

Tools for Working with Time Series: The Nature Conservancy's IHA

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Lecture Overview

- The natural flow regime (*Poff et al. 1997*)
- Examples of important hydro-ecological flow regime components
- IHA Software (*Richter et al. 1996, 1997*)

The Natural Flow Regime

A paradigm for river conservation and restoration

N. LeRoy Poff, J. David Allan, Mark B. Bain, James R. Karr, Karen L. Prestegard, Brian D. Richter, Richard E. Sparks, and Julie C. Stromberg

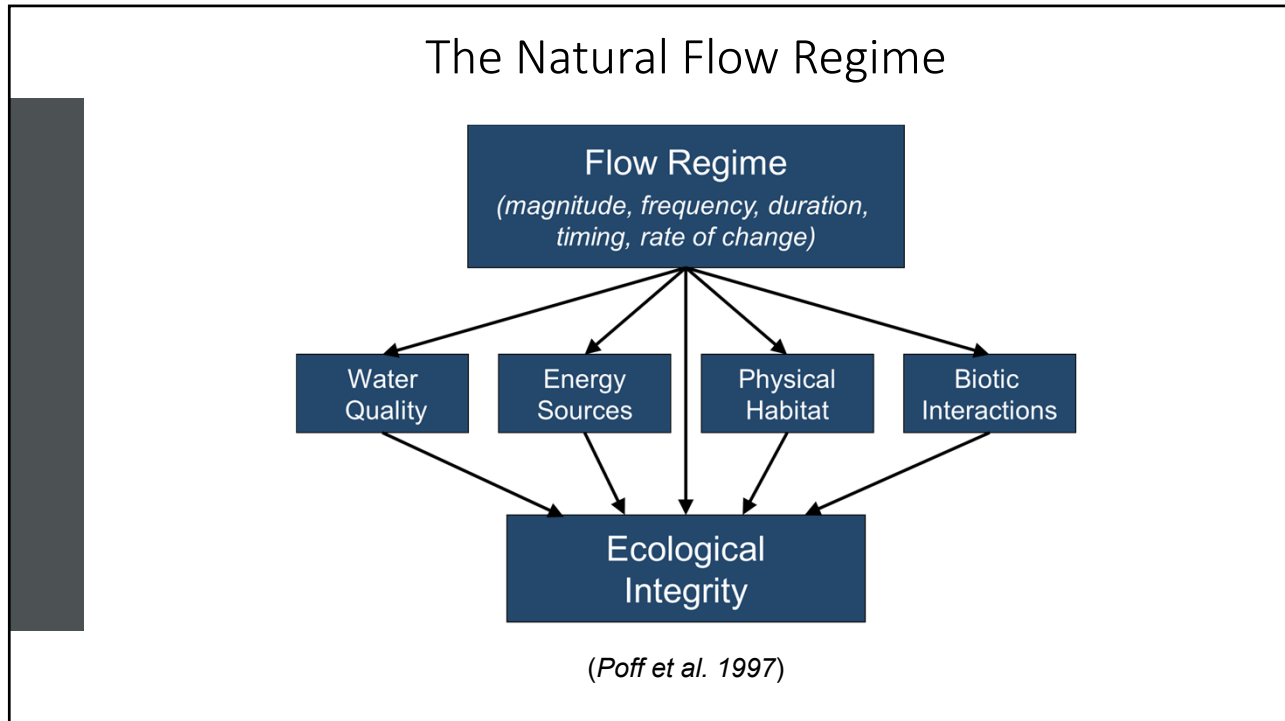
Humans have long been fascinated by the dynamism of free-flowing waters. Yet we have expended great effort to tame rivers for transportation, water supply, flood control, agriculture, and power generation. It is now recognized that harnessing of streams and rivers comes at great cost. Many rivers no longer support socially valued native species or sustain healthy ecosystems that provide important goods and services (Naiman et al. 1992, NRC 1992).

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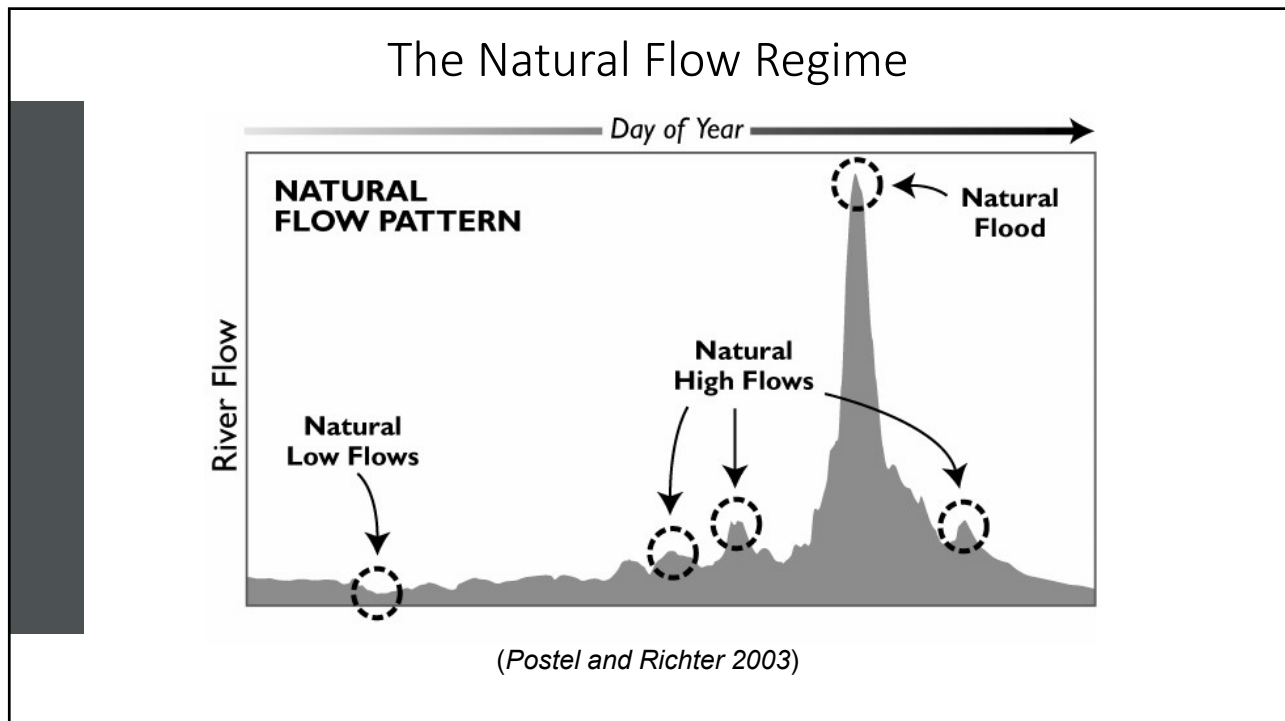
The ecological integrity of river ecosystems depends on their natural dynamic character

The extensive ecological degradation and loss of biological diversity resulting from river exploitation is eliciting widespread concern for conservation and restoration of healthy river ecosystems and the public value of rivers (Hughes and al. 1993, TNC et al. 1996). Estuarine fisheries, game fisheries, and intense flooding are degraded as a consequence of river management policies (Allmaror et al. 1996, Naiman et al. 1996). National broad social support for the Clean Water Act, the recognition value of nonconsumptive uses, and the proliferation of conservation and self-sustaining free-flowing rivers. Society's ability to restore the degraded river systems requires that management actions be grounded in science. However, current management approaches often fail to recognize the fundamental scientific principle that the integrity of flowing water systems depends largely on their natural dynamic character, as a result, these methods frequently prevent successful river conservation or restoration. Streamflow quantity and timing are critical components of water supply, water quality, and the ecological integrity of river systems. Indeed, streamflow, which is strongly correlated with many critical physicochemical characteristics of rivers,

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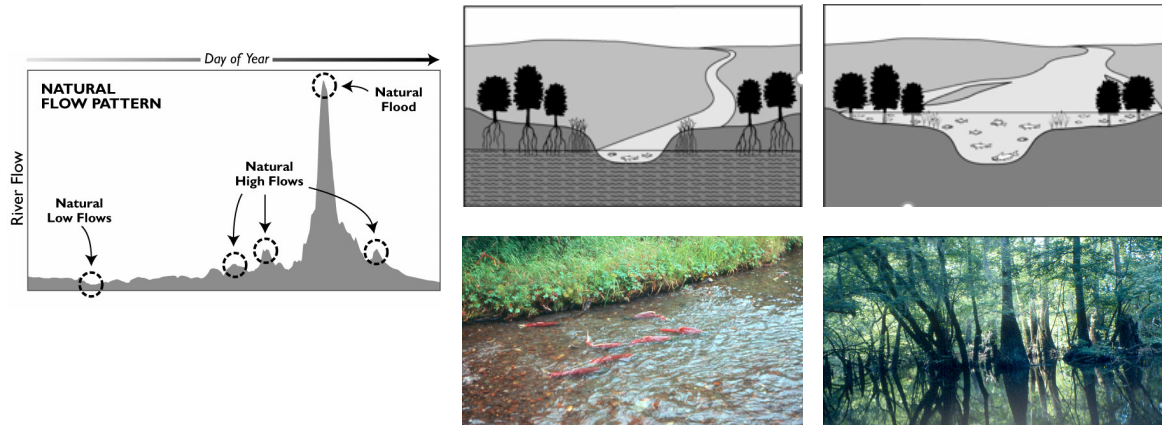


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Ecological Functions of the Natural Flow Regime

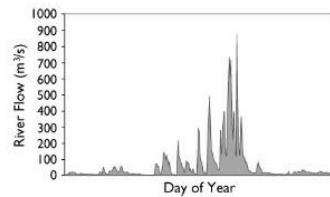


(Postel and Richter 2003)

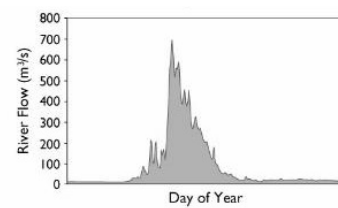
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Diversity of Natural Flow Regimes

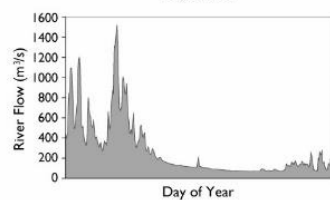
**Nam-gang River,
Korea**



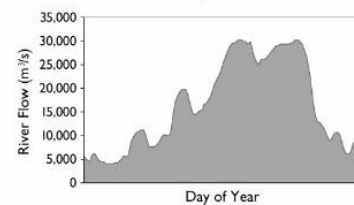
**Yampa River,
Colorado,
United States**



**Cuiaba River,
Brazil**



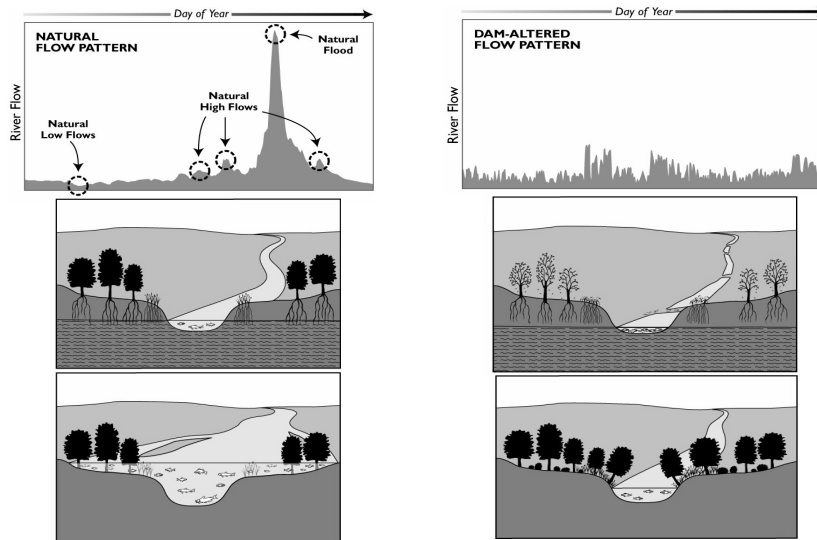
**Mississippi River,
United States**



(Postel and Richter 2003)

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Impacts of Altered Hydrologic Regimes



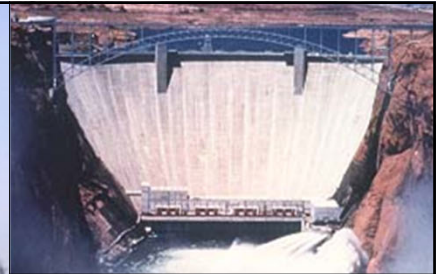
(Postel and Richter 2003)

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IHA Software (Richter et al. 1996, 1997)

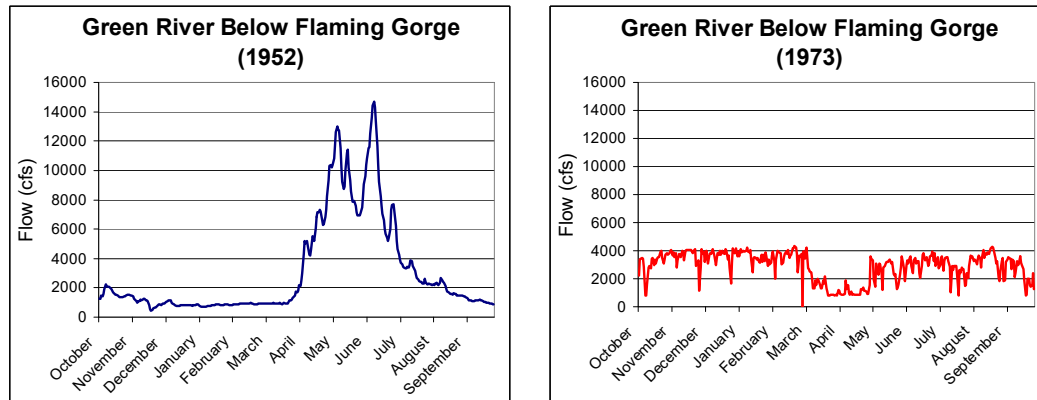
- Analyzes hydrologic characteristics and their changes over time.
- Computes 67 ecologically-relevant flow statistics using daily hydrologic data.
- Designed to be a user-friendly, flexible tool, applicable to a variety of hydrologic systems

The goal of IHA is to show changes to hydrology. The next step is to connect this to river functions and ecology.



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Comparing Time Series



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Analysis Options

Type of analysis and statistics:

- Two period (before and after) analysis or trend analysis
- Parametric or non-parametric statistics

Time periods to analyze:

- Can analyze a subset of water years in the period of record
- Can analyze seasonal periods (i.e. shorter than a 12-month water year).

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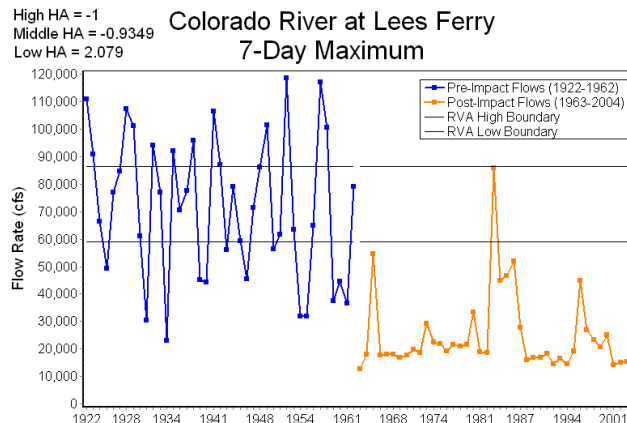
IHA Annual Statistics (33 parameters; *Richter et al. 1996*)

- Monthly average flows
- Magnitude of annual extremes
(1-, 3-, 7-, 30-, and 90-day highs and lows)
- Timing of annual extremes (1-day max and min)
- Zero flow days
- Frequency and duration of high and low pulses
- Rates of flow changes and reversals
- Base flow index

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Range of Variability Analysis

- Measures the natural range of variability of each parameter
- Quantifies how this variability has been altered



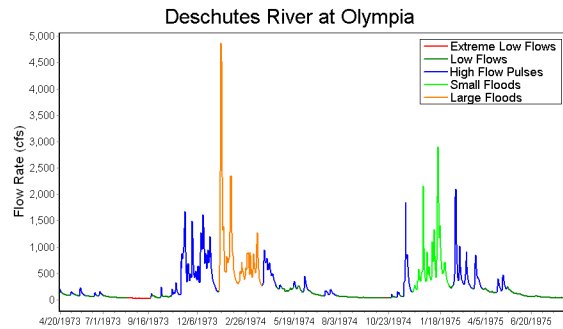
(*Richter et al. 1997*)

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Environmental Flow Components (EFCs)

(34 parameters; *Richter and Thomas 2007*)

- **Monthly low flows:** mean/median
- **Extreme low flows:** magnitude (mean, median, minimum), frequency, duration, timing
- **High flow pulses:** magnitude (mean, median, maximum), frequency, duration, timing, rise/fall rates
- **Small floods (i.e., 2-10 yr events):** magnitude (mean, median, maximum), frequency, duration, timing, rise/fall rates
- **Large floods (i.e., >10 yr events):** magnitude (mean, median, maximum), frequency, duration, timing, rise/fall rates



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IHA Workflow

Hydro Data file

Flow Date	Flow rate in cfs	Water Depth
6/0/1949	71	153
6/9/1949	70	155
6/4/1949	70	156
5/5/1949	70	157
6/6/1949	69	158
6/1/1949	67	159
6/9/1949	66	161
6/10/1949	66	162
6/11/1949	64	163
6/12/1949	63	164
6/13/1949	62	165
6/4/1949	61	166
6/5/1949	60	167
6/6/1949	59	168
6/17/1949	58	169

Project

Project Deschutes

Project Name: Deschutes

Using Database: C:\ProgramData\IHA\IHA\Deschutes.gdb

Hydro Data File Information:

Input Data: Deschutes Flow

Label: DeschutesFlow

Label Period: 1949-1950

Flow Rate: CFS (Flow Rate Period: CFS)

Flow rate units to use for output tables and graphs:

Flow Rate Unit: CFS

Water Year 1949 begins on: 10/1/1948

Water Year 1950 ends on: 9/30/1949

Analyses

Project Deschutes

Analysis Name: DeschutesFlow

Start Date: 10/1/1948

End Date: 9/30/1949

High Flow Percentile: 95.000

Low Flow Percentile: 5.000

Flow Period Frequency: 1949-1950

Flow Period Frequency: 1949-1950

Outputs (tables and graphs)

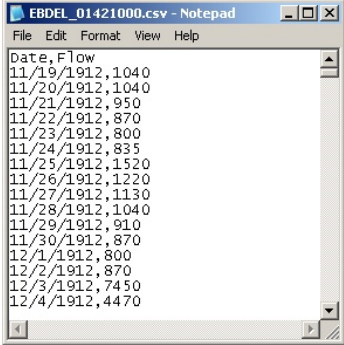
Deschutes River at Olympia Monthly Flows for October

Deschutes River at Olympia Environmental Flow Components (1949-2000)

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IHA Input Data

- Can import daily data from text files
 - From USGS: waterdata.usgs.gov
 - Two-column text format (calendar date, flow value)
- Batch imports also an option

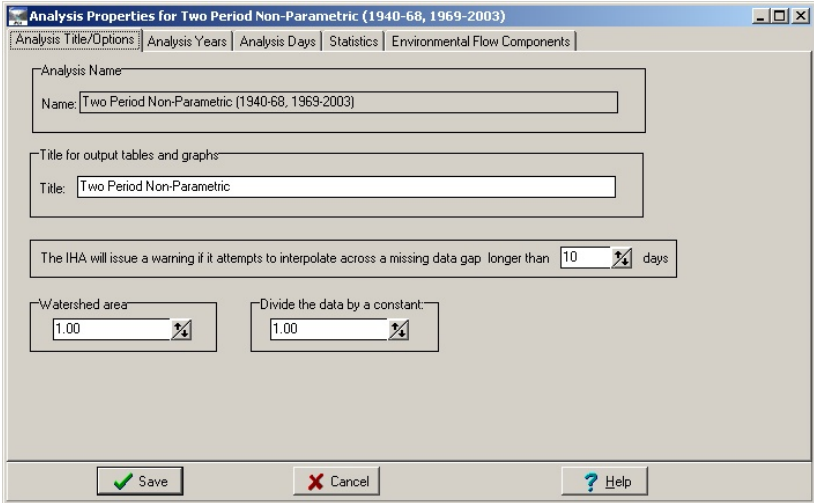


```

EBDEL_01421000.csv - Notepad
File Edit Format View Help
Date, Flow
11/19/1912,1040
11/20/1912,1040
11/21/1912,950
11/22/1912,870
11/23/1912,800
11/24/1912,835
11/25/1912,1520
11/26/1912,1220
11/27/1912,1130
11/28/1912,1040
11/29/1912,910
11/30/1912,870
12/1/1912,800
12/2/1912,870
12/3/1912,7450
12/4/1912,4470
  
```

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Analysis Set Up: General Options



Analysis Properties for Two Period Non-Parametric (1940-68, 1969-2003)

Analysis Title/Options | Analysis Years | Analysis Days | Statistics | Environmental Flow Components

Analysis Name
Name: Two Period Non-Parametric (1940-68, 1969-2003)

Title for output tables and graphs
Title: Two Period Non-Parametric

The IHA will issue a warning if it attempts to interpolate across a missing data gap longer than 10 days

Watershed area: 1.00

Divide the data by a constant: 1.00

Save Cancel Help

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Analysis Set Up: One or Two Periods

Analysis Properties for Two Period Non-Parametric (1940-68, 1969-2003)

Analysis Title/Options | Analysis Years | Analysis Days | Statistics | Environmental Flow Components

Type of analysis:

Analyze a single period:
 Select the Begin and End Water Years for your analysis (by dragging the sliders at the far left and far right)
 1940-2003

Compare two periods:
 Choose the Impact Water Year (by dragging the slider at the center either left or right)
 1940-1968 | 1969-2003
 Select the portion of the Pre-Impact period to be analyzed: | Select the portion of the Post-Impact period to be analyzed
 1940-1968 | 1969-2003

Save Cancel Help

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Analysis Set Up: Shortened Time Periods

Analysis Properties for Two Period Non-Parametric (1940-68, 1969-2003)

Analysis Title/Options | Analysis Years | Analysis Days | Statistics | Environmental Flow Components

Beginning of Water Year:
 The water year starts on day (mm/dd): 10/01 Julian Day: 275

For IHA parameters you may limit the analysis to only a part of the year:
 Yes, Limit Analysis to only a part of the year.
 Begin on day (mm/dd): 04/01 Julian Day: 92
 and end on day (mm/dd): 09/01 Julian Day: 245

Season definitions for Environmental Flow Components:
 Yes, Use Two Seasons (Note: Seasons cannot overlap)
 Season 1 begins on day (mm/dd): 11/15 Julian Day: 320, and ends on day (mm/dd): 04/30 Julian Day: 121
 Season 2 begins on day (mm/dd): 07/01 Julian Day: 183, and ends on day (mm/dd): 09/15 Julian Day: 259

Save Cancel Help

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Analysis Set Up: Parametric or Non-Parametric

Analysis Properties for Two Period Non-Parametric (1940-68, 1969-2003)

Analysis Title/Options | Analysis Years | Analysis Days | **Statistics** | Environmental Flow Components

Select Type of Statistics:

Use Parametric (mean/standard deviation) statistics:

High and low flow pulse thresholds are defined as the mean plus or minus Standard Deviation(s)

RVA Category boundaries are the mean plus or minus Standard Deviation(s)

Use Non-Parametric (percentile) statistics:

High flow and Low flow pulse thresholds are the median plus or minus Percent

RVA Category boundaries are the median plus or minus Percent

If the low pulse threshold is less than 0, it will be reset to the 25th percentile.
 If an RVA Category boundary is outside the range of the pre-impact data, it will be reset to the 25th or 75th percentile.
 If either of these situations occurs, a notice will be posted in the message report.

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Analysis Set Up: EFC Definition

Analysis Properties for Two Period Non-Parametric (1940-68, 1969-2003)

Analysis Title/Options | Analysis Years | Analysis Days | Statistics | **Environmental Flow Components**

Environmental Flow Component (EFC) analysis computes statistics for five different flow components: extreme low flows, low flows, high flow pulses, small floods, and large floods. If you wish, this analysis may be performed for two separate seasons (see Analysis Days tab).

The parameters used to define EFCs can be set below.

High Flow Pulses

All flows that exceed percent of flows for the period will be classified as high flow pulses.

No flows that are below percent of flows for the period will be classified as high flow pulses.

Between these two flow levels, a high flow pulse will begin when flow increases by more than percent per day, and will end when flow decreases by less than percent per day.

Flood Definition

A small flood event is defined as a high flow pulse with a recurrence time of at least years.

A large flood event is defined as a high flow pulse with a recurrence time of at least years.

Extreme Lowflow Definition

An extreme low flow is defined as a flow in the lowest percent of all low flows in the period.

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IHA Outputs

IHA output tables contain:

- Annual values for each parameter (for each water year)
- Statistics calculated from these annual values
 - Will differ depending on whether parametric/non-parametric statistics or one- or two-period analysis were selected
- Daily flow values by EFC type
- List of warning messages

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IHA Outputs

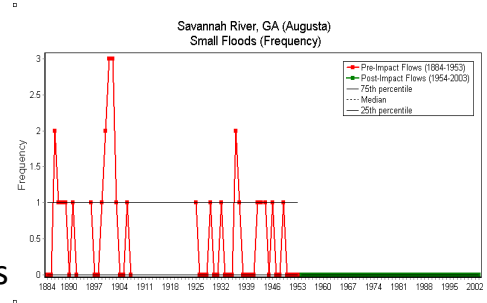
Year	October	November	December	January	February	March	April	May	June
1912	9060	9060	9060	6620	9500	21400	9945	9280	
1913	2620	3090	3250	5140	4260	9060	7010	4260	
1914	3740	4430	5870	7400	11650	11400	8210	4780	
1915	2460	2460	10900	14700	10900	8210	6620	4430	
1916	6080	3160	3630	8130	8130	5700	4800	4290	
1917	2930	2660	3160	8570	7280	15900	7280	5700	
1918	2270	2615	1620	4430	10900	7010	13300	8630	
1919	2040	4085	8630	9960	7400	9960	7400	10400	
1920	3090	2770	3410	3740	8210	8630	9280	4780	
1921	2270	3215	12500	10000	11750	8000	7310	6280	
1922	1620	3540	3700	4860	14150	17200	7080	9500	
1923	3540	2930	4180	9000	12750	17200	8150	5380	
1924	2760	3440	5030	10000	6500	9520	11850	15600	
1925	5380	4525	6500	16800	10000	6900	5205	5740	
1926	2270	3230	4040	5740	11600	6900	6120	3440	
1927	1620	3360	4690	5030	8150	7720	8590	3740	
1928	5030	3230	10000	6900	8590	6900	7925	5740	
1929	5030	4360	4360	5030	7510	14400	8590	8590	
1930	6480	8650	7320	7970	7970	5680	5480	3800	
1931	859	2105	2370	4050	2935	4260	8000	6390	
1932	1280	1485	2710	5300	6390	8150	7500	4810	

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IHA Outputs

IHA graphs include:

- Annual data graphs
- Daily data graphs
- Range of Variability graphs
- Monthly mean/median graphs
- Flow duration curve graphs



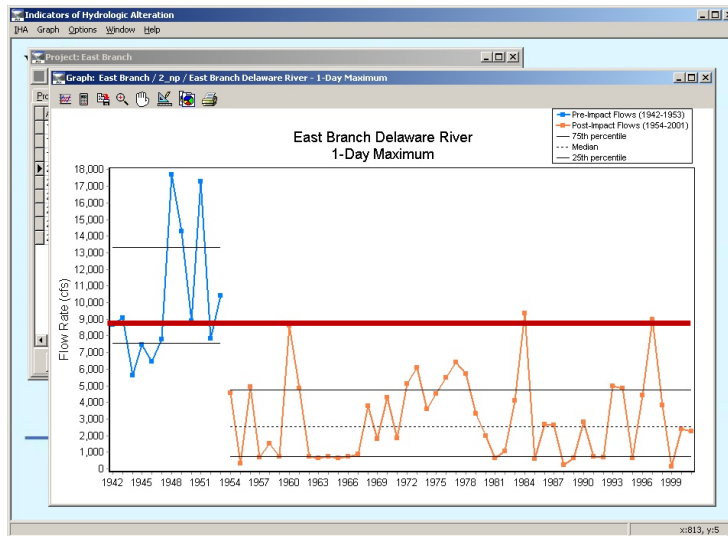
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While Examining Hydrology,
think about Ecology!

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IHA Outputs

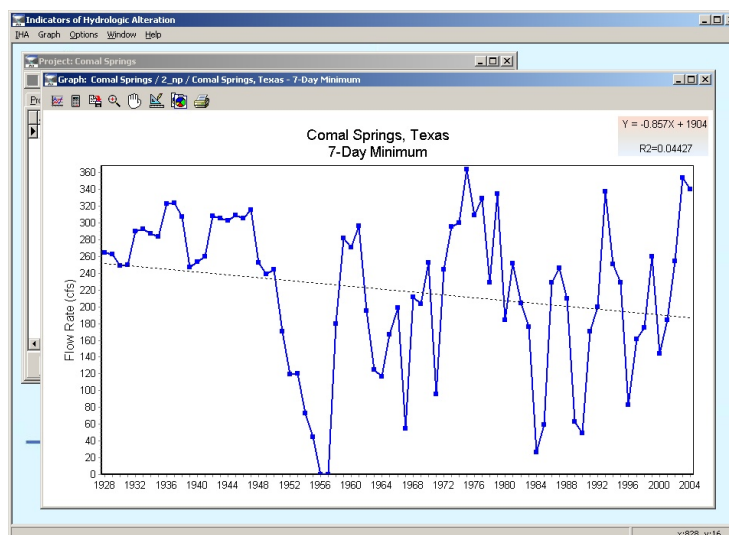


- The red line is an estimate of overbank flow. How might post-impact flows might affect ecology?

- Limited overbank flow to interact with floodplains
- Possible reduction in cues for fish to move upstream for spawning
- Sediment dynamics might change without the higher flows

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IHA Outputs

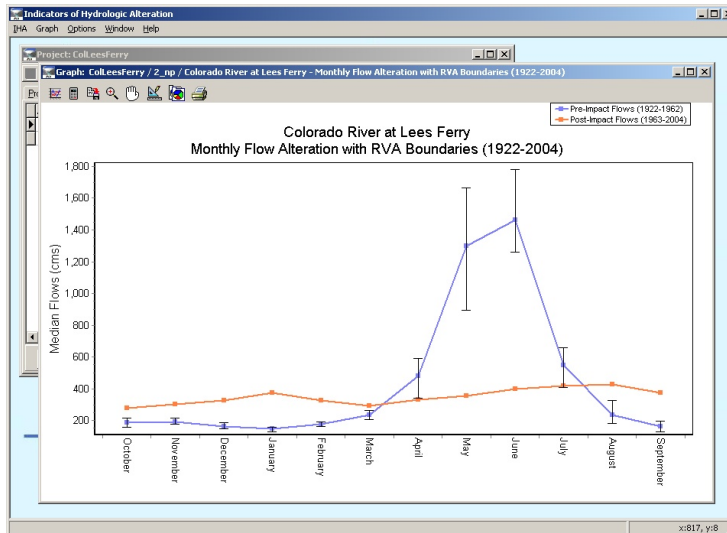


- Who or what might be impacted by this trend?

- A declining trend of low flows might be costly to a water utility.
- Declining low flows might affect species like mussels who need a minimum flow
- In reverse, this dynamic could help some trees or aquatic species establish/outcompete others.

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IHA Outputs

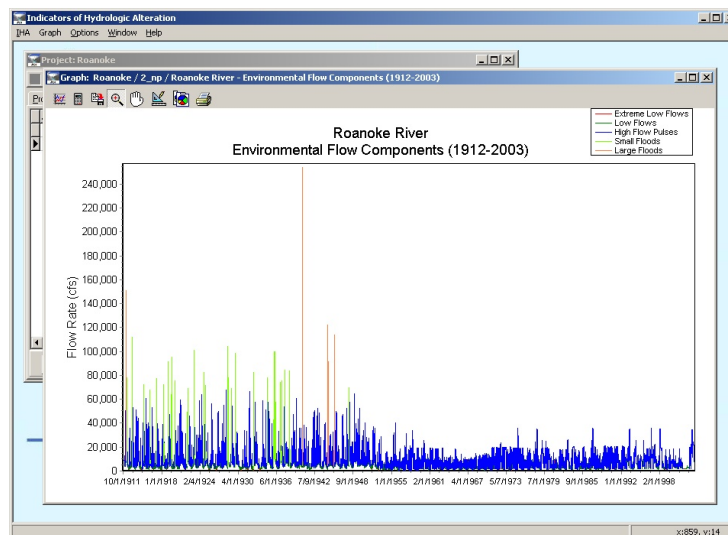


- How might post-impact flows might affect ecology?

- The temperature of the water might change.
- Likely a reduction in cues for fish to move upstream for spawning
- Sediment dynamics might change without the higher flows

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IHA Outputs



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For more information:
www.conservationgateway.org/ConservationPractices/Freshwater/

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The Nature Conservancy 

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