What is Watershed Integrity?

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National Health and Environmental Effects Lab
Corvallis, OR

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Watershed Integrity

**Definition** the capacity of a watershed to support and maintain the full range of ecological processes ... and services provided to society

**Watershed Integrity** on a scale where a value of 1 represents a watershed absent of anthropogenic stress

**Human Health** approach to evaluate the condition of vital systems

Drini River Basin

Skadar Lake Basin

Prespa Lake Basin

Drina River Basin

http://www.exploringmacedonia.com/prespa-lake.nspx
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**Human Body Systems**
- Nervous
- Digestive
- Muscular
- Circulatory
- Respiratory
- Skeletal

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Human Health: Approach to evaluate the condition of vital systems.

The presence of different risk factors, or stressors, would serve as indicators of system health.

Human Body Systems

- Circulatory
- Respiratory
- Skeletal
- Digestive
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Amount of Physical Activity
- Diet
- Family History
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CIRCULATORY SYSTEM INTEGRITY
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Questions?
Watershed Integrity

- Hydrology
- Chemistry
- Sediment
- Connectivity
- Temperature
- Habitat
Watershed Integrity

- Hydrology
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- Riparian Removal
- Impervious Surfaces
Watershed Integrity

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Watershed Integrity

Hydrology

Chemistry

Sediment

Connectivity

Temperature

Habitat
Watershed Integrity

- **Hydrology**
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**Groundwater Pumping**

Physical blockages (e.g., culverts)
Which function(s) face stress in your community?
Terminology
Streamline

n=13778
Can a watershed and a catchment be the same size?

A. Yes  
B. No  
C. Maybe
Which following ICI/IWI value demonstrates that there is **no** stressor and **high** integrity?

A. 0  
B. .5  
C. 1  
D. 100
Quiz Questions

Which river or lake basin is the largest?

A. Drina River Basin
B. Drini River Basin
C. Prespa Lake Basin
D. Skadar Lake Basin
Which river or lake basin is the largest?

A. Drina River Basin
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Quiz Questions

Which river or lake basin do you think has the highest IWI?

A. Drina River Basin
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How is the Watershed Integrity in the Western Balkans?

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2. Catchment statistics

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Downstream impacts
1. Raw data

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Most of the water and energy originates upstream

Downstream impacts
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Watershed Integrity
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**All 6 functions** must be present for a catchment to have integrity.
**All 6 functions** must be present for a watershed to have integrity.
Quiz Questions

Which river or lake basin do you think has the highest IWI?
A. Drina River Basin
B. Drini River Basin
C. Prespa Lake Basin
D. Skadar Lake Basin
Which river or lake basin do you think had the highest IWI?

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<td>ICI</td>
<td>0.54</td>
<td>0.47</td>
<td>0.49</td>
<td>0.63</td>
</tr>
<tr>
<td>IWI</td>
<td>0.51</td>
<td>0.49</td>
<td>0.45</td>
<td>0.61</td>
</tr>
</tbody>
</table>
Which river or lake basin do you think had the highest IWI?

<table>
<thead>
<tr>
<th></th>
<th>Drina River Basin</th>
<th>Drini River Basin</th>
<th>Skadar Lake Basin</th>
<th>Prespa Lake Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrology</td>
<td>0.94</td>
<td>0.95</td>
<td>0.96</td>
<td>0.96</td>
</tr>
<tr>
<td>Chemistry</td>
<td>0.85</td>
<td>0.82</td>
<td>0.79</td>
<td>0.88</td>
</tr>
<tr>
<td>Sediment</td>
<td><strong>0.87</strong></td>
<td>0.83</td>
<td>0.83</td>
<td>0.86</td>
</tr>
<tr>
<td>Connectivity</td>
<td>0.91</td>
<td>0.89</td>
<td>0.90</td>
<td>0.93</td>
</tr>
<tr>
<td>Temperature</td>
<td>0.95</td>
<td>0.94</td>
<td>0.95</td>
<td>0.97</td>
</tr>
<tr>
<td>Habitat</td>
<td>0.89</td>
<td>0.90</td>
<td>0.90</td>
<td>0.94</td>
</tr>
<tr>
<td>ICI</td>
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<td>0.51</td>
<td>0.49</td>
<td>0.45</td>
<td>0.61</td>
</tr>
<tr>
<td>Watershed Integrity</td>
<td>Chemistry</td>
<td>Sediment</td>
<td>Connectivity</td>
<td>Temperature</td>
</tr>
<tr>
<td>---------------------</td>
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<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Surface area of reservoirs</td>
<td>Surface area of reservoirs</td>
<td>Surface area of reservoirs</td>
<td>Surface area of reservoirs</td>
<td>Surface area of reservoirs</td>
</tr>
<tr>
<td>Stream channelization and levee construction (NA)</td>
<td>Stream channelization and levee construction (NA)</td>
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<td>Stream channelization and levee construction (NA)</td>
<td>Stream channelization and levee construction (NA)</td>
</tr>
<tr>
<td>Percent of the watershed comprising agricultural land use</td>
<td>Atmospheric deposition of anthropogenic sources of NH₄ and NO₃</td>
<td>Percent of invasive species within riparian vegetation</td>
<td>Percent of invasive species within riparian vegetation</td>
<td>Percent of invasive species within riparian vegetation</td>
</tr>
<tr>
<td>Percent imperviousness of catchment</td>
<td>Percent of watershed composed of urban land uses</td>
<td>Density of industrial facilities</td>
<td>Percent of invasive species within riparian vegetation</td>
<td>Percent of invasive species within riparian vegetation</td>
</tr>
<tr>
<td>Percent of invasive species within riparian vegetation</td>
<td>Presence and density of wastewater discharge sites</td>
<td>Density of industrial facilities</td>
<td>Presence and density of wastewater discharge sites</td>
<td>Presence and density of wastewater discharge sites</td>
</tr>
<tr>
<td>Boundaries, depths, and flows of aquifers (NA)</td>
<td>Fertilizer application rates</td>
<td>Density of industrial facilities</td>
<td>Percent of riparian zone composed of urban land uses</td>
<td>Density of industrial facilities</td>
</tr>
<tr>
<td>Total length and density of canals/ditches (NA)</td>
<td>Density of Industrial facilities</td>
<td>Density of industrial facilities</td>
<td>Percent of riparian zone composed of agricultural land uses</td>
<td>Density of industrial facilities</td>
</tr>
<tr>
<td>Groundwater use (NA)</td>
<td>Groundwater use (NA)</td>
<td>Soil erodibility</td>
<td>Groundwater use (NA)</td>
<td>Groundwater use (NA)</td>
</tr>
</tbody>
</table>

*NA* indicates data not available.
Quiz Questions

Which biogeographic zone had the lowest ICI and IWI values?

A. Alpine
B. Continental
C. Mediterranean
Are IWI or ICI values generally higher?

A. The ICI values are higher and I know why.
B. The ICI values are higher and I do not know why.
C. The IWI values are higher and I know why.
D. The IWI values are higher and I do not know why.
E. The values are the same.
Are IWI or ICI values generally higher?

A. The ICI values are higher and I know why.

B. The ICI values are higher and I do not know why.

C. The IWI values are higher and I know why.

D. The IWI values are higher and I do not know why.

E. The values are the same.

Quiz Questions

\[ \widehat{IWI}_{i,w} = \frac{\sum_{j=1}^{n_{i,w}}[1 - \left( \frac{S_{j,w}}{S_{j,w}^{cmax}} \right)]}{n_{i,w}} \]
How does the IWI apply to my community?

Kelsey Aho
ORISE Fellow at the US EPA Office of Research and Development
National Health and Environmental Effects Lab
Corvallis, OR
Which data did you use (e.g., catchments, stressors)?

Share an insight that you gained!

Which software did you use (e.g., ArcGIS, QGIS)?

For what do you hope to use the data and/or software?
1. Read about the individual functional components. For which one does your community have the highest score? Lowest score? Is there a big difference between the ICI and IWI values?
1. Read about the individual functional components. For which one does your community have the highest score? Lowest score? Is there a big difference between the ICI and IWI values?

2. Review the stressors identified for the functional component facing the greatest amount of stress. Do you agree? Which stressors are missing?
1. Read about the individual functional components. For which one does your community have the highest score? Lowest score? Is there a big difference between the ICI and IWI values?

2. Review the stressors identified for the functional component facing the greatest amount of stress. Do you agree? Which stressors are missing?

3. Discuss the provided options. Is your community already doing these activities? Which could your community begin implementing? If you have time, add more options!
How can we use the IWI to Manage River and Lake Basins?

Kelsey Aho
ORISE Fellow at the US EPA Office of Research and Development
National Health and Environmental Effects Lab
Corvallis, OR

The views expressed in this presentation are those of the authors and do not necessarily represent the views or policies of the U. S. Environmental Protection Agency
Where: Town, City, Municipality
Who: Local government, schools, businesses, organizations

Hydrologic Unit: Catchment
IWI Metric: Stressor

What
Local government, schools, businesses, and organizations can identify a stressor with a low value in their town, city, or municipality. They can 1) **share information** locally by reaching out to schools or businesses and 2) incorporate the stressors into local **policy and management**. By addressing a single stressor, multiple functional components may improve, since many stressors impact more than one functional component.

How (examples)
1) Address **imperviousness land cover** by using permeable paving materials in local construction,
2) Address **invasive vegetation in the riparian zone** by planting native vegetation along bodies of water,
3) Address **fertilizer use** by using nitrogen-fixing cover crops,
4) Address **urban waste water treatment facilities** by collecting waste-water
5) Address **soil erodibility** by increasing use of cover crops.
By identifying the functional component (and the corresponding stressors) with the lowest value in an individual catchment or watershed, the regional or national management authorities can incorporate the findings into management plans. The two functional components with the lowest integrity in all four watersheds were SED and CHEM.

**How (Examples)**

1. National ministries could improve SED by requiring dam audits for operational deficiencies and potential uncontrolled releases, recommending permeable paving materials in new construction, enforcing wetland disturbance permits, and planting riparian vegetation.

2. Actions that may improve CHEM include requiring training for fertilizer use and treating waste water. Regarding a national ministry, they could identify the functional component with the lowest value, CHEM, and address one or more of the contributing stressors: reservoirs and dams; atmospheric deposition; urban land cover; agricultural land cover; fertilizer use; industrial facilities; urban waste water facilities; mines; grazing cattle; non-native plants.
International watershed or basin managers can use the ICI and IWI, in addition to stressors and functional components for international management plans, Memorandum of Understandings, protocols, and reports.

**How (Examples)**
1) Using the ICI and IWI, hot spots and spatial trends can be used for a Memorandum of Understanding, policies, protocols, and reports.
2) Managers of biological resources may target areas with low ICI and high IWI (High-Low): Management can respond directly to catchments with stressors degrading aquatic functions and these improvements will be supported by the natural infrastructure of an intact watershed. Conversely, management action within a catchment with relatively high integrity but low watershed integrity could require extensive human and monetary capital investment upstream and would only be recommended for critical problems (e.g., flood control) for which significant expenditures are justified.

**Where**
Transboundary

**Who**
International river basin commissions, managers, regulators

**Hydrologic Unit**
Basin

**IWI Metric**
ICI and IWI
International watershed of basin managers can use the ICI and IWI, in addition to stressors and functional components.

**How (Examples)**

1) Using **IWI** values, hot spots and spatial trends can be used for a Memorandum of Understanding, policies, protocols, and reports.

2) Managers of biological resources may target areas with **low ICI** and **high IWI** (High-Low): Management can respond directly to catchments with stressors degrading aquatic functions and these improvements will be supported by the natural infrastructure of an intact watershed. Conversely, management action within a catchment with relatively high integrity but low watershed integrity could require extensive human and monetary capital investment upstream and would only be recommended for critical problems (e.g., flood control) for which significant expenditures are justified.
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### Local

**Where:** Town, City, Municipality  
**Who:** Local government, schools, businesses, organizations  
**Hydrologic Unit:** Catchment  
**IWI Metric:** Stressor

**What**
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4) Address urban waste water treatment facilities by collecting waste-water
5) Address soil erodibility by increasing use of cover crops.

### National

**Where:** Country  
**Who:** Ministry, organization, business that works at the national scale  
**Hydrologic Unit:** Watershed(s)  
**IWI Metric:** Functional Component

**What**
By identifying the functional component (and the corresponding stressors) with the lowest value in an individual catchment or watershed, the regional or national management authorities can incorporate the findings into management plans. The two functional components with the lowest integrity in all four watersheds were SED and CHEM.

**How** (Examples)
1) National ministries could improve SED by requiring dam audits for operational deficiencies and potential uncontrolled releases, recommending permeable paving materials in new construction, enforcing wetland disturbance permits, and planting riparian vegetation.
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### International

**Where:** Transboundary  
**Who:** International river basin commissions, managers, regulators  
**Hydrologic Unit:** Basin  
**IWI Metric:** ICI and IWI

**What**
International watershed or basin managers can use the ICI and IWI, in addition to stressors and functional components for international management plans, Memorandum of Understandings, protocols, and reports.

**How** (Examples)
1) Using the ICI and IWI, hot spots and spatial trends can be used for a Memorandum of Understanding, policies, protocols, and reports.
2) Managers of biological resources may target areas with low ICI and high IWI (High-Low): Management can respond directly to catchments with stressors degrading aquatic functions and these improvements will be supported by the natural infrastructure of an intact watershed. Conversely, management action within a catchment with relatively high integrity but low watershed integrity could require extensive human and monetary capital investment upstream and would only be recommended for critical problems (e.g., flood control) for which significant expenditures are justified.
What size activities does your community or organization manage?

a. Local (town, city, municipality)
b. National
c. International

Who do you work with?

a. Local government
b. Local schools
c. Local businesses
d. Local organizations
e. Regional Ministry
f. National Ministry
g. International River Basin Commission
h. International Managers
i. International Regulators
Discussion

Which Aquatic Features would your community or organization address? Be Specific! Draw a Map!

a. Stream
b. Watershed or Sub-Basin
c. Basin
Which Level of Information would your community or organization use?

a. Stressors: Which stressors would you address?
b. Functional components: Which Functions would you address?
c. ICI or IWI: Would you use trends of a specific Stressor or Function, or would you use High-Low hot spots?
Discuss the community results and how they apply to the aquatic feature you identified!

- a. Where are the stressors?
- b. Who should your action plan include?
- c. How long will the restoration or conservation activity take?
- d. Why should communities, up and down stream, care?
Please report:

1) Which **Functional Components** had the lowest and the highest scores? Were any **stressors** surprising? Were any missing?

2) Which of the **activities** is your community already doing?

3) The size of the activities your community or organization manages.

4) Which **Aquatic Features** that your community or organization can address. Please describe your map!

5) Which **Level of Information** would your community or organization use?

6) **Why should communities, up and down stream, care?**
Questions or comments?
Contact Kelsey at aho.kelsey@epa.gov or ahokelsey@gmail.com