

Design, Sample, Analyze, and Assess:

Putting Kansas surface water quality monitoring into perspective

(with emphasis on probabilistic stream monitoring)

15 August 2008 • Ft. Scott, KS • Kansas Environmental Leadership Program



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Stream Probabilistic Monitoring Program

Bureau of Environmental Field Services

Stream probabilistic monitoring program

- Fairly new program (2005)
- Will share program details
- But first – the bigger picture
- Who, what, when, where, why, how?

WHY do we monitor?

- All states required to monitor, assess, and protect surface waters
- KDHE bears responsibility for Kansas
 - BEFS monitors ambient conditions
- Responsibility derives from Federal and State statutes and regs (*see handout*)
 - Clean Water Act (1972)
 - Code of Federal Regulations
 - Section 65 of Kansas statutes

WHO does the monitoring?

- Bureau of Environmental Field Services
 - Only enviro bureau that doesn't issue permits
 - We design, sample, analyze, assess, report
 - Framework is *Five-year Monitoring Strategy*
 - Analytical support from KDHE Labs
 - Water quality criteria and support from BOW
 - Note: We do other work, incl. spill & fishkill response, special projects, etc. (Groundwater monitoring in abeyance)

This is different from:

- Ensuring quality of drinking water or wastewater (KDHE-BOW)
- Monitoring for status of game, nongame, invasive, and endangered aquatic species (KDWP)
 - *Note: fish tissue = KDHE/KDWP shared responsibility*
- Managing land for watershed/riparian protection & restoration (KSCC, USDA-NRCS, KDHE-BOW)



This is also different from:

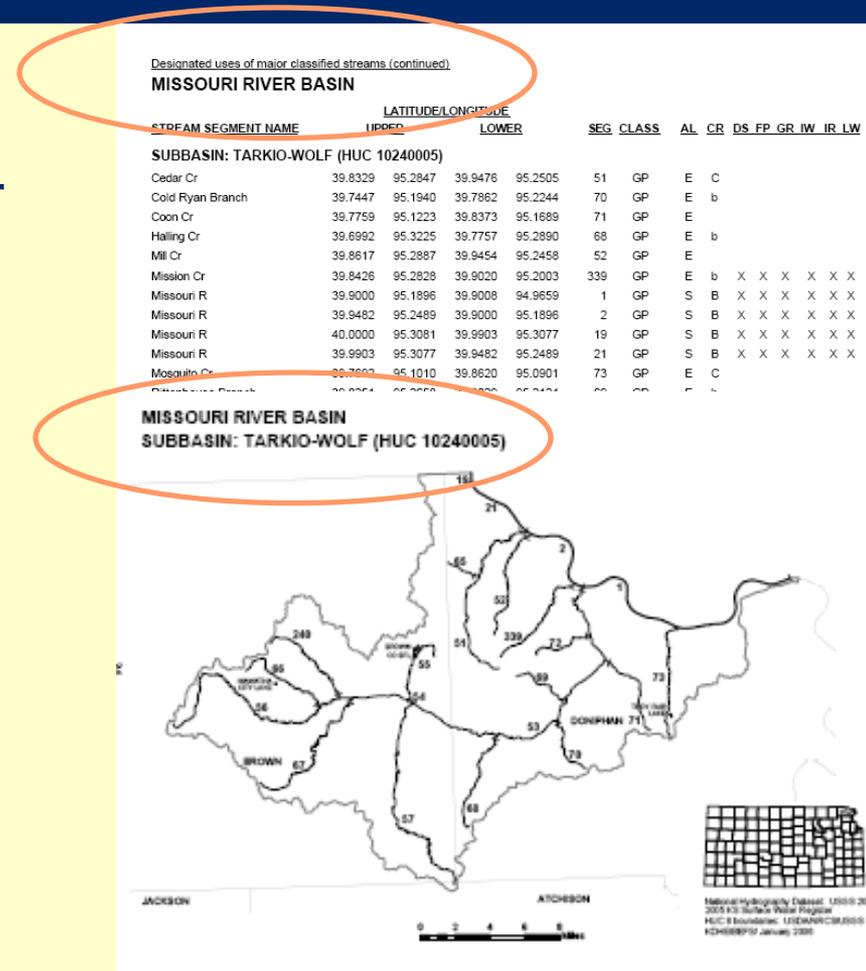
- Managing for water appropriation (KDOA-DWR) or overall policy/planning (KWO)
- Permitting for dredging/filling (USACE) or instream structures (KDOA-DWR)
- Monitoring and reporting on flow-related issues (USGS)

WHERE is monitoring done?

- Streams, rivers, lakes and wetlands
- How are they defined and identified?
- All waters subject to some protections
- Special focus on *classified waters* (as defined through statute & regulation)
- *Major* classified waters are listed in Kansas Surface Water Register (KSWR)

Kansas Surface Water Register

- Explicit framework (list + map) defining surface water resources
 - Based on National Hydrography Dataset
 - ~30K stream miles as ~2200 segments
 - ~ 360 lakes/wetlands
- Maintained by BEFS Use Assessment Section
 - Revisions subject to public review and EPA approval

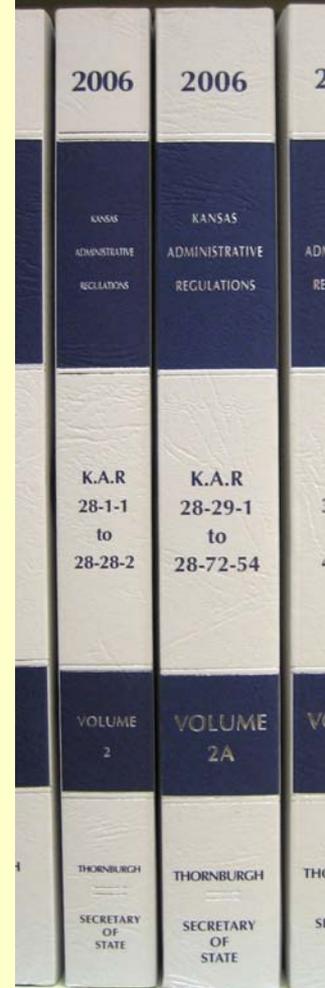


WHAT exactly is assessed?

- All waters have some narrative protection
- Classified waters protected for *designated beneficial* uses
- CWA said “place to dump yucky stuff” is not a legitimate use – thus *beneficial*
- Not all waterbodies naturally able to attain all functions – thus *designated*
- Is water quality sufficient such that waterbody is serving its full range of natural and social functions: “*Is it supporting its uses?*”

Assessment considerations

- All waters subject to narrative protection
- Classified waters (~KSWR) subject to numeric water quality criteria and some additional narrative criteria
 - Criteria proposed by KDHE-Bureau of Water
 - Subject to public review & EPA approval
- Surface Water Quality Standards (KAR 28-16-28b–g) include definitions as well as uses, criteria, and antidegradation policy



Standard narrative protection



The following criteria shall apply to all surface waters, regardless of classification:

Surface waters shall be free, at all times, from... harmful effects of substances that originate from artificial sources of pollution and that produce any public health hazard, nuisance condition, or impairment of a designated use...

Standard narrative protection



... hazardous materials derived from artificial sources, including toxic substances, radioactive isotopes, and infectious microorganisms... in concentrations or combinations that jeopardize public health or the survival or well-being of livestock, domestic animals, terrestrial animals, or aquatic or semiaquatic life...

Standard narrative protection



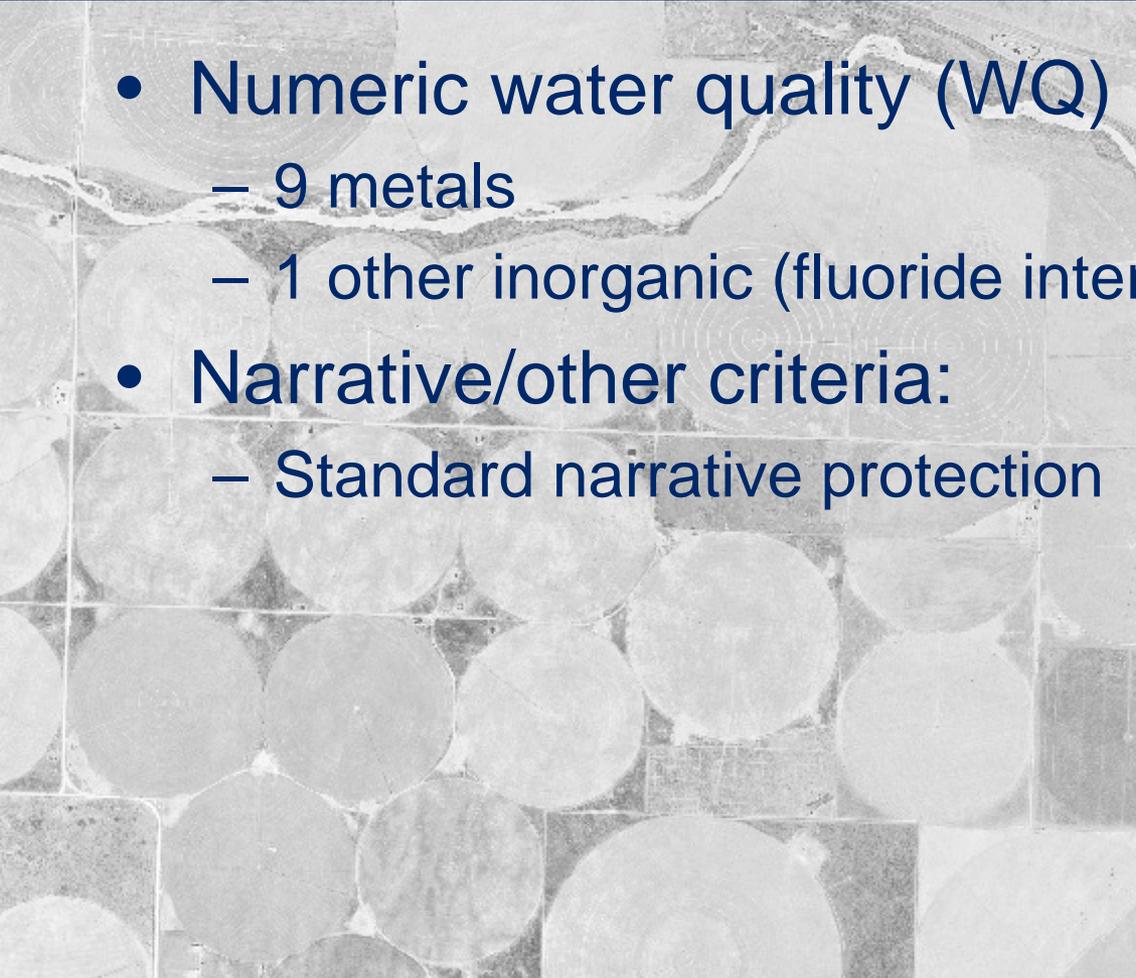
...shall be free of [an itemized list of pollutants, including:] trash, garbage, offal, grass clippings, discarded construction materials, car bodies, tires, floating debris, scum, oil and grease, deposits of sludge or fine solids, artificial substances that produce unpleasant tastes or odors or alter natural appearance of water...

KS designated uses

- Three universal (CWA 101(a)) uses
 - Aquatic life support
 - Recreation
 - Food procurement
- Five additional state uses
 - Groundwater recharge
 - Drinking water supply
 - Industrial water supply
 - Livestock watering
 - Irrigation
- Different criteria for different uses

Irrigation

- Numeric water quality (WQ) criteria:
 - 9 metals
 - 1 other inorganic (fluoride interferes with plant growth)
- Narrative/other criteria:
 - Standard narrative protection



Livestock watering



I'm
thirsty

- Numeric WQ criteria:
 - 10 metals
 - 3 other inorganics
 - 25 organics
- Narrative/other criteria:
 - Standard narrative protection

Groundwater recharge

- Numeric WQ criteria:
 - None
- Narrative/other criteria:
 - No degradation of groundwater, *i.e.*, no statistically significant increase in concentration of chemical, radiological, or infectious contaminant



Domestic water supply

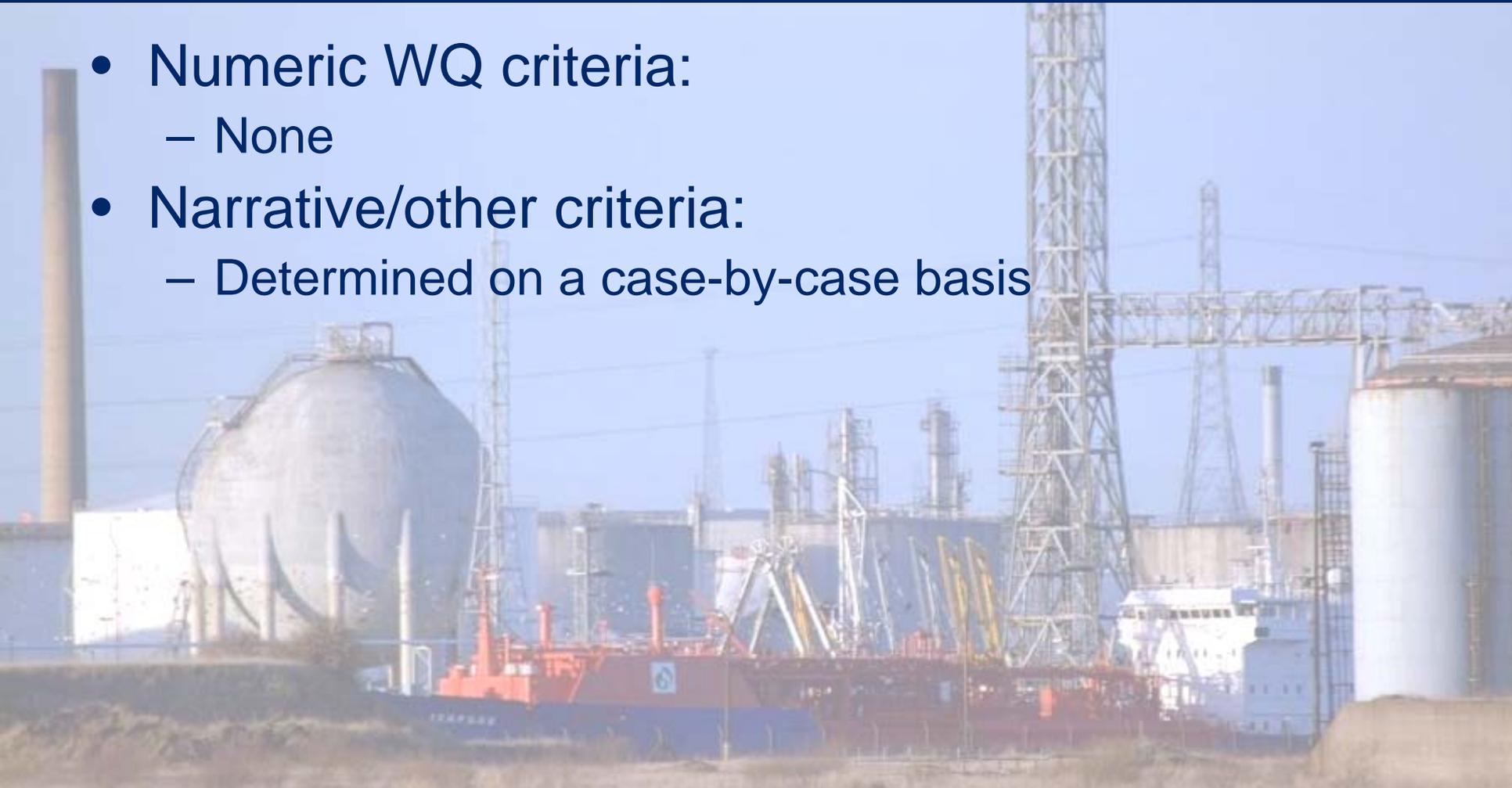
- Numeric WQ criteria:
 - 5 radionuclides
 - 15 metals
 - 7 other inorganics
 - 53 organics
- Narrative/other criteria:
 - Limit toxic, carcinogenic, teratogenic, or mutagenic substances to non-harmful levels
 - Limit plant nutrients (algal blooms)
 - Disinfect wastewater effluent

People are thirsty.



Industrial Water Supply

- Numeric WQ criteria:
 - None
- Narrative/other criteria:
 - Determined on a case-by-case basis



Recreation

- Numeric WQ criteria:
 - Limits for *E. coli* concentrations
 - Criteria differ by classification type (five types, based on level of public access and expected degree of contact)
- Narrative/other criteria:
 - Control plant nutrients (to prevent algae and nuisance vegetation)
 - Disinfect wastewater effluent



Food Procurement

- Numeric WQ criteria:
 - 9 metals
 - 1 other inorganic
 - 106 organics
- Narrative/other criteria:
 - Limit bioaccumulative contaminants (metals and organics), according to EPA guidelines for risk assessment (e.g. fish tissue)

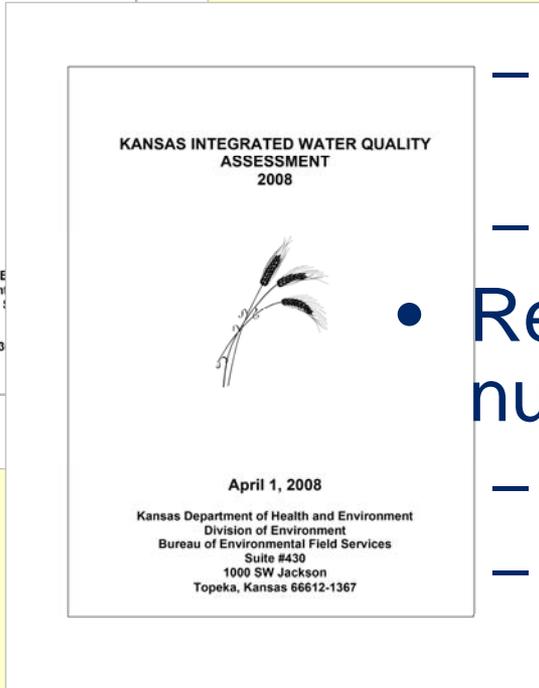
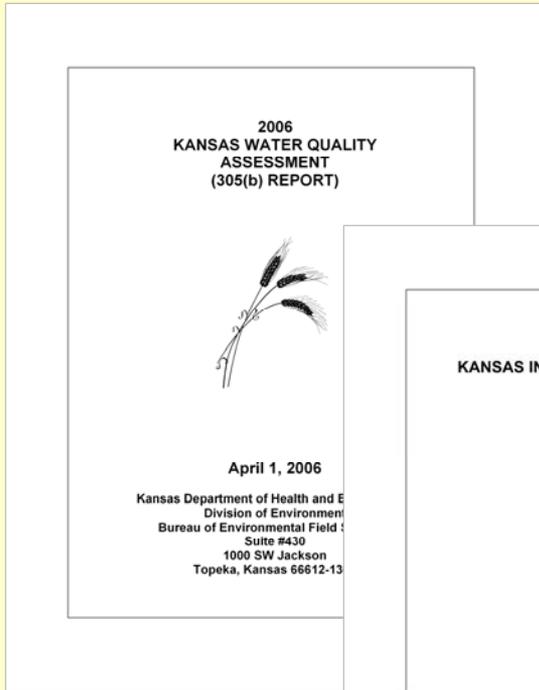
Aquatic Life Support

- Numeric WQ criteria:
 - for both acute and chronic exposure
 - 17 metals
 - 5 other inorganics
 - 126 organics
 - DO, pH, ammonia, temperature
- Narrative/other criteria:
 - Limit nutrients, suspended solids, toxic substances
 - Bioassessment of aquatic life communities – currently using phytoplankton, macrophytes, aquatic macroinvertebrates (including mussels)

Antidegradation policy

- Uses are protected and cannot be removed arbitrarily
- Existing water quality (even if above that required) is protected and cannot be degraded arbitrarily
- Three-tier system: some waters have additional protections (Outstanding National Resource Waters, Exceptional State Waters)
- This policy is used primarily in permit review (KDHE-BOW) rather than assessment

WHEN is assessment done?



- Monitoring is year-round
 - Kansas has monitored water since late 1800s
 - Continuous network monitoring since 1960s
 - More details in a moment...
- Report produced in even-numbered years
 - Originally a stand-alone (305(b))
 - Now part of Integrated Report

HOW is monitoring performed?



- Stream/river monitoring separate from lake/wetland
- Lentic has not changed
- Lotic monitoring has changed since 2005
- All work still done according to approved Quality Assurance Management Plans

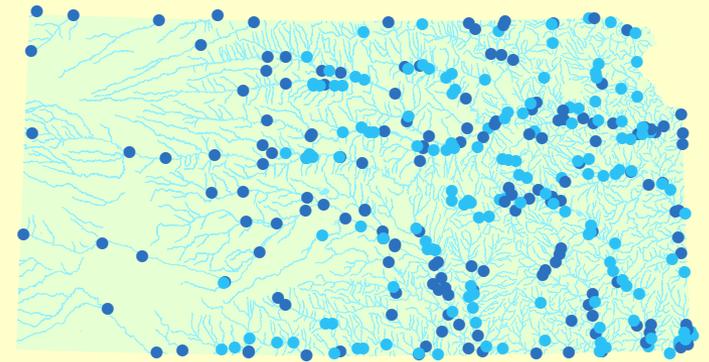
Lake and Wetland Program



- Near-census approach for larger lakes and wetlands
- 3 – 5 year rotational basis
- Over 100 core physical and chemical parameters
- Chlorophyll-a, phaeophytin-a, and *E. coli*
- Abundance and taxonomy of aquatic macrophytes and algae
- Special parameters as needed

Stream Monitoring History

- Before 2006, all stream/river monitoring for Water Quality Assessment done by:
 - Stream Chemistry program
 - 319 stations, ~200 sampled each year, 6x
 - Stream Biology program
 - 200 stations, ~60 sampled each year, 1x
- Targeted site selection
 - Watershed integrator sites
 - Larger perennial streams



Improvements were needed

- **Increased demands** on parent programs
 - 303(d)/TMDL follow-ups
 - Revised bacteriological sampling schedule
- **Smaller streams needed monitoring**
 - Assessed linear mileage was only **~61% of KSWR** despite 97% contributing area coverage
 - Use Assessment Section work* reflects importance of intermittent waters
- **Level of bias unknown** (sites hand-selected)

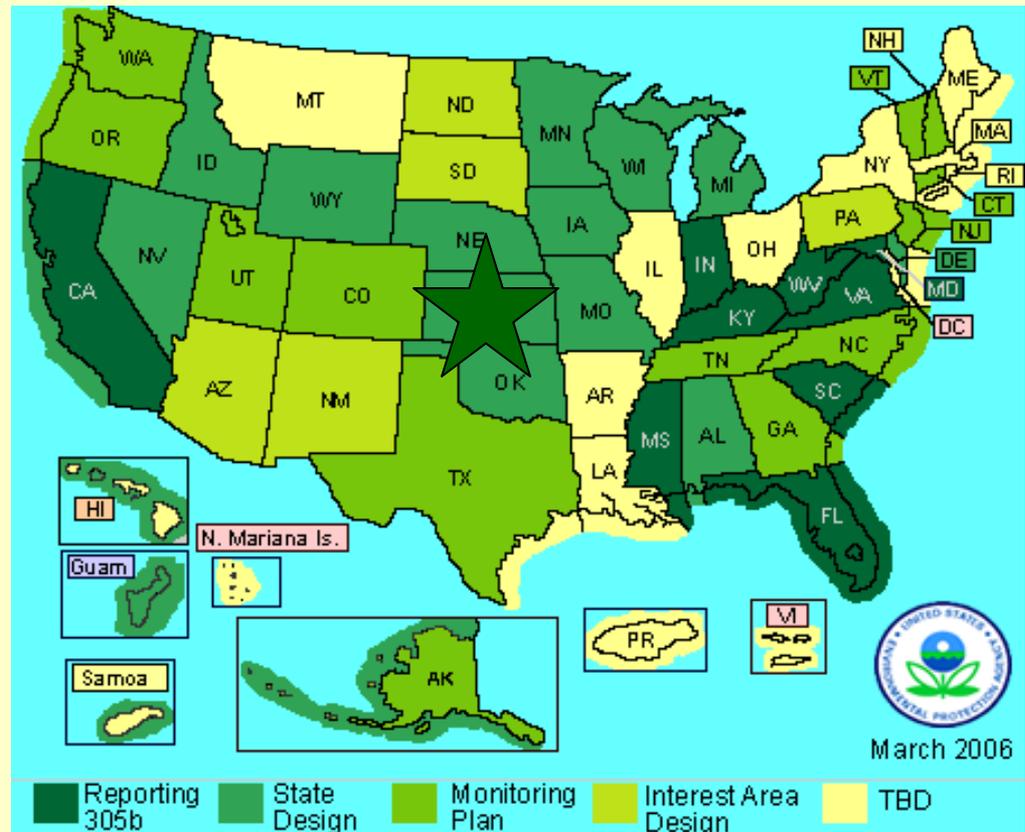
*accelerated by passage and amendment of KSA 82a-2001

Stream probabilistic monitoring

- New program
 - Started sampling in 2006
 - First assessment in 2008
- Working collaboratively with Stream Biology and Stream Chemistry programs
- Field sampling methodologies adopted from parent programs
 - New data are comparable with historical data
 - Minor additions/modifications
- Site selection methodology entirely different

Benefits of probabilistic site selection

- Yields statistically sound results
 - Random & unbiased
 - Spatially balanced
 - Known confidence
- High confidence relative to cost
- Stratifiable/flexible
- Comparable across states



*EMAP = USEPA Ecological Monitoring and Assessment Program, responsible for survey design and support. See www.epa.gov/emap

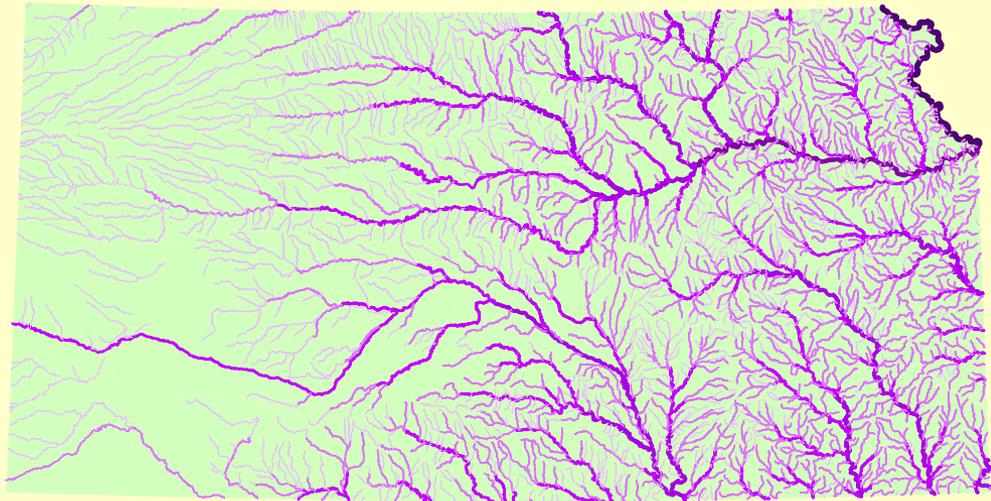
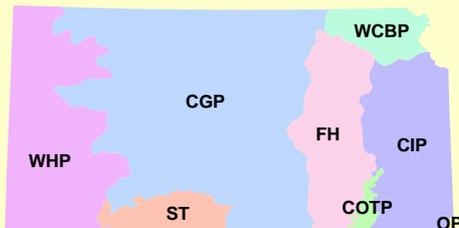
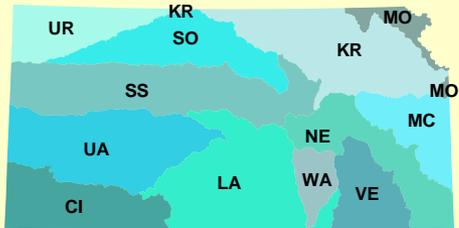
Benefits of program to Kansas



- Entire KSWR represented in assessment
- Advance our understanding of headwater streams
- Parent programs can reallocate resources to special studies, targeted work, program development, etc.

Survey design / site selection

- Requires explicit graphical representation of resource
- Sample frame = Dec 2005 KSWR, trimmed at state boundaries (29,091 mi)
- Considered stratifying by river basin, ecoregion, or discharge class (USGS estimated median flow)

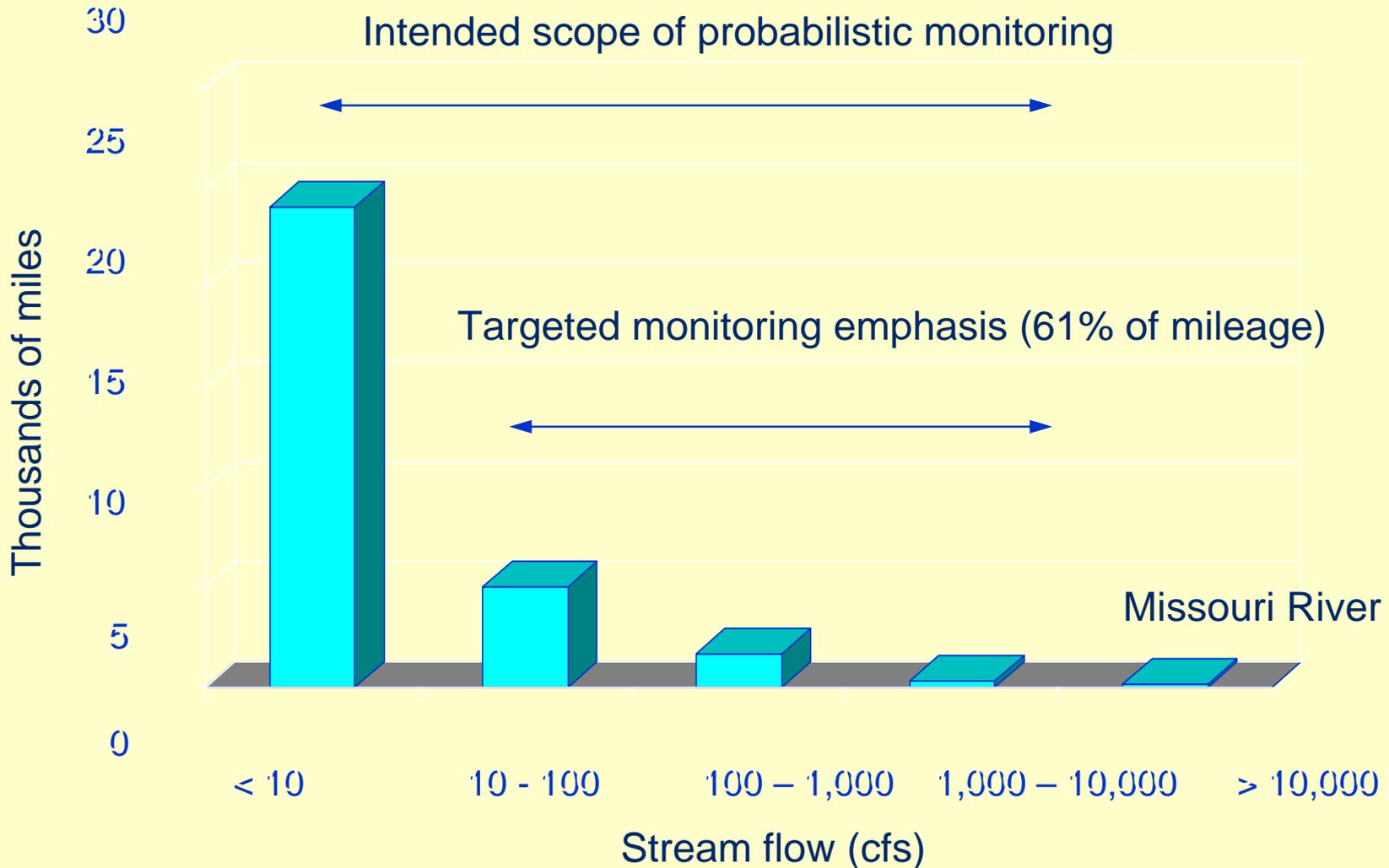


Kansas major river basins approx. equivalent to 6-digit HUCs. Kansas has 8 Omernik Level III ecoregions. Median flow estimates in order-of-magnitude classes from <1 cfs to >10,000 cfs (USGS, 2002).

Survey design

- Decided to use unweighted design
 - To date, KS is only state to opt for this
- Over 80% of Kansas streams have est. median flow ≤ 10 cfs (40% ≤ 1 cfs)
 - Sites are proportionally representative
 - *De facto* emphasis on smaller streams
- Goal = sample 50 new sites each year
 - Initially, no repeat sampling across years
 - ~200 sites for 4-yr assessment period

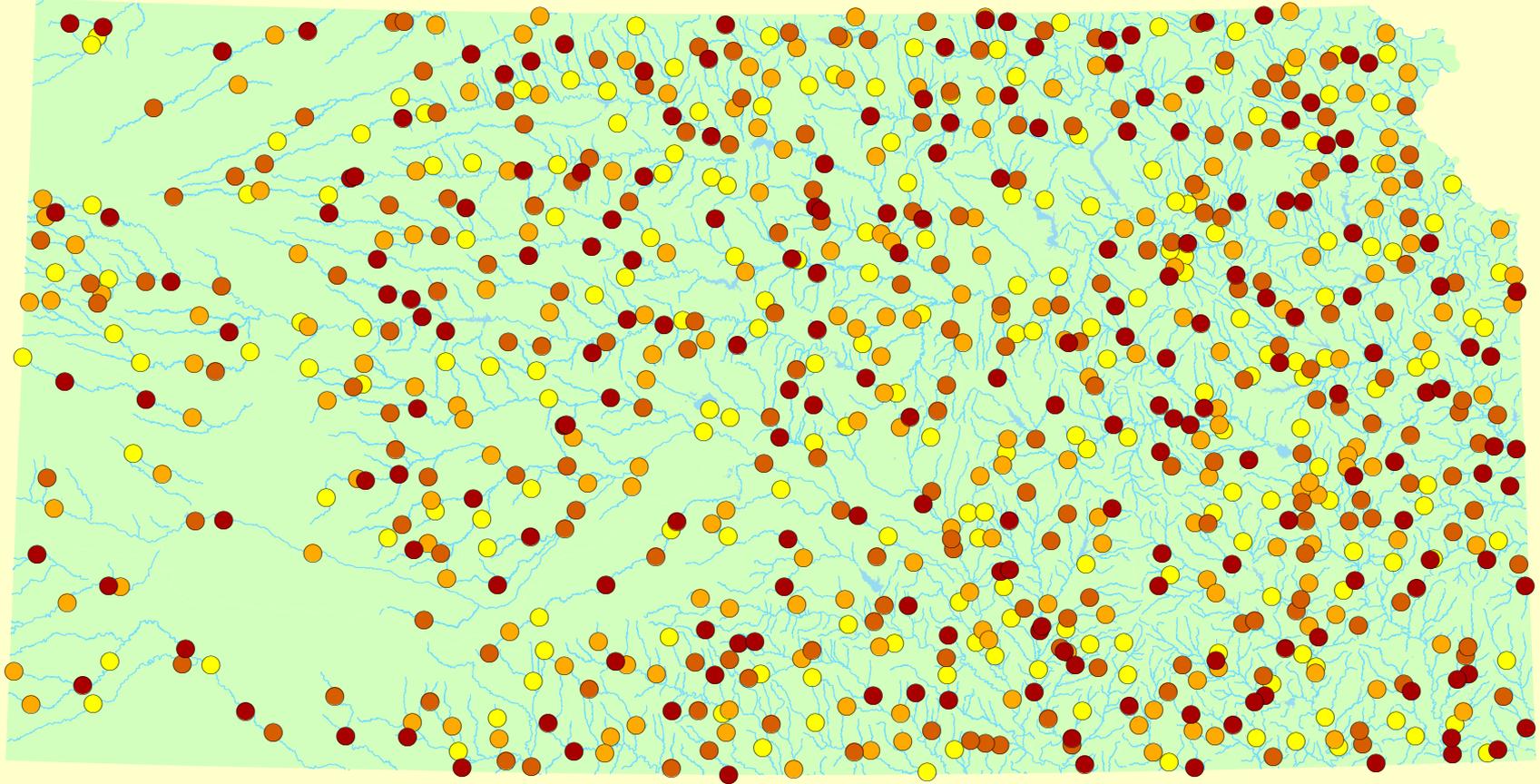
CLASSIFIED STREAM MILEAGE PARTITIONED BY TEN-YEAR MEDIAN STREAM FLOW



Site selection

- EPA design team created design to our specs
- Sample sites generated via GRTS algorithm (generalized random tessellation stratified)
 - Best qualities of both systematic and random sampling
 - Nested, hierarchically addressed grids used to select sample points
 - Flexible: accommodates stratification
 - Generates results with known confidence
- List of 800 random X-sites (sample coordinates) generated to last ~4 yrs
 - Not all sites will be used

Survey design / site selection



The 800 prospective stream sample sites of Probabilistic Survey Design A (Feb. '06), 200 of which will be sampled 2006-2009.

Final site selection

- Sites must be evaluated strictly
 - Systematically to avoid bias
 - In sequence to preserve spatial balance
- Final selection depends on two factors
 - Legal access to X-site (permission)
 - Sampleability (reconnaissance)
- Some sites are rejected during permissions and reconnaissance
 - Thus the generous oversample (800 prospective sites to ensure 200 good sites)

Two-stage reconnaissance



Headwater reach of unnamed stream



Salty Creek, BA Co.

- Desk recon using aerial photos
- If inconclusive, then field recon

Permissions

“To protect the health and environment of all Kansans by promoting responsible choices.”

–KDHE mission

We are grateful to the citizens and landowners of Kansas who provide access to sample for statewide water quality monitoring. Without their cooperation, this program would not be possible.

The Kansas Department of Health and Environment



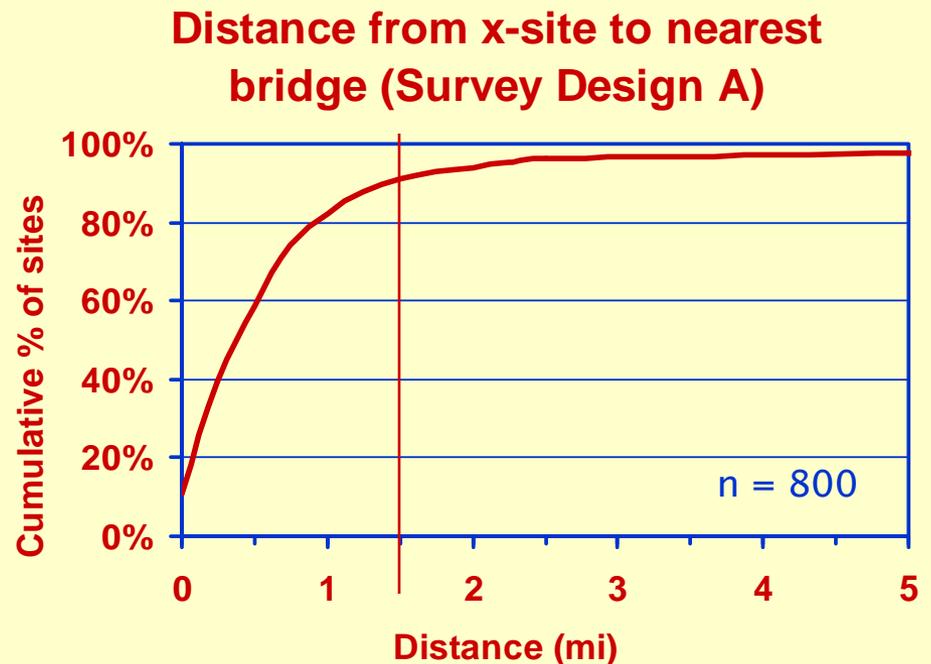
Probabilistic Stream Monitoring Program

- Expected “yes” rate of ~50%
- Achieving ~70%
- Priority on positive landowner relations

CONTACT INFORMATION

Site identification

- Site for macroinvertebrate & habitat sampling
 - Use X-site coordinates (often a hike)
- Site for chemistry and fish sampling
 - Easy, all-weather access required
 - Establish companion site at nearest bridge crossing (up/down)
 - No confluences or land use changes between two sites
 - >90% at ≤ 1.5 mi



Water chemistry sampling



- Samples taken from bridge
- Quarterly schedule
- Over 80 analytes
 - *E. coli*, metals, nutrients, metals, biocides, turbidity, *etc.*

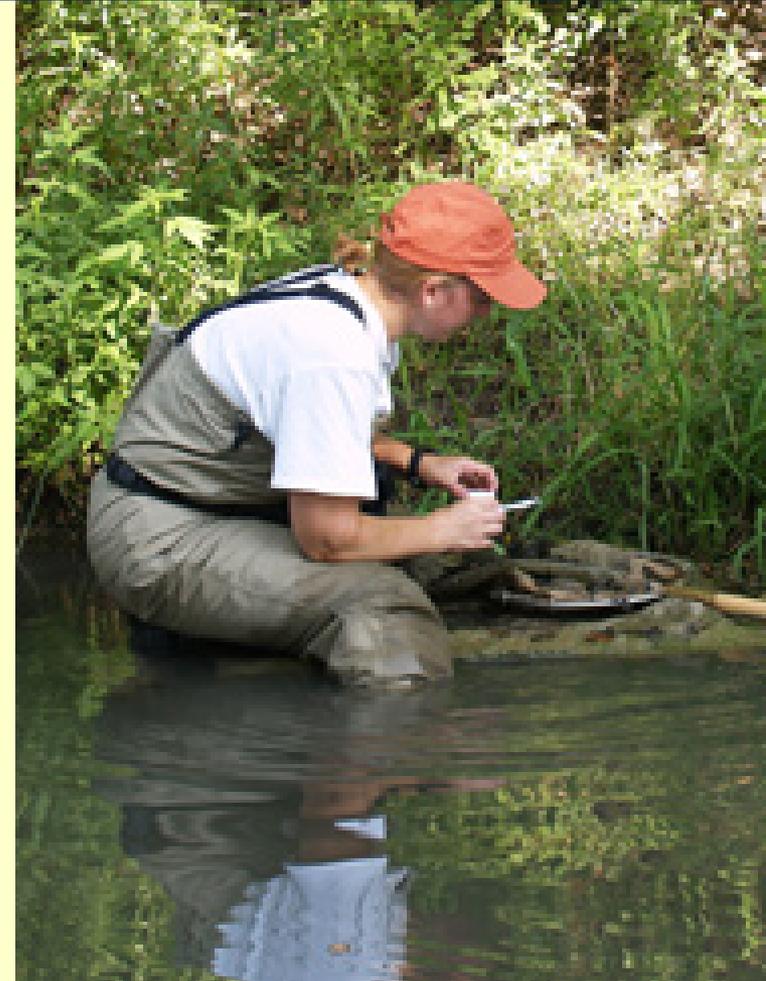
Biological sampling

- 150-m reach bracketing X-site
- Aquatic insects
- Live mussels and spent valves
- Fish for tissue analysis (15/50 sites)
- Chlorophyll-a / phytoplankton



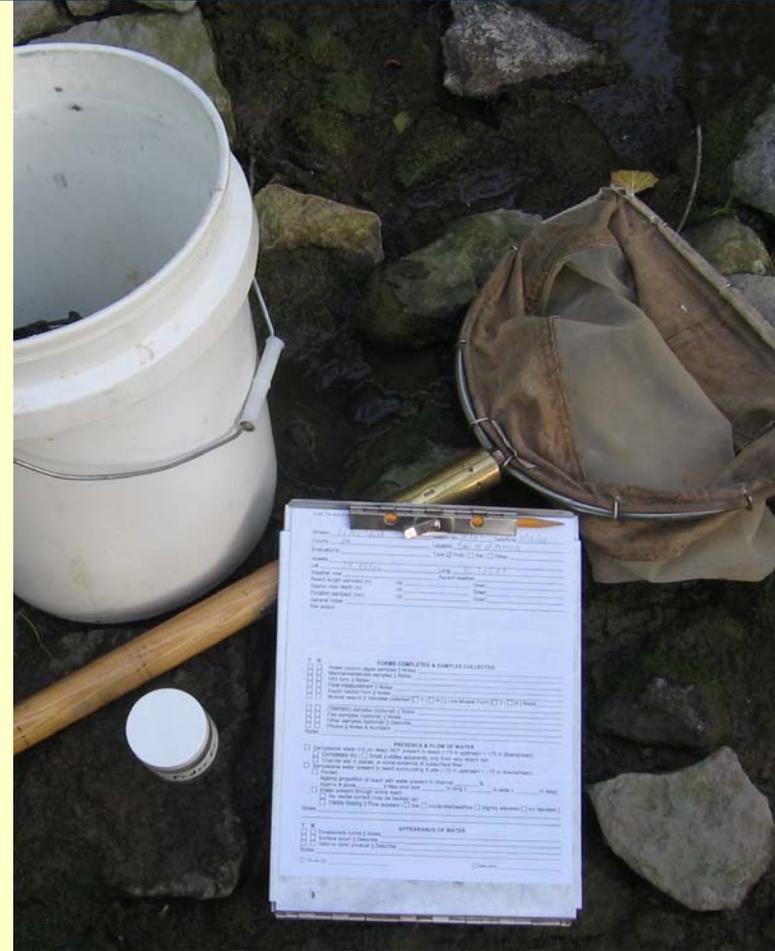
Aquatic macroinvertebrates

- Kick/sweep with D-net
 - Field pick (unaided eye)
- Timed collection
 - 2 people x ≥ 30 min
 - Time \propto habitat types
 - Preferred 200 organisms
- Macroinverts identified to genus or species
- Several indices used in assessment (*e.g.*, EPT, diversity, tolerance)

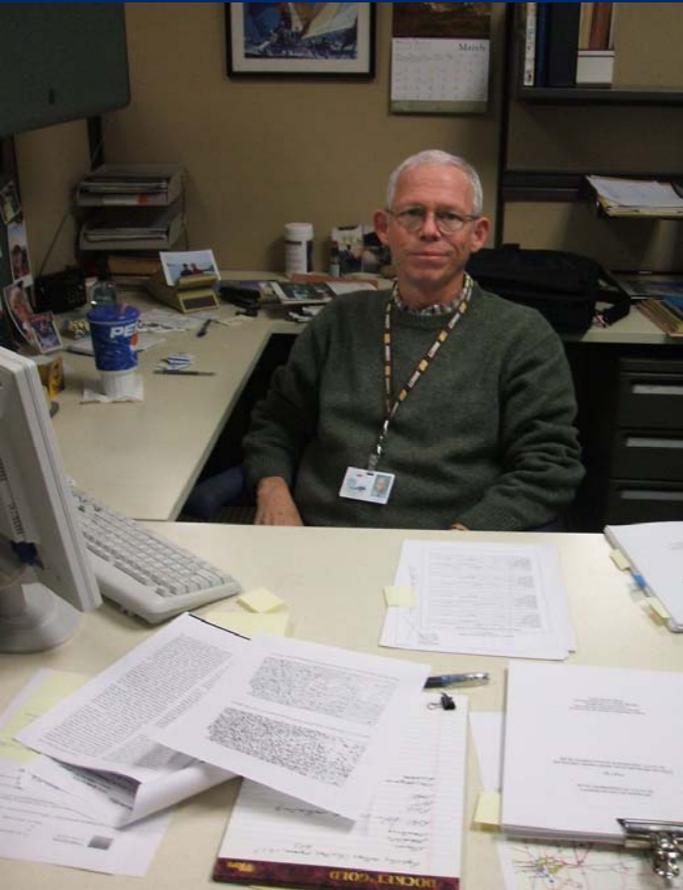


Habitat data

- Physical habitat
 - EPA Rapid Habitat Assessment (reach-wide)
 - Habitat Diversity Index (sampled habitat)
- Other observations
 - Qualitative & semiquantitative: Flow condition, channel dimensions, dominant substrates, land use, human influence, etc.



In the office



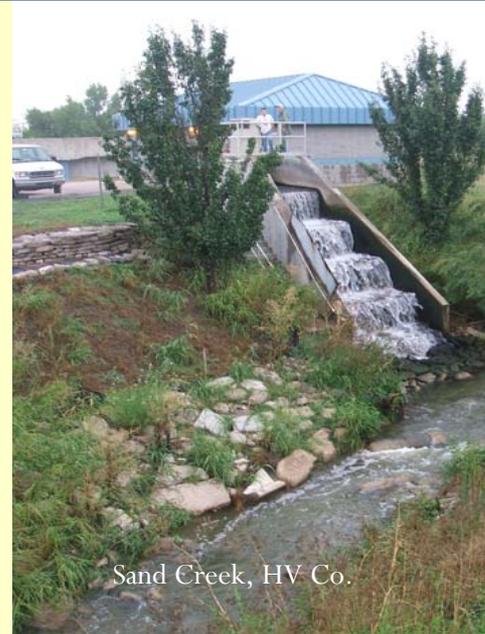
- Sample identification
- Data management
- Assessment

SF Big Nemaha River, NM Co.

Our Vision – Healthy Kansans living in safe and sustainable environments.

General impressions

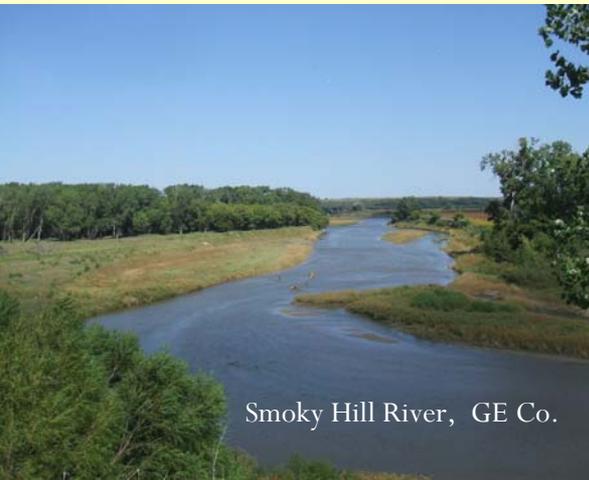
- Wide variation among sites
 - High quality to degraded
 - Small intermittent to large perennial



Sand Creek, HV Co.



SF Big Nemaha River, NM Co.



Smoky Hill River, GE Co.

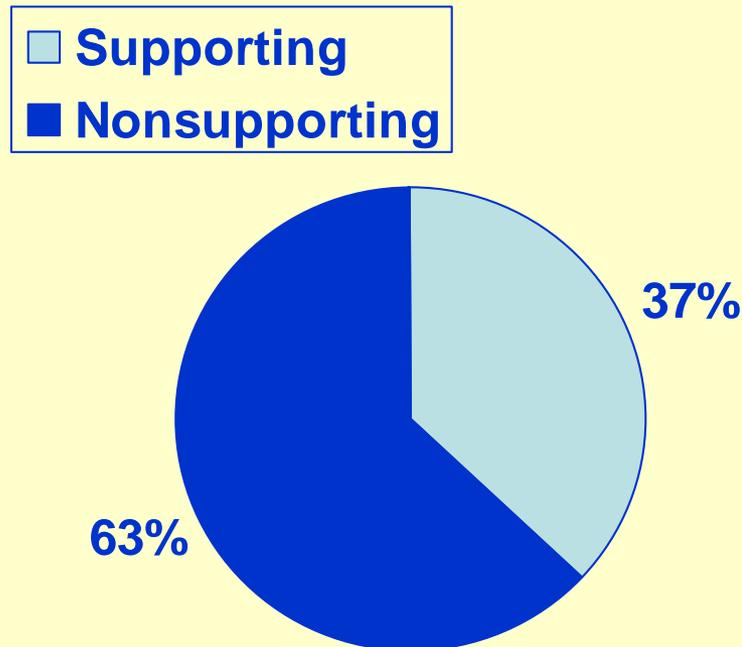


Mill Creek, WB Co.



Sand Creek, KM Co.

2008 Integrated Report results



- 37% ($\pm 8\%$) fully supporting all CWA 101(a) uses
- Compare to 61% from 2006 assessment (based on targeted sampling)

Long-term goals

- Compare results with historical data
- Refine design and assessment methods
- Refine sampling methodologies
- Integrate habitat data into assessment
- Rigorously characterize reference conditions
- Refine biological criteria
- Improve understanding of intermittent streams

Where will it take us?

- Everywhere and in all weather!
- To a statistically confident assessment of the status of the flowing waters of Kansas
- To more efficient allocation of monitoring resources
- To better knowledge of headwater and intermittent systems
- To improved understanding of reference conditions and development of biological criteria



Surface Water Assessment – the big picture

- **WHY?** Mandated by CWA other laws/regs
- **WHO?** KDHE - BEFS
- **WHERE?** KSWR (major classified waters)
- **WHAT?** Designated uses, with water quality standards and other data
- **WHEN?** Year-'round monitoring, with biennial reporting
- **HOW?** Several programs, adhering to strict QMPs

What happens after assessment?

- Water quality advisories may be issued in severe cases
- Biennial report: supporting vs. nonsupporting
- Follow-up sampling to confirm nonsupporting sites
 - Follow-up sampling performed by Stream Biology, Stream Chemistry, and Lake/Wetland programs
 - Input on priority/schedule from BOW-TMDL
 - Sampling may be done by BEFS or contracted out

What happens after assessment?

- BEFS monitoring results also evaluated by BOW-TMDL program to:
 - identify impaired streams (“303(d) list”)
 - determine probable causes of impairment in watershed context
 - develop Total Maximum Daily Load plans
- Problems may be addressed through TMDL plan or other means (e.g., permitting for point-source issues, WRAPS for non-point issues)
- Problems addressed with variety of sticks & carrots (by different programs & agencies)

Acknowledgements

Bob Angelo

Mike Butler

Ed Carney

Diana Chamberlain

Steve Haslouer

Layne Knight

Patricia Lieber-Haines

Craig Thompson

...and many stock photographs were taken from: www.FreeFoto.com

Fivemile Cr., LV Co, 17JUL06

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Questions or comments?



North Fork of the Ninnescah River, Reno Co, 12JUL06

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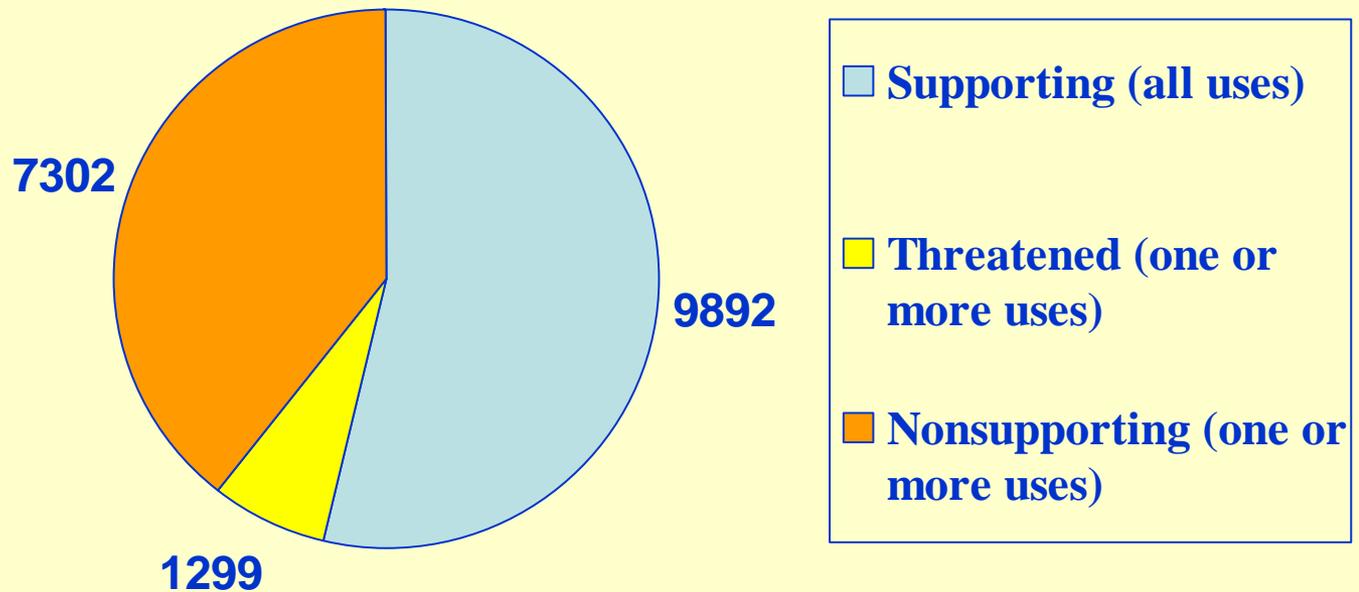
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2006 Kansas Water Quality Assessment – Stream Summary





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