APPENDIX D:

FACStream Results for the Crystal River

A FACStream Primer

An Overview for the Colorado Stream Mitigation Study Team

12/15/2014

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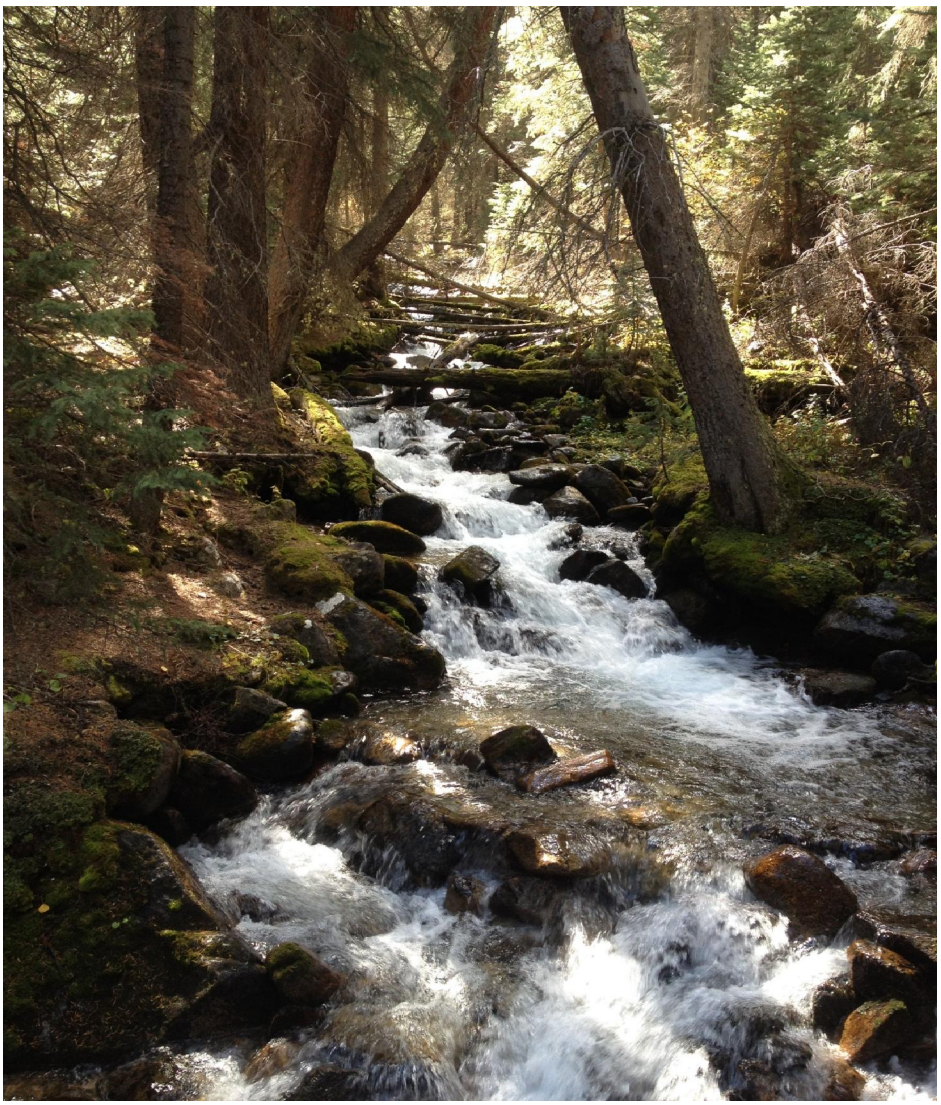

A FACStream Primer

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0	River/Stream	Date	0
0	Site/Reach ID:	Evaluators	0
0	Project ID:		
0	Reach length (Valley length in feet)	Affiliation	0

0	V_{hyd}	0	$V_{hyd}1$: Total Volume	Process Domain: Confinement	0
0	Confidence	0	$V_{hyd}2$: Peak Flows	Valley Slope	0
		0	$V_{hyd}3$: Base Flows	Stream Order	0
0	V_{sed}	0	$V_{sed}1$: Land Erosion	Physographic Region	0
0	Confidence	0	$V_{hyd}2$: Channel Erosion	Ecosystem	0
		0	$V_{hyd}3$: Delivery	Riparian Reference	0
0	V_{chem}	0	$V_{chem}1$: Temperature	Morphology: Stream Type	Rosgen / SEM
0	Confidence	0	$V_{chem}2$: Organics/Nutrients	Existing	0 / 0
		0	$V_{chem}3$: Water Quality	Reference	0 / 0
0	V_{veg}	0	$V_{veg}1$: Riparian Veg.		
0	Confidence	0	$V_{veg}2$: Streamside Veg.		
0	V_{deb}	0	$V_{deb}1$: LWD		
0	Confidence	0	$V_{deb}2$: Detritus		
0	V_{morph}	0	$V_{morph}1$: Stream Evolution		
0	Confidence	0	$V_{morph}2$: Planform		
		0	$V_{morph}3$: Dimension		
		0	$V_{morph}4$: Profile		
0	V_{con}	0	$V_{con}1$: FP Access		
0	Confidence	0	$V_{con}2$: FP Extent		
		0	$V_{con}3$: Saturation Duration		
0	V_{stab}	0	$V_{stab}1$: Dynamic Eq.		
0	Confidence	0	$V_{stab}2$: Resilience		
0	V_{str}	0	$V_{str}1$: Coarse Structure		
0	Confidence	0	$V_{str}2$: Fine Structure		
0	V_{bio}	0	$V_{bio}1$: Microbes	Functional scores by EPA category	
0	Confidence	0	$V_{bio}2$: Macrophytes	Biology Functions	0
		0	$V_{bio}3$: Macroinvertebrates	Physicochemical Functions	0
		0	$V_{bio}4$: Fish/Amphibians	Geomorphology Functions	0
		0	$V_{bio}5$: Other Animals	Hydraulic Functions	0
0	Reach Condition Score				

Figure 1: FACStream Scorecard. The components of FACStream are discussed in this "primer."

What is FACStream

FACStream (Functional Assessment of Colorado Streams) is a method for assessing functional condition of stream reaches in Colorado using 29 **subvariables** to score 10 **state variables** that combine to an overall **condition score** based on the degree of impairment.

A FACStream analysis reads like a report card representing the functional condition, or "health" of a reach at increasing levels of detail (Figure 1). The condition score, state variables, and subvariables are all scored using the academic grading scale where letter grades (A-F) correspond to numerical scores on a 50-100 scale (Table 1). Each grade represents a condition class defined by the degree of impairment. Pristine streams that have no impact would score 100 (A+). 50 (F-) represents the lowest level of functioning for a reach that is profoundly impaired but still recognizable as a feature conveying water.

Score	Grade	Impairment
90-100	A	Negligible
80-89	B	Mild
70-79	C	Significant
60-69	D	Severe
50-59	F	Profound (or unsustainable)

Table 1: Scoring represents degree of impairment.

FACStream uses a diagnostic approach similar to that in Western medicine. Health and condition are holistic terms, but assessing them is done by considering the basic components of the individual being evaluated. In humans, the individual is assessed based on their component systems, orthopedic, cardiovascular, psychological, etc. In stream ecology these components are called **state variables**. Natural interactions amongst state variables produce a healthy stream system that performs vital ecological functions. That is, each state variable represents a basic component in the "natural infrastructure" of a reach that performs the functions which are valued by society. The condition of each variable is assessed by the degree of impairment, and the combination of scores for each of these components describes overall condition of the reach. Like the medical assessment model, FACStream usually starts with a rapid evaluation of condition, which can then be expanded and augmented by intensive tests and procedures which pin-point specific areas of concern.

The health or condition of a reach is the primary determinant in its ability to function[1]. Thus, when being used in mitigation planning the FACStream condition score is converted to a Functional Capacity Index (FCI) which represents the percentage of possible aquatic functioning the stream is performing (Figure 2). FCI is the primary factor in quantifying ecological lift when calculating credits for stream mitigation.

[1] Merriam Webster medical definition of health: *1) the condition of an organism or one of its parts in which it performs its vital functions normally or properly*.

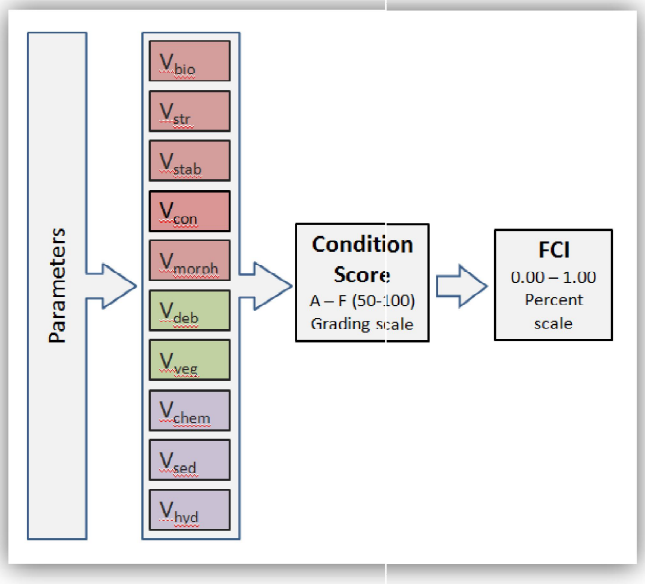

Figure 2: Basic structure of FACStream

FACStream Structural Model

The components of a stream's natural infrastructure operate at different organizational levels of the landscape: the contributing watershed, riparian zone, and the reach itself (Figures 3 and 4). FACStream variables are organized according to these basic levels and color-coded to help the evaluator keep track of which level they need to be focusing upon to make the evaluation. Even though the FACStream assessment is focused on the stream, the "assessment area" is defined as the stream reach plus the riparian zone. The contributing watershed is defined as the watershed area tributary to the bottom of the reach and is also commonly known as the "catchment."

This breakdown is important for practical reasons in addition to the logical ones. It helps keep track of where the sources of impairment are located and the feasibility of mitigating them. Whereas the reach and riparian variables represent components of the site itself, watershed components are "inherited to the site" from the contributing watershed, or catchment.

Most of the time, mitigation and restoration is accomplished with reach-scale projects. Reach-scale projects can effectively treat the impairment of reach and riparian variables, while the impairment of watershed variables is best understood as a constraint to functioning that cannot be mitigated with on-site treatments. For instance, if the main source of impairment is water quality (V_{chem}), then this is a constraint to the amount of lift that could be achieved by doing reach-level treatments.

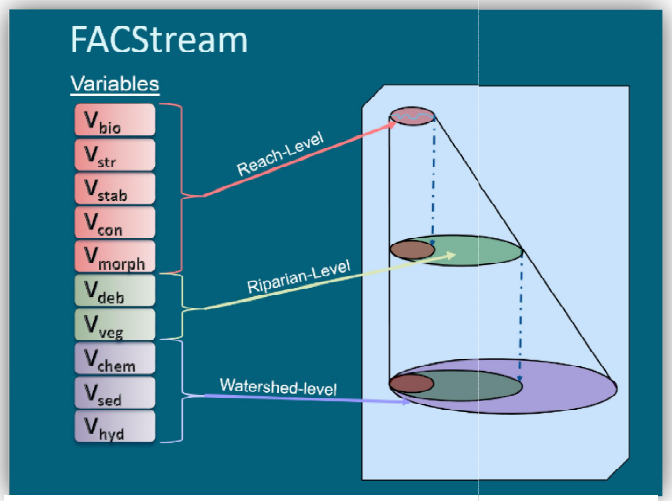

Figure 3: The organizational pyramid in FACStream shows the relationship of watershed, riparian, and reach-scale variables.

Improving function on such a reach would require fixing the water quality issue within the contributing watershed. Moreover, if the source of impairment is identified in riparian variables, then riparian treatments would be required to increase condition and functioning in addition to any necessary in-stream work.

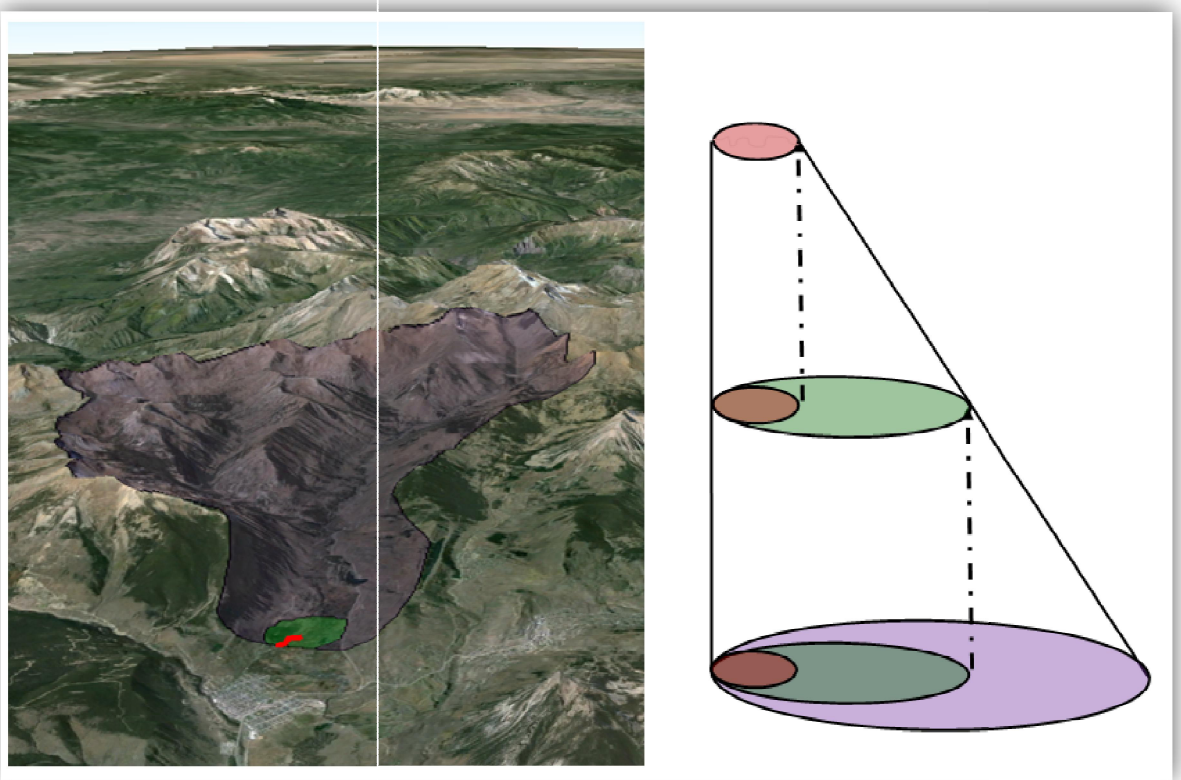

Figure 4: The FACStream organizational pyramid reflects processes occurring at different scales of the landscape. The photo shows a reach of the Slate River near Crested Butte, CO. The components of the pyramid (contributing watershed, riparian zone, and reach) are highlighted in the respective colors.

FACStream's approach acknowledges interactions amongst variables and how one stressor or impact can have multiple or cascading effects. For example, shrub clearing in the riparian zone impairs riparian vegetation condition and debris supply directly, but it also likely indirectly affects channel stability and structure. Such instability might then lead to morphological changes (channel evolution) that could, in turn, affect floodplain connectivity and physical structure. Changes to riparian vegetation and debris supply would also likely have an impact on the assemblages of certain biota, particularly those that have terrestrial life stages or depend heavily on detritus, and these impacts could cascade to other taxa via trophic and competition interactions. As this simple example illustrates, a single stressor may cause impairment to many state variables because these variables are highly integrated through complex interactions.

FACStream and the EPA 1-2-3 Approach.

Like the US EPA Function-Based Framework for Stream Assessment and Restoration Projects (a.k.a. the Stream Functions Pyramid Framework)[2], FACStream is an information framework and a working model to create an overall assessment of functional capacity. The model can accept any level of data as input, be it a first impression based on remote survey (EPA level 1), rapid field assessment (EPA Level 2), or intensive field assessment usually involving quantitative data (EPA Level 3; Figure 5). FACStream includes protocols for using the framework in rapid assessment mode, employing a stressor/impact analysis as the basis for level 2 variable scoring, but any level 2 variable score can be backed by quantitative data (level 3).

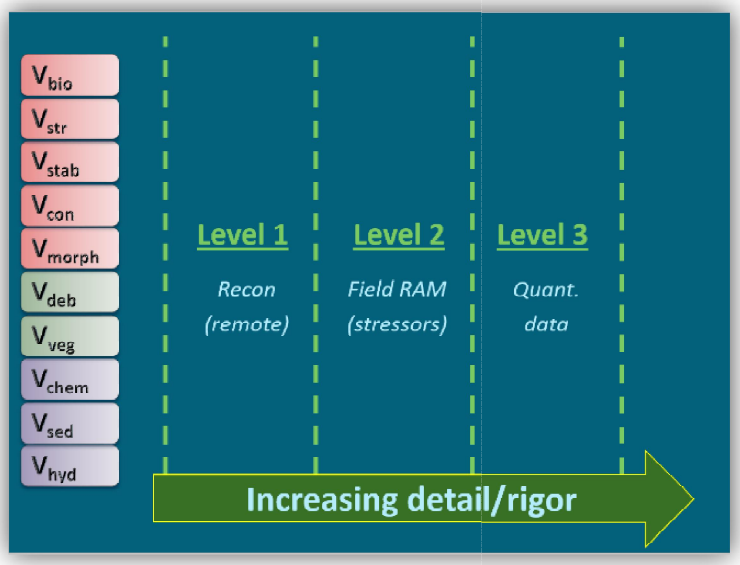

Figure 5: Each of the 10 FACStream variable scores can be evaluated at any level of data rigor, but EPA level 2 data is a minimum standard for using FACStream to calculate mitigation credits. Monitoring and evaluation of success criteria will usually require level 3 methods.

In FACStream, the evaluator uses specific scoring guidelines to rate the condition of each of the 29 subvariables based on the best evidence available (level 1, 2, or 3), and then the values of state variables are calculated from the relevant subvariables. The evaluator has an option of overriding a calculated state variable score, but may only do so if valid rationale is provided. Finally, all of the state variables are combined into a comprehensive condition score for the reach.

The ability to utilize data and evidence of varying quality is an important component of FACStream, since it allows variables to be scored using the best data available and the method is not constrained to simply being a rapid assessment using best professional judgment. To make the quality of the evidence supporting a variable score transparent, the evaluator also rates the degree of confidence. Confidence ratings do not affect variable or condition scores, but they do provide a means for communicating the quality of that score, and this is helpful to both the evaluator and the reviewer.

[2] Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs, C. Miller. 2012. A Function-Based Framework for Stream Assessment and Restoration Projects. US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington DC EPA 843-K-12-006

Level 2 is the lowest level of data rigor that should be used in mitigation planning, but level 1 is often sufficient for watershed inventories, watershed profiles, creating watershed plans, and searching for mitigation sites. Level 3 data is necessary to adequately monitor mitigation projects and evaluate success criteria, but for most projects only certain key variables will need to be monitored quantitatively, using standard field methods. FACStream clearly conveys which variables have been impaired, identifying the stressors responsible for impairment along the way. This information provides a rationale for the restoration plan, which is then used to outline performance standards and the monitoring program that will be used to show compliance.

FACStream Framework

The FACStream framework consists of a set of state variables, each with several subvariables, organized according to the landscape pyramid. These components are ordered in an outline. State variables are identified in the form V_{xxx}, with the subscript indicating a particular variable. The subvariables for each state variable are simply numbered, for example $V_{hyd}1$ is a subvariable for the V_{hyd} variable, water supply.

Watershed Scale

Water Supply (V_{hyd}) - Water is supplied to the reach from its contributing watershed in a characteristic pattern represented by its hydrograph. Anthropogenic stressors in the watershed may alter the hydrograph to change the overall annual volume of water that the reach receives ($V_{hyd}1$), and/or the frequency, magnitude, and duration of peak flows ($V_{hyd}2$) and low flows ($V_{hyd}3$). This variable rates the degree to which the amount and timing of water source is impacted by stressors within the watershed.

$V_{hyd}1$: Total Volume

$V_{hyd}2$: Peak Flows

$V_{hyd}3$: Minimum Flows

Sediment Supply (V_{sed}) - Sediment is produced in the contributing watershed via land erosion ($V_{sed}1$) (including both surface erosion, mass erosion, and point sources), and channel erosion ($V_{sed}2$). Some sediment enters the reach directly from valley side slopes, but most is discharged to the reach from the contributing watershed as bedload and suspended sediment in the stream. Watershed impacts affect sediment production, and major drainage impacts such as dams affect the delivery of sediment to the reach ($V_{sed}3$). This variable rates the degree of impact to the natural rate of sediment supply including the amount, timing, and size distribution of sediment.

$V_{hyd}1$: Land Erosion

$V_{hyd}2$: Channel erosion

$V_{hyd}3$: Transport

Chemical Supply (V_{chem}) - The physicochemical properties of the stream reach are largely inherited to the site from the contributing watershed, and biochemical processing by stream organisms and physical changes within the channel and floodplains can alter these conditions on the reach to some lesser degree. This variable uses three subvariables to rate the degree of departure from a natural temperature regime ($V_{chem}1$), amounts of organic inputs (POM, DOM) and nutrients (N, P, K) ($V_{chem}2$) in the incoming water as well as shifts to the characteristic water quality subvariables such as pH, conductivity, turbidity, and contaminants ($V_{chem}3$).

$V_{hyd}1$: Temperature

$V_{hyd}2$: Organics/nutrients

$V_{hyd}3$: Water Quality

Riparian Scale

Riparian Vegetation (V_{veg}) - Riparian vegetation is critically important to supporting a stream reach. It provides the root structure and roughness that stabilizes banks, channels, and floodplains as well as providing a buffer to the stream from nearby stressors. Riparian vegetation also provides cover, shading, and habitat for species whose life history utilizes both aquatic and terrestrial life stages. This variable rates impacts to the natural extent, cover, and composition of riparian vegetation across the width of the historic floodplain ($V_{veg}1$) as well as along the edge of the stream ($V_{veg}2$).

$V_{hyd}1$: Riparian vegetation

$V_{hyd}2$: Streamside vegetation

Debris supply (V_{deb}) - Organic debris consists of the bodies and fragments of dead organisms, especially plants. Large woody debris (LWD) is the coarsest organic input to the stream, functioning primarily as a structural component and secondarily as a nutrient and energy source. Detritus includes smaller vegetative fragments such as leaves, needles, twigs, and grass, plus animal bodies and feces. Detritus is often the primary energy source for a stream reach, but it also functions in forming microhabitat and substrate structure. This variable considers these two materials separately ($V_{deb}1$ and $V_{deb}2$) to rate the degree to which the amount, timing and character of organic debris supply to the reach has been altered by stressors in the fetch area which includes the riparian area and adjacent side slopes.

$V_{hyd}1$: LWD Supply

$V_{hyd}2$: Detritus Supply

Reach Scale

Stream Morphology (V_{morph}) - Streams exhibit characteristic patterns of geometry (morphology) by process domain as a result of geomorphic processes such as dynamic

equilibrium between hydrology and sediment, adaptations to natural disturbances, and response to biotic agents such as vegetation and beavers. Morphology is also frequently altered directly by humans. This variable rates the degree of departure from the reference stream morphology arising from channel evolution ($V_{morph}1$), and as a degree of departure from reference conditions in planform ($V_{morph}2$), dimension ($V_{morph}3$), and profile ($V_{morph}4$). Morphological impairment on streams in alluvial valleys is often a consequence of instability caused by stressors within or outside the reach.

$V_{morph}1$: Evolution

$V_{morph}2$: Planform

$V_{morph}3$: Dimension

$V_{morph}4$: Profile

Floodplain Connectivity (V_{con}) - Floodplain connectivity describes the degree to which water can access and hydrate the active floodplain. The amount and timing of water flow interacts with reach-scale channel and floodplain morphology to create a characteristic pattern in the frequency ($V_{con}1$), lateral extent ($V_{con}2$), and duration of saturation ($V_{con}3$) from overbank flows and groundwater exchange on the reach. Thus, floodplain connectivity may be drastically altered by either watershed-scale hydrologic impacts (hydrograph) or site-scale geomorphic impacts including artificial levees, channelization, channel enlargement, and entrenchment. While the term floodplain has many different meanings in different disciplines, the area of concern in this variable is the active "bankfull" floodplain that typically has a saturation return interval of 0-5 years.

$V_{con}1$: Saturation Frequency

$V_{con}2$: Floodplain Width

$V_{con}3$: Saturation Duration

Stream Stability (V_{stab}) - Stability and resilience are considered together to rate the probability that the stream will maintain its geomorphic structure. Stability assessment ($V_{stab}1$) is based on the dynamic equilibrium concept of balance between sediment supply and transport represented by Lane's Balance. Thus, stressors include anthropogenic alterations to stream power including hydrology (V_{hyd}), channel morphology (V_{morph}), sediment supply (V_{sed}), and stabilizing factors like riparian vegetation (V_{veg}). Resilience ($V_{stab}2$) rates the ability of the system to recover after a large disturbance such as a large flood, wildfire, or mass erosion event. Primary factors include its ability to move and adjust, so riparian vegetation (V_{veg}) and floodplain connectivity (Vc_{on}) are key, along with stressors such as channel hardening and floodplain encroachment.

$V_{stab}1$: Dynamic Equilibrium

$V_{stab}2$: Resilience

Physical Structure (V_{str}) - Heterogeneity in the physical structure of a stream is the result of complex interactions between water, substrate, and debris, via the processes of erosion, scour, and deposition that shape the form of bed, banks, and substrate. As in the case for morphology, biological drivers such as riparian vegetation and beavers may have a profound impact on physical structure and diversity. This variable rates the degree to which characteristic patterns of structural heterogeneity are altered by stressors by considering two scales of resolution. The coarse scale $V_{str}1$ is meant to represent a level relevant for fish and larger animals by considering patterns of water velocity, depth, and physical cover. At a finer scale, $V_{str}2$ is more relevant to benthic macroinvertebrate habitat, looking at characteristic substrate material size, type, and packing.

$V_{stab}1$: Coarse Structure

$V_{stab}2$: Fine Structure

Biotic Structure (V_{bio}) - Biotic structure is the amount and diversity of organisms that live in the stream reach for all or part of their life history. The biota supported by the reach is not only a high-order function, but also component of the natural infrastructure of the reach that performs biochemical processing through a characteristic trophic structure. Sticking with convention, the diversity of organisms are assessed by taxonomic group in subvariables ($V_{bio}1$-5) to account for alterations caused by direct and indirect stressors.

$V_{bio}1$: Microbes

$V_{bio}2$: Macrophytes

$V_{bio}3$: Macroinvertebrates

$V_{bio}4$: Fish

$V_{bio}5$: Other Animals

FACStream Scoring Sheets for the Crystal River

The Ecosystem Functional Assessment evaluated ten state variables using the Functional Assessment of Colorado Streams (FACStream) framework. State variables include: flow regime, sediment regime, water quality, floodplain connectivity, riparian vegetation, debris supply, morphology, stability, physical structure, and biotic structure. The Crystal River was delineated into 36 separate assessment reaches defined by local channel form and degree of valley confinement to provide appropriate spatial resolution for assessment activities focused on reach or channel-scale conditions (Figure A-1).

State variable assessments evaluated current conditions and characterized the degree of departure from an unimpacted reference state using a forensic, weight-of-evidence approach. Assignment of functional condition scores for each state variable generally followed FACStream scoring criteria where a score of 100 indicated pristine conditions and a score of 50 indicated severe impairment. Each reach also received an overall condition score based on composite scoring of all state variables. Summary sheets for individual reaches indicate the relative degree of impact by each stressor on individual state variable scores.

Figure A-1: FACStream reaches delineation along the Crystal River

Crystal River FACStream Level 2 Assessment

Reach	Distance from Headwaters (miles)	Valley Slope	Valley Confine	Stream Type	Ref. stream	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
1	3.67	H	VC	A	A	98	95	95	95	95	95	95	95	95	95
2	4.20	VH	VC	Aa+	Aa+	98	92	95	95	95	95	95	95	95	95
3	4.51	M	CC	B	B	98	92	95	95	95	95	95	95	95	95
4	5.26	VL	UC	C	C	98	90	92	88	88	92	95	95	95	88
5	6.29	M	CC	B	B	98	92	95	95	95	95	95	95	95	88
6	7.36	L	PC	D	D	98	92	95	75	82	85	82	78	85	88
7	8.63	M	CC	F	B	98	92	95	88	88	92	85	82	92	88
8	9.50	M	VC	G	G	98	92	95	95	95	95	95	95	95	88
9	10.26	M	CC	B	B	98	92	95	95	92	95	95	95	95	88
10	10.59	L	PC	D	D	98	92	95	85	85	92	95	95	95	88
11	11.22	L	CC	B	B	98	92	95	95	95	95	95	95	95	88
12	11.76	L	PC	C	DA	98	92	95	78	78	85	82	85	82	88
13	12.40	L	UC	DA	DA	98	92	95	95	92	95	95	95	95	88
14	12.91	L	PC	C	C	98	92	95	82	85	88	85	88	88	88
15	15.58	M	VC	G	G	98	92	95	82	78	75	82	75	85	88
16	16.54	L	PC	D	D	98	85	92	85	82	82	92	85	88	88
17	17.71	L	PC	D	D	98	72	88	68	72	78	82	72	82	82
18	19.43	M	CC	B	B	98	78	92	82	88	85	85	82	85	82
19	20.16	L	PC	C	D	98	80	92	82	75	82	85	85	85	82
20	21.24	M	VC	A/G	A/G	98	85	92	92	92	95	95	92	95	82
21	21.81	L	PC	D	D	84	85	92	82	82	85	88	82	85	82
22	22.18	L	CC	B	B	84	85	92	92	95	95	92	88	92	82
23	23.19	L	PC	D	D	84	85	92	85	78	82	88	85	85	82
24	23.64	L	CC	B	B	84	82	92	82	78	82	85	82	82	82
25	25.06	L	VC	F	F	74	85	88	85	92	88	92	88	92	82
26	25.44	L	PC	D	D	74	82	88	85	85	85	85	82	82	82
27	26.29	L	CC	B	B	81	85	88	75	82	82	85	82	78	82
28	27.23	L	PC/CC	C/B	C/B	81	85	85	82	88	88	88	85	85	82
29	27.72	L	PC	D	D	62	85	82	74	82	85	85	78	65	82
30	29.02	L	CC/VC	B/F	B/F	63	88	82	95	92	92	92	88	68	82
31	30.94	L	PC/CC	C/B	C/B	67	88	82	85	85	85	92	88	75	82
32	32.03	L	PC	C	C	70	88	82	78	82	85	85	82	72	82
33	33.49	L	PC	C	C	82	85	82	75	75	72	82	78	80	82
34	33.74	L	PC	C/D	C	82	82	85	88	82	85	85	78	85	82
35	34.92	L	CC	B	B	91	85	85	92	88	88	92	92	85	82
36	35.06	L	PC	C	C	91	85	88	91	92	95	82	95	85	82

Crystal River FACStream Assessment

Reach	Condition Score	Notes
1	96	Wilderness reach with no significant impacts apparent
2	95	Wilderness reach with no significant impacts apparent
3	95	Wilderness reach with no significant impacts apparent
4	92	Primary impact is Beaver Lake and the dam/dike that separates it from floodplain (nutrient rich drainage water, cleared veg, floodplain isolation).
5	95	Confined reach in secluded canyon with minimal impact
6	87	The upper part has few impacts. Impacts begin at Island Lake, especially dike/dam that separates lake from the stream, highway fill and revetment.
7	91	Road encroachment is primary impact, causing B -> G conversion doe to confinement.
8	95	Very confined reach in secluded canyon with no apparent impacts
9	94	Confined reach in secluded canyon with minimal impact at campground
10	92	Some impact from Bogan Flats Campground development on valley bottom
11	95	Confined reach in secluded canyon with minimal impact
12	87	Pasture clearing and floodplain druying evident on right side affects large floodplain area, channel appears to be straightened (?) and side channel access cut off.
13	94	Similar stream and valley configurarion as Reach 12, but few floodplain impacts are evident.
14	90	Road and ranching impacts on left floodplain area.
15	86	Road encroachment and hardening on an already very confined valley affects most of the length of the reach, further constriction at multiple bridges.
16	89	Impacts related to valley bottom residential development, bridge constriction.
17	81	Sediment inputs from Coal Creek subbasin - past anthropogenic mass erosion, channel erosion from mining, Yet stream form similar to R 16. Bridges, levee, valley bottom development, roads at Redstone
18	87	Acute impacts due to road encroachment, otherwise minimal impairment. Any sediment source impacts are not felt due to high transport capacity confined threshold channel
19	86	Pasture clearing and floodplain druying evident on right side.
20	92	A confined or very confined reach with few reach-scale impacts.
21	84	Floodplain development is the primary impact, with residential, reservoir/pond, levee/dam, road fills and hardening.
22	89	A confined or very confined reach with few reach-scale impacts.
23	85	Reach-scale impacts primarily road fills, pasture clearing and FP development
24	83	Reach-scale impacts primarily road fills, pasture clearing and FP development. Sweet Jessup diversion point and bypass channel are significant impacts.
25	85	A confined or very confined reach with few reach-scale impacts.
26	82	Primary impacts are road fill and hardening. Hydro impacts infered.
27	81	Primary impacts are road fill and hardening. Hydro impacts infered.
28	84	Borderline/alternating confinement. Lotixc XS show confinement with ER ~1.5 - 2.0. Most development is above valley-bottom,but the few low FP areas present on the reach are developed (e.g. KOA CG).
29	75	Reach-scale impacts primarily road fills, pasture clearing and FP development. Diversion dam and bypass channel are significant impacts.
30	82	Lotic XS show confinement with ER ~1.5 - 2.0. Few reach-scale impacts. Development is above valley-bottom.
31	81	Bordderline confined valley (ER ~2-3). Some floodplain development, hydro impacts infered.
32	79	Significant dvelpment on valley bottom including hatchery and pond. Hydro impacts infered.
33	79	Primary reach-scale impacts are valley-bottom land use conversion to residential, pasture, and golf course, plus constriction at multiple bridges. Hydro impacts infered.
34	83	Major impact id push-up dam and localized effects, plus pasture clearing on lower right FP. Hydro impacts infered.
35	88	Minimal impacts. Bridge. Hydro impacts infered.
36	89	Minimal impacts on floodplain or channel. Grazing. Short reach at confluence. Hydro impacts infered.

Reach 1	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	A-	A	A	A	A	A	A	A	A
Score	98	92	95	95	95	95	95	95	95	95
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance										
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion								
Bridges/ constrictions										
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										
Narrative summary	equivalent of IHA results above all diversions		No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors

Reach 2	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	A-	A	A	A	A	A	A	A	A
Score	98	92	95	95	95	95	95	95	95	95
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance										
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion								
Bridges/ constrictions										
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										
Narrative summary	equivalent of IHA results above all diversions		No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors

Reach	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade 3	A+	A-	A	A	A	A	A	A	A	A
Score	98	92	95	95	95	95	95	95	95	95
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance										
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion								
Bridges/ constrictions										
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										
Narrative summary	equivalent of IHA results above all diversions		No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors

Reach 4	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	B+	A-	B+	B+	A-	A	A	A	B+
Score	98	90	92	88	88	92	95	95	95	88
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance										
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion	Roads	Roads	Roads					
Bridges/ constrictions		Bridge/constriction at bottom of reach		Bridge/constriction at bottom of reach						
Dam/diversion										
Levee/dike		Beaver Lake dam	Beaver Lake dam	Beaver Lake dam	Beaver Lake dam	Beaver Lake dam				Beaver Lake dam--release high water temps/ macrophyte rich H20 below (though off-channel)
By-pass channel										
Ditch										
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation					Few weeds					
Exotic fauna, managed fishery										managed fishery
Narrative summary	equivalent of IHA results above all diversions						No significant stressors	No significant stressors	No significant stressors	

Reach 5	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	A-	A	A	A	A	A	A	A	B+
Score	98	92	95	95	95	95	95	95	95	88
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance										
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion								
Bridges/ constrictions		Bridge/constriction above the reach								
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										managed fishery
Narrative summary	equivalent of IHA results above all diversions		No sifnificant stressors	No sifnificant stressors	No sifnificant stressors	No sifnificant stressors	No sifnificant stressors	No sifnificant stressors	No sifnificant stressors	

Reach 6	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	A-	A	C	B-	B	B-	C+	B	B+
Score	98	92	95	75	82	85	82	78	85	88
Land use - development										
Land use - pasture clearing					Veg clearing/bare ground					
Land use - mining disturbance										
Land use - golf course/park					Island Lake on floodplain replace veg with open water habitat	Island Lake on floodplain limits detritus		Island Lake on floodplain limits resilience		
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion		Road fill at for highway	Road fill at for highway			Road fill at for highway	Road fill at for highway	
Bridges/ constrictions					Bridge					
Dam/diversion										
Levee/dike				Island lake berm						
By-pass channel										
Ditch										
Bank/channel armor							Island Lake dike and road fill revetment - rip-rap	Island Lake dike and road fill revetment - rip-rap	Island Lake dike and road fill revetment - rip-rap	
Channel alteration							Straightening at Island Lake	Straightening at Island Lake	Straightening at Island Lake	
Grazing										
Weeds/exotic vegetation					Weeds					
Exotic fauna, managed fishery										managed fishery
Narrative summary	equivalent of IHA results above all diversions		No significant stressor							

Reach 7	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	A-	A	B+	B+	A-	B	B-	A-	B+
Score	98	92	95	88	88	92	85	82	92	88
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance										
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion		Highway encoachment along significant length	Highway encoachment along significant length	Highway encoachment along significant length	Highway encoachment along significant length	Highway encoachment along significant length	Highway encoachment along significant length	
Bridges/ constrictions										
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor							Rip-rap at road fill along significant length	Rip-rap at road fill along significant length		
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										managed fishery
Narrative summary	equivalent of IHA results above all diversions		No significant stressors							

Reach 8	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	A-	A	A	A	A	A	A	A	B+
Score	98	92	95	95	95	95	95	95	95	88
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance										
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion								
Bridges/ constrictions		bridge constriction at start of the reach								
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										managed fishery
Narrative summary	equivalent of IHA results above all diversions		No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	

Reach 9	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	A-	A	A	A-	A	A	A	A	B+
Score	98	92	95	95	92	95	95	95	95	88
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance										
Land use - golf course/park					Campground (roads,pads, veg clearing) but primarily above floodplain					
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion								
Bridges/ constrictions										
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation					weeds					
Exotic fauna, managed fishery										managed fishery
Narrative summary	equivalent of IHA results above all diversions		No significant stressors	No significant stressors		No significant stressors	No significant stressors	No significant stressors	No significant stressors	

Reach 10	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	A-	A	B	B	A-	A	A	A	B+
Score	98	92	95	85	85	92	95	95	95	88
Land use - development				Campground developed on floodplain	Campground developed on floodplain	Campground developed on floodplain				
Land use - pasture clearing										
Land use - mining disturbance										
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion								
Bridges/ constrictions										
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation					few weeds					
Exotic fauna, managed fishery										managed fishery
Narrative summary	equivalent of IHA results above all diversions		No significant stressors				No significant stressors	No significant stressors	No significant stressors	

Reach 11	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	A-	A	A	A	A	A	A	A	B+
Score	98	92	95	95	95	95	95	95	95	88
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance										
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion								
Bridges/ constrictions										
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										managed fishery
Narrative summary	equivalent of IHA results above all diversions		No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	

Reach 12	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	A-	A	C+	C+	B	B-	B	B-	B+
Score	98	92	95	78	78	85	82	85	82	88
Land use - development										
Land use - pasture clearing					Pasture clearing most of right floodplain	Pasture clearing most of right floodplain				
Land use - mining disturbance										
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion								
Bridges/ constrictions		bridge in middle of reach								
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch				Floodplain drained						
Bank/channel armor										
Channel alteration				Side channels and branches cut off, floodplain drained	Unnaturally dry floodplain, conifer encroachment		Straightened Side channels cut off	Straightened Side channels cut off	Straightened Side channels cut off	
Grazing										
Weeds/exotic vegetation					weeds					
Exotic fauna, managed fishery										managed fishery
Narrative summary	equivalent of IHA results above all diversions		No significant stressors							

Reach 13	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	A-	A	A	A-	A	A	A	A	B+
Score	98	92	95	95	92	95	95	95	95	88
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance										
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion								
Bridges/ constrictions										
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation					unnatural drying of the floodplain					
Exotic fauna, managed fishery										Managed fishery
Narrative summary	equivalent of IHA results above all diversions		No significant stressors	No significant stressors		No significant stressors	No significant stressors	No significant stressors	No significant stressors	

Reach 14	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	A-	A	B-	B	B+	B	B+	B+	B+
Score	98	92	95	82	85	88	85	88	88	88
Land use - development										
Land use - pasture clearing					left floodplain	left floodplain				
Land use - mining disturbance										
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion		fill for secondary road near lower end of reach	fill for secondary road near lower end of reach					
Bridges/ constrictions										
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor							along road lower left	along road lower left	along road lower left	
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										Managed fishery
Narrative summary	equivalent of IHA results above all diversions		No significant stressors							

Reach 15	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	A-	A	B-	C+	C	B-	C	B	B+
Score	98	92	95	82	78	75	82	75	85	88
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance										
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion		Highway fill and hardening along most of the reach	Highway fill and hardening along most of the reach	Road limits LWD transport from adjacent hillslopes	Highway fill and hardening along most of the reach	Highway fill and hardening along most of the reach	Highway fill and hardening along most of the reach	
Bridges/ constrictions				Multiple bridges with some constriction			Multiple bridges with some constriction	Multiple bridges with some constriction	Multiple bridges with some constriction	
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor				Highway fill and hardening			Highway fill and hardening	Highway fill and hardening	Highway fill and hardening	
Channel alteration										
Grazing										
Weeds/exotic vegetation					few weeds					
Exotic fauna, managed fishery										managed fishery
Narrative summary	equivalent of IHA results above all diversions		No significant stressors					primary effect of stressors is on resilience. Highly armored threshold channel but limited capacity for recovery due to road fill		

Reach 16	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	B	A-	B	B-	B-	A-	B	B+	B+
Score	98	85	92	85	82	82	92	85	88	88
Land use - development				Houses and lawns on right side valley bottom	Houses and lawns on right side valley bottom	Houses and lawns on right side valley bottom				
Land use - pasture clearing										
Land use - mining disturbance		mining exacerbated land erosin	historic mining effects							
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion		Highway and road fills on Redstone side						
Bridges/ constrictions										
Dam/diversion										
Levee/dike				Levee along R bank protecting Redstone town					Levee along R bank protecting Redstone town	
By-pass channel										
Ditch										
Bank/channel armor				some armoring along roadside reaches			some armoring along roadside reaches	some armoring along roadside reaches	some armoring along roadside reaches	
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										managed fishery
Narrative summary	equivalent of IHA results above all diversions							Major deposition upstream of bridge constrictions		

Reach 17	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	C-	B+	D+	C-	C+	B-	C-	B-	B-
Score	98	72	88	68	72	78	82	72	82	82
Land use - development			Town developed on valley bottom	Town developed on valley bottom	Town developed on valley bottom	Town developed on valley bottom				
Land use - pasture clearing										
Land use - mining disturbance		elevated sediment supply from mining in Coal Creek	elevated sediment supply from mining in Coal Creek							
Land use - golf course/park				Veg clearing and park development	Veg clearing and park development					
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion								
Bridges/ constrictions				Several bridges with significant constriction limits floodplain access			Several bridges with significant constriction limits floodplain access	Several bridges with significant constriction limits floodplain access	Several bridges with significant constriction limits floodplain access	
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor							along road and town levee	along road and town levee	along road and town levee	
Channel alteration				straightening through town			straightening through town	straightening through town	straightening through town	
Grazing										
Weeds/exotic vegetation					weeds and exotic lawn veg					
Exotic fauna, managed fishery										managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results			equivalent of IHA results above all diversions						

Reach 18	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	C+	A-	B-	B+	B	B	B-	B	B-
Score	98	78	92	82	88	85	85	82	85	82
Land use - development					minimal upland development	minimal upland development				
Land use - pasture clearing										
Land use - mining disturbance		elevated sediment supply from mining in Coal Basin	elevated sediment supply from mining in Coal Basin							
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)		unpaved roads contribution to total surface erosion		Highway			Highway	Highway	Highway	
Bridges/ constrictions				Several bridges			Several bridges	Several bridges	Several bridges	
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results									

Reach 19	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	C+	A-	B-	C	B-	B	B	B	B-
Score	98	80	92	82	75	82	85	85	85	82
Land use - development										
Land use - pasture clearing				ranch on right valley botom	ranch on right valley bottom	ranch on right valley bottom				
Land use - mining disturbance		Residual Coal Basin effects	Residual Coal Basin effects							
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)										
Bridges/ constrictions										
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch				artificial floodplain drying						
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results						side channels cut off (compare to upper portion of reach)			

Reach 20	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A+	B	A-	A-	A-	A	A	A-	A	B-
Score	98	85	92	92	92	95	95	92	95	82
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance		residual Coal Basin sed supply	residual Coal Basin sed supply							
Land use - golf course/park										
Water withdrawals										
Road (fills, encroachment)										
Bridges/ constrictions										
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results			No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	No significant stressors	

Reach 21	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	**B**	B	A-	B-	B-	B	B+	B-	B	B-
Score	**84**	**85**	**92**	**82**	**82**	**85**	**88**	**82**	**85**	**82**
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance										
Land use - golf course/park										
Water withdrawals	Major withdrawals begin below this reach									
Road (fills, encroachment)										
Bridges/ constrictions										
Dam/diversion										
Levee/dike				Levee and pond constructed on FP	Levee and pond constructed on FP					
By-pass channel										
Ditch										
Bank/channel armor				Hardened banks along road and levee			Hardened banks along road and levee	Hardened banks along road and levee	Hardened banks along road and levee	
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results					reduced vegetatative supply				

Reach 22	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	B	B	A-	A-	A	A	A-	B+	A-	B-
Score	84	85	92	92	95	95	92	88	92	82
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance										
Land use - golf course/park										
Water withdrawals	Major withdrawals begin below this reach									
Road (fills, encroachment)				road fill/encroachment at two short segments			road fill/encroachment at two short segments	road fill/encroachment at two short segments	road fill/encroachment at two short segments	
Bridges/ constrictions				One bridge with narrow constriction			One bridge with narrow constriction	One bridge with narrow constriction	One bridge with narrow constriction	
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results				No significant stressors	No significant stressors				

Reach 23	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	B	B	A-	B	C+	B-	B+	B	B	B-
Score	84	85	92	85	78	82	88	85	85	82
Land use - development				Residential development encroaches onto FP	Residential development encroaches onto FP					
Land use - pasture clearing					Pasture clearing RB, most of R FP	Pasture clearing RB, most of R FP				
Land use - mining disturbance		Residual Coal Basin effects	Residual Coal Basin effects							
Land use - golf course/park										
Water withdrawals	Major withdrawals begin below this reach									
Road (fills, encroachment)				Highway fill and hardening along portion of LB			Highway fill and hardening along portion of LB	Highway fill and hardening along portion of LB	Highway fill and hardening along portion of LB	
Bridges/ constrictions										
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor							Hardened banks alomg road fill	Hardened banks alomg road fill	Hardened banks alomg road fill	
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results									

Reach 24	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	B	B-	A-	B-	C+	B-	B	B-	B-	B-
Score	84	82	92	82	78	82	85	82	82	82
Land use - development				FP converted to ponds	FP converted to ponds	FP converted to ponds				
Land use - pasture clearing										
Land use - mining disturbance		Residual Coal Basin effects	Residual Coal Basin effects							
Land use - golf course/park										
Water withdrawals	First major diversion on this reach (Sweet Jessup)									
Road (fills, encroachment)										
Bridges/ constrictions				One bridge with narrow constriction			One bridge with narrow constriction			
Dam/diversion		On-site Push-up dam and diversion causing localized aggradation. Many push-up dams above						Push-up dam at SJ diversion	Push-up dam at SJ diversion	
Levee/dike										
By-pass channel	Unregulated by-pass channel to SJ diversion intake									
Ditch										
Bank/channel armor							Hardening along SJ bypass channel, bridge, RB pond	Hardening along SJ bypass channel, bridge, RB pond	Hardening along SJ bypass channel, bridge, RB pond	
Channel alteration							creation of by-pass channel, natural branches cut off		creation of by-pass channel, natural branches cut off	
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results									

Reach 25	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	C	B	B+	B	A-	B+	A-	B+	A-	B-
Score	74	85	88	85	92	88	92	88	92	82
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance		Residual Coal Basin effects								
Land use - golf course/park										
Water withdrawals	Cumulative withdrawals		water temp effects							
Road (fills, encroachment)				Highway fill and hardening along entire length of LB			Highway and Crystal R Rd fill and hardening	Highway and Crystal R Rd fill and hardening	Highway and Crystal R Rd fill and hardening	
Bridges/ constrictions				One bridge with narrow constriction			One bridge with narrow constriction			
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor							Highway and Crystal R Rd fill and hardening	Highway and Crystal R Rd fill and hardening	Highway and Crystal R Rd fill and hardening	
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results									

Reach 26	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	C	B-	B+	B	B	B	B	B-	B-	B-
Score	74	82	88	85	85	85	85	82	82	82
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance		Residual Coal Basin effects								
Land use - golf course/park										
Water withdrawals	Cumulative withdrawals		temperature effects during low flows							
Road (fills, encroachment)				Highway fill and hardening along entire length of LB			Highway and Crystal R Rd fill and hardening	Highway and Crystal R Rd fill and hardening	Highway and Crystal R Rd fill and hardening	
Bridges/ constrictions										
Dam/diversion		On-site Push-up dam and diversion causing localized aggradation. Many push-up dams above		PU dam on this reach			PU dam on this reach	PU dam on this reach	PU dam on this reach	
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor							Highway and Crystal R Rd fill and hardening	Highway and Crystal R Rd fill and hardening	Highway and Crystal R Rd fill and hardening	
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results									

Reach 27	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	**B-**	B	B+	C	B-	B-	B	B-	C+	B-
Score	**81**	**85**	**88**	**75**	**82**	**82**	**85**	**82**	**78**	**82**
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance		Residual Coal Basin effects								
Land use - golf course/park										
Water withdrawals	Cumulative withdrawals		temperature effects during low flows							
Road (fills, encroachment)				Highway fill and hardening along entire length of LB			Highway fill and hardening along entire length of LB	Highway fill and hardening along entire length of LB	Highway fill and hardening along entire length of LB	
Bridges/ constrictions				One bridge with narrow constriction						
Dam/diversion										
Levee/dike				Major levee on RB, cuts off significant portion of FP area	Levee = unnatural hydrology in cutoff FP. Veg impacts observed					
By-pass channel										
Ditch										
Bank/channel armor							Highway fill and hardening along entire length of LB	Highway fill and hardening along entire length of LB	Highway fill and hardening along entire length of LB	
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results									

Reach 28	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	**B-**	B	B	B-	B+	B+	B+	B	B	**B-**
Score	**81**	**85**	**85**	**82**	**88**	**88**	**88**	**85**	**85**	**82**
Land use - development					Residential and Campground					
Land use - pasture clearing										
Land use - mining disturbance		Residual Coal Basin effects								
Land use - golf course/park										
Water withdrawals	Cumulative withdrawals		temperature effects during low flows							
Road (fills, encroachment)				One bridge with very narrow opening						
Bridges/ constrictions										
Dam/diversion		On-site Push-up dam and diversion causing localized aggradation. Many push-up dams above					Pushup dam at diversion point	Pushup dam at diversion point	Pushup dam at diversion point	
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor				at bridge and diversion				at bridge and diversion	at bridge and diversion	
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery										managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results									

Reach 29	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	D-	B	B-	C-	B-	B	B	C+	D	B-
Score	62	85	82	74	82	85	85	78	65	82
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance		Residual Coal Basin effects								
Land use - golf course/park										
Water withdrawals	Cumulative withdrawals		temperature effects from low summer flows	decreased peak discharge = decreased stage and FP access					baseflow and variability alteration	
Road (fills, encroachment)										
Bridges/ constrictions										
Dam/diversion		On-site Push-up dam and diversion causing localized aggradation. Many push-up dams above					Low profile push-up dam and levee to feed bypass channel	Low profile push-up dam and levee to feed bypass channel	Low profile push-up dam and levee to feed bypass channel	
Levee/dike				Levee on RB limits FP access						
By-pass channel	Uncontrolled diversion to bypass channel -> water loss on bypass reach			hydro losses to bypass channel decrease stage						
Ditch										
Bank/channel armor							Hardening/rip-rap on RB and levee	Hardening/rip-rap on RB and levee	Hardening/rip-rap on RB and levee	
Channel alteration							Excavation for PU dam and bypass channel	Excavation for PU dam and bypass channel	Excavation for PU dam and bypass channel	
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery									D score on WUA (Eco-DSS)	managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results									supported by Eco-DSS

Reach 30	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	D-	B+	B-	A	A-	A-	A-	B+	D+	B-
Score	63	88	82	95	92	92	92	88	68	82
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance		Residual Coal Basin effects								
Land use - golf course/park										
Water withdrawals	Cumulative withdrawals		temperature effects Cumulative withdrawals					baseflow and flow variability alteration	baseflow and flow variability alteration	
Road (fills, encroachment)										
Bridges/ constrictions										
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery									D/C score on WUA (Eco-DSS)	managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results			No significant stressors	No significant stressors	No significant stressors	No significant stressors			supported by Eco-DSS

Reach 31	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	D+	B+	B-	B	B	B	A-	B+	C	B-
Score	67	88	82	85	85	85	92	88	75	82
Land use - development										
Land use - pasture clearing										
Land use - mining disturbance		Residual Coal Basin effects								
Land use - golf course/park										
Water withdrawals	Cumulative withdrawals		temperatjure effects from low summer flows						basflow and variability alteration	
Road (fills, encroachment)										
Bridges/ constrictions				one bridge at Thomas Cr Road						
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor							at bridge	at bridge		
Channel alteration										
Grazing										
Weeds/exotic vegetation										
Exotic fauna, managed fishery									C score on WUA (Eco-DSS)	managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results		Cumulative effects				no significant stressors	cumulative effects of contributing variable impairments		supported by Eco-DSS

Reach 32	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	D+	B+	B-	C+	B-	B	B	B-	C-	B-
Score	70	88	82	78	82	85	85	82	72	82
Land use - development					Residetial lanscaping, turf, mowing, tree/shrub removal	Residetial lanscaping, turf, mowing, tree/shrub removal				
Land use - pasture clearing					Downstream of North Crystal Bridge	Downstream of North Crystal Bridge				
Land use - mining disturbance		Possible extended impacts from Coal Basin inputs, no obvious signs								
Land use - golf course/park					Golf course vegetation conversion - turf, mowing, tree/shrub removal	Golf course vegetation conversion - turf, mowing, tree/shrub removal				
Water withdrawals			temperature effects from low summer flows						baseflow and variability alteration	
Road (fills, encroachment)										
Bridges/ constrictions				2 major bridges with significant constriction			C -> F at bridges	Increased risk of catastrophic failure, diminished resilience, but good bridge design	Constriction scour, upstream deposition	
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor							Hardening/armor at bridges	Hardening/armor at bridges	Hardening/armor at bridges	
Channel alteration										
Grazing										
Weeds/exotic vegetation					Exotics associated with residential and golf course landscaping, some weeds					
Exotic fauna, managed fishery									D/B- score WUA (Eco-DSS)	managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results		Cumulative effects							supported by Eco-DSS

Reach 33	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	B-	B	B-	C	C	C-	B-	C+	B-	B-
Score	82	85	82	75	75	72	82	78	80	82
Land use - development					Residetial lanscaping, turf, mowing, tree/shrub removal	Residetial lanscaping, turf, mowing, tree/shrub removal				
Land use - pasture clearing					Downstream of North Crystal Bridge	Downstream of North Crystal Bridge				
Land use - mining disturbance		Possible extended impacts from Coal Basin inputs, no obvious signs								
Land use - golf course/park					Golf course vegetation conversion - turf, mowing, tree/shrub removal	Golf course vegetation conversion - turf, mowing, tree/shrub removal				
Water withdrawals			temperature effects from low summer flows							
Road (fills, encroachment)										
Bridges/ constrictions		5 bridges with significant constriction		5 bridges with significant constriction			C -> F at bridges	Increased risk of catastrophic failure, diminished resilience, but good bridge design	Constriction scour, upstream deposition	
Dam/diversion										
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor							Hardening/armor at bridges	Hardening/armor at bridges	Hardening/armor at bridges	
Channel alteration										
Grazing										
Weeds/exotic vegetation					Exotics associated with residential and golf course landscaping, some weeds					
Exotic fauna, managed fishery									B- score WUA (Eco Dss)	managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results		Cumulative effects							support by Eco-DSS

Reach 34	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	B-	B-	B	B+	B-	B	B	C+	B	B-
Score	82	82	85	88	82	85	85	78	85	82
Land use - development			Start of Carbondale							
Land use - pasture clearing					Lower RB only--trees only present in 50% of the reach	Lower RB only--trees only present in 50% of the reach	Riparian Veg impairment--destabilizes bank and allows widening	Riparian Veg impairment		
Land use - mining disturbance		Residual Coal Basin effects	Residual Coal Basin effects							
Land use - golf course/park										
Water withdrawals	Cumulative		temperature effects from altered flow regime							
Road (fills, encroachment)							west side ditch road-fill armors bank			
Bridges/ constrictions										
Dam/diversion		On-site Push-up dam and diversion causing localized aggradation. Many push-up dams above					Push-up dam/diversion created in-channel vegetated bar and widened channel above	Push-up dam and diversion causing localized aggradation	Push-up dam and diversion causing localized aggradation	
Levee/dike										
By-pass channel										
Ditch				Ditch and berm constructed withing FP	Ditch and berm constructed withing FP--different veg present		Riparian Veg impairment	LB		
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation					some weeds					
Exotic fauna, managed fishery									B score WUA (Eco-DSS)	managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results									

Reach 35	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A-	B	B	A-	B+	B+	A-	A-	B	B-
Score	91	85	85	92	88	88	92	92	85	82
Land use - development			Carbondale surrounds							
Land use - pasture clearing										
Land use - mining disturbance		Residual Coal Basin effects?								
Land use - golf course/park										
Water withdrawals	Cumulative		temperature effects from altered flow regime							\
Road (fills, encroachment)										
Bridges/ constrictions		CRMS bridge near end of reach		bridge is amost as wide as valley--minimal impact			deep pool formatin from scour under bridge near pier		sediment supply and morphology	
Dam/diversion									sediment supply	
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor									sediment supply	
Channel alteration									sediment supply	
Grazing										
Weeds/exotic vegetation					some weeds					
Exotic fauna, managed fishery									B score WUA (Eco-DSS)	managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary					CRMS bridge does not have major impact	Roadfill from CRMS bridge is less than 1%		cumulative morphology, sediment supply, floodplain impacts		supported by Eco-DSS

Reach 36	V_{hyd}	V_{sed}	V_{chem}	V_{conn}	V_{veg}	V_{deb}	V_{morph}	V_{stab}	V_{str}	V_{bio}
Grade	A-	B	B+	A-	A-	A	B-	A	B	B-
Score	91	85	88	91	92	95	82	95	85	82
Land use - development			Carbondale surrounds	Carbondale surrounds						
Land use - pasture clearing										
Land use - mining disturbance		Residual Coal Basin effects								
Land use - golf course/park										
Water withdrawals	Cumulative									
Road (fills, encroachment)										
Bridges/ constrictions		CRMS bridge with narrow constriction					CRMS bridge with narrow constriction			
Dam/diversion		many PU dams on reaches above					many PU dams on reaches above			
Levee/dike										
By-pass channel										
Ditch										
Bank/channel armor										
Channel alteration										
Grazing										
Weeds/exotic vegetation					some weeds					
Exotic fauna, managed fishery									B score WUA (Eco-DSS)	managed fishery; notably smaller populations than in reference stream/upper Crystal
Narrative summary	IHA results					No significant impacts		No significant impacts		