COLORADO DISASTER RECOVERY

LESSONS LEARNED

A GUIDE TO PLAN, REACT, ADAPT, EVOLVE, AND ACHIEVE THE BEST POSSIBLE OUTCOMES FOR OUR COMMUNITIES AND STREAM CORRIDORS

NFFA Webinar: Disaster Recovery Lessons Learned. May 12, 2020
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A WATERSHED APPROACH

BACKGROUND ON COLORADO'S RECOVERY PROGRAM

THE FLOOD OF 2013

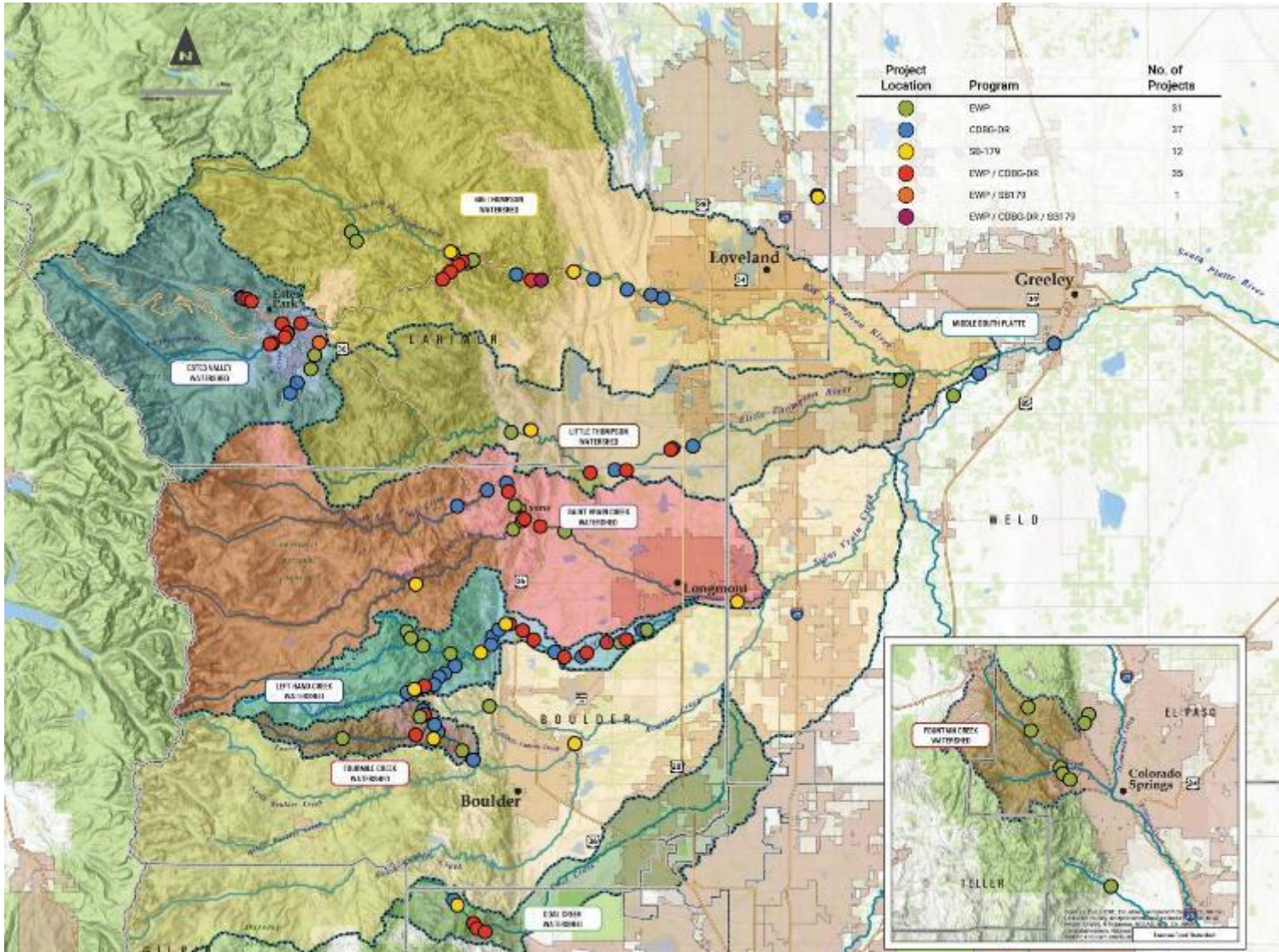
WATERSHED BASED FLOOD RECOVERY

- Protect life and property while restoring ecological processes that connect land and water
- Complete recovery work on a watershed scale
- Support early planning to identify root issues, develop holistic solutions, and allow time to secure appropriate funding
- Support watershed coalitions as a model for stakeholder engagement
- Execute projects with multiple objectives
- Incorporate resiliency into every project

RECOVERY: BY THE NUMBERS

- **117** total flood recovery projects completed (68 EWP)
- Total construction costs of over **$70 million** (~$50 million EWP)
- Over **$270 million** – value of infrastructure and private structures protected
- **65 miles** of river and floodplain improvements implemented (40 miles EWP)
- **12** watershed master plans finalized
- **34** resiliency planning studies completed
- **23** comprehensive recovery planning studies completed
- Over **700** private property owners engaged
- **$4.2 million** across 10 coalitions for capacity building staffing grants. CWCB supplemented this with an additional $400,000.

*These are numbers for the CWCB and DOLA led recovery efforts for the 2013 flood.



HOW AND WHY OF LESSONS LEARNED

- Recommendations that will allow state and federal disaster response programs to implement more resilient and holistic recovery actions (noted as **Recommendations for Changes to State and Federal Disaster Response**).
- Actions to implement immediately after a disaster has occurred (noted as **Recommendations for Disaster Recovery Actions**).
- Action items that can be completed by a community ahead of the next disaster (noted as **Recommendations for Pre-Disaster Actions**).

RT A COMPREHENSIVE RECOVERY VISION

mendations for Disaster Recovery Actions:

p a comprehensive recovery program led by an agency that
he entirety of the disaster-affected region, e.g. a state agency or
authority that has the necessary in-house expertise for disaster
nd an understanding of natural systems. This agency should employ
rivers and flood risk. Ideally that agency should be responsible for river corridor
in administrator and be responsible and
The expertise housed within this department is central to
ate assessments of problems and ongoing risk, informed
king conceptual designs, as well as responsible and
decisions. There are professional certifications (CFM,
e training and continuing education in the field of
nd the agency that houses professionals with these
a strong candidate for the central leadership role--
ere is currently not a certification for professional
, biologists or ecologists, all of whom would
a recovery program.

objectives for recovery and communicate
throughout the duration of the programs.
a foundation to which to return when
nd solving complex problems.

hases of disaster recovery should be
t provide temporary fixes during the
s Office of Emergency Management
d agencies that have the expertise
nterventions. These agreements
ill complement and build upon
fixes are either compatible with
d to be removed or replaced

- [ ] Comprehensive recovery takes time and the lead agency must, with support of elected officials and local partners, work out realistic timelines that allow the program to execute successful and meaningful projects and negotiate with funding agencies to make these timelines a reality.
- [ ] There may be significant opportunities to create in-kind match for federal funding with materials sourced from road reconstruction or other infrastructure projects. Forward thinking and programmatic planning can leverage these opportunities to identify match funding for projects without the use of local cash.
- [ ] Leadership should be prepared to encounter and resolve conflicts that arise from federal, state, and local agencies whom may have different priorities in order to promote and execute the holistic recovery vision.
- [x] The lead agency should organize and establish a single technical assistance team with expertise in flood management and river processes to guide flood recovery across agencies and funding programs.
- [ ] The lead agency should empower local groups, coalitions and local governments to work together. Often these groups have pre-established relationships within the impacted communities; they understand local values and are already established in close proximity to the need. Empowered correctly, these local groups can effectively act as an extension of state and federal resources and may improve the ability of state and federal staff to remain focused on the overall vision and road to recovery.
- [ ] The lead agency should develop a culture of collaboration with a vision of raising the standard of performance within the local engineering, design, and construction industry. There can be significant distrust and defensiveness on the front end of large collaboration efforts. Ultimately, the objective must be to create strong partnerships, founded on the goal of achieving the best possible outcome on implemented projects--in other words, professionals need to work across disciplines and in collaboration with competitors to ensure that no opportunity is left behind.

PHOTO: Disaster Response, Saint Vrain Creek, Lyons, CO

Recommendations for Pre-Disaster Actions:

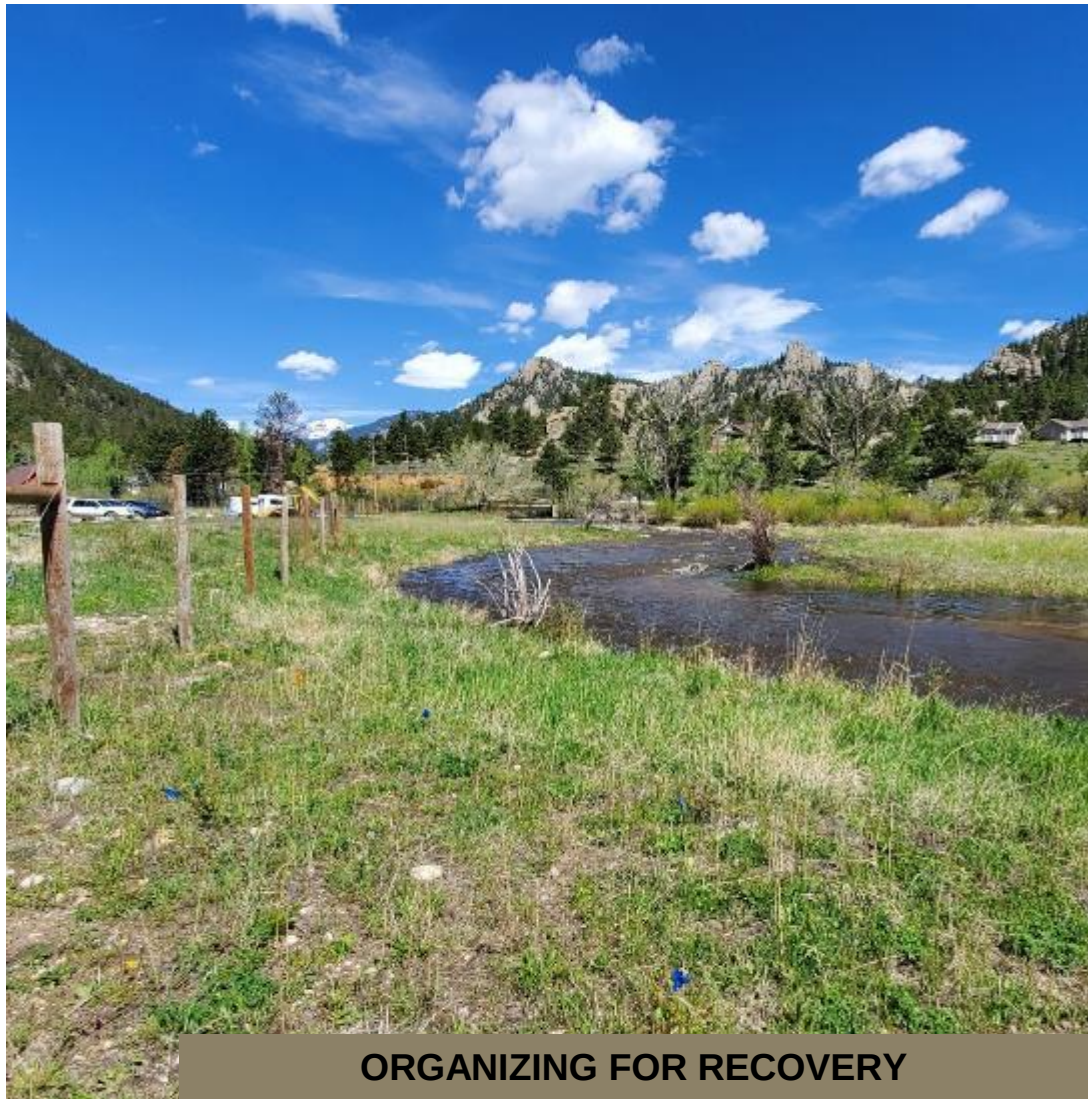
- [ ] Invest in developing personal relationships with state and federal partner
  Knowing federal program managers on a first name basis and having a high degree of trust with them can make a huge difference during flood recovery.
- [x] Determine leadership responsibilities and organizational structures for specific disaster types, (i.e. wildfires or flooding, on a state or regiona basis). This structure will establish how funding will be distributed and which agency will set the vision and overall goals and objectives of the recovery effort and allow recovery efforts to hit the ground running when disaster strikes.
- [ ] Invest in and allow for longer timelines for recovery project developmen and construction. Longer timelines can improve outcomes by allowing proper vetting of alternatives, public outreach and communication, and expanded partnerships for funding and multiple benefits. Longer timeline also provide a better opportunity to resolve unforeseen and length permitting processes that might otherwise create significant challenges t project implementation.

ORGANIZING FOR RECOVERY

WITH ORGANIZATION COMES EMPOWERMENT

DEVELOP A CENTRAILIZED RECOVERY PROGRAM THAT CAN SUPPORT A COMPREHENSIVE VISION

1. Reduce Hazards and Protect Life Safety and Property
2. Use Federal and State Funding Effectively
3. Enhance the Health and Resilience of Watersheds and Stream Corridors
4. Build Capacity of Watershed Coalitions
5. Advance a Watershed Approach to Flood Recovery

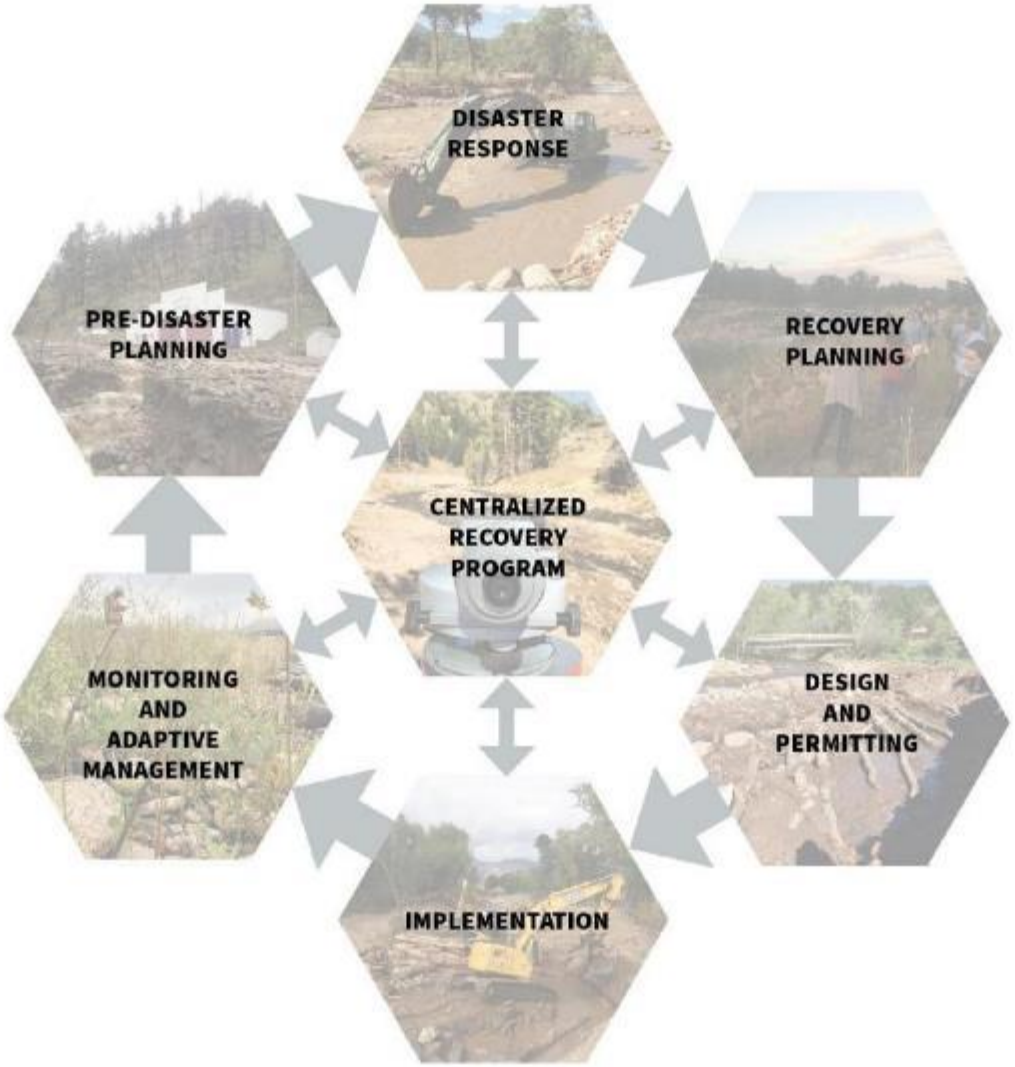


The Human Element
Communication
Stakeholders
Training

Pre-Disaster Planning
Multi-Hazard Risk Identification
Pre-Disaster Agreements

Monitoring and Adaptive Management
Monitoring
Adaptive Management

Implementation
Construction Oversight
Standard Specifications and Invoicing
Construction Procurement
Planning for Revegetation
Plant Installation
Revegetation Maintenance



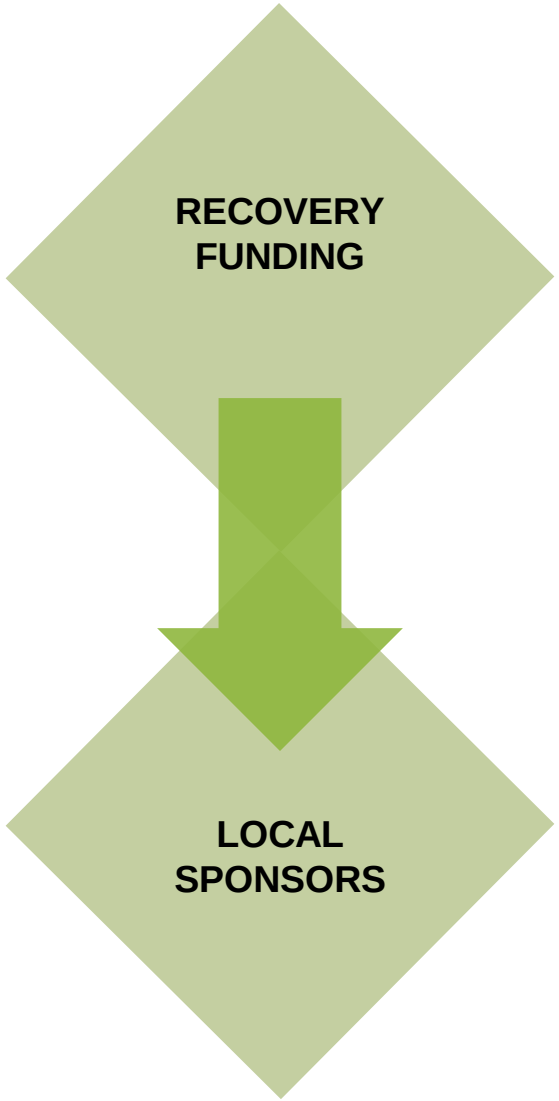
Disaster Response
Emergency Actions
Bring Together Technical Experts
Post Disaster Data Collection and Analysis

Recovery Planning
Shared Corridors
Locally Led Plan
Evaluate Buyouts
Project Scoping and Prioritization

Design and Permitting
Funding for Design
Design Strategies and Standards
Quality Assurance and Quality Control
Infrastructure and Resiliency
Permitting
Floodplain Management

GRAPHIC: Conceptual Model for Disaster Recovery. The figure above is representative of the disaster recovery process implemented by the Colorado Water Conservation Board and Colorado Department of Local Affairs following the 2013 flood.

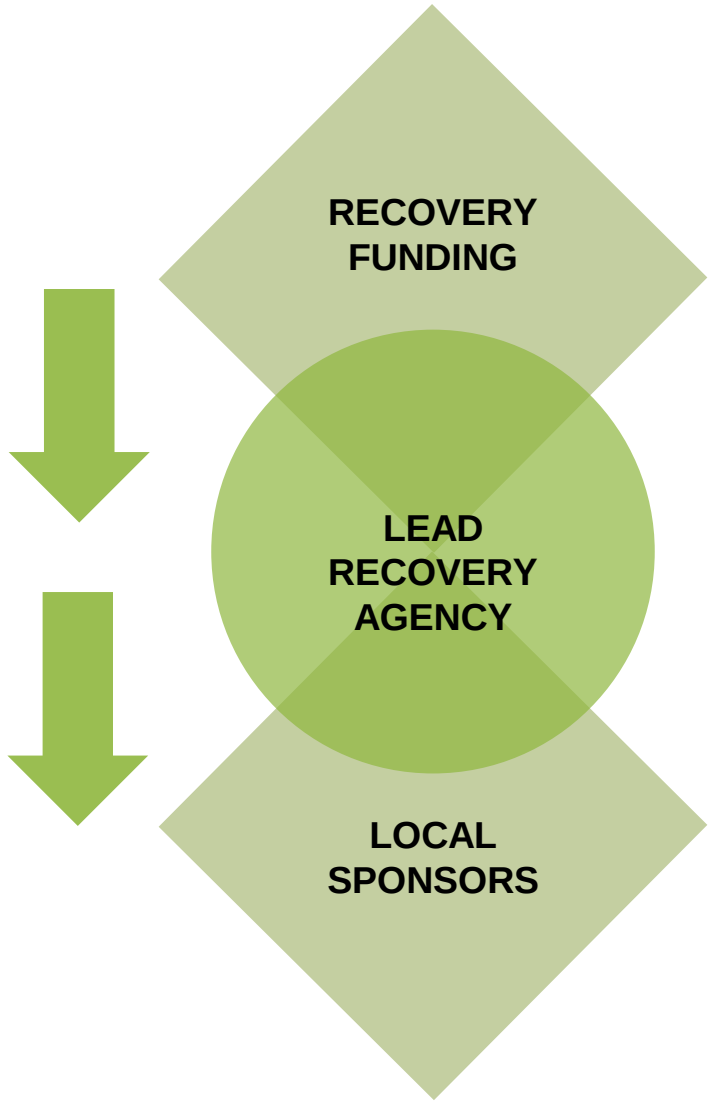
MAXIMIZE THE BENEFIT OF FEDERAL FUNDING THROUGH CENTRALIZED LEADERSHIP AND ORGANIZATION



MAXIMIZE THE BENEFIT OF FEDERAL FUNDING THROUGH CENTRALIZED LEADERSHIP AND ORGANIZATION

OPPORTUNITIES

- Creates a program Technical Assistance team to support program management, design, construction oversight, and QA.
- Set program expectations, e.g. get away from overly restrictive design requirements that are inappropriate for stream rehabilitation (e.g. 100% design)



RESPONSIBILITIES

- Provides funding and program oversight,
- Addresses programmatic requirements such as environmental compliance

- Sets the recovery vision
- Provides partial match funding
- Sets guidelines and standards

- Communication with local stakeholders
- Oversees project implementation
- Raises local match
- Commits to O&M

AUTHORIZE STATE AND LOCAL RECOVERY FUNDING

- Get people working
- Keep local disaster recovery money as flexible as possible
- Use local funding for recovery plans
- Leverage local dollars for construction match

PROJECT EXAMPLE: Colorado Recovery Planning

- Funding for master planning was made available via CWCB
- Move watershed coalitions and communities towards prioritization and implementation of recovery projects:
  - Reduced flood and geomorphic hazards
  - Improved ecological conditions
- The master plans defined each watershed's vision for recovery and enhanced the community's understanding of the river corridor and associated risks

ORGANIZING FOR RECOVERY

A TALE OF TWO RECOVERY PROGRAMS

ORGANIZING FOR RECOVERY

DISASTER RESPONSE

GUIDING EMERGENCY EFFORTS TOWARDS RESILIENT LONG-TERM OUTCOMES

+

SHARED CORRIDORS

RIVERS, ROADS, AND RESIDENCES

Getting the foundation for a successful long-term design set immediately after the flood in the emergency response actions is imperative for recovery success.

WHAT DO STREAMS LOOK LIKE IMMEDIATELY FOLLOWING A FLOOD?

AND WHY DO THEY LOOK SO DIFFERENT A FEW MONTHS LATER?

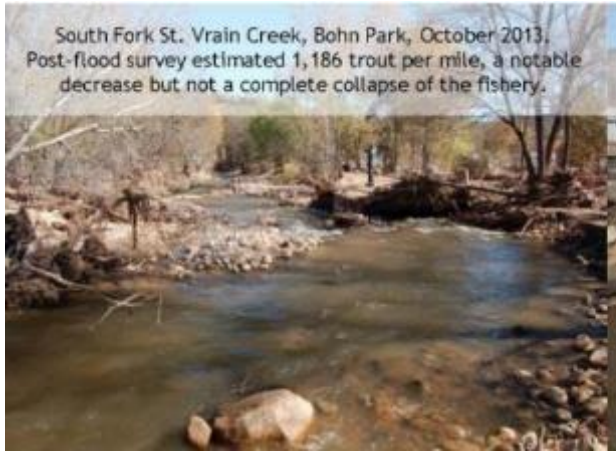
REFRAME THE FLOOD: From a “river problem” to a “human problem”

DISASTER RESPONSE & SHARED CORRIDORS

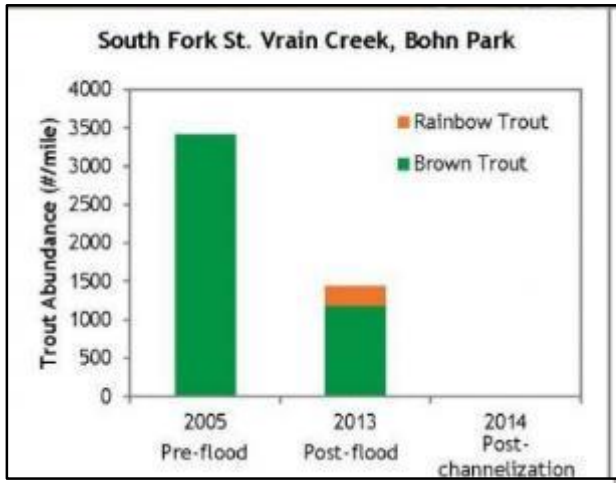
THE 2013 FLOOD RESPONSE REFRAMED

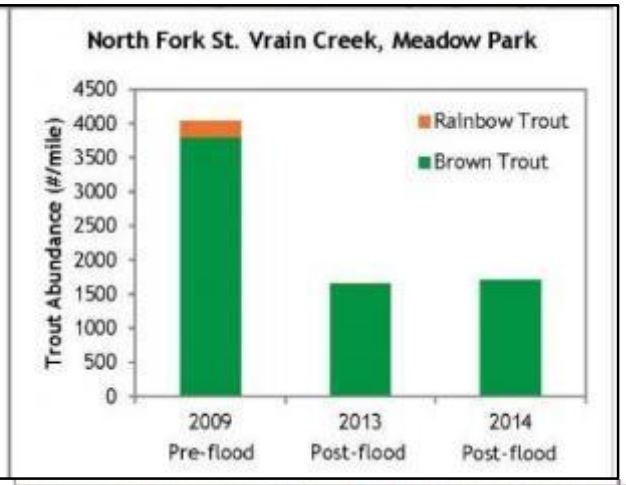
POST-FLOOD EMERGENCY REPAIRS

Negative Ecosystem Impacts: CPW POST-FLOOD Fish Survey Data

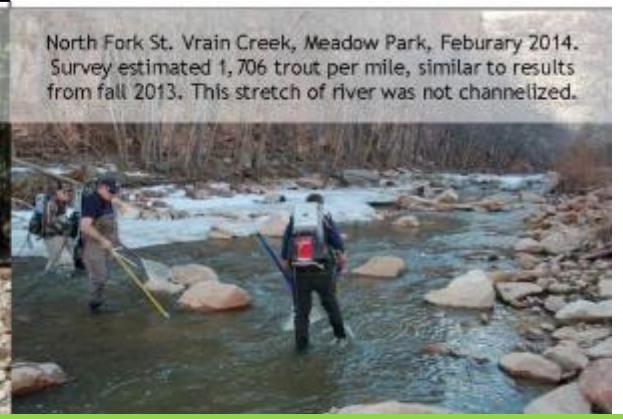

South Fork St. Vrain Creek, Bohn Park, October 2013. Post-flood survey estimated 1,186 trout per mile, a notable decrease but not a complete collapse of the fishery.


South Fork St. Vrain Creek, Bohn Park, February 2014. Post-channelization survey estimated 9 trout per mile, a complete collapse of the trout fishery.





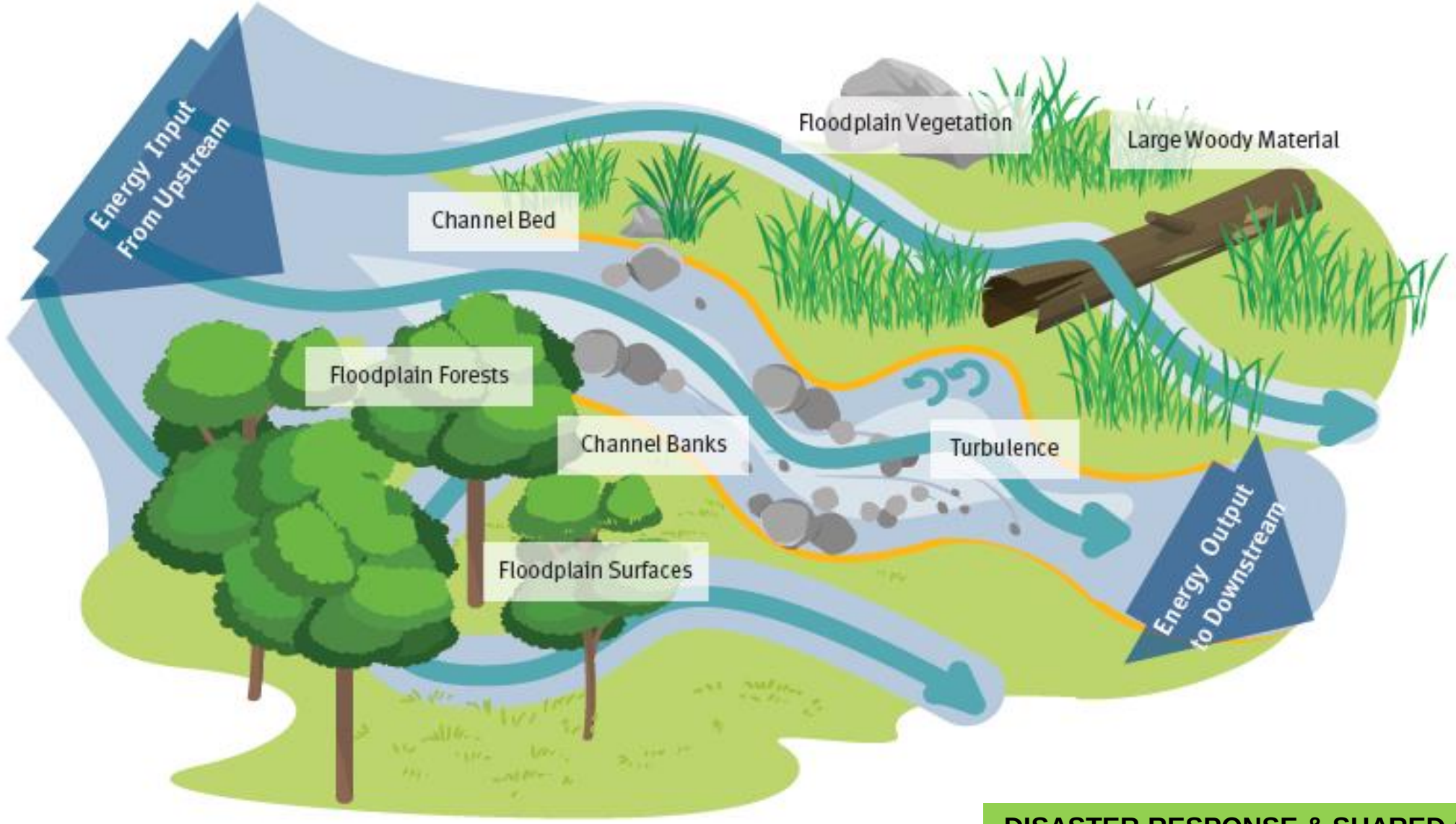

North Fork St. Vrain Creek, Meadow Park, September 2013. An electrofishing survey in October 2013 yielded 1,646 trout per mile.


North Fork St. Vrain Creek, Meadow Park, Feburary 2014. Survey estimated 1,706 trout per mile, similar to results from fall 2013. This stretch of river was not channelized.

Streams need space to accommodate their energy and sediment

DISASTER RESPONSE & SHARED CORRIDORS

Conceptual Model of Energy Continuity



Conceptual Model of Energy Continuity: Channelized

Shared Corridors: Consider the difference between addressing a problem and transferring a problem

DISASTER RESPONSE & SHARED CORRIDORS

Colorado Disaster Recovery: Lessons Learned

County Road 43
Larimer County—FHWA project

Box 1.—Big Thompson River – U.S. Highway 34 Improvements
After a devastating flood in 2013, the Colorado Department of Transportation repaired and re-built a canyon-bound highway. Many portions of the highway were washed out, especially where the road ran along the outside of river bends (right). The highway was elevated above and moved away from one such high hazard area as part of the post-flood reconstruction. Other resilient designs include setbacks from the river, vegetated floodplain benches, and integration of vegetation into embankments. Though costly, these improvements reduce the risk of future damage and the economic costs of losing a major transportation corridor from the next flood.

Managing Infrastructure in the Stream Environment

Advisory Committee on Water Information
Subcommittee on Sedimentation
Environment and Infrastructure Working Group

Prepared by:

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2: Natural Resources Conservation Service, National Design, Construction, and Soil Mechanics Center, Fort Worth, Texas
3: U.S. Forest Service, National Stream and Aquatic Ecology Center, Fort Collins, Colorado

DISASTER RESPONSE & SHARED CORRIDORS

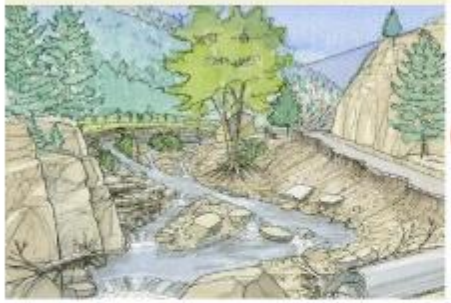
Disaster Response and Shared Corridors

TEMPORARY BECOMES PERMANENT

FLOOD RECOVERY PLANNING

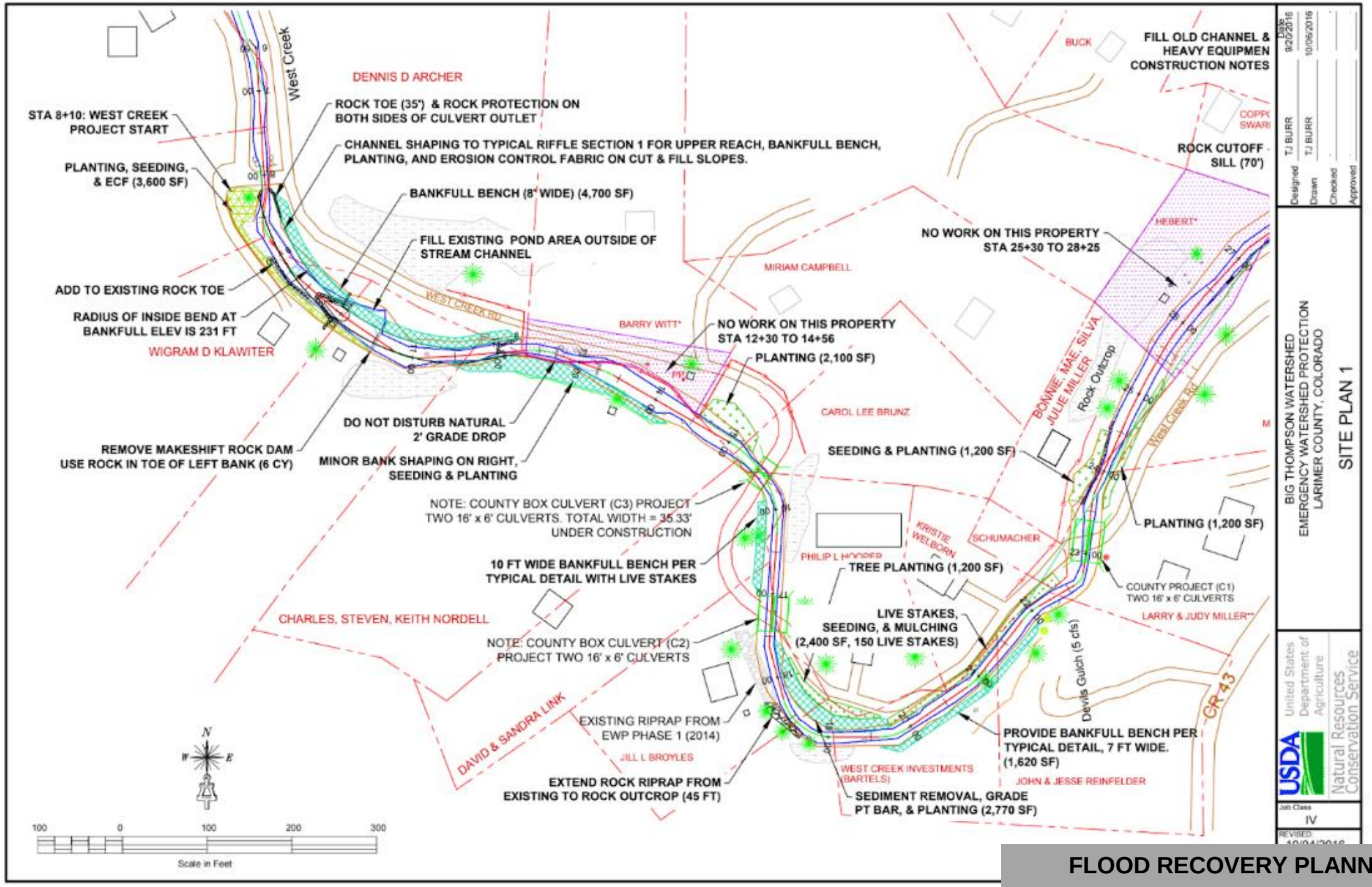
VALUES, GOALS, AND OBJECTIVES

FLOOD RECOVERY PLANNING

WATERSHED ZONE STREAM DESCRIPTION		PRE-FLOOD	POST-FLOOD	POTENTIAL FUTURE
CANYONS	**Pre-Flood:** Stream is located in headwater or confined valley, frequently adjacent to roads and homes. Stream is in quasi-equilibrium state and typically has higher transport and stream power. **Post-Flood:** Significant damage with new flow paths, debris flows, large sediment deposition. **Future:** A wider stream corridor for stream movement. Rip-rap is replaced with natural solutions like large wood, providing structure and improvement of riparian habitat.			
ALLUVIAL FAN	**Pre-Flood:** Partly confined stream with moderate channel grade and low sinuosity. Homes adjacent to stream bank and in the floodplain. Stream has moderate channel grade and low sinuosity. **Post-Flood:** Stream migrated significantly and deposited large amounts of sediment. **Future:** Floodplain is free of major development allowing normal riparian habitat development with secondary channels used to help transport future high flows.			
HIGH PLAINS	**Pre-Flood:** Low grade stream is typically unconfined with adjacent floodplain or entrenched with adjacent houses and agricultural land. Stream is single thread and straightened in some areas, and bridges are common. **Post-Flood:** Stream exceeded channel capacity, damaging roads and depositing trash and other debris. **Future:** Additional room for the stream and channel capacity. Invasive crack willows are removed and normal channel evolution occurs with bars, riffles, and pools.			

Conceptual Model for Left Hand Creek Watershed


OXFORD
64TH
73RD
USCOMBE
68ST
NIMBUS
OXFORD
DIAGONAL
AIRPORT
67TH



FLOOD RECOVERY PLANNING


Project Sponsored By:
COAL CREEK CANYON
WATERSHED PARTNERSHIP
Coal Creek Canyon Watershed Partnership
More Information at www.cccwp.org

PROJECT IDENTIFICATION AND SCOPING

LAYING THE FOUNDATION FOR SUCCESSFUL RECOVERY

PROJECT IDENTIFICATION & SCOPING

PROJECT IDENTIFICATION & SCOPING

TA Team Rank	Applicant	Watershed Coalition	Project Type	Coalition Rank	Project Cost	Notes	TA Recommended Award
1	Big Thompson River Restoration Coalition	Big Thompson	Habitat, hydraulic, floodplain improvement, bank stabilization, geomorphic risk	1 of 1	$296,791	Fund project as proposed	
1	Coal Creek Canyon Watershed Partnership	Coal Creek	Debris, erosion, bank restoration	1 of 1	$177,604	Fund to full $300,000 and extend the project length	
1	Fourmile Watershed Coalition	Fourmile	Revegetation, restoration	2 of 4	$72,379	and BoCo to design build the project originally identified as the SB-179 project (before the money	
1	Fourmile Watershed Coalition	Fourmile	Debris, erosion, bank restoration	N/A	$227,621		
1	James Creek Watershed Initiative	Lefthand	Restoration	High	$299,892	Examine these two Lefthand Projects and determine if they can be completed for a total of $300K	
1	Lefthand Watershed Oversight Group	Lefthand	Debris, Floodplain, Channel	High	$298,739		
1	Fountain Creek Watershed, Flood Control and Greenway District	Upper Fountain Creek/Cheyenne Creek Coalition	LID demonstration project on Cheyenne creek	1 of 1	$290,000	Fund project as proposed	
1	Estes Valley Watershed Coalition	Estes Valley	Wetland restoration, riprap, channel reshaping	1 of 1	$287,900	Fund project as proposed	
1	Little Thompson Watershed Restoration Coalition	Little Thompson	Restoration, stabilization, mitigation	1 of 1	$299,200	See TA notes on how to allocate funds if not all 5 sites are construction ready	
1	Town of Lyons	St. Vrain	Bank restoration	3 of 3	$278,218	Increase fund request to full $300,000 and ask that Lyons extend upstream of town boundary to old south st. vrain bridge (see TA notes)	
						SUBTOTAL	
2	Town of Lyons	St. Vrain	Bank restoration	?	$300,000	Recommend this project be partially funded for channel work only at $75/lf and combined with SB-179 fund project	
2	Lefthand Watershed Oversight Group	Lefthand	Public engagement, engineering design, weed management	High	$254,238	Consider partial funding for further debris removal and revegetation	
2	City of Longmont	St. Vrain	Revegetation, stream restoration, diversion, culvert	?	$150,000	Consider funding reveg only	
2	Boulder County	Fourmile	Stabilization, debris rack	1 of 4	$250,313	Request revised proposal to innovate debris rack design and install a demonstration project. Do not fund for channel armoring as proposed. Consider	
						SUBTOTAL (FLEXIBLE)	
3	Boulder County	St. Vrain	Breach closure, stabilization	?	$300,000	Combine into planning/implementation project in round 2	
3	Boulder County	St. Vrain	Breach closure, stabilization	2 of 3	$300,000		
3	Boulder County	St. Vrain	Breach closure, stabilization	?	$300,000		

Watershed Coalition	Project Name	Project Type	Coalition Rank	Project Cost	Notes	TA Recommended Award
Big Thompson		Habitat, hydraulic, floodplain improvement, bank stabilization, geomorphic risk	1 of 1		Fund project as proposed	
Coal Creek		Debris, erosion, bank restoration	1 of 1		Fund to full $300,000 and extend the project length	
Fourmile		Revegetation, restoration	2 of 4		Fund Logan Mill Project. Coordinate with CWCB and BoCo to design build the project originally identified as the SB-179 project (before the money was turned into road planning funds)	
Fourmile		Debris, erosion, bank restoration	N/A			
Lefthand		Restoration	High		Examine these two Lefthand Projects and determine if they can be completed for a total of $300K	
Lefthand		Debris, Floodplain, Channel	High			
Upper Fountain Creek/Cheyenne Creek Coalition		LID demonstration project on Cheyenne creek	1 of 1		Fund project as proposed	
Estes Valley		Wetland restoration, riprap, channel reshaping	1 of 1		Fund project as proposed	
Little Thompson		Restoration, stabilization, mitigation	1 of 1		See TA notes on how to allocate funds if not all 5 sites are construction ready	
St. Vrain		Bank restoration	3 of 3		Increase fund request to full $300,000 and ask that Lyons extend upstream of town boundary to old south st. vrain bridge (see TA notes)	
					SUBTOTAL	
St. Vrain		Bank restoration	?		Recommend this project be partially funded for channel work only at $75/lf and combined with SB-179 fund project	
Lefthand		Public engagement, engineering design, weed management	High		Consider partial funding for further debris removal and revegetation	
St. Vrain		Revegetation, stream restoration, diversion, culvert	?		Consider funding reveg only	
Fourmile		Stabilization, debris rack	1 of 4		Request revised proposal to innovate debris rack design and install a demonstration project. Do not fund for channel armoring as proposed. Consider funding for culvert removal and installation of a low water road crossing as has been used in other fire burned areas.	
					SUBTOTAL (FLEXIBLE)	
St. Vrain		Breach closure, stabilization	?		Combine into planning/implementation project in round 2	
St. Vrain		Breach closure, stabilization	2 of 3			
St. Vrain		Breach closure, stabilization	?			
Fourmile		Stream restoration design	3 of 4		Consider for Round 2 after further design/budget development	
Lefthand		Stream restoration design	?		Consider for Round 2 after further design/budget development	

PROJECT IDENTIFICATION & SCOPING

PROJECT IDENTIFICATION & SCOPING

CONSTRUCTION

MAKING THIS OPPORTUNITY COUNT

CONSTRUCTION

Upper Coal Creek Improvements Project

Weekly Construction Update

Date: 04/28/2017
By: Mark Schutte
Location: Coal Creek Canyon, Jefferson County, CO.

Colorado Emergency Watershed Protection (EWP) Program

PROJECT SPONSOR: Coal Creek Canyon Watershed Partnership

Work In Progress

Completed all improvements on Lowe property

1. Excavation and installation of two low benches with void-filled riprap backslopes.
2. Boulder toe installation completed between channel and low bench areas.
3. Construction of double-stacked boulder wall completed. Riprap backslope installed.

Began red soil removal efforts on Simonetti property.

Above: Completed installation of double-stacked boulder wall and boulder toe on Lowe Property.
Below: Began excavation of low benches on Lowe property, river left.

Upcoming Work

1. Mobilize to Cameron property and begin channel improvements.
2. Continue red soil removal on Simonetti property.
3. Revegetation work on Adair and Khachatrian properties.

Other Notes

1. A larger crew will be on-site in the coming weeks to speed up revegetation.
2. Contractor will protect sites with additional erosion control if necessary in preparation for precipitation over the weekend.

COLORADO Colorado Water Conservation Board

USDA Natural Resources Conservation Service

CONSTRUCTION

CONSTRUCTION

CONSTRUCTION

CONSTRUCTION

SOIL LIFT

INSTALLATION

STAGE 1

FOUNDATION:
Footer rock placed according to plan detail to support soil lifts and to provide protection from toe scour.

STAGE 2

FORMING:
Stabilizer board place to establish front face of soil lift. Board held in place by rebar stakes.

STAGE 3

FORMING:
Blanket placed on top of foundation and formed up to stabilizer board. Lift ready for backfill. Note, seeding is installed before lift is wrapped and staked.

STAGE 4

FORMING:
First layer placed and blanket wrapped around soil and staked. Form set for second soil lift and willow cuttings being placed in between lifts.

SOIL LIFT

DESCRIPTION

PRACTICE DESCRIPTION

Soil lifts are vertical layers of soil wrapped with erosion control fabric and integrated with vegetation to "build" or reconstruct stream banks.

PURPOSE

This technique is used for slope stabilization, streambank and shoreline restoration and stream relocations. Soil lifts provide immediate and short-term structural support, allowing for root development and growth of vegetation which ultimately provides long-term structural bank stabilization as the erosion control fabric degrades, the structural support of the bank transfers to the plant-based treatment.

COMMON NAMES

Soil Wrapped Lift
Brush Layering

CONSTRUCTION REQUIREMENTS

MATERIALS

- COIR MATTING AND JUTE FABRIC
- SOIL (ONSITE AND/OR TOPSOIL)
- LIVE CUTTINGS
- BACKFILL
- STABILIZER BOARD
- REBAR PIN
- HARDWOOD STAKES
- WEDGE STAKES

EQUIPMENT

- EXCAVATOR/BACKHOE
- CONSTRUCTED LIFT FRAME
- SLEDGE HAMMER
- DRIVEL

Soil lifts along Left Hand Creek following installation, but prior to planting and staking.

BANK STABILIZATION

CONSTRUCTION TECHNIQUES

INSTALLATION FUNDAMENTALS

- Understanding the designed geometry and final grade elevations.
- Using a stabilizer board to form the front edge of the soil lift.
- Keeping the coir fabric tightly wrapped around the lift and not loose or wrinkled.
- Storage and installation of live cuttings.
- Compacting the soil within each lift during construction.
- Hydrologic connectivity.

POTENTIAL ENHANCEMENTS

- Install coir block to provide inner support and long-term structural protection of the soil mass at the toe of each wrap. Vegetation will grow through the coir block and embed into the soil mass within.
- Container seedling or plugs can be installed through the geotextile fabric along horizontal benches and provide additional support.
- Use in concert with other bioengineering techniques, such as brush layering, pole planting, and wattles/live fascines.

COMMON FAILURES

- Soil lifts must be properly constructed in a consistent even manner that is resistant to erosion and scour.
- Inner fabric too thin, resulting in more rapid degradation.
- Not enough abrasion resistance, adequate amount of soil and rock must be used to fill the void between the bank and the soil lifts.
- Inadequate toe foundation; toe erosion.
- Not properly keying in the structures and/or the erosion control fabric at the upstream end.
- Installing vegetation at suboptimal times reduces chances of survival.
- Not adequately backfilling the holes will kill the cutting as roots cannot survival in dry air. Adequately backfill hole, then tamping, followed by watering to ensure good soil-to-stem contact.

RELATED INSTALLATION PRACTICES

LIVE CUTTINGS

CONSTRUCTION

PERIODIC ESTIMATE FOR PARTIAL PAYMENT

SUMMARY AND APPROVALS

PERIODIC ESTIMATE NO. # - PERIOD XXXX, 201? THROUGH XXXXXX, 201?

ORIGINAL CONTRACT WORK

Bid Item	Description	ORIGINAL CONTRACT WORK				THIS PAY PERIOD		COMPLETED TO DATE		
		Quantity	Pay Unit	Unit Price	Total Cost	Quantity	Total Cost	Quantity	Total Cost	Percent Complete
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
TASK 1 - REMOVALS AND RELOCATIONS										
1	Clearing and Grubbing	0	Acre	$0.00	$0.00	0	$0.00	0	$0.00	#DIV/0!
2	Removal of Debris	0	Load	$0.00	$0.00	0	$0.00	0	$0.00	#DIV/0!
3	Removal of Tree	0	EA	$0.00	$0.00	0	$0.00	0	$0.00	#DIV/0!
4	Reset Pedestrian Footbridge	0	EA	$0.00	$0.00	0	$0.00	0	$0.00	#DIV/0!
5	Reset Fence	0	LF	$0.00	$0.00	0	$0.00	0	$0.00	#DIV/0!
********** INSERT ADDITIONAL PAY ITEMS ABOVE THIS LINE **********										
Task Subtotal					**$0.00**		**$0.00**		**$0.00**	**#DIV/0!**
TASK 2 - EARTHWORK AND GRADING										
6	Unclassified Excavation (Complete in Place)	0	CY	$0.00	$0.00	0	$0.00	0	$0.00	#DIV/0!
7	Topsoil	0	CY	$0.00	$0.00	0	$0.00	0	$0.00	#DIV/0!

Some common monitoring parameters and the stream health factors they most directly inform Black = direct indicator Grey = strong indirect indicator White = weak or no indicator	Floodplain connectivity	Riparian condition	Organic materials	Morphology	Stability	Physical structure	Trophic structure
Floodplain width (Q_{bkf}, Q_2, Q_{10}, etc)	■	▒	▒	▒	▒		
Floodplain area (Q_{bkf}, Q_2, Q_{10}, etc)	■	▒	▒	▒	▒		
Overbank return interval	■	▒	▒	▒	▒		
Riparian wetland area (delineation)	▒	■					
Prevalence Index (hydric plants)	▒	■					
Species diversity/richness index		■					
Percent woody cover		■	▒	▒	▒	▒	▒
Percent cover by guild		■	▒	▒			
Percent cover by species		■					
NRCS Root strength index		■			▒		
Noxious weed cover		■					
In-stream wood (number, volume,			■			▒	
Floodplain wood (number, volume,			■				
Detritus (volume, mass)			■				▒
Stream type/evolutionary stage	▒	▒	▒	■	▒	▒	▒
Sinuosity (stream length/valley	▒			■		▒	
Branching rate, bifurcation ratio	▒			■		▒	
Meander width (or ratio)	▒			■			
Cross sectional area (capacity)	▒			■	▒		
Entrenchment Ratio	▒			■	▒		
Bank Height Ratio	▒			■	▒		
Cross section area	▒			■	▒		
Width/depth ratio				■	▒	▒	▒
Slope (bankfull, water surface)				■	▒		
Aggradation rate					■		
Degradation rate					■		
Shear stress/critical shear stress					■		
Lateral accretion rate					■		
Erosion per length (volume, mass)					■		
Length or area by depth/velocity						■	▒
Pool area (RPD>1.0, 1.5, 2.0)						■	▒
Overhead cover (length or area)						■	▒
Substrate (size, distribution, % fines)					▒	■	▒
Embeddedness						■	▒
Fish biomass/number by							■
Invertebrate biomass/number by							■
Invertebrate impact indices							■

Flood Recovery Project Monitoring Methods

Mark Beardsley and Brad Johnson *March 7, 2018*

Field-acquired aerial imagery

Field survey

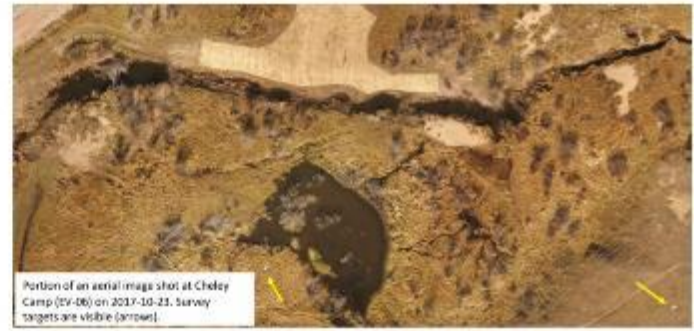
Field-acquired aerial imagery is obtained using unmanned aerial vehicles (UAVs), otherwise known as drones. For large areas, we fly program the drone to take multiple photos in a systematic grid and stitch them together into a single image mosaic using software such as Pix4D. Surveying visible targets in the field makes it so they can be orthorectified.

Data products

Aerial images (digital photo files)
Orthoimages (if digitally rectified using surveyed targets)

Comments

Aerial images are extremely useful for monitoring, especially on reaches in unconfined valleys, multi-channel streams, and wide riparian zones. They can be used for mapping, qualitative observations, and measuring quantitative stream and riparian parameters. Field-acquired images are higher resolution than public aerial images (e.g. Google Earth) and can be scheduled for specific dates. Orthorectifying is very helpful to enable quantitative measures and to assure that images can be overlaid.



Portion of an aerial image shot at Cheley Camp (EV-06) on 2017-10-23. Survey targets are visible (arrows).

Portion of an aerial image shot at Upper Fish Creek (EV-15) on 2017-10-24. Survey targets are visible (yellow arrows).

MONITORING AND ADAPTIVE MANAGEMENT

PRE-DISASTER PLANNING

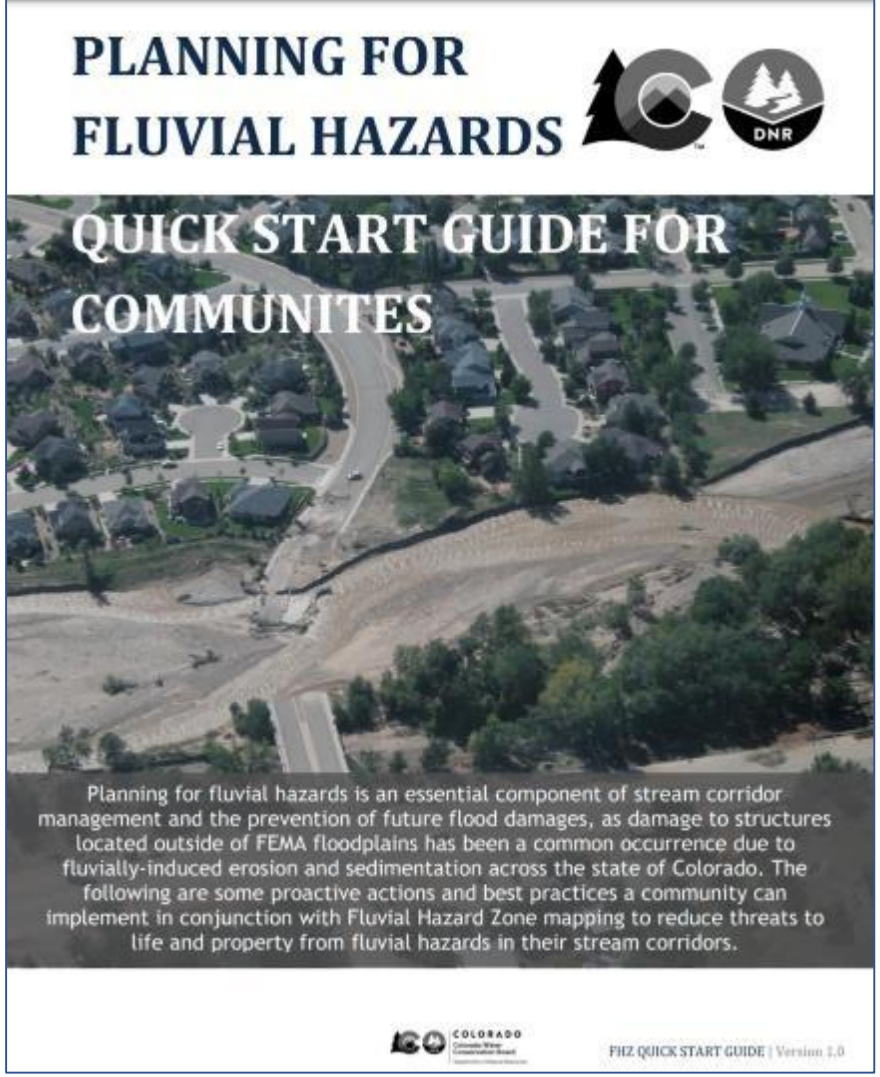
PREPARING FOR THE FUTURE

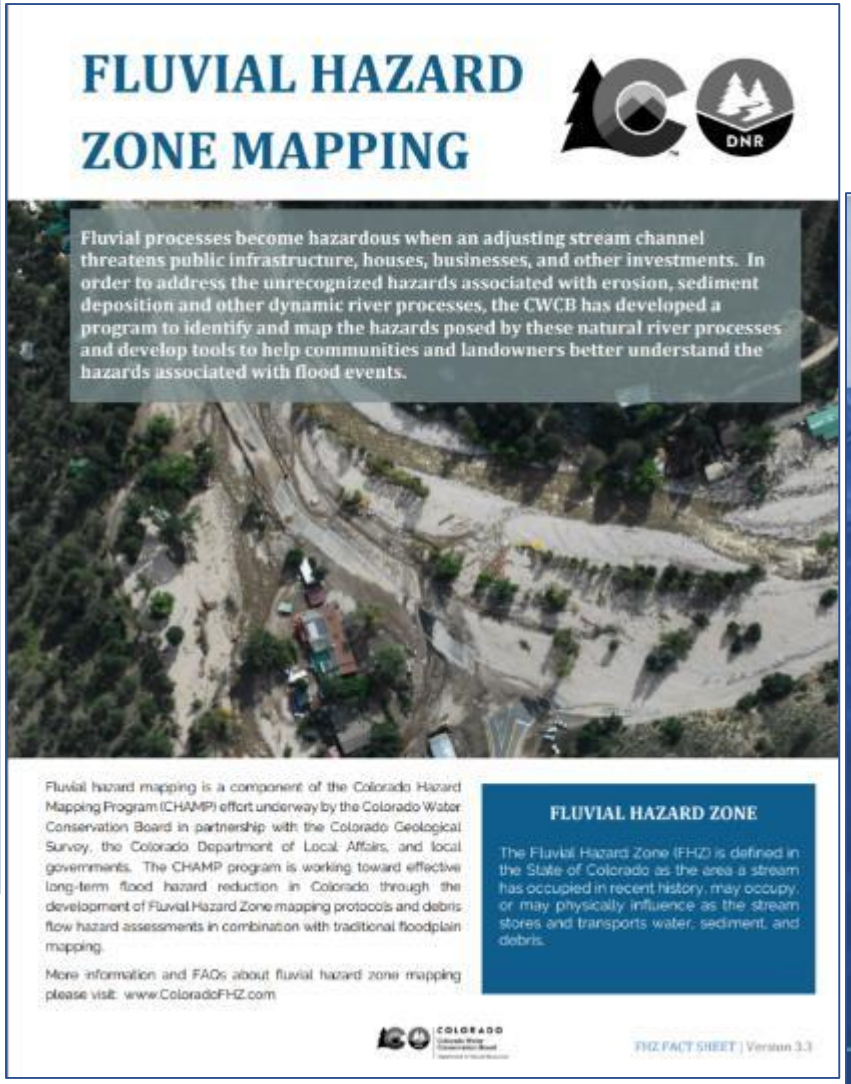
Pre-Disaster Planning

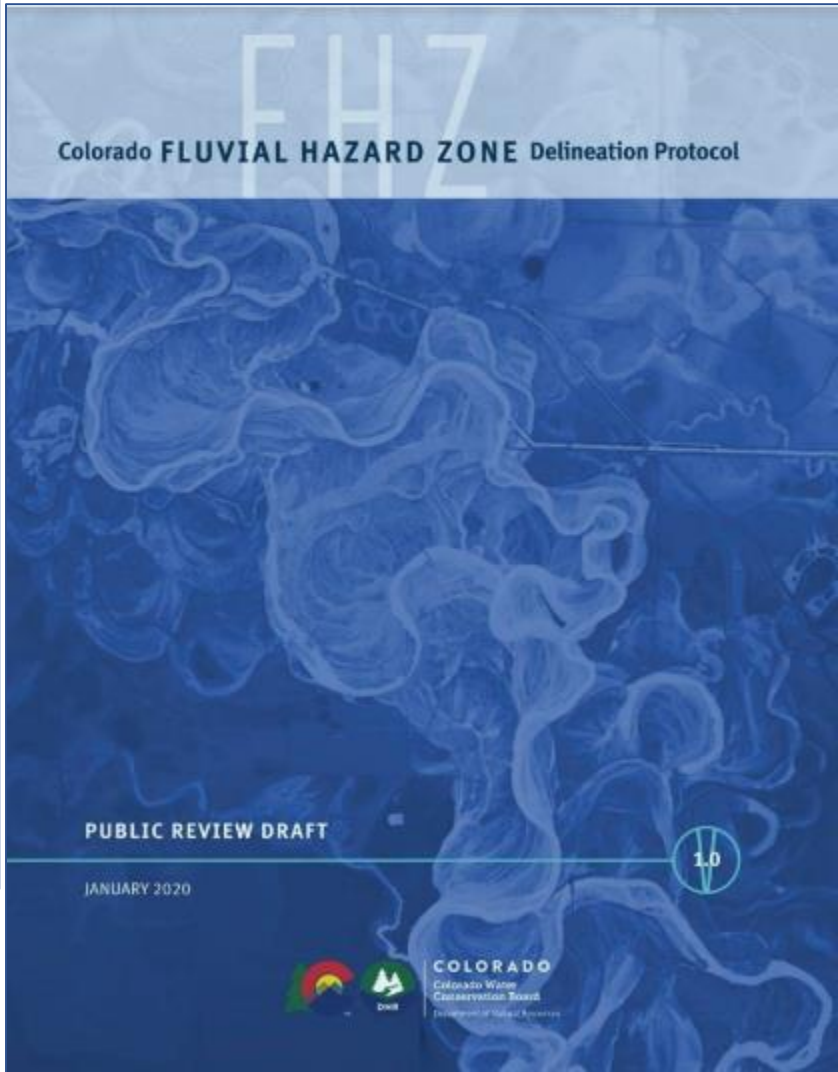
Roles and Relationships

Adequately identify all hazards in the corridor.

Pre-identify Project Areas (i.e., response zones)







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THANK YOU

Questions?

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