Response to Call for Scientific Information Related to Oklahoma Scenic Rivers Phosphorus Standard Review

Presented by
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On behalf of
the Northwest Arkansas Council

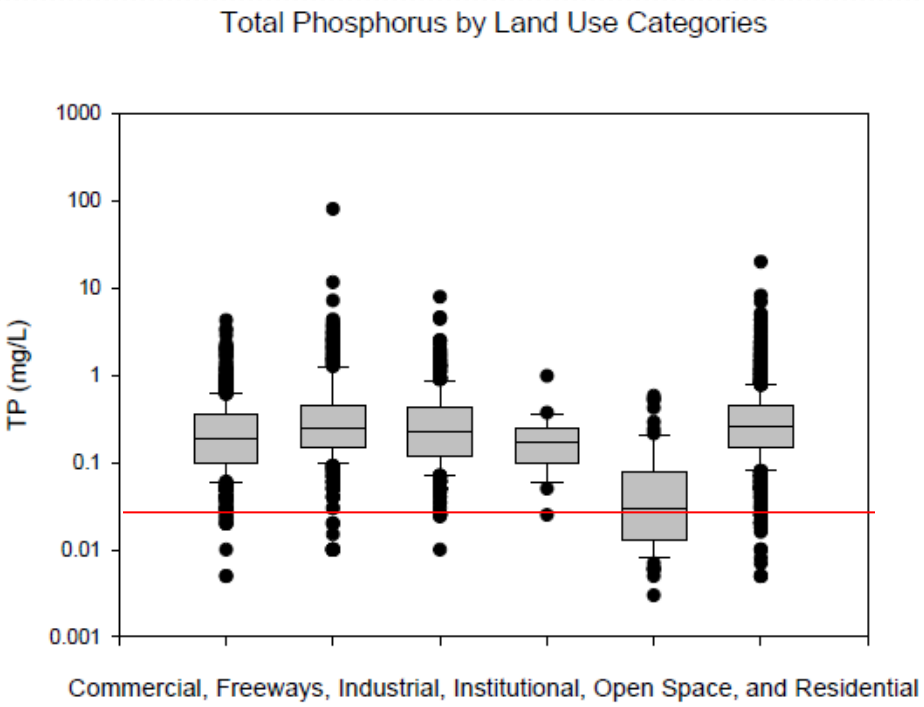
August 11, 2011

Focus of WWE's Comments

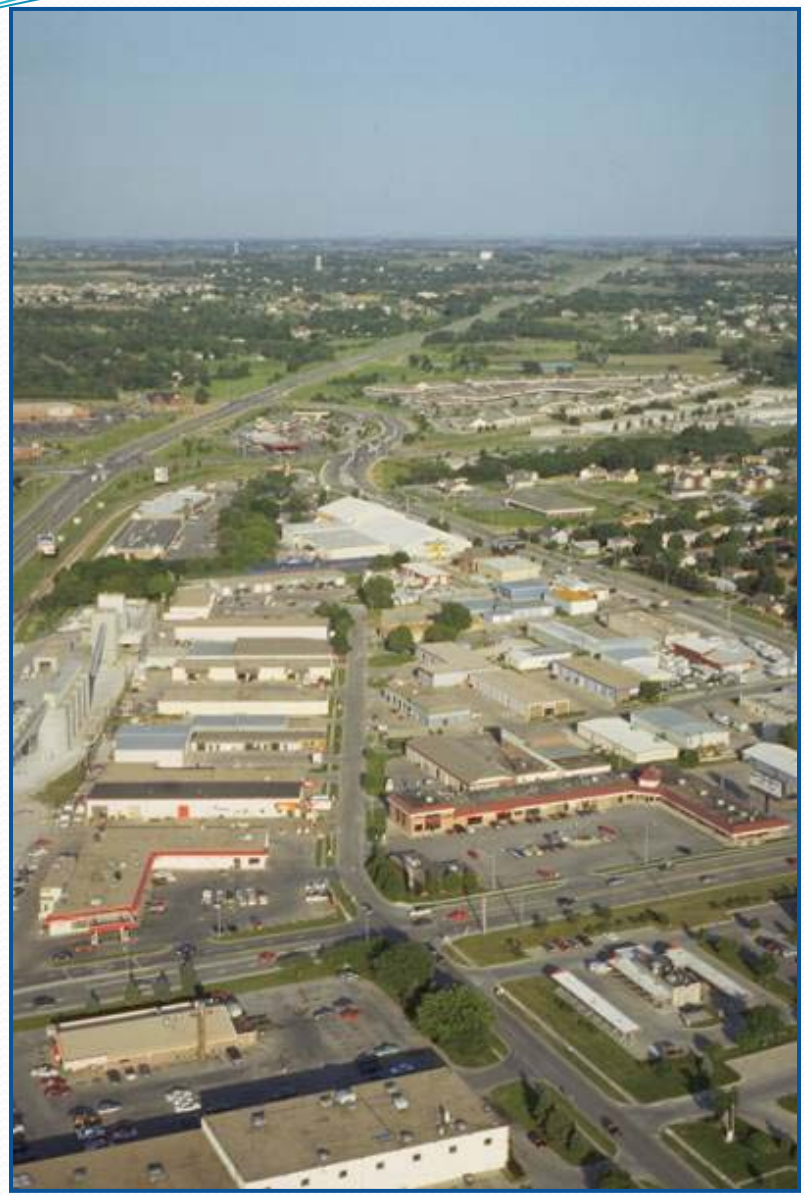
- Attainability of the Standard (Findings 1-3)
  - Runoff Quality
  - BMP Effluent Quality
- Use of reference streams as basis of standard under urbanized and active agricultural production watershed conditions (Finding 4)
- Use of models in the criterion reevaluation process (Finding 5)

Finding 1. Phosphorus in Runoff

- **Total P in runoff from both developed and undeveloped areas routinely exceeds 0.037 mg/L.**
- **Literature for forest and grassland runoff includes median values of 0.07 to 0.14 mg/L.**
- **Protected low-slope forest may meet standard (0.032 mg/L).**



Source: Maestre and Pitt (2005), as provided in Urban Stormwater Management in the United States (NRC 2008)

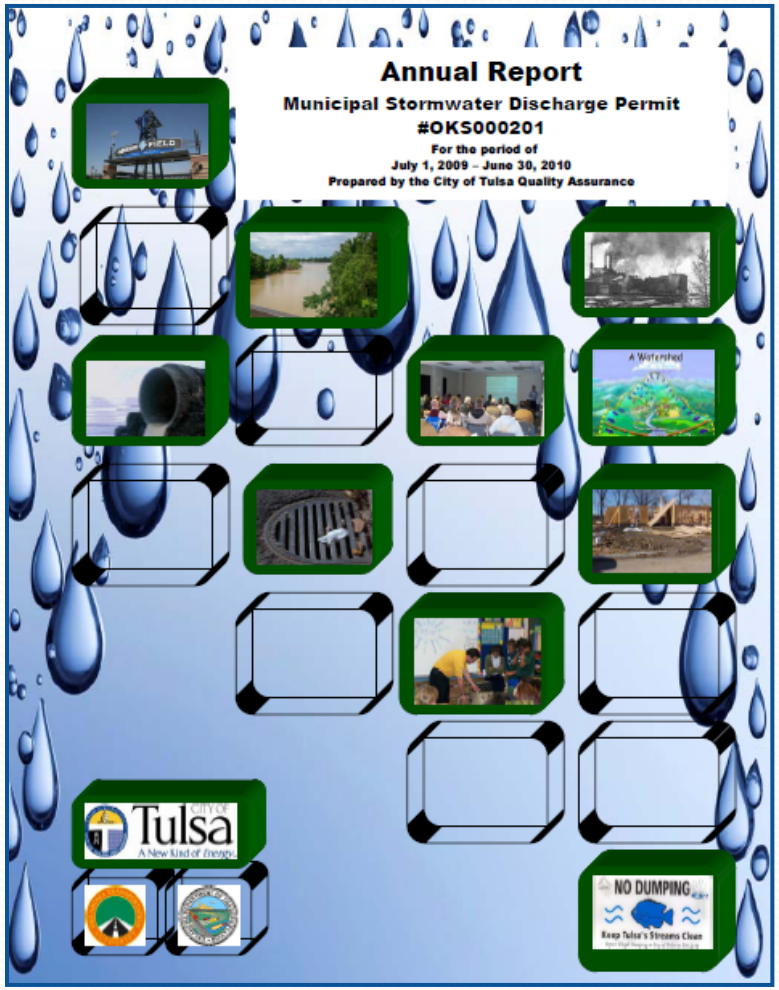


Developed Areas

Lightly Developed to Undeveloped

Tulsa NPDES Monitoring

- EMC Data from 1994 to 2010
- Median annul TP range (1994-2010):
  - 0.15 mg/L to 0.47 mg/L
- Median value for 2009-2010 was 0.30 mg/L
- "no significant degradation occurred during the reporting period" (Relates to Finding 4)



Finding 2. Urban Stormwater BMP Performance for TP.*

- **Some types of properly designed, constructed and maintained urban stormwater BMPs can provide significant reductions in total phosphorus concentrations.**
- **However, treated runoff effluent concentrations routinely exceed 0.037 mg/L.**
- **Most BMP-treated effluent concentrations are several times greater than the instream standard.**

*The 0.037 mg/L standard applies instream, not at end-of-pipe or edge-of-field.

Wet Pond

Wetland

Landscaped Filter Beds

Bioretention and Pervious Pavement

INTERNATIONAL STORMWATER BMP DATABASE
www.bmpdatabase.org

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Project Sponsors | **Home** | **BMP Performance Summaries** | **Retrieve BMP Studies** | **Research Tools/ Master Database** | **Data Entry Spreadsheets** | **Monitoring/ Evaluation** | **Publications**

WERF
Water Environment Research Foundation

ASCE
American Society of Civil Engineers

EWRI

EPA

U.S. Department of Transportation
Federal Highway Administration

APWA

Project Team

Welcome to the International Stormwater Best Management Practices (BMP) Database project website, which features a database of over 300 BMP studies, performance analysis results, tools for use in BMP performance studies, monitoring guidance and other study-related publications. The overall purpose of the project is to provide scientifically sound information to improve the design, selection and performance of BMPs. Continued population of the database and assessment of its data will ultimately lead to a better understanding of factors influencing BMP performance and help to promote improvements in BMP design, selection and implementation.

The project, which began in 1996 under a cooperative agreement between the American Society of Civil Engineers (ASCE) and the U.S. Environmental Protection Agency (USEPA), now has support and funding from a broad coalition of partners including the Water Environment Research Foundation (WERF), ASCE Environmental and Water Resources Institute (EWRI), USEPA, Federal Highway Administration (FHWA) and the American Public Works Association (APWA). Wright Water Engineers, Inc. and Geosyntec Consultants are the entities maintaining and operating the database clearinghouse and web page, answering questions, conducting analyses of newly submitted BMP data, conducting updated performance evaluations of the overall data set, disseminating project findings, and expanding the database to include other approaches such as Low Impact Development techniques. The database itself is downloadable to any individual or organization that would like to conduct its own assessments.

What's New

2007 Data Analysis Report released in October 2007

Website revised with new, ease-to-use performance summary information

Master Database exceeds 300 BMP studies with access to a new bibliography

Florida Department of Environmental Protection BMP Database Integrated into International Stormwater BMP Database--searchable online

What Type of User Are You? Let us help you enter our website to find the level of detail you need:

Low-Intensity	Mid-Intensity	Researcher	Data Provider	New to BMP Monitoring
Get Basic Performance Summary Information for BMPs Typical Users: Public officials, casual users, those seeking quick/fast answers	Get Detailed Statistical Analysis for Individual BMPs Typical Users: Consultants, Public Works Staff, Designers	Download the Master Database to Conduct Independent Research Typical Users: University Professors	Obtain Data Entry Spreadsheets Typical Users: Public agencies, consulting firms, university researchers	Obtain Monitoring Guidance Typical Users: Public agencies, consulting firms, university researchers

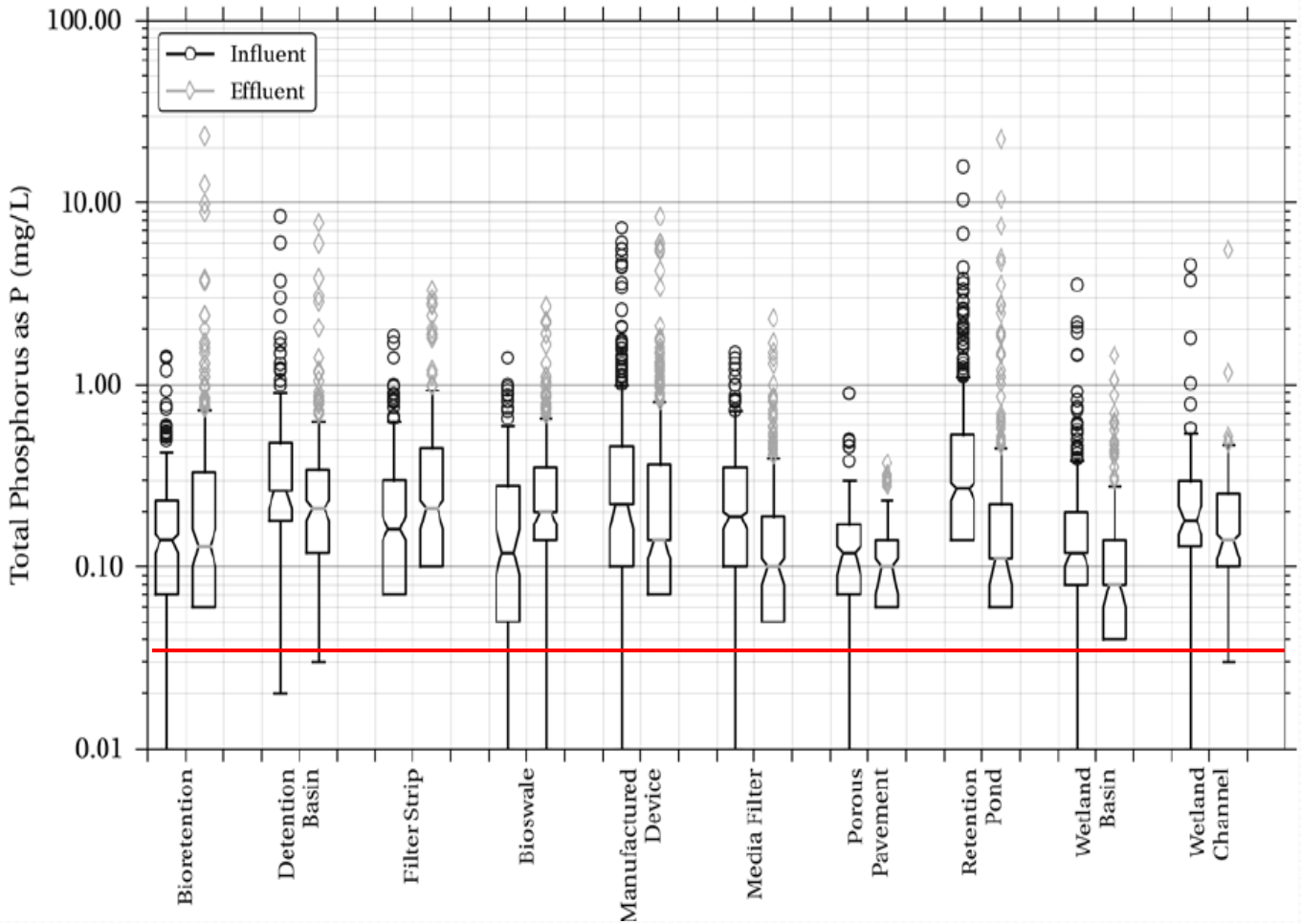
Table 2-1. Category-level BMP Performance for Total Phosphorus

(Analysis based on December 2010 Release of BMP Database, as presented in Geosyntec and Wright Water Engineers 2010)

BMP Type	Count (Studies/Data Pts.)		25th Percentile (mg/L)		Median (95% Conf. Interval) (mg/L)		75th Percentile (mg/L)	
	In	Out	In	Out	In	Out	In	Out
Bioretention	12/187	12/157	0.07	0.06	0.14 (0.12,0.15)	0.13 (0.10,0.16)	0.23	0.33
Detention Basin	17/222	17/241	0.18	0.12	0.26 (0.21,0.26)	0.21 (0.18,0.23)	0.48	0.34
Filter Strip	14/245	14/169	0.07	0.10	0.16 (0.14,0.19)	0.21 (0.16,0.23)	0.30	0.45
Bioswale	17/257	19/293	0.05	0.14	0.12 (0.09,0.16)	*0.20 (0.17,0.20)*	0.28	0.35
Manufactured Device	34/457	41/456	0.10	0.07	0.22 (0.16,0.22)	**0.14 (0.11,0.14)**	0.46	0.36
Media Filter	19/291	20/282	0.10	0.05	0.19 (0.16,0.20)	**0.10 (0.08,0.11)**	0.35	0.19
Porous Pavement	5/65	6/65	0.07	0.06	0.12 (0.09,0.13)	0.10 (0.07,0.11)	0.17	0.14
Retention Pond	38/578	40/561	0.14	0.06	0.27 (0.23,0.29)	**0.11 (0.08,0.11)**	0.53	0.22
Wetland Basin	12/284	13/271	0.08	0.04	0.12 (0.10,0.12)	**0.08 (0.06,0.08)**	0.20	0.14
Wetland Channel	6/88	6/83	0.13	0.10	0.18 (0.15,0.22)	**0.14 (0.11,0.15)**	0.30	0.25

Figure 2-1. Influent/Effluent Summary Statistics for Total Phosphorus

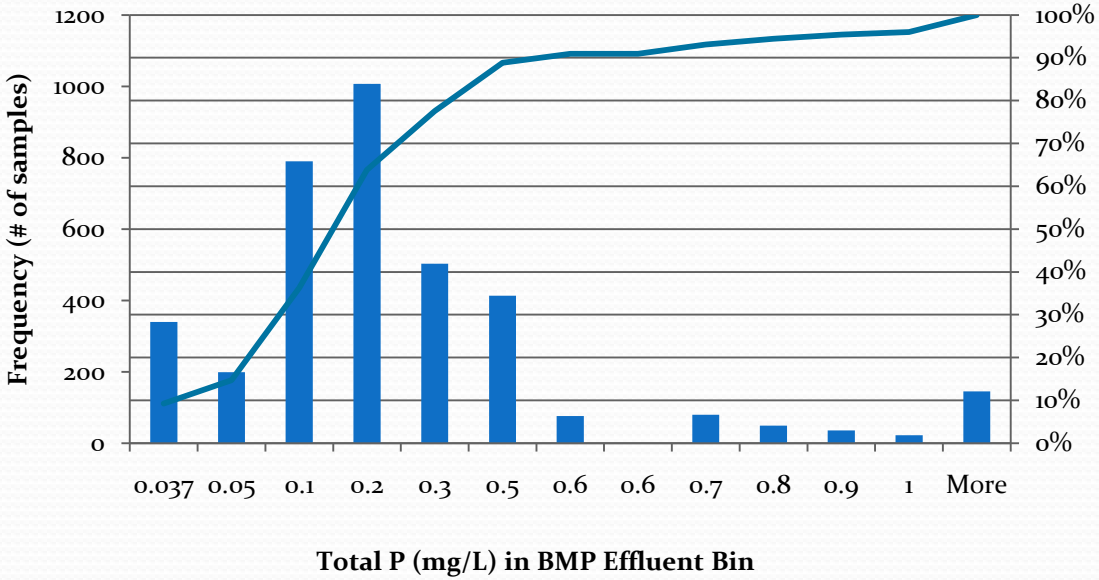
(Source: International Stormwater BMP Database, in Geosyntec and WWE 2010)



Additional Cumulative Analysis of July 2011 BMP Database

Descriptive Statistic	In-flow	Out-flow
Mean	0.36	0.27
Median	**0.22**	**0.14**
Std. Dev.	0.47	0.64
Minimum	0.002	0.001
Maximum	8.44	23.10
Count	3651	3661

Figure 2-2. Histogram and Cumulative Frequency Distribution for BMP Database Total P Data in Treated Effluent



Irreducible Concentrations of P in BMP-treated Effluent

Source: Pulaski County 2010, Prepared by Tetra Tech

Table A-2 Lower Limit Effluent Concentrations

Structural BMP	Concentration (mg/L)		
	TP	TSS	TOC
Extended Detention Wet Pond	0.084 n = 18 mne = 8	10.4 n = 19 mne = 8	9.9 n = 8 mne = 5
Extended Detention Dry Basin	0.121 n = 13 mne = 8	12.5 n = 14 mne = 8	10.9 n = 6 mne = 5
Extended Detention Stormwater Wetland	0.099 n = 17 mne = 8	7.9 n = 15 mne = 8	9.9 [b]
Bioretention	0.090 n = 9 mne = 8	6.8 n = 6 mne = 8	9.8 [a]
Sand Filter	0.071 n = 14 mne = 8	4.6 n = 14 mne = 8	9.8 n = 11 mne = 5
Grass Swale	0.233 n = 6 mne = 8	20.3 n = 6 mne = 8	13.4 [c]
Vegetated Filter Strip with Level Spreader	0.151 n = 12 mne = 8	12.8 n = 12 mne = 8	13.4 n = 12 mne = 5

[a] Bioretention TOC set equal to Sand Filter
[b] Stormwater Wetland TOC set equal to Wet Pond
[c] Grass Swale TOC set equal to Vegetated Filter Strip with Level Spreader

Notes
n refers to number of unique site BMPs used to calculate first quartile values
mne refers to the minimum number of events sampled for a site to be used in the analysis

Urban Stormwater BMP Costs

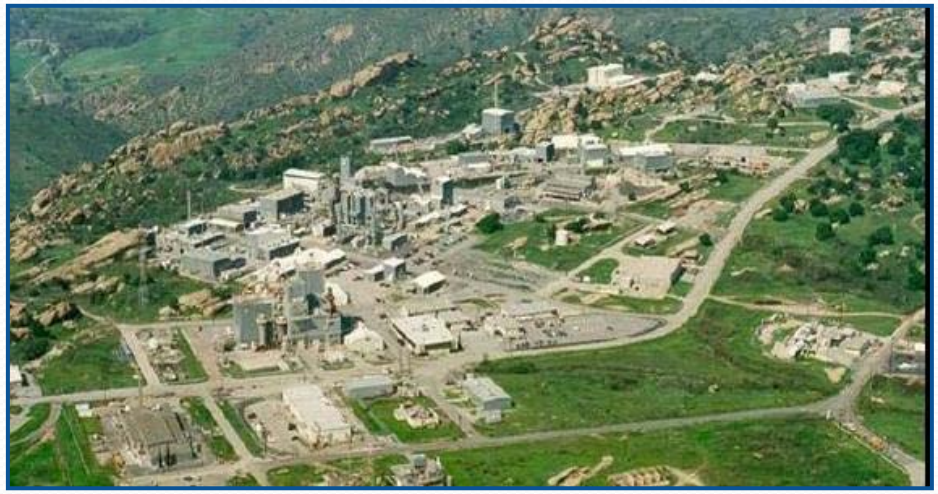
- Cost of retrofitting existing development are substantial:
  - Using bioretention and sand filters as examples
  - Costs are estimated $265 million to $ 1.05 billion in existing urban area in Arkansas in the Illinois River watershed (excluding long-term maintenance and operation)
- Even with these expenditures, implementation of such BMPs would not be expected to result in standard attainment during wet weather conditions.

Sand filter basin

Bioretention

Expected Level of Treatment Needed to Attempt Meeting a 0.037 mg/L TP Limit

- BMPs necessary to meet a 0.037 mg/L standard would likely require multi-stage treatment approaching WWTP-level practice:
  - Large storage basins
  - Chemical addition
  - Filtration
- Such facilities would be economically and physically unrealistic to implement at a watershed scale.



Santa Susana Research Facility
Ventura County, California

Finding 3. Other BMP Applications

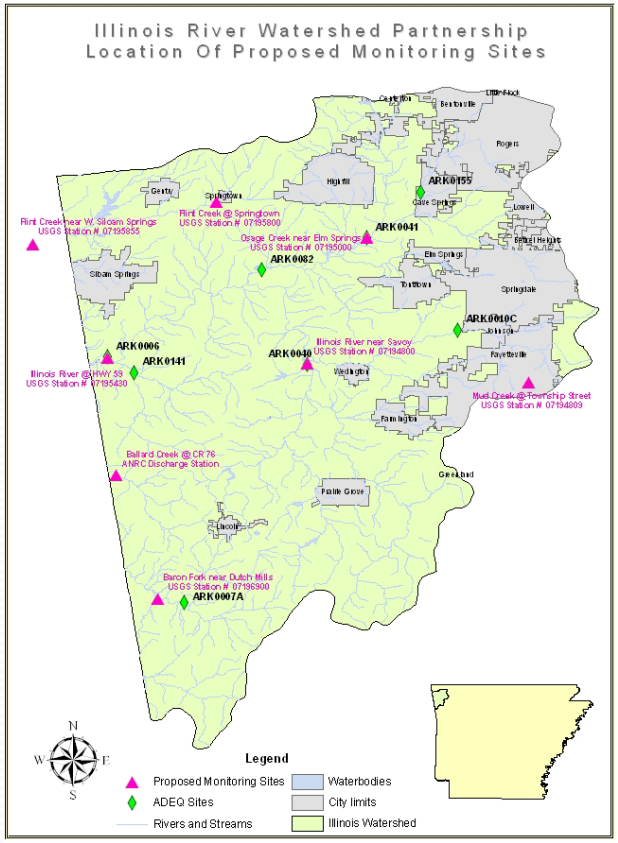
- BMPs applied in other settings have many benefits but are unlikely to result in consistent attainment of a 0.037 mg/L standard. Examples include:
  - Construction sites
  - Permeable turfgrass areas
  - Stream channels
    - Stream channel (stabilization efforts)
    - Streambed ("legacy" phosphorus issues)
  - Riparian corridors (preservation of buffers)
- Practical and economic limitations at a watershed scale.

Ozarks Stream Photo: Watershed Conservation Resource Center, 2011

Applewood Golf Course, Golden, Colorado

Finding 4. Use of Reference Stream Approach to Develop Total Phosphorus Standard

- A reference stream approach to establishing a phosphorus stream standard is not appropriate basis for a large watershed with a long-term human use and presence.
- Stream standards should be based on conditions necessary to protect beneficial uses for the specific stream being regulated.
- Standards should take into account specific stream characteristics and cause-and-effect relationships between nutrients and biological responses.

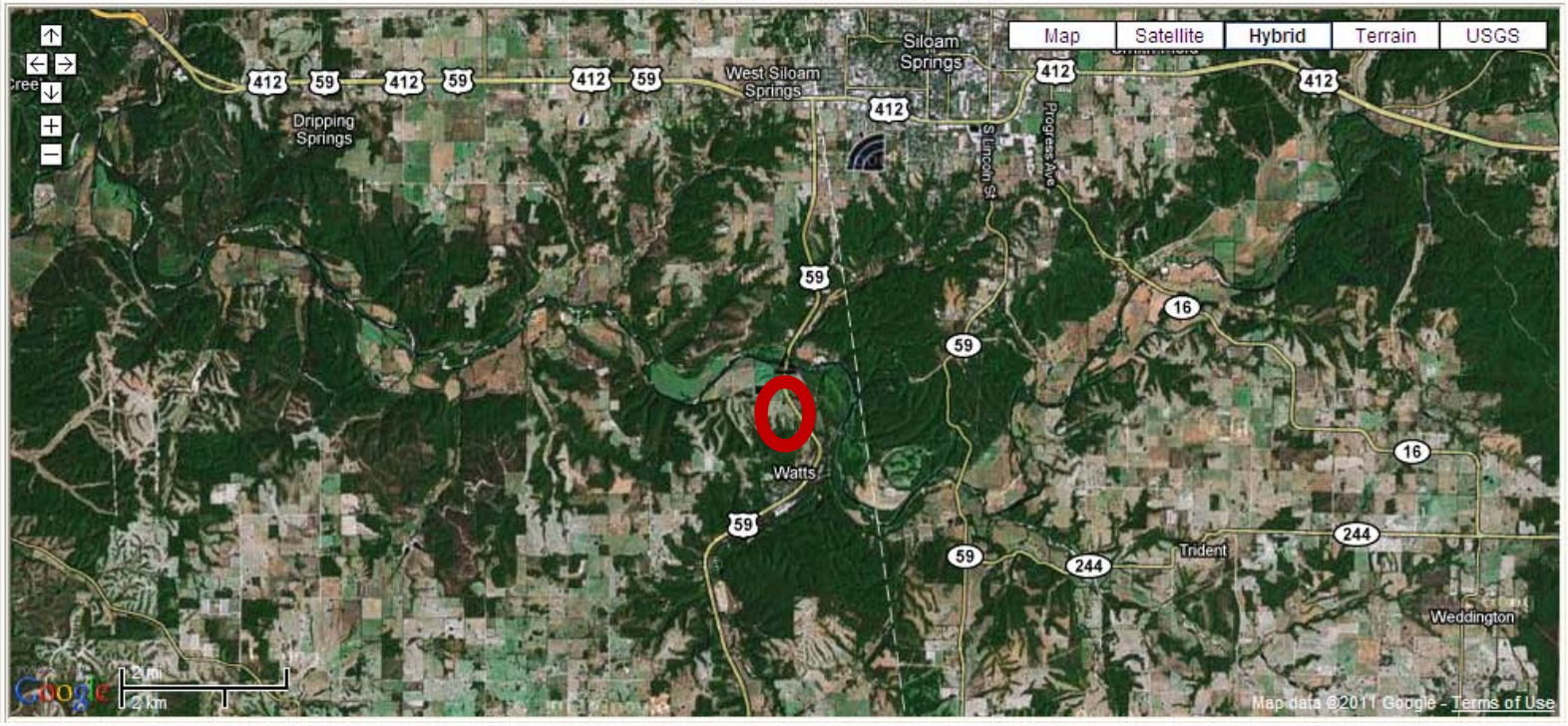


Map Source: Massey and Haggard 2010

Illinois River USGS Gage @ Watts

Adair County, Oklahoma
Hydrologic Unit Code 11110103
Latitude 36°07'48", Longitude 94°34'19" NAD27
Drainage area 635 square miles
Contributing drainage area 635 square miles
Gage datum 893.78 feet above NGVD29

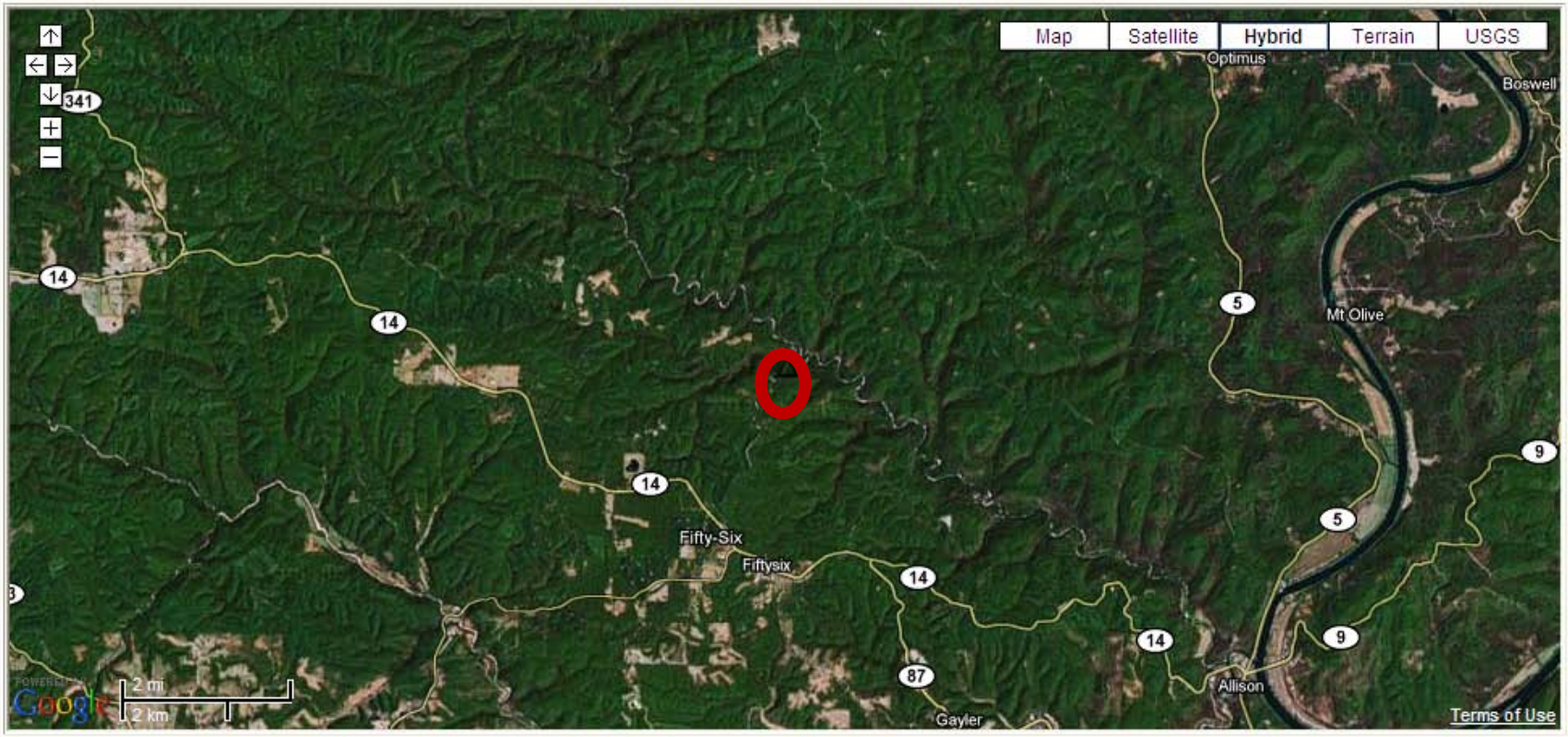
Location of the site in Oklahoma.



Sylamore Creek AR
(Reference Stream in Clark et al. 2000)

Stone County, Arkansas
Hydrologic Unit Code 11010004
Latitude 35°59'30", Longitude 92°12'50" NAD83
Drainage area 58.1 square miles
Gage datum 434.99 feet above NGVD29

Location of the site in Arkansas.



** References to non-U.S. Department of the Interior (DOI) products do not constitute an endorsement by the DOI. By viewing the Google Maps API on this web site the user agrees to these TERMS of Service set forth by Google.*

Examples of Key Differences Between Several Reference Streams in Clark Report and the Illinois River at Watts

- Drainage Area:
  - North Sylamore Creek, Cossatot River & Kiamichi River : 40-90 sq. mi.
  - Illinois River at Watts: over 635 sq. mi., and 1,600 sq. mi. overall.
  - Illinois River is a 6th-order stream, with substantially different physical, chemical and biological characteristics than lower order streams.
- Protected Tributary Area:
  - Buffalo River has been a protected national river since 1972 and a wide publically owned buffer for the length of the river. Other reference stream key land uses in AR include national forest or state parks.
  - Illinois River has long-term urban development (13%) in the upper watershed and active agricultural production (46% pasture/hayland).

Examples of Key Differences Between Several Reference Streams in Clark Report and the Illinois River at Watts

- Populations:
  - <2,000 people in each reference stream watershed in AR
  - >300,000 people in the upper Illinois River watershed
- WWTP Discharges (comparing AR reference streams):
  - No or small (0.1 MGD) municipal discharges in AR reference watersheds
  - Five municipal WWTPs with a combined permitted discharge of 40 MGD in the Illinois River.

National Recognition for Site-specific Factors Affecting Response to Nutrients

Protocol for Developing Nutrient TMDLs (EPA 1999): "Many natural factors, including light availability, temperature, flow levels, substrate, grazing, bedrock type and elevation, control the levels of macrophytes, periphyton, and phytoplankton in waters."

Gans Creek, Columbia, Missouri

National Recognition for Site-specific Factors Affecting Response to Nutrients (cont.)

Nutrient Criteria Technical Guidance Manual (EPA 2000): "…The geomorphology of a river or stream—its shape, depth, channel materials—affects the way the waterbody receives, processes and distributes nutrients."

Arkansas River, Southwest Kansas

High-Mountain Streams in Colorado

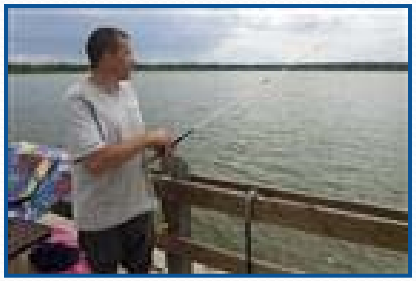
April 2010 Scientific Advisory Board (SAB) Ecological Processes and Effects Committee Review of EPA's Empirical Approaches for Nutrient Criteria Derivation

- "…. Numeric nutrient criteria developed and implemented without consideration of site specific conditions can lead to management actions that may have negative social and economic and unintended environmental consequences without additional environmental protection."

- "…statistical associations may not be biologically relevant and do not prove cause and effect. Without a mechanistic understanding and a clear causative link between nutrient levels and impairment, there is no assurance that managing for particular nutrient levels will lead to the desired outcome…"

- the SAB recommends … "a weight of evidence approach that is used to establish the likelihood of causal relationships between nutrients and their effects for criteria derivation."

Cherry Creek State Park, Denver, Colorado



Finding 5. Use of Models in Standard Review

- The TMDL modeling for the Illinois River should be a useful tool in reevaluating the standard, provided that the model is
  - properly calibrated,
  - validated, and
  - supported by appropriate uncertainty analysis.
- A good model should also help to better understand issues related to attainability and economic implications of the standard.
- The current parallel track of the modeling effort and standard review limit the extent to which the model findings will be able to be fully considered as part of a public process.

Conclusions Based on Findings 1-5

- Current total phosphorus standard is not consistently attainable in the Illinois River watershed.
- Reference stream approach is not an appropriate basis for nutrient standards for the Illinois River in Oklahoma.
- An alternative basis for the standard is needed that relies on "the weight of evidence" approach demonstrating "cause-and-effect" between stressors and response variables.
- Illinois River modeling has potential to be helpful in review of the standard, provided certain principles are met. Parallel track of standard and Illinois River modeling limits the use of this model.