DEPARTMENT OF NATURAL RESOURCES

Groundwater Thresholds and Modeling Impact

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Division of Ecological and Water Resources

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Statewide Annual Reported Groundwater Use



Density of Water Use





Water Use Index

Water Use Index (use/available %)						
•	0.00					
	0.01 - 5.00					
	5.01 - 10.00					
	10.01 - 20.00					
	20.01 >					

DNR Responsibility... (Statute 103G.287)

- When establishing limits DNR must consider the sustainability of the resource, including:
 - Current and projected water levels
 - Water quality
 - Protect ecosystems
 - Future generations to meet their needs

Issuing Permits in Areas of High Use or "Concern"



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Sustaining Ecosystems: Establishing Thresholds and Defining Impact

Ian Chisholm | Supervisor – River Ecology Unit

Division of Ecological and Water Resources

Our Responsibility & Rationale:

- 1. Sustainability accounts for ecosystems and future generations,
- 2. Identifying a threshold for ecological health/sustainability is a key task,

3. Management prescriptions are developed to maintain the threshold and thereby, ecosystem health and sustainability.

Our Responsibility & Rationale:

2. Identifying a **threshold for ecological health/ sustainability** is a key task









Day of Year

Our Responsibility & Rationale:

3. Management prescriptions are developed to maintain the threshold and thereby, ecosystem health



Management prescriptions: essentially, what hydrology will maintain the desired state of ecosystem health?

Percentage of Flow

Conceptually simple Provides protection for natural flow variability • Relatively simple to implement

from Richter et al. (2011)

Percent of what flow? August

- August is a **biologically critical month** in Minnesota;
 - low flow month
 - part of growing season (June-Sept)
 - biological 'bottleneck'
 - determinant of species richness







Figure 6: Effect of mean August discharge (restricted cubic spline with 5 knots) on richness estimated by the fitted model with 95% CI with other variables adjusted to their median. Blue dots represent the density of points along the x-axis. The overall F-test is provided at the top of graph.

Why use fish habitat data to determine ecological impact?

- We have information on them, across the state
- Fish are used as surrogates for sustaining the ecosystem
 - Sustain fish, sustain opportunities for future users







What are the important elements of a stream ecosystem?





Simplified Food Web







MNDNR STREAM HABITAT PROGRAM HABITAT PREFERENCE CURVES

sampling years - 1987-2016 50 rivers/156 survey sites/ 10,104 samples >232,000 fish observations 129 species / 345 species-life stages > 500 mussel observations 150 fish species-life stage habitat preference curves 9 mussel species habitat preference curves



For more information contact: Stream Habitat Program MN DNR 500 Lafayette Rd St. Paul, MN 55155 651.259.5113 Email: ann.kuitunen@state.mn.us





159 habitat-based response curves for August; representing 63 species life stages and covering 9 streams, across Minnesota.



Comparison of habitat- based response curves using SHP method (colored lines) and Michigan's abundance-based response curves (thick solid black lines).

The MI curves are digitized from graphs presented in Hamilton and Seelbach (2011). **Red dots** mark the GWCAC ARI threshold and the **blue crosses** mark the MI Legislature ARI threshold (for warm water streams).





Key threshold levels are indicated by **dashed lines**. The **ABF** is the **A**ugust Median **B**ase Flow.



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Habitat Response **Curves for habitat** guild representative species using Fast **Riffles (FR), Slow** Riffles (SR), and **Raceway (RW)** habitats.

Solid black line

represents the current modeled depletion level.

What flow serves as an 'index flow' for management?

Summary of August Flow Statistics (2005-2014; includes modeled depletion)

Summary Statistic	August Daily Flow (cfs)	August Baseflow (cfs)	
Average	26.2	16.5 7.3	
Median	7.8		
Standard Deviation	47.4	21.0	
Range	4.1 – 309.9	4.1 - 108.8	

- August average flow is higher and more variable than the median baseflow
- Median and median baseflow are essentially the same
- August median baseflow is a flow that regularly occurs in the stream; the August average flow does not



August daily flows and baseflows in

Little Rock Creek, 2005 to 2014; showing similarity of median values and relationship of average flows to distributions. Boxes represent the middle 50% of values for each distribution.



daily_flow daily_flow_plus_depletion



Location Ecological C		Goal Cumulative allowable Considerations Decision process depletion						
Location		Ecological Goal		Cumulativ allowable depletion	'e	Examples of the percent of flow		
Michigan		Maintain baseline		6-15% of /	-15% of August being used for			
	or existing median flow condition		W	water management				
	needs		For sub-basins, maximum level of August median streamflow alteration ranges from 3-10% for Categories 1 and 2 for			2011, with additions). These		
Location Florida (SWFWMD)		Ecological Goal Avoid significant ecological harm (maximum 15% habitat loss)		Cumulative allowable depletion 8-19% of daily flows		examples restrict both ground and surface water allocation.		

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Flow-Model Application: Little Rock Creek

Glen Champion | Hydrogeologist

Division of Ecological and Water Resources

Study Area



Study Area – Focus Area Water Use



Study Area – Geology



Study Area – Geology



Study Area – Hydrologic Data



Study Area – Hydrologic Data



Study Area – Hydrologic Processes



Model – Approach and Codes



Model – Development



Model – Results



Model – Results



Model - Results

- Calculated August monthly depletion (2006, 2008-14)
 - Both Mean and Median > 35% of August median base flow
 - Only slightly lower percentage of August median total flow

Model – Future Applications



Barlow and Leake (2013), USGS



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Geology



Model Results



Recharge with and without irrigation for a representative model cell