

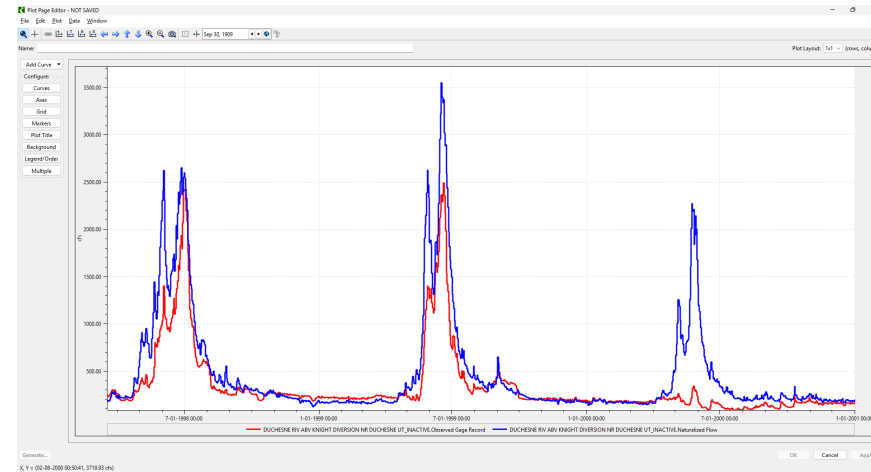
The CUWCD Natural Flow Model

A RiverWare Framework for Naturalized Flow Development

Provo, Spanish Fork, and Duchesne River Basins

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PRECISION
WATER RESOURCES ENGINEERING



The Goal Is a Transparent, Living Naturalized-Flow Dataset

Developed to support CUPSIM and other CUWCD RiverWare models and hydrologic analyses across the Provo, Spanish Fork, and Duchesne basins.

Three-Part Story

- 1 Why naturalized flow matters
- 2 How RiverWare organizes the calculations
- 3 How the record is completed and reused

Observed and Naturalized Flows Answer Different Questions

Observed Flow

Streamflow measured or calculated after upstream operations have affected the river.

It reflects both hydrology and historical management.

Naturalized Flow

Observed flow adjusted for the selected upstream effects represented in the framework.

For modeling, it provides the consistent hydrologic input that the model can reoperate.



Naturalization Is an Upstream Water Balance

Naturalized Flow = Observed Flow

- +** Diversions
- Return Flows
- +** Change in Storage
- +** Evaporation
- +** Exports
- Imports

Generalized form shown; terms vary by target and application.

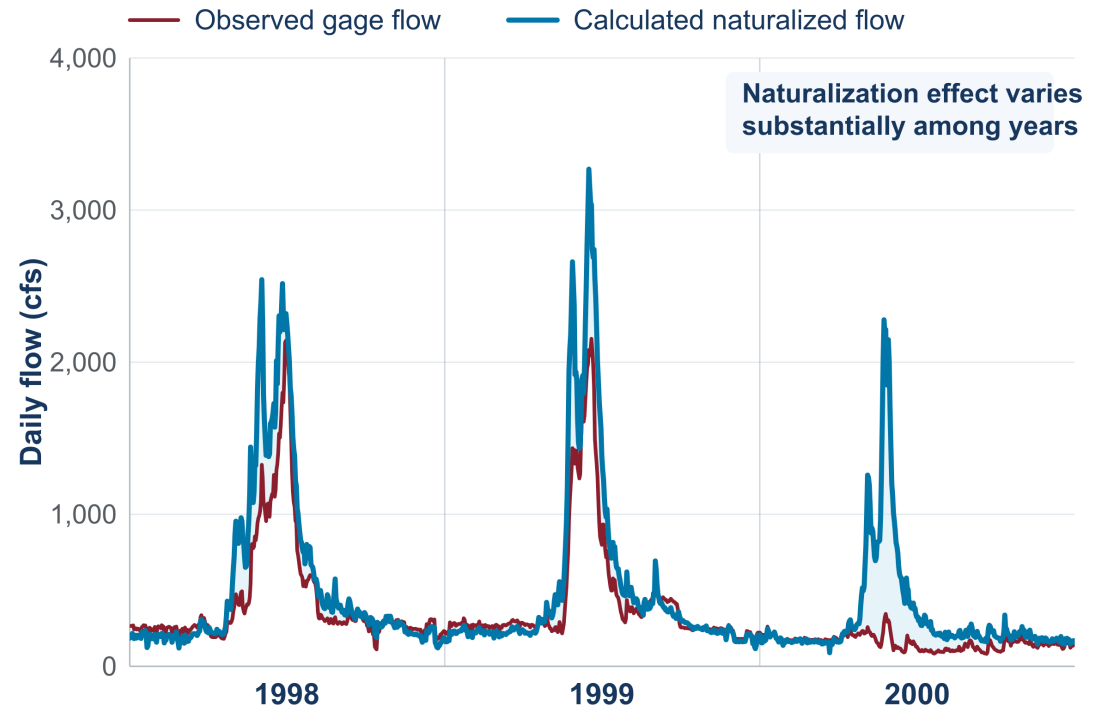
Managed Flow Can Hide the Hydrologic Signal

Operations Can:

- Shift water across seasons and basins
- Capture or reshape runoff peaks
- Change as infrastructure and demands evolve

Duchesne River above Knight Diversion

January 1, 1998–December 31, 2000



The Hard Part Is Consistency Through Time

Data Completeness

- Missing is unknown—not zero.
- Calculate only when every required upstream input is present.
- A series must mean the same thing through time.

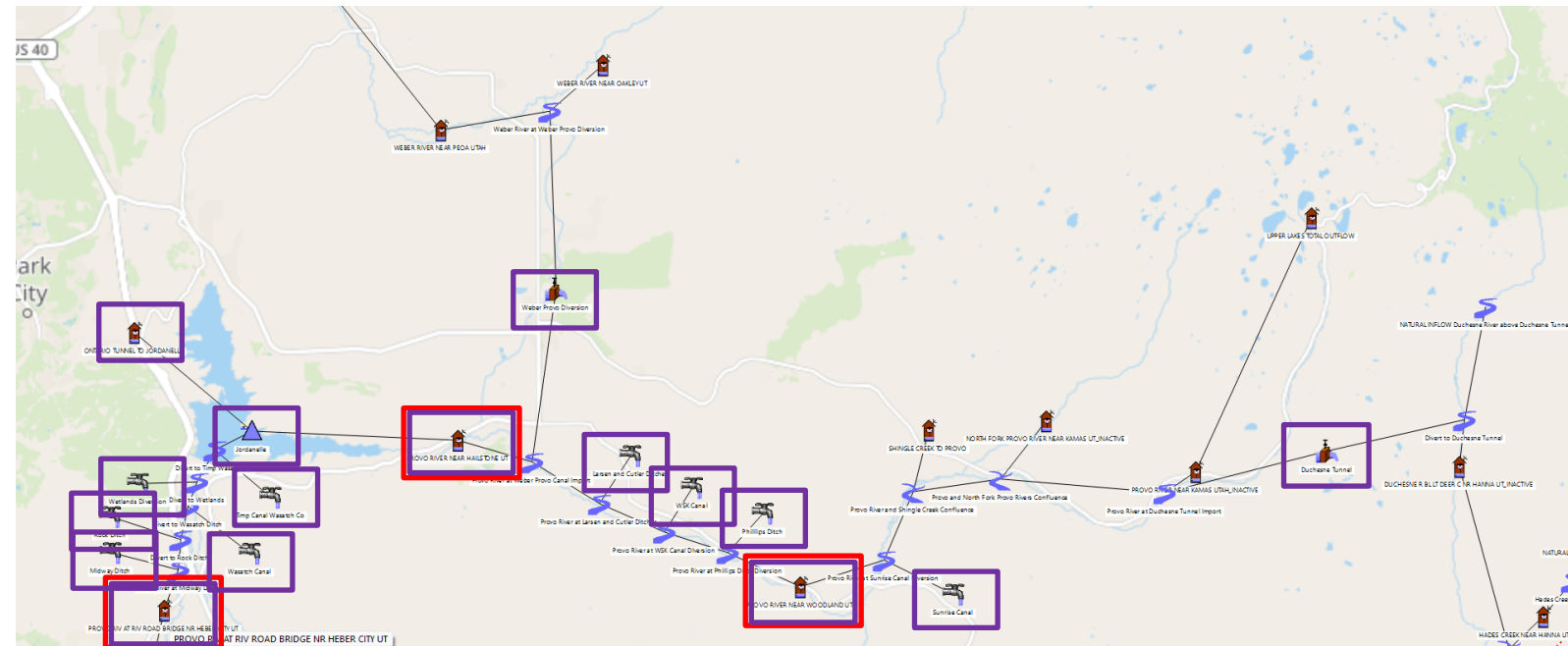
Model Consistency

- Match the flow definition to the model configuration.
- Make operations explicit when they may change.
- Keep other effects implicit—and never count them twice.

RiverWare Organizes the Calculations and Documents Their Scope

The Network

- Organizes gages and the upstream operations represented
- Maps each target's upstream data dependencies
- Shows what is explicit—and what remains implicit



Naturalization target gage

Upstream data Dependencies

RiverWare Provides Structure Without a Conventional Simulation

Network

Organizes basin dependencies

Initialization

Loads source data

Selected Object Methods

Handle specific calculations

Single Rule

Calculates naturalized flows at all targets

RiverWare Produces a Traceable Source Record

The output is intentionally incomplete:

- Naturalized values are calculated only when every required input is available
- Gaps remain visible instead of being treated as zero
- Coverage varies by target and period

Source-Calculated Naturalized Flow by Model Water Year (acre-feet)

Rock Creek subbasin • Model WY 1960–1995

One long-term active gage anchors four historical records.

Model WY	Mountain Home	Above South Fork	Near Talmage	Near Hanna	South Fork near Hanna
1960	94,445	---	---	84,389	6,598
1961	73,666	---	---	62,055	4,459
1962	154,838	---	---	141,211	13,787
1963	109,242	---	partial	96,996	8,148
1964	136,048	---	135,894	122,253	11,486
1965	183,909	partial	196,017	165,675	16,194
1966	99,572	74,138	108,776	83,808	8,135
1967	154,733	122,575	160,080	137,919	11,890
1968	145,817	120,857	147,814	133,107	11,090
1969	139,156	108,551	155,397	partial	11,205
1970	109,269	88,842	111,100	---	7,529
1971	144,575	122,497	141,723	---	9,840
1972	142,217	114,540	139,789	---	11,710
1973	129,180	104,549	132,282	---	9,261
1974	111,269	88,717	109,617	partial	8,003
1975	159,697	114,807	154,814	136,973	13,044
1976	89,224	68,019	91,248	78,034	7,567
1977	54,305	39,905	53,764	43,702	2,935
1978	122,793	109,176	125,403	117,836	8,090
1979	95,230	77,738	96,516	87,306	9,638
1980	126,258	114,827	137,256	119,457	12,108
1981	92,965	70,512	106,742	80,811	7,757
1982	158,136	133,712	163,222	147,497	14,023
1983	180,704	152,461	177,128	172,362	15,506
1984	166,923	partial	169,954	130,231	11,044
1985	129,719	---	125,576	111,431	10,498
1986	196,343	---	202,167	180,567	18,085
1987	129,501	---	119,889	111,604	10,241
1988	78,460	partial	75,479	partial	5,859
1989	85,746	65,224	86,651	---	5,703
1990	98,162	75,566	99,753	---	6,756
1991	97,105	76,868	100,241	---	6,647
1992	65,869	51,734	72,125	---	partial
1993	138,502	111,660	141,622	---	---
1994	77,240	partial	partial	---	---
1995	166,868	---	---	---	---

■ Long-term active gage ■ Partial source year ■ No source record

Post-Processing Fills Gaps Without Replacing Known Values

Outside RiverWare, a separate process fills and extends the remaining gaps.

Source and RiverWare-calculated values are preserved.

Each estimate remains traceable—with its fill method and a quality indicator.

Naturalized Source Records



Develop Relationships



Complete Daily Series

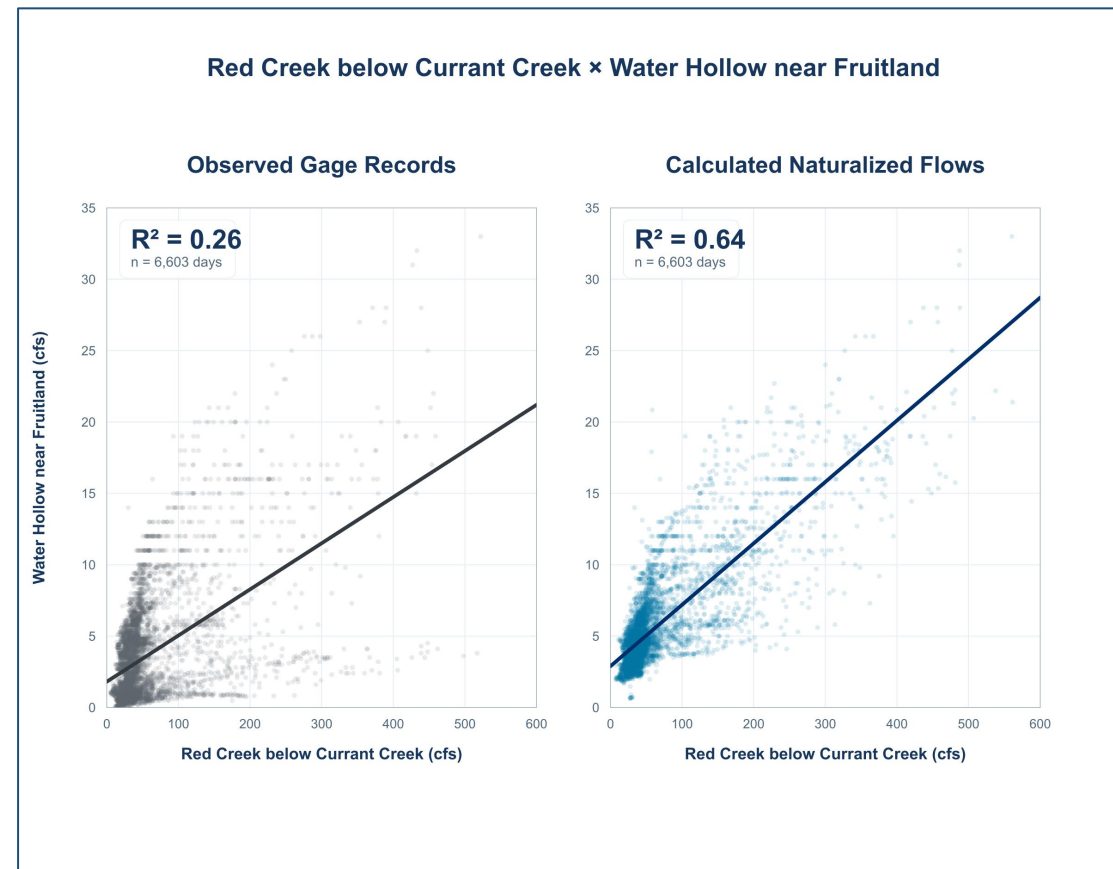
Naturalization Strengthens Relationships Used for Extension

Adjusting for Operations Can:

- Improve hydrologic comparability
- Reveal stronger relationships
- Support MOVE-type extension

For this pair:

R^2 0.26 $\rightarrow$ 0.64



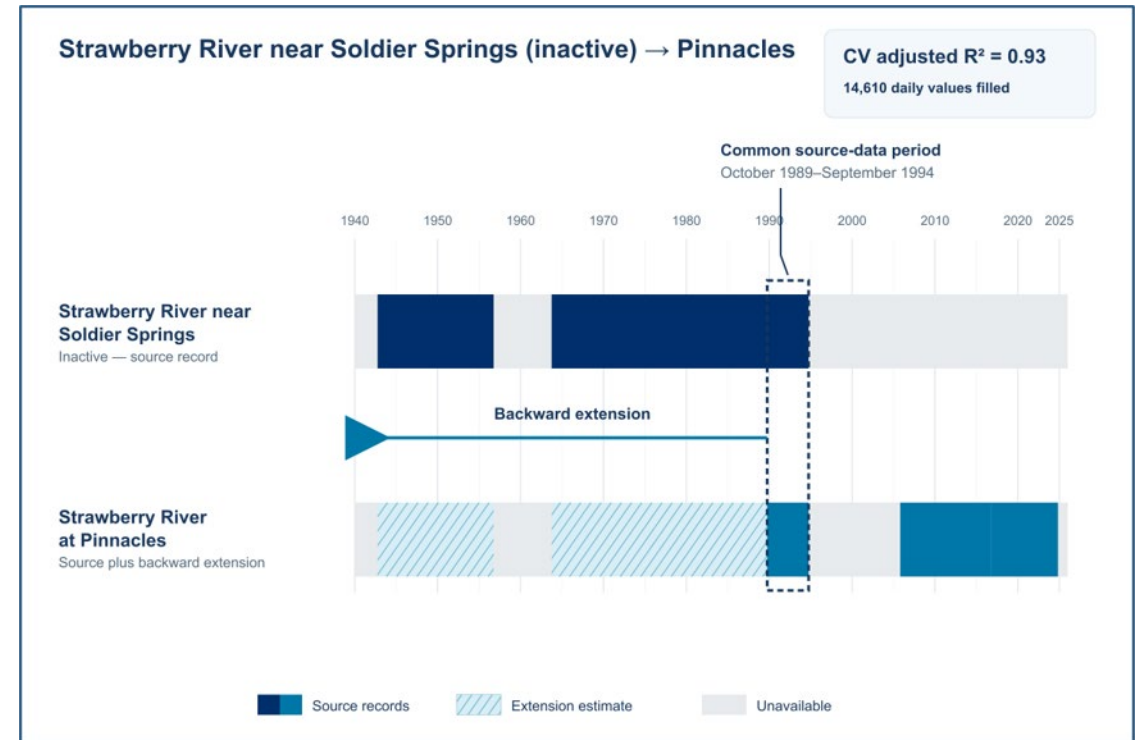
Inactive Gages Can Extend the Available Record

Inactive Gages

- Old gage records preserve periods and locations missed by the current gage network.
- A discontinued gage can still be one of the best records of an earlier period.
- Help bridge gaps in current records.

Current Implementation

- Inactive records supplied about 293 years worth of daily estimates across 20 target gages.
- Used where overlap and measured performance support their value.



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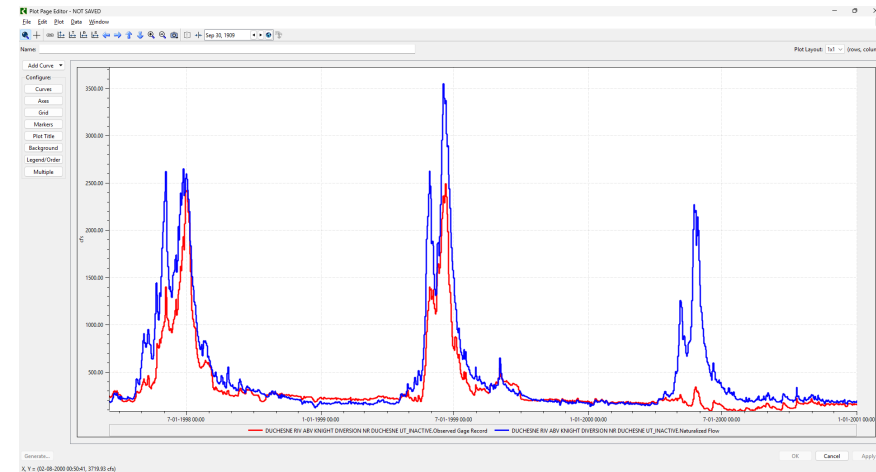
Questions?

Acknowledgements

CUWCD team

PWRE team

CADSWES team



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