Proposed Protected Instream Flows (PISF) for the Souhegan River Designated Reach

University of New Hampshire

University of Massachusetts

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Milford, NH

The Completed Efforts to Date

- Who are the “players” – IPUOCR identification
- Which are “Flow-Dependent” IPUOCR?
- Are there Groundwater Effects?
- Methods to Assess the Flow Needs of Each Flow-Dependent IPUOCR
- PISF Assessments and Report

IPUOCR – Instream Public Uses, Outstanding Characteristics, and Resources

PISF Assessments and Report

- The IPUOCR, location, water needs
- IPUOCR evaluation methods and results
- How the river meets the proposed PISF
- Identify river reaches that do not meet the proposed PISF
- TRC presented these results and then review and comment

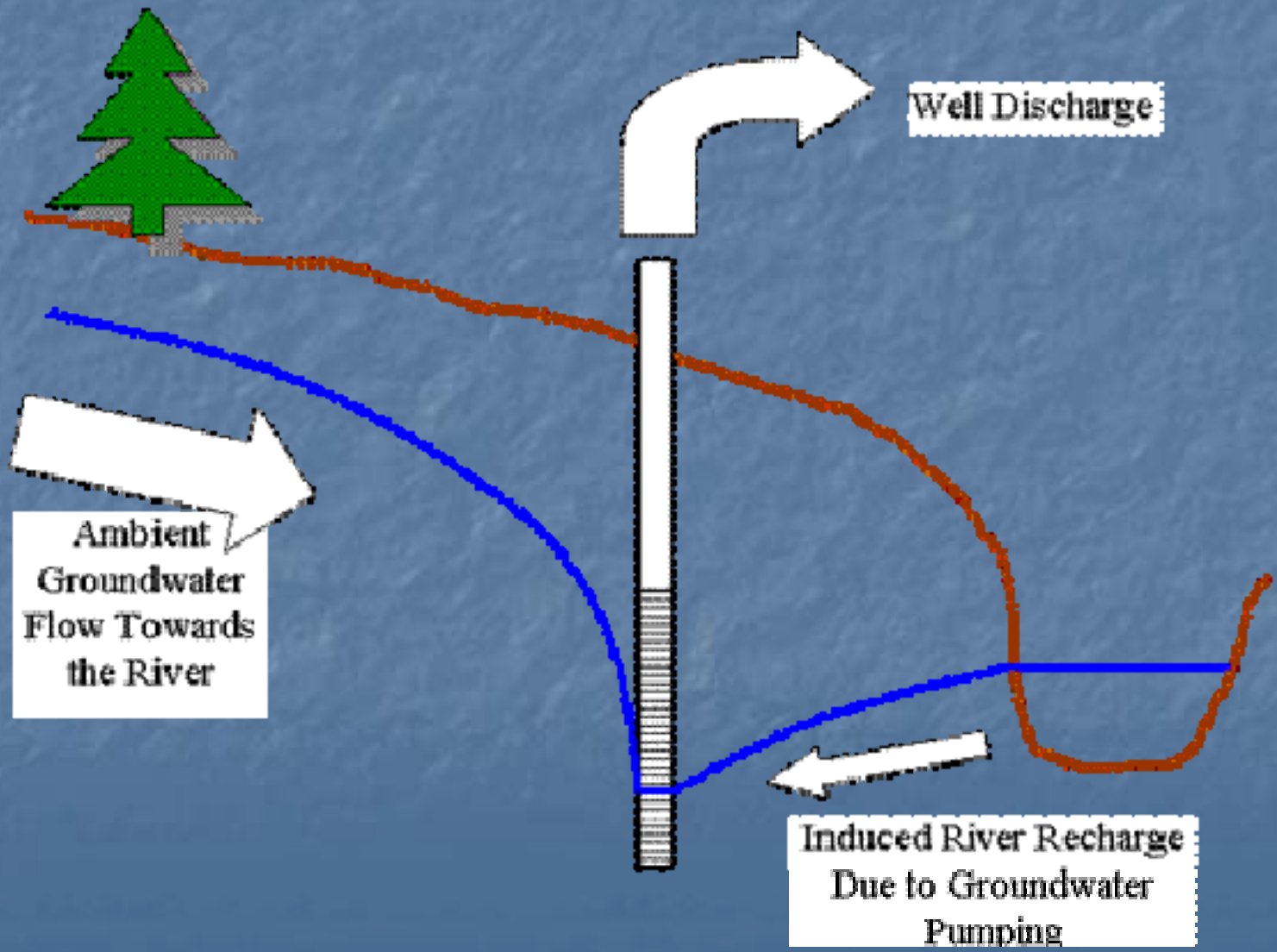
Flow-Dependent IPUOCR Classes

- Human
- Fish
- Rare, Threatened, and Endangered Species (RTE)

Groundwater Effects

Three of the studied wells induce recharge

Induced Recharge to be Considered in the Management Plan



Methods to Determine the IPUOCR Flow Needs

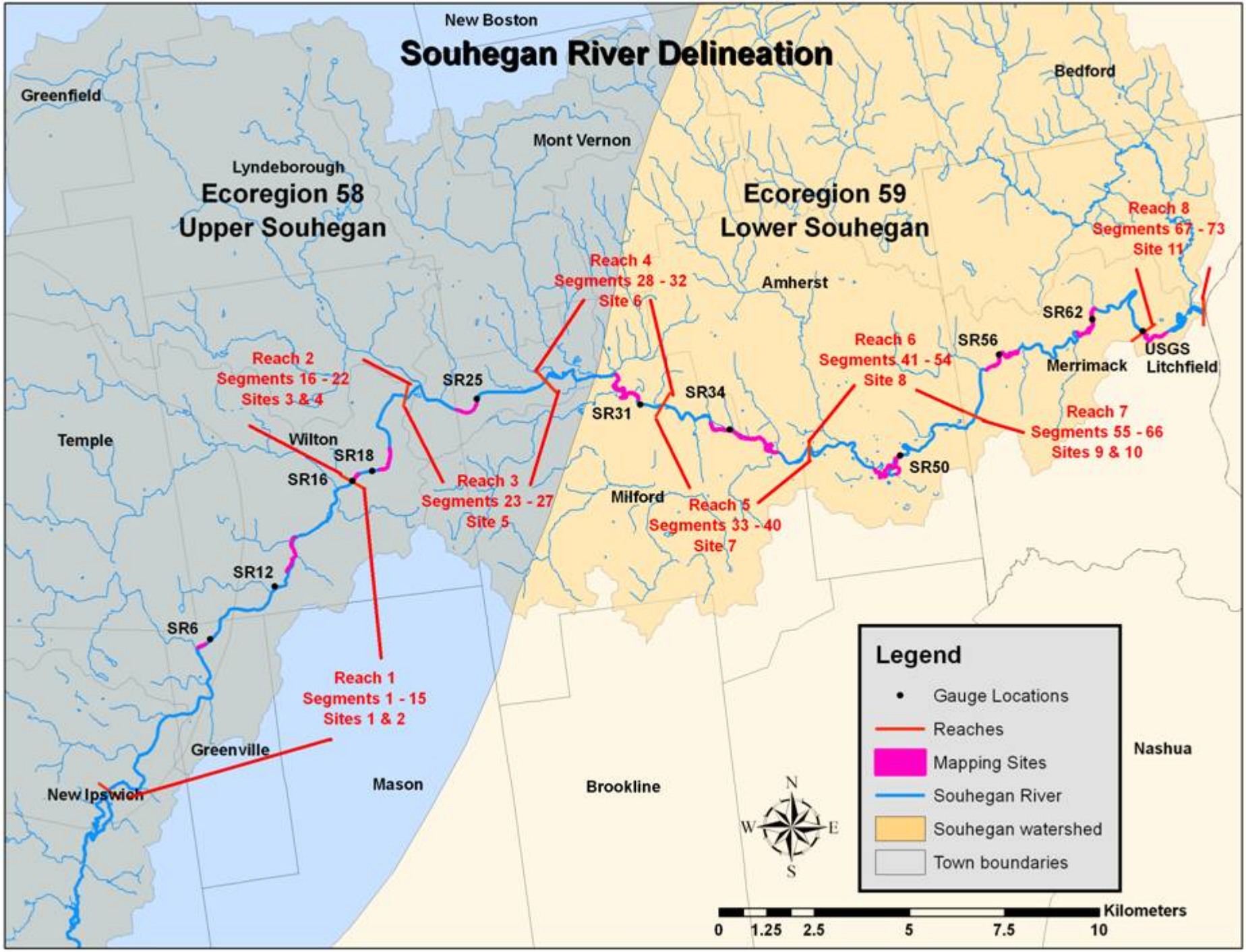
- Human – Surveys, regulations, interviews
- Fish – Field surveys, reference communities, target communities, modeling
- RTE - Field surveys, reference communities/habitat needs

Proposed PISF for Each IPUOCR

Each IPUOCR possess water (river flow) needs that may vary throughout the year and vary along the river.

Units of Flow

- Typically measured and reported at a specific location as *cubic feet per second* (cfs)
- Normally, river flow increase in the downstream direction as more tributaries and baseflow join the main stem
- To compare flows from one location along the river to another, flow is divided by the watershed area at the point of interest. Watershed area is measured in square miles.
- The units of flow divided by watershed are *cubic feet per second per square mile* (cfsm)

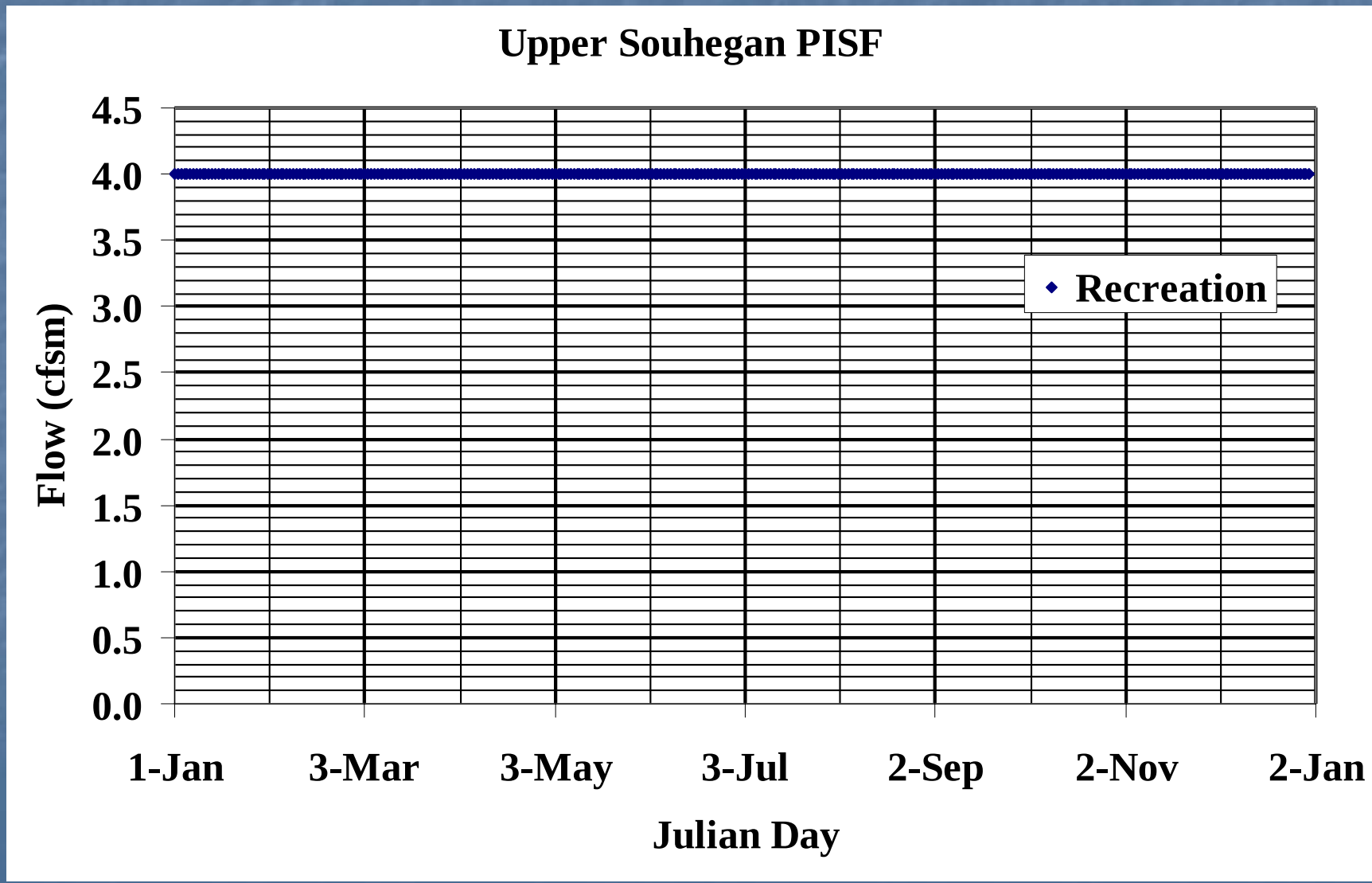

Souhegan River Delineation
New Boston
Greenfield
Mont Vernon
Lyndeborough
Ecoregion 58
Upper Souhegan
Ecoregion 59
Lower Souhegan
Bedford
Amherst
Reach 8
Segments 67 - 73
Site 11
Reach 4
Segments 28 - 32
Site 6
SR62
SR56
Reach 6
Segments 41 - 54
Site 8
Merrimack
USGS
Litchfield
Reach 2
Segments 16 - 22
Sites 3 & 4
SR25
SR34
SR31
Reach 7
Segments 55 - 66
Sites 9 & 10
Temple
Wilton
SR18
SR16
SR50
Reach 3
Segments 23 - 27
Site 5
Milford
Reach 5
Segments 33 - 40
Site 7
SR12
SR6
Reach 1
Segments 1 - 15
Sites 1 & 2
Greenville
Nashua
New Ipswich
Mason
Brookline
Legend
Gauge Locations
Reaches
Mapping Sites
Souhegan River
Souhegan watershed
Town boundaries
N
W
E
S
Kilometers
0
1.25
2.5
5
7.5
10

Example of an IPUOCR PISF

Recreation

4 cfsm in Reaches 1 and 2 (Upper Souhegan)

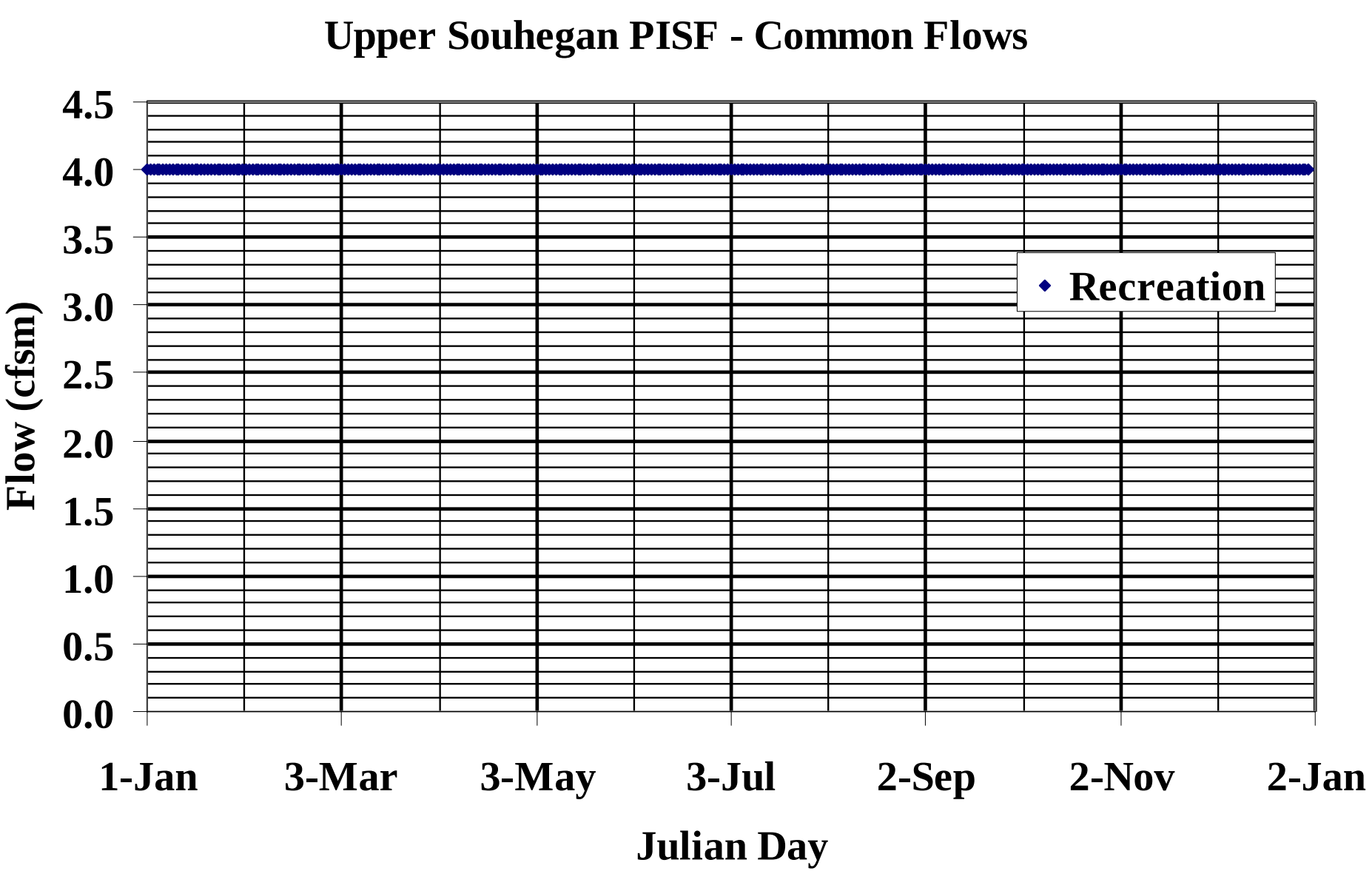
Graphical Presentation of the IPUOCR Flow Need

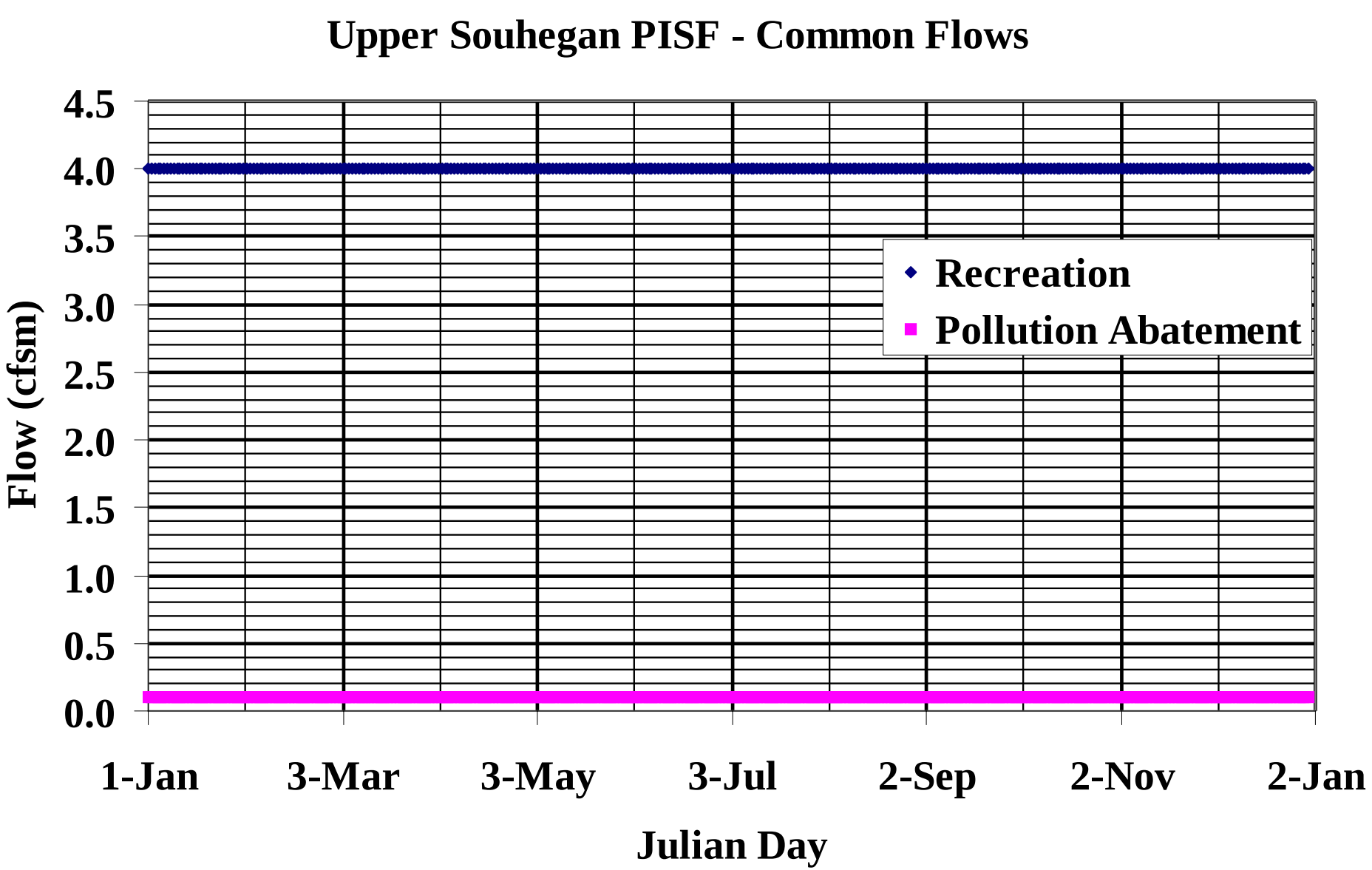


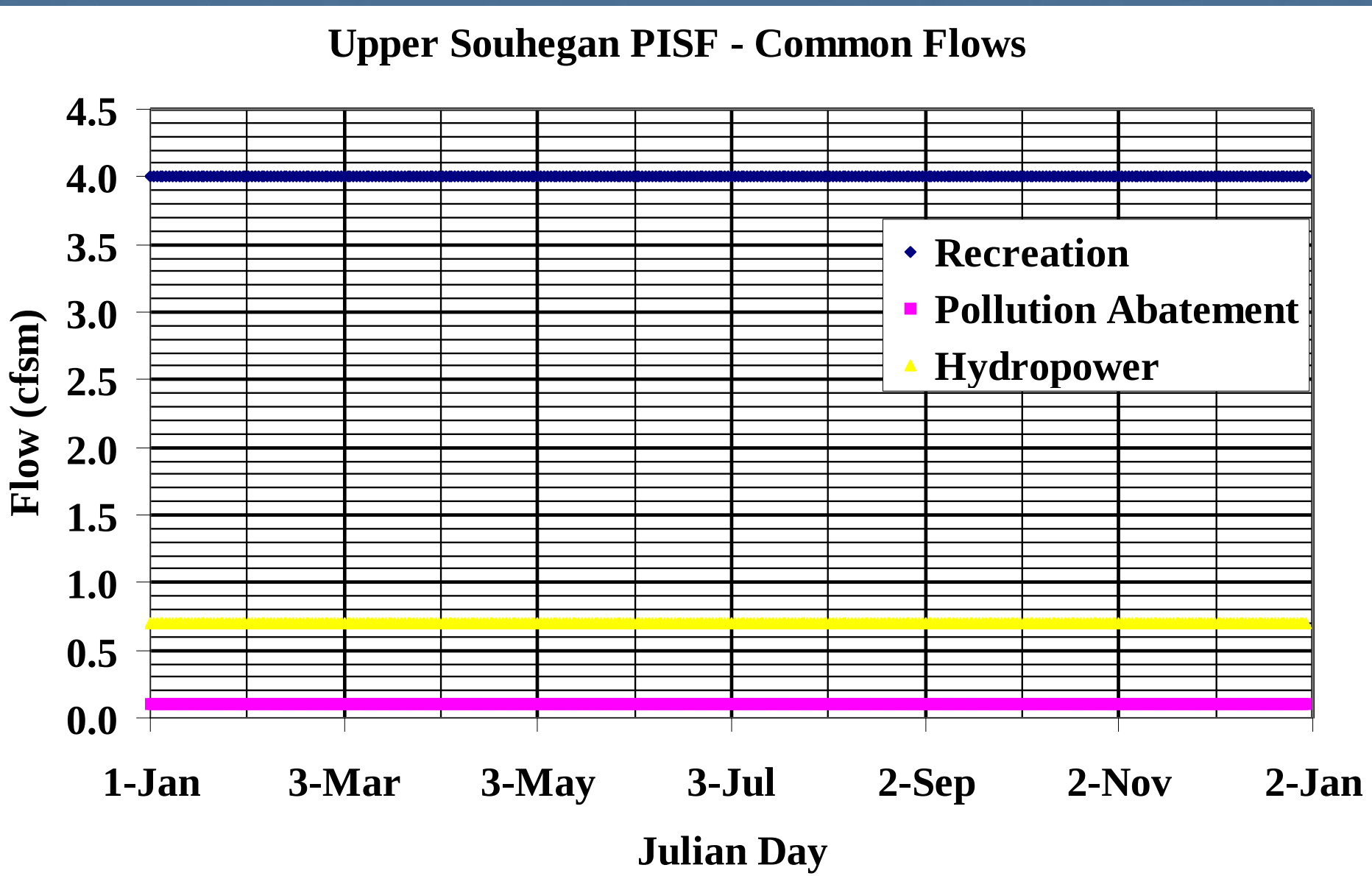
Fish PISF

- Common Flow – Very good habitat, frequently occurring
- Critical Flow – Not much quality habitat, frequency of occurrence 2-3 years
- Rare Flow – very little habitat, decadal frequency

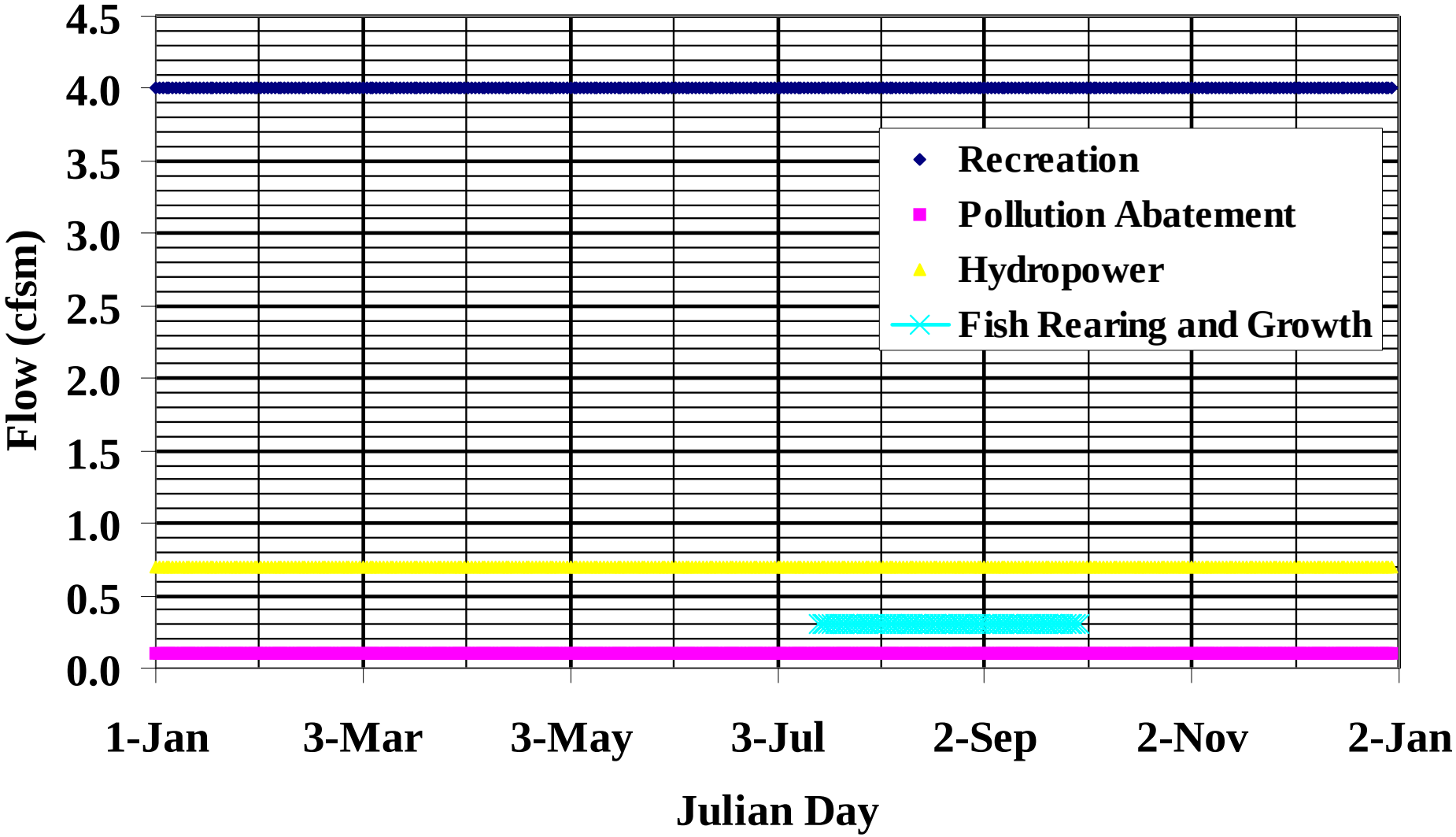
All PISF Are Overlaid to Understand which IPUOCR Flow is the Strictest (and When)

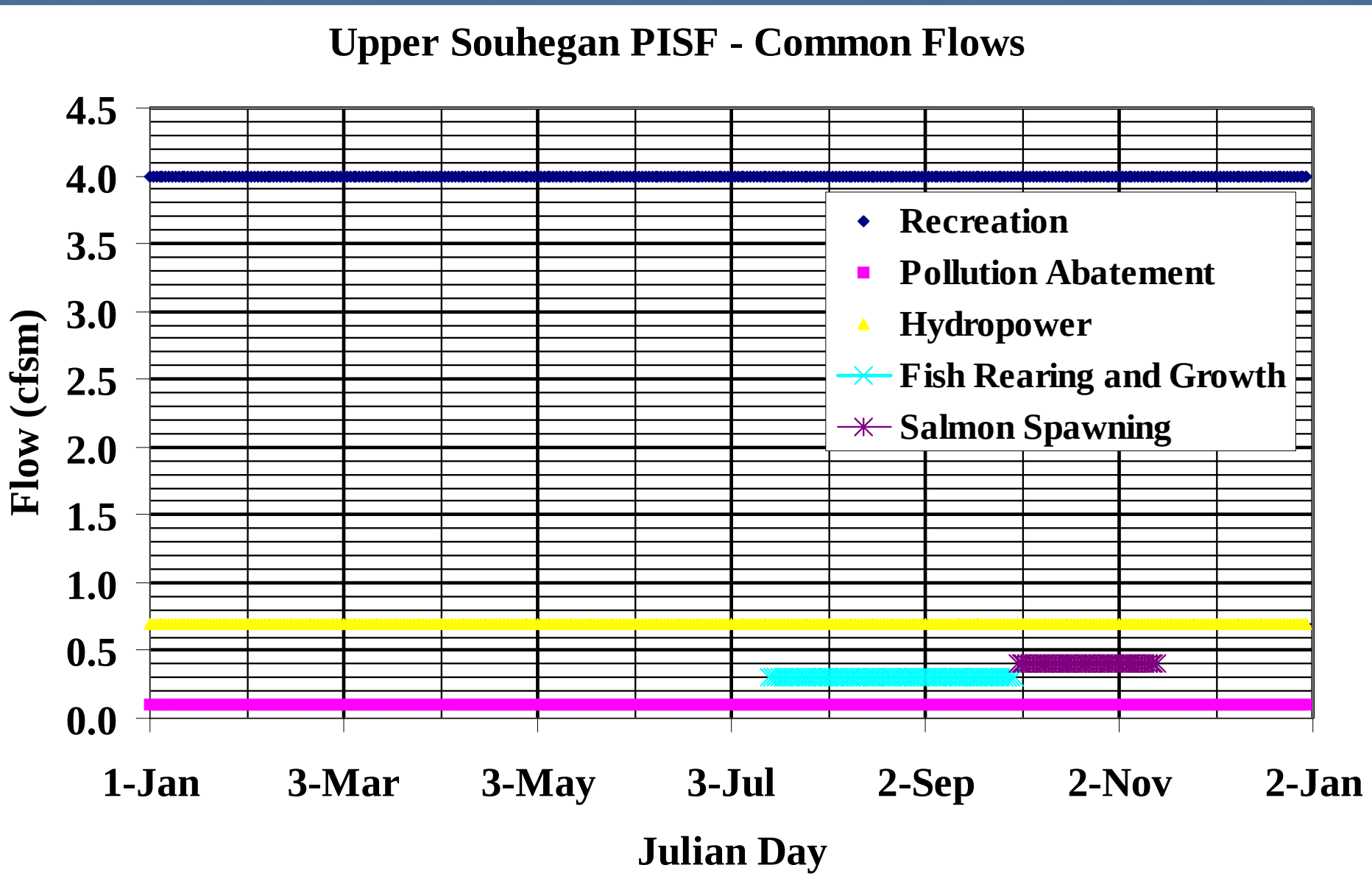

Upper Souhegan PISF - Common Flows
Flow (cfsm)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Recreation
1-Jan
3-Mar
3-May
3-Jul
2-Sep
2-Nov
2-Jan
Julian Day


Upper Souhegan PISF - Common Flows
Flow (cfsm)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Recreation
Pollution Abatement
1-Jan
3-Mar
3-May
3-Jul
2-Sep
2-Nov
2-Jan
Julian Day

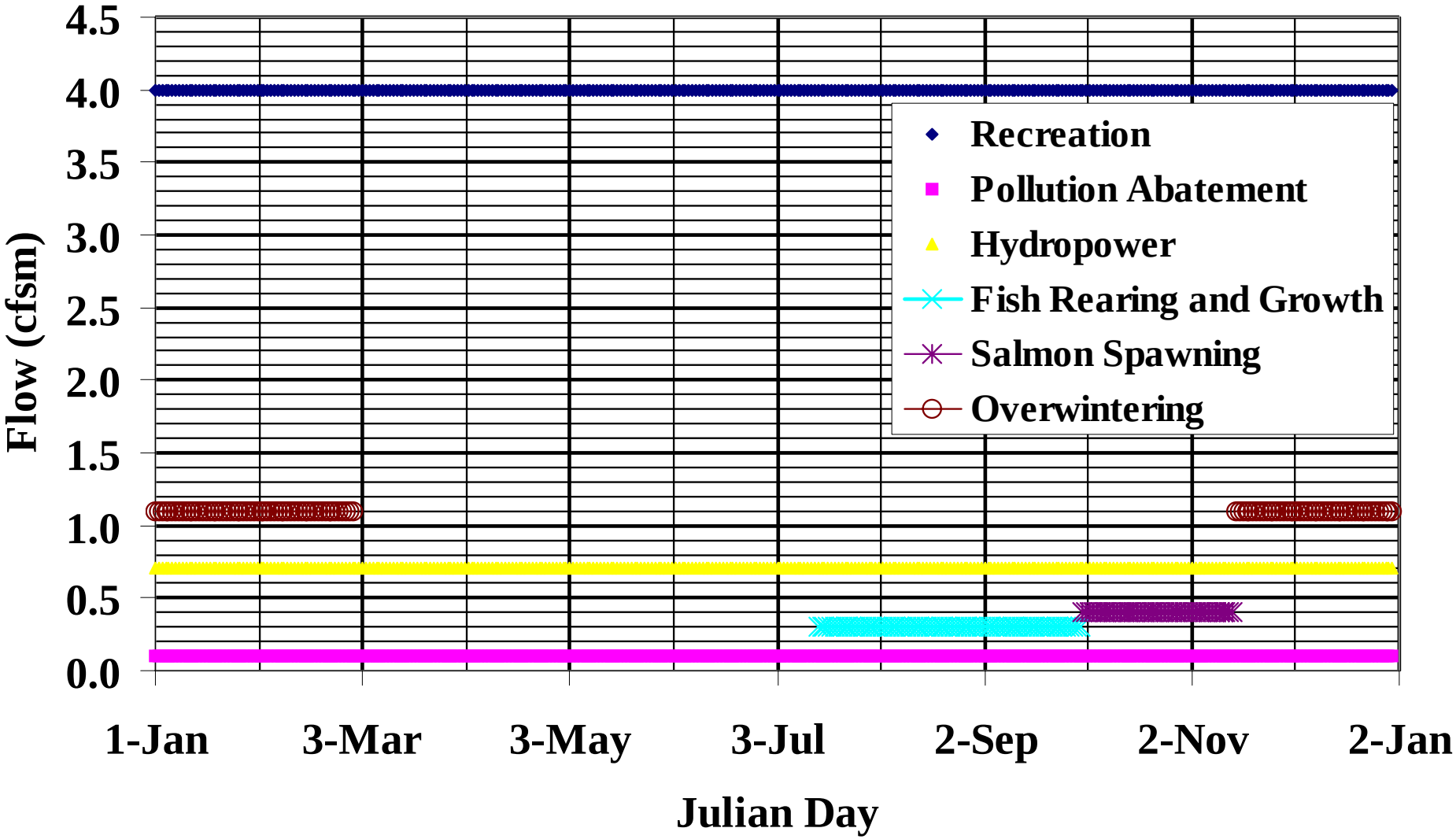

Upper Souhegan PISF - Common Flows
Flow (cfsm)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Recreation
Pollution Abatement
Hydropower
1-Jan
3-Mar
3-May
3-Jul
2-Sep
2-Nov
2-Jan
Julian Day

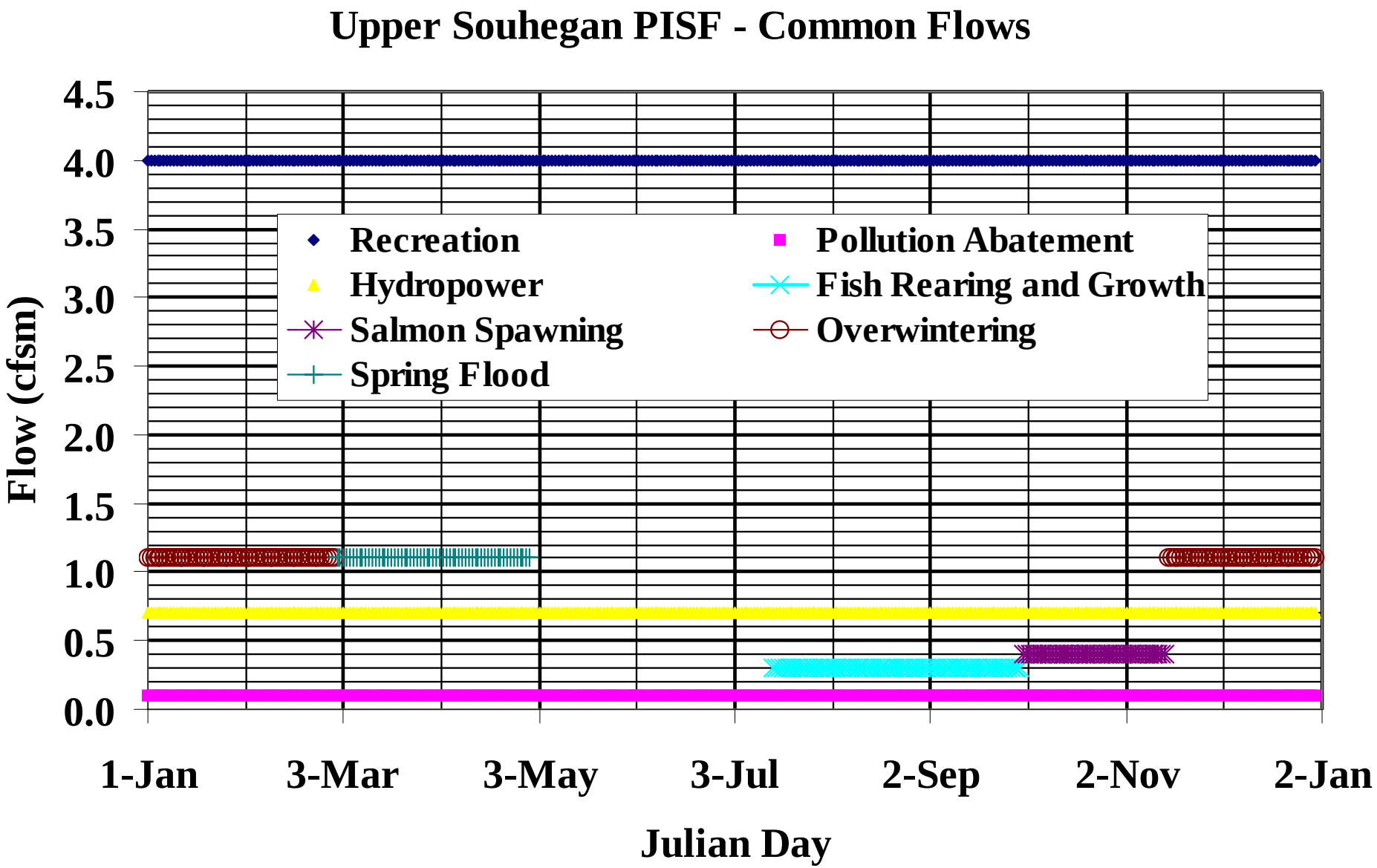
Upper Souhegan PISF - Common Flows



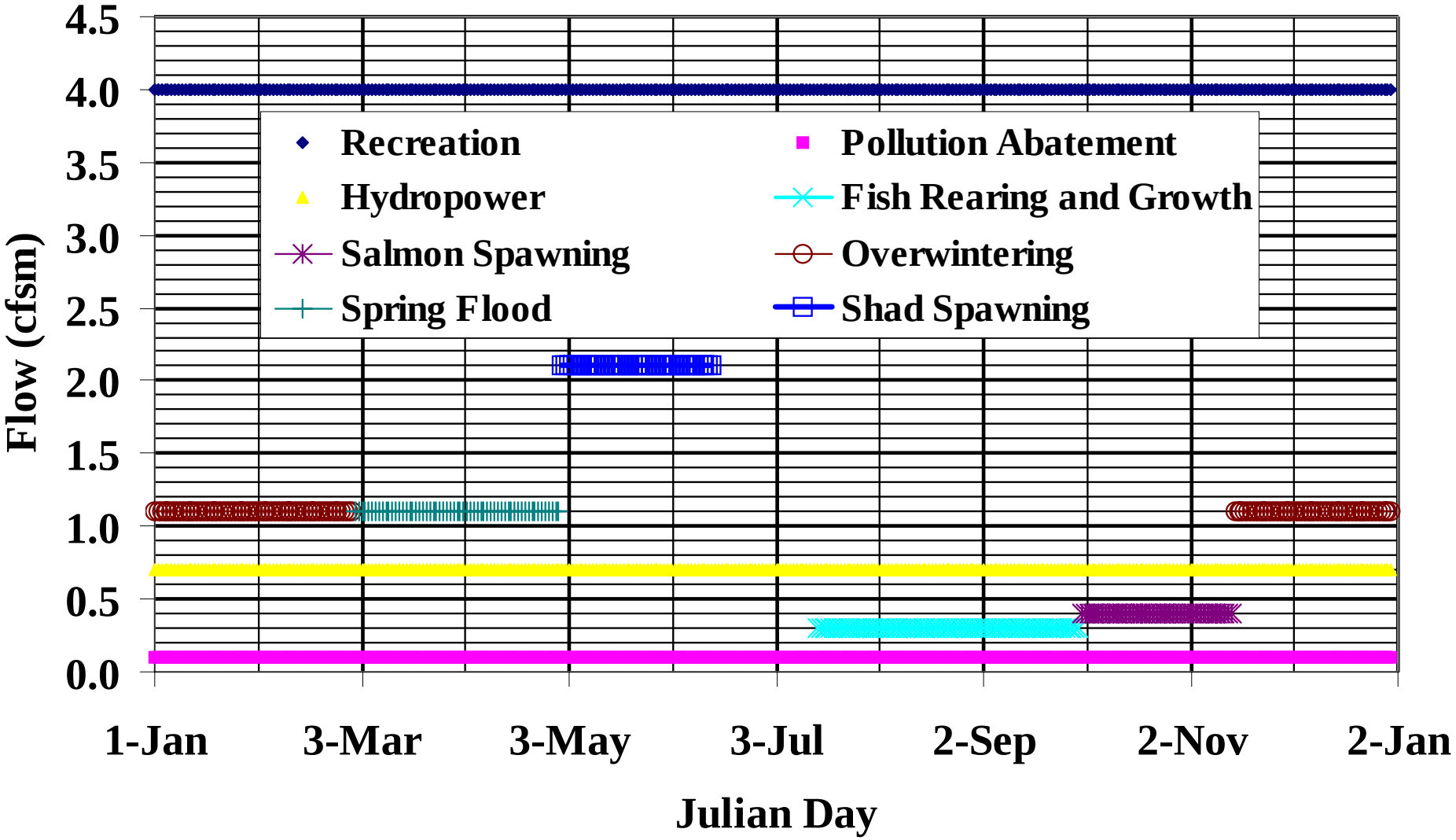

Upper Souhegan PISF - Common Flows
Flow (cfsm)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Recreation
Pollution Abatement
Hydropower
Fish Rearing and Growth
Salmon Spawning
1-Jan
3-Mar
3-May
3-Jul
2-Sep
2-Nov
2-Jan
Julian Day

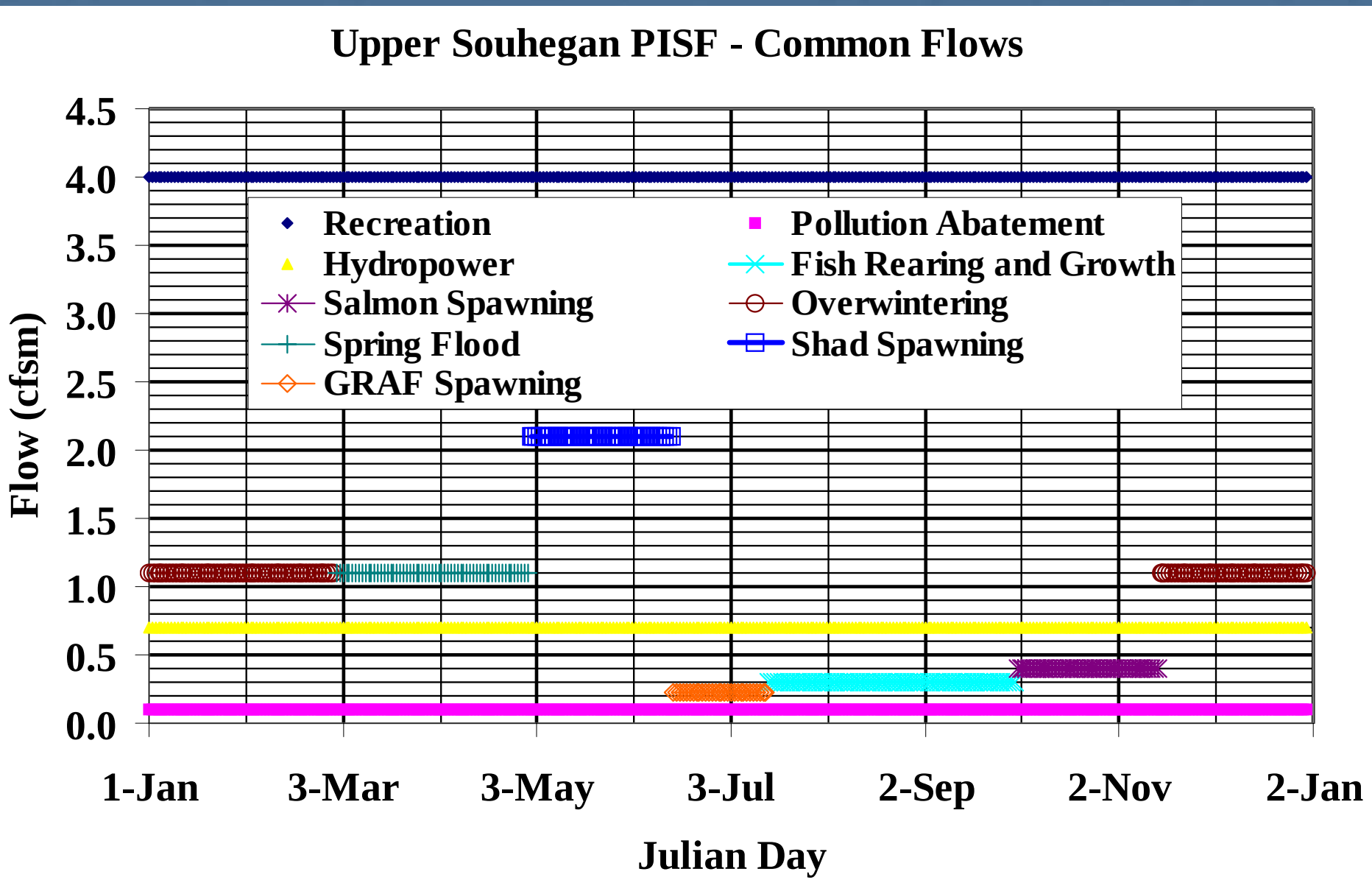
Upper Souhegan PISF - Common Flows




Upper Souhegan PISF - Common Flows
Flow (cfsm)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Recreation
Pollution Abatement
Hydropower
Fish Rearing and Growth
Salmon Spawning
Overwintering
Spring Flood
1-Jan
3-Mar
3-May
3-Jul
2-Sep
2-Nov
2-Jan
Julian Day

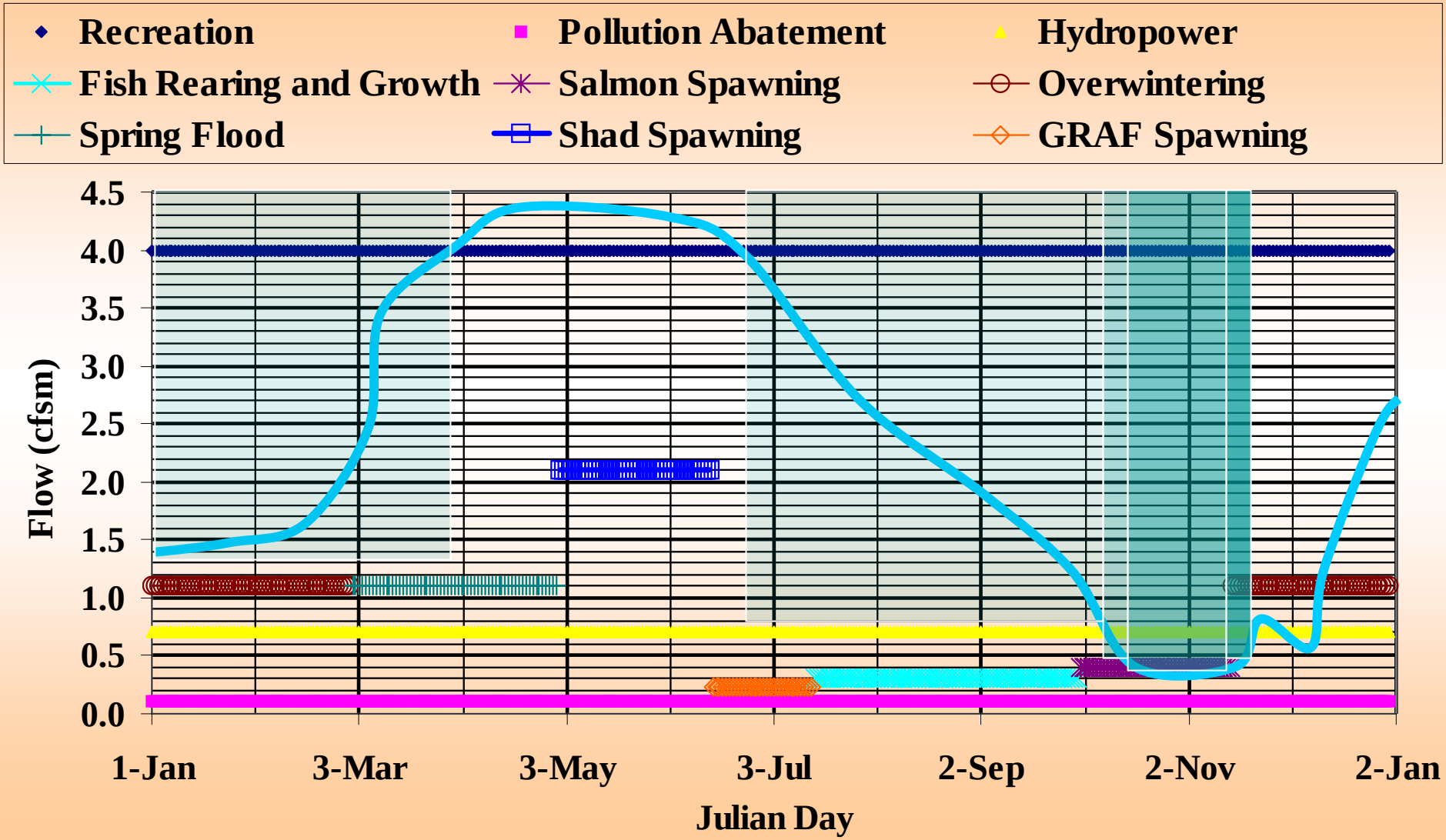
Upper Souhegan PISF - Common Flows




Upper Souhegan PISF - Common Flows
Flow (cfsm)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Recreation
Hydropower
Salmon Spawning
Spring Flood
GRAF Spawning
Pollution Abatement
Fish Rearing and Growth
Overwintering
Shad Spawning
1-Jan
3-Mar
3-May
3-Jul
2-Sep
2-Nov
2-Jan
Julian Day

By satisfying the highest of these PISF, all others are satisfied: the most IPUOCR are protected when flow in the river equals or exceeds the highest of these PISF

Upper Souhegan PISF - Common Flows



Synthesized PISF

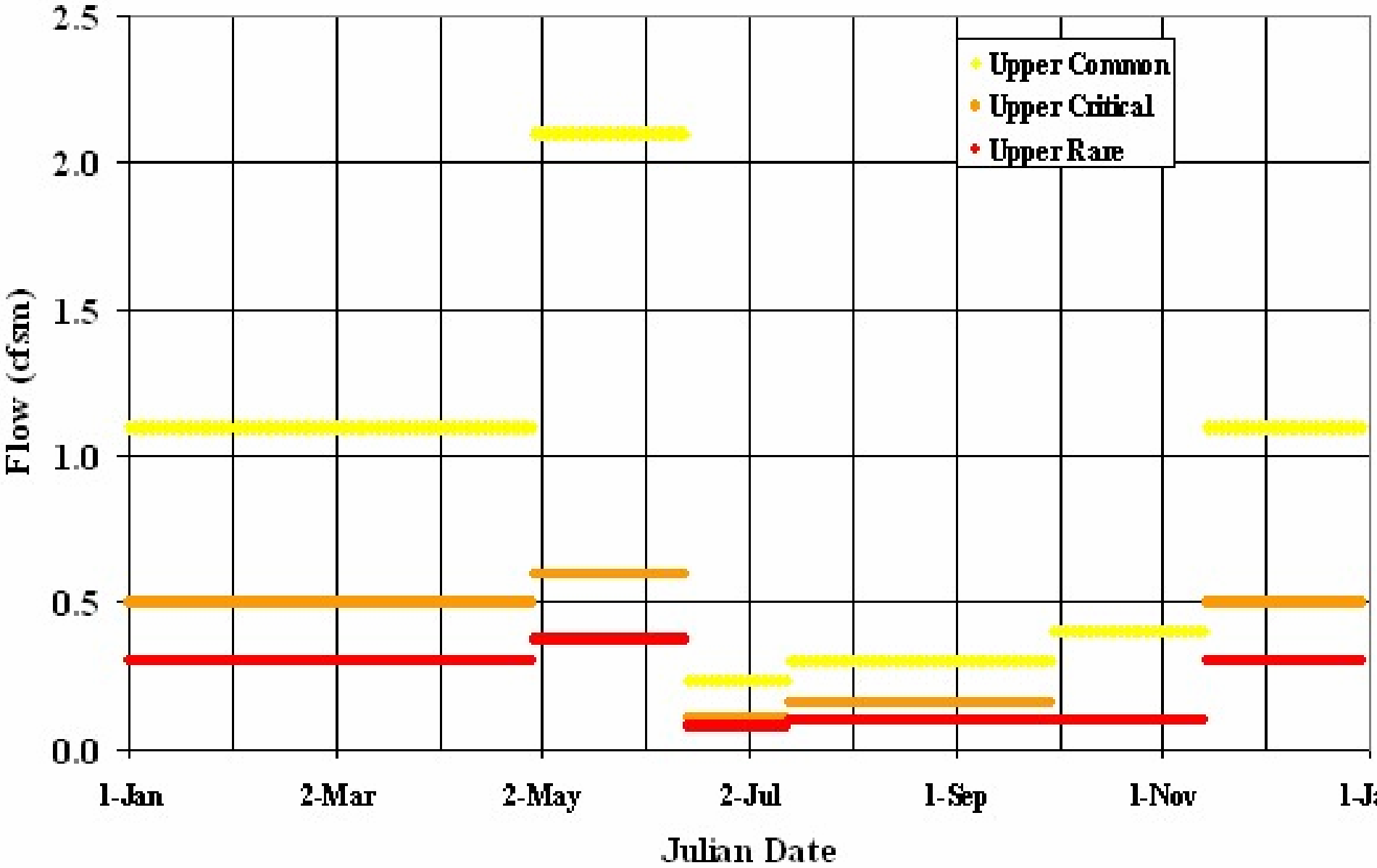
When comparing the PISF need for each IPUOCR for every day of the year, on the low flow end, the largest of the individual IPUOCR PISF controls: meeting that PISF means that all other PISF are met.

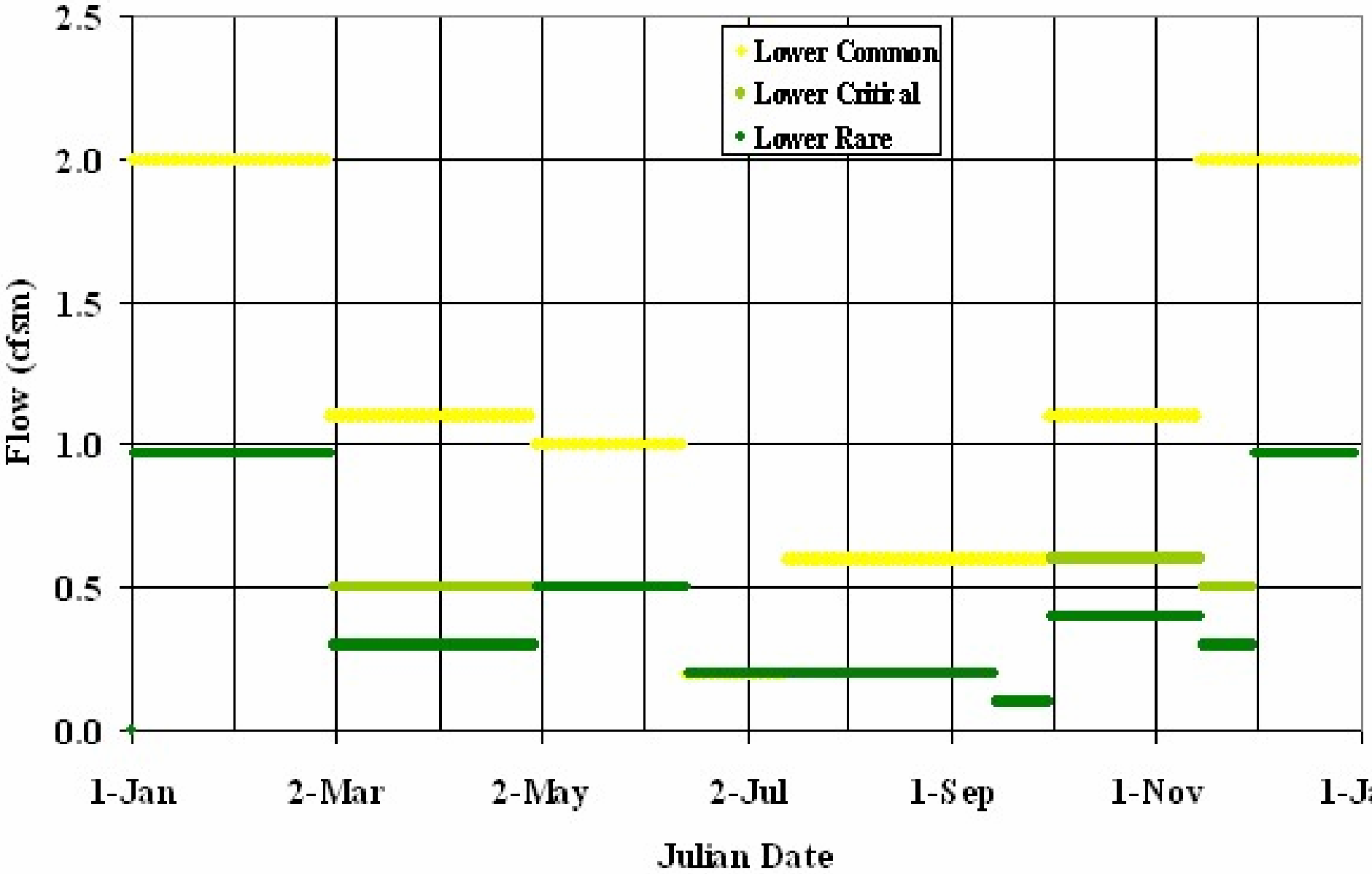
Human needs (recreation and hydropower) are the largest of the low flow PISF.

Achievable Synthesized PISF

The river system has very little conservation storage (stored water that could be released over long periods) to meet human PISF.

It was decided that the human PISF would be met as they have been historically: "run-of-river", and therefore subsequent water management strategies will focus on the non-human, synthesized PISF.


2.5
2.0
1.5
1.0
0.5
0.0
Flow (cfsm)
Upper Common
Upper Critical
Upper Rare
1-Jan
2-Mar
2-May
2-Jul
1-Sep
1-Nov
Julian Date

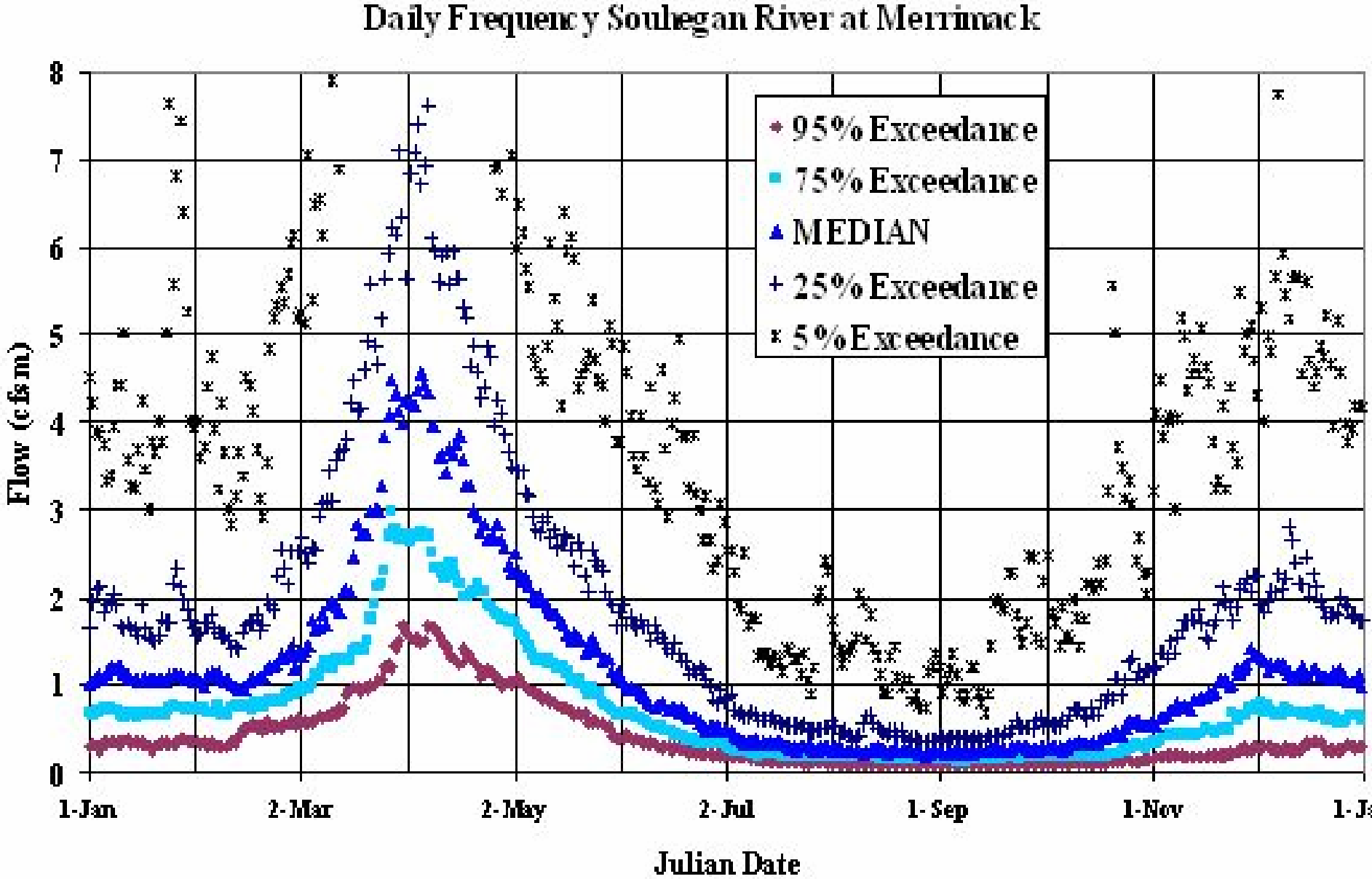

Lower Common
Lower Critical
Lower Rare
2.5
2.0
1.5
1.0
0.5
0.0
Flow (cfsm)
1-Jan
2-Mar
2-May
2-Jul
1-Sep
1-Nov
Julian Date

Comparison of the Proposed PISF to River Flow

- Generate Hydrology
- Compare River flow to synthesized PISF
- Determine characteristics of when the river flow does not meet the PISF

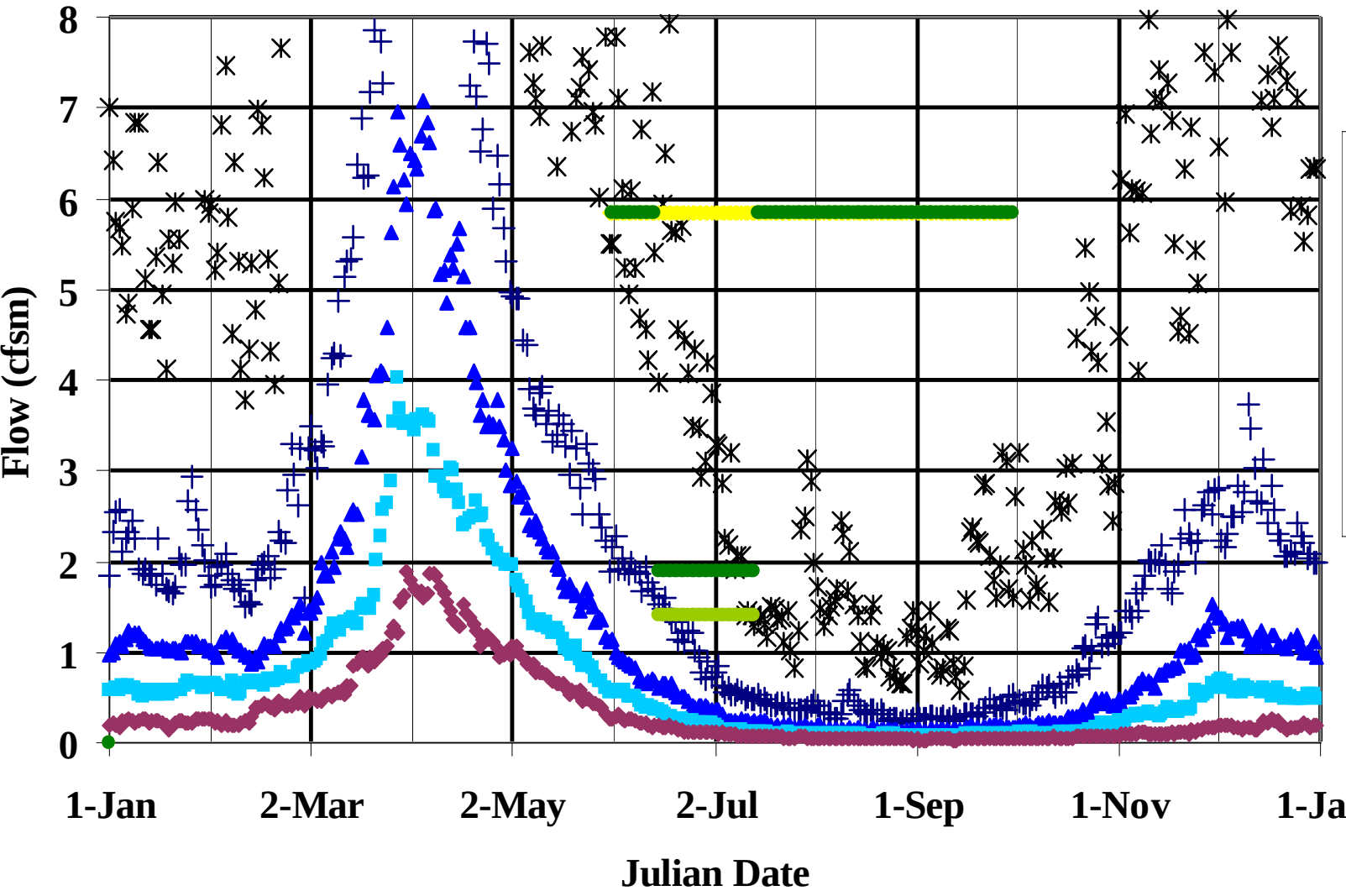
River Hydrology

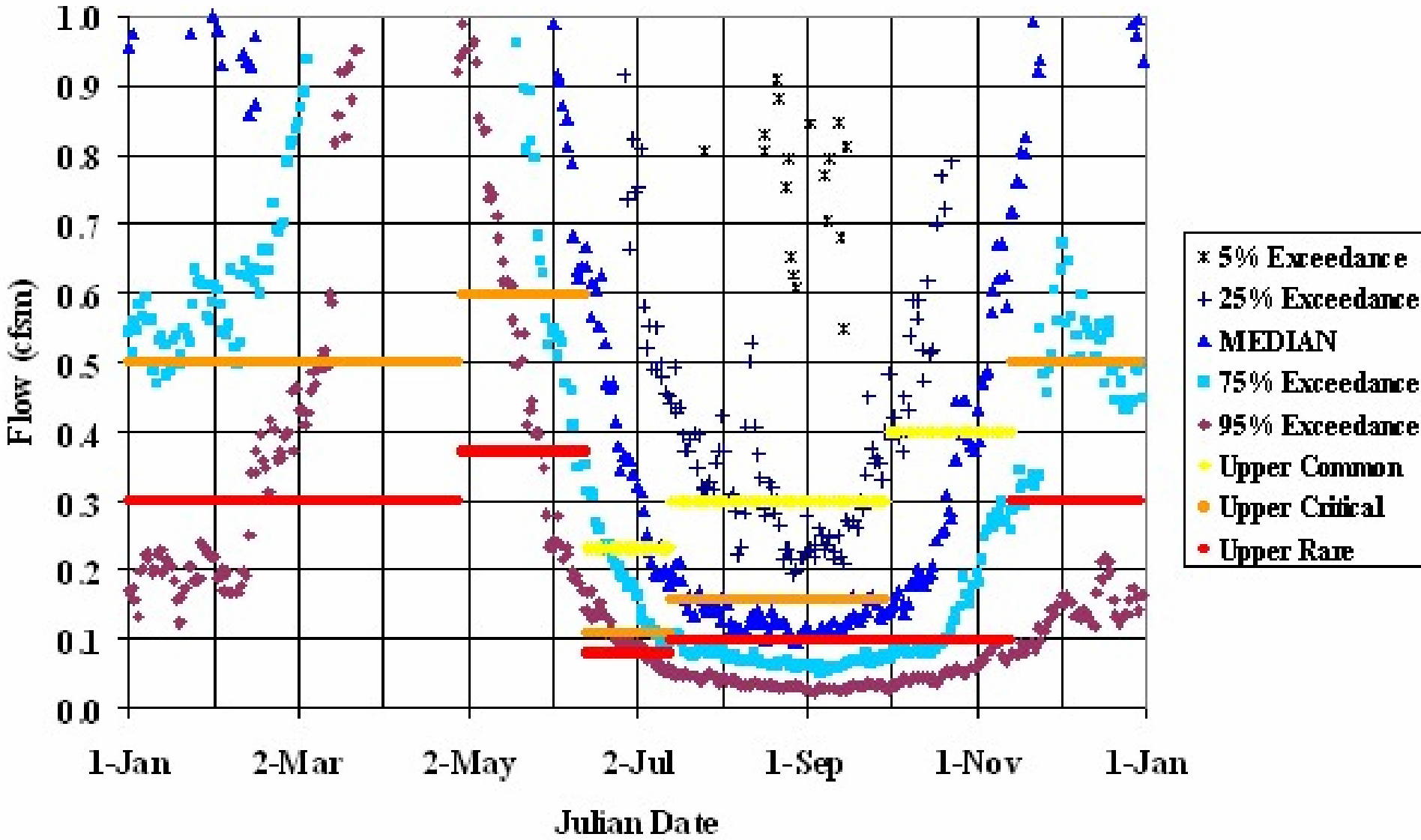
- USGS Gage Data
- Concurrent flow measurements
- Statistical re-creation of flow at various locations along the river

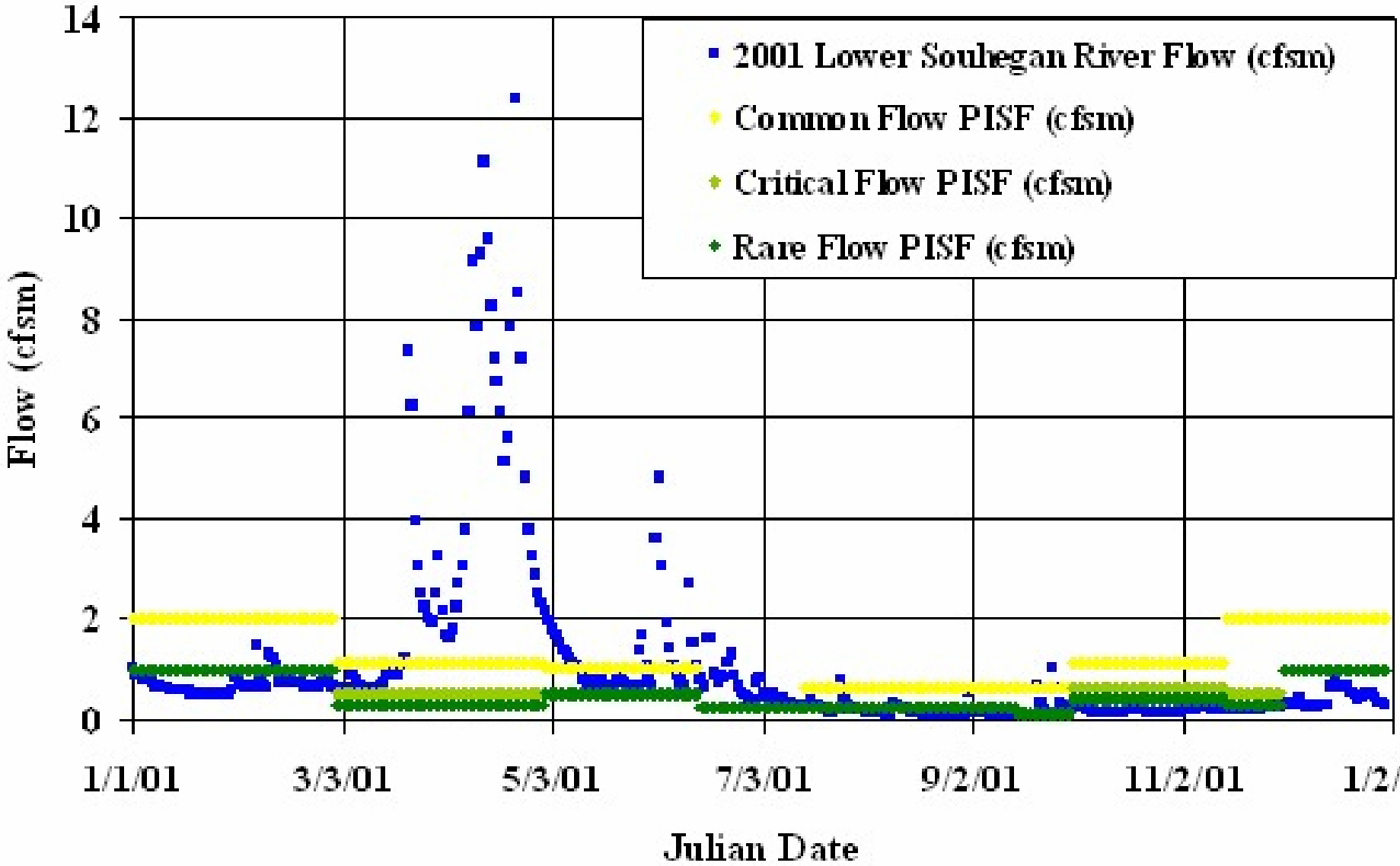

Daily Frequency Souhegan River at Merrimack
95% Exceedance
75% Exceedance
MEDIAN
25% Exceedance
5% Exceedance
Flow (cfsm)
0
1
2
3
4
5
6
7
8
1-Jan
2-Mar
2-May
2-Jul
1-Sep
1-Nov
Julian Date

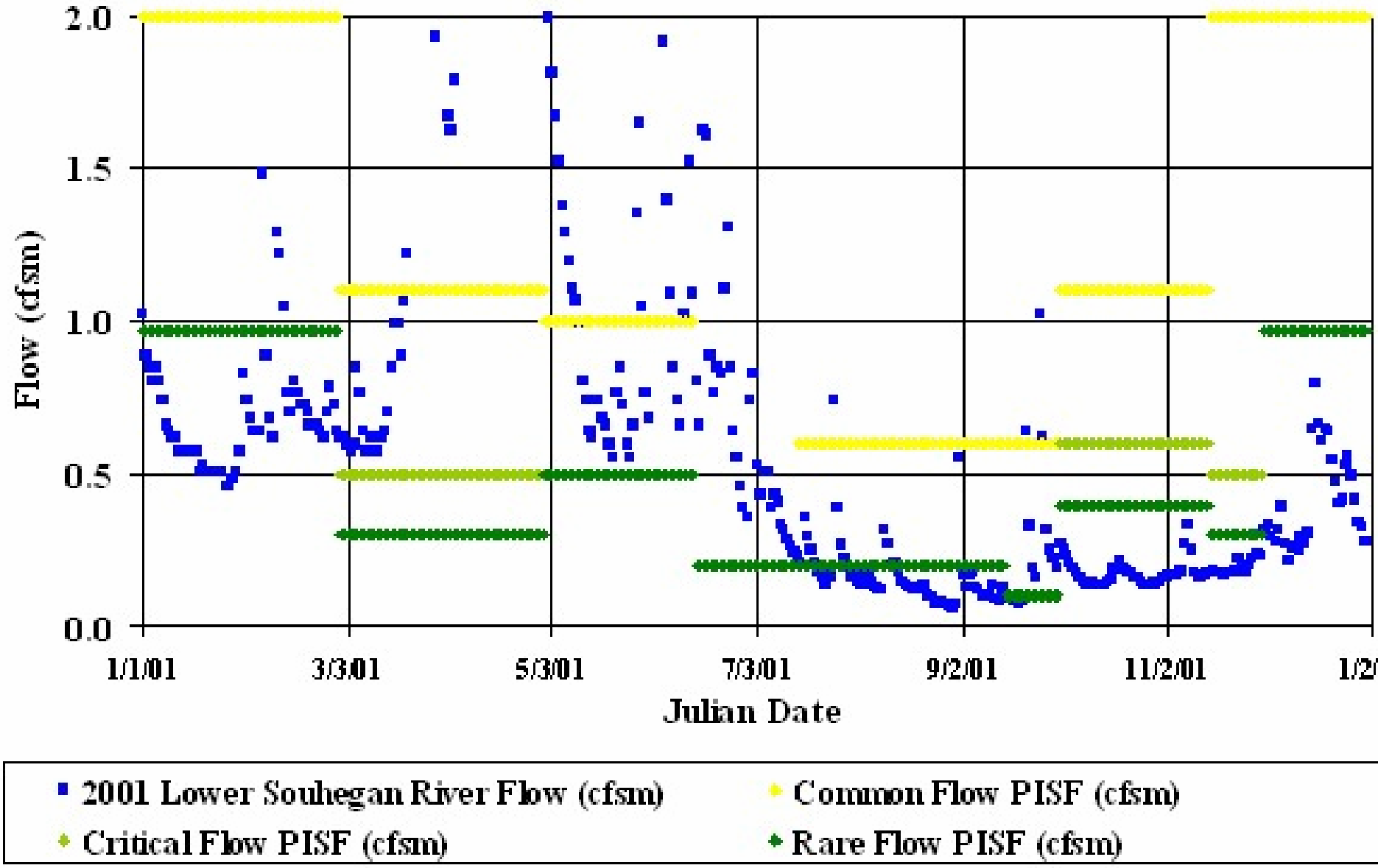
Hydrology and the Ability of the Existing System to Meet the Proposed PISF

Daily Frequency - Lower Souhegan River and High Flow PISF




1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Flow (cfsm)
1-Jan
2-Mar
2-May
2-Jul
1-Sep
1-Nov
1-Jan
Julian Date
5% Exceedance
25% Exceedance
MEDIAN
75% Exceedance
95% Exceedance
Upper Common
Upper Critical
Upper Rare


2001 Lower Soulegan River Flow (cfsm)
Common Flow PISF (cfsm)
Critical Flow PISF (cfsm)
Rare Flow PISF (cfsm)
Flow (cfsm)
14
12
10
8
6
4
2
0
1/1/01
3/3/01
5/3/01
7/3/01
9/2/01
11/2/01
1/2/0
Julian Date


2.0
1.5
1.0
0.5
0.0
Flow (cfsm)
1/1/01
3/3/01
5/3/01
7/3/01
9/2/01
11/2/01
Julian Date
2001 Lower Souhegan River Flow (cfsm)
Common Flow PISF (cfsm)
Critical Flow PISF (cfsm)
Rare Flow PISF (cfsm)

Important Points to Make as We Move into the Water Management Phase

- Significant habitat can be created without increasing flows, but through stream corridor restoration measures
- Increasing flows alone is not as important as also addressing high temperatures

Human ISF

- Hydropower – 0.7 cfsm (Upper Souhegan)
- Recreation – 4 cfsm (Upper Souhegan)
- Pollution Abatement – 0.1 cfsm

Fish ISF (part 1)

Bioperiod Approximate dates	**Rearing & Growth** July 15 - Sept. 30		**Salmon Spawning** Oct. 1 - Nov. 14		**Over-Wintering** Nov. 15 - Feb. 28	
	Recommended flows		**Recommended flows**		**Recommended flows**	
Concurrent Gauge (SR#)	SR 25	USGS	SR 25	USGS	SR 25	USGS
Watershed area (mi^2)	102	171	102	171	102	171
Location	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	
Common flow (cfs)	31	103	41	184		342
Common flow (cfsm)	0.3	0.6	0.4	1.1	1.1	2.0
Allowable duration under (days)	30	20	30	23		35
Catastrophic duration (days)	42	40	40	40		50
Critical flow (cfs)	16	26	10	96		86
Critical flow (cfsm)	0.16	0.15	0.1	0.6	0.5	0.5
Allowable duration under (days)	15	15	12	12		15
Catastrophic duration (days)	35	20	30	40		30
Rare flow (cfs)	10	17	10	70		51
Rare flow (cfsm)	0.1	0.1	0.1	0.4	0.3	0.3
Allowable duration under (days)	5	5	10	5		5
Catastrophic duration (days)	30	10	23	10		10

Fish ISF (part 1)

Bioperiod Approximate dates	**Spring Flood** March 1 - April 30		**Shad Spawning** May 1 - June 14		**GRAF Spawning** June 15 - July 14	
	Recommended flows		**Recommended flows**		**Recommended flows**	
Concurrent Gauge (SR#)	SR 25	USGS	25	USGS	25	USGS
Watershed area (mi^2)	102	171	102.3	171	102.3	171
Location	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**
Common flow (cfs)	N/A	N/A	215	178	24	39
Common flow (cfsm)	1.1	1.1	2.1	1.0	0.23	0.11
Allowable duration under (days)	N/A	N/A	25	15	20	17
Catastrophic duration (days)	N/A	N/A	40	25	27	25
Critical flow (cfs)	N/A	N/A	61	96	11	239
Critical flow (cfsm)	0.4	0.4	0.6	0.6	0.11	1.4
Allowable duration under (days)	N/A	N/A	10	5	10	13
Catastrophic duration (days)	N/A	N/A	15	10	20	23
Rare flow (cfs)	N/A	N/A	38	88	8	325
Rare flow (cfsm)	0.3	0.3	0.37	0.5	0.08	1.9
Allowable duration under (days)	N/A	N/A	4	5	10	10
Catastrophic duration (days)	N/A	N/A	7	10	15	10

RTE ISF – Part 1

IPUOCR	Status	General Location	Sensitive Bioperiod(s)	General Flow Requirements.	PISF (at Merrimack Gauge)
Wood Turtle *Clemmys insculpta*	Special Concern	Lower Souhegan	June through Sept.	No flooding during nesting in mid to high floodplain	< 1,000 cfs (5.8 cfsm)
			Nov. through March	No exposure during in-channel hibernation	Dec-March flows above mean Oct-Nov flows (107 – 225 cfs)
Fowler's Toad *Bufo* Fowleri	Special Concern	Lower Souhegan	April through May	High spring flows to fill backwaters/oxbows	>600 cfs (3.5 cfsm) (based on transect obs.)
			Late May through mid-Aug.	Sufficient inundation of eggs/tadpoles in backwaters	>30 cfs (0.18 cfsm) (based on transect And mesoHABSIM)
Osprey *Pandion* haliaetus	State-Threatened	Lower Souhegan	Spring through Fall	Sufficient flows to protect prey (fish) in channel	(see GRAF Fish recommended flows)
Common Loon *Gavia* immer	State-Threatened	Lower Souhegan	Spring through Fall	Sufficient flows to protect prey (fish) in channel	(see GRAF Fish recommended flows)

RTE ISF (part 2)

IPUOCR	Status	General Location	Sensitive Bioperiod(s)	General Flow Requirements.	PISF (at Merrimack Gauge)
Wild Garlic *Allium* canadense	State-Threatened	Lower Souhegan	Spring	Occassional scouring by high spring floods	>5,000 cfs (29.2 cfsm) every 10 years (10-yr flood)
Wild Senna *Cassia* hebecarpa	State Endangered	Lower Souhegan	Spring	Occassional scouring by high spring floods	>5,000 cfs (29.2 cfsm) every 10 years (10-yr flood)
High-Energy Riverbank	S3/S4	Upper Souhegan	Spring/Winter	Flood and ice scour of bankfull channel	>500 cfs (2.9 cfsm)
Silver Maple Floodplain Forest	S2	Lower Souhegan	Spring	1-3 year flooding (< 2 yr return flood)	>2,000 cfs (11.7 cfsm) every 1-3 years
Sycamore Floodplain Forest	S1	Upper Souhegan	Spring	1-3 year flooding (>two-year return flood)	>3,000 cfs (17.5 cfsm) every 1-3 years
Oxbow/Backwater Marsh	S3	Lower Souhegan	Spring	Filling of backwaters/oxbows	>600 cfs (3.5 cfsm) in spring
			Summer	Transect obs. of water levels	>30 cfs (0.18 cfsm) part of summer