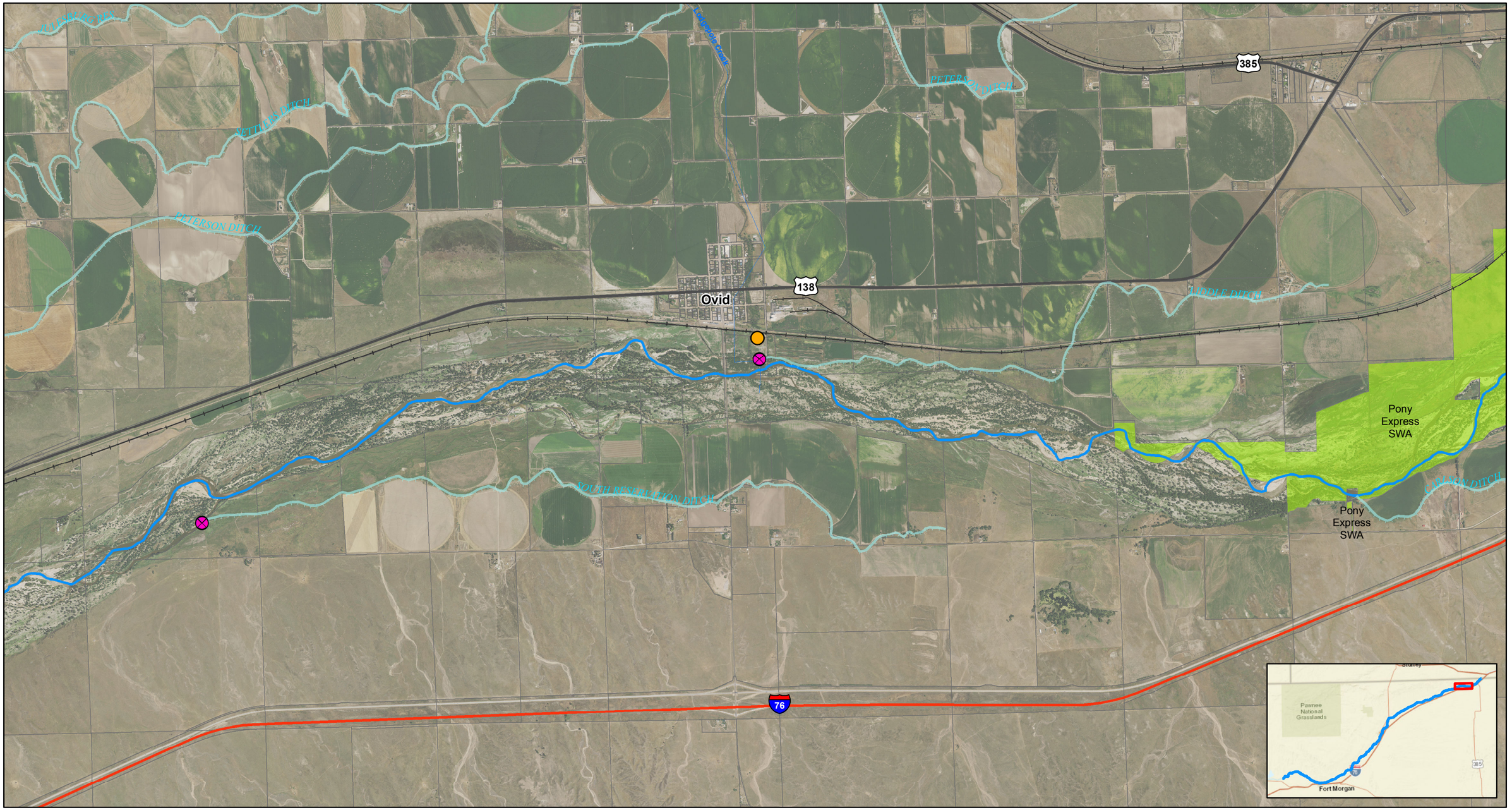

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Miles

USDA NAIP 2015

Headgate
Oil & Gas Well
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
Private Parcel
Private, Limited Management Parcel
Public Access Lands

South Platte River Master Plan

Figure B-18: Land Ownership

Reach: 18

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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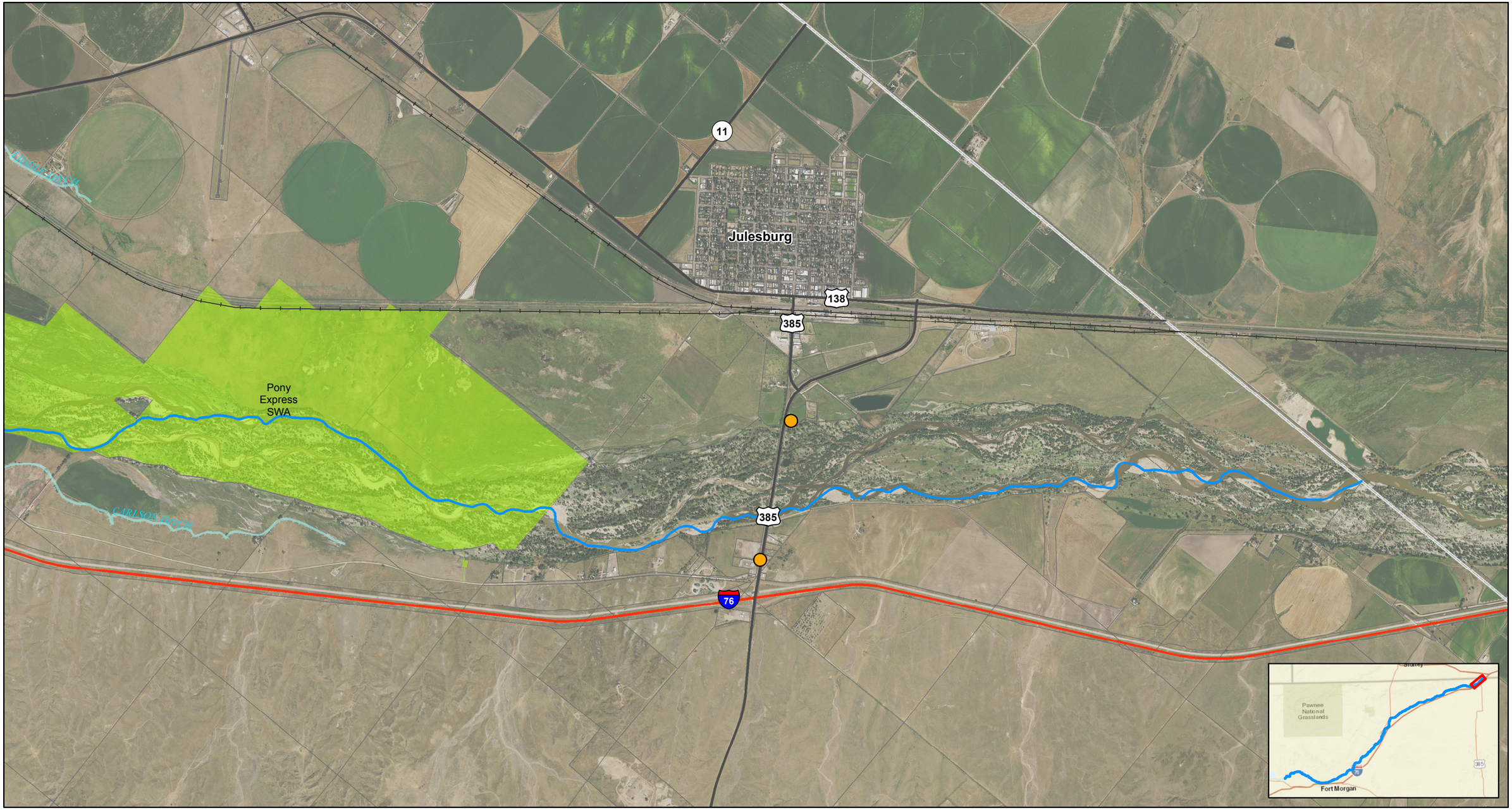

Headgate
Oil & Gas Well
NPDES
South Platte River
Tributary
Canal
Interstate
Highway
Railroad
County Boundary
Private Parcel
Private, Limited Management Parcel
Public Access Lands

0 0.5 1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure B-19: Land Ownership

Reach: 19

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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Appendix C

Site Visit Field Notes and Photos

RE: May 15-17 site visits on the Lower South Platte River

Attendees: Andrea Harbin, Elias Gruber, Chris Pauley, Luke Swan

During our spring site visit to the Lower South Platte River study area, we met with a variety of people, including Joe Frank with the Lower South Platte Water Conservancy District, Evan Snyder and Bruce Phillips with the Colorado Division of Water Resources, George Good with the City of Sterling, and Allyn Wind and Darrel Groth, both private home owners.

General Problems

With this visit, it was apparent that one overriding problem within the project area is that of erosion and excess sedimentation. There are many instances of sedimentation within the main channel, as well as in the canals, which are periodically dredged to ensure that water can pass.

One contributing factor to sedimentation is the surrounding land ownership, and the contradictory priorities of various land owners. There are many instances where one side of the river is agricultural, cultivated land, while the opposite side is owned by hunting clubs and the vegetation is allowed to grow freely. These opposing land management techniques result in the cultivated land experiencing excessive erosion.

Another general problem throughout the project area is that during times of flood there is uncontrolled water in many canals and ditches that cause additional flooding because water has no route back to the river.

Specific Problems

Specific problem areas include the "Sand Chutes" area. The Sterling #1 ditch in this area experienced flooding in both 2013 and 2015 because uncontrolled water came into the ditch and was unable to get back to the river. There is a gate in the "Sand Chutes" area that could allow water to be released back to the river; the gate, however, is broken and not functional. This is an example of something that could be fixed to help prevent flooding in the Sterling area from this ditch.

Another specific problem was the Town of Messex, which flooded in both 2013 and 2015 because water jumped the railroad tracks and became trapped on the north side, with no route back to the river. Water became stagnant and septic systems in the area backed up, becoming a health hazard.

The City of Sterling experiences several specific issues, as well. First, the Henderson-Smith Ditch Headgate has been washed out and is laden with sediment. The city rebuilds the ditch with sand periodically, but it is not a long-term solution. Second, the Lowline Ditch, southwest of the city, often becomes the main channel of the South Platte River. The river changing course in this way is a threat to the ethanol plant located in the southern portion of the City of Sterling.

The City of Sterling has also experienced problems with their sub-station during the 2015 flood, leaving many worried about a widespread power outage, and with their wastewater treatment plant. In 2015, residents were instructed not to flush their toilets for days on end because the wastewater treatment plant had been impacted by high waters

04/19-20/2017; w/ CHRIS PAULEY – ACE MAY 3, 2017 ADDITIONS

ROAD/BRDG XINGS
SH 144/MCR 1+
SH 39/MCR 5
WARREN ST/MCR 9.5
SH 144/MCR 12
SH 52/MCR 18
MCR 24
SH 71/MCR 29.5
MCR 33 (COOPER BRDG) PLUSED
RR
WCR 59
US 6

WELD
GOODRICH
WELDONA
JACKSON RES
ORCHARD
MORGAN HEIGHTS
MORGAN
SNYDER
#1 SEO WATER DIST. #64
BALZAC
MESSEX
LOGAN
LOGAN WASA
PREWITT RESERVOIR
WASHINGTON
HILLROSE
BRUSH
LOG LANE VILLAGE
FORT MORGAN
Riverside Res.
Empire Res.
LOWDEN STOCK FARMS
DOG HERE GAGE
SH 144
MCR 29.5
WCR 59
1
2
3
4
5
6
7
8
9
10
11
52
144
39
71
34
6
76

39 Blow Oak

CO 144 Alt in Sept to realign

• STREAM GAGES

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Miles

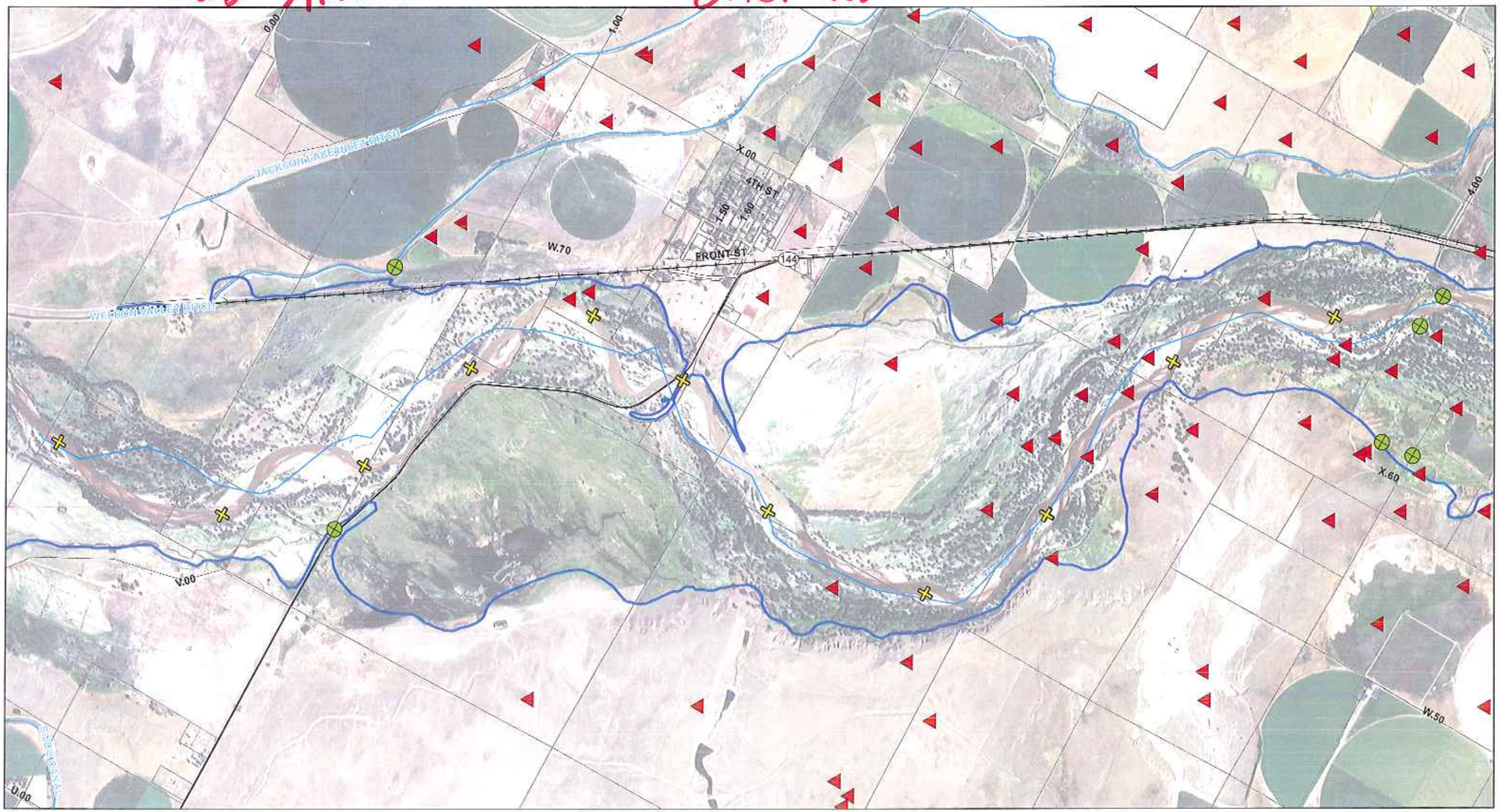
Legend
Major Roads
Railroad

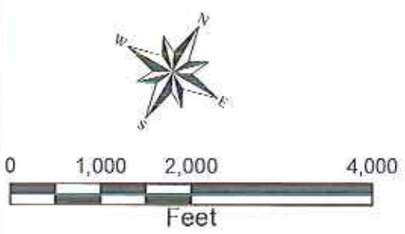
South Platte River Restoration Master Plan

Morgan and Washington County Index Map

WELD / MORGAN

ORCHARD



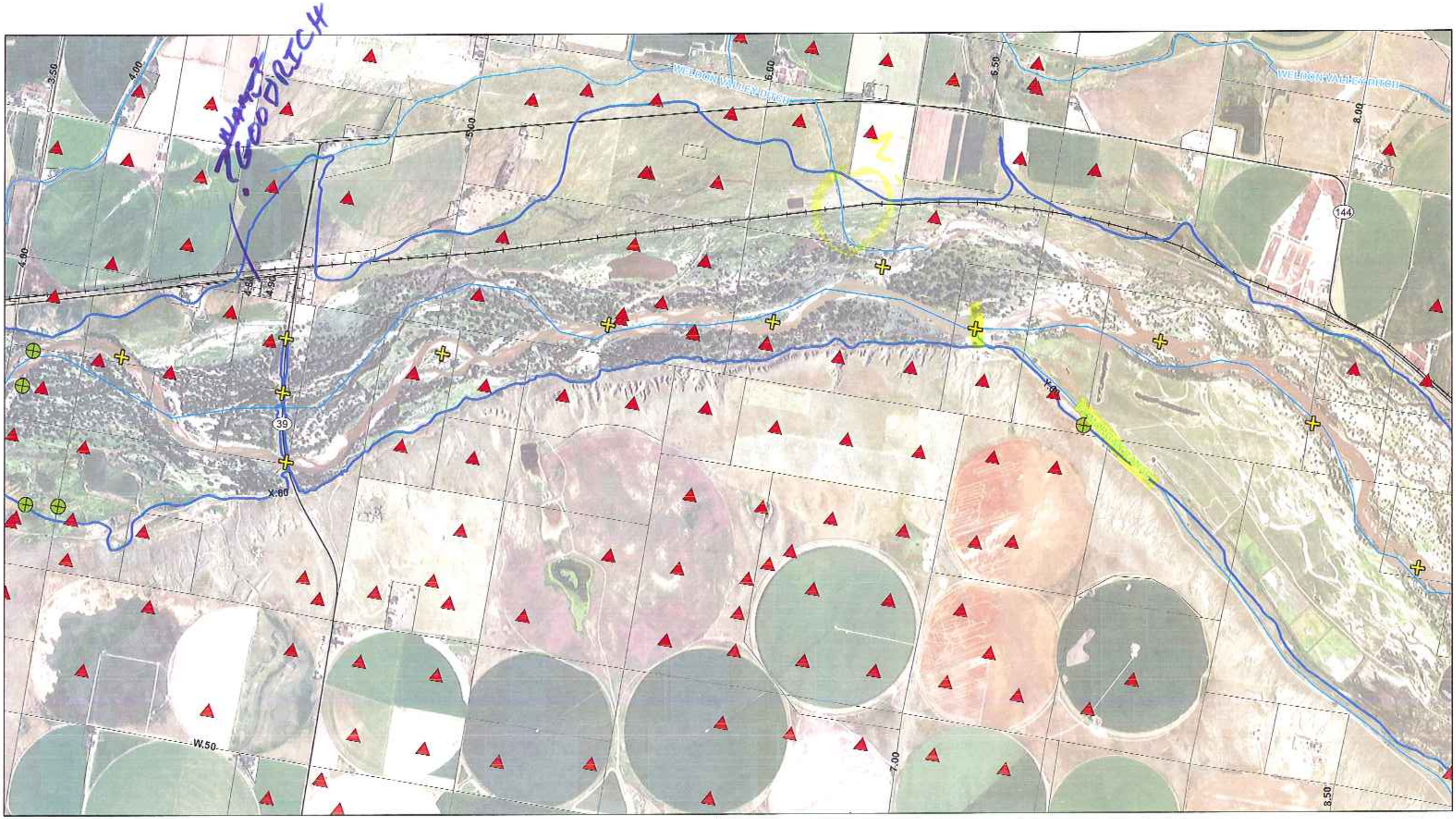


Legend

- CHAMP Survey Location
- Oil/Gas Wells
- Power Plants
- Natural Gas Underground Storage
- Ethanol Plants
- Irrigation Structures
- NPDES
- 100 - Year FP
- Canals and Ditches
- Parcels
- Major Roads
- Local Roads
- Railroad
- CPW Public Access Properties
- CPW Walk In Access

South Platte River Restoration Master Plan

Map - 1



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Feet

Legend

- CHAMP Survey Location
- Oil/Gas Wells
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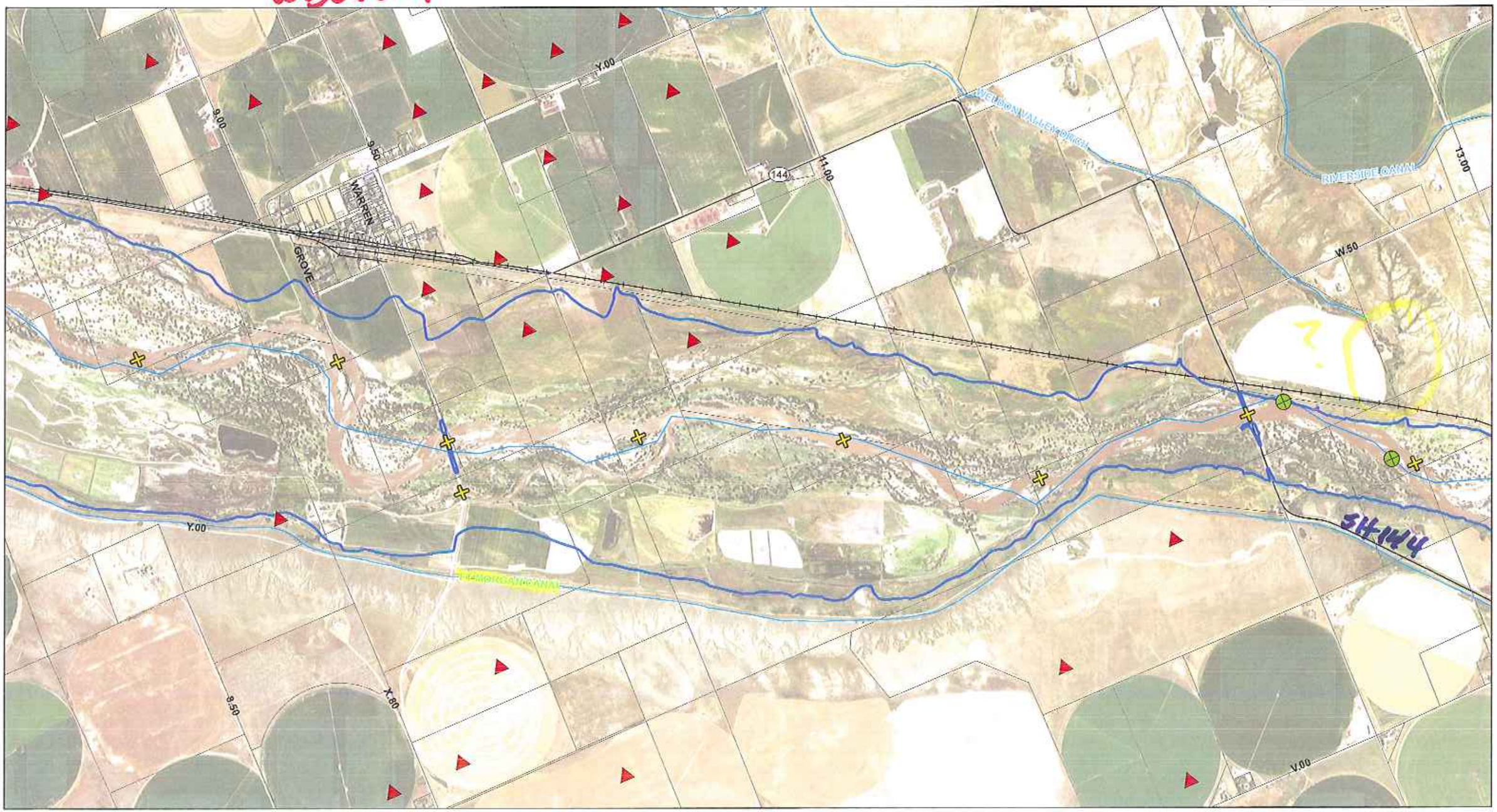
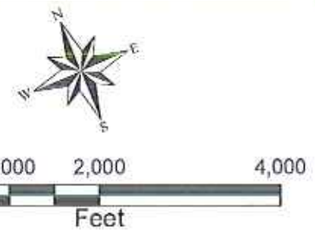
- CPW Walk In Access

South Platte River Restoration Master Plan

Map - 2

WELDONA





Legend

- CHAMP Survey Location
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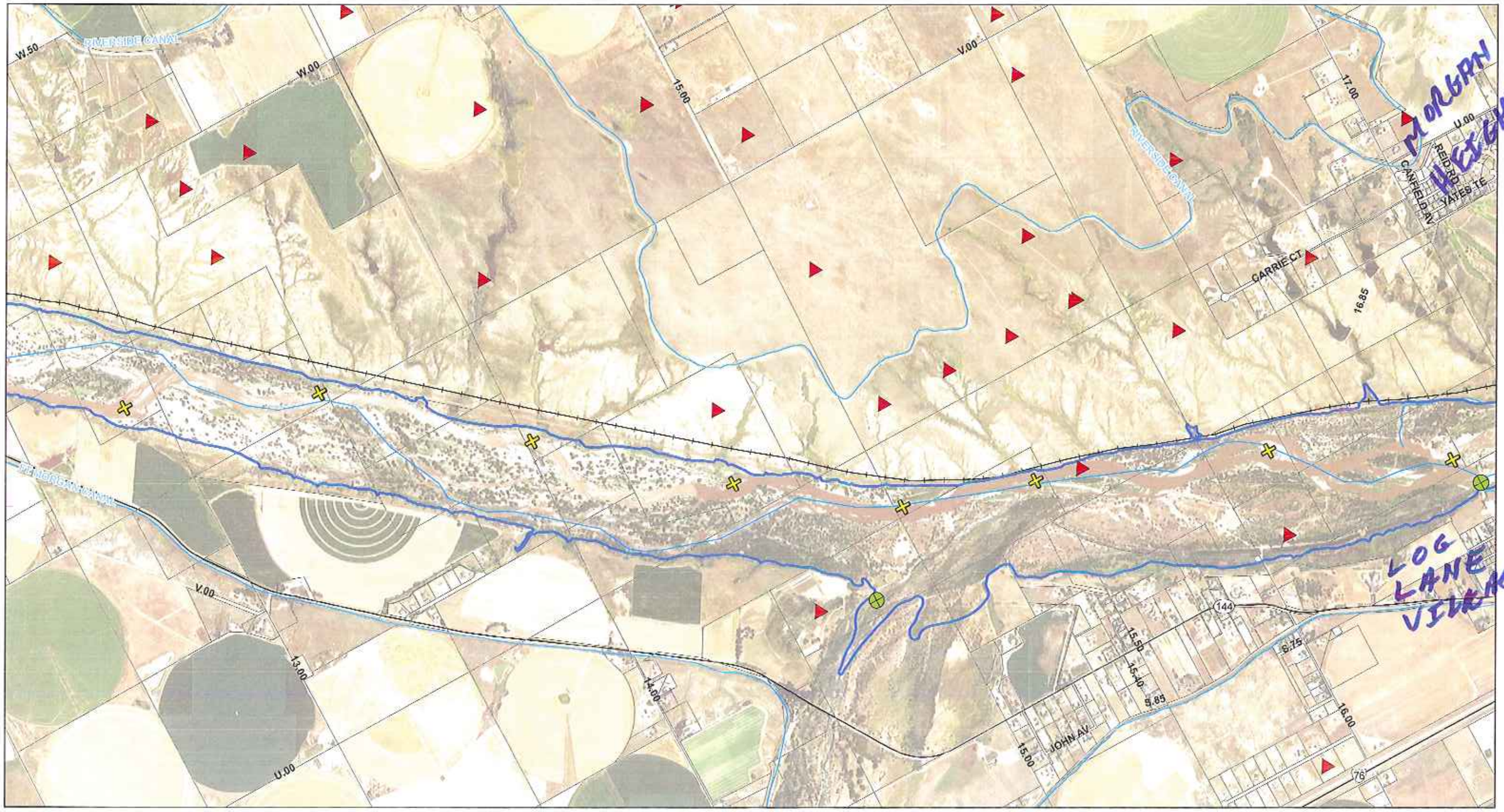
South Platte River Restoration Master Plan

Map - 3



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Feet

Legend

- CHAMP Survey Location
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- Railroad
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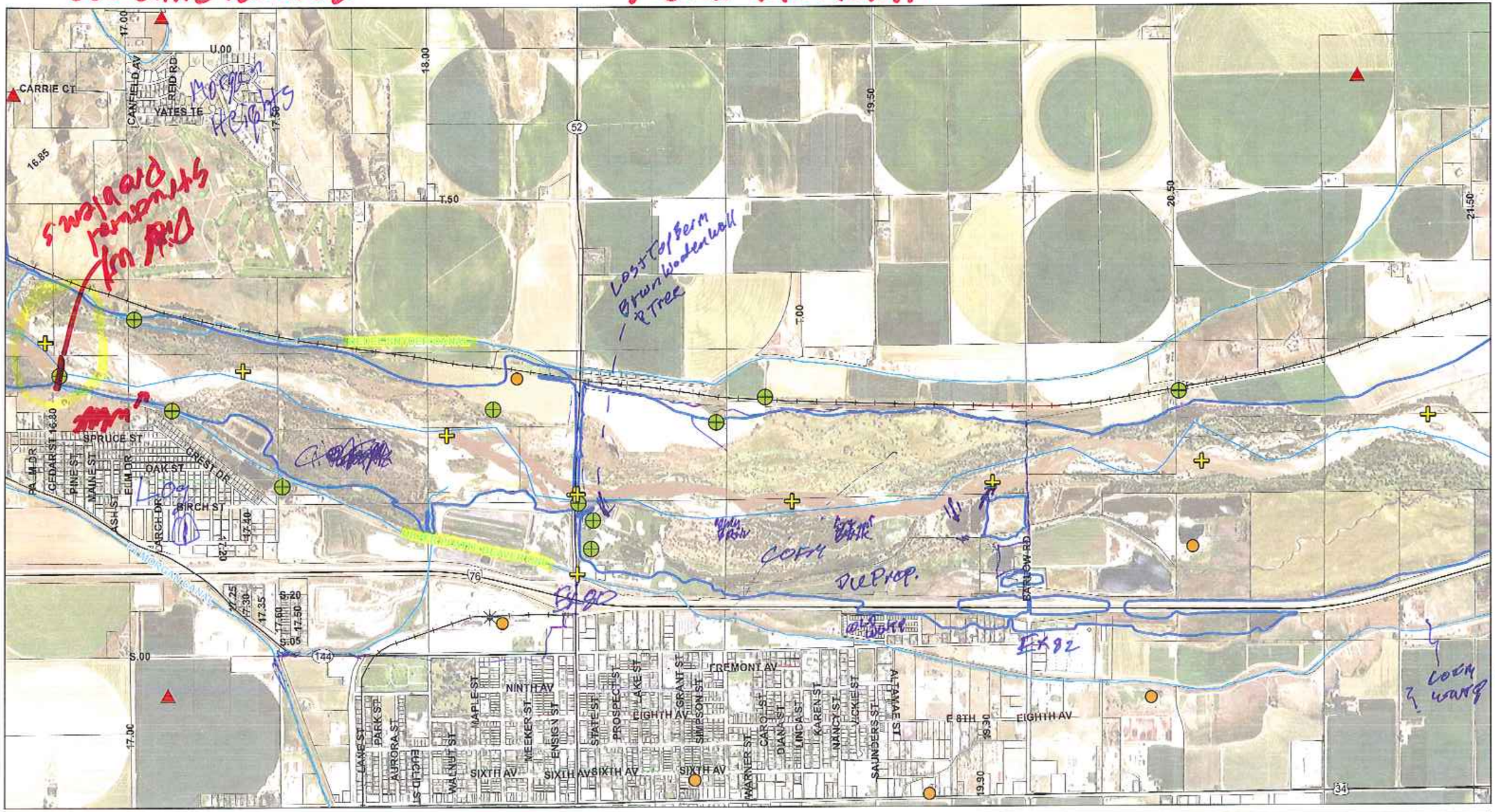
- CPW Walk In Access

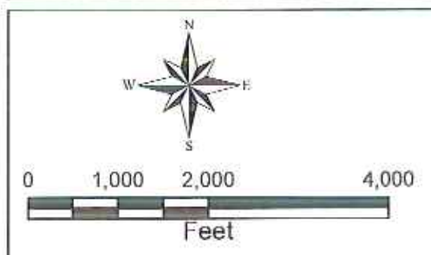
South Platte River Restoration Master Plan

Map - 4

1 LOG LANE VILLAGE

FORT MORGAN





Legend

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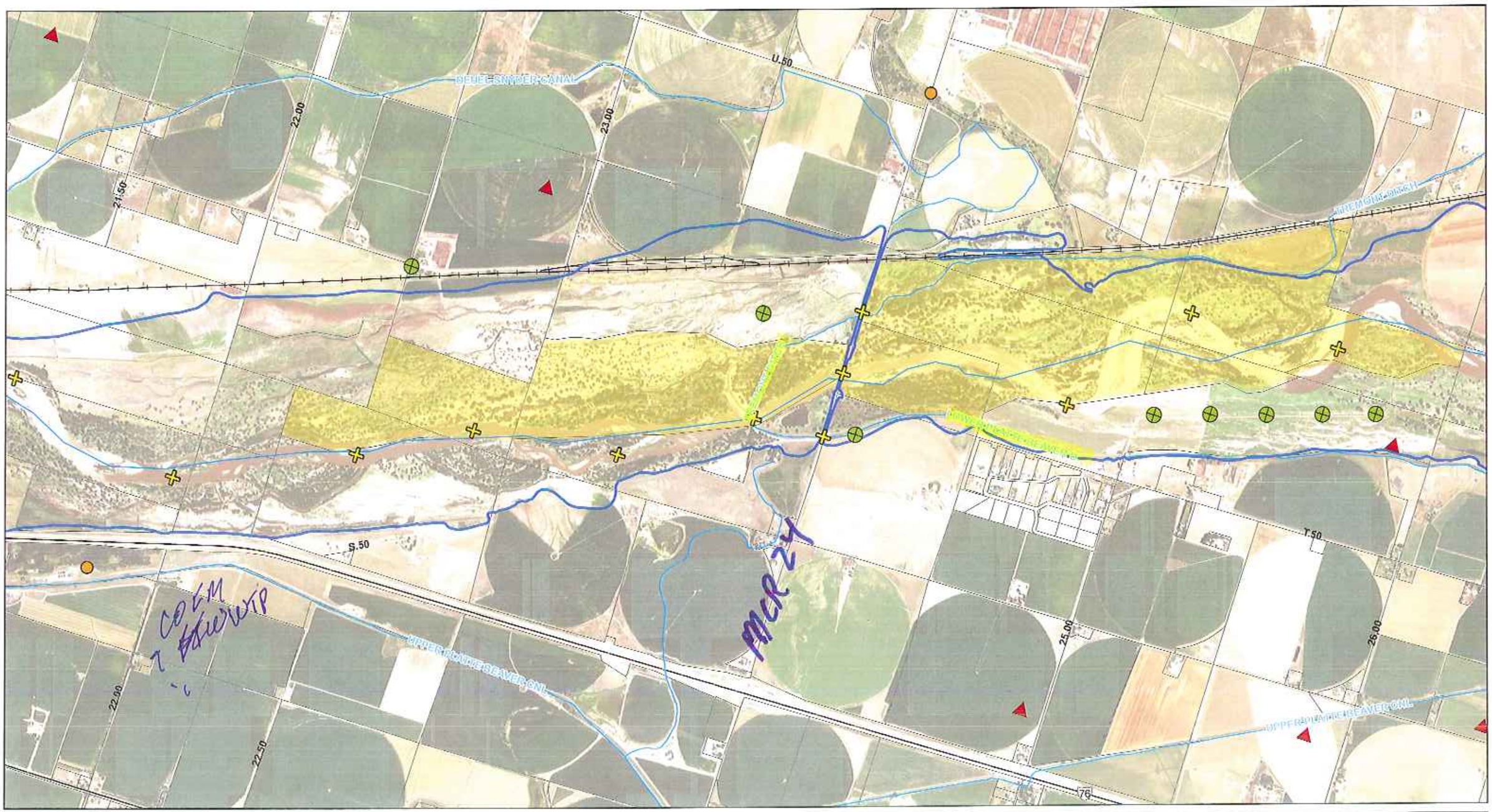
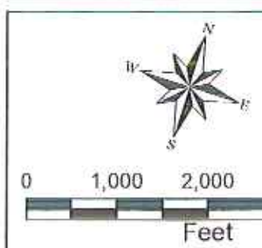
South Platte River Restoration Master Plan

Map - 5





Legend

- CHAMP Survey Location
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- NPDES
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- Railroad
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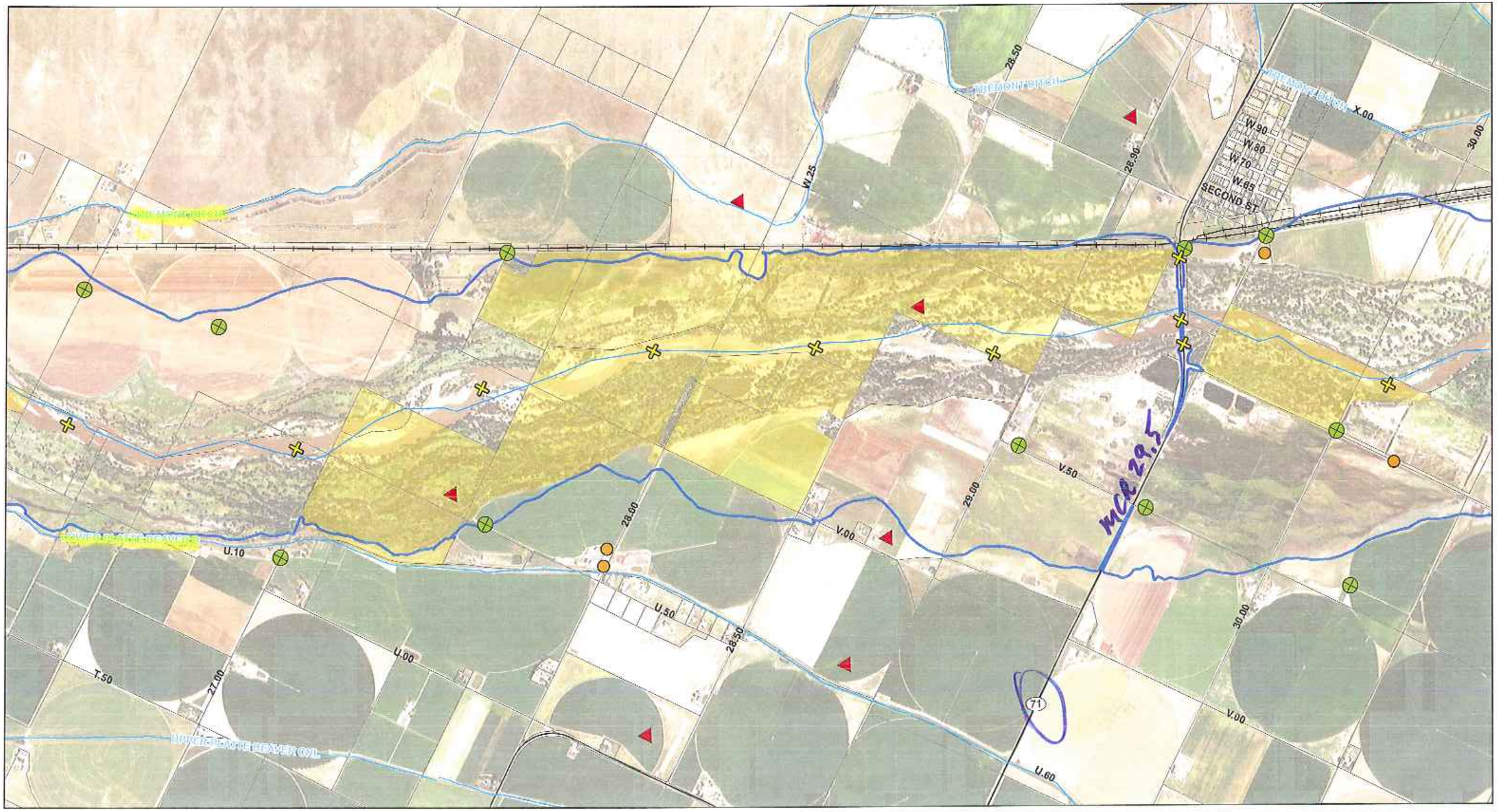
- CPW Walk In Access

South Platte River Restoration Master Plan

Map - 6

SNYDER



Legend

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- Power Plants
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- Ethanol Plants
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- NPDES
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- CPW Walk In Access

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Feet

South Platte River Restoration Master Plan

Map - 7

BALZAC

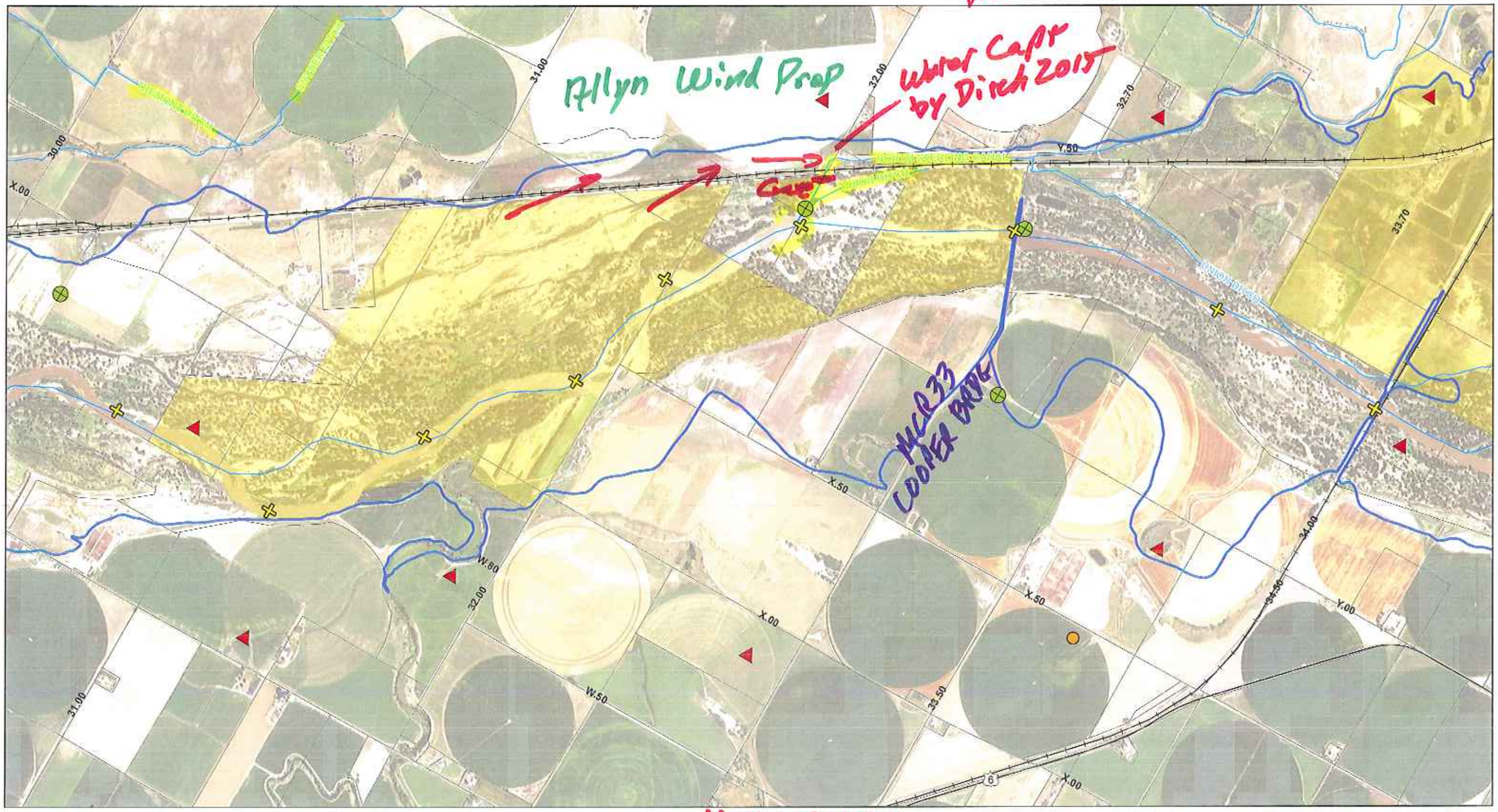
Allyn Wind Prop

Water Capt by Ditch 2015

Capt

MCR 33 Cooper Bridge

HILLROSE



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Feet

Legend

- CHAMP Survey Location
- Oil/Gas Wells
- Power Plants
- Natural Gas Underground Storage
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- CPW Public Access Properties
- CPW Walk In Access

South Platte River Restoration Master Plan

Map - 8

Last WL = 200 cfs CAP

MORGAN WASH.

Water Enters & Floods

Breach Released Press on CNL capture

WASTEWAY

SEO WATER DIST. #1

#64

WW Gate Maybe Frzn

Morgan Wash

Lose 700 cfs Cap.

S. Platte Ditch

34.50

33.70

34.30

35.50

Z-00

AA-00

30.00

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P

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Legend

- CHAMP Survey Location
- Oil/Gas Wells
- Power Plants
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South Platte River Restoration Master Plan

Map - 9

Ponded During 2013

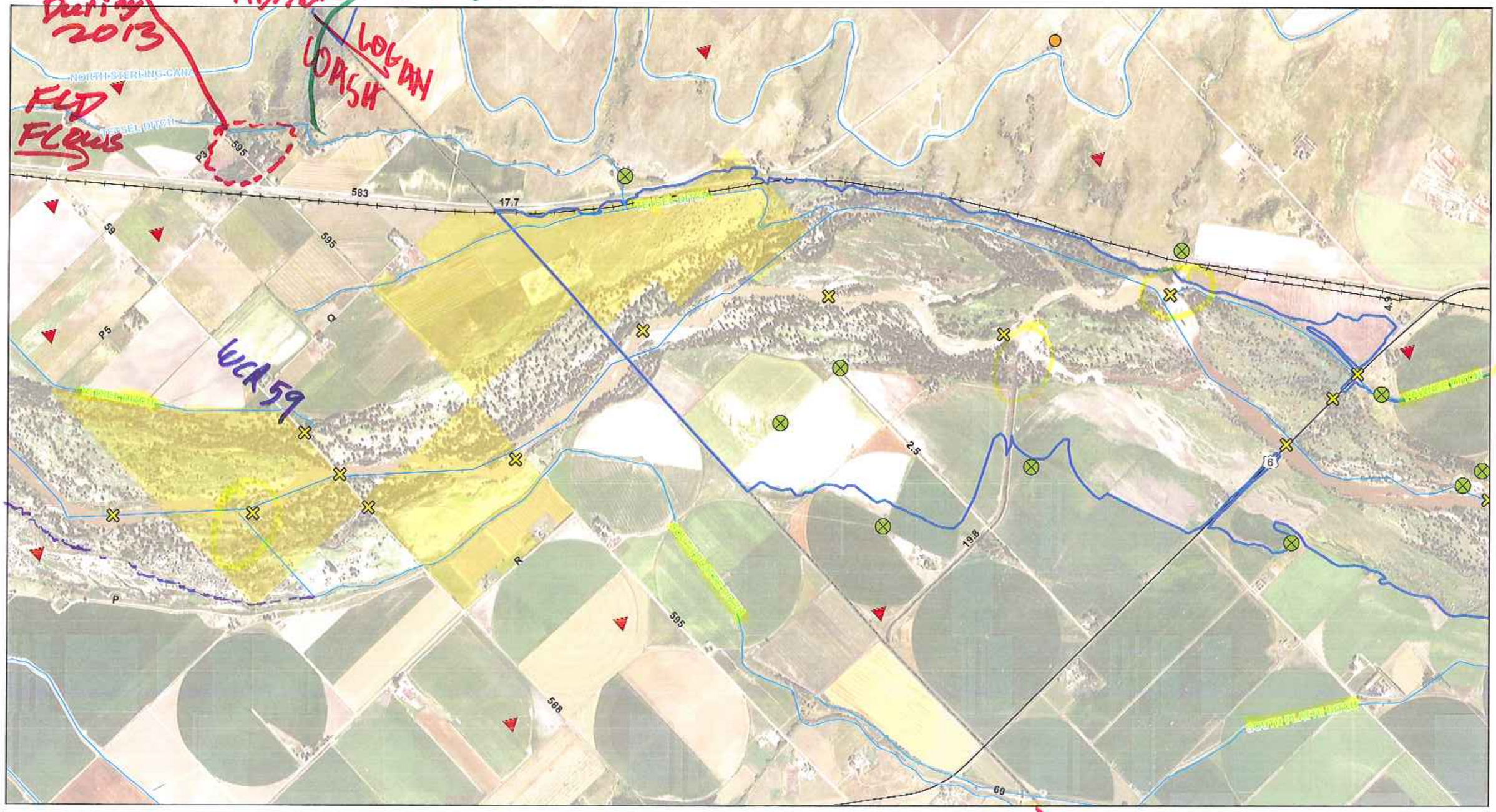
MESSEX

LOGAN WASH

LF DRAW

FLD FLOWS

WCR 59



Legend

- CHAMP Survey Location
- Oil/Gas Wells
- Power Plants
- Natural Gas Underground Storage
- Ethanol Plants
- Irrigation Structures
- NPDES
- 100 - Year FP
- Canals and Ditches
- Parcels
- Major Roads
- Local Roads
- Railroad
- CPW Public Access Properties
- CPW Walk In Access

0 1,000 2,000 4,000

Feet

South Platte River Restoration Master Plan

Map - 10

LOGAN WASH

04/20/2017 w/ MAY 3 2017 ADDITIONS CHRIS PAULEY - ACE

N. Sterling Res.

Julesburg Res

SEDGWICK

Julesburg NE

Julesburg

OVID

SCR 27.75

CROOK

ALIFF

STERLING

MERINO

WILDWOOD

LOGAN

Interval for redesign.

LCR 93 Red Lion Ditch

LCR 59

LCR 40

US 138

US 385

US 6

US 34

US 76

US 59

US 61

US 63

US 71

US 113

CO 14

CO 55

CO 11

CO 23

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

CONST. season July - Oct ... WT when dewatering per Trtg. w/ no more construction disturbance than 10 to Dec 21st ... ice edge during flows

N
W E
S

0 3 6 12
Miles

Legend

- Major Roads
- Railroad

LCR 59/ILIFF
LCR 93/ Red Lion
SCR 27.75/ Ovid
LCR 40
} 3 City Bridges that tie to I-76

47
5?

South Platte River Restoration Master Plan

Logan and Sedgwick County Index Map

WASH / LOGAN

NORTH STERLING CANAL

PETSEL DITCH

P3

595

583

17.7

WCR 59

595

P5

α

PETSEL DITCH

Riprap Repair

PAWNEE DITCH

4.5

2.5

6

R

SOUTH PLATTE DITCH

19.8

P

595

588

SOUTH PLATTE DITCH

60

Legend

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Feet

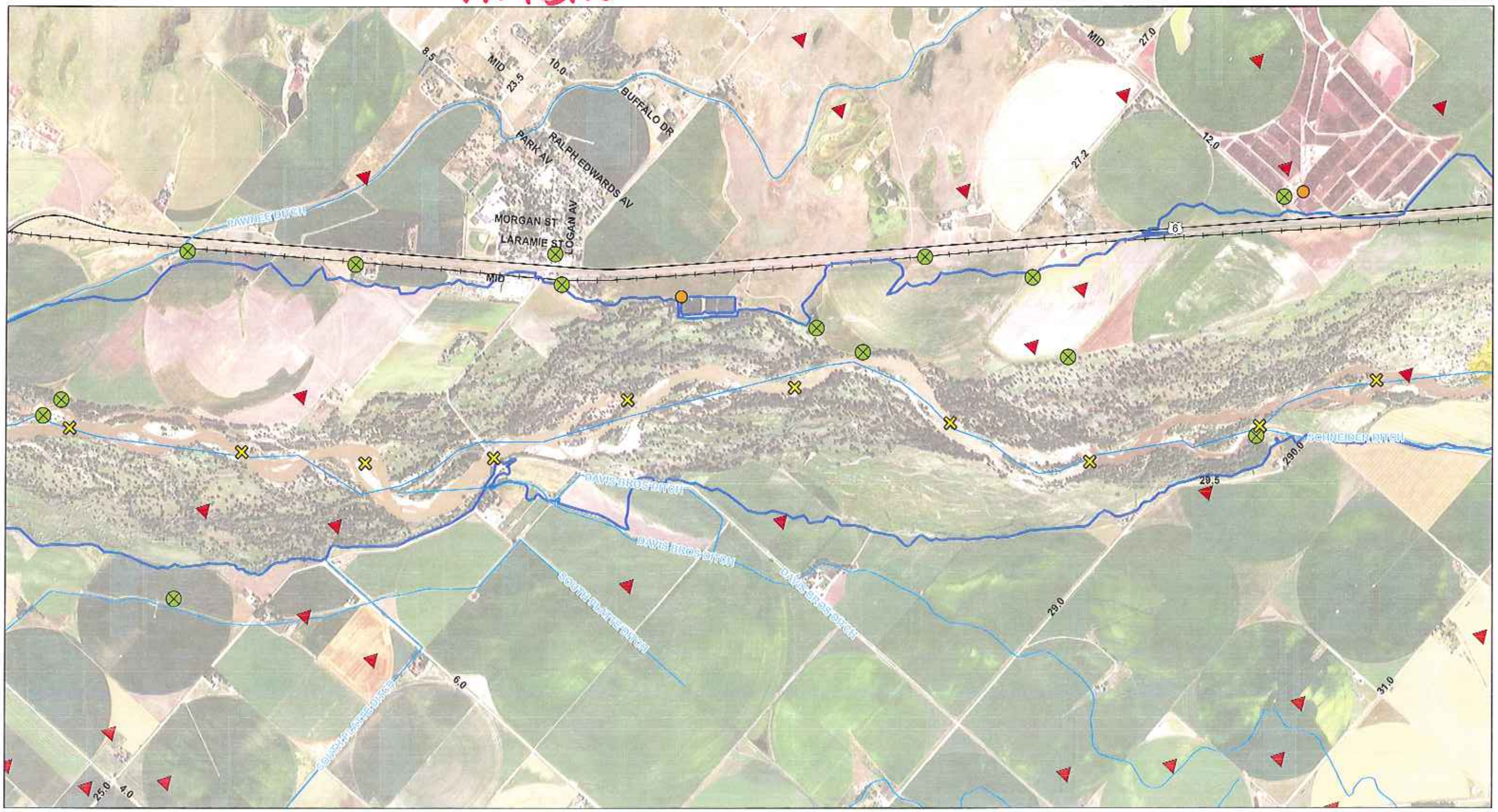
South Platte River Restoration Master Plan

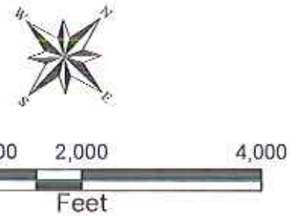
Map - 10

PREWITT RESERVOIR

LOGAN WASH

MERINO





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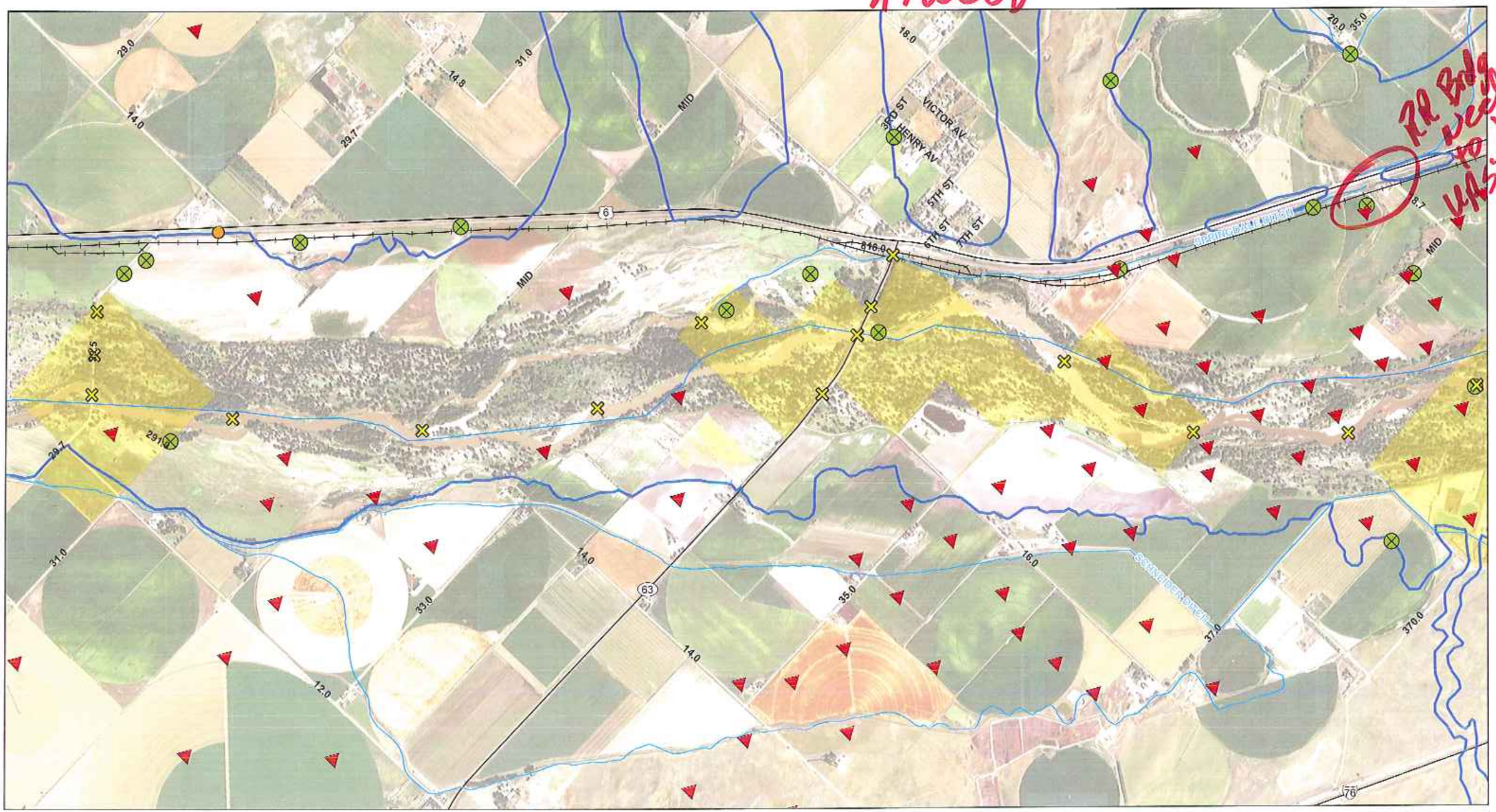
South Platte River Restoration Master Plan

Map - 11

ATWOOD

RR Bridge needs to be replaced



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Feet

Legend

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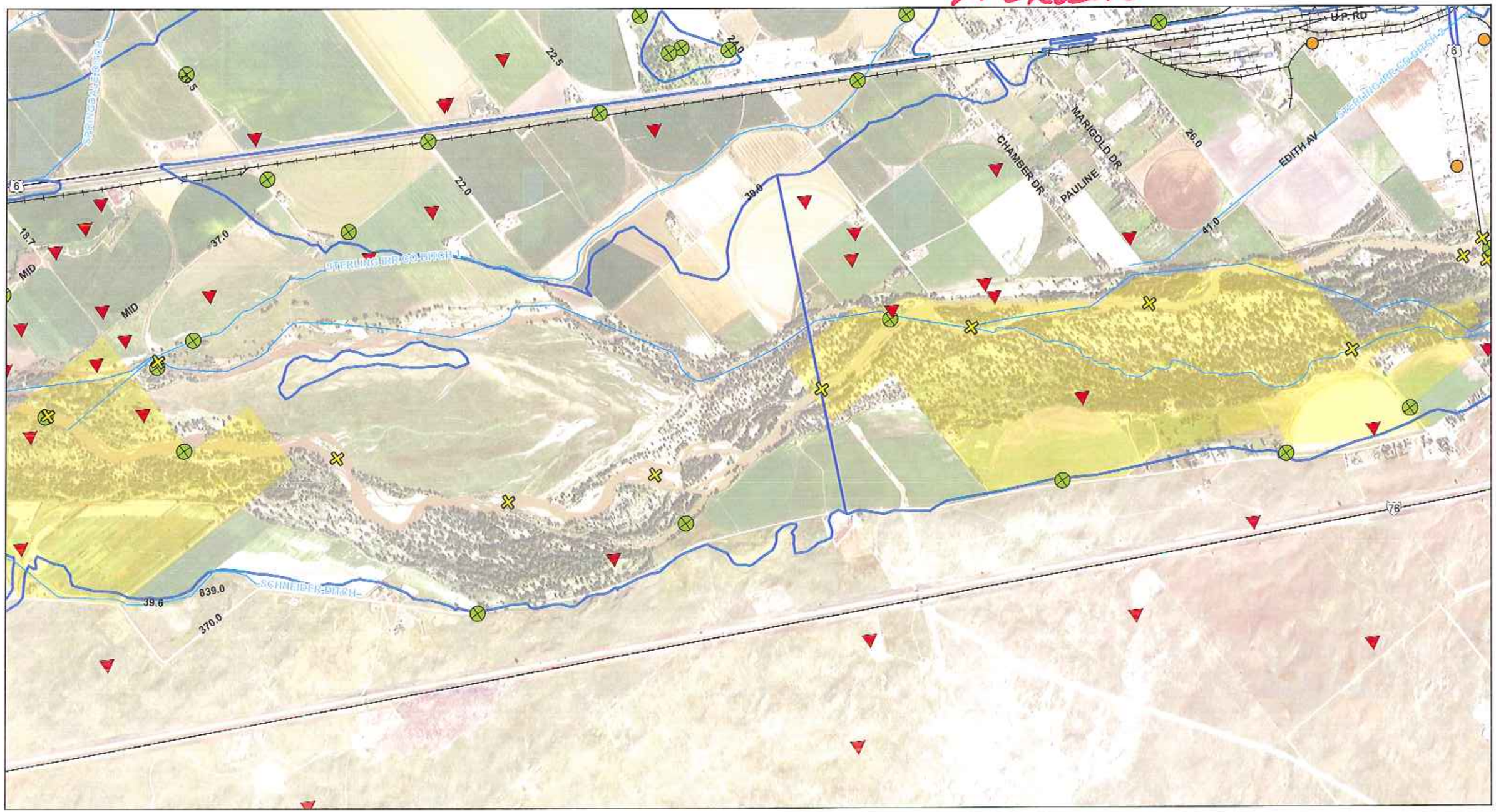
South Platte River Restoration Master Plan

Map - 12

STERLING



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Feet

Legend

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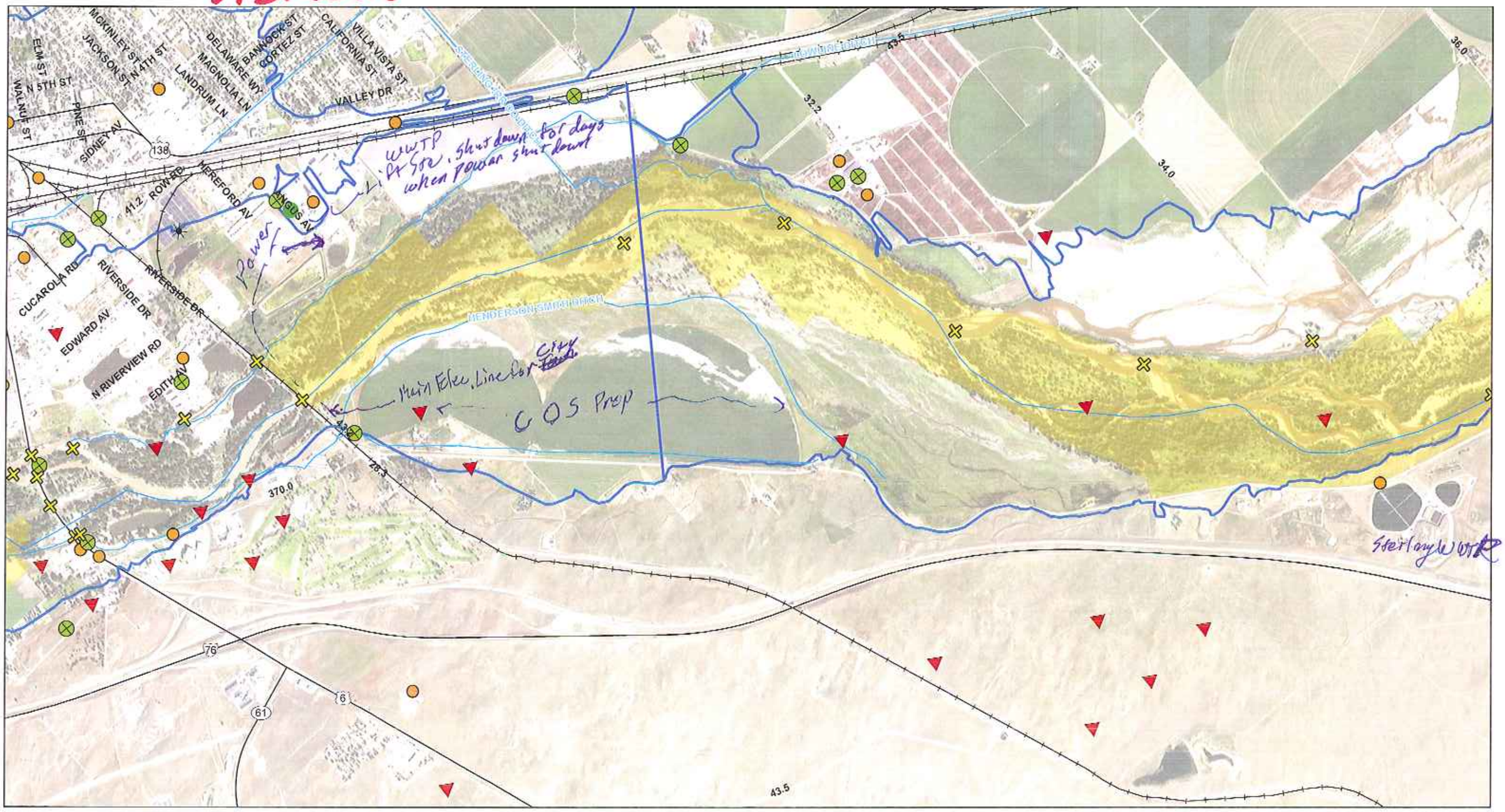
South Platte River Restoration Master Plan

Map - 13

STERLING



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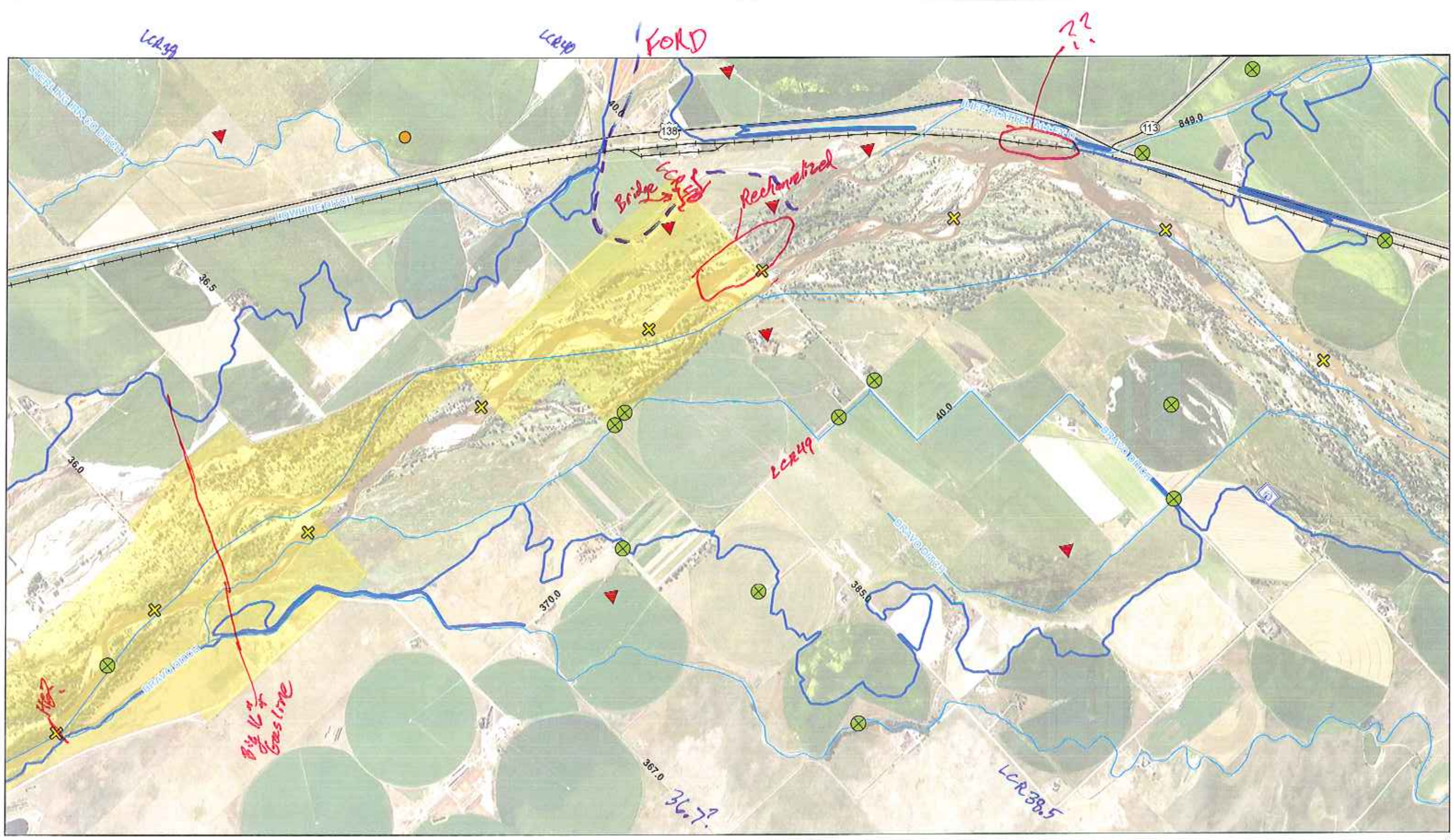
South Platte River Restoration Master Plan

Map - 14



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Feet

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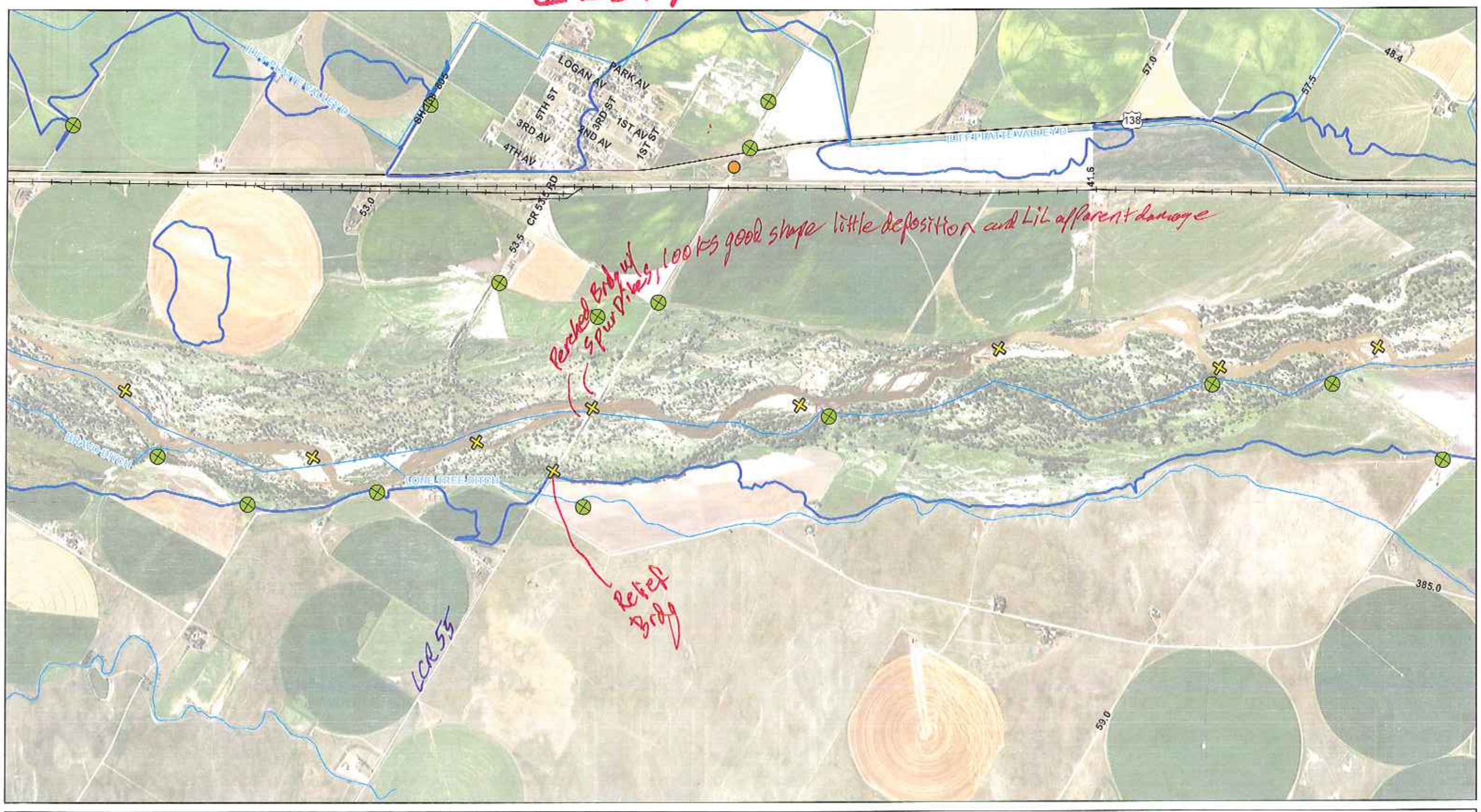
South Platte River Restoration Master Plan

Map - 15

ILIFF



0 1,000 2,000 4,000
Feet

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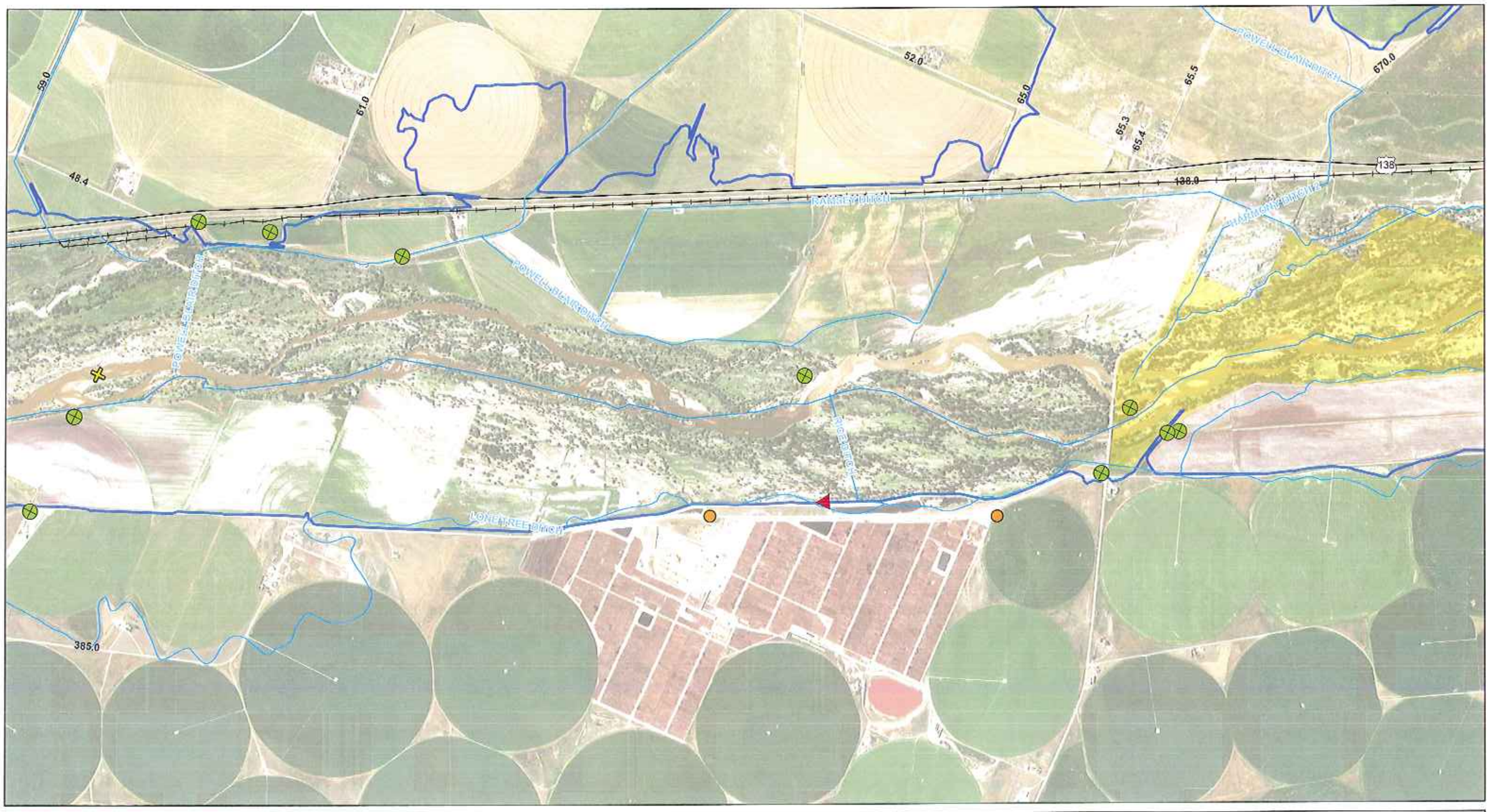
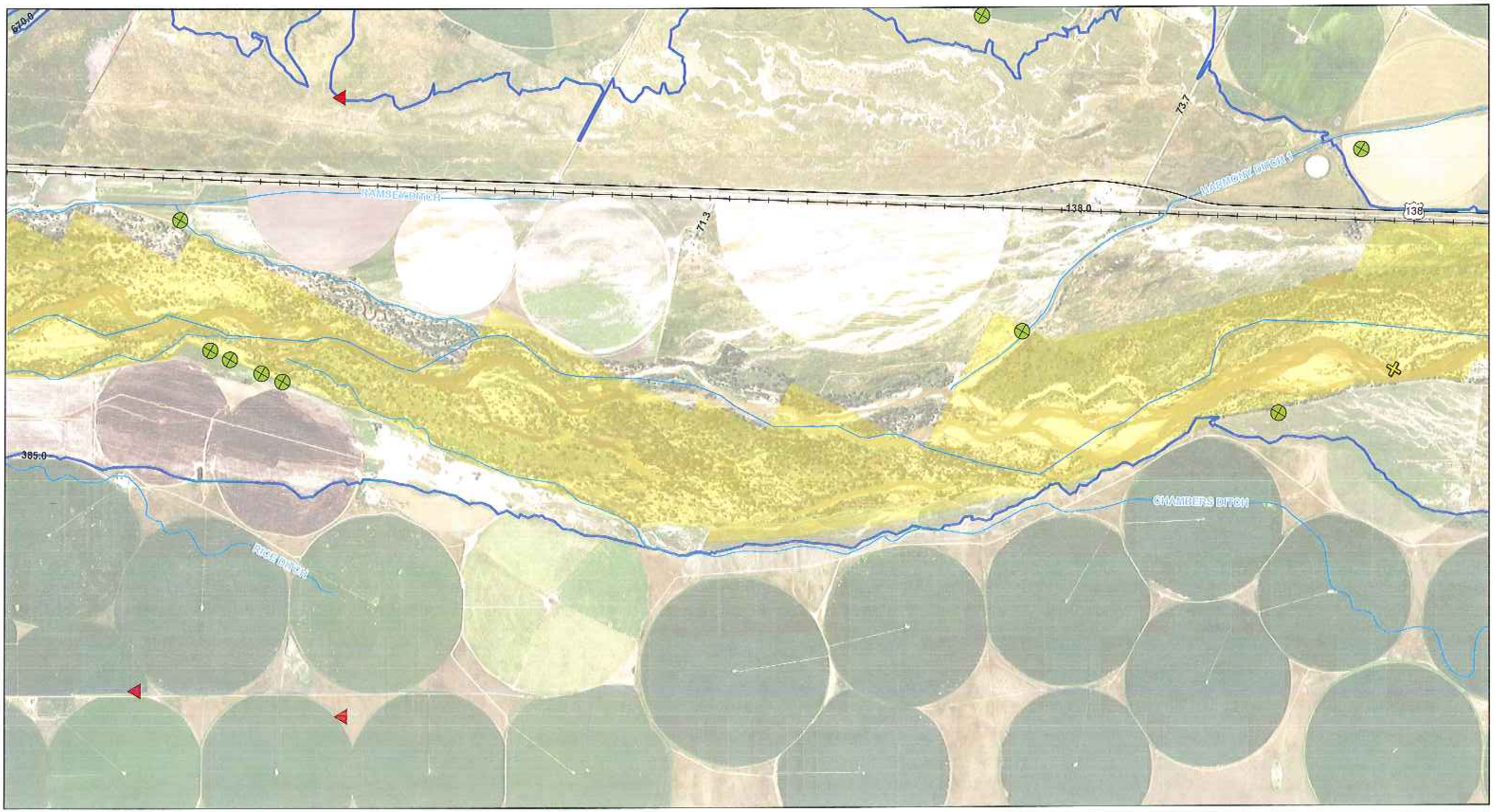
South Platte River Restoration Master Plan

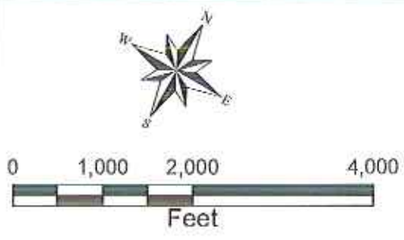
Map - 16



South Platte River Restoration Master Plan

Map - 17





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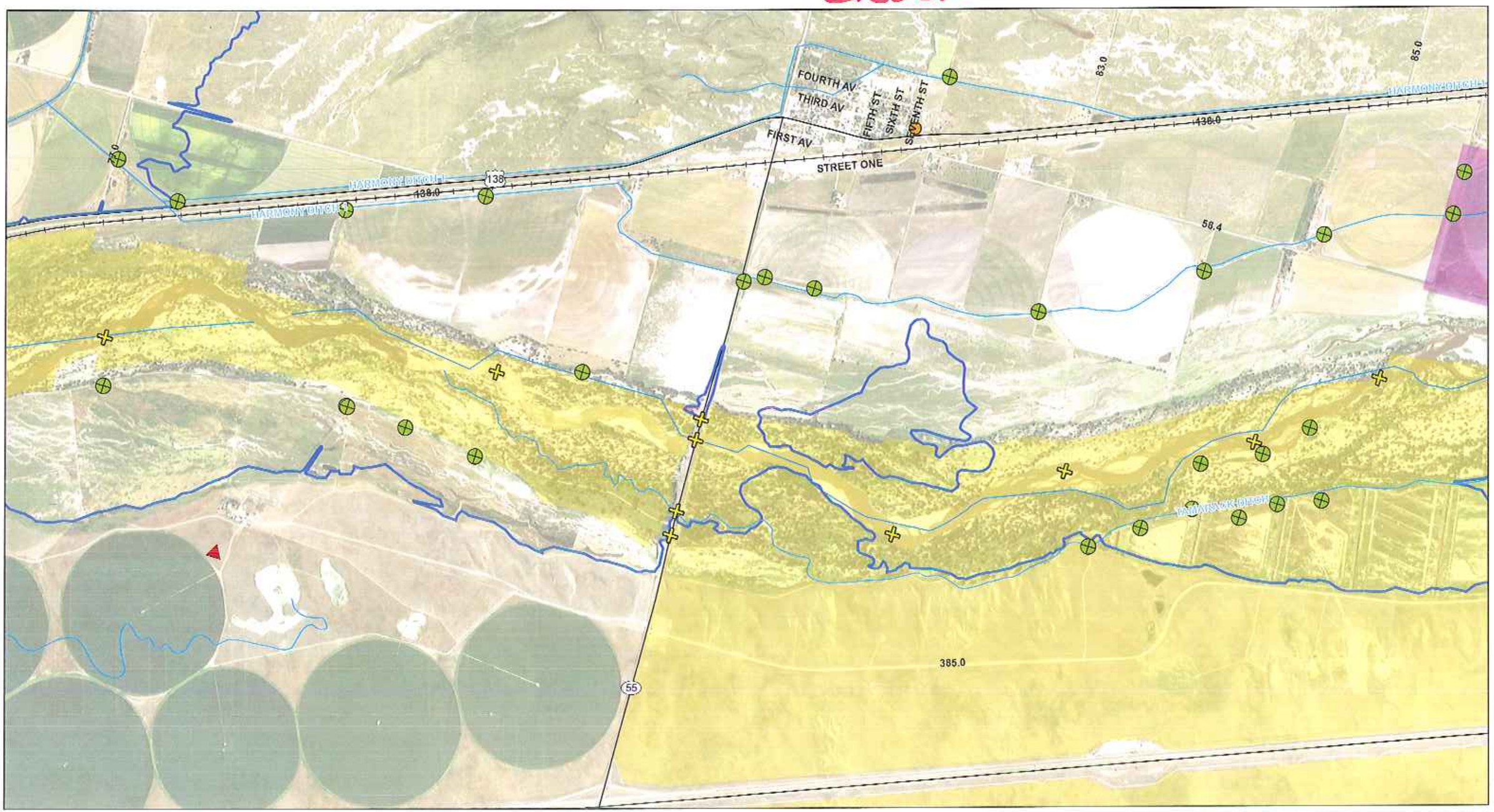
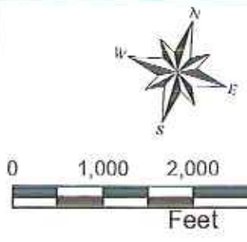
South Platte River Restoration Master Plan

Map - 18

CROOK





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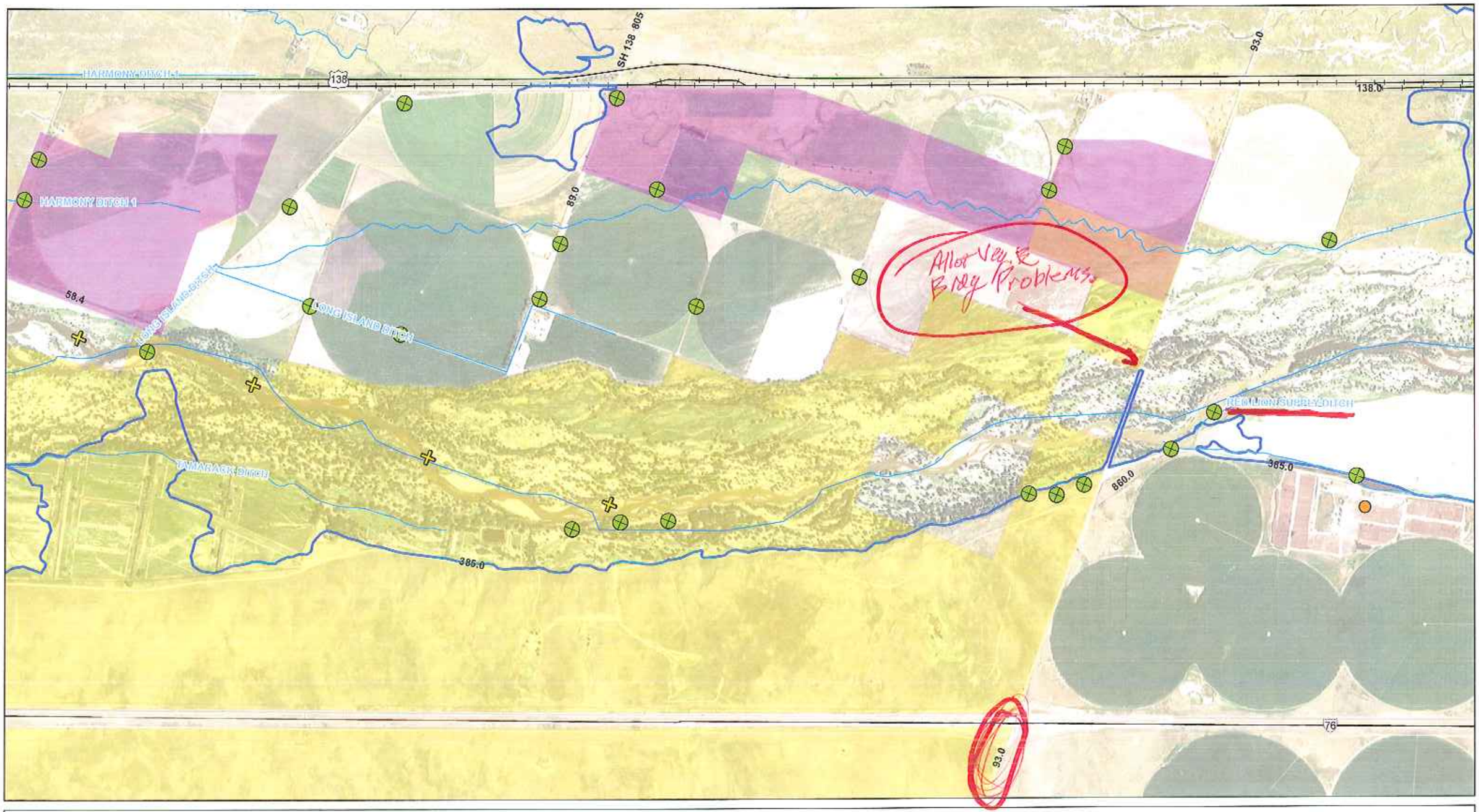
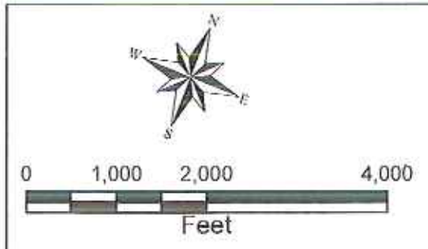
South Platte River Restoration Master Plan

Map - 19





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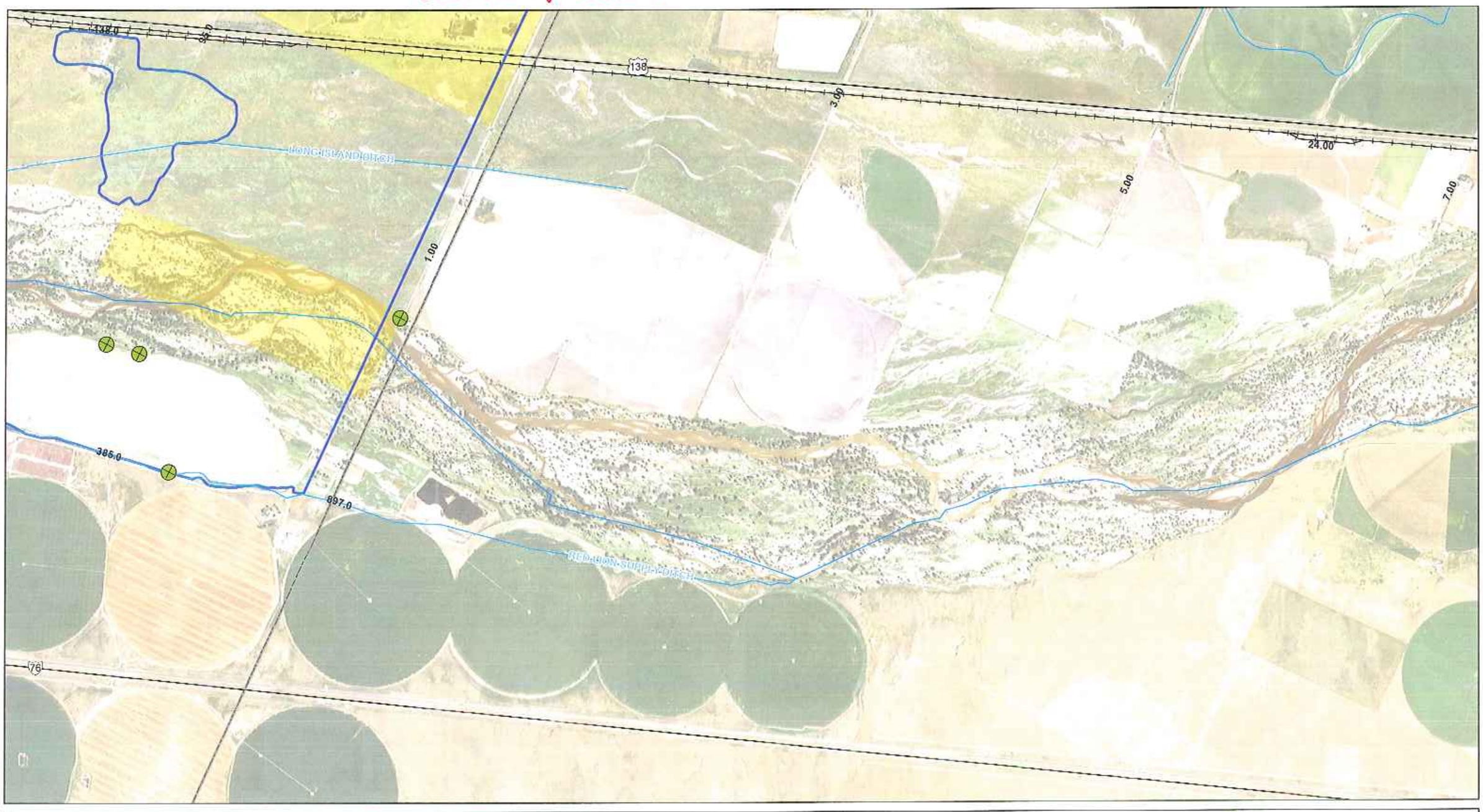
South Platte River Restoration Master Plan

Map - 20

LOGAN / SEDGWICK



Legend

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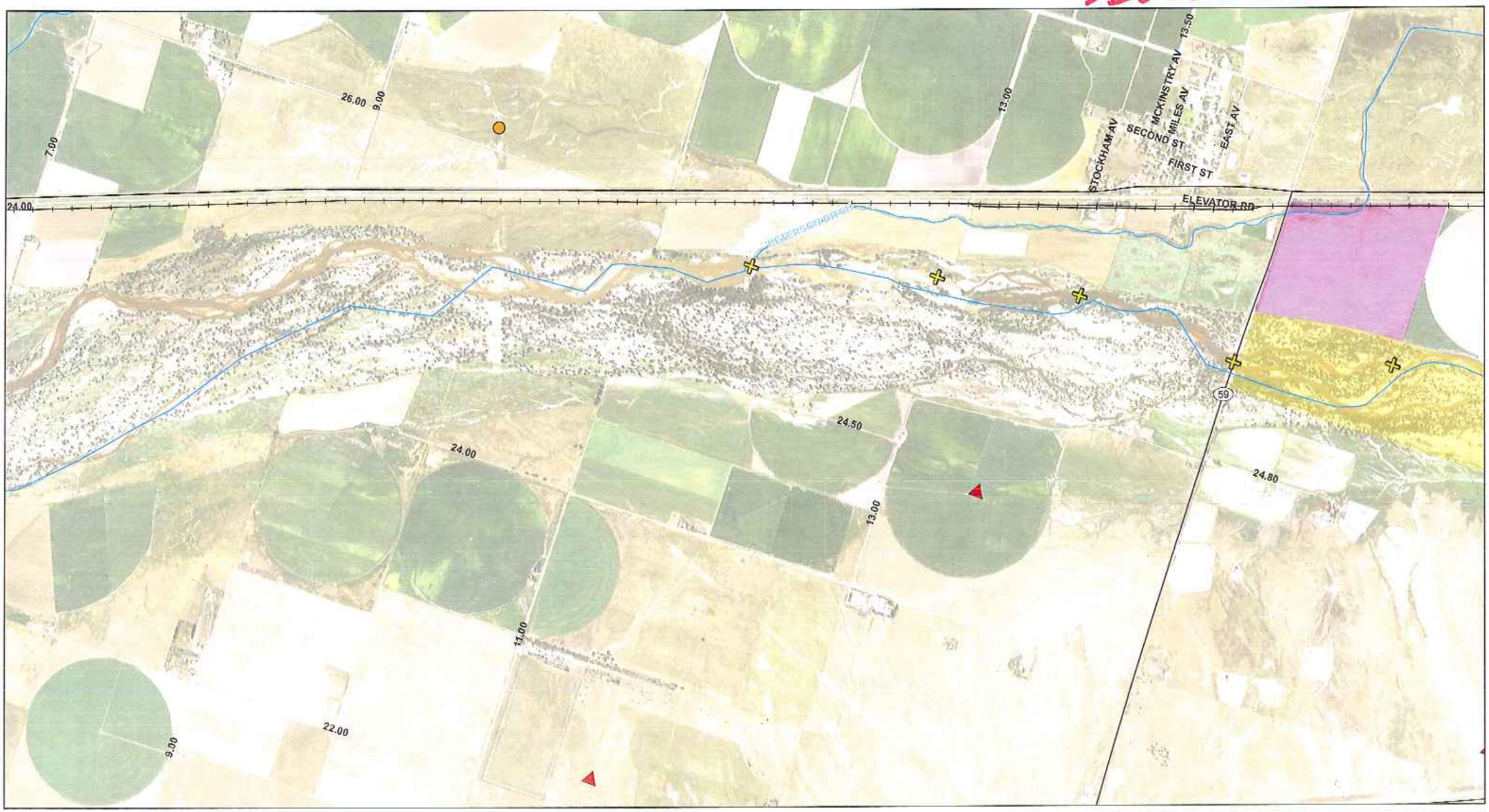
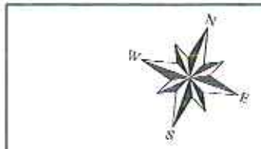
0 1,000 2,000 4,000
Feet

South Platte River Restoration Master Plan

Map - 21

SEDGWICK





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Feet

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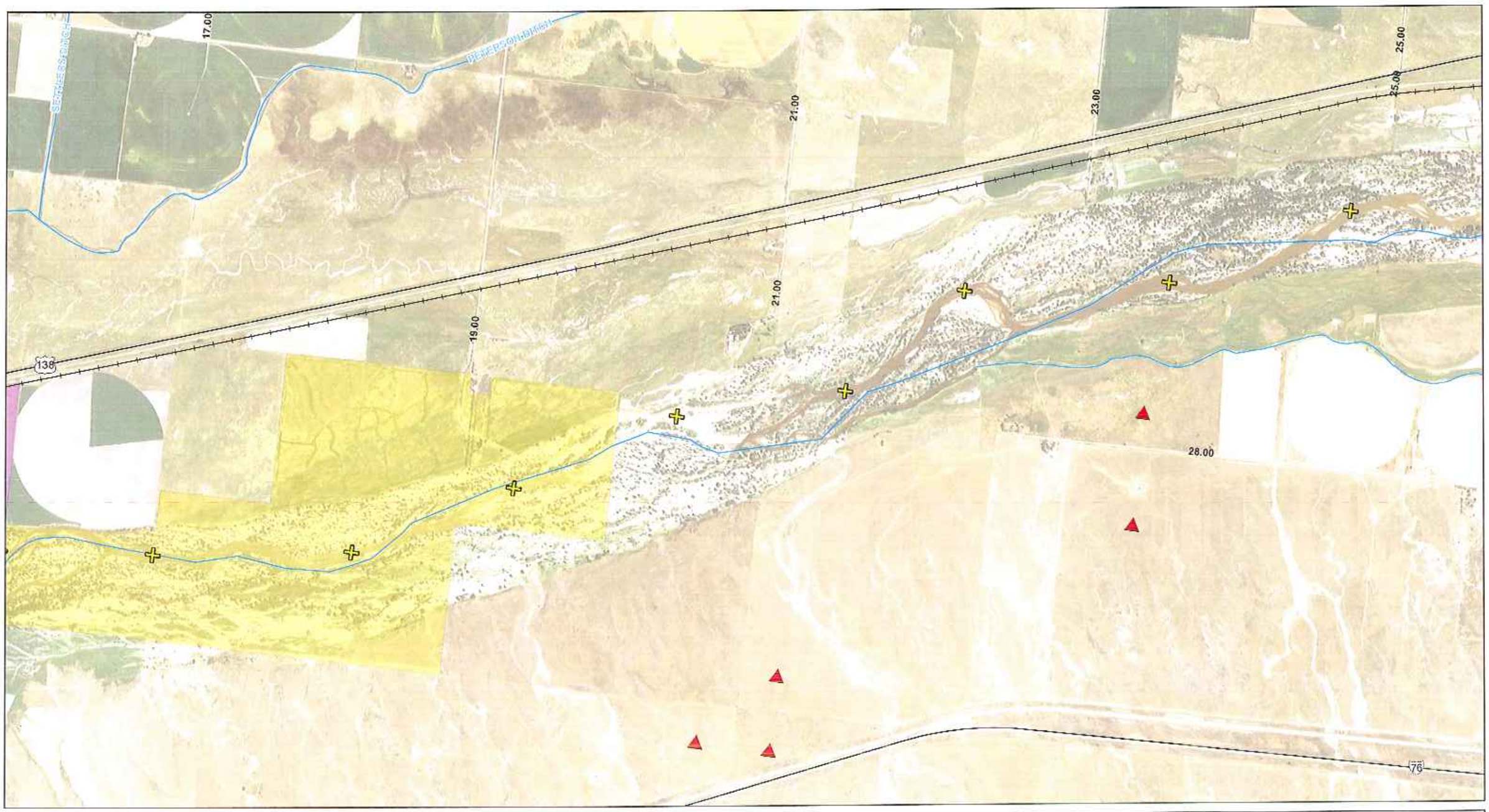
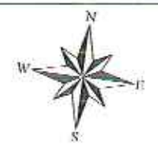
South Platte River Restoration Master Plan

Map - 22





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Feet

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South Platte River Restoration Master Plan

Map - 23

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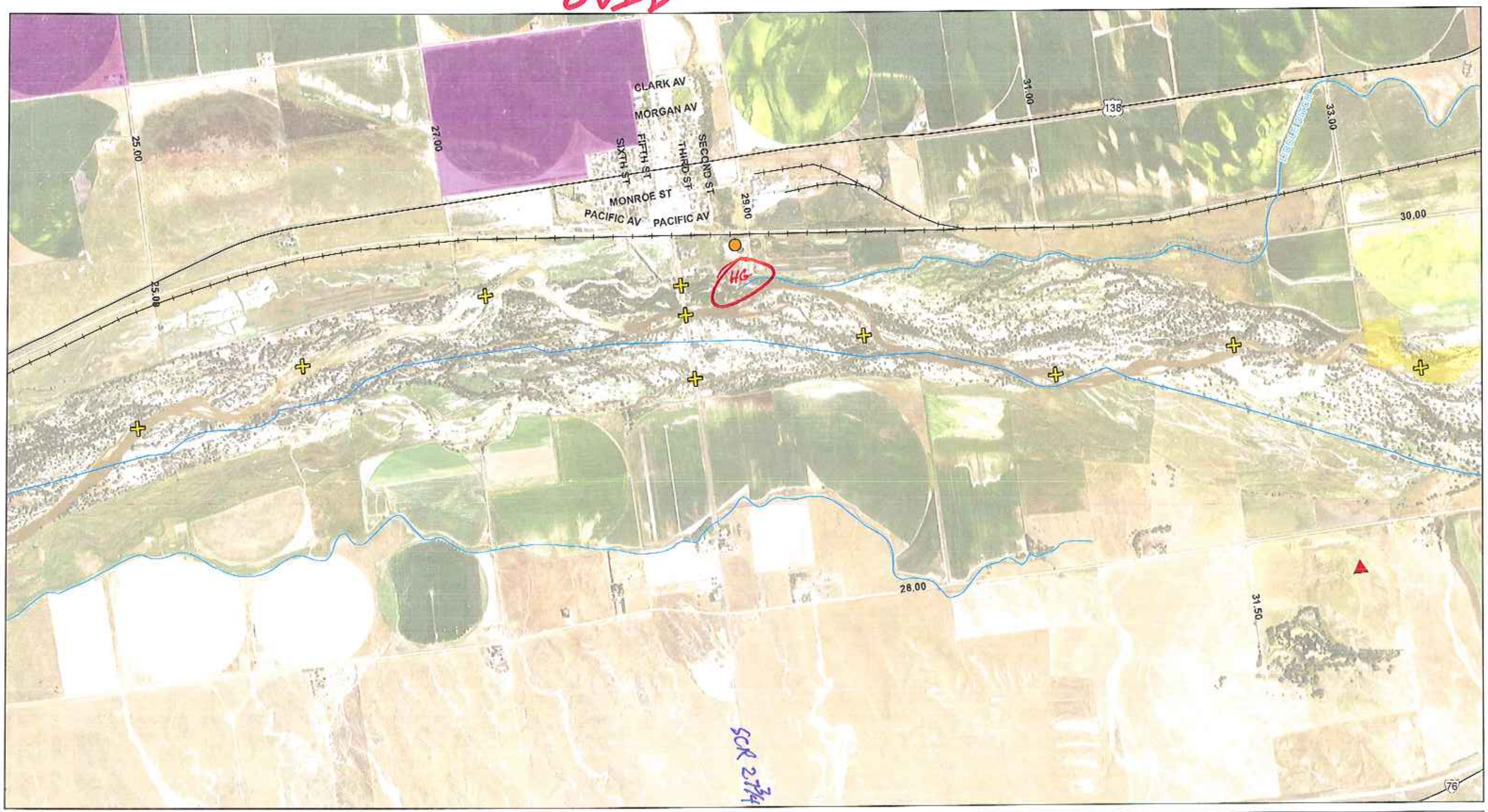

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Feet

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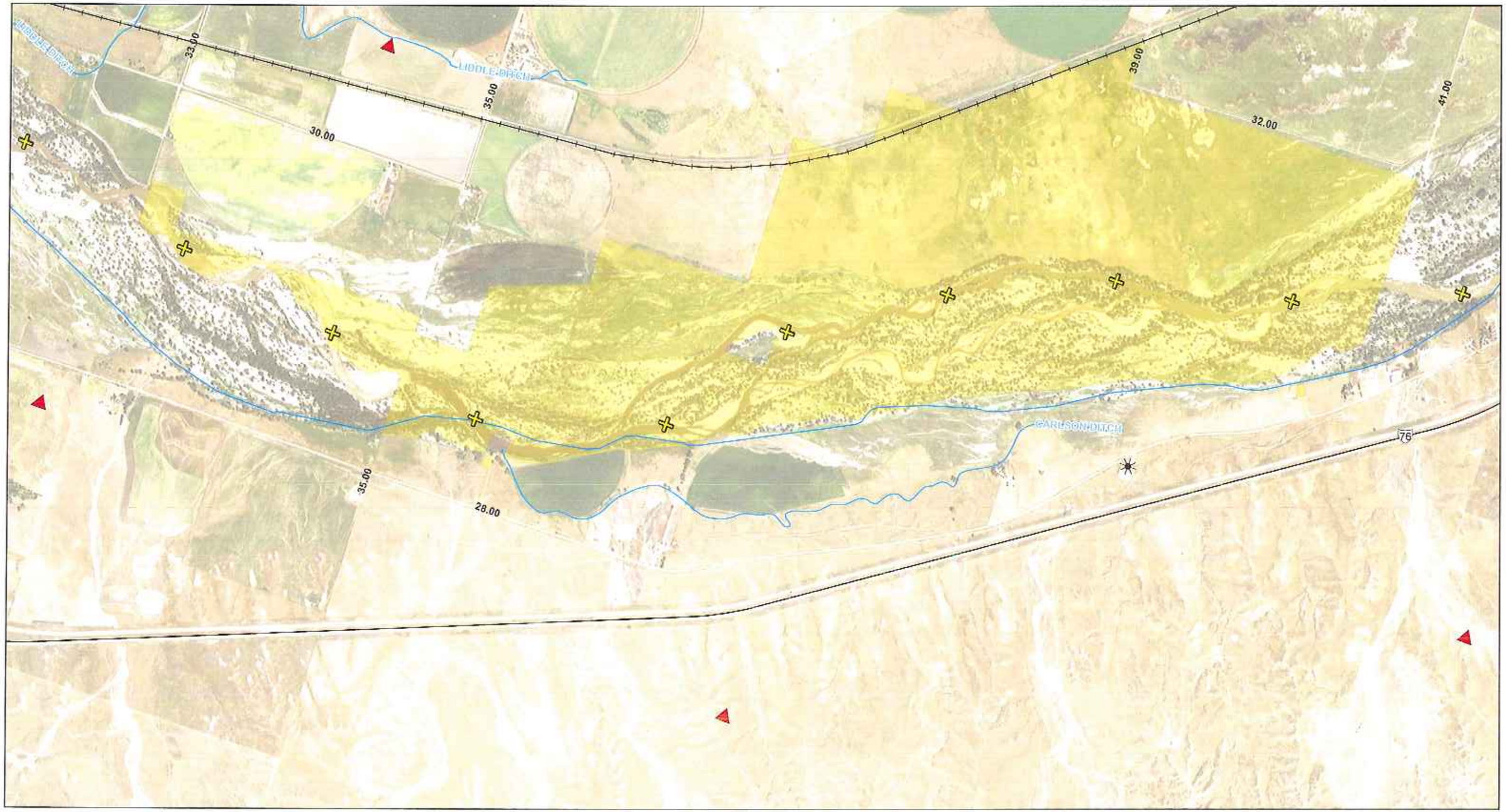
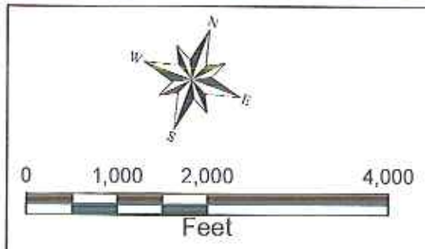
South Platte River Restoration Master Plan

Map - 24





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South Platte River Restoration Master Plan

Map - 25

JULESBURG

CO NE

RAILROAD ST
UNION ST
PLUM ST
PINE ST
ELM ST
ASH ST
32.75 RD
OLD 385
CONSTRUCTION AV
138
385
76
1ST ST
5TH ST
9TH ST
STREET A
39.00
32.90
43.00
43.50
41.50
32.70
41.00
32.00
32.30
32.50
28.00
47.50
30.00

Hwy Veg
Island

Jetties & RR Repair

Audubon
Pt.

Sedgewick county Lake
Flows in mid. CA.

0 1,000 2,000 4,000
Feet

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South Platte River Restoration Master Plan

Map - 26

04/20/2017 CHRIS DALLEY-ACE

LOGAN

SEDGWICK

SEDGWICK

OVID

Julesburg

Julesburg NE

SCR 27.75

CROOK

KILLIFF

STERLING

MERINO

MILLWOOD

LCR 93 Red Lion Ditch

Interview for under design.

LCR 40

US 138

US 6

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

113 14 71 6 61 63 55 76 59 138 385 11 385 23

N W E S

0 3 6 12

Miles

Legend

Major Roads

Railroad

LCR59/ILIFF
LCR93/Red Lion
SCR27.75/Ovid
LCR40
WCR40
} 3 Cnty Brdg X-ings then tie to I-76

47?
5?

South Platte River Restoration Master Plan

Logan and Sedgwick County Index Map

Const. season July - Oct when river is dry. Will run time const. difficult to do to Breeze ditch; using temp flows

WASH / LOGAN

NORTH STERLING CANAL
TETSEL DITCH
P3
595
583
17.7
WCR 59
595
P5
Q
TETSEL DITCH
TETSEL DITCH
Riprap Repair
2.5
PAWNEE DITCH
6
19.8
SOUTH PLATTE DITCH
R
595
P
588
SOUTH PLATTE DITCH
60

0 1,000 2,000 4,000
Feet

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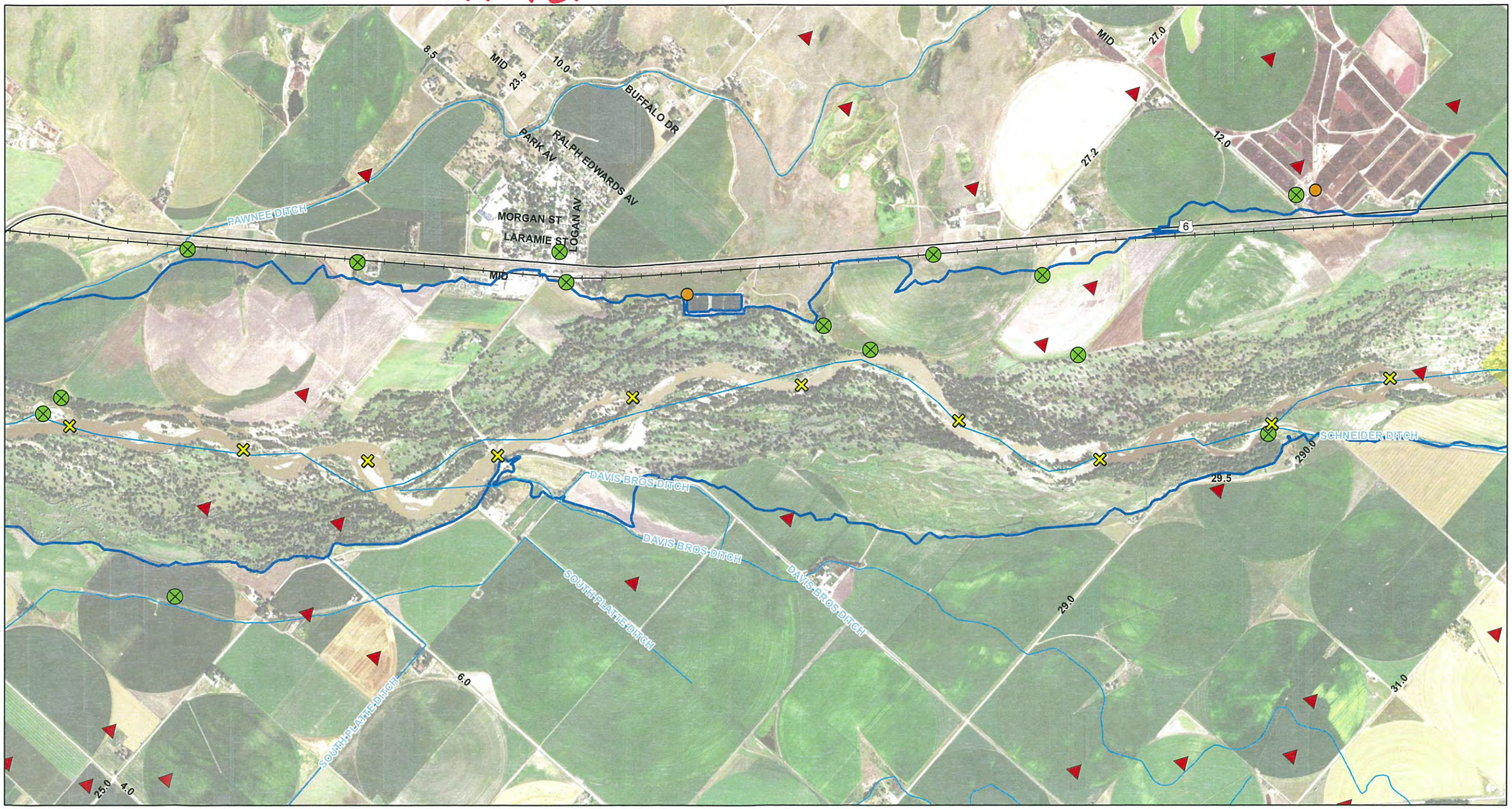
South Platte River Restoration Master Plan

Map - 10

PREWITT RESERVOIR
LOGAN

MERINO



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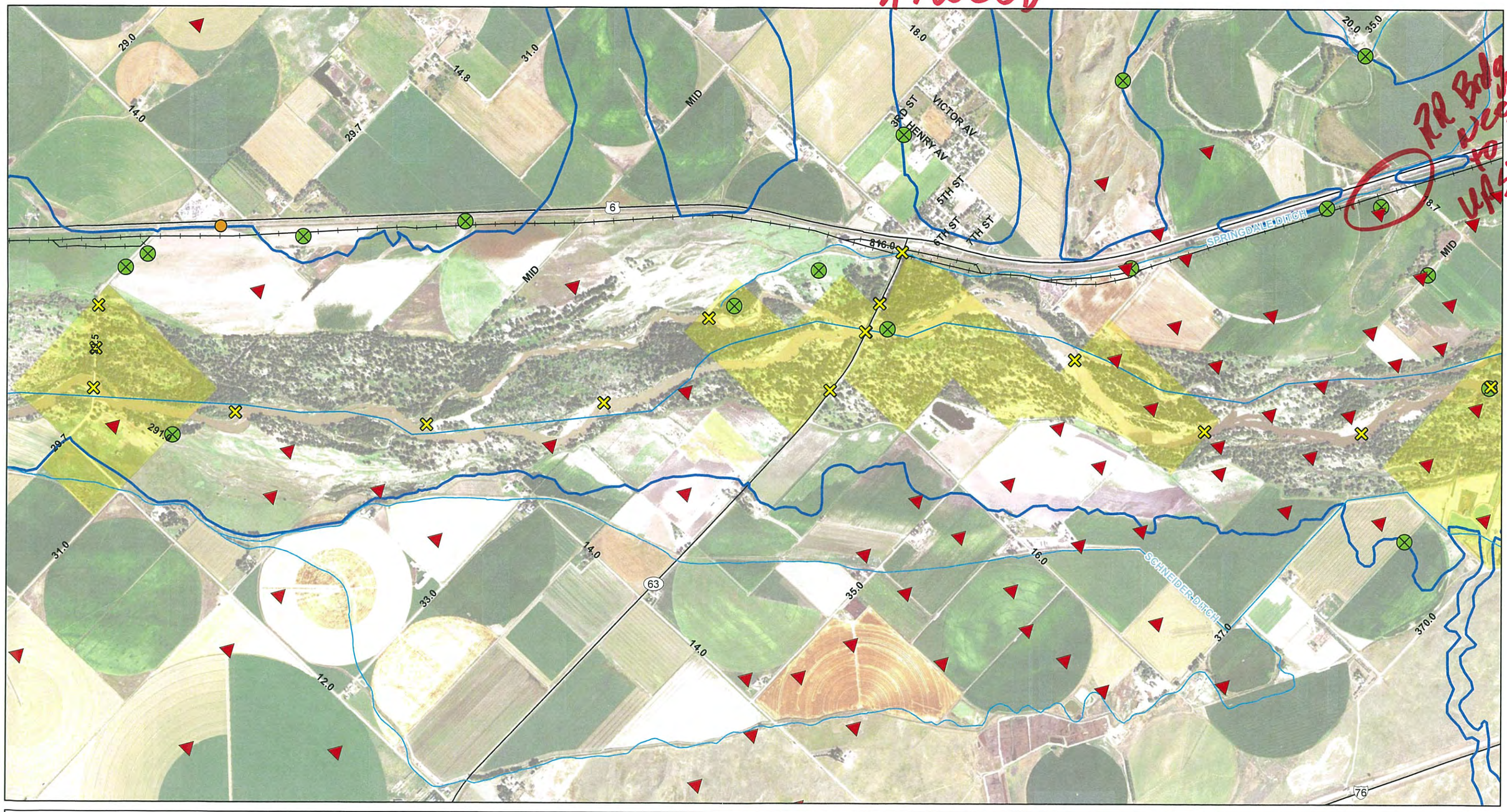
South Platte River Restoration Master Plan

Map - 11

ATWOOD

RR Bridge needs to be upsized



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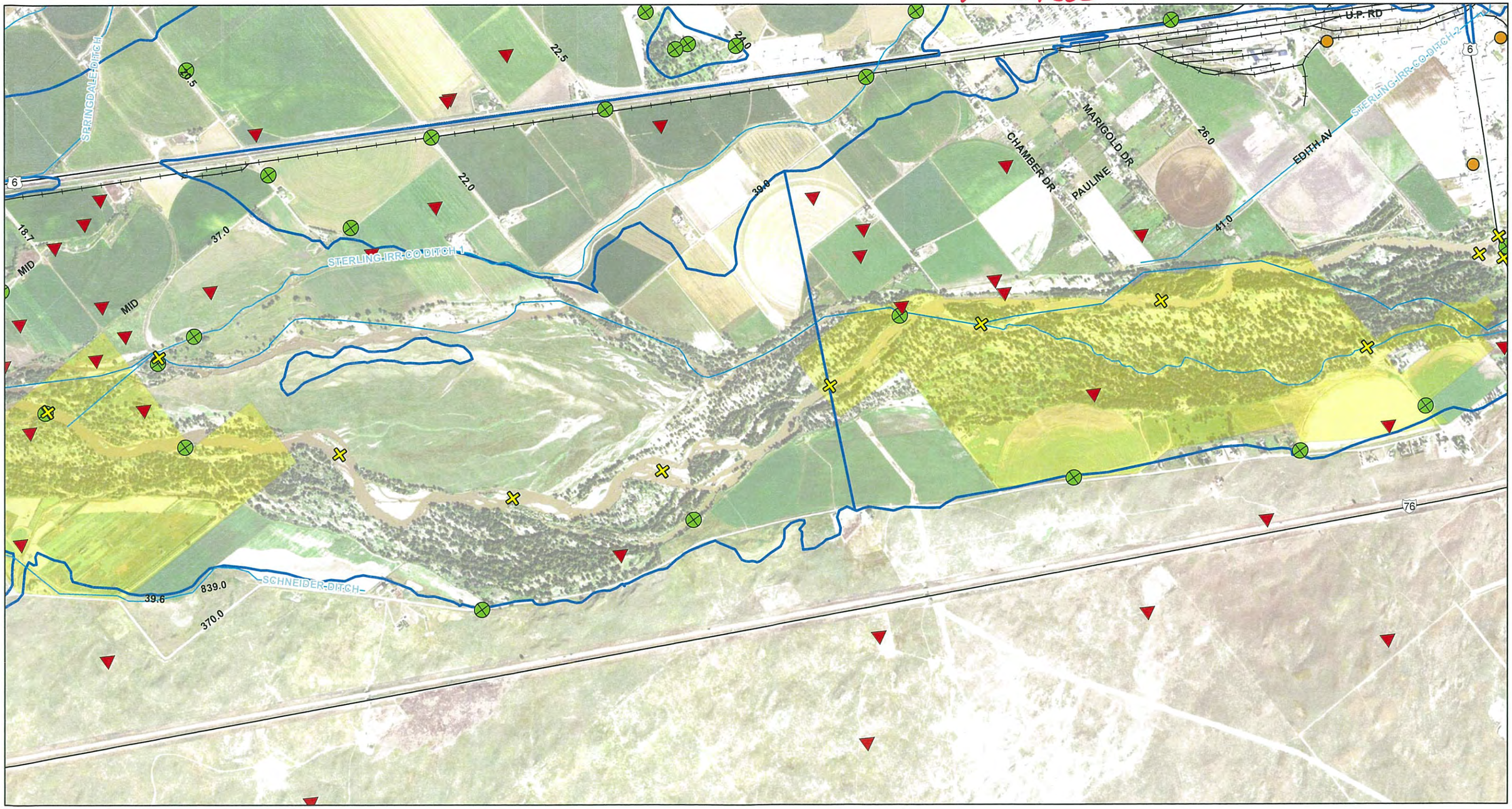
South Platte River Restoration Master Plan

Map - 12

STERLING



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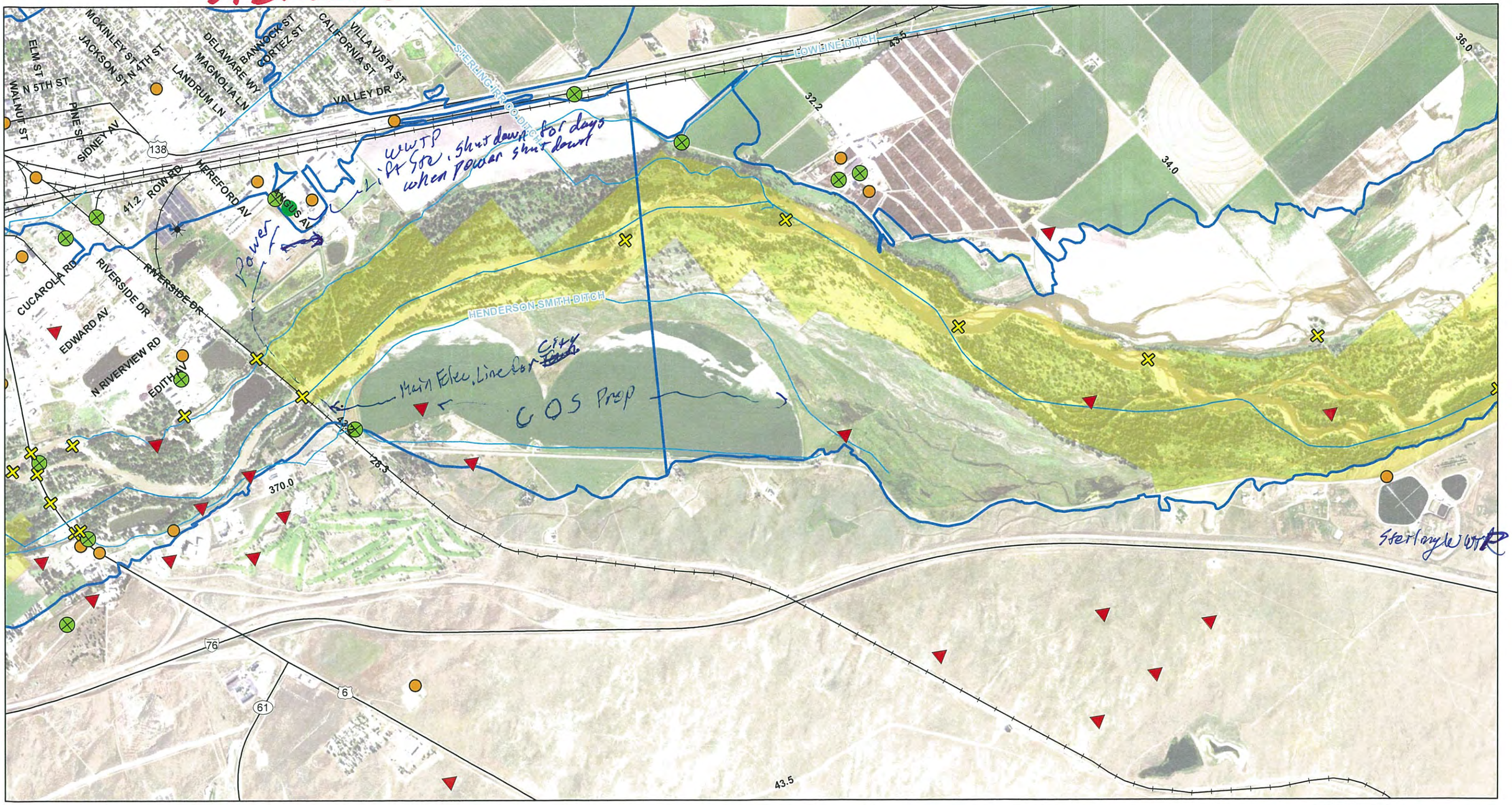
0 1,000 2,000 4,000
Feet

South Platte River Restoration Master Plan

Map - 13

STERLING



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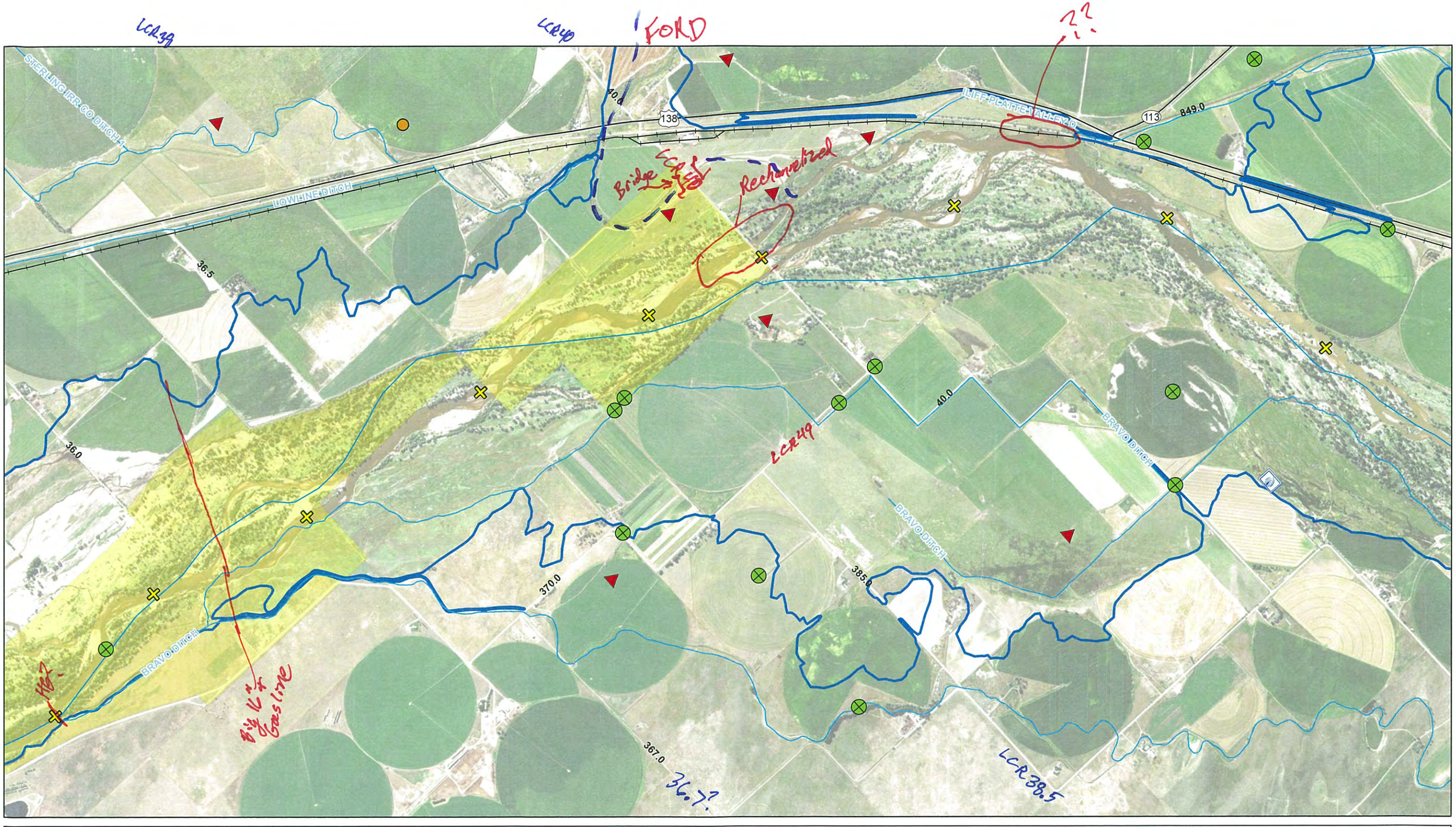
South Platte River Restoration Master Plan

Map - 14



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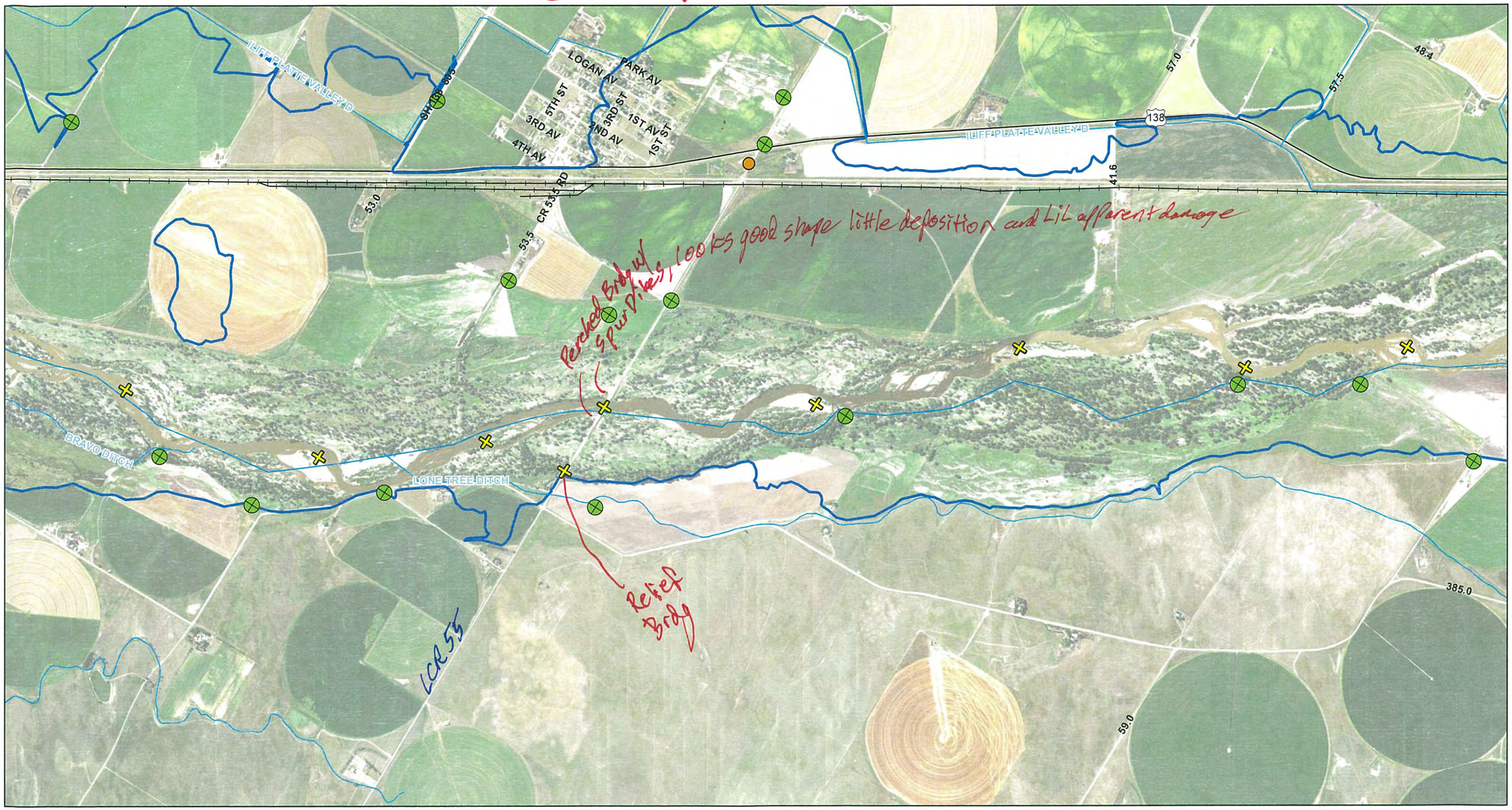
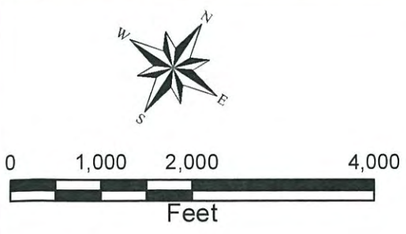
- Canals and Ditches
- Parcels
- Major Roads
- Local Roads
- Railroad
- CPW Public Access Properties
- CPW Walk In Access

South Platte River Restoration Master Plan

Map - 15

ILIFF



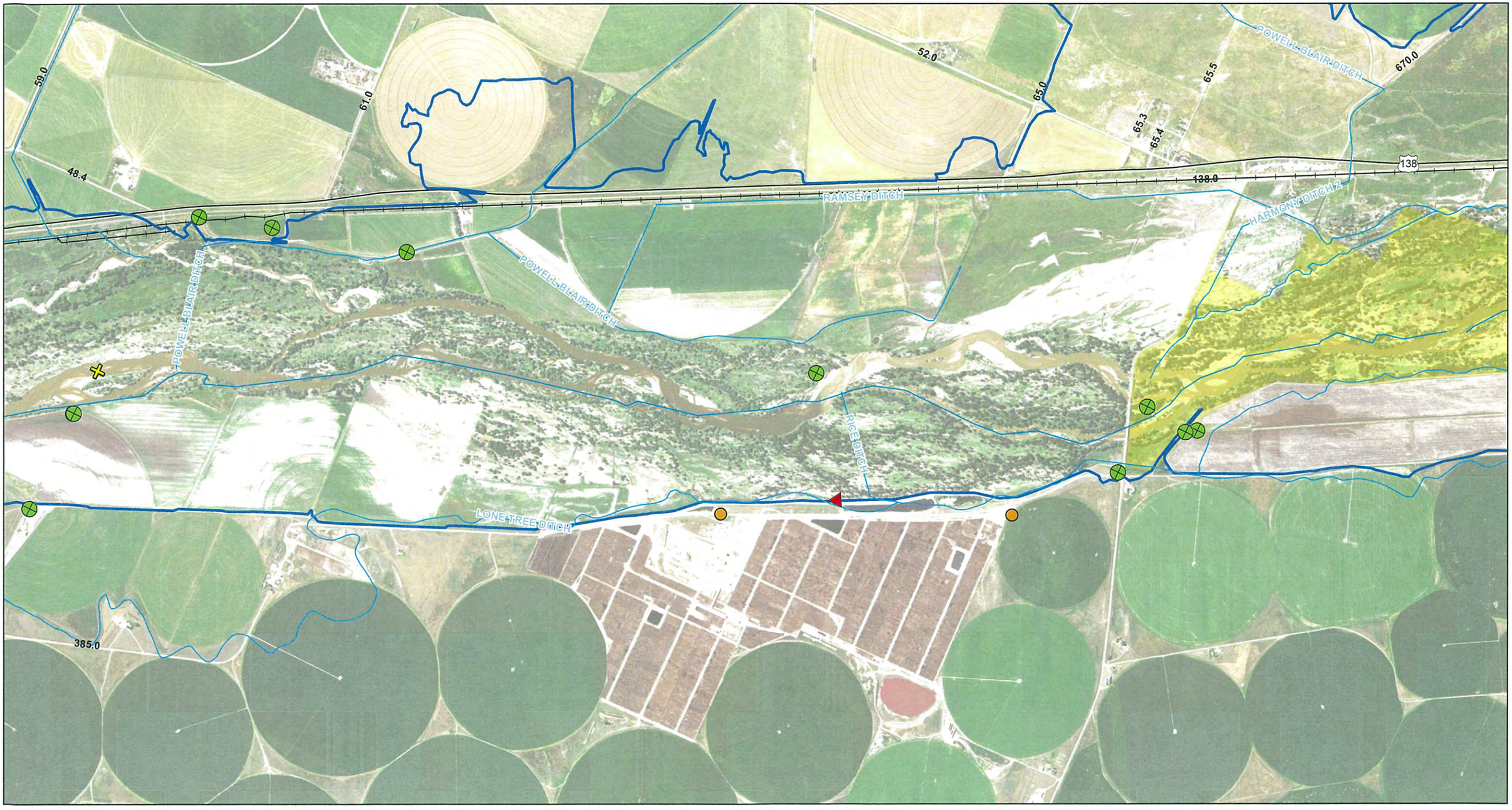


Legend

- CHAMP Survey Location
- Oil/Gas Wells
- Power Plants
- Natural Gas Underground Storage
- Ethanol Plants
- Irrigation Structures
- NPDES
- 100 - Year FP
- Canals and Ditches
- Parcels
- Major Roads
- Local Roads
- Railroad
- CPW Public Access Properties
- CPW Walk In Access

South Platte River Restoration Master Plan

Map - 16

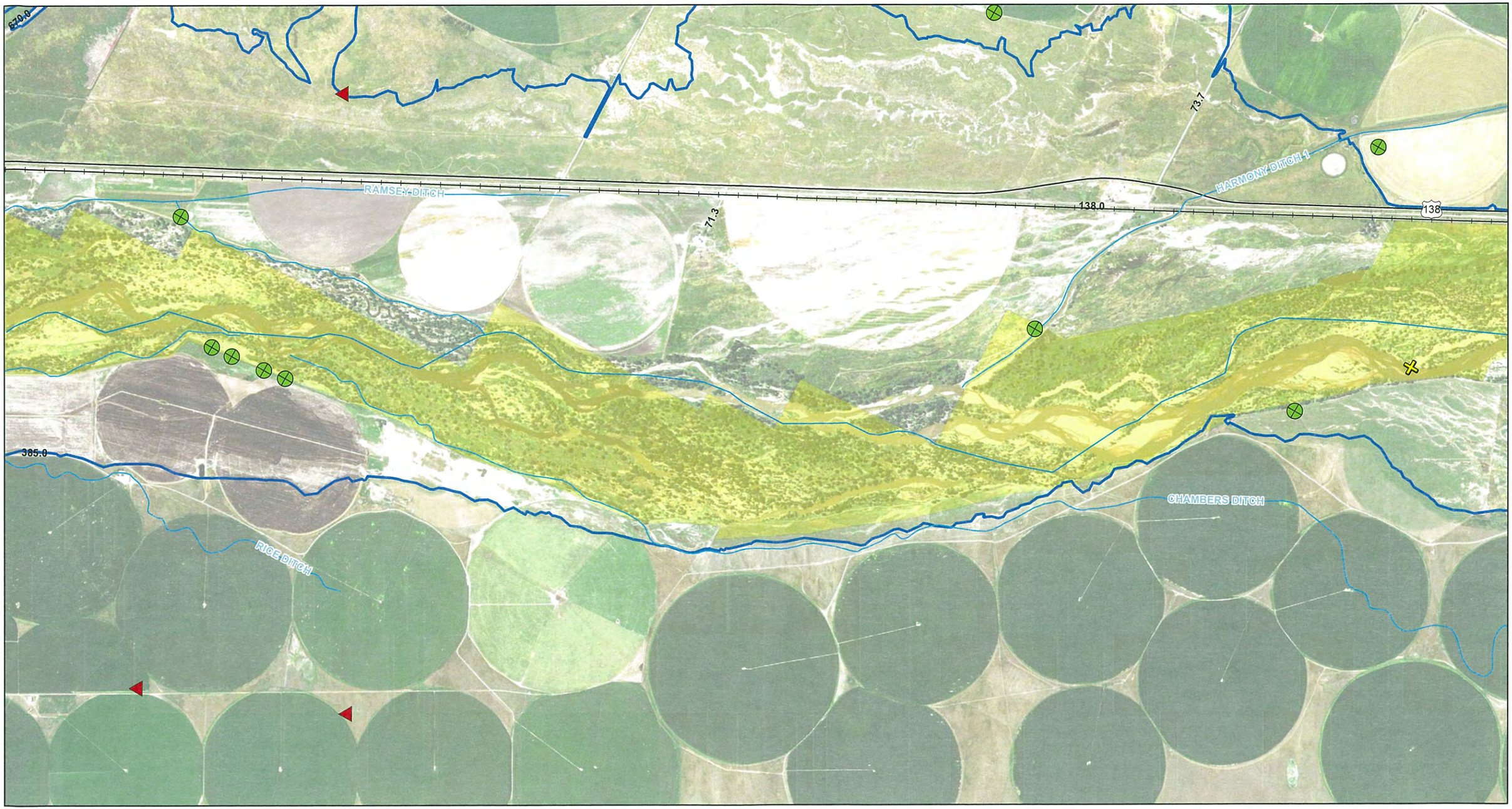


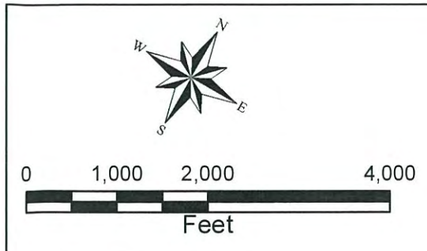
Legend

- CHAMP Survey Location
- Oil/Gas Wells
- Power Plants
- Natural Gas Underground Storage
- Ethanol Plants
- Irrigation Structures
- NPDES
- 100 - Year FP
- Canals and Ditches
- Parcels
- Major Roads
- Local Roads
- Railroad
- CPW Public Access Properties
- CPW Walk In Access

South Platte River Restoration Master Plan

Map - 17





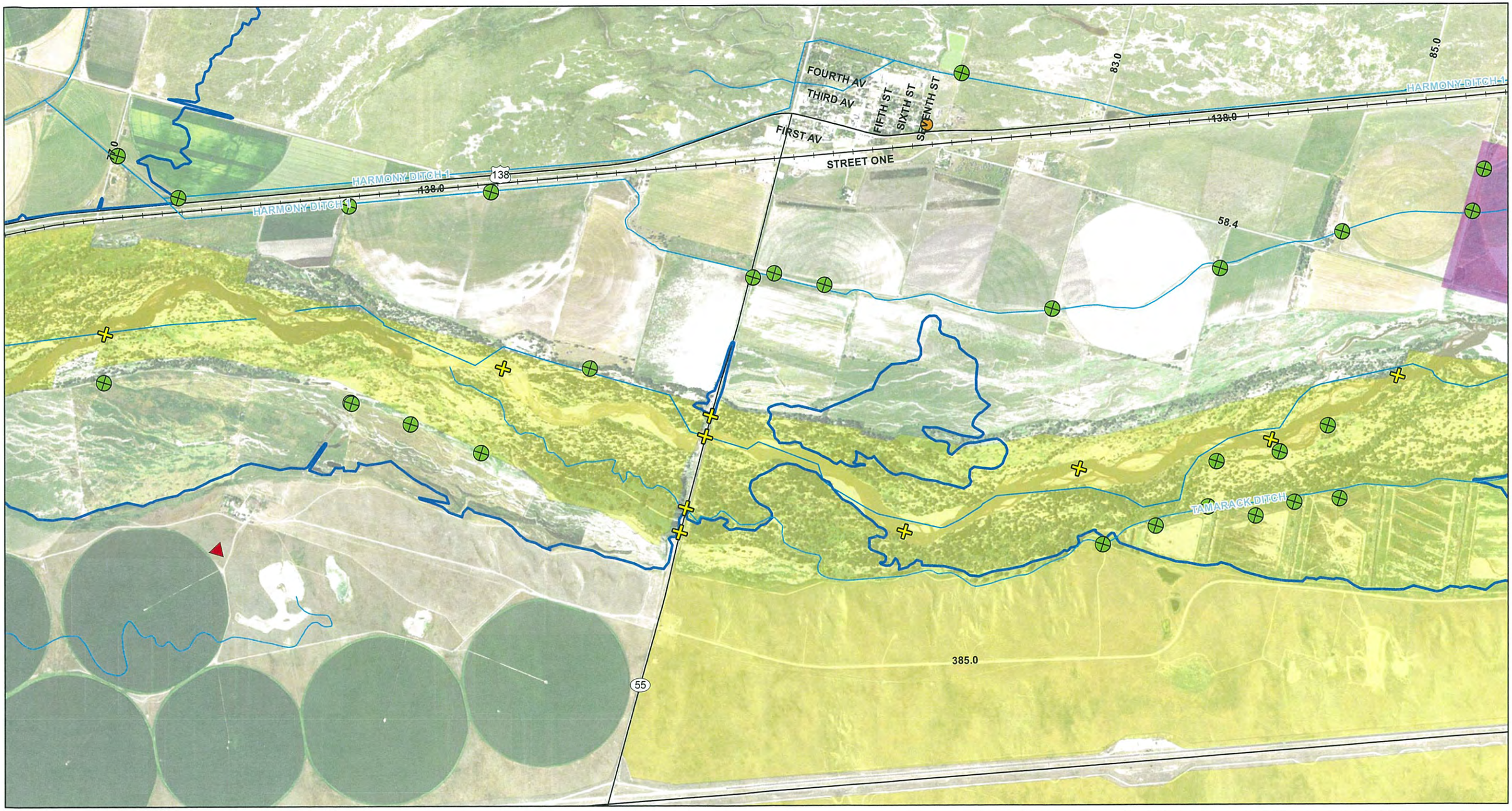
Legend

- CHAMP Survey Location
- Oil/Gas Wells
- Power Plants
- Natural Gas Underground Storage
- Ethanol Plants
- Irrigation Structures
- NPDES
- 100 - Year FP
- Canals and Ditches
- Parcels
- Major Roads
- Local Roads
- Railroad
- CPW Public Access Properties
- CPW Walk In Access

South Platte River Restoration Master Plan

Map - 18

CROOK



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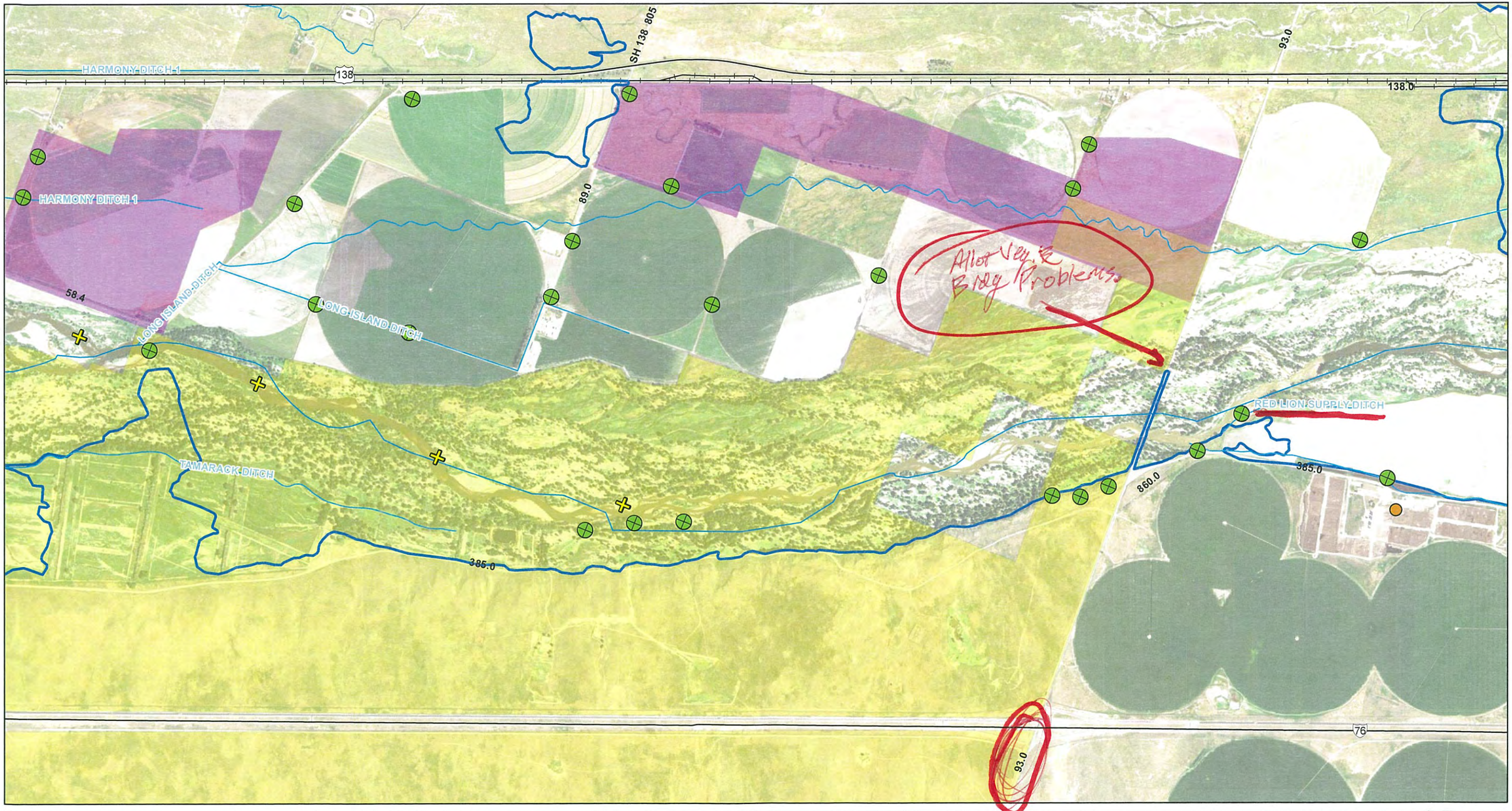
Feet

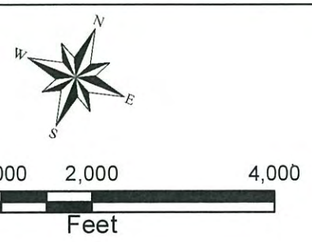
Legend

- CHAMP Survey Location
- Oil/Gas Wells
- Power Plants
- Natural Gas Underground Storage
- Ethanol Plants
- Irrigation Structures
- NPDES
- 100 - Year FP
- Canals and Ditches
- Parcels
- Major Roads
- Local Roads
- Railroad
- CPW Public Access Properties
- CPW Walk In Access

South Platte River Restoration Master Plan

Map - 19





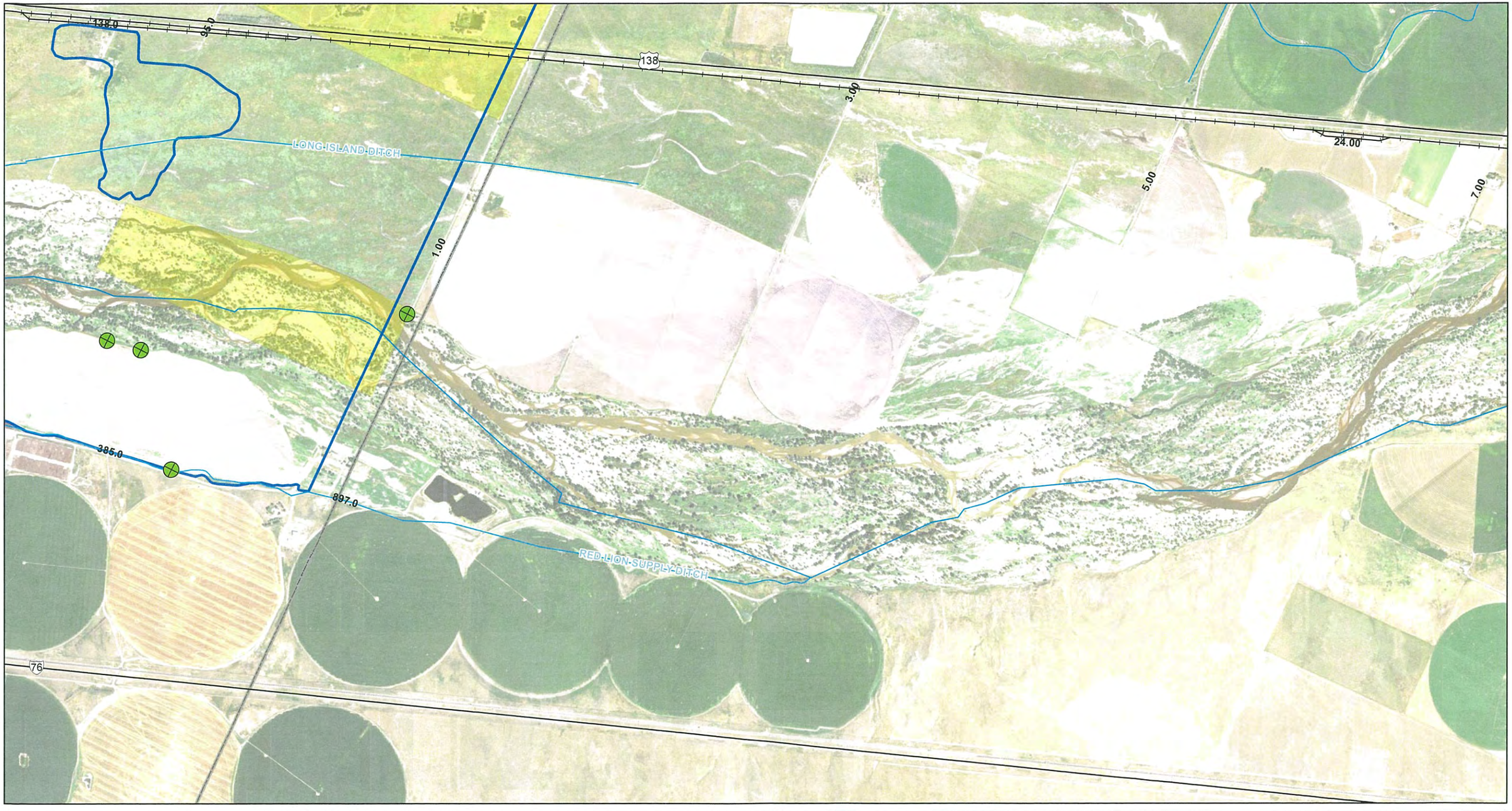
Legend

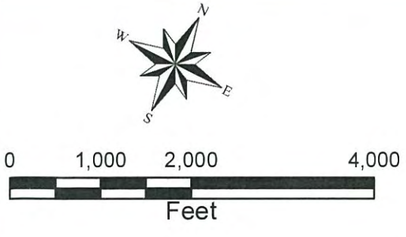
- CHAMP Survey Location
- Oil/Gas Wells
- Power Plants
- Natural Gas Underground Storage
- Ethanol Plants
- Irrigation Structures
- NPDES
- 100 - Year FP
- Canals and Ditches
- Parcels
- Major Roads
- Local Roads
- Railroad
- CPW Public Access Properties
- CPW Walk In Access

South Platte River Restoration Master Plan

Map - 20

LOGAN / SEDGWICK





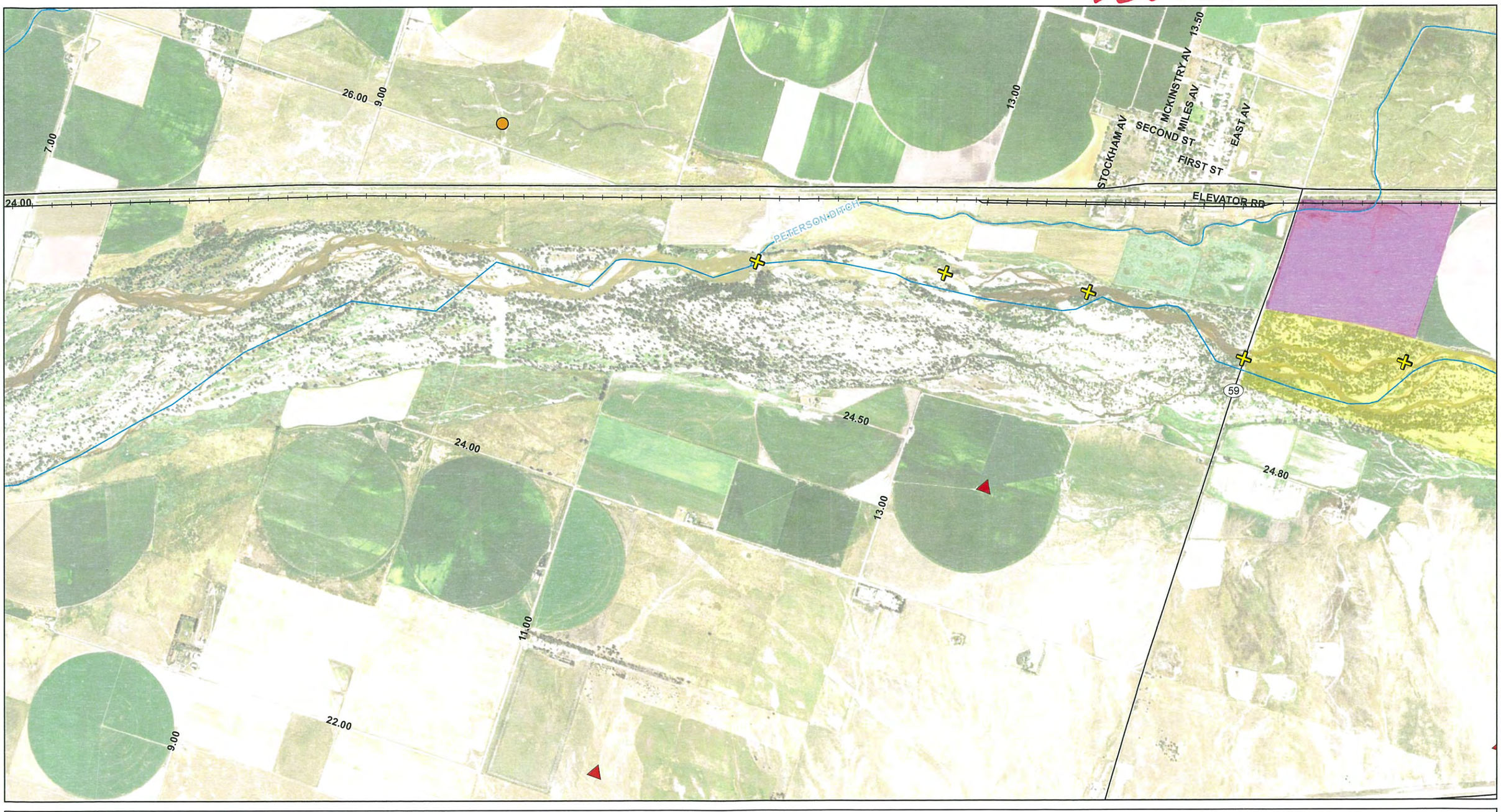
Legend

- CHAMP Survey Location
- Oil/Gas Wells
- Power Plants
- Natural Gas Underground Storage
- Ethanol Plants
- Irrigation Structures
- NPDES
- 100 - Year FP
- Canals and Ditches
- Parcels
- Major Roads
- Local Roads
- Railroad
- CPW Public Access Properties
- CPW Walk In Access

South Platte River Restoration Master Plan

Map - 21

SEDGWICK



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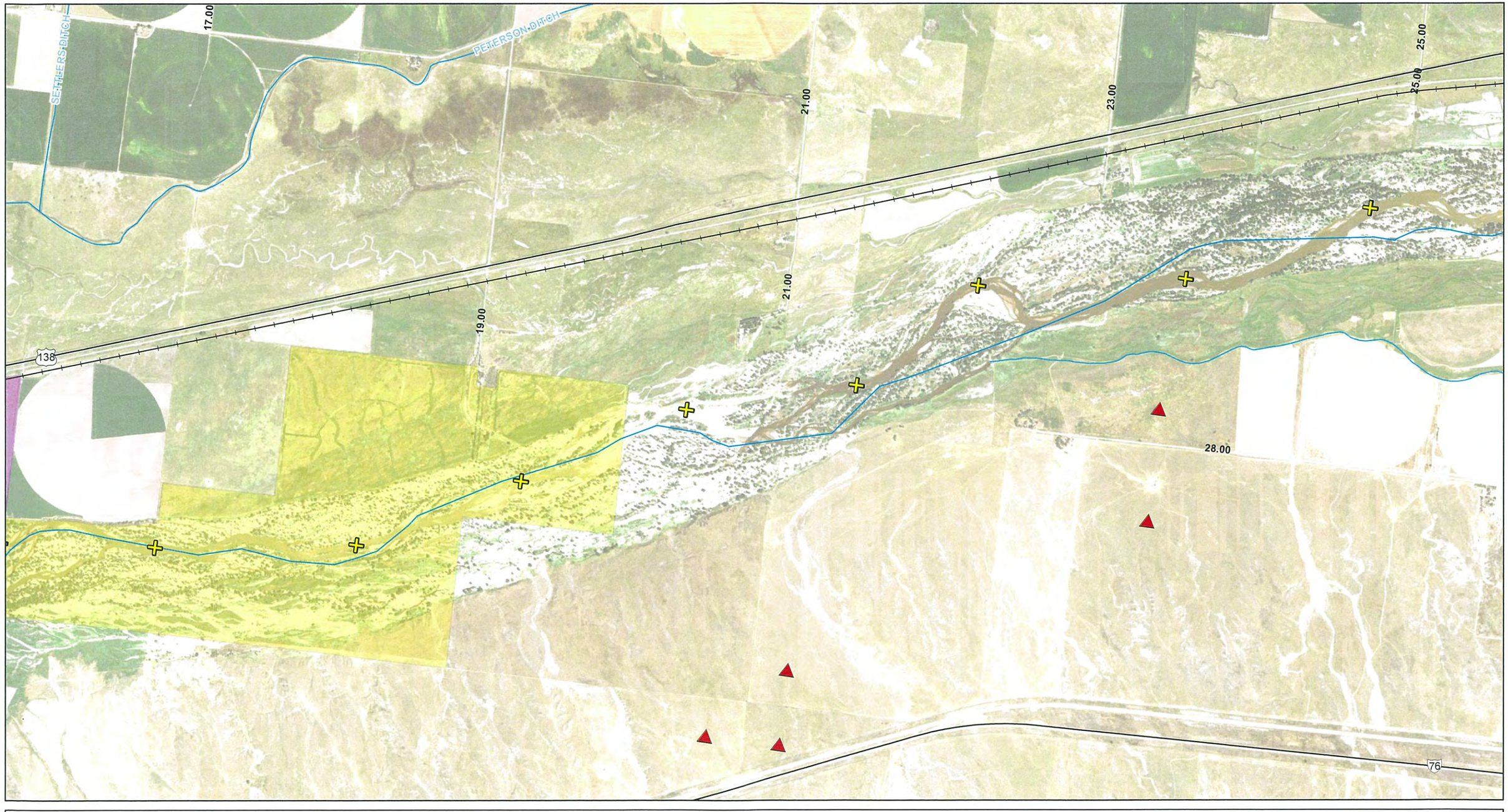
Feet

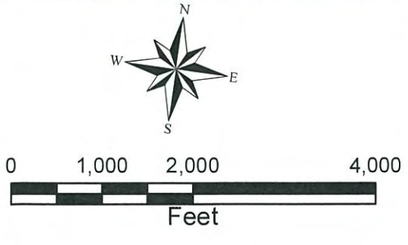
Legend

- CHAMP Survey Location
- Oil/Gas Wells
- Power Plants
- Natural Gas Underground Storage
- Ethanol Plants
- Irrigation Structures
- NPDES
- 100 - Year FP
- Canals and Ditches
- Parcels
- Major Roads
- Local Roads
- Railroad
- CPW Public Access Properties
- CPW Walk In Access

South Platte River Restoration Master Plan

Map - 22





Legend

- CHAMP Survey Location
- Oil/Gas Wells
- Power Plants
- Natural Gas Underground Storage
- Ethanol Plants
- Irrigation Structures
- NPDES
- 100 - Year FP
- Canals and Ditches
- Parcels
- Major Roads
- Local Roads
- Railroad
- CPW Public Access Properties
- CPW Walk In Access

South Platte River Restoration Master Plan

Map - 23

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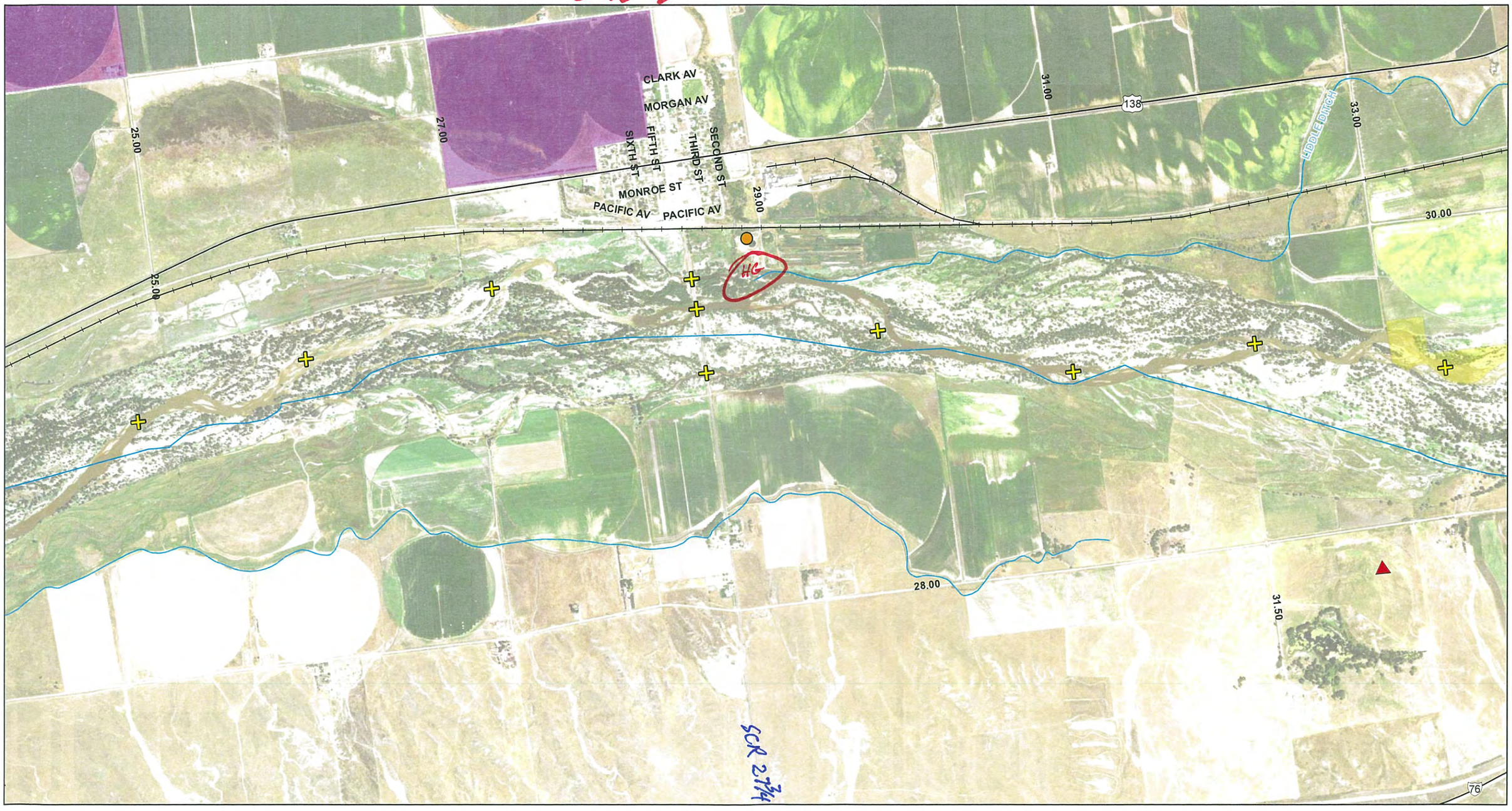

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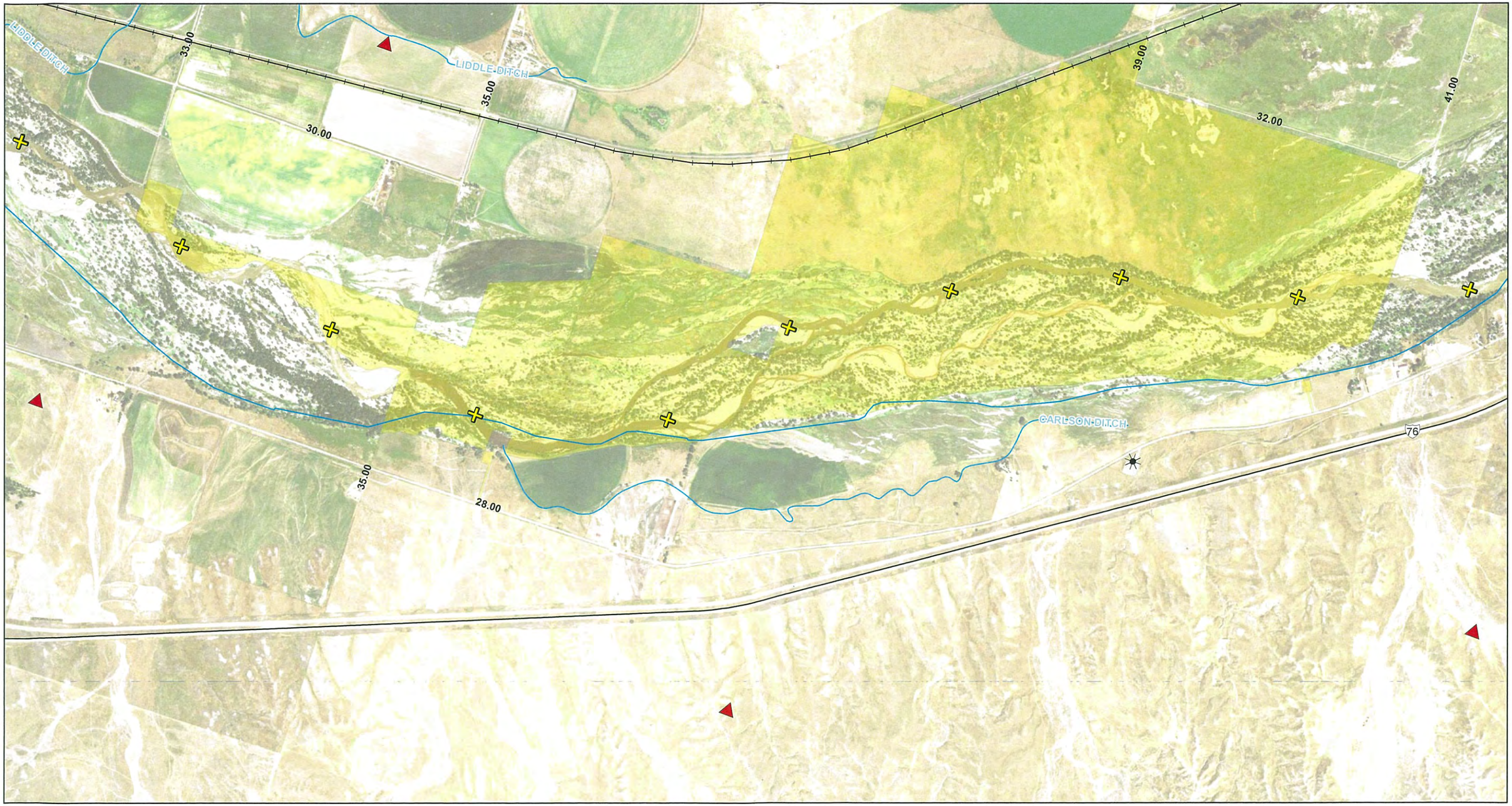
Feet

Legend

- CHAMP Survey Location
- Oil/Gas Wells
- Power Plants
- Natural Gas Underground Storage
- Ethanol Plants
- Irrigation Structures
- NPDES
- 100 - Year FP
- Canals and Ditches
- Parcels
- Major Roads
- Local Roads
- Railroad
- CPW Public Access Properties
- CPW Walk In Access

South Platte River Restoration Master Plan

Map - 24



N
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0 1,000 2,000 4,000
Feet

Legend

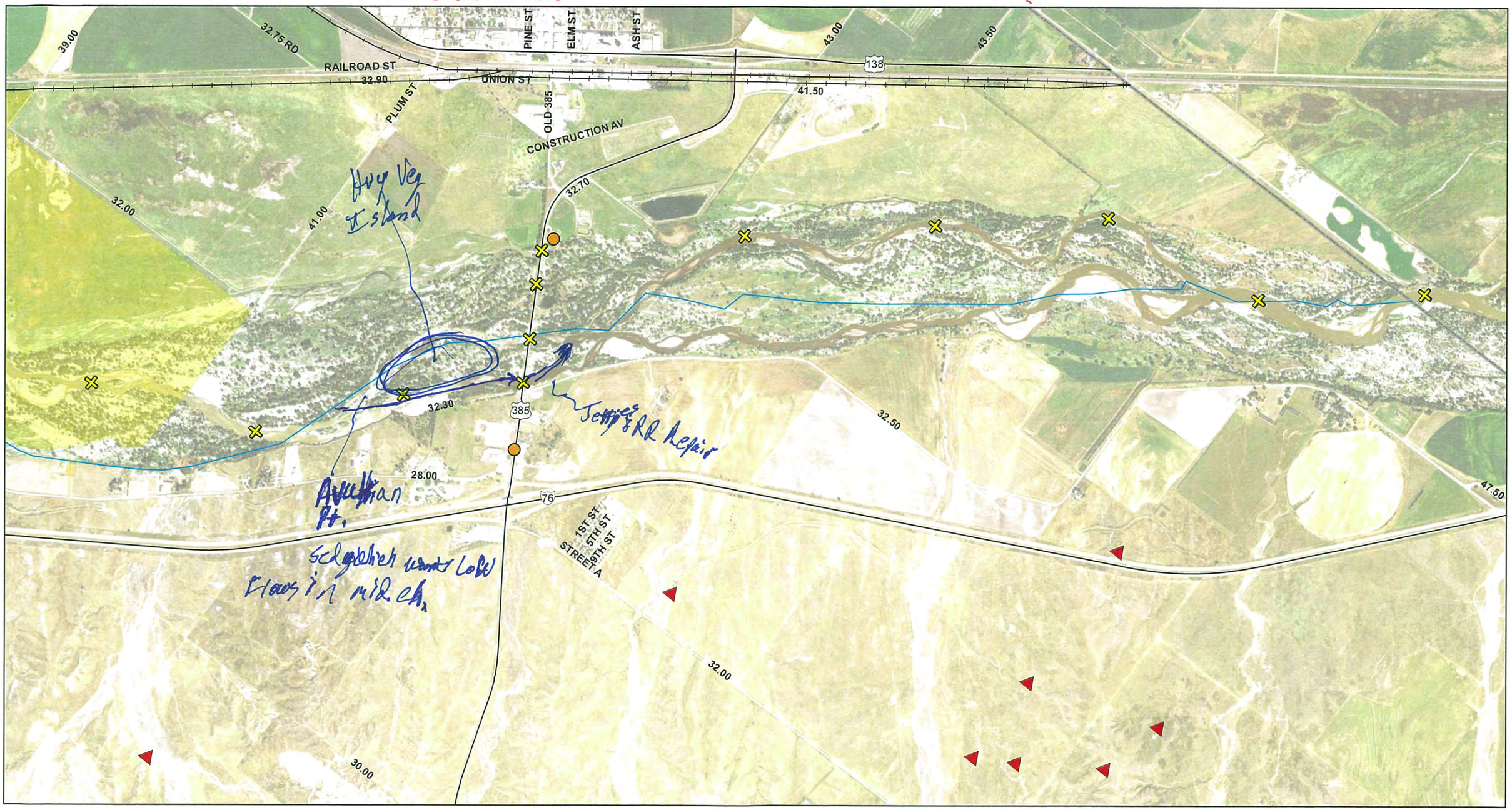
- CHAMP Survey Location
- Oil/Gas Wells
- Power Plants
- Natural Gas Underground Storage
- Ethanol Plants
- Irrigation Structures
- NPDES
- 100 - Year FP
- Canals and Ditches
- Parcels
- Major Roads
- Local Roads
- Railroad
- CPW Public Access Properties
- CPW Walk In Access

South Platte River Restoration Master Plan

Map - 25

JULESBURG

CO NE



Legend

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- Oil/Gas Wells
- Power Plants
- Natural Gas Underground Storage
- Ethanol Plants
- Irrigation Structures
- NPDES
- 100 - Year FP
- Canals and Ditches
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- Local Roads
- Railroad
- CPW Public Access Properties
- CPW Walk In Access

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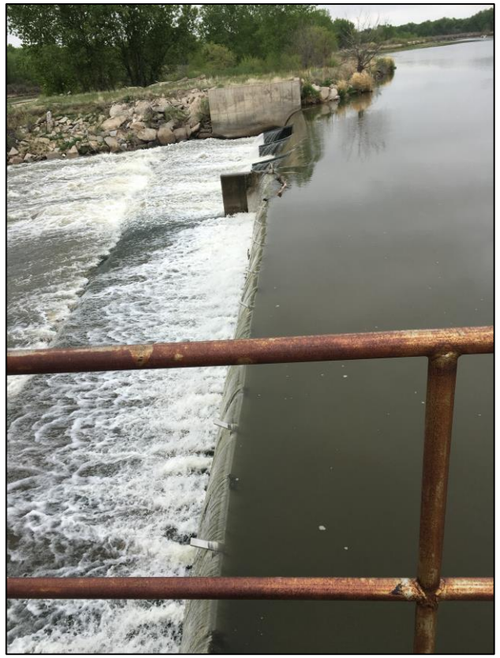
Feet

South Platte River Restoration Master Plan

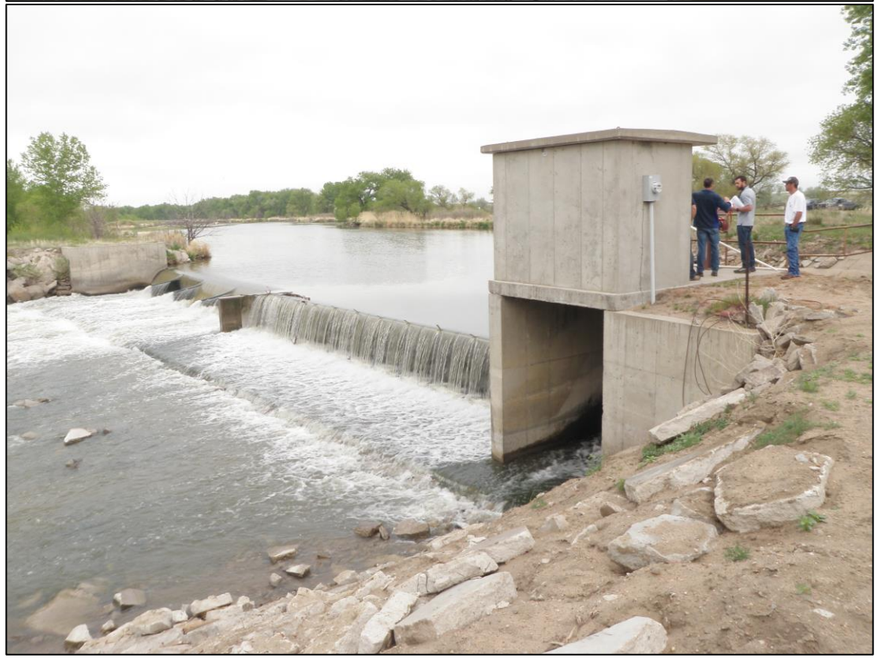
Map - 26

Reach 1

Reach 2



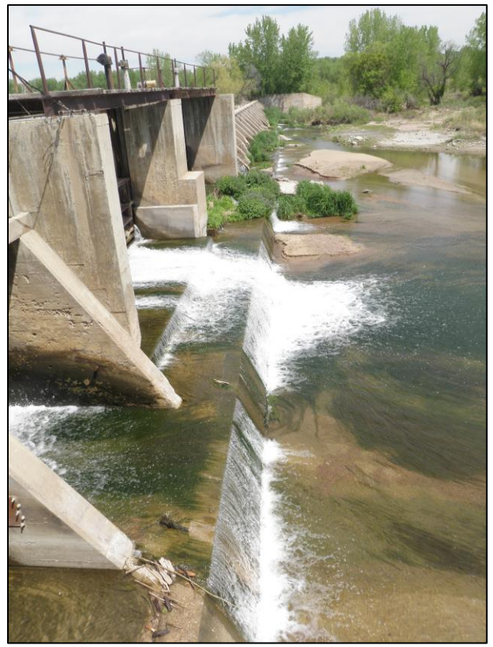
WELDON VALLEY
1997
DITCH COMPANY

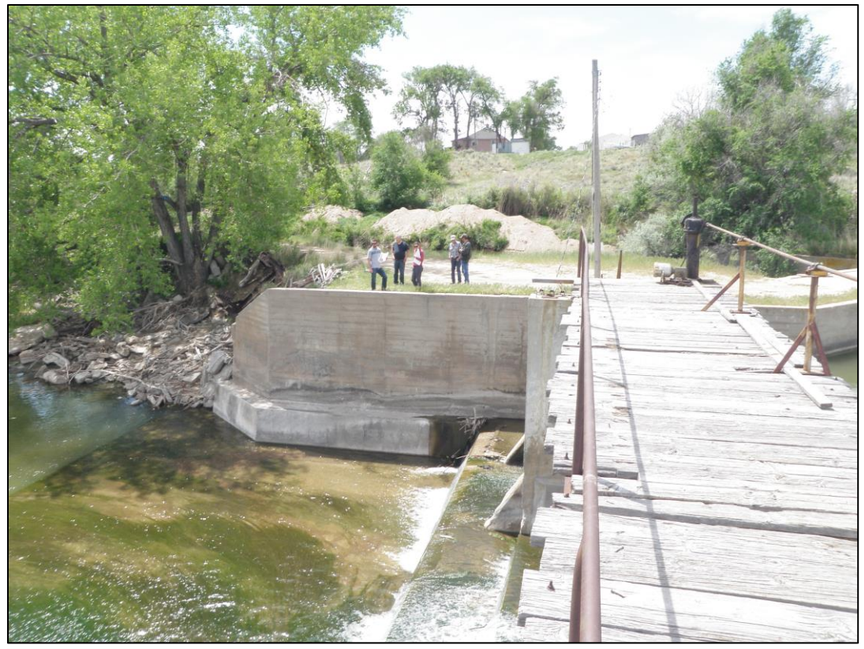


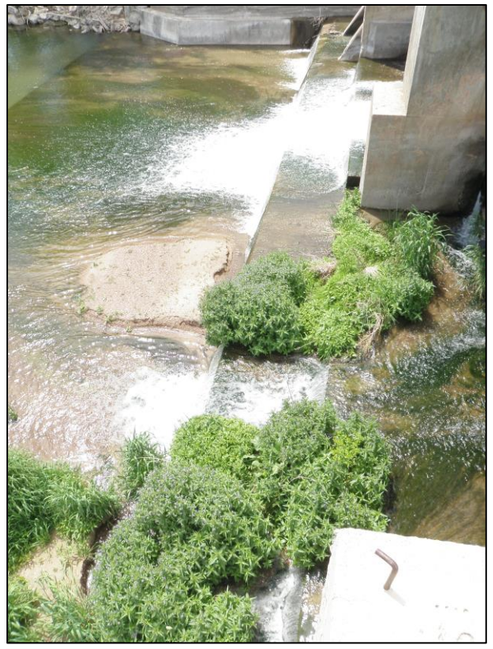
2012

Reach 3

Reach 4







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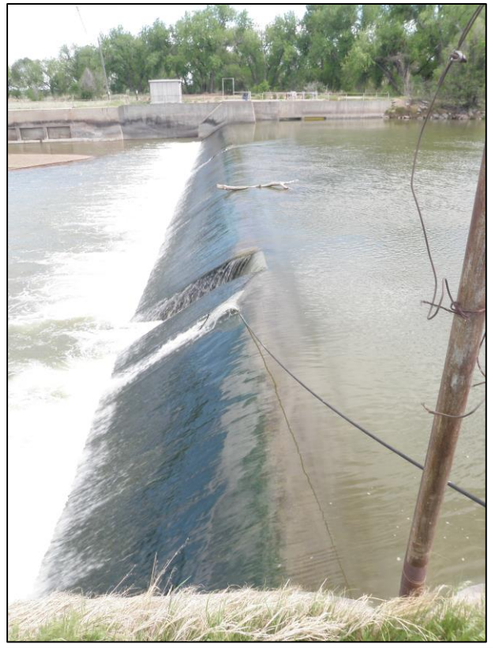
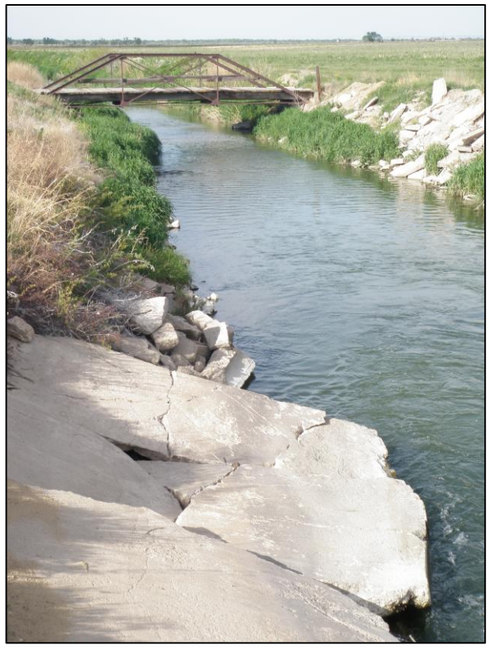


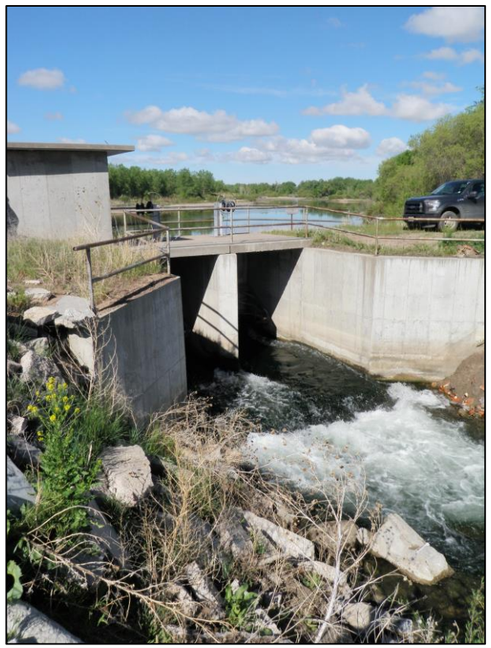
Reach 7

Reach 8



Reach 9

Reach 10



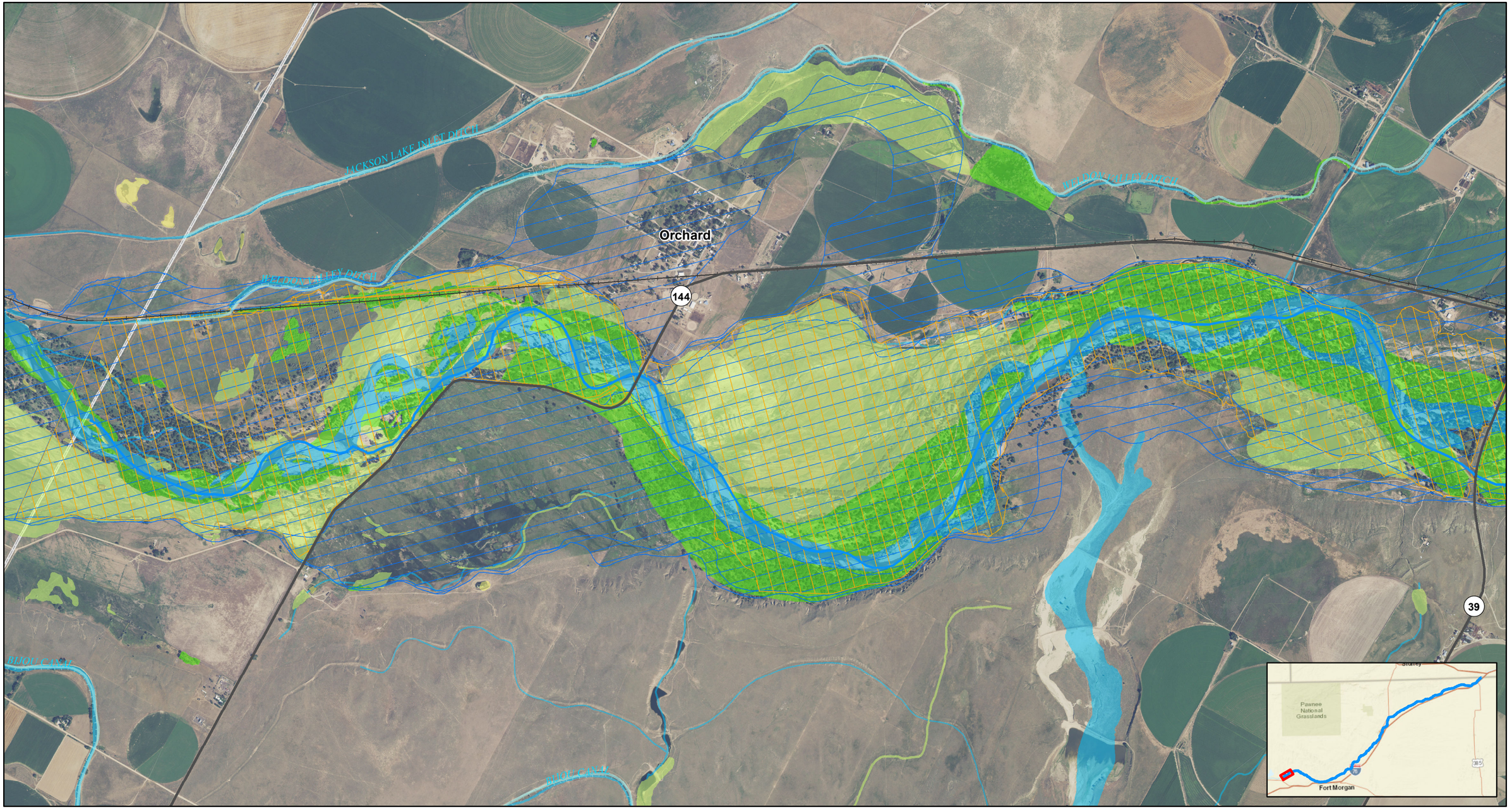
Reach 11

Reach 13

Reach 15

Reach 18

Appendix D
Hydrologic Data



Headgate
Oil & Gas Well
NPDES
South Platte River
Tributary
Canal
Interstate
Highway
Railroad
County Boundary
10-year Floodplain
100-year Floodplain

National Wetlands Inventory Feature
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Riverine
Other

0 0.5 1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure D-1: Hydrologic Data

Reach: 1

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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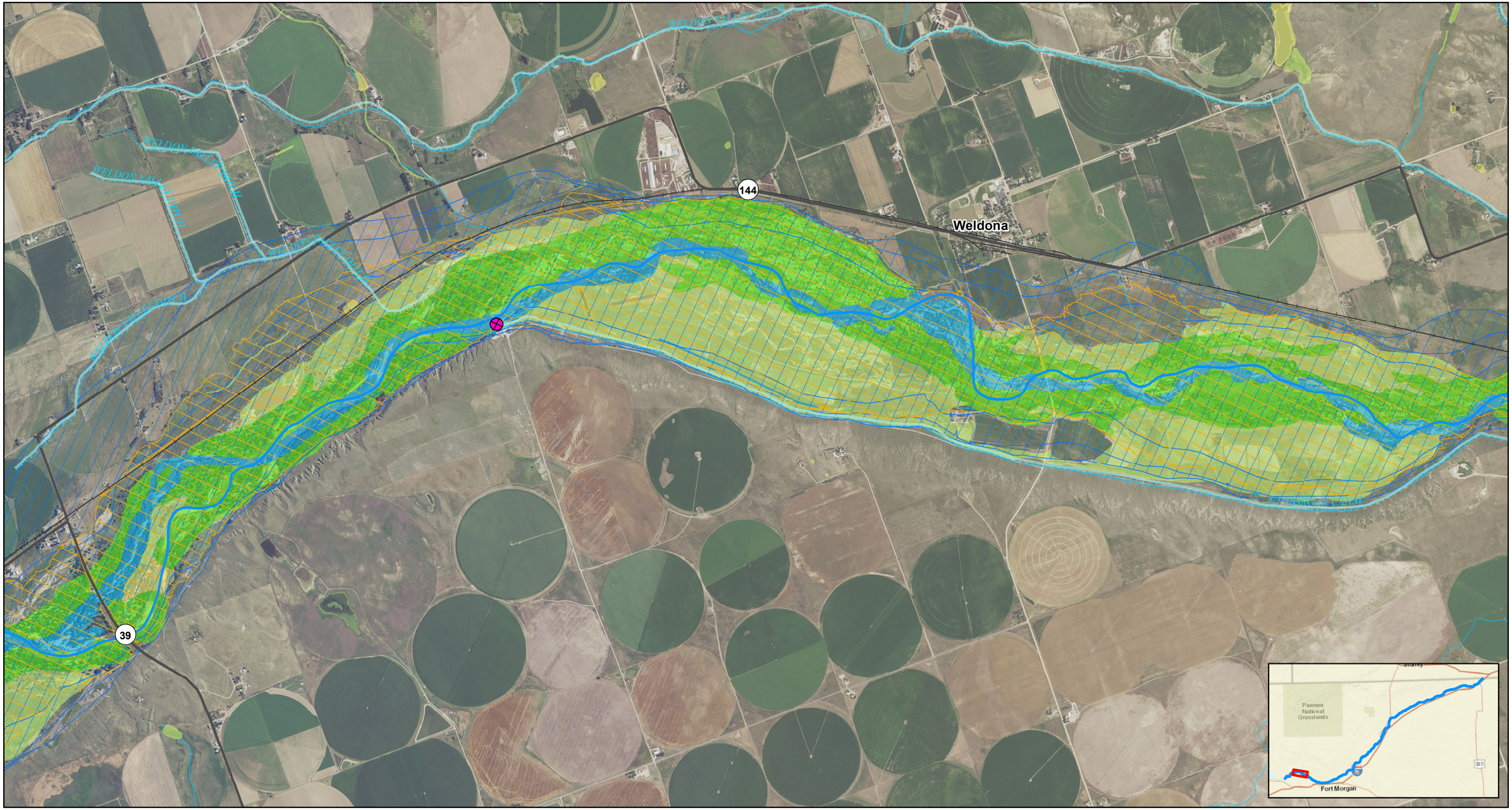

South Platte River Master Plan

Figure D-2: Hydrologic Data

Reach: 2

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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Headgate
Oil & Gas Well
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain

National Wetlands Inventory Feature
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond

Lake
Riverine
Other

0 0.5 1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure D-3: Hydrologic Data

Reach: 3

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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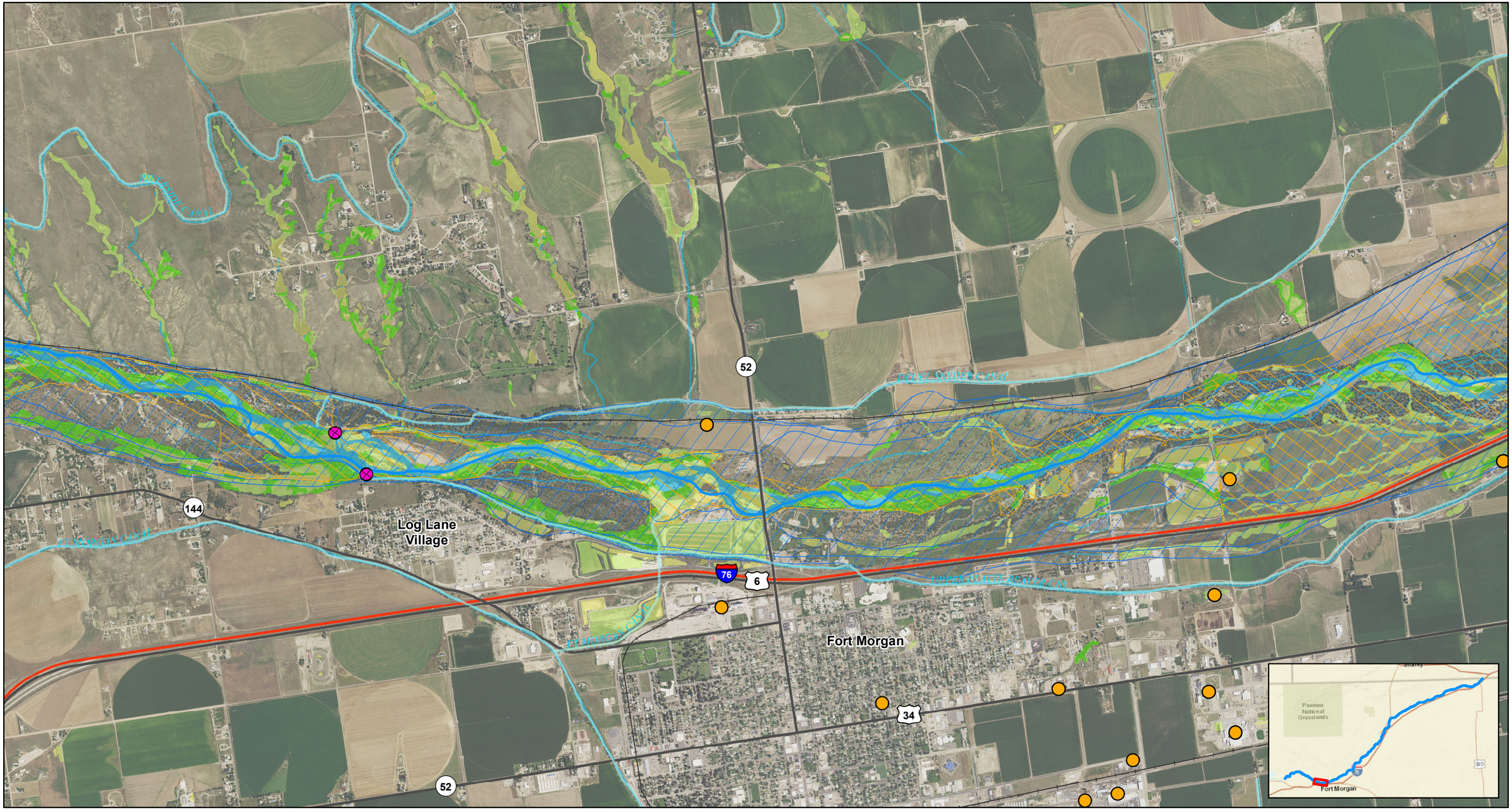

Headgate
Oil & Gas Well
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain

National Wetlands Inventory Feature
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Riverine
Other

N
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0.5
1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure D-4: Hydrologic Data

Reach: 4

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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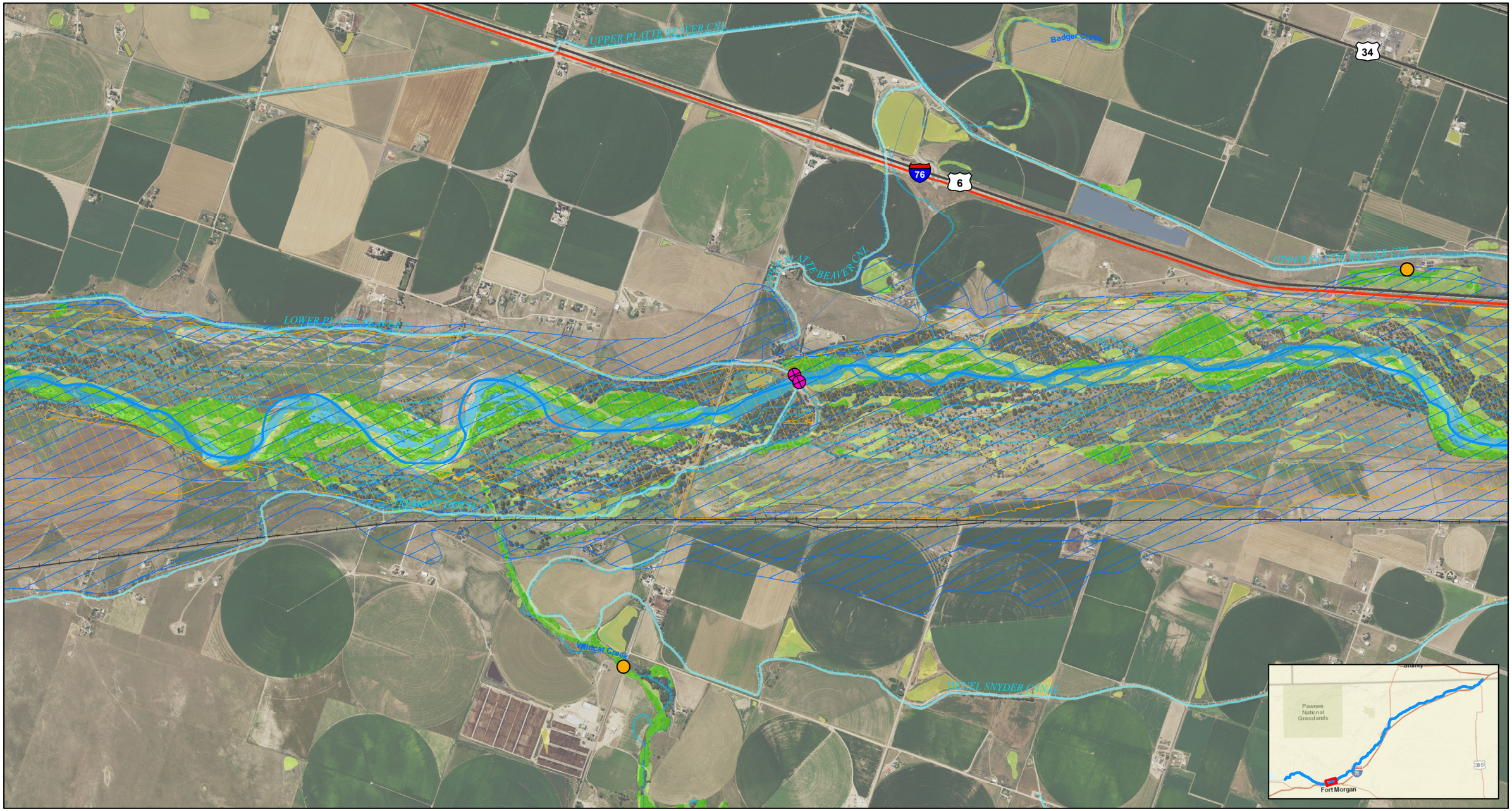

Headgate
Oil & Gas Well
NPDES
South Platte River
Tributary
Canal
Interstate
Highway
Railroad
County Boundary
10-year Floodplain
100-year Floodplain

National Wetlands Inventory Feature
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Riverine
Other

0 0.5 1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure D-5: Hydrologic Data

Reach: 5

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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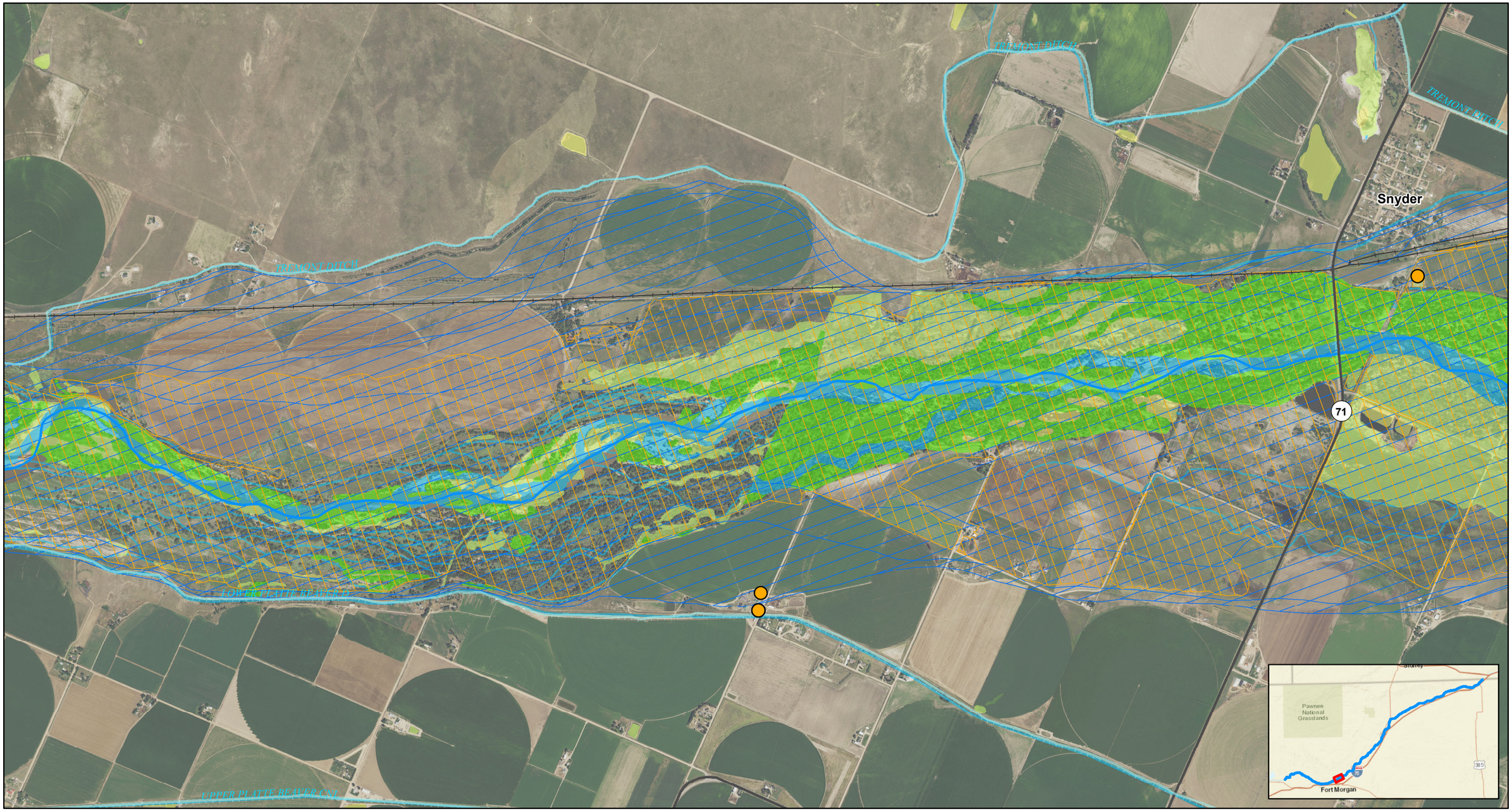

N
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Miles

USDA NAIP 2015

Headgate
Oil & Gas Well
NPDES
South Platte River
Tributary
Canal
Interstate
Highway
Railroad
County Boundary
10-year Floodplain
100-year Floodplain

National Wetlands Inventory Feature

Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Riverine
Other

South Platte River Master Plan

Figure D-6: Hydrologic Data

Reach: 6

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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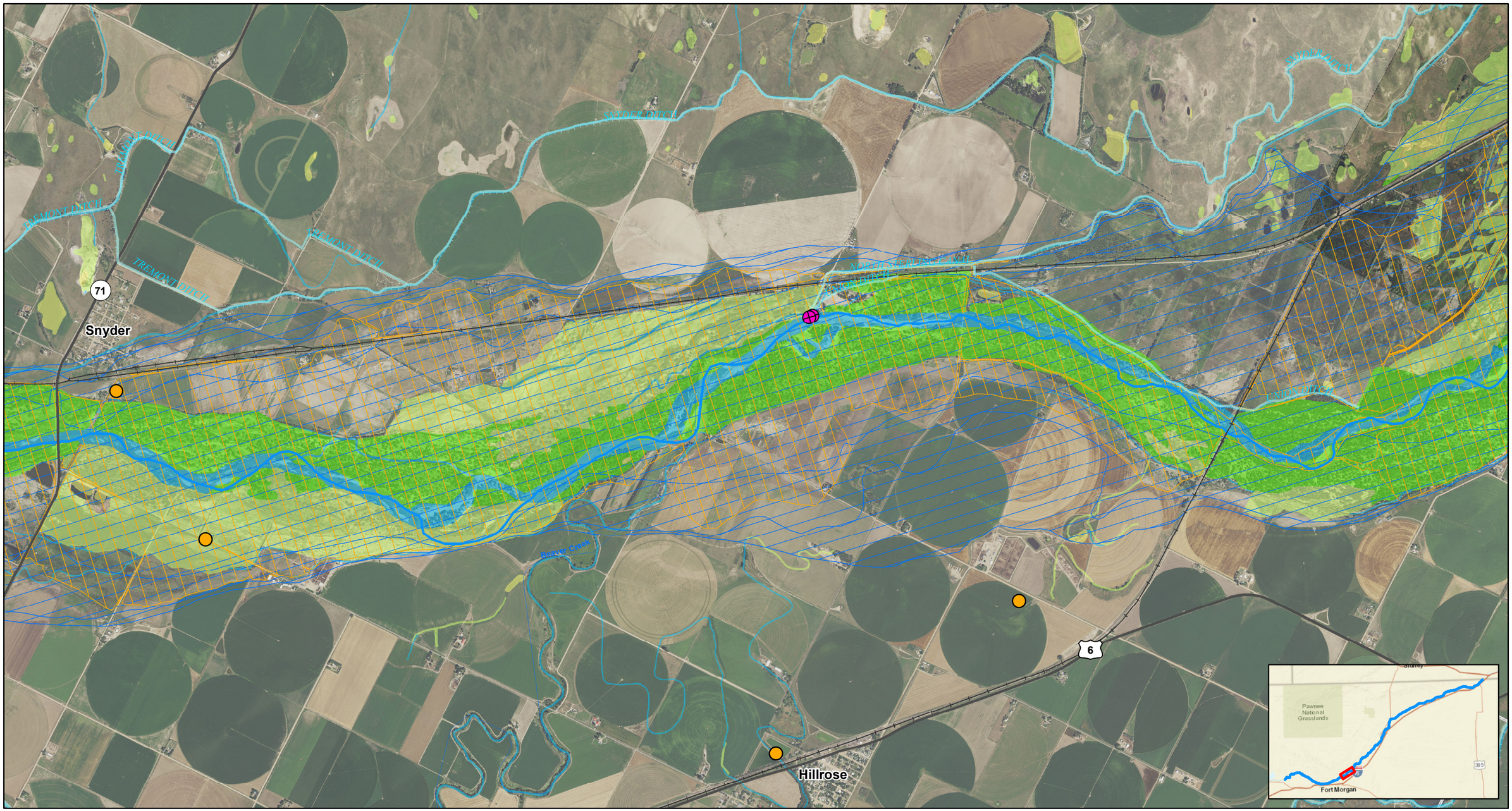

Headgate
Oil & Gas Well
NPDES
South Platte River
Tributary
Canal
Interstate
Highway
Railroad
County Boundary
10-year Floodplain
100-year Floodplain

National Wetlands Inventory Feature
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Riverine
Other

N W E S

0 0.5 1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure D-7: Hydrologic Data

Reach: 7

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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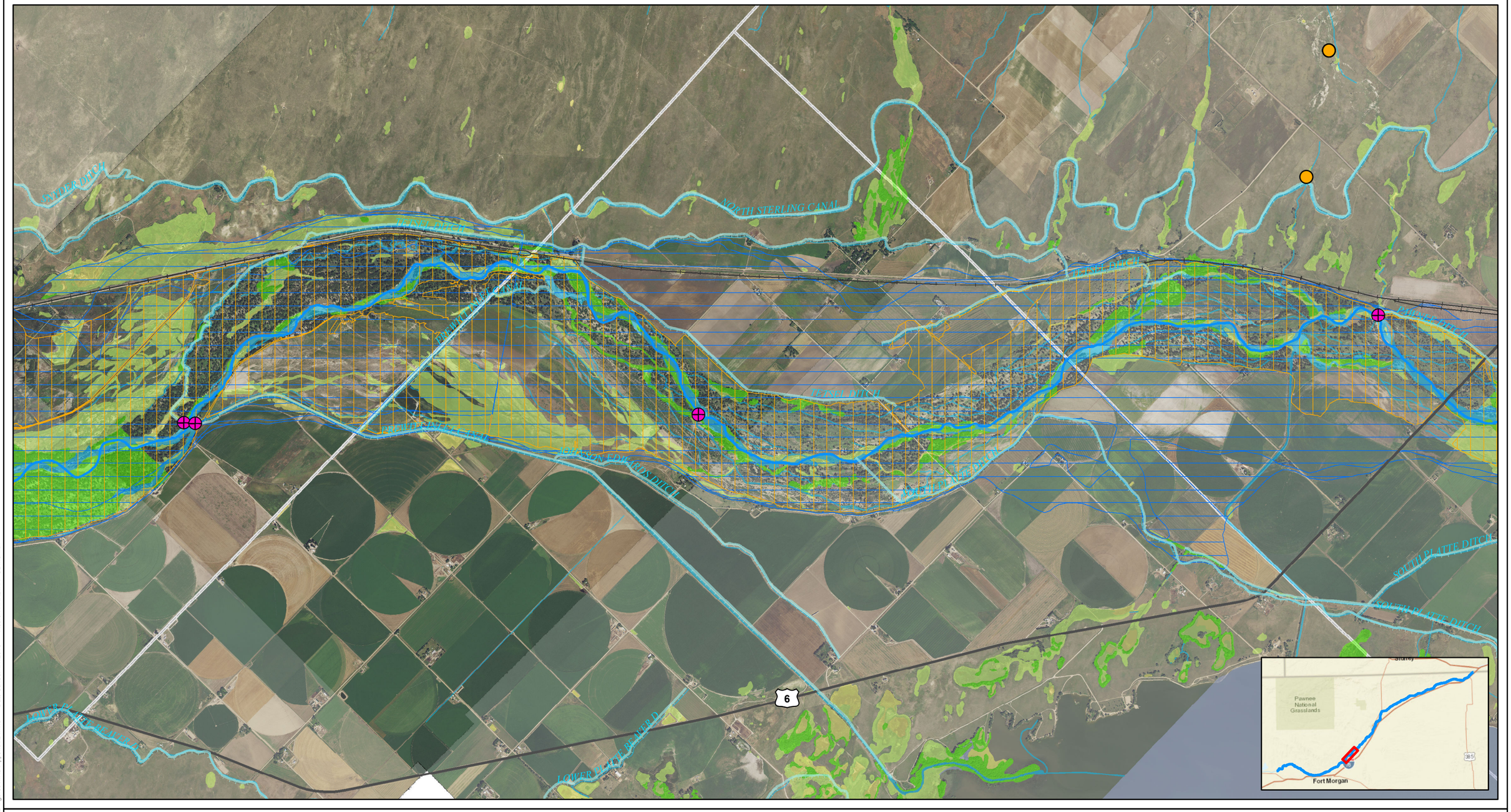

South Platte River Master Plan

Figure D-8: Hydrologic Data

Reach: 8

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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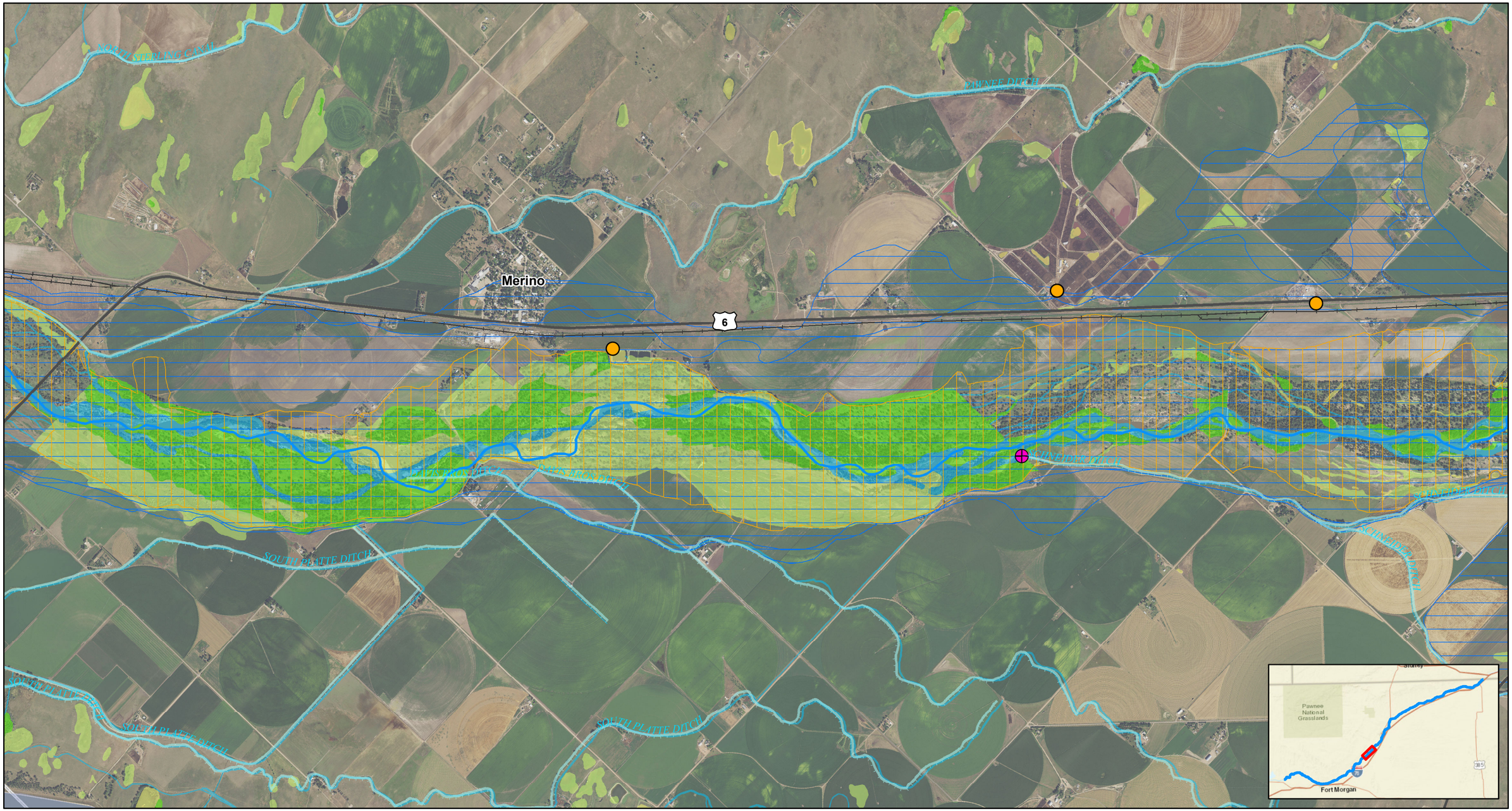

Headgate
Oil & Gas Well
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain

National Wetlands Inventory Feature
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond

Lake
Riverine
Other

0 0.5 1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure D-9: Hydrologic Data

Reach: 9

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

CDM Smith

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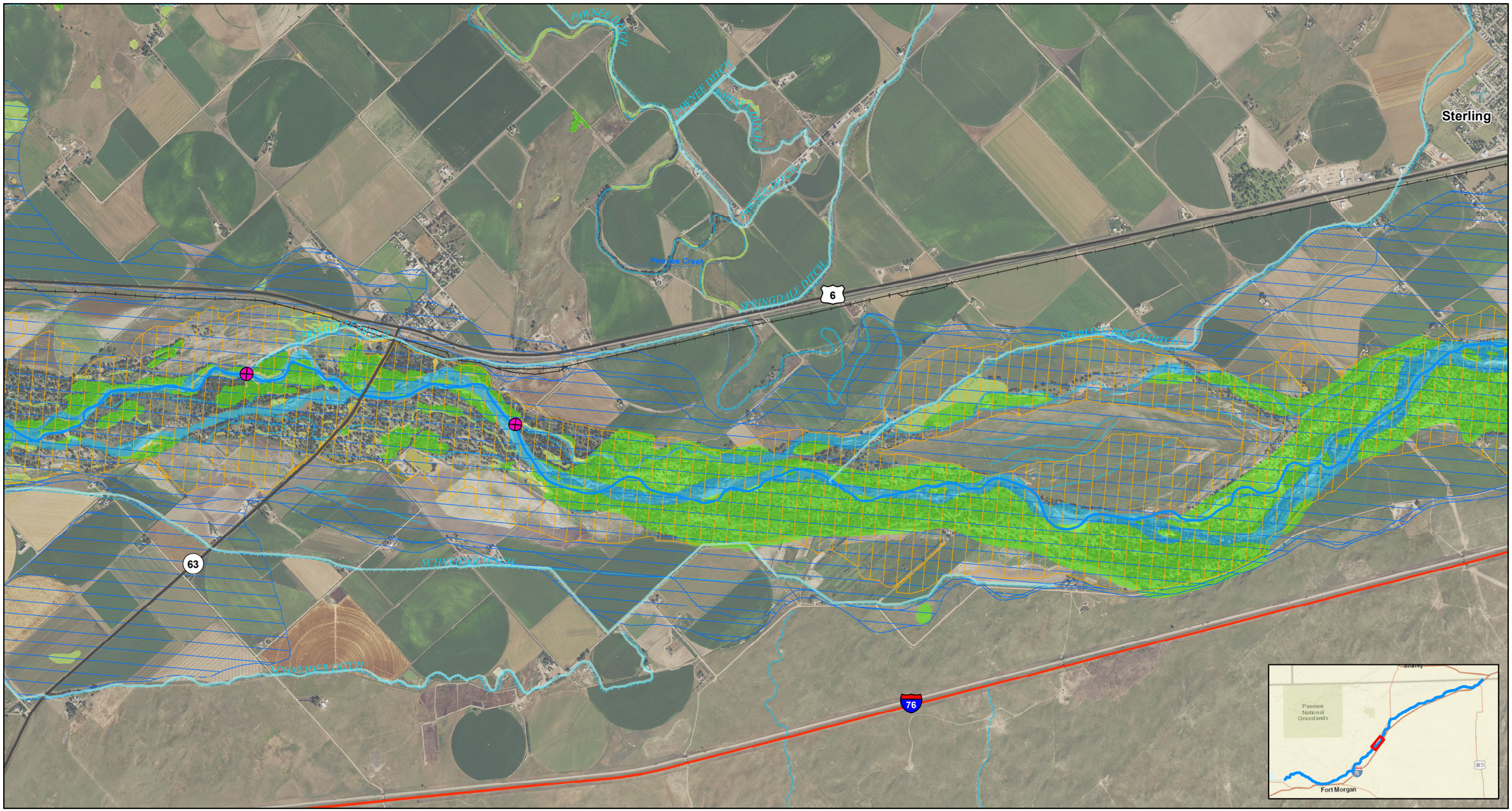

Headgate
Oil & Gas Well
NPDES
South Platte River
Tributary
Canal
Interstate
Highway
Railroad
County Boundary
10-year Floodplain
100-year Floodplain

National Wetlands Inventory Feature
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Riverine
Other

0 0.5 1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure D-10: Hydrologic Data

Reach: 10

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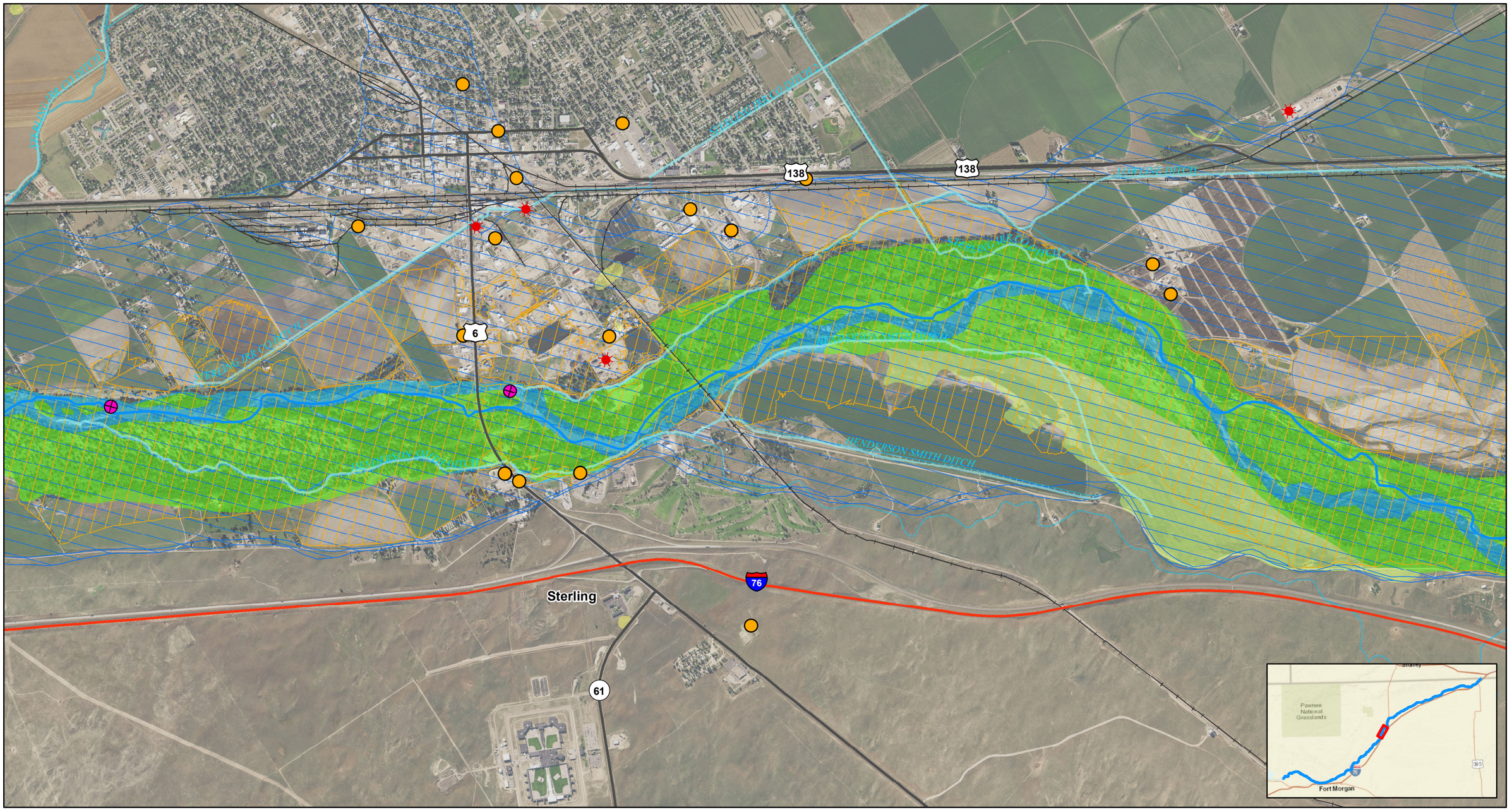

Headgate
Oil & Gas Well
NPDES
South Platte River
Tributary
Canal
Interstate
Highway
Railroad
County Boundary
10-year Floodplain
100-year Floodplain

National Wetlands Inventory Feature
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Riverine
Other

0 0.5 1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure D-11: Hydrologic Data

Reach: 11

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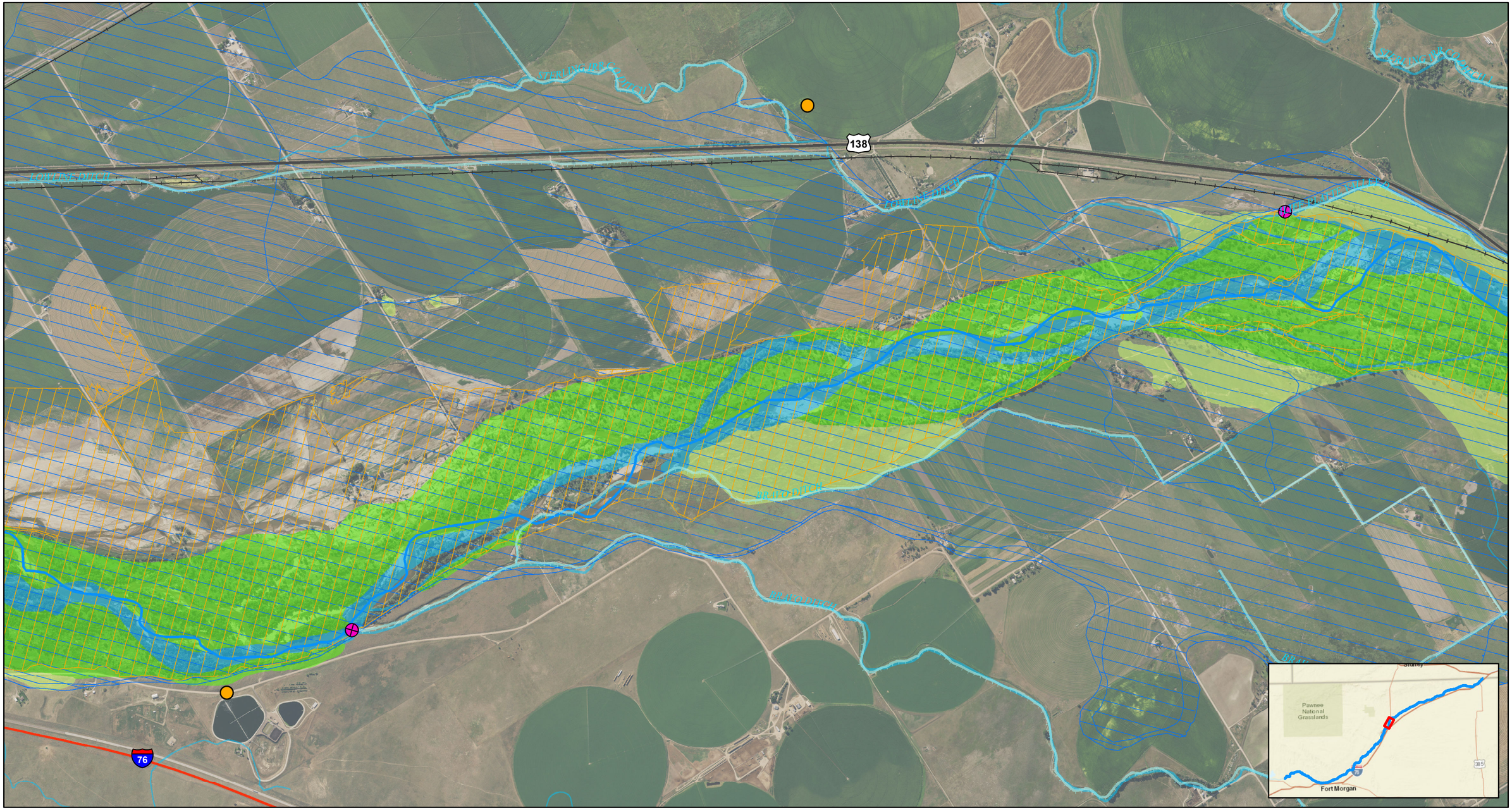

Headgate
Oil & Gas Well
NPDES
South Platte River
Tributary
Canal
Interstate
Highway
Railroad
County Boundary
10-year Floodplain
100-year Floodplain

National Wetlands Inventory Feature
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Riverine
Other

0 0.5 1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure D-12: Hydrologic Data

Reach: 12

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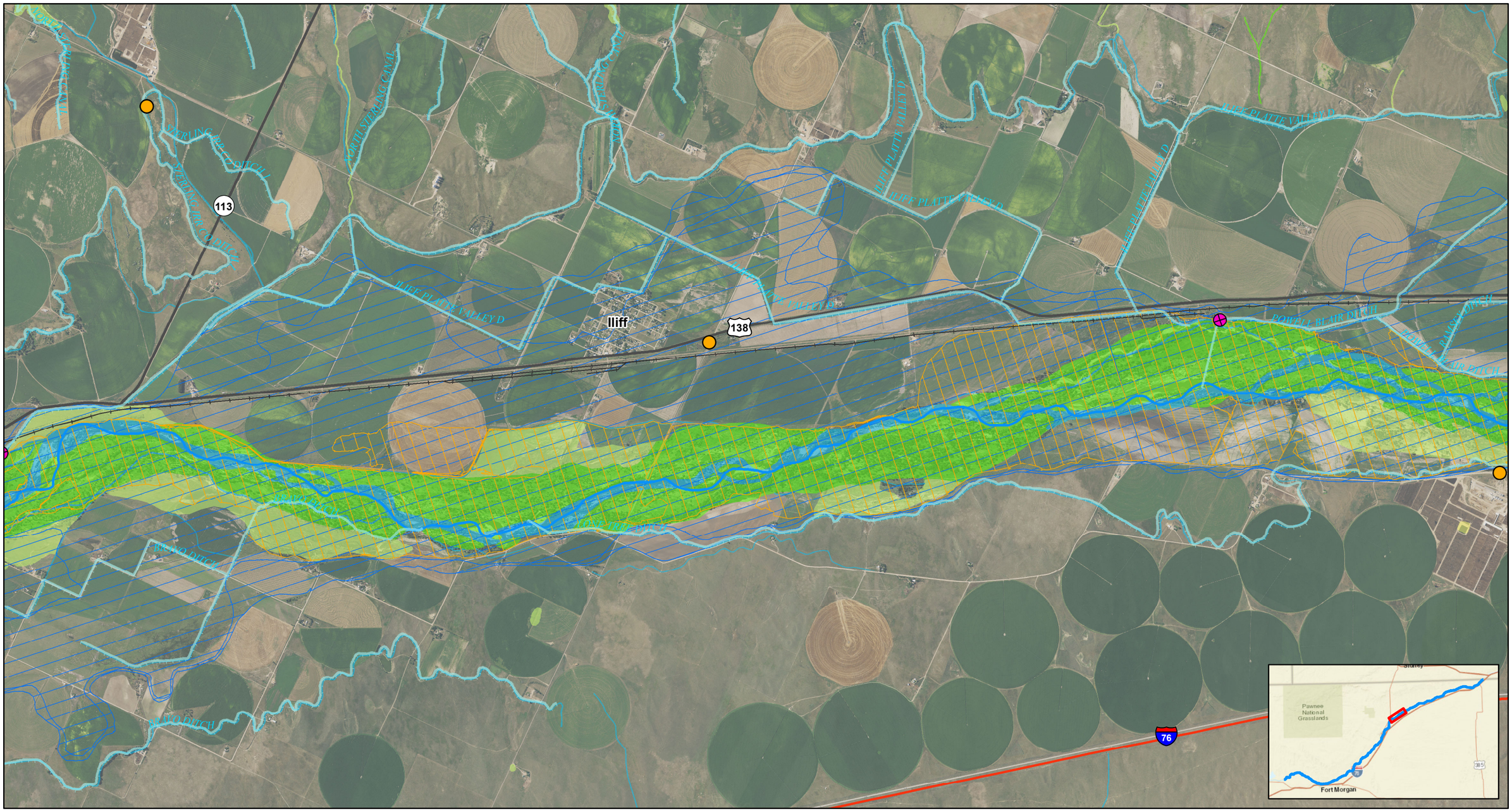
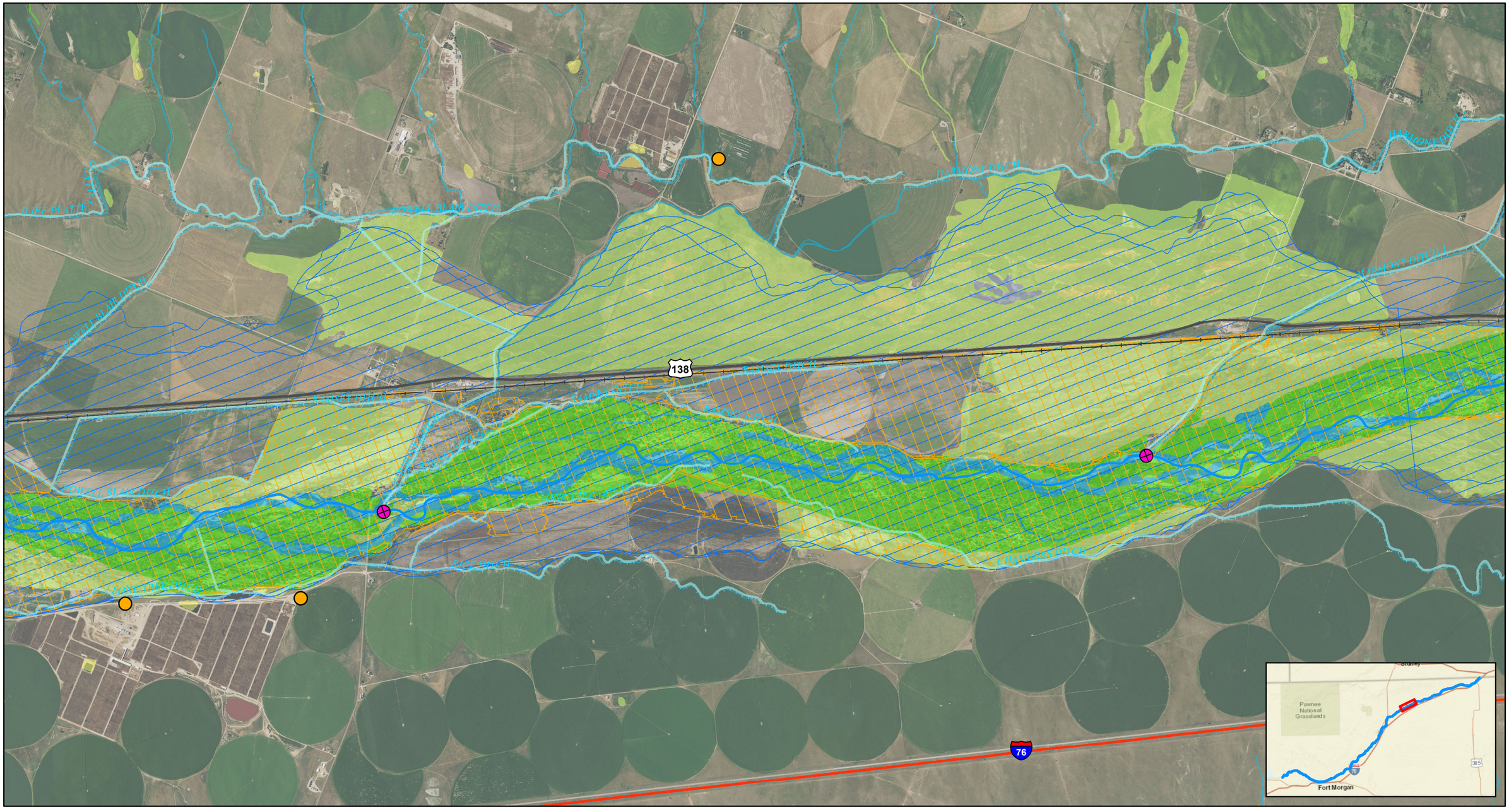

SOUTH PLATTE RIVER
SOUTH PLATTE RIVER
SOUTH PLATTE RIVER


LEE PLATTE
POWELL BLUE DITCH
POWELL BLUE DITCH
HARMONY DITCH
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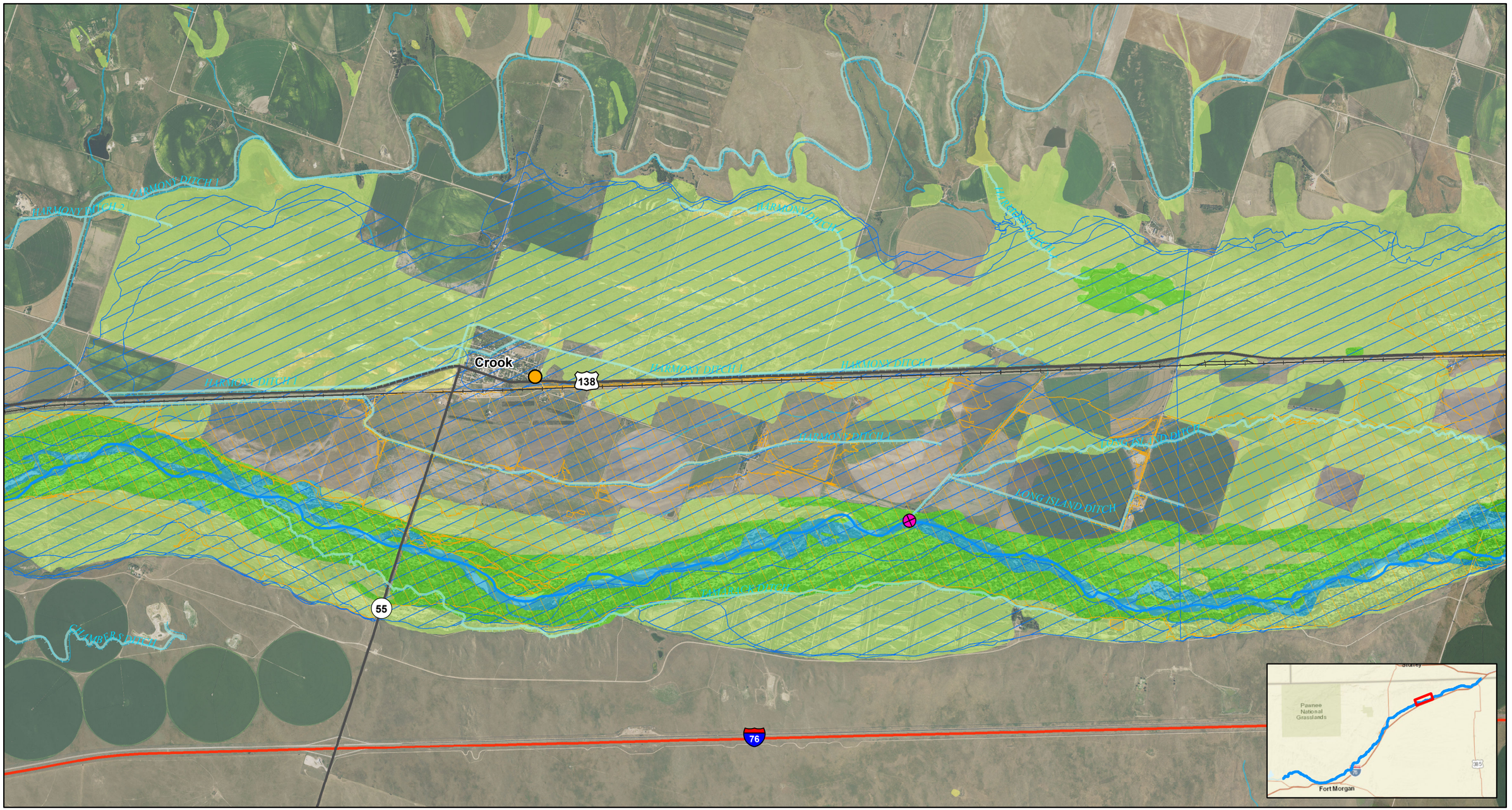
138
POWELL DITCH
POWELL DITCH
POWELL DITCH



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USDA NAIP 2015

Headgate
Oil & Gas Well
NPDES
South Platte River
Tributary
Canal
Interstate
Highway
Railroad
County Boundary
10-year Floodplain
100-year Floodplain

National Wetlands Inventory Feature
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Riverine
Other

South Platte River Master Plan

Figure D-15: Hydrologic Data

Reach: 15

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Headgate
Oil & Gas Well
NPDES
South Platte River
Tributary
Canal
Interstate
Highway
Railroad
County Boundary
10-year Floodplain
100-year Floodplain

National Wetlands Inventory Feature
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Riverine
Other

N W E S

0 0.5 1
Miles

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South Platte River Master Plan

Figure D-16: Hydrologic Data

Reach: 16

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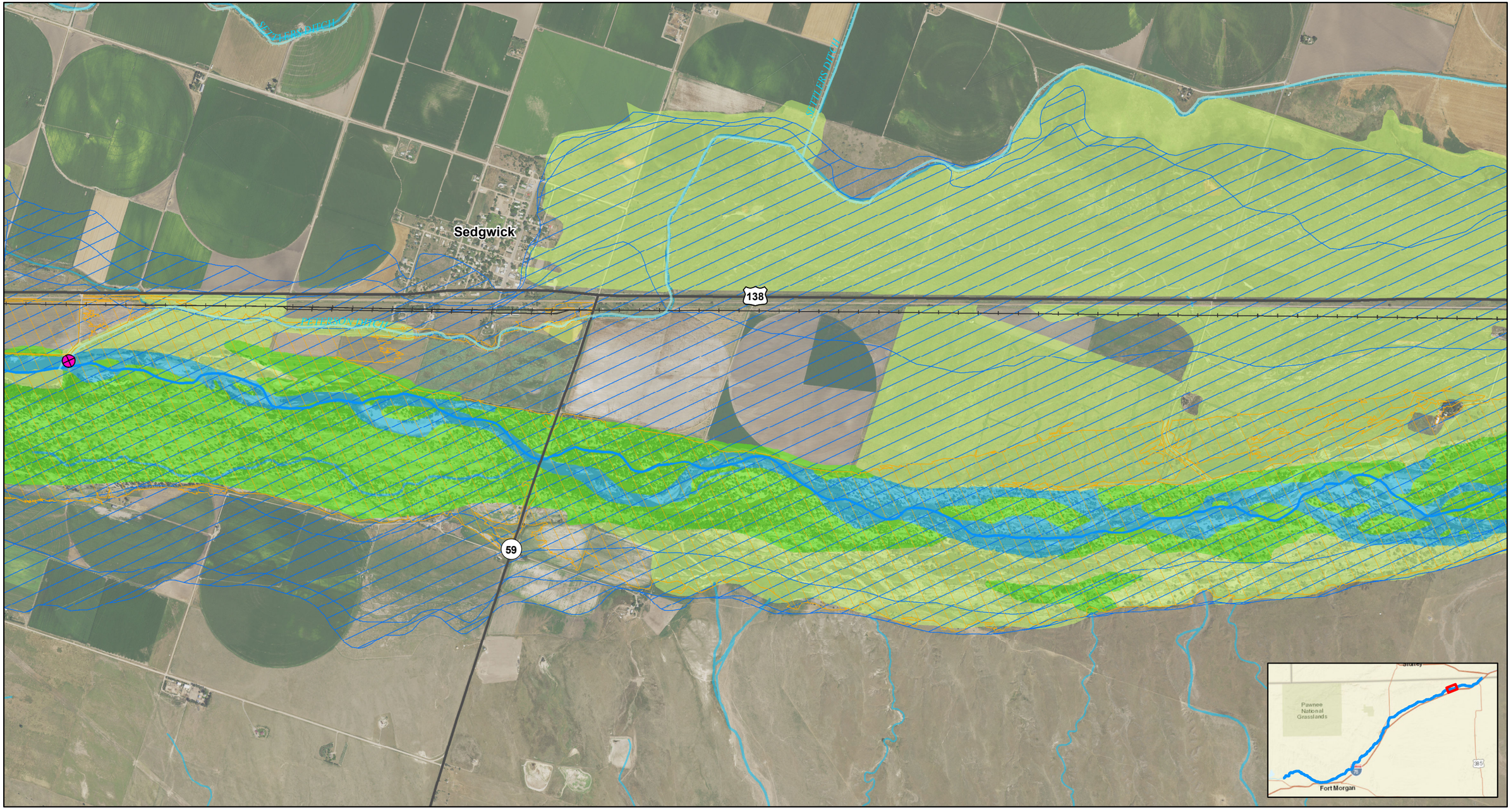

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Miles

USDA NAIP 2015

Headgate
Oil & Gas Well
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain

National Wetlands Inventory Feature
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond

Lake
Riverine
Other

South Platte River Master Plan

Figure D-17: Hydrologic Data

Reach: 17

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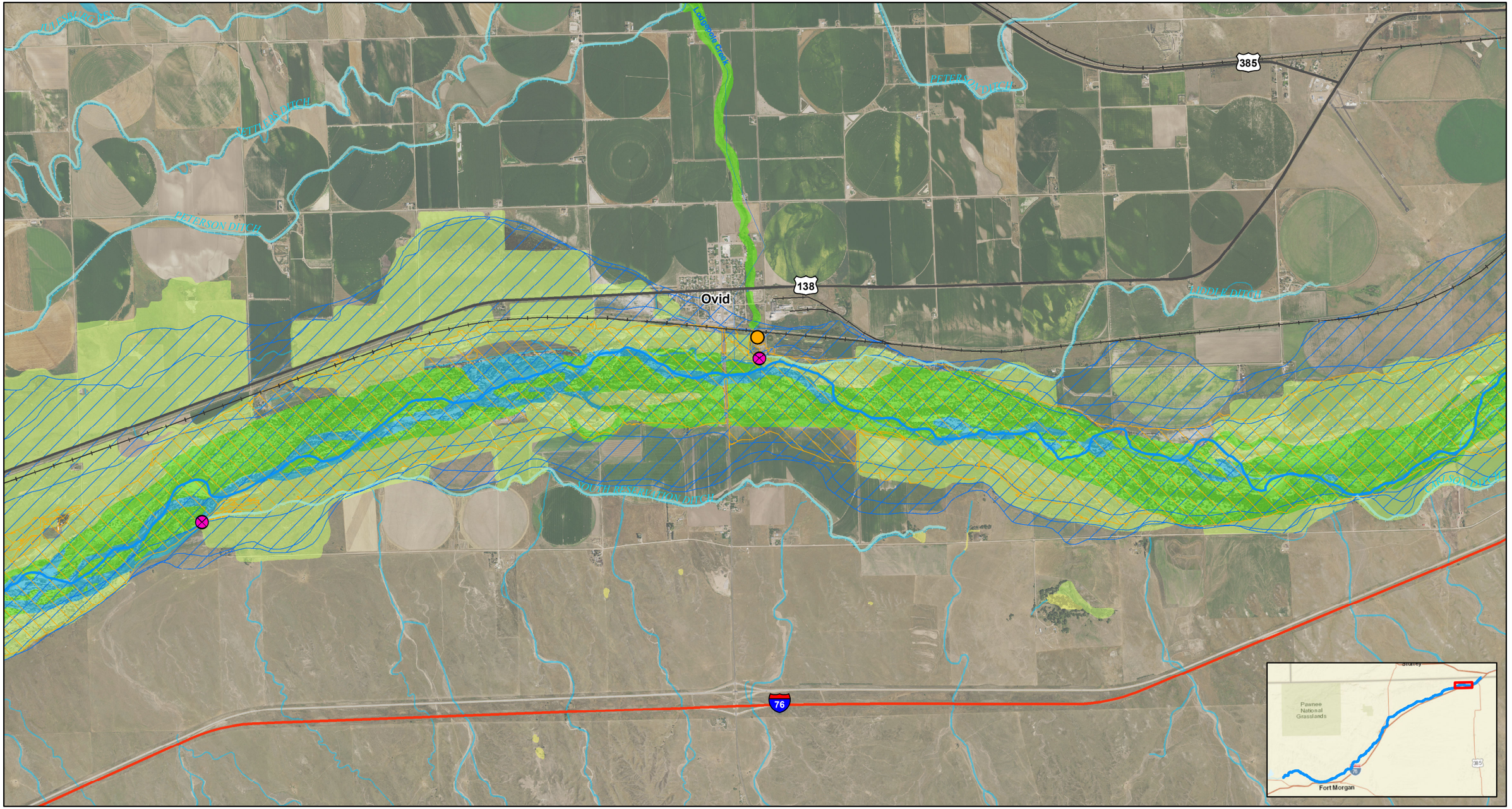

N
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0 0.5 1
Miles

USDA NAIP 2015

Headgate
Oil & Gas Well
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain

National Wetlands Inventory Feature
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond

Lake
Riverine
Other

South Platte River Master Plan

Figure D-18: Hydrologic Data

Reach: 18

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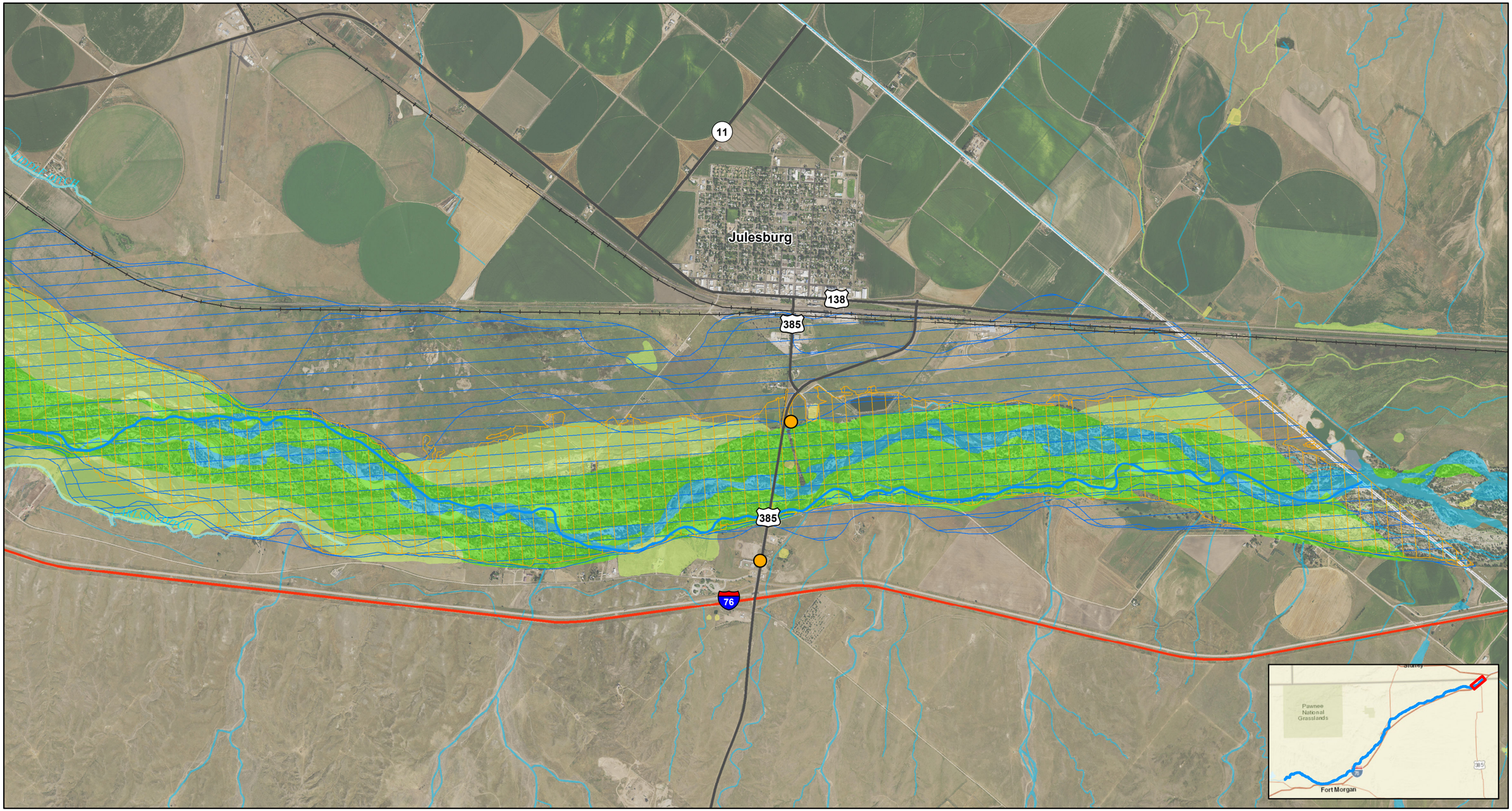

Headgate
Oil & Gas Well
NPDES
South Platte River
Tributary
Canal
Interstate
Highway
Railroad
County Boundary
10-year Floodplain
100-year Floodplain

National Wetlands Inventory Feature
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Riverine
Other

0 0.5 1
Miles

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Figure D-19: Hydrologic Data

Reach: 19

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Appendix E

Effective Discharge and Stream Power

C.1 Introduction

Effective discharge is commonly defined as the discharge that transports the largest portion of the annual sediment yield over a period of years (Andrews 1980). CDM Smith performed an effective discharge calculation for the lower South Platte River near Fort Morgan to predict the impact of alteration of watershed conditions with respect to sediment loads and hydrology on channel stability.

C.2 Frequency of Occurrence

To calculate the effective discharge, a curve describing the relationship between frequency of occurrence and discharge was developed. Daily peak discharges were used from the South Platte River near Weldona USGS gage. This analysis requires that the curve have only a single peak, and a bin analysis was executed to generate this curve. A bin size of 100 cfs produced a curve with a single peak. Smaller bin sizes produced curves with multiple peaks (**Figure E-1**).

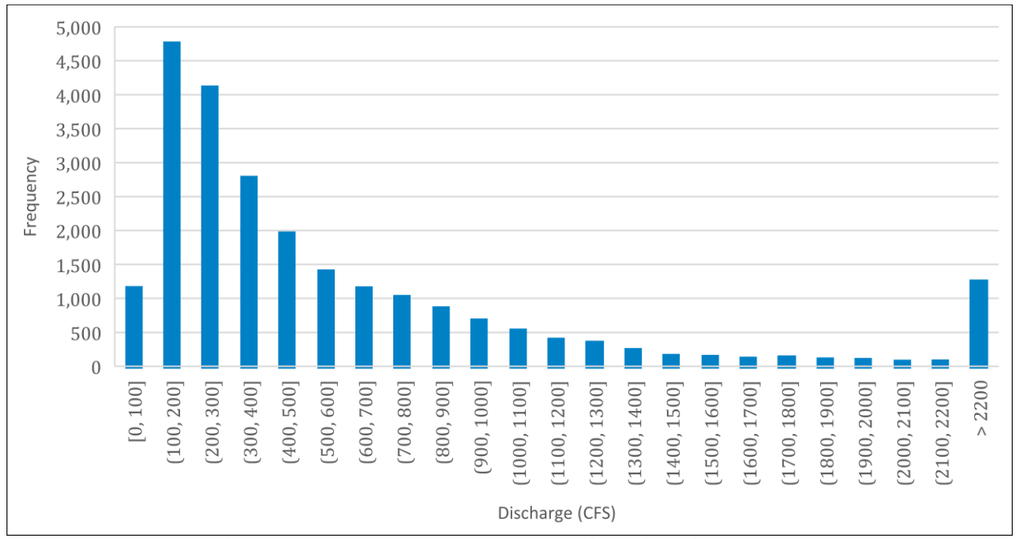


Figure E-1: Frequency of Occurrence a the USGS Weldona Gage (100 cfs Bin)

C.3 Transport Rate

The upstream side of the Colorado State Highway 52 bridge in Fort Morgan was selected to evaluate transport rates within the project area. Using the Draft CHAMP HEC- RAS model developed by CWCB, cross section 1105586 was selected and the Hydraulic Design feature in HEC-RAS was used to calculate the sediment transport capacity using the Ackers-White equation. The analysis leveraged sediment gradations developed from the South Platte River Sediment Transport Modeling and Project Feasibility Study (CDM Smith 2016), which consisted primarily of medium and coarse sand. The gradations from the middle South Platte River in that study were consistent with the lower South Platte River sediment gradations based on field observations performed as part of this Master Plan. The small fraction of gravel comprising the sediment gradations were excluded from the HEC-RAS gradation input as these grain sizes are outside the applicable range of the transport equation, and the dominant transport mechanism was assumed to be suspended load. This calculation is also sensitive to variations in water temperature and was therefore run using three different temperature scenarios: 55° F, 65° F, and 75° F, which represent typical water temperatures along the South Platte River.

The HEC-RAS model was developed to run using the flows determined by the midpoint of each of the bin sizes previously calculated. For example, the flow input incorporated for the 0-100 cfs bin was 50 cfs. Running the HEC-RAS model produced the sediment transport rate at the specified cross section location under different flow rates (**Figure E-2**).

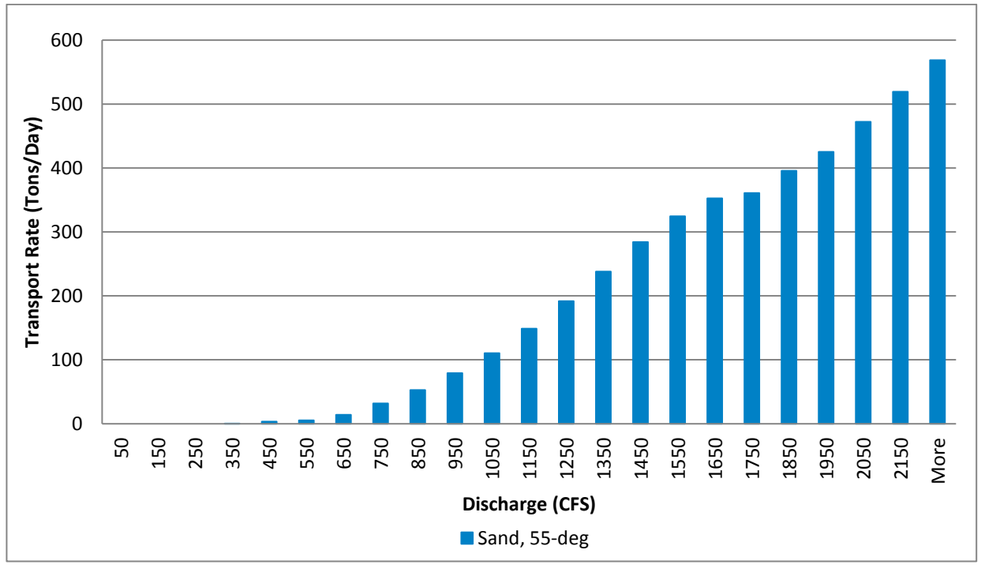


Figure E-2: Transport Rate Upstream of Colorado State Highway 55

C.4 Effective Discharge

Effective discharge is the product of the magnitude of the sediment transport rate and the frequency of discharge. By multiplying the curves described in the previous 2 sections, the effective discharge curve can be plotted. The peak of this curve is the effective discharge. Each curve developed in the sensitivity analysis of the sediment transport rate was tested to see if it changed the effective discharge. In all cases the effective discharge remained the same. The resulting effective discharge calculated is between 1,200 and 1,300 cfs (**Figure E-3**). This range of flows is approximately equal to the 1-year flow calculated at the Weldona Gage. Typical effective discharges are closer to the 2-year flood. The low to moderate flows indicate that recurrence intervals associated with effective discharges are on the low end of the 1- to 3- year recurrence intervals commonly reported in other studies. However, the high recurrence interval is probably representative of the large watershed, and recurrence intervals of effective discharges in smaller watersheds could be quite different. Note that the effective discharge is not typically a discharge associated with the most extreme flood events, which may carry large amounts of sediment load butoccur infrequently.

An effective discharge corresponding to the 1-year event suggests that more moderate flows (less than the bankfull flow) transport the most sediment over time. This could be an indication of an imbalance between the channel geometry and the current hydrologic and sediment regime. Channel instability is the result of an imbalance in

sediment supply and transport capacity as the river attempts to achieve “dynamic equilibrium” between the sediment supply and transport capacity by adjusting its geometry, slope, planform, and sediment gradations. If the river were stable, excessive erosion or deposition would not occur over long periods of time. Per the preliminary analysis results shown in Figure 4-7, the lower South Platte River is relatively unstable, which results in more sediment being eroded from source areas (i.e. upstream watershed, steep-slope reaches, stream bed & banks, etc.) and more sediment being deposited in depositional areas (i.e. mild-slope reaches, confluences, bridge crossings, etc.) than one would typically find in a more stable river system.

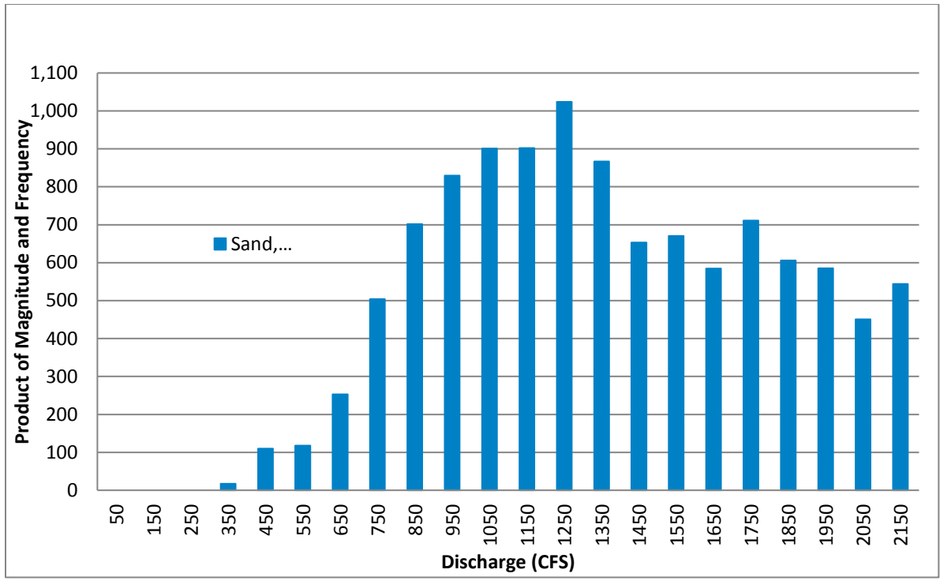


Figure E-3: Effective Discharge Upstream of Colorado State Highway 52 in Fort Morgan

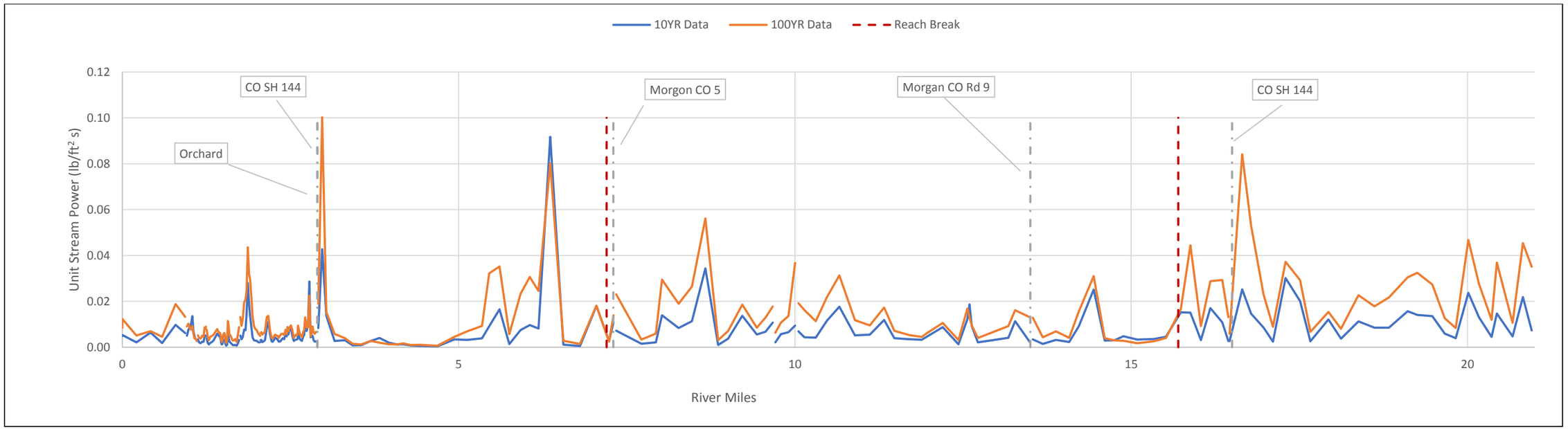


Figure E-4: Stream Power throughout Reaches 1, 2, and 3

[1] River miles from the Weld-Morgan county line

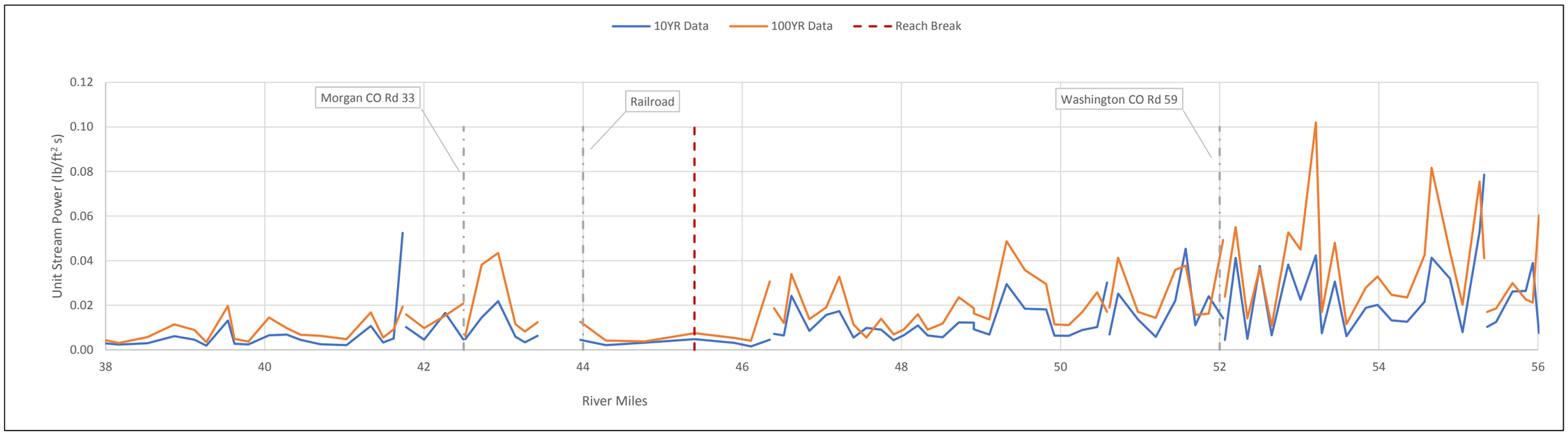


Figure E-5: Stream Power throughout Reaches 7 and 8

[1] River miles from the Weld-Morgan county line

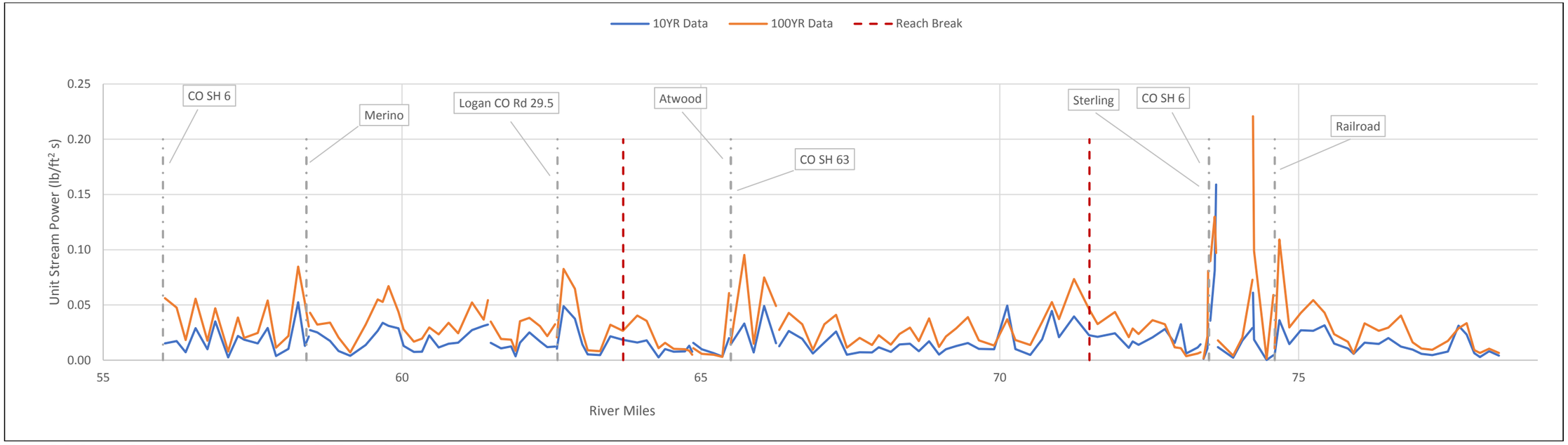


Figure E-6: Stream Power throughout Reaches 9, 10, and 11

[1] River miles from the Weld-Morgan county line

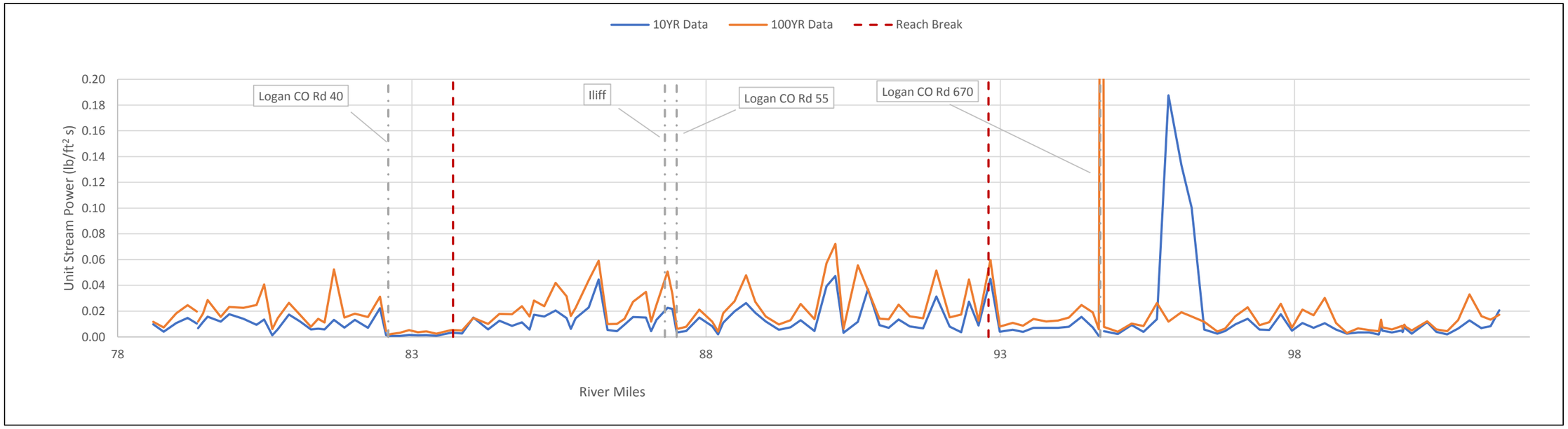


Figure E-7: Stream Power throughout Reaches 12, 13, and 14

[1] River miles from the Weld-Morgan county line

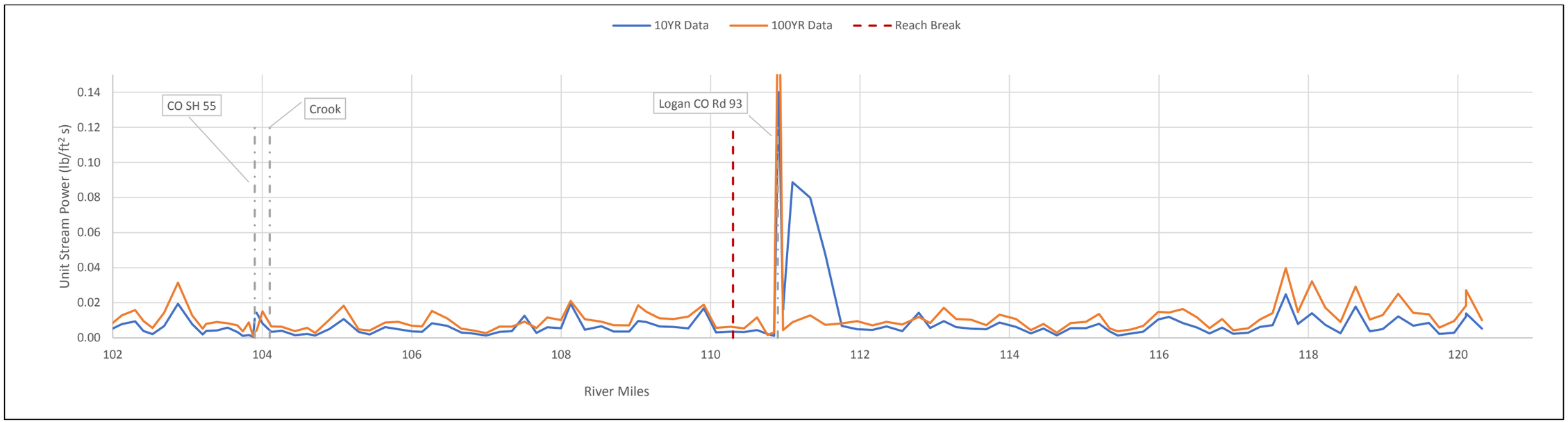


Figure E-8: Stream Power throughout Reaches 15 and 16

[1] River miles from the Weld-Morgan county line

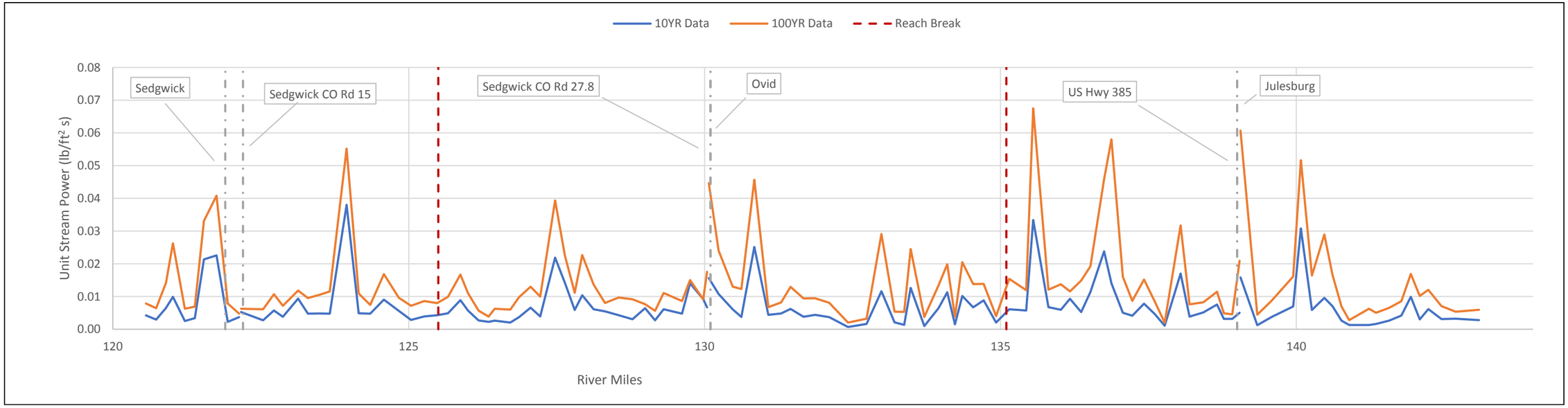
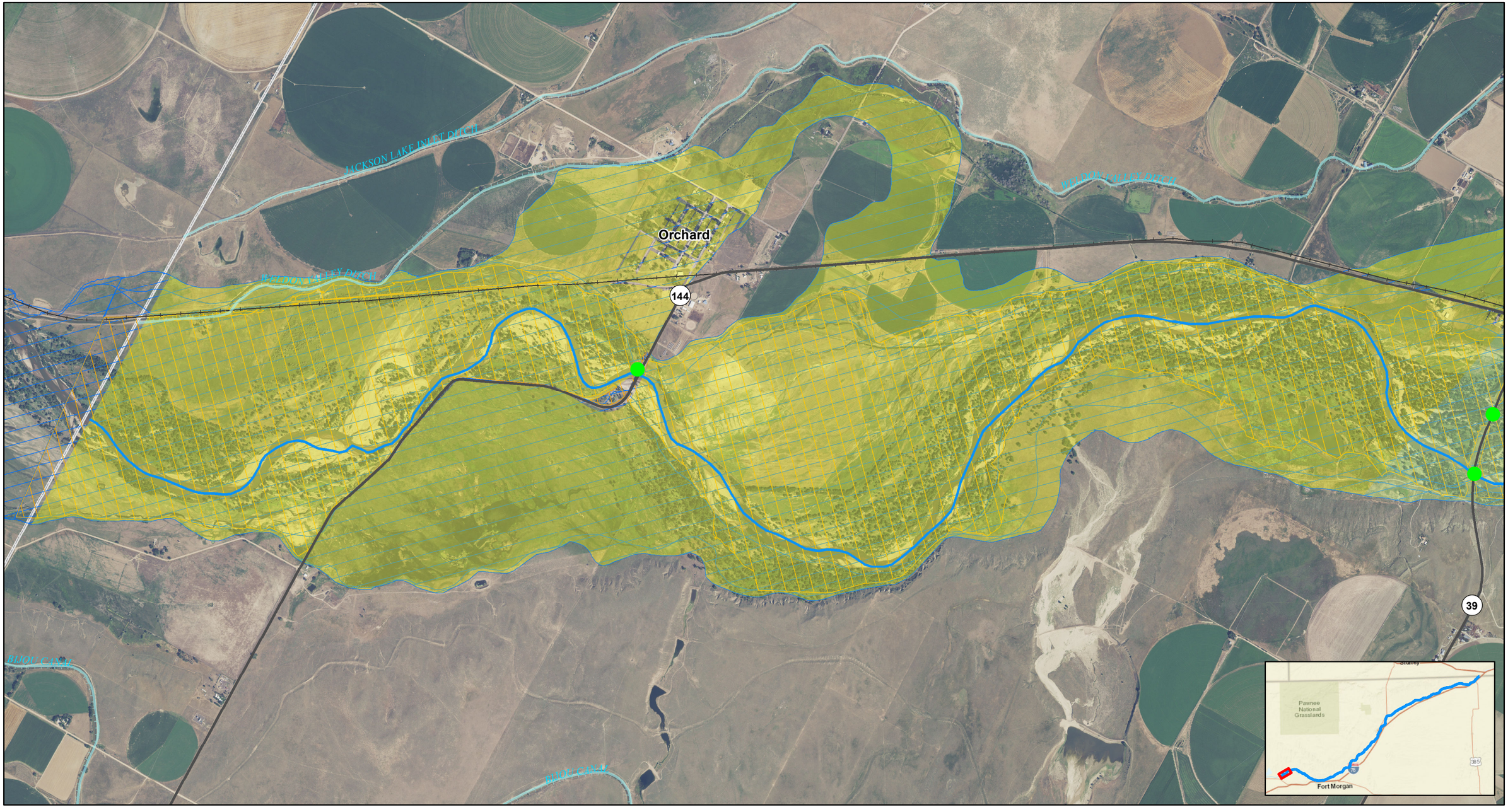


Figure E-9: Stream Power throughout Reaches 17, 18, and 19

[1] River miles from the Weld-Morgan county line

Appendix F

Flood Hazard Risk Analysis



Headgate
Bridge
Critical Infrastructure
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain
100Year

Structures per Mile
0 - 5
6 - 14
>14

N
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0 0.5 1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure F-1: Flood Hazard Risk Analysis

Reach: 1

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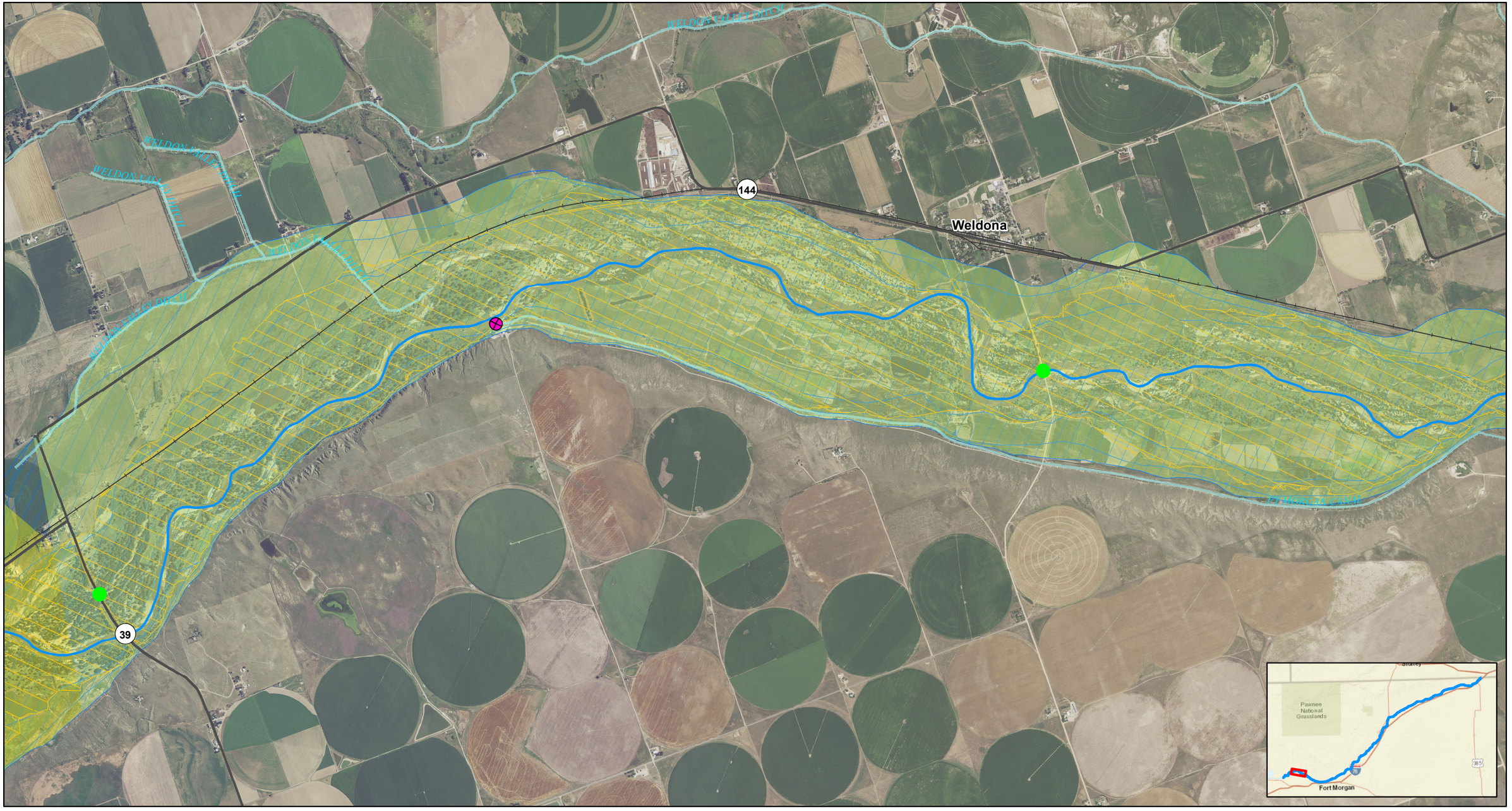

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Miles

USDA NAIP 2015

Headgate
Bridge
Critical Infrastructure
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain
100Year

Structures per Mile
0 - 5
6 - 14
>14

South Platte River Master Plan

Figure F-2: Flood Hazard Risk Analysis

Reach: 2

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Department of Natural Resources

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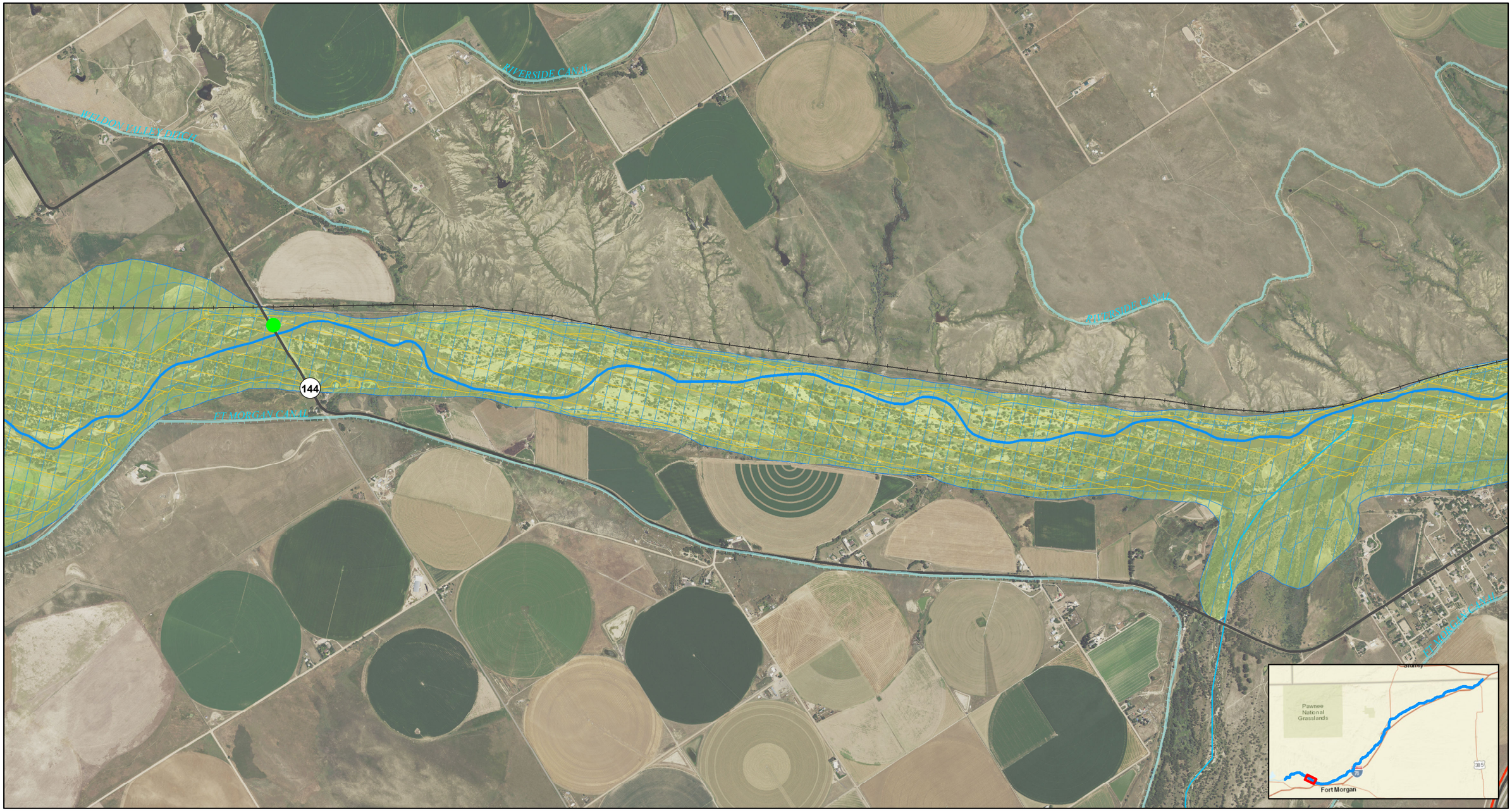

Headgate
Bridge
Critical Infrastructure
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain
100Year

Structures per Mile
0 - 5
6 - 14
>14

0 0.5 1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure F-3: Flood Hazard Risk Analysis

Reach: 3

COLORADO
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Department of Natural Resources

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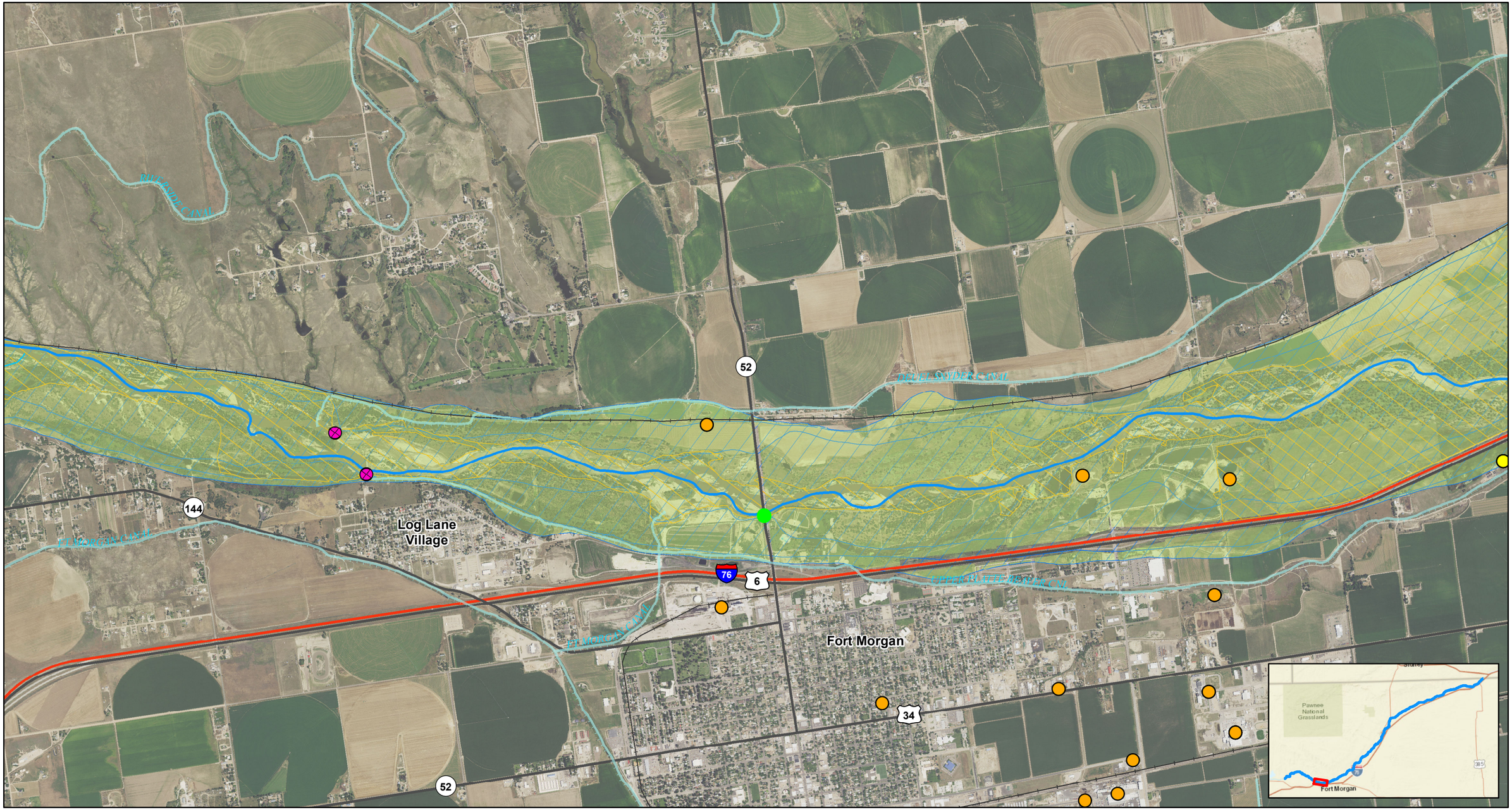

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USDA NAIP 2015

Headgate
Bridge
Critical Infrastructure
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain
100Year

Structures per Mile
0 - 5
6 - 14
>14

South Platte River Master Plan

Figure F-4: Flood Hazard Risk Analysis

Reach: 4

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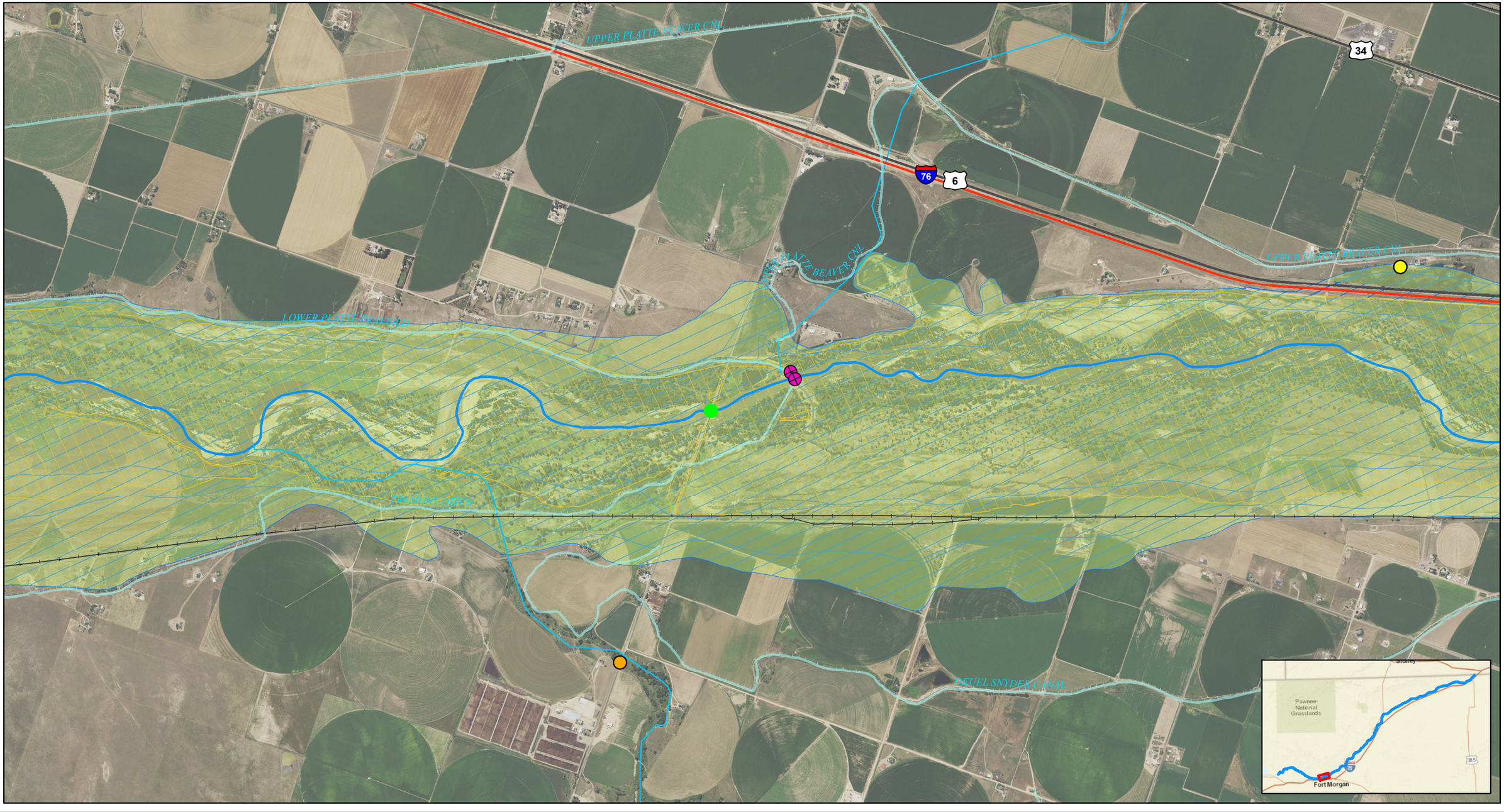

Headgate
Bridge
Critical Infrastructure
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain
100Year

Structures per Mile
0 - 5
6 - 14
>14

0 0.5 1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure F-5: Flood Hazard Risk Analysis

Reach: 5

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Miles

USDA NAIP 2015

Headgate
Bridge
Critical Infrastructure
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain
100Year

Structures per Mile
0 - 5
6 - 14
>14

South Platte River Master Plan

Figure F-6: Flood Hazard Risk Analysis

Reach: 6

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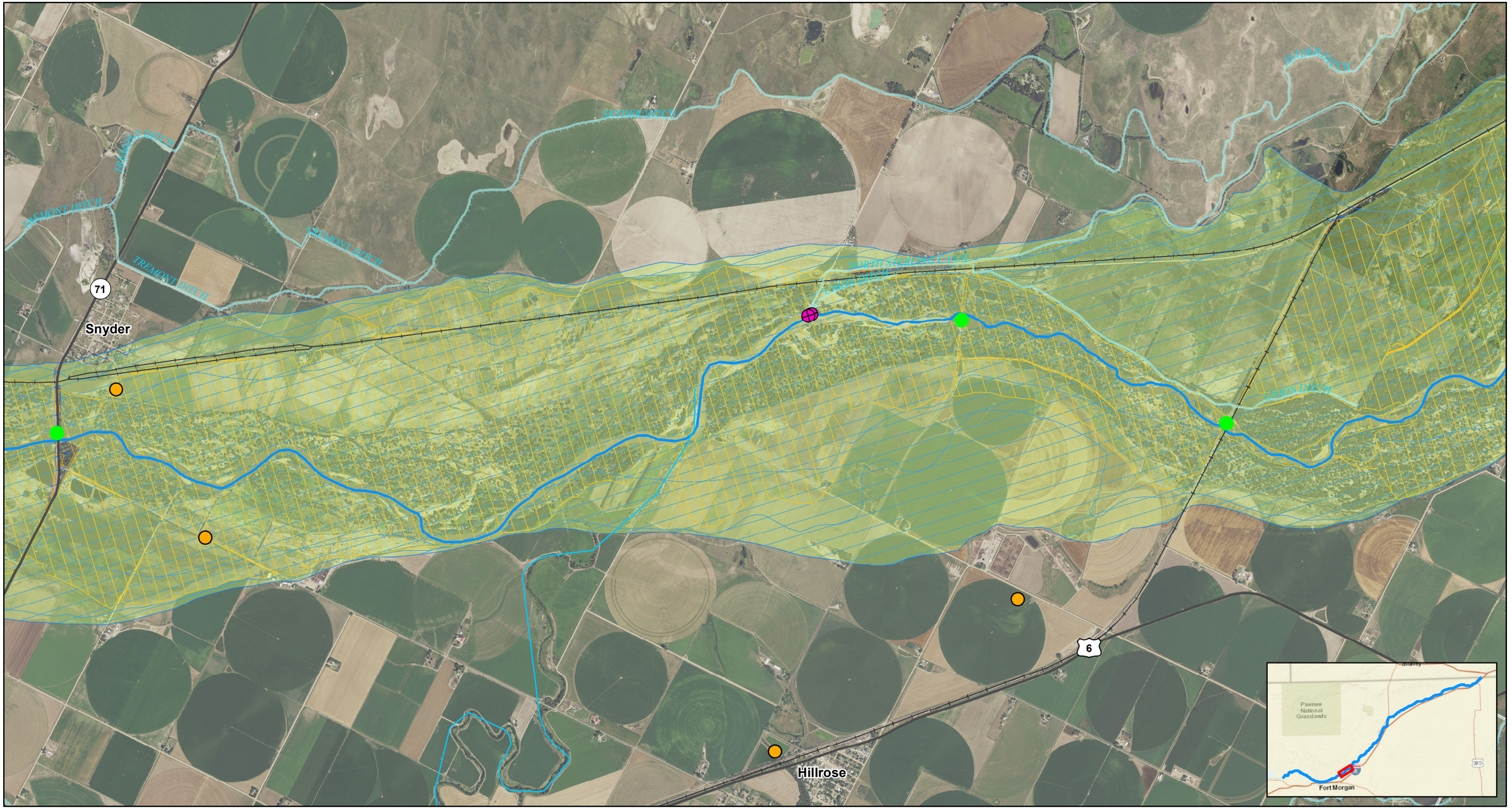

South Platte River Master Plan

Figure F-7: Flood Hazard Risk Analysis

Reach: 7

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Headgate
Bridge
Critical Infrastructure
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain
100Year

Structures per Mile
0 - 5
6 - 14
>14

0 0.5 1
Miles

USDA NAIP 2015

South Platte River Master Plan

Figure F-8: Flood Hazard Risk Analysis

Reach: 8

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Figure F-9: Flood Hazard Risk Analysis

Reach: 9

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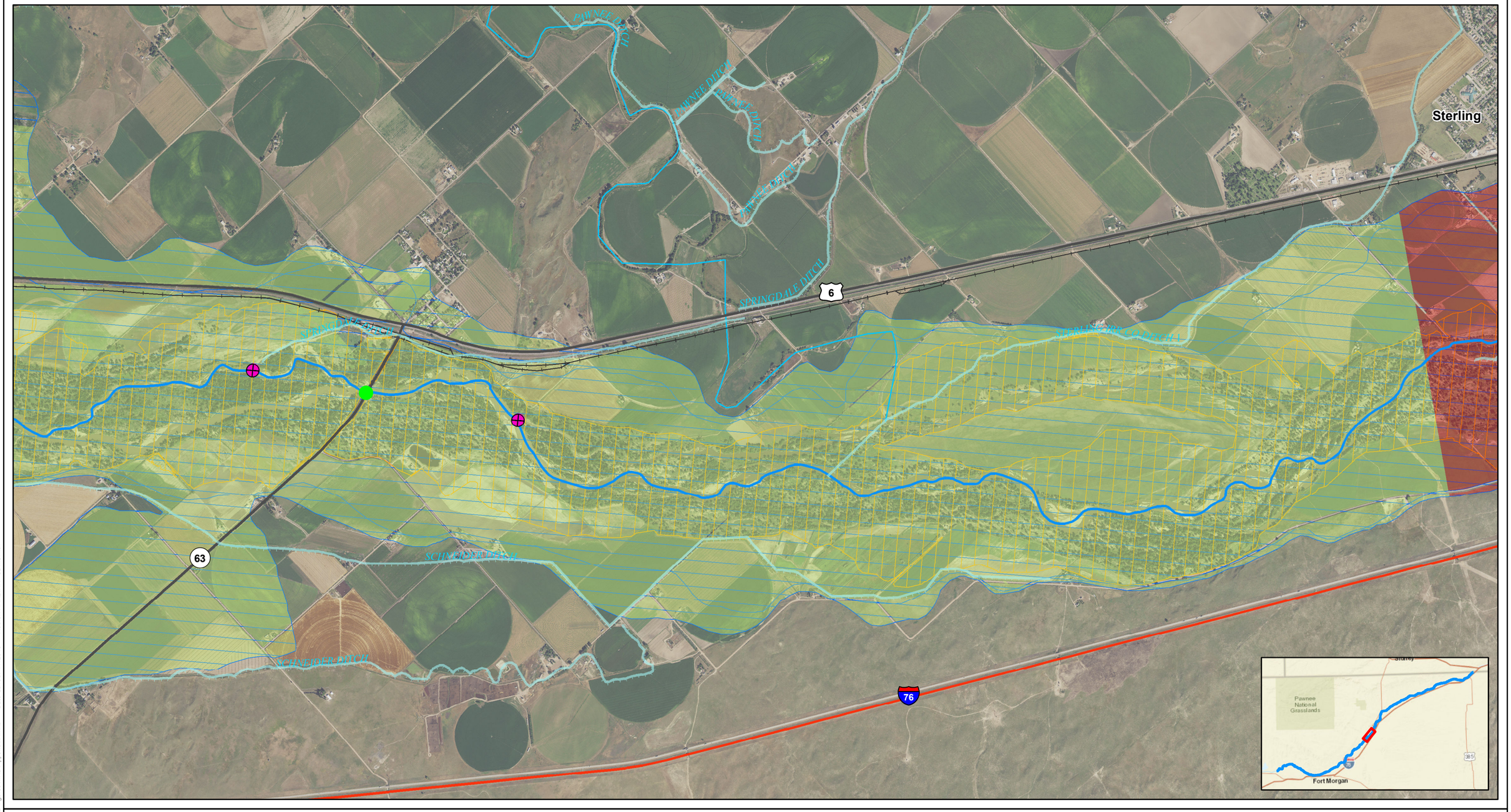

Headgate
Bridge
Critical Infrastructure
NPDES

South Platte River
Tributary
Canal

Interstate
Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain
100Year

Structures per Mile
0 - 5
6 - 14
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W N S E

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USDA NAIP 2015

South Platte River Master Plan

Figure F-10: Flood Hazard Risk Analysis

Reach: 10

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Headgate
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South Platte River
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County Boundary
10-year Floodplain
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South Platte River Master Plan

Figure F-11: Flood Hazard Risk Analysis

Reach: 11

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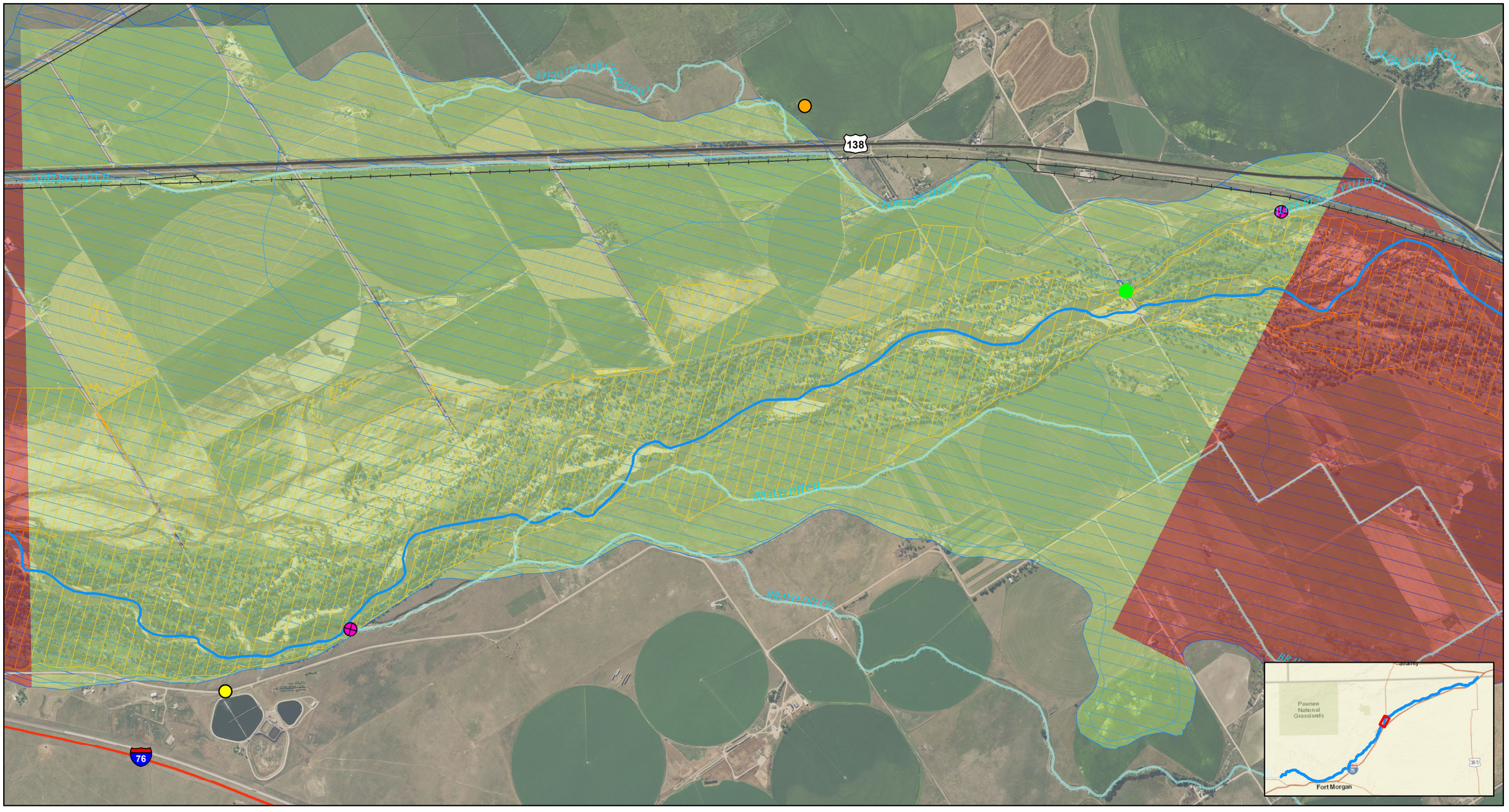

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Structures per Mile
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South Platte River Master Plan

Figure F-12: Flood Hazard Risk Analysis

Reach: 12

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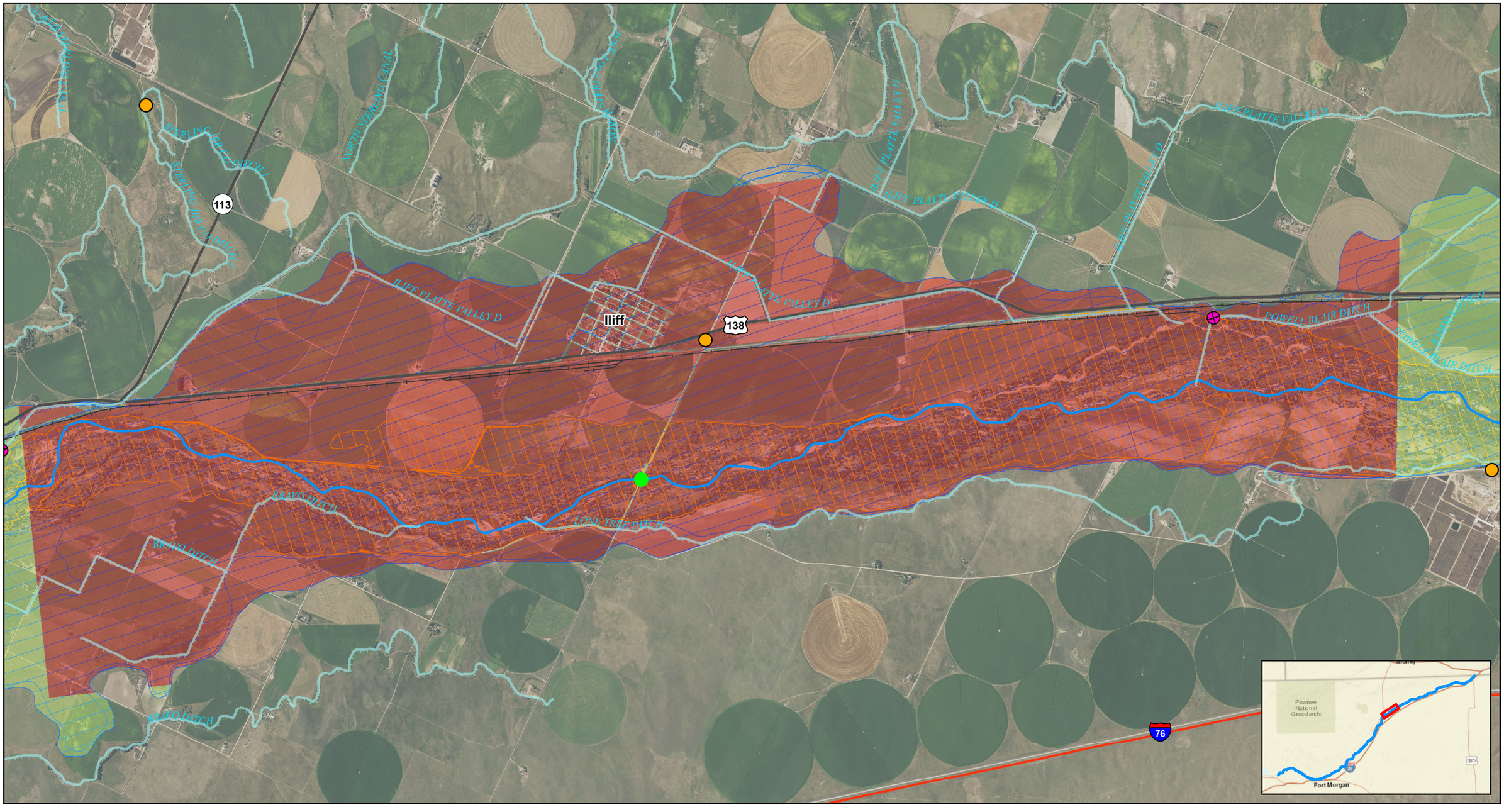

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10-year Floodplain
100-year Floodplain
100Year

Structures per Mile
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South Platte River Master Plan

Figure F-13: Flood Hazard Risk Analysis

Reach: 13

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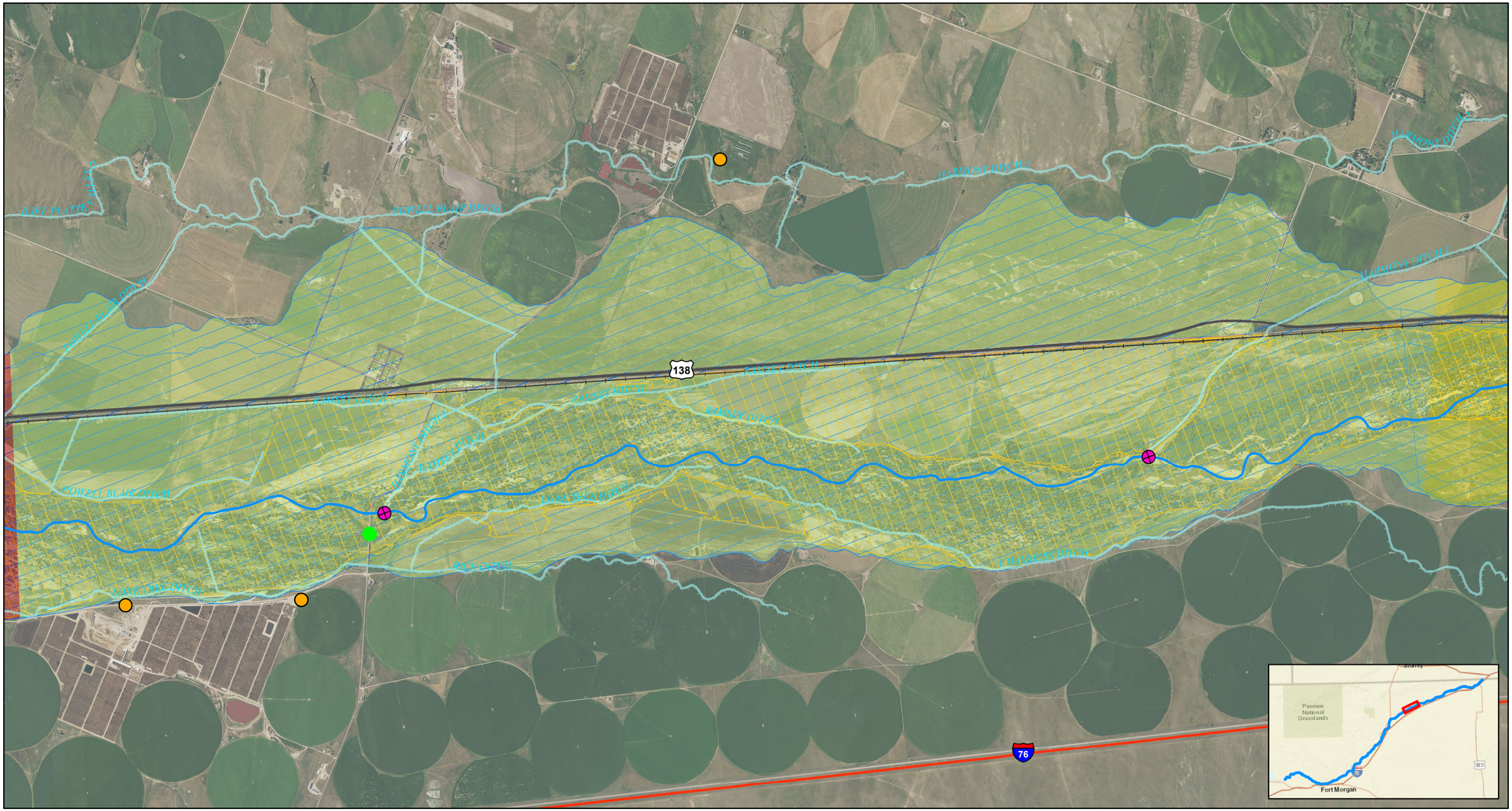

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Railroad

County Boundary
10-year Floodplain
100-year Floodplain
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Structures per Mile
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Figure F-14: Flood Hazard Risk Analysis

Reach: 14

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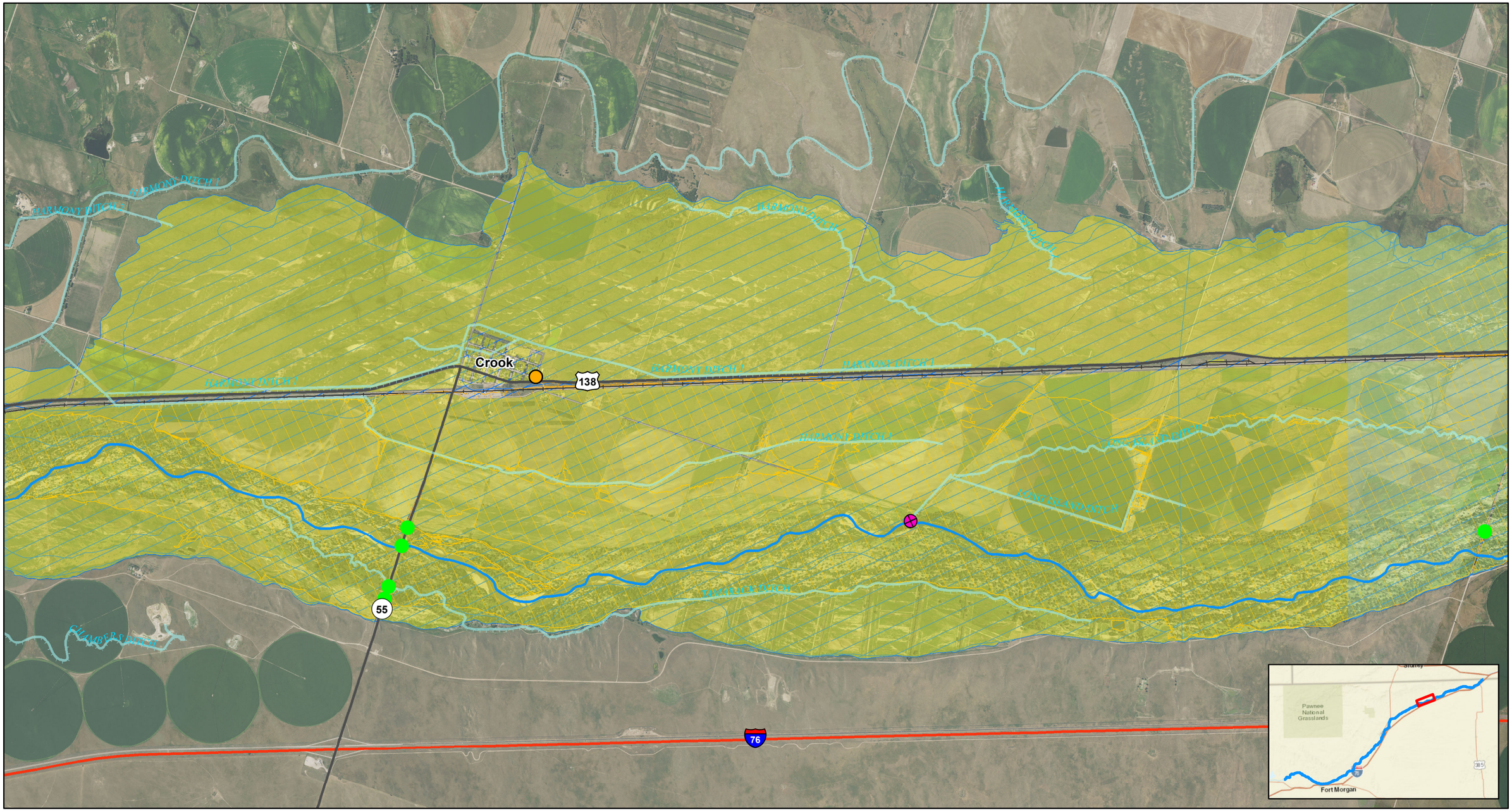
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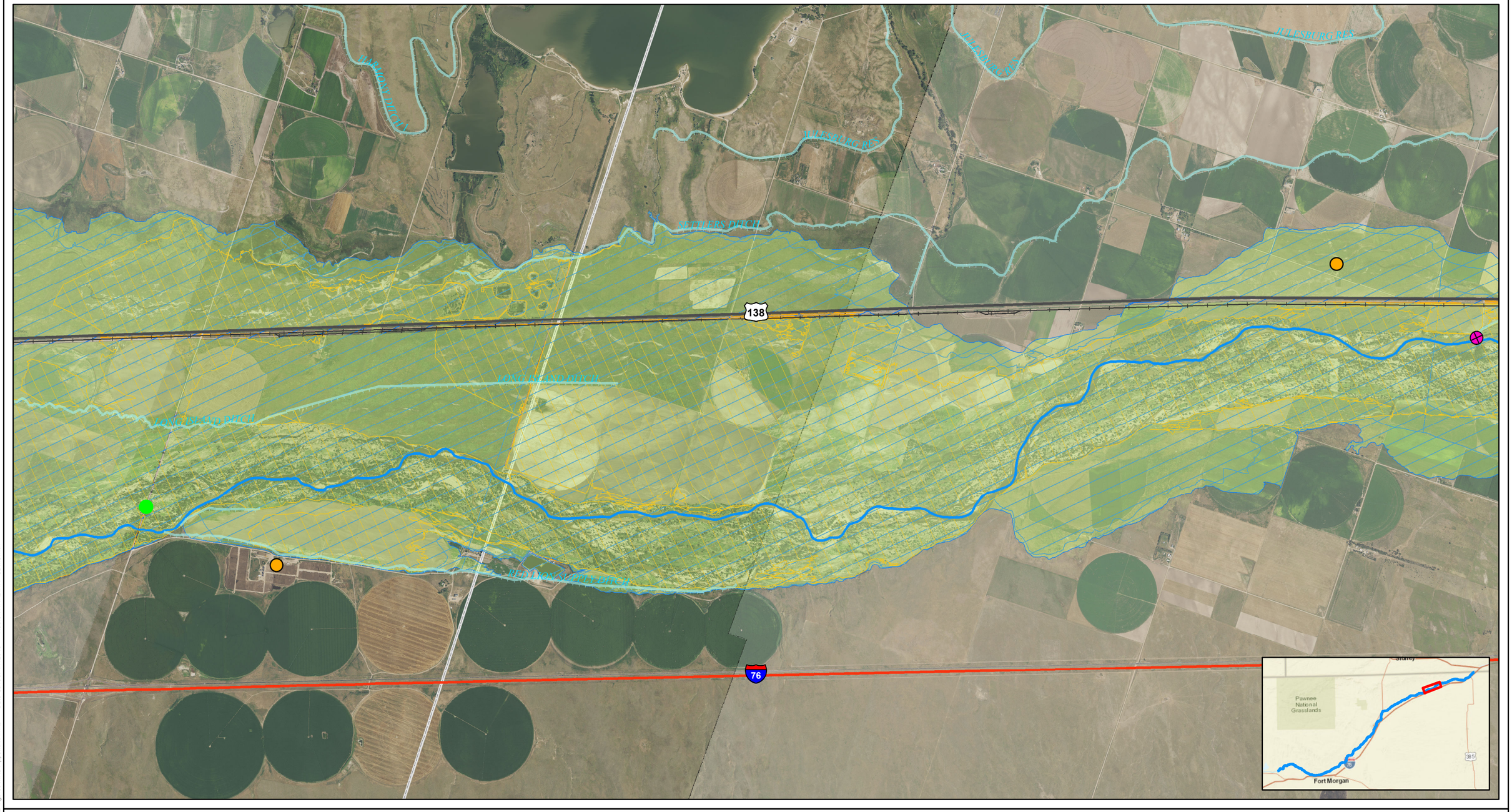

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South Platte River
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Interstate
Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain
100Year

Structures per Mile
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South Platte River Master Plan

Figure F-16: Flood Hazard Risk Analysis

Reach: 16

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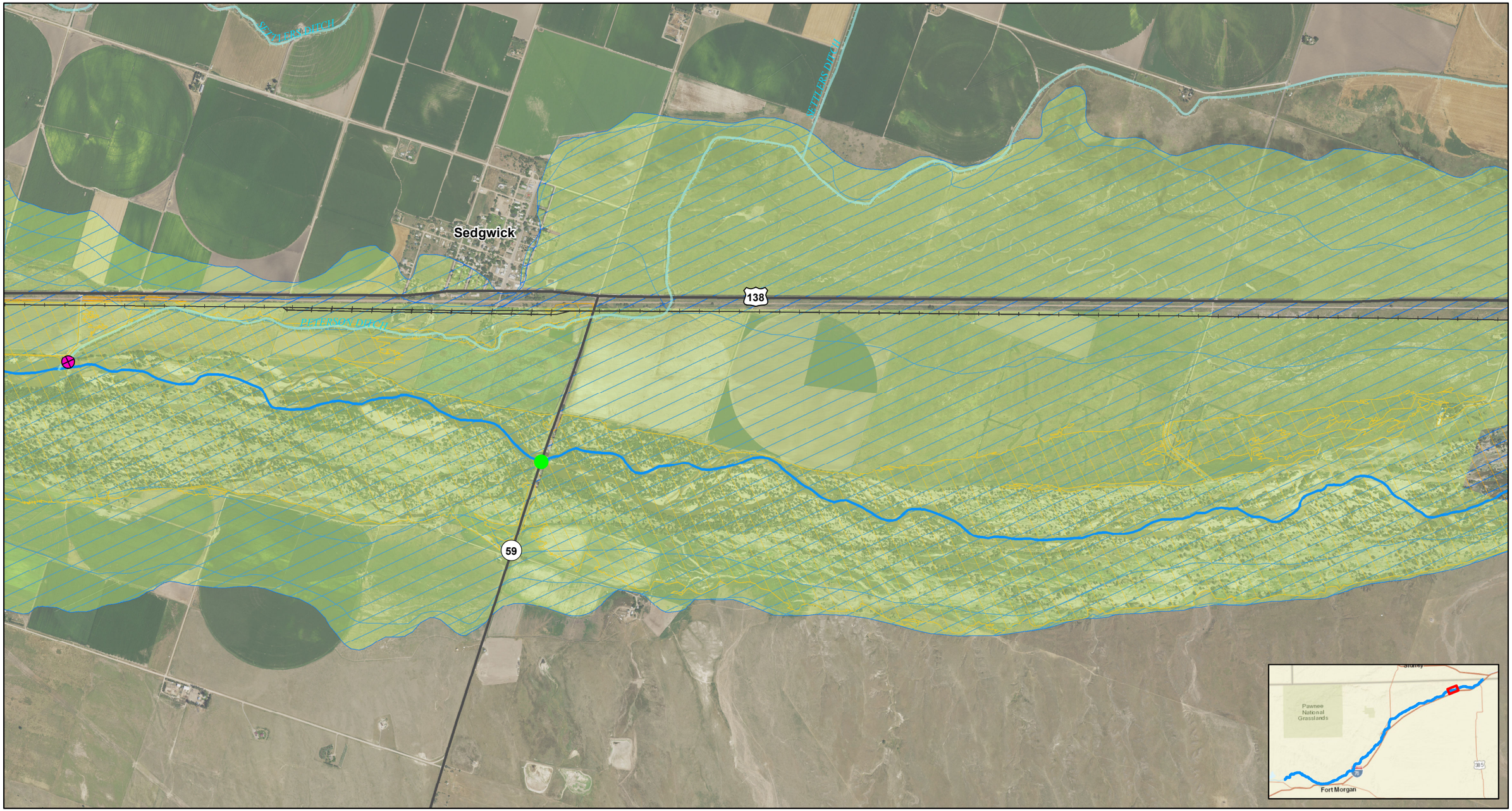

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South Platte River
Tributary
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Interstate
Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain
100Year

Structures per Mile
0 - 5
6 - 14
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South Platte River Master Plan

Figure F-17: Flood Hazard Risk Analysis

Reach: 17

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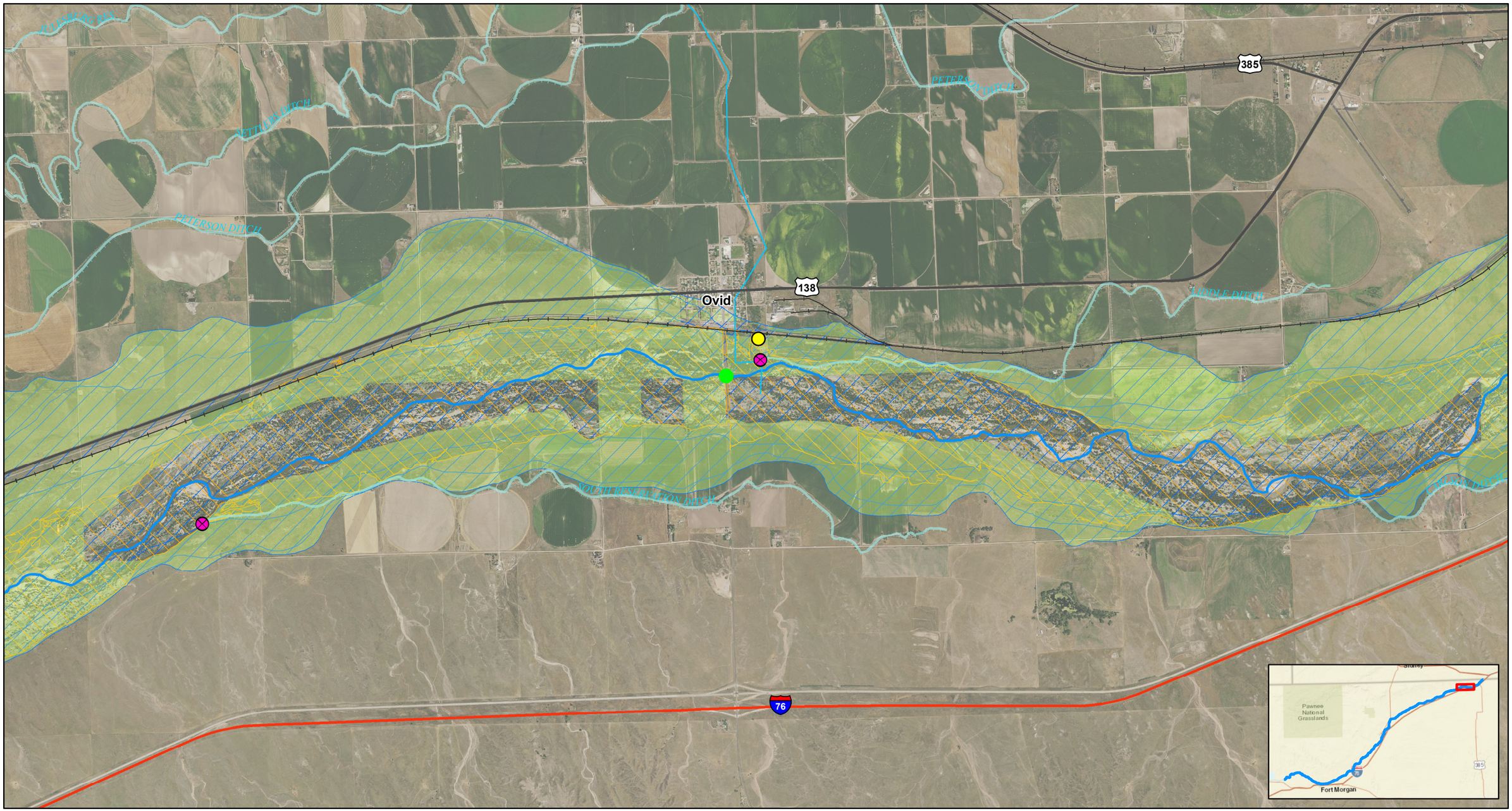

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Headgate
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South Platte River
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Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain
100Year

Structures per Mile
0 - 5
6 - 14
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South Platte River Master Plan

Figure F-18: Flood Hazard Risk Analysis

Reach: 18

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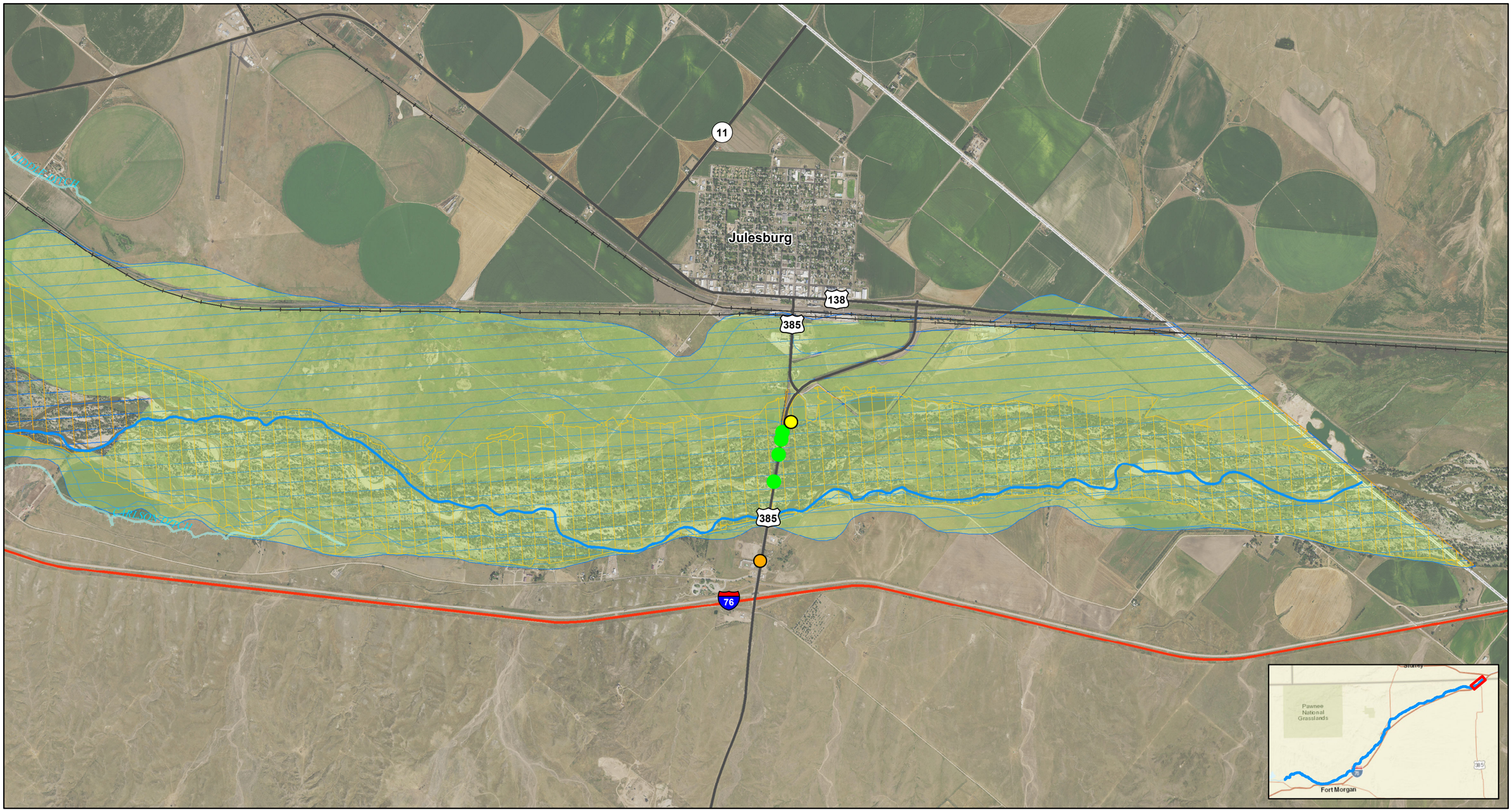

Headgate
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South Platte River
Tributary
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Interstate
Highway
Railroad

County Boundary
10-year Floodplain
100-year Floodplain
100Year

Structures per Mile
0 - 5
6 - 14
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Miles

USDA NAIP 2015

South Platte River Master Plan

Figure F-19: Flood Hazard Risk Analysis

Reach: 19

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Appendix G

Fluvial Geomorphic Risk Analysis

Technical Memorandum

To:	Eli Gruber – CDM Smith
From:	Brian Clarke – Otak
Copies:	Luke Swan, Tracy Emmanuel – Otak
Date:	4/6/2018
Subject:	Geomorphic Risk Assessment
Project No.:	18173

Introduction

During the September 2013 flooding, flood-related impacts outside of the 100-year FEMA floodplain were observed throughout the Lower South Platte River watershed and Colorado Front Range, despite many peak discharge estimates having magnitudes less than or equal to the 100-year flood (Houck 2014, Yochum 2015). Of particular concern for many Colorado communities is the discrepancy between observed flooding extent and FEMA's National Flood Insurance Program (NFIP) maps, which are elevation-based, delineating only flood inundation hazards by applying a water surface elevation based standard (i.e., the 100- and 500-year base flood elevations). The hazard depicted in these maps is always approximate because of uncertainty in topographic data and flow frequency estimates, and unaccounted for morphological changes during floods. Moreover, the traditional method of mapping the floodplain assumes clear water conditions, ignoring the influences of sediment, ice, and debris transport and disregarding the fundamental, albeit complex, mechanics of river change during floods.

Broadly defined, the **fluvial hazard zone (FHZ)** is the area a stream has occupied in recent history, could occupy, or could physically influence as it stores and transports sediment and debris during flood events. The objective of mapping the FHZ is to identify lands most vulnerable to fluvial hazards in the near term.

Identification and management of these additional flood hazards can aid in reducing flood damage to vulnerable public and private infrastructure and the costs of future flood recovery. The FHZ delineation process and the maps it produces are intended to provide local land use and floodplain managers insight into the likely long-term behavior of their streams and serve as additional flood hazard information. They may also serve as supplemental information to landowners who may not be aware of these additional flood hazards and whose improvements may not be appropriately insured or protected. Combining flood elevation maps with fluvial hazard maps may help mitigate these hazards by guiding development, moving or protecting critical infrastructure, and encouraging long-term conversion of these areas as active river corridors. Preservation of these areas also results in concomitant gains in improved water quality, recreation opportunities, and ecological function.

Methods

Here we outline a combined framework for FHZ mapping and risk assessment along the Lower South Plate River based on:

- Geomorphic reach delineation and characterization
- Relative elevation model (REM) assessment
- Identification of the active channel (AC), erosional hazard area (EHA), and historical river corridor (HRC)
- Identification of at-risk infrastructure, lands, and property
- Quantification of reach-averaged hydraulic processes
- Identification of potential erosion areas
- Delineation of relative risk of fluvial hazard on a reach-by-reach basis

Reach Delineation

Reach delineation subdivides the channel into areas of similar geomorphic and hydrologic properties, which can assist in mapping fluvial features and informing the relative hazards and risks in different areas. Significant changes in geomorphology and hydrologic regime in turn affect channel planform and vegetation which were also used to inform the locations of reach breaks. Reach breaks are typically defined by changes in:

- Channel and valley gradient
- Geologic controls on channel elevation
- Confinement from the valley or land development
- Tributary junctions
- The presence of dams or diversions that significantly alter the hydrologic regime
- Political boundaries

The reach breaks for the study area were determined based on the variation of valley confinement and urban or agricultural development influence, channel planform, and valley gradient as observed in the topography and aerial photography. Tributary influence, vegetative changes, and political boundaries were also considered in the determination of the reach breaks.

Relative Elevation Model

The relative elevation model (REM) was created from 2016 LiDAR digital topography to show the relative elevation of the river corridor and valley above the bottom of the active channel (Figure 1). This process removes the broad scale valley gradient, so comparisons can be made between any regions within the study area based on relative elevations above the active channel, as opposed to absolute elevations, which are influenced by valley slope. The process of creating the REM was completed through GIS processing of LiDAR data by denoting the location of the channel bottom, then detrending and extracting that elevation from the topography, and subtracting that elevation from the surrounding river corridor and valley elevations. The exact methods and appropriate GIS tools are outlined in the Planning-Level Channel Migration Zone (pCMZ) methodology (WSDOE, 2014).

The REM enhances the ability to visualize and quantify fluvial features within the active and historical river corridor compared to the original topography (Figure 1). The high-resolution topography (1-meter resolution LIDAR) used to create the REM was an important factor in the visibility of fluvial features and the mapping

precision of the REM and subsequent FHZ, due to the relatively small scale of many fluvial features. The REM allows us to identify and quantify the active river channel and the historical river corridor (Figure 1) based on relative elevation and distinct geomorphic features currently and/or historically confining the river corridor.

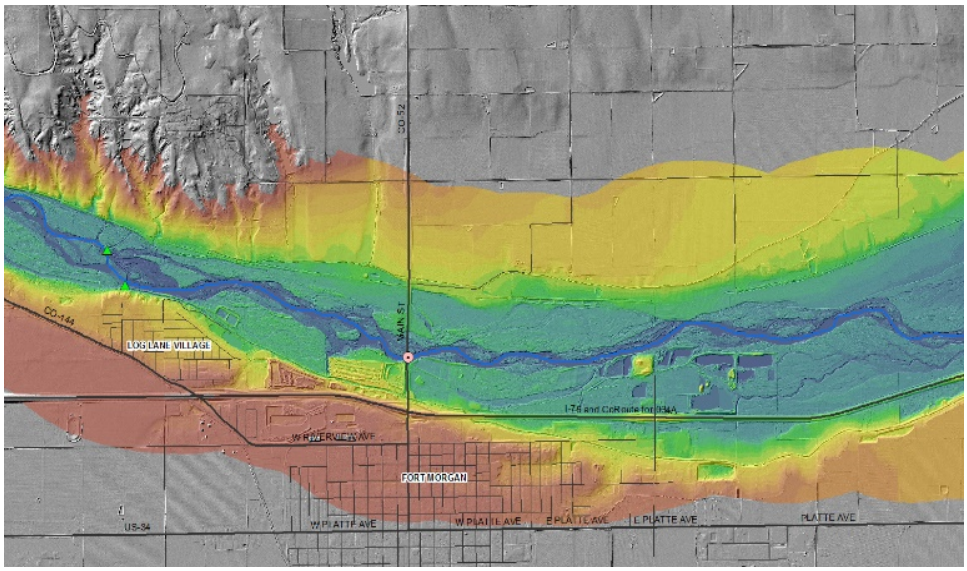
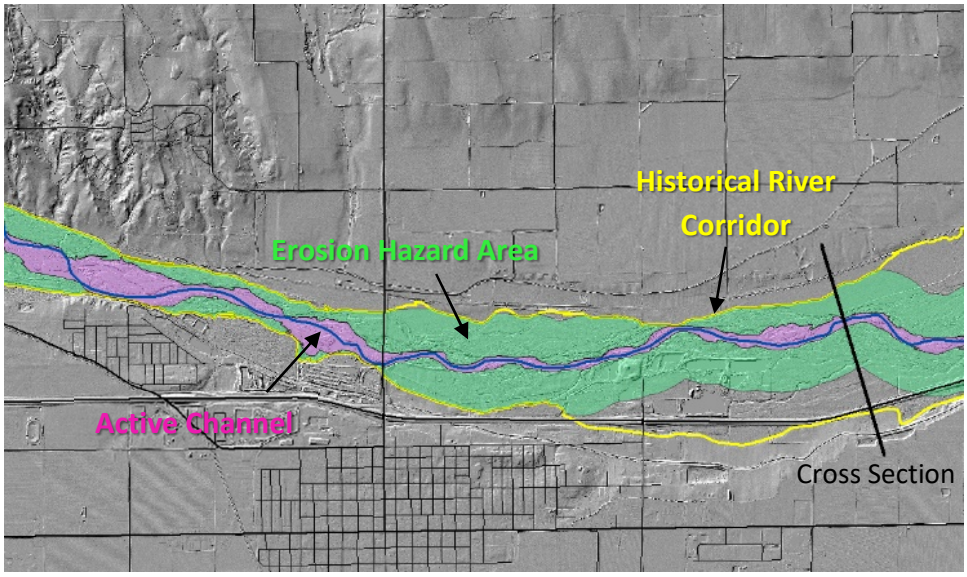


Figure 1. Relative Elevation Model (REM) at Fort Morgan created from the existing topography to show the relative elevation of the valley above the channel bottom, which enhances the ability to visualize fluvial features, the historical river corridor, and the current active channel.



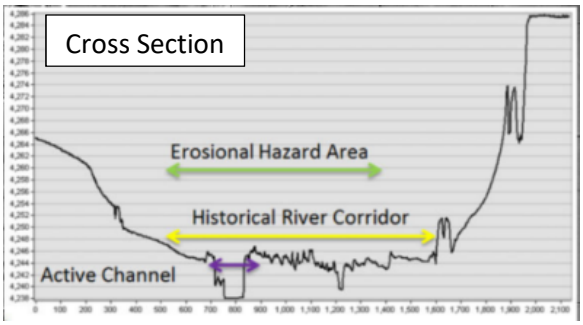


Figure 2. FHZs and cross section (from black line) identifying mapping zones

- Historical River Corridor – area where the river has occupied in the past
- Active Channel – area where the river is occupying presently
- Erosion Hazard Area – area susceptible to erosion and channel migration; buffer distance from the active channel based on observed erosion rates

Fluvial Hazard Zones

Based on the REM, GIS, and aerial imagery analyses we identified and delineated three fluvial hazard zones: the active channel, the erosional hazard area, and the historical river corridor (Figure 2).

- The **active channel (AC)** is the region the river currently occupies or could occupy over an annual timeframe. This is the region most susceptible to fluvial impact and change, where the channel is actively transporting water and sediment driving erosion and deposition along the bed and banks. In the photograph to the right, the active channel is visually identified by the active sediment plain, bound on each side with dense vegetation.

- The **erosional hazard area (EHA)** is based on calculation of the potential channel migration over a 100-year timeframe (Figure 2). An average river migration rate was calculated based on time-series analysis of aerial imagery for select locations throughout the project reaches. The river migration rate was then extrapolated over 100 yr. to create a buffer adjacent to the active channel representative of areas with long-term hazard potential. For this broad-scale watershed analyses we determined an average migration rate of 13 ft/yr, based on numerous lateral meander migration measurements identified in the aerial imagery – giving an erosional hazard area buffer of 1,317 ft.

- The **historical river corridor (HRC)** is the area the river has occupied in the past. Based on GIS and REM analysis, the historical river corridor can be defined by distinct features that currently or have historically confined the river corridor (such as, steep bedrock walls, high previously incised terraces, etc.).

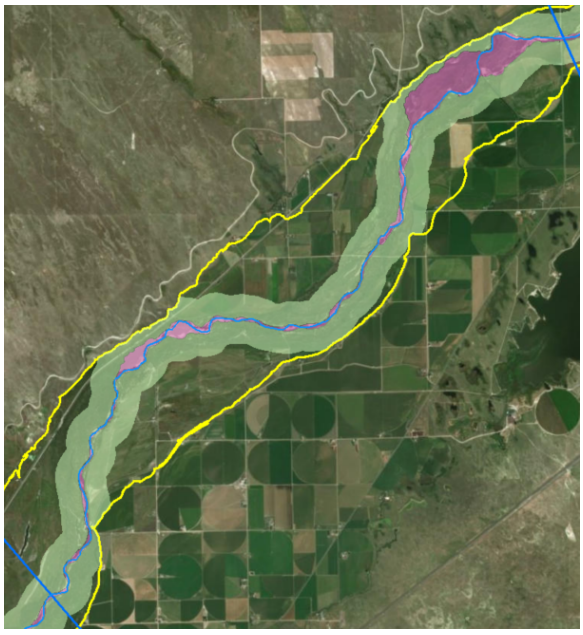


Figure 3. Reach 8: Downstream of Washington/Logan County Boundary, showing broad meander bends and variable widening in the active channel (pink), erosional hazard area (green), and historical river corridor (yellow). The reach has connected floodplain and riparian corridor except where meanders are migrating into agricultural land

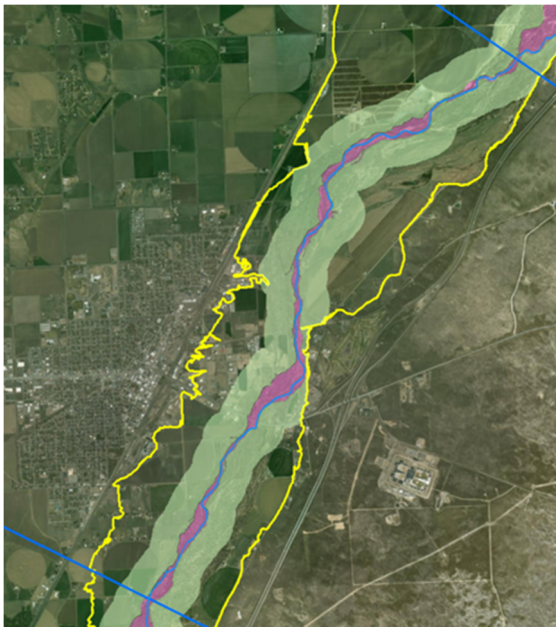


Figure 4. Reach 11: Sterling, showing a narrow and linear active channel zone (pink), erosional hazard area (green), and historical river corridor (yellow). The reach is highly channelized by urban development and agriculture, with minimal floodplain or riparian habitat.

Identification of At-Risk Infrastructure, Lands, and Property

By overlaying mapping of the active channel, erosional hazard area, and historical river corridor we can identify areas most likely to be impacted by fluvial and flooding processes – with likelihood of impact decreases with distance from the river from the active channel, through the erosional hazard area, to the historical river corridor. However, fluvial risk only applies to areas containing assets of value, as there are lower consequences of fluvial impacts to areas with limited current value. Therefore, by identifying valued infrastructure within the fluvial hazard zones we can highlight the most (or least) at-risk infrastructures susceptible to fluvial impacts. Yet, mapping the entire river corridor, even areas without current assets, provides a broad overview of fluvial hazard, which can help guide future development and land use. Here we have differentiated at-risk infrastructure into three broad and generalized categories: 1) Low population, low building density areas that have no buildings within the active channel and only 0-5 buildings within the erosional hazard area. 2) medium population and building density areas, often associated with small towns or more populated areas close to the river with 1-2 building within the active channel and 6-10 buildings within the erosional hazard zone. 3) high population, high density areas associated with more densely populated urbanized towns with >2 building/assets within the active channel and > 10 buildings within the erosional hazard area.

Reach-Averaged Hydraulic Processes

Hydraulic analysis data were provided by CDM Smith, based on CHAMPS flood hazard modeling results. Stream power, discharge, and velocity data were acquired for the 10 yr. and 100 yr. flood stages at each of the flood

model cross sections, and then averaged across each of the individual reaches. Stream power is a measure of a rivers ability to perform work on the channel bed and banks, and is therefore a key indicator of the rivers ability to alter the channel corridor and influence fluvial hazard and risk. Therefore, reach-averaged stream power was the primary hydraulic metric used in the fluvial hazard assessment and risk designation. All reach-averaged hydraulic results are presented in the attached Summary Table.

Identification of Potential Erosion Areas

The FHZs delineate a broad-scale assessment of fluvial hazard along the river corridor. However, it should be noted that some areas, such as on the outside of pronounced meander bends, are more prone to experience erosion or alteration due to fluvial processes than other less fluvially active areas. We have identified "potential erosion areas", where a section of the river with high potential for erosion and migration is either encroaching on critical infrastructure or has potential to erode the active channel outside of the historical river corridor. These points highlight specific erosional hazard areas beyond the broad-scale FHZs.

Fluvial Geomorphic Potential and Severity

Fluvial geomorphic risk was determined on a reach-by reach basis by independently assessing and scoring the fluvial geomorphic potential and the fluvial geomorphic severity. The combination of the fluvial geomorphic potential and severity determines the fluvial geomorphic risk for each reach.

Fluvial Geomorphic Potential Scores

The potential for fluvial erosion and channel alteration under future high flow conditions was investigated for each reach based on reach-averaged stream power (discussed above) and qualitative assessment of valley confinement, channel characteristics, and erosion and lateral meander migration potential, based on topographic data, relative elevation models, aerial imagery, and FHZ mapping. Each reach was assigned a fluvial impact potential score of low (1), medium (2), or high (3) denoting the potential for planform change due to fluvial erosion and migration during future high flow stages. It should be noted that this is a reach scale assessment, and that there is some erosion potential on the outside of nearly all meander bends in the project area. The following criteria was used for each fluvial geomorphic potential classification:

1 – Low Potential

- Low reach-averaged stream power (10 yr = <0.45 lbs/ft s; 100 yr = <1.0 lbs/ft s)
- Partially to well confined valleys by bedrock and/or large terraces with minimal opportunities to over-widen
- Low erosion and lateral migration potential, with low sinuosity meanders confined well within channel corridor and a well-connected floodplain and/or riparian habitat zone

2 – Medium Potential

- Medium reach-averaged stream power (10 yr = 0.45 – 0.6 lbs/ft s; 100 yr = 1.0-1.5 lbs/ft s)
- Partially confined valleys with moderate sinuosity meanders and moderate lateral meander migration and erosion potential
- Partially connected floodplain with some riparian habitat

3 – High Potential

- High reach-averaged stream power (10 yr > 0.6 lbs/ft s; 100 yr > 1.5 lbs/ft s)

- Partially or unconfined valleys or valleys that have been channelized and confined by urban development
- Poorly-connected or disconnected floodplains with limited to no riparian corridor
- Medium to high meander migration and erosion potential.

Fluvial Geomorphic Severity Scores

The severity of impacts from fluvial erosion and channel alteration under future high flow condition was assessed independently of the fluvial geomorphic potential for each reach. The severity of future fluvial impacts was determined based on the number of assets within the active channel and erosional hazard zone, the number of potential erosion areas – where the channel is encroaching on critical assets or the boundary of the historical river corridor, and the type of land use bounding the river corridor. Each reach was assigned a fluvial geomorphic severity score of low (1), medium (2), or high (3) denoting the severity of potential damage to buildings, infrastructure, and land use. The following criteria was used for each fluvial geomorphic severity classification:

1 – Low Severity

- Low population with low density buildings and assets (no buildings in AC; 0-5 in EHZ)
- Minimal (0-2) potential erosion areas
- The channel corridor is predominantly bound by vacant land or a riparian buffer

2 – Medium Severity

- Minimal assets within AC (1-2) and moderate assets within the EHA (6-10)
- Moderate potential erosion areas (3-4) encroaching on assets or HRC boundary
- Channel corridor bound by mostly farmland with minimal riparian buffer

3 – High Severity

- Higher populations with higher building densities (e.g., towns), with >2 assets within AC and >10 buildings/assets within the EHA
- Significant potential erosion areas (>5) encroaching on assets, buildings, or HRC boundary
- Channel corridor primarily bound by significant assets, towns, and urbanization

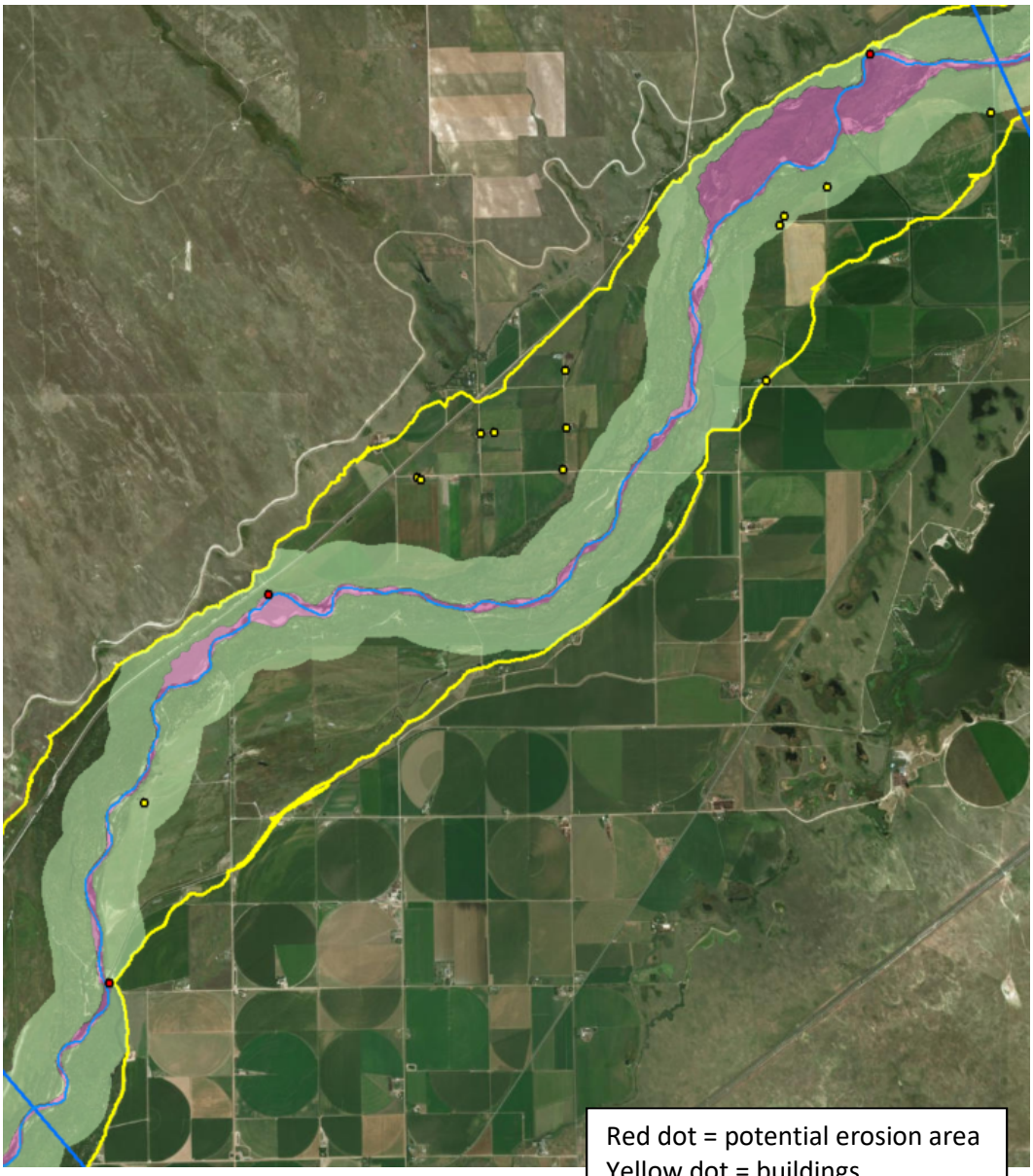


Figure 5. Reach 8: Downstream of Washington/Logan County Boundary. Sinuous, meandering channel with low stream power. Moderate lateral migration and erosion potential on outside of meander bends where the channel is encroaching/eroding into the HRC and agricultural land. Inside bends and transition/strait sections of the channel are buffered by floodplains, point bars, and riparian habitat. Assets/buildings dominantly located on the inside of meander bends outside, or on the edge, of EHA. ***Fluvial geomorphic potential: medium (2); fluvial geomorphic severity: low (1); fluvial geomorphic risk: low (3)***

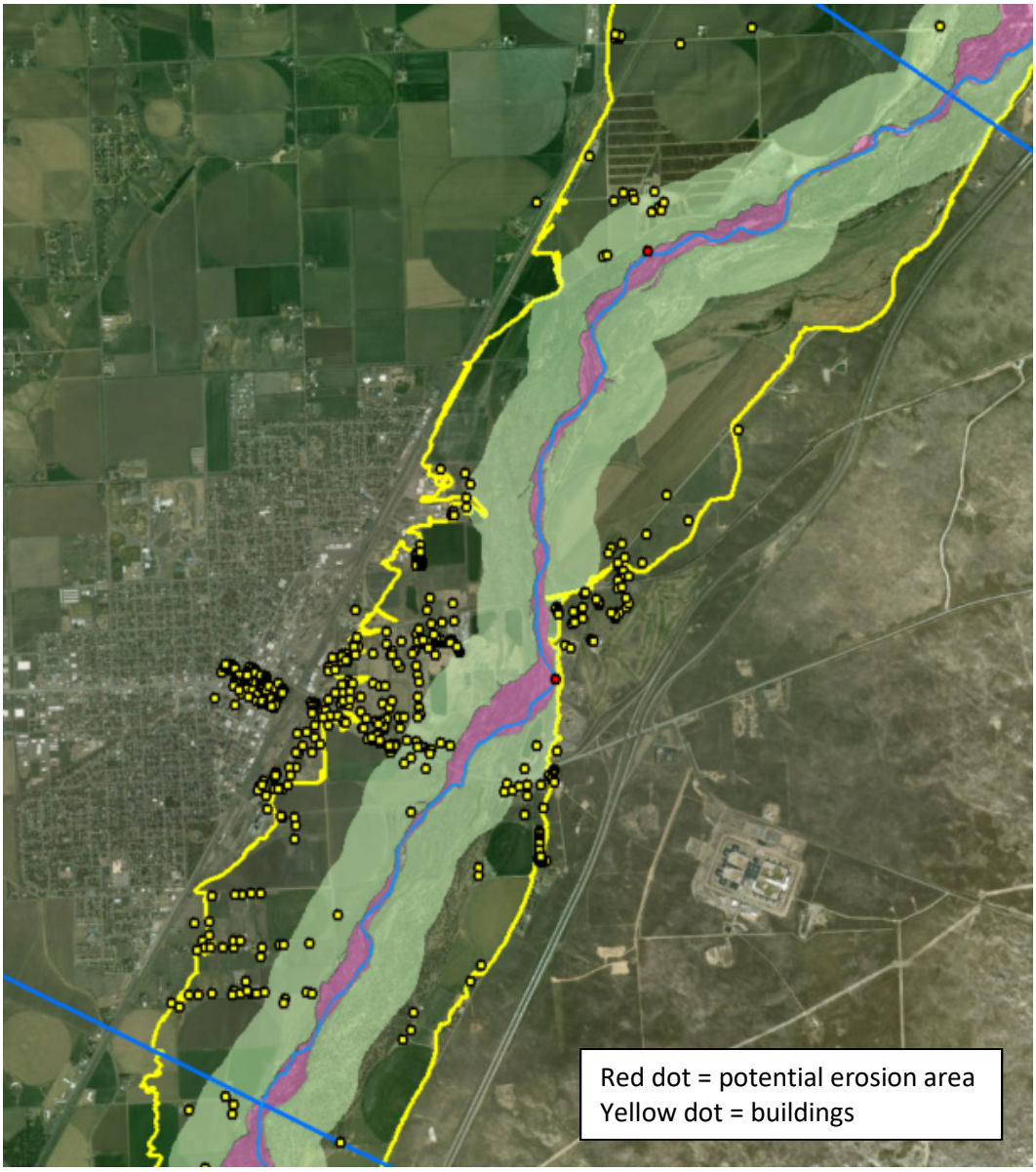


Figure 6. Reach 11: Sterling. Narrow, low-sinuosity channel with medium/high stream power and significant development driven channelization. High lateral migration and erosion potential with the channel encroaching/eroding on urban and/or agricultural land along the entire reach. Significant Assets/buildings/infrastructure within the EHA, with the highest density centered on Sterling. ***Fluvial geomorphic potential: high (3); fluvial geomorphic severity: high (3); fluvial geomorphic risk: high (6)***

Fluvial Geomorphic Risk and Results

Each reach was assigned a relative fluvial geomorphic risk ranking of Low, Medium, or High based on a combination of the fluvial geomorphic potential and severity scores shown in the fluvial geomorphic risk matrix (Table 1). Fluvial geomorphic risk for each reach is shown in Figure 7 and further described in the Reach Summary and Reach Characteristics tables (attached).

Fluvial Geomorphic Risk

Potential	Severity		
	1	2	3
1	low	low	med
2	low	med	high
3	med	high	high

Table 1. Fluvial Geomorphic Risk Matrix

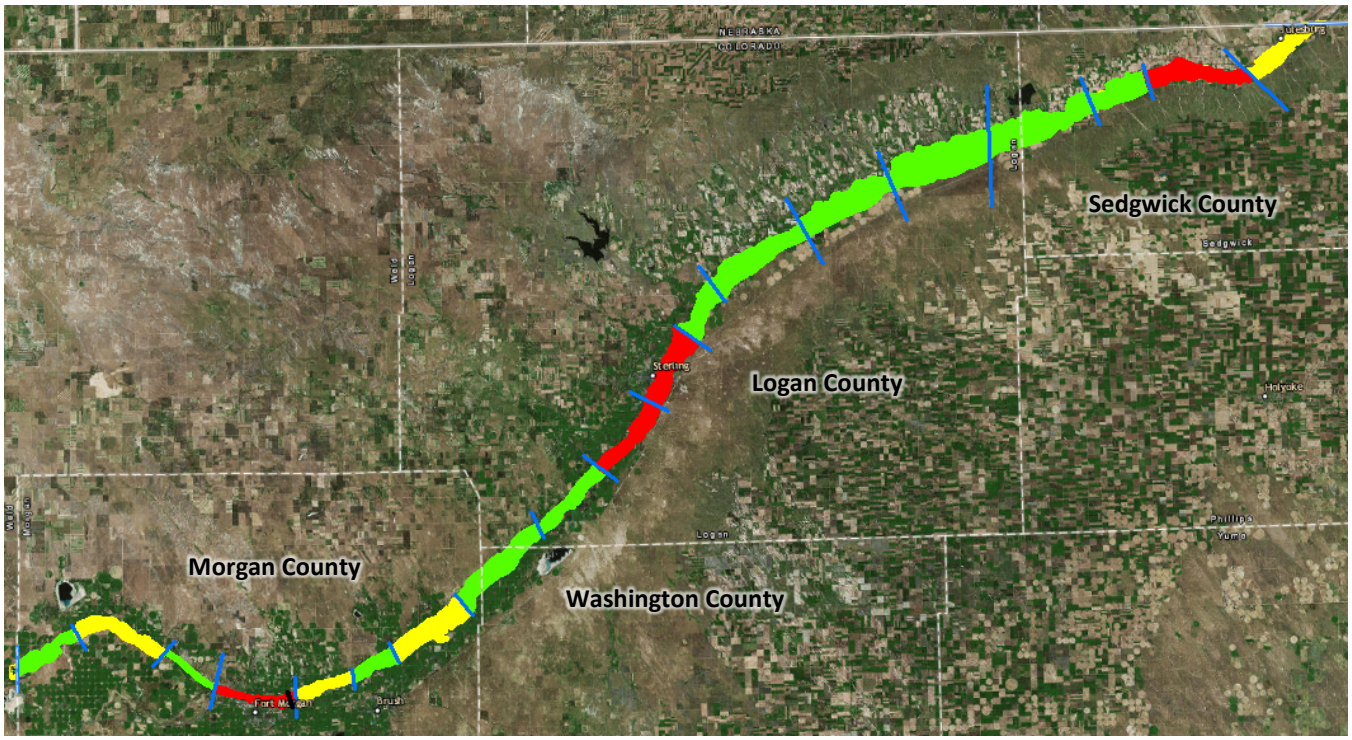


Figure 7. Fluvial Geomorphic Risk for the Lower South Platte River. Green = low, Yellow = Medium, Red = High

Limitations

1. Hazard and/or risk are not uniform within the EHA. Fluvial hazard is greatest directly adjacent to the active channel and diminishes with increasing distance (except in the case of avulsion hazards – discussed below). Likewise, hazard varies based on proximity to fluvial features (e.g., inside vs outside of meander bends, at large changes in stream power, etc). This analysis is a reach-scale assessment and does not account for these smaller-scale, but significant, factors. The South Platte River is sensitive to changes in boundary conditions (e.g., vegetation type and cover) and driving processes (e.g., discharge and sediment supply), and changes to either may have dramatic effects on river behavior.
2. Avulsion hazards, where the river jumps its banks and creates a new course down valley, were not identified in this analysis. Avulsion hazards may be a significant hazard and risk factor in some less confined areas with large meander bends (e.g., near Messex) or where significant deposition may be possible.
3. This analysis utilizes reach-averaged stream power and does not incorporate unit stream power (which may be more appropriate) or assessment of stream power variations along individual reaches (i.e., at the sub-reach scale). As a result, this analysis does not consider the impact of diversions and bridges on fluvial hazard and risk or the potential impacts of significant aggradation or degradation on the river bed that would result from large changes in stream power at the sub-reach scale.
4. Building locations, conditions, and values are not fully considered in this analysis. The exact number of valuable assets within each FHZ cannot be fully accounted for without more detailed information and field visits. Likewise, this analysis does not consider the value of individual buildings or assets – either the absolute value or the value to the surrounding community.

Suggested Additional Analyses

The size of the project area and rapid timeframe in which to complete the analysis necessitated the use of a rapid, reach scale approach to defining and delineate geomorphic risk. In order to address the limitations described above, and to also build upon the work performed for this study, additional analyses can be performed to increase the spatial resolution of the study (i.e., examine risk at the site scale) and/or augment the data used for the study. Recommendations on next steps and/or additional analyses to perform are outlined below.

1. Detailed analysis of unit stream power (by individual cross section). A detailed, sub-reach, analysis of unit stream power would provide valuable insight into the variability in the rivers capacity to perform work on the bed and banks and transport sediment through the system. Large increases or decreases in unit stream power have the potential to drive significant erosion/degradation or aggradation events, respectively. Therefore, identifying large changes in unit stream power highlights areas most susceptible to fluvial geomorphic impact.
    - Calculate unit stream power (more informative than total stream power)
    - Assess percent change in unit stream power between up- and down-stream cross sections.
    - Calculate the percent change in unit stream power by dividing the downstream cross section by the upstream cross section (upstream SP/downstream SP). This reveals the percent change (e.g., 2-fold, 3-fold, 50% change) rather than absolute difference, which can be more informative for changes in geomorphic work potential. For example: At lower unit stream powers, a 2-fold increase in unit

stream power may be more geomorphically significant, yet have a smaller absolute difference, than a region with high stream power where the percent change is smaller but the absolute difference is larger.

- Large increases or decreases in the percent change in unit stream power highlight major changes in the rivers ability to do work on the channel and help identify potential locations for significant change and sediment aggradation or deposition.
- Remove results from cross sections at bridges and diversions that may be inaccurate artifacts from the modeling process

2. Assess the impact of diversions structures, return flows, bridges, etc. on hydrology and sediment transport. An understanding of how impediments and diversion operations impact the timing and magnitude of flows and sediment transport capacity at various locations in the project area can help determine geomorphic risk, and also identify management operations and/or treatments that can reduce the impacts of river processes to the communities.
3. Assess vegetation/land use impact on fluvial hazard and active channel stability. A well-connected floodplain and riparian corridor can help improve channel stability and mitigate flood and high flow impacts. Assessment of vegetation and land use along the river corridor can help land managers and planners to utilize floodplains and riparian habitat to help better protect urban and farm land from fluvial hazards.
4. Assess/assign value to assets within FHZs to help better quantify potential consequence/severity. This analysis strictly considers the quantity of assets within the FHZ and not the actual value to the owners or communities. The more valuable assets are the greater the consequences and severity if they are impacted by fluvial hazards. Having a better understanding of the actual value of assets within the FHZs will give owners and river managers a more accurate understanding of the true fluvial geomorphic risk.

Reach Summary Table

Reach	Geographic Description	HRC Area (sq. mi)	Avg. Stream Power 10yr	Avg. Q 10yr	Avg. Velocity 10yr	Avg. Stream Power 100yr	Avg. Q 100yr	Avg. Velocity 100yr	Buildings in AC	Buildings in EHA	Buildings in HRC	Diversions passing Sed.	Diversions not passing Sed.	Potential Erosion Points	Potential Score	Severity Score	Risk Score
1	Weld County to Goodrich	5	0.68	15816.75	4.12	1.47	47879.40	5.17	0	3	9	0	0	7	2	1	3
2	Goodrich to Narrows	6	0.47	16101.00	4.34	1.05	52194.99	5.55	0	2	30	1	0	5	2	2	4
3	Narrows to Fort Morgan	1	0.94	16625.24	5.01	2.38	53898.58	7.02	0	0	0	0	0	7	1	1	2
4	Fort Morgan	3	1.27	16862.10	4.54	2.07	54666.55	6.84	0	7	7	0	2	6	3	3	6
5	Fort Morgan to end of Jean K Tool SWA	3	0.57	16990.00	4.63	1.14	55079.99	5.96	0	5	5	1	1	3	2	2	4
6	Jean K Tool to D/S of Snyder	3	0.47	16990.00	4.45	0.85	55079.99	5.52	0	4	11	0	1	0	0	1	2
7	Snyder to near County line (Fort Morgan/Washington)	9	0.65	16206.67	4.23	1.10	54559.71	5.31	0	7	18	1	0	1	2	2	4
8	Downstream of Washington/Logan County boundary	10	0.43	15088.00	4.96	0.92	52549.00	6.12	0	5	12	1	3	3	2	1	3
9	Washington County to Pawnee Creek	5	0.41	15088.00	5.01	0.95	52549.00	6.37	0	1	2	0	1	1	1	1	2
10	Pawnee Creek to Sterling	6	0.52	15088.00	4.58	1.01	52549.00	5.73	0	9	14	1	1	2	2	3	5
11	Sterling	8	0.51	15376.60	4.67	1.10	53606.68	5.81	0	40	234	0	2	2	3	3	6
12	Sterling to Seven mile Creek	5	0.43	15458.00	3.95	0.83	53905.00	5.17	0	3	6	0	2	1	1	1	2
13	Seven mile Creek to Tamarack Ranch SWA	11	0.37	15142.29	4.59	0.85	53215.36	5.76	1	3	267	0	2	3	1	1	2
14	Tamarack Ranch SWA to Downstream of Harmony Ditch 1	13	0.86	14588.00	4.31	0.85	52005.00	5.04	0	2	37	1	3	2	1	1	2
15	Tamarack Ranch SWA to Sedgwick County	19	0.33	14243.71	4.04	0.70	51253.71	4.94	0	0	132	0	3	2	1	1	2
16	Sedgwick County to Peterson Ditch	15	0.53	14039.00	4.27	0.67	50807.00	5.03	1	3	12	1	0	2	1	2	3
17	Peterson Ditch to South Reservation Ditch	7	0.42	13889.56	4.38	0.77	50480.89	5.70	0	1	21	0	0	0	1	1	2
18	South Reservation Ditch to Pony Express SWA	8	0.42	13657.30	4.20	1.03	49973.90	5.64	0	13	20	1	2	3	2	3	5
19	Pony Express SWA to Stateline	6	0.47	13525.00	4.18	1.20	49685.00	5.82	1	1	9	0	0	4	2	2	4

Appendix H

Ecological Risk Analysis

Channel Condition

Reach	No more than 1 bar forming in channel		Minimal lateral migration and bank erosion A few shallow places in reach, due to sediment deposits Minimal bar formation (less than 3)			Moderate lateral migration and bank erosion Deposition of sediments causing channel to be very shallow in places 3-4 bars in channel			Severe lateral channel migration, and bank erosion Deposition of sediments causing channel to be very shallow in reach Braided channels (5 or more bars in channel)		
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
1					X						
2						X					
3				X							
4						X					
5					X						
6			X								
7					X						
8			X								
9						X					
10						X					
11					X						
12						X					
13							X				
14						X					
15						X					
16						X					
17					X						
18							X				
19						X					

Hydrologic Alteration

Reach	Bankfull or higher flows occur according to the flow regime that is characteristic of the site, generally every 1 to 2 years **and** No dams, dikes, or development in the floodplain[1], or water control structures are present **and** natural flow regime[2] prevails		Bankfull or higher flows occur only once every 3 to 5 years or less often than the local natual flow regime Developments in the floodplain, stream water withdrawals, flow augmentation, or water control structures may be present, but do not significatnly alter the natural flow regime[2]			Bankfull or higher flows occur only once every 6 to 10 years, or less often than the local natural flow regime Developments in the floodplain, stream water withdrawals, flow augmentation, or water control structures alter the natural flow regime[2]			Bankfull or higher flows rarely occur Stream water withdrawals completely dewater channel; and/or flow augmentation, stormwater, or urban runoff discharges directly into stream and severely alters the natural flow regime[2]		
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	[1] Development in the floodplain refers to transporation infrastructure (roads, railways), commercial or residential development, land conversion for agriculture or other uses, and similar activities that alter the timing, concentration, and delivery of precipitation as surface runoff or subsurface drainage. [2] As used here, "natural flow regime" refers to streamflow patterns unafffected by water withdrawals, floodplain development, agricultural or wastewater effluents, and practices that change surface runoff (dikes and levees) or subsurface drainage (tile drainage systems).										
1					X						
2							X				
3				X							
4							X				
5						X					
6				X							
7								X			
8								X			
9							X				
10						X					
11								X			
12						X					
13						X					
14							X				
15						X					
16				X							
17						X					
18							X				
19						X					

Bank Condition

Reach	Banks are stable; protected by roots of natural vegetation, wood, and rock[1]		Banks are moderately stable, protected by roots of natural vegetation, wood, or rock or a combination of materials			Banks are moderately unstable; very little protection of banks by roots of natural wood, vegetation, or rock			Banks are unstable; no bank protection with roots, wood, rock, or vegetation		
	No fabricated structures present on bank		Limited number of structures present on bank			Fabricated structures cover more than half of reach or entire bank			Riprap and/or other structures dominate banks		
	No excessive erosion or bank failures[2]		Evidence of erosion or bank failures, some with reestablishment of vegetation			Excessive bank erosion or active bank failures			Numerous active bank failures		
	No recreational or livestock access		Recreational use and/or grazing do not negatively impact bank condition			Recreational and/or livestock use are contributing to bank instability			Recreational and/or livestock use are contributing to bank instability		
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**

ot mean riprap, log cribs, or other fabricated revetments.
hat collapses and falls into the stream, usually because of slope instability.

1 Left			X								
1 Right					X						
2 Left				X							
2 Right					X						
3 Left					X						
3 Right			X								
4 Left							X				
4 Right							X				
5 Left				X							
5 Right					X						
6 Left											
6 Right				X							
7 Left					X						
7 Right							X				
8 Left					X						
8 Right						X					
9 Left					X						
9 Right						X					
10 Left						X					
10 Right						X					
11 Left				X							
11 Right					X						
12 Left						X					
12 Right						X					
13 Left				X							
13 Right						X					
14 Left				X							
14 Right						X					
15 Left				X							
15 Right						X					
16 Left				X							
16 Right					X						
17 Left					X						
17 Right					X						
18 Left				X							
18 Right					X						
19 Left				X							
19 Right						X					

Riparian Area Quality

Reach	Natural and diverse riparian vegetation with composition, density and age structure appropriate for the site		Natural and diverse riparian vegetation with composition, density and age structure appropriate for the site: Little or no evidence of concentrated flows through area			Natural vegetation compromised			Little or no natural vegetation		
	No invasive species or concentrated flows through area					Evidence of concentrated flows running through the riparian area			Evidence of concentrated flows running through the riparian area		
			Invasive species present in small numbers (20% cover or less)			Invasive species common (>20%<50% cover)			Invasive species widespread (>50% cover)		
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
1 Left							X				
1 Right							X				
2 Left							X				
2 Right							X				
3 Left							X				
3 Right							X				
4 Left							X				
4 Right							X				
5 Left							X				
5 Right							X				
6 Left						X					
6 Right						X					
7 Left							X				
7 Right							X				
8 Left							X				
8 Right							X				
9 Left							X				
9 Right							X				
10 Left							X				
10 Right							X				
11 Left							X				
11 Right							X				
12 Left							X				
12 Right							X				
13 Left							X				
13 Right							X				
14 Left							X				
14 Right							X				
15 Left							X				
15 Right							X				
16 Left							X				
16 Right							X				
17 Left							X				
17 Right							X				
18 Left							X				
18 Right							X				
19 Left							X				
19 Right							X				

Riparian Area Quantity

Reach	Natural plant community extends at least two bankfull widths or more than the entire active floodplain and is generally contiguous throughout property		Natural plant community extends at least one bankfull width or more than 1/2 to 2/3 of active floodplain and is generally contiguous throughout property		Natural plant community extends at least 1/2 of the bankfull width or more than at least 1/2 of the active floodplain		Natural plant community extends at least 1/3 of the bankfull width or more than 1/4 of active floodplain			Natural plant community extends less than 1/3 of the bankfull width or less than 1/4 of active floodplain	
			Vegetation gaps do not exceed 10% of the estimated length of the stream on the property		Vegetation gaps do not exceed 30% of the estimated length of the stream on the property		Vegetation gaps exceed 30% of the estimated length of the stream on the property			Vegetation gaps exceed 30% of the estimated length of the stream on the property	
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	Note: Score for this element is left bank score plus right bank score, divided by 2. IF the score of one bank is 7 or greater an the score of the other bank is 4 or less, subtract 2 points from the final score.										
1 Left								X			
1 Right										X	
2 Left							X				
2 Right									X		
3 Left						X					
3 Right							X				
4 Left									X		
4 Right							X				
5 Left				X							
5 Right							X				
6 Left					X						
6 Right					X						
7 Left				X							
7 Right					X						
8 Left							X				
8 Right						X					
9 Left							X				
9 Right								X			
10 Left									X		
10 Right									X		
11 Left											X
11 Right								X			
12 Left						X					
12 Right								X			
13 Left								X			
13 Right								X			
14 Left							X				
14 Right							X				
15 Left					X						
15 Right				X							
16 Left							X				
16 Right								X			
17 Left							X				
17 Right						X					
18 Left							X				
18 Right								X			
19 Left						X					
19 Right						X					

Canopy Cover

Reach	>75% of water surface shaded within the length of the stream in landowner's property		75-50% of water surface shaded within the length of the stream in landowner's property			49-20% of water surface shaded within the length of the stream in landowner's property			<20% of water surface shaded within the length of the stream in landowner's property		
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
1									X		
2									X		
3									X		
4									X		
5							X				
6							X				
7							X				
8								X			
9									X		
10							X				
11								X			
12							X				
13									X		
14							X				
15							X				
16								X			
17								X			
18								X			
19								X			

Water Appearance

Reach	Water is very clear, or clarity appropriate to site; submerged features in stream (rocks, wood) are visible at depths of 3 to 6 feet No motor oil sheen on surface; no evidence of metal precipitates in streams			Water is slightly turbid, especially after storm event, but clears after weather clears; submerged features in stream (rocks, wood) are only visible at depths of 1.5 to 3 feet No motor oil sheen on surface or evidence of metal precipitates in stream			Water is turbid most of the time; submerged features in stream (rocks, wood) are visible at depths of only .5 to 1.5 feet **and/or** Motor oil sheen is present on water surface or areas of slackwater **and/or** There is evidence of metal precipitates in stream			Very very turbid water most of the time; submerged features in stream (rocks, wood) are visible only within .5 feet below surface **and/or** Motor oil sheen is present on the water surface or areas of slackwater	
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
1					X						
2					X						
3					X						
4					X						
5					X						
6					X						
7					X						
8					X						
9					X						
10					X						
11					X						
12					X						
13					X						
14					X						
15					X						
16					X						
17					X						
18					X						
19					X						

Nutrient Enrichment

Reach	Clear water along entire reach Little algal growth present		Fairly clear or slightly greenish water Moderate algal growth on substrates			Greenish water particularly in slow sections Abundant algal growth, especially during warmer months **and/or** Slight odor of ammonia or rotten eggs **and/or** Sporadic growth of aquatic plants within slack water areas			Pea green color present; thick algal mats dominating stream **and/or** Strong odor of ammonia or rotten eggs **and/or** Dense stands of aquatic plants widely dispersed		
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
1			X								
2						X					
3						X					
4						X					
5					X						
6		X									
7				X							
8		X									
9				X							
10					X						
11			X								
12		X									
13				X							
14				X							
15				X							
16		X									
17		X									
18				X							
19		X									

Manure and Human Waste Presence

Reach	Livestock do not have access to stream No pipes or concentrated flows discharging animal waste or sewage directly into stream		Livestock access to stream is controlled and/or limited to small watering or crossing areas No pipes or concentrated flows discharging animal waste or sewage directly into stream			Livestock have unlimited access to stream during some portion of the year Manure is noticeable in stream **and/or** Pipes or concentrated flows discharge treated animal wasted or sewage directly into stream			Livestock have unlimited access to stream during entire year Manure is noticeable in stream **and/or** Pipes or concentrated flows discharge untreated animal waste or sewage directly into stream		
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
1					X						
2								X			
3	X										
4				X							
5					X						
6			X								
7						X					
8				X							
9						X					
10				X							
11							X				
12			X								
13			X								
14								X			
15			X								
16						X					
17			X								
18			X								
19			X								

Pools

Reach	More than two deep pools seperated by riffles, each with greater than 30% of the pool bottom obscured by depth, wood, or other cover Shallow pools also present		One or two deep pools seperated by riffles, each with greater than 30% of the pool bottom obscured by depth wood, or other cover At least one shallow pool present			Pools present but shallow (<2 times maximum depths of the upstream riffle) Only 10-30% of pool bottoms are obscured due to depth or wood cover			Pools absent, but some slow water habitat is available No cover discernbile **or** Reach is dominated by shallow continuous pools or slow water		
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
1								X			
2								X			
3									X		
4									X		
5								X			
6									X		
7									X		
8							X				
9									X		
10								X			
11								X			
12								X			
13									X		
14									X		
15							X				
16								X			
17									X		
18								X			
19								X			

Barriers to Aquatic Species Movement

Reach	No artificial barriers that prohibit movement of aquatic organisms during any time of the year	Physical structures, water withdrawals and/or water quality seasonally restrict movement of aquatic species			Physical structures, water withdrawals and/or water quality restrict movement of aquatic species throughout the year				Physical structures, water withdrawals and/or water quality prohibit movement of aquatic species		
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
1	X										
2				X							
3	X										
4				X							
5				X							
6	X										
7				X							
8				X							
9				X							
10				X							
11				X							
12				X							
13				X							
14				X							
15				X							
16	X										
17				X							
18				X							
19	X										

Fish Habitat Complexity

Reach	# of features	Length of Reach (Miles)	Normalized # of features	Ten or more habitat features available, at least one of which is considered optimal in reference sites (large wood in forested streams)		Eight to nine habitat features available		Six to seven habitat features available		Four to five habitat features available		Less than four habitat features available		
				10	9	8	7	6	5	4	3	2	1	0
				off-channel habitats										
1	8	7.2	3.33									X		
2	6	8.5	2.12									X		
3	2	5.2	1.15									X		
4	1	6.9	0.43									X		
5	2	5.6	1.07									X		
6	0	3.9	0.00									X		
7	1	8	0.38									X		
8	5	10.6	1.42									X		
9	5	7.7	1.95									X		
10	8	7.8	3.08									X		
11	5	6.9	2.17									X		
12	7	5.3	3.96									X		
13	11	9.2	3.59									X		
14	2	8.6	0.70									X		
15	3	8.8	1.02									X		
16	9	10.1	2.67									X		
17	1	5.1	0.59									X		
18	4	9.7	1.24									X		
19	1	7.9	0.38									X		

Aquatic Invertebrate Habitat

Reach	# of features	Length of Reach (Miles)	Normalized # of features	At least 9 types of habitat present		8 to 6 types of habitat			5 to 4 types of habitat present		3 to 2 types of habitat present		None to 1 type of habitat present	
				A combination of wood with riffles		Site may be in need of more wood or refrence habitat								
				(If nonforested stream, condsider if reference site's optimal habitat type needed for this high score)										
				10	9	8	7	6	5	4	3	2	1	0
				vegetation, undercut banks, pools, and root mats.										
1	8	7.2	3.33								X			
2	6	8.5	2.12									X		
3	2	5.2	1.15									X		
4	1	6.9	0.43										X	
5	2	5.6	1.07										X	
6	0	3.9	0.00											X
7	1	8	0.38										X	
8	5	10.6	1.42									X		
9	5	7.7	1.95									X		
10	8	7.8	3.08								X			
11	5	6.9	2.17									X		
12	7	5.3	3.96							X				
13	11	9.2	3.59							X				
14	2	8.6	0.70										X	
15	3	8.8	1.02										X	
16	9	10.1	2.67								X			
17	1	5.1	0.59										X	
18	4	9.7	1.24									X		
19	1	7.9	0.38										X	

SVAP2 Results

Reach	Channel Condition	Hydrologic Alteration	Bank Condition	Riparian Area Quanity	Riparian Area Quality	Canopy Cover	Water Appearance	Nutrient Enrichment	Manure and Human Waste Presence	Pools	Barriers to Aquatic Species Movement	Fish Habitat Complexity	Aquatic Invertebrate Habitat	Average	Ecological Condition
1	6	6	14	2	4	2	6	8	7	3	10	2	3	5.6	Fair
2	5	4	13	3	4	2	6	5	3	3	7	2	2	4.5	Poor
3	7	7	14	4.5	4	2	6	5	10	2	10	2	2	5.8	Fair
4	5	4	8	3	4	2	6	5	7	2	7	2	1	4.3	Poor
5	6	5	13	5	4	3	6	6	6	3	7	2	1	5.2	Fair
6	8	7	16	6	5	4	6	9	8	2	10	2	0	6.4	Fair
7	6	3	10	6.5	4	4	6	7	5	2	7	2	1	4.9	Poor
8	8	3	11	5	4	3	6	9	7	4	7	2	2	5.5	Fair
9	5	4	11	3.5	4	2	6	7	5	2	7	2	2	4.7	Poor
10	5	5	10	2	4	4	6	6	7	3	7	2	3	4.9	Poor
11	6	3	12	2.5	4	3	6	8	4	3	7	2	2	4.8	Poor
12	5	5	10	4	4	4	6	9	8	3	7	2	4	5.5	Fair
13	4	5	11	3	4	2	6	7	8	2	7	2	4	5.0	Fair
14	5	4	12	4	4	4	6	7	3	2	7	2	1	4.7	Poor
15	5	5	12	6.5	4	4	6	7	8	4	7	2	1	5.5	Fair
16	5	7	12	4	4	3	6	9	5	3	10	2	3	5.6	Fair
17	6	5	12	4.5	4	3	6	9	8	2	7	2	1	5.3	Fair
18	4	4	12	4	4	3	6	7	8	3	7	2	2	5.1	Fair
19	5	5	12	5	4	3	6	9	8	3	10	2	1	5.6	Fair

Ecological Risk Scores

Reach	Average	Ecological Condition	Risk Score	Priority Score	Ecological Risk Score
1	5.6	Fair	2	2	Medium
2	4.5	Poor	2	2	Medium
3	5.8	Fair	2	1	Low
4	4.3	Poor	2	2	Medium
5	5.2	Fair	2	3	High
6	6.4	Fair	2	3	High
7	4.9	Poor	2	3	High
8	5.5	Fair	2	3	High
9	4.7	Poor	2	2	Medium
10	4.9	Poor	2	2	Medium
11	4.8	Poor	2	3	High
12	5.5	Fair	2	3	High
13	5.0	Fair	2	2	Medium
14	4.7	Poor	2	3	High
15	5.5	Fair	2	3	High
16	5.6	Fair	2	2	Medium
17	5.3	Fair	2	3	High
18	5.1	Fair	2	2	Medium
19	5.6	Fair	2	3	High