Workshop on Reviewing and Critiquing Environmental Regulations and Documents

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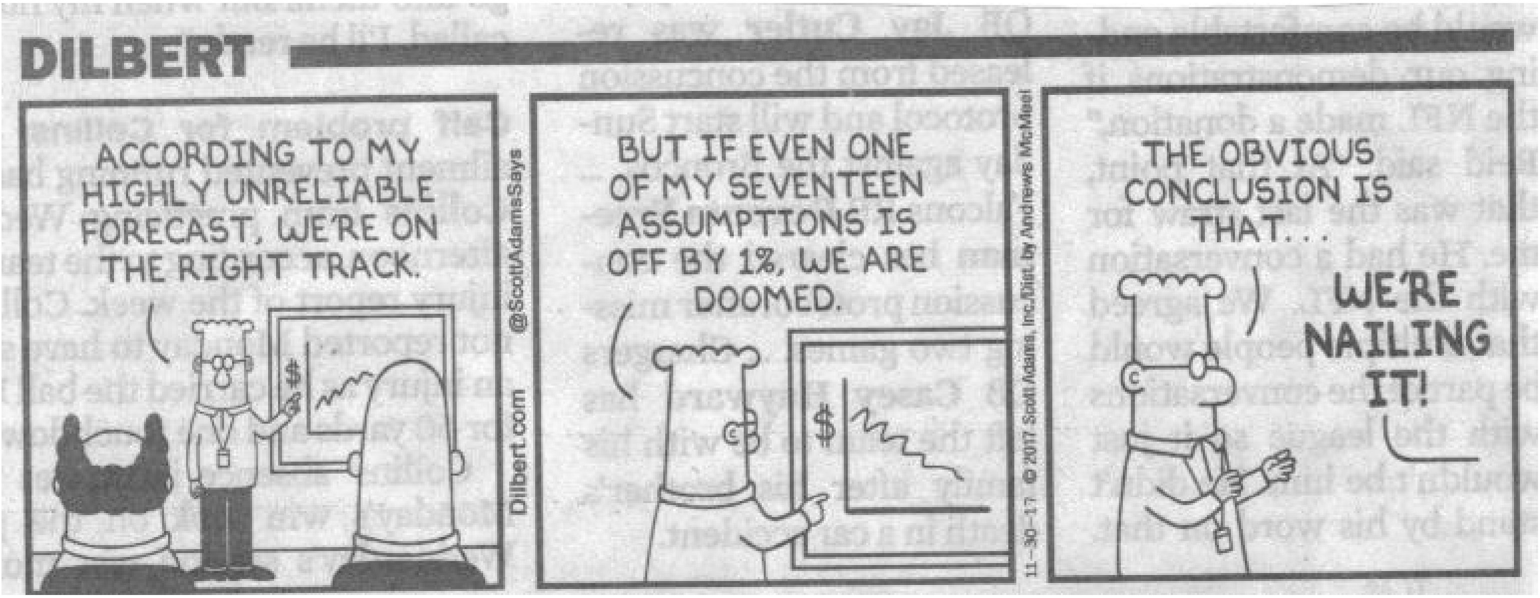
Topics for Discussion

- How to evaluate reports, research, and regulatory proposals
- Did the author
  - choose appropriate data sources
  - make proper assumptions
  - conduct suitable analyses
  - reach conclusions that are justifiable and supported by the information in the document
- Examples of less-than-optimal documents and how they were reviewed



Overview of the Approach

- Read documents
- Make notes and comments
- Evaluate the data used as well as other data sources that were not used
  - Intentional
  - Unintentional – unknown to the author
- Look for any assumptions made by the author
  - Clearly stated
  - Not stated or misleading
- Review the analytical methods used by the author
  - Appropriate choice
  - Proper calculations
- Verify that the conclusions are supported by the rest of the report
  - Could they be interpreted in an alternate way?

Environmental Documents – U.S. EPA

- In the development of its environmental regulations and reports, the EPA collects data, makes certain assumptions, and analyzes the data. The data may be technical or economic in nature, but the general approach is the same.
- Data are collected from published reports, from State regulatory agencies, through analyses conducted for EPA by contractors, and from the regulated community
- Before EPA receives the data, some assumptions have usually been made by the generators of the raw data that influence the way that data set is presented and perceived
- EPA assembles the data and adds a second level of assumptions

EPA Documents (2)

- Typically, EPA must combine multiple data sets generated by different sources and representing different sectors of the regulated community and different geographic regions
- After making its own assumptions, EPA performs some type of analysis, statistical or otherwise, to support its regulatory proposal
- If any component of this process is inappropriate, misleading, or misunderstood, the final result may be inaccurate
- Depending on the magnitude and number of individual errors, the final conclusion can be substantially different from a conclusion using more appropriate data, assumptions, and analysis

Implications and Impacts

- When the conditions of a proposed regulation have an economic impact on another party, the affected party is wise to review and critique all components of the analysis. In a national rulemaking, the economic stakes are usually high.
- It is the responsibility of the regulated community to examine and critique the data, assumptions, and analysis that go into a regulator's conclusion
- In most cases, the regulated community has a much more extensive and intimate knowledge of the activities being regulated than does the regulator
- Most major industry groups, including the oil and gas industry, have historically devoted extensive resources to reviewing and commenting upon significant EPA rulemakings

Brandolini's Law

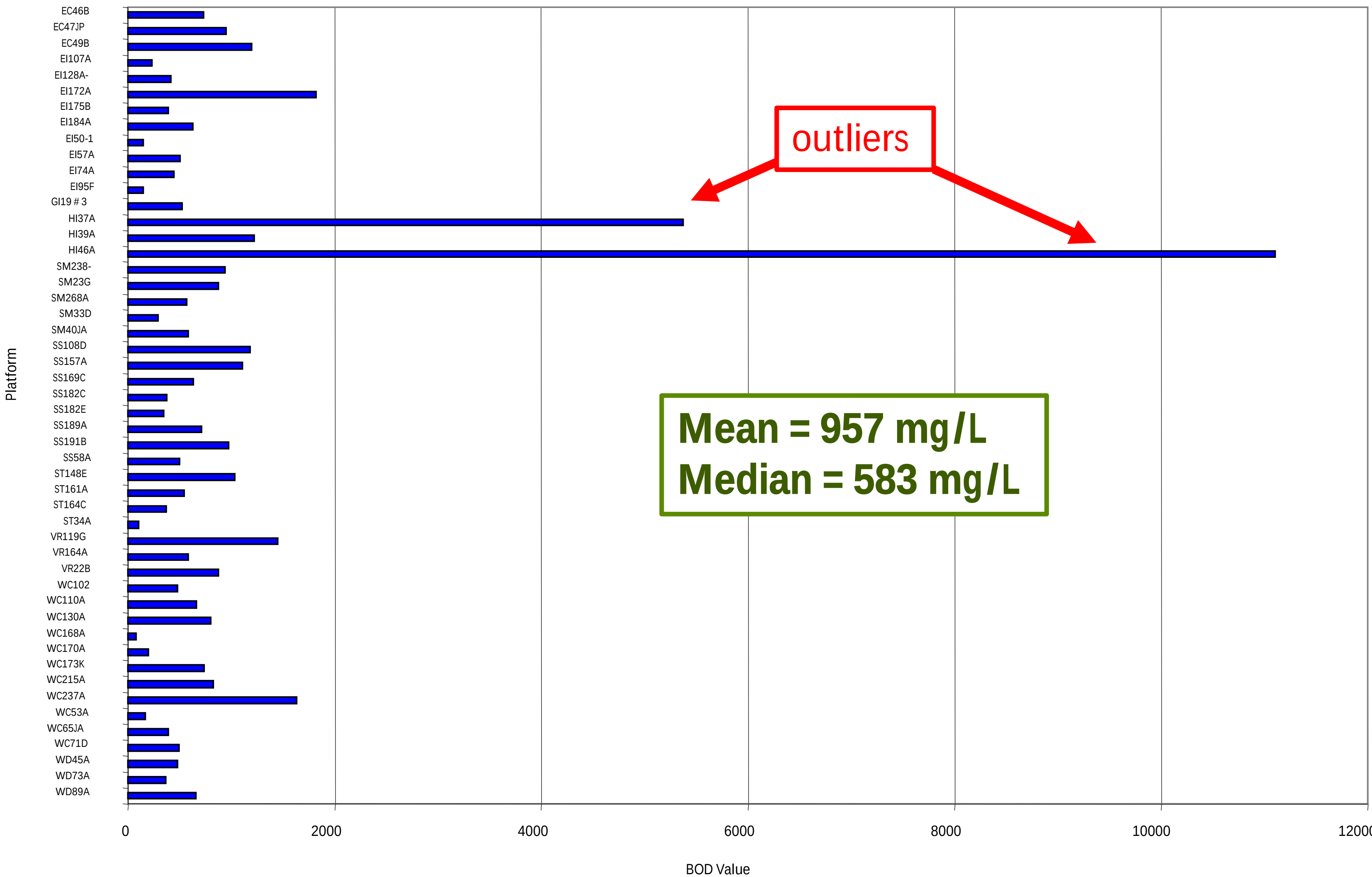
- Also known as the Bulls**t Asymmetry Principle
  - Alberto Brandolini - Italian independent software development consultant - 2013
  - http://ordrespontane.blogspot.com/2014/07/brandolinis-law.html

> "The amount of energy needed to refute bulls**t is an order of magnitude bigger than to produce it."

Data

- What data are used?
- How many data points make up data set?
- How are data displayed or referenced in the document?
  - Summary table
  - All data
  - Numerical vs. graphical
- Is there an explanation for why those data were selected?
- Are there other sets of data that could be added to the data set or be substituted for the existing data?
  - If so, is it obvious why the author did not use those data?
  - Can you supply any alternate and relevant data
    - Existing
    - Generate new data
- Are the data used relevant to answering the question at hand?
- How are outlier data points treated?

BOD Results from 50 Gulf of Mexico Platforms (in mg/L)



Data (2)

- Are units consistent and clearly identified?
  - mg/L vs. µg/L
  - ppm vs. ppb
  - These units are different by factor of 1,000
- How are the data characterized (average, mean, median, standard deviation, min/max, quartiles, etc)?
- How is uncertainty addressed?
- How are low data values (i.e., BDL - below detection level or ND - nondetectable) displayed?
- How are low data values treated when calculating averages or other statistics?
  - 0
  - Value of DL
  - ½ of DL

Calculating Average with Different Approaches

Pollutant	% of values BDL	Averaging Method (data expressed as mg/l)			
		Mean w/ BDL =DL	Mean w/ BDL = 0	Mean w/ BDL = 0.5DL	Median
Arsenic	33	0.420	0.407	0.414	0.011
Benzene	18	2.55	2.55	2.55	1.40
Copper	28	0.159	0.148	0.154	0.159
Iron	4	53.5	53.5	53.5	16.4
Lead	70	12.6	12.6	12.6	0.500
Mercury	65	0.131	0.130	0.130	0.0013
Naphthalene	48	0.123	0.098	0.111	0.058
Nickel	66	1.16	1.10	1.13	0.31
Pentachloro-phenol	99	0.192	0.003	0.098	no value given
Phenol	26	3.41	3.40	3.40	0.738
Silver	64	0.059	0.041	0.050	0.071
Thallium	64	0.566	0.409	0.488	1.10
Total Xylenes	41	0.454	0.447	0.451	0.35
Zinc	17	1.10	1.09	1.10	0.150

Assumptions

- Did the author state most/all of the assumptions and caveats they used?
- Are these clear and easy to follow?
- Are the assumptions reasonable/justifiable?
- Do you think that alternate assumptions would lead to a more accurate outcome?
- Are terms defined? If so, are the definitions realistic?

Analysis

- What types of analysis were used in the document?
  - Chemical analysis
    - Approved vs. non-approved methods
    - Calibration of instruments
    - QA/QC on sample collection, storage, and analytical methods
  - Numerical analysis
    - Simple equations
    - Complex models
  - Economic analysis
    - modeling

Analysis (2)

- Are these analytical choices appropriate to answer the question?
- Are there sufficient data of reasonable quality to conduct a legitimate analysis?
- Do the analyses require an excessive number of assumptions or caveats?
- Are the analytical results likely to reasonable reflect reality?

Other

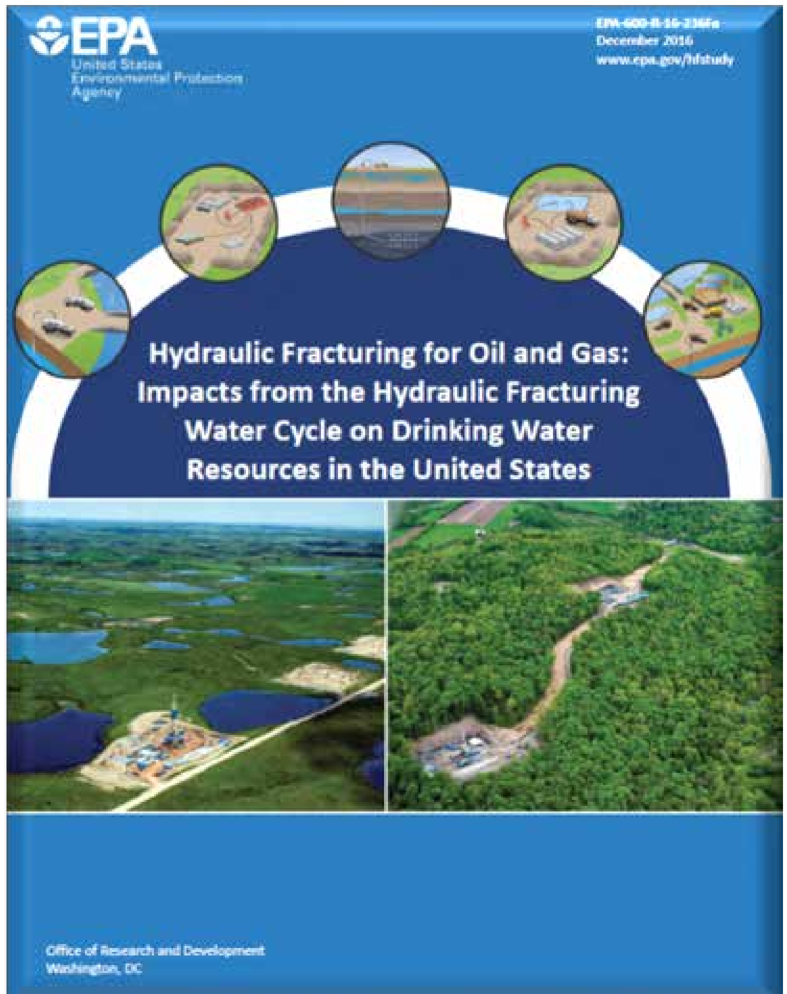
- Are data and “factual” statements referenced to other published work?
  - Peer-reviewed vs. other
- Are those references reasonably current and relevant?
  - Are alternate references better?
- Does the author have an obvious slant or agenda they are trying to promote?
- Do final conclusions reflect the information presented in the document?
  - Is enough evidence given through data and interpretation to support the conclusions?
- Are the conclusions factually correct but misleading?
  - Gasland video clip
  - Yale report on shale gas production and sexually transmitted illnesses

Other (2)

- In the case of regulations, are the proposed requirements justifiable under the legal authorities?
- Can it pass the “red-face test”?
- Reviewers should feel free to challenge any or all components of a report or proposal, but they should be prepared to provide a rationale for their objections
- A comment is more likely to result in a change if it includes a suggestion for an alternative component
  - Just objecting to something is not good enough

Example 1 – EPA Hydraulic Fracturing Study

- In 2009, Congress urged EPA to study the relationship between hydraulic fracturing and drinking water in the United States.



Final Report – December 2016

- The final HF study is a long and comprehensive effort that attempts to identify the potential of activities in the hydraulic fracturing water cycle to affect drinking water resources
- Consists of three documents -- an executive summary, the main assessment report, and a separate document containing appendices. Each of these is a large document, with a combined length of more than 1,200 pages.
- I read all three reports and prepared comments on the report for a client
- Portions of the report have exceptional value as current compilations of data and will serve as an excellent resource for future researchers and policy-makers
  - However the report does have various issues with data, assumptions, analysis, and portrayal of results

Comments Relating to Data

- EPA used FracFocus data from 2011 to 2013. The types of chemicals used in later years and the numbers of submittals to FracFocus changed notably since 2013. EPA may not be using currently relevant data.
- The large number of chemicals on EPA's lists as well as other lists that have been compiled by fracking opponents can be misleading and are often made part of anti-fracking literature. In reality, for any given frac job, a much small number of chemicals is used.
- EPA gave three case examples to highlight suggested drinking water contamination from HF (Dimock, PA; Pavillion, WY; and Kern County, CA). Upon close examination of the facts and interpretations, none of these are clear-cut examples that indict oil and gas operations.
- EPA notes that the amount of produced water from a well varies and depends on several factors. However, its discussion is limited to unconventional formations. EPA does not discuss produced water from conventional formations. Hundreds of thousands of U.S. wells produce from conventional formations.

Comments Relating to Data (2)

- EPA presents information about the extent of roadspreading as a means of managing or disposing produced water. EPA cited a report published by the American Petroleum Institute in 2000.
- The API (2000) data were collected in a survey during 1996 that looked at 1995 data. That information is now over 20 years old. Many changes to oil and gas regulations and management practices have been made since then, such that those volumes are unlikely to be representative any longer.
- Several northern states continue to allow produced water from conventional wells to be applied to roads under certain conditions. Generally flowback and produced water from fractured wells is not allowed to be applied to roads.

Comments Relating to Assumptions

- EPA defines drinking water resources as: *"any body of groundwater or surface water that now serves, or in the future could serve, as a source of drinking water for public or private use."* However, it is unrealistic to open the door infinitely wide to allow any water source that could potentially be used at any time in the future. This unreasonably broadens EPA's scope.
- EPA suggests that wells are frequently refractured – they are not, at least not during the years when the study was being prepared.

Comments Relating to Assumptions (2)

- EPA correctly notes that spills of chemicals do not have equal impacts on surface and ground water supplies. The concept of varying levels of risk and using a risk assessment protocol to evaluate that risk is very important. Often it is not accepted or understood by members of the public or opponents to oil and gas. In their minds, any spill is a catastrophe.
- EPA data show that spills of chemicals and mixed frac fluids can occur, but they are uncommon. When spills do occur, they most often reach soils where the spills are cleaned up leaving minimal opportunities to affect drinking water. EPA was unable to identify any cases in which spills impacted ground water resources.

Comments Relating to Analysis

- Table F-3 in Appendix F is an interesting attempt by EPA to generate estimates of treatment performance by combining limited data from a variety of literature sources. However, the resulting numbers do not reflect real data.
  - Percent removal by different technologies
  - Influent concentrations of chemicals in different fields
  - Resulting concentrations following treatment
  - It is likely that those performance levels will be cited by future authors without the recognition that the values were generated with lots of assumptions and uncertainties
- This creates a dangerous precedent and does not reflect reality
  - Levels of uncertainty are compounded by combining already uncertain data sets

Comments Relating to Analysis (2)

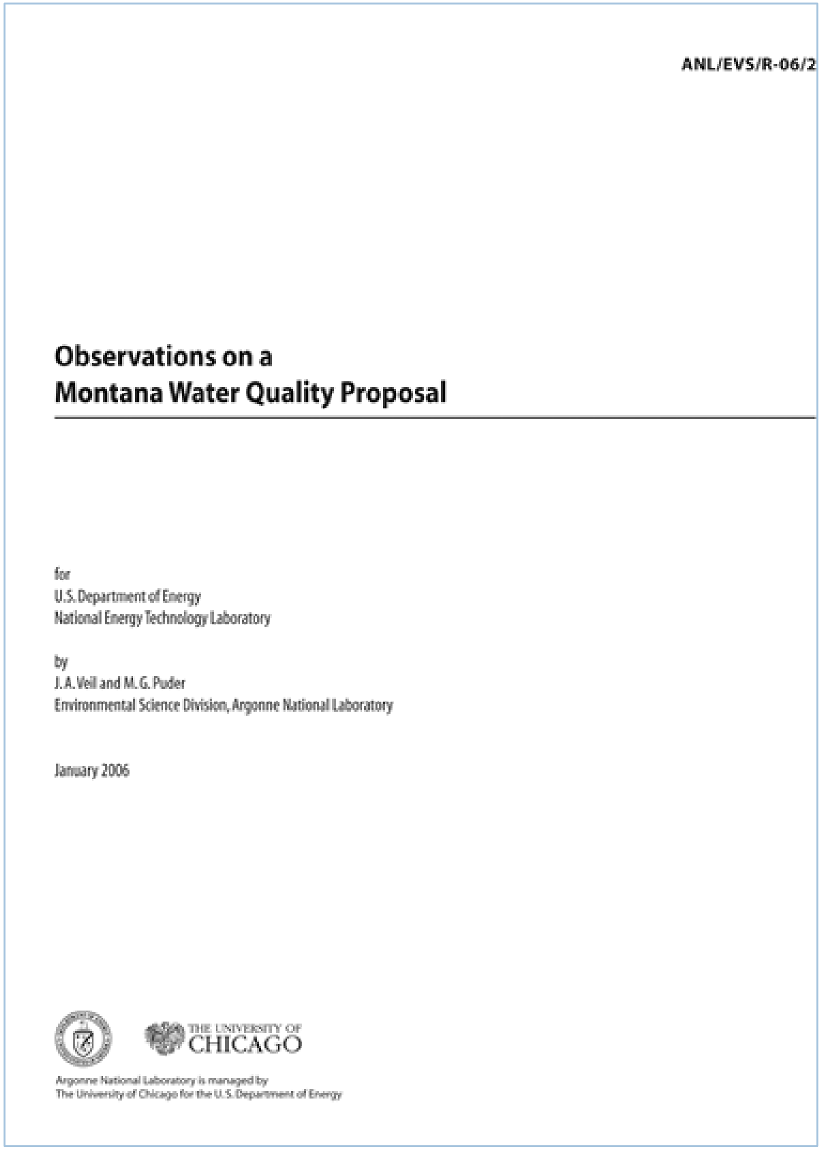
- EPA indicates that certain chemicals were found in drinking water resources (presumably in surface water samples). The presence of those chemicals by itself poses no particular risk, however. It is the presence of those chemicals at concentrations exceeding a toxicity threshold that is the key factor. EPA has not documented that the chemicals were found at concentrations exceeding a toxicity threshold at a point where the water is actually withdrawn for drinking water purposes.

Comments Relating to Portrayal of Results

- After several years of effort, EPA released a draft version of the HF study in June 2015. One of the most widely cited conclusions from that study was: *"We did not find evidence that these mechanisms have led to widespread, systemic impacts on drinking water resources in the United States. ….. The number of identified cases, however, was small compared to the number of hydraulically fractured wells."*
- EPA states in the Conclusion chapter of the final 2016 report: "*Overall, we conclude activities in the hydraulic fracturing water cycle can impact drinking water resources under some circumstances. Impacts can range in frequency and severity, depending on the combination of hydraulic fracturing water cycle activities and local- or regional-scale factors."*
- This is a reasonable statement, but persons with different viewpoints may interpret this language in different ways because the text included several qualitative words or terms.
- Change in tone of language in final
  - Timing - end of Obama Administration

Example 2 – Critique of a Montana Proposed Regulation on Coal Bed Methane

- During the fall of 2005, the Montana Board of Environmental Review (BER) announced proposed changes to the Montana water quality regulations directed toward discharges of water from coal bed methane (CBM) production.
- DOE reviewed the BER proposal and believed that the proposal could restrict CBM production in Montana and Wyoming. To aid in the review of the proposal, DOE asked Argonne National Laboratory to review and comment on proposal
  - I prepared a written report and later traveled to Montana to testify at the hearing


ANL/EVS/R-06/2

Observations on a
Montana Water Quality Proposal

for
U.S. Department of Energy
National Energy Technology Laboratory

by
J. A. Veil and M. G. Puder
Environmental Science Division, Argonne National Laboratory

January 2006

THE UNIVERSITY OF CHICAGO

Argonne National Laboratory is managed by
The University of Chicago for the U.S. Department of Energy

Comments on BER Proposal

- Does the proposal consider CBM produced water as an undesirable pollutant or as a valued resource?
  - Inconsistent characterization in different parts of the proposal
- Did the BER proposal adequately follow federal CWA authority and guidance concerning technology-based effluent limits?
  - Does not follow the CWA guidelines for establishing technology-based limits (either BAT or BPJ)
  - Failed to identify a model technology that is affordable and in current use
  - Chose to require zero discharge instead of a discharge limit
  - Required dischargers to use a specific technology rather than setting an acceptable discharge limit and allowing dischargers to find technology to achieve the limit
  - Based some of the justification for requiring zero discharge on the costs of disposal wells, but used costs from an EPA report that had never been released and was marked “InterAgency Draft Report — DO NOT QUOTE OR CITE”

Comments on BER Proposal (2)

- Does the proposal preclude the use of other innovative or beneficial technologies?
  - Some of the existing uses of CBM water provide affordable management for operators while providing direct benefit to landowners. For example, managed irrigation or off-channel impoundments that can provide livestock watering and recreational opportunities for landowners. The wording of the proposal would not allow these valid and beneficial uses of water nor would it encourage development of more cost-effective water management technologies.
- Are the proposed discharge standards stricter than needed to meet Montana water quality standards?
  - The proposed effluent limits are much stricter than necessary to meet water quality standards in Montana water bodies. Dischargers must treat to levels significantly cleaner than the receiving waters.
  - The proposal appears to blur the distinction between technology-based limits and water-quality-based limits. Technology-based limits ignore the potential impact on water quality and are only concerned with the performance of one or more technologies. Thus, it is inappropriate to justify a technology-based limit by saying it is necessary to achieve water quality.

Example 3 -- Critique of July 2012 Fact Sheet from Natural Resources Defense Council

WATER FACTS

Hydraulic Fracturing Can Potentially Contaminate Drinking Water Sources

Communities across the country are concerned about the risks that oil and gas production using fracking poses to drinking water sources. Hydraulic fracturing, or fracking, is the practice of injecting water, chemicals, and proppant[1] at high pressure into a gas or oil well. The high-pressure injection fractures or re-fractures the rock, stimulating oil and gas production. But scientists and environmentalists are increasingly concerned about groundwater and surface water contamination that may be associated directly or indirectly with fracking. NRDC opposes expanded fracking until effective safeguards are in place. To protect drinking water sources from contamination, NRDC urges the use of key management practices to minimize the risks associated with fracking activities. This includes (1) federal regulation of all hydraulic fracturing under the Safe Drinking Water Act, (2) regulation of toxic oil and gas waste under federal and state hazardous waste laws, and (3) stronger standards and enforcement under the federal Clean Water Act and state laws.

NRDC

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Excerpt from 2nd page

Mismanagement of fracking waste

After fracking, some of the fracking fluid, often referred to as flowback, returns up the wellbore to the surface. In addition, naturally-occurring fluid is brought to the surface along with the produced oil or gas (referred to as "produced water.") This waste, consisting of both flowback and produced water, can be toxic, and the oil and gas industry generates trillions of gallons of it each year.[4] In addition to the chemicals that were initially injected, flowback and produced water may also contain hydrocarbons, heavy metals, salts,[5] and naturally occurring radioactive material (NORM). The wastewater is sometimes stored in surface pits. If the pits are inadequately regulated[6] or constructed, they run the risk of leaking or overflowing and can pollute groundwater and surface water.[7] The waste may also be disposed of on the surface, reused in another well, re-injected underground, or transported to a treatment facility. Each of these activities carries its own inherent risks, including spills, leaks, earthquakes (in the case of underground injection) and threats to groundwater and surface water.

Comments on this Statement

- The reference for this statement (#4) refers to a 2012 GAO report. The primary source of information GAO discusses relating to produced water volume is a 2009 Argonne National Laboratory report that evaluated produced water volumes for the 2007 calendar year (I was the project manager and a co-author of that Argonne report).
  - Undesirable to cite a secondary or tertiary reference – don't always understand the basis and assumptions used to prepare the original data and conclusions.
- The volume estimate was 21 billion bbl of all types of produced water for the entire year. This equals 882 billion gallons in a year.
  - While this is nearly 1 trillion gallons, it is not "trillions".
- This number reflects produced water from all types of oil and gas production, not just shale gas.
  - In 2006 and 2007, when the data were collected, only a small percentage of all produced water came from unconventional wells. The actual volume of wastewater resulting from unconventional wells at that time was far lower than trillion of gallons.

Other Applications

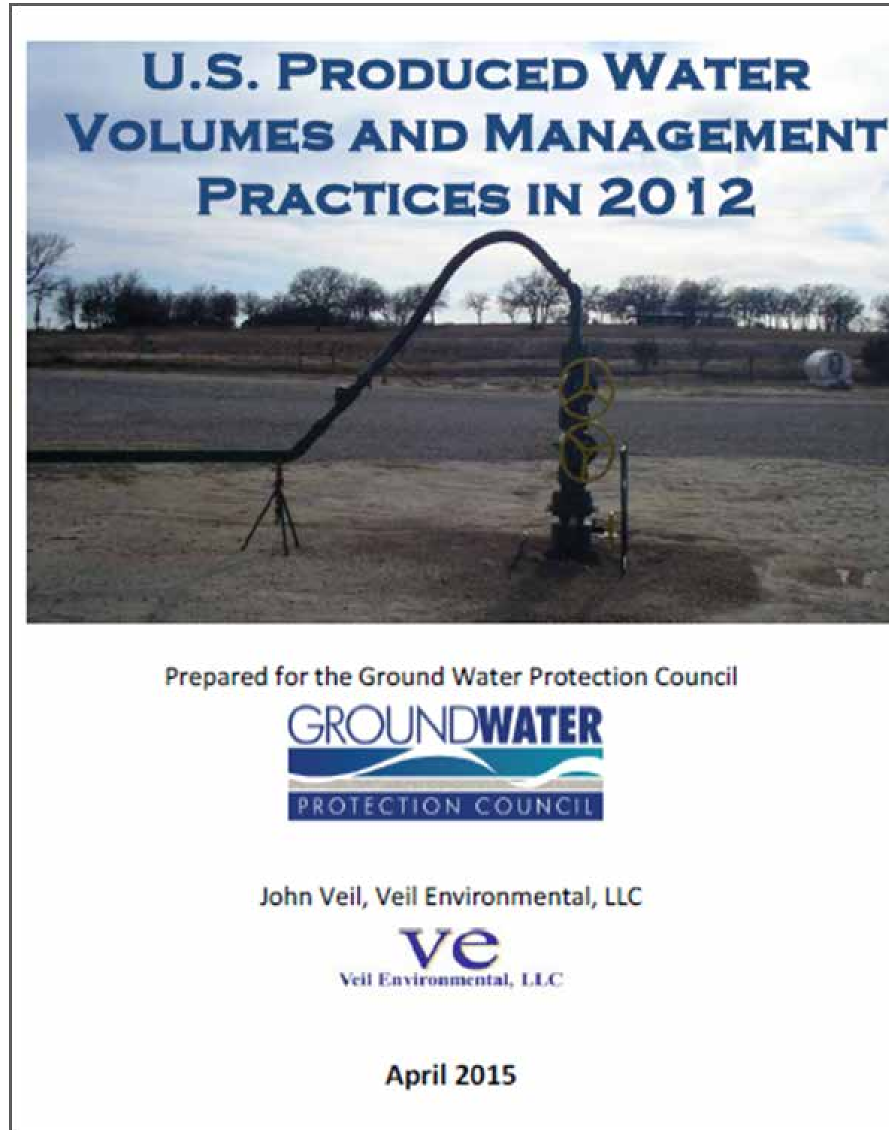
- Expert witness work
  - Review documents prepared by opposition
  - Assist your client's lawyer in finding flaws in opposition case
- Preparation of your own reports
  - Follow the same approach to make the reports as strong as possible and able to withstand scrutiny
- Peer reviewing manuscripts for scientific journals
- Factual but misleading efforts
  - Gasland flaming faucet scene
  - Report by Yale School of Public Health
- Can be intentional by the authors, or made sensational by the media

Expert Witness

- I cannot talk about details or identities of my clients in this presentation
- The case involved underground injection practices
- The organization filing the lawsuit against my client hired an expert witness who had served in that capacity many times
  - The person knew oil and gas issues, but was not an expert on injection
- I was hired to review that “expert’s” written material and conclusions about injection practices
- I found many flaws in data, assumptions, and analysis
- I prepared a rebuttal report for my client and sat for a deposition by the opponent’s lawyer
- Case was settled prior to trial

Following the Approach in My Own Reports

- 2015 produced water report done for the Ground Water Protection Council
- Collected data from oil and gas and environmental agencies in 31 states.
  - They had differing degrees of data detail and quality
- In order to compile data from all sources, I needed to fill in many gaps and use assumptions and extrapolations
  - These were explained as clearly as possible in the text



Requests for Data

- Produced water, oil, and gas volume data

Type of Hydrocarbon	# Wells Producing Primarily That Type of Hydrocarbon	Total Volume of Produced Water Brought to Surface (bbl/year)	Volume of Hydrocarbon Produced (bbl/year or Mmcf/year)
Crude oil from conventional formations			
Natural gas from conventional formations			
Crude oil from unconventional formations			
Natural gas from unconventional formations			
Other			
Total			

Requests for Data (2)

- Produced water management data

Management Practice	# Wells Using That Practice	Total Volume of Produced Water Managed by That Practice (bbl/year)	Percentage of Produced Water Managed by That Practice
Injection for enhanced recovery			
Injection for disposal			
Surface discharge			
Evaporation			
Offsite commercial disposal			
Beneficial reuse			
Other			

Colorado Example

- Data on water production were initially obtained from a large database on the COGCC website. More recent data were provided by Thom Kerr (consultant who had recently retired from the COGCC).
- The volume of flowback water from wells that had been hydraulically fractured is typically not included in the disposal volumes. Mr. Kerr calculated a flowback volume that was added to the other produced water.

Type of Hydrocarbon	# Wells Producing Primarily That Type of Hydrocarbon	Total Volume of Produced Water Brought to Surface (bbl/year)	Volume of Hydrocarbon Produced (bbl/year or Mmcf/year)
Crude oil from conventional and unconventional formations	18,000	331,349,662	49,361,146 bbl/yr
Natural gas from conventional and unconventional formations	32,000		1,104,038 Mmcf/yr
Crude oil from unconventional formations	no data		no data
Natural gas from unconventional formations (shale and CBM)	no data		605,339 Mmcf/yr
Other – flowback water from hydraulically fractured wells	no data	27,039,785	no data
Total	50,000	358,389,447	49,361,146 bbl/yr 1,709,377 Mmcf/yr

Colorado Example (2)

- Data on produced water management methods were not available from the COGCC website. COGCC staff suggested that they do receive monthly reports from the operators. The reports indicate how much water was managed in one of five ways:
  - Commercial disposal facility (this represents water sent to commercial pits)
  - Onsite pit (most of the water evaporates, or the excess water was hauled to disposal wells)
  - Central disposal pit (These are central facilities owned by a single producer. Water from multiple wells was collected and managed in a centralized location. Some water was recycled but much was injected into disposal wells)
  - Injected (This water was injected into wells under the COGCC's UIC authority. Roughly half of this water was injected for purposes of enhanced recovery)
  - Surface discharge (This water was either fresh or treated to acceptable standards and discharged to a surface water body).
- The COGCC maintains this information in an internal database. Mr. Kerr was able to query the database to provide the composite volumes of water managed in each of those general categories.

Colorado Example (3)

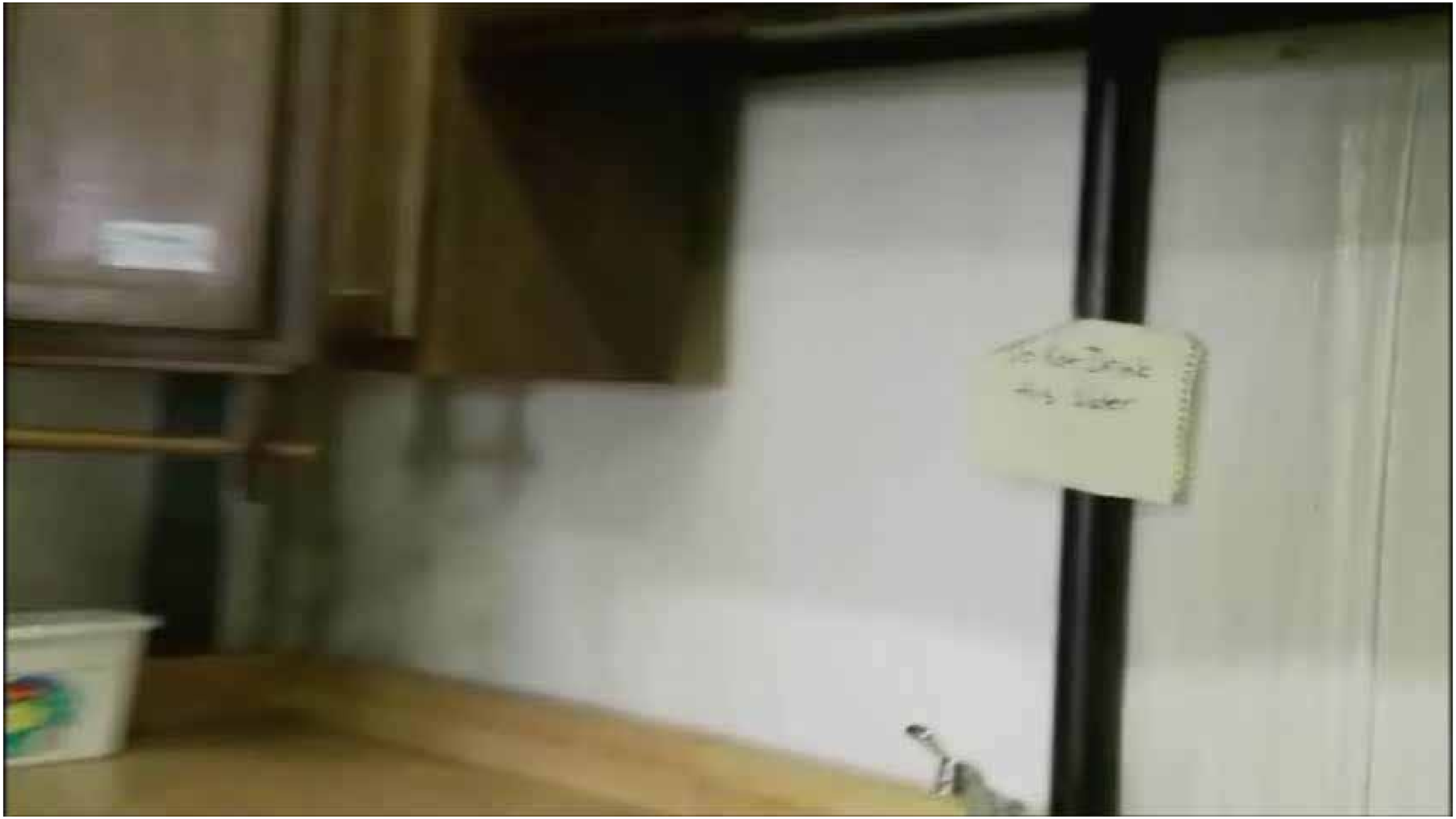
- Mr. Kerr also provided estimates of the volume of water injected for disposal vs. the volume injected for enhanced recovery
- The data provided by him were very helpful but they required some recalculation and assumptions before entering them into the water management tabular format used for the other states. The table shows those data. A list of assumptions was provided in the report

Management Practice	# Wells Using That Practice	Total Volume of Produced Water Managed by That Practice (bbl/year)	Percentage of Produced Water Managed by That Practice
Injection for enhanced recovery	445	123,854,742	31.5%
Injection for disposal	292	123,889,551	31.5%
Surface discharge	no data	40,315,420	10.3%
Evaporation	no data	35,002,477	8.9%
Offsite commercial disposal (pits)	no data	22,392,182	5.7%
Beneficial reuse (recycled produced water and flowback used to make new frac fluids)	no data	47,648,287	12.1%
Total Volume Managed		393,102,659	

Peer Review Process

- Most scientific journals require that manuscripts get reviewed by other “peers”
  - Ironically, authors are asked to provide names of potential reviewers
- I have reviewed numerous manuscripts and often found
  - Poor choices of data
  - Failure to acknowledge or use legitimate data (particularly in other “grey literature”
  - Failure to provide clear explanations of assumptions made and why they were made
  - Overly complicated analyses (modeling) to develop conclusions
  - Reliance on modeling results that may contradict real-world situations
- When an author uses poor terminology or is sloppy in writing introductory material, it raises questions about whether the data, assumptions, and calculations are sloppy too

Factual but Misleading Material (1) - Excerpt from Gasland Movie



Factual but Misleading Material (2) - Yale School of Public Health Study

PLOS | ONE

RESEARCH ARTICLE

Shale gas activity and increased rates of sexually transmitted infections in Ohio, 2000–2016

Nicole C. Deziel[1*], Zoe Humeau[1,2], Elise G. Elliott[1], Joshua L. Warren[3], Linda M. Niccolai[4]

1 Yale School of Public Health, Department of Environmental Health Sciences, New Haven, CT, United States of America, 2 McGill University, Montreal, Canada, 3 Yale School of Public Health, Department of Biostatistics, New Haven, CT, United States of America, 4 Yale School of Public Health, Department of Epidemiology of Microbial Diseases, New Haven, CT, United States of America

- The study found that Ohio counties with high shale gas activity experienced 21% higher annual rates of chlamydia and 19% higher annual rates of gonorrhea, compared to counties with no shale gas activity, after adjustment for secular trends and other confounders
- They acknowledged that this was not due to chemical effects from the shale gas activity, but was related to the transient and mostly male work force
- Media did not make that distinction and sensationalized the results

Example of a Complex Study Involving Field Sampling from Numerous Locations

- Special attention paid to data, assumptions, analysis
- Relevant data, carefully collected and analyzed, and appropriate modeling work allowed for good science to influence regulatory policy
- Good results required good planning and preparation

2004-2005 Study of Produced Water Discharges to the Gulf of Mexico Hypoxic Zone

- Each year, a large hypoxic zone (dissolved oxygen <2.0 mg/L) forms in the near-shore Gulf of Mexico
- Primary contribution is nutrient inputs from Mississippi River and Atchafalaya River
- Nutrients cause rapid growth of phytoplankton
- Later these die off and sink to the bottom where they are decomposed by microorganisms
  - This depletes the available oxygen

Basis for Study

- No good data existed on the oxygen-demanding properties of produced water
- EPA did not want to continue produced water discharges indefinitely without having data and analysis to show the level of impact caused by the discharges
  - In other words, EPA wanted to evaluate the risks to Gulf of Mexico water quality posed by produced water discharges
- EPA issued a permit in late 2004 requiring a sampling program involving many platforms with the results being submitted by August 2005

Project Goal

- Provide information on the concentration of nutrient and oxygen demanding chemicals present in Gulf of Mexico produced water discharges
- Estimate loadings of those parameters from all platforms in the hypoxic zone
- Compare loadings to other sources of pollutants that contribute to hypoxic zone

Sample Design and Schedule

- Sampled 10% of approximately 500 discharges in the hypoxic zone
  - 16 platforms sampled three times
  - 34 platforms sampled one time
- Parameters tested

Measure Indirect Oxygen Demand

ammonia

nitrate

nitrite

total Kjeldahl nitrogen (TKN)

total phosphorus

orthophosphate

Measure Direct Oxygen Demand

BOD

TOC

Other Parameters

pH

conductivity

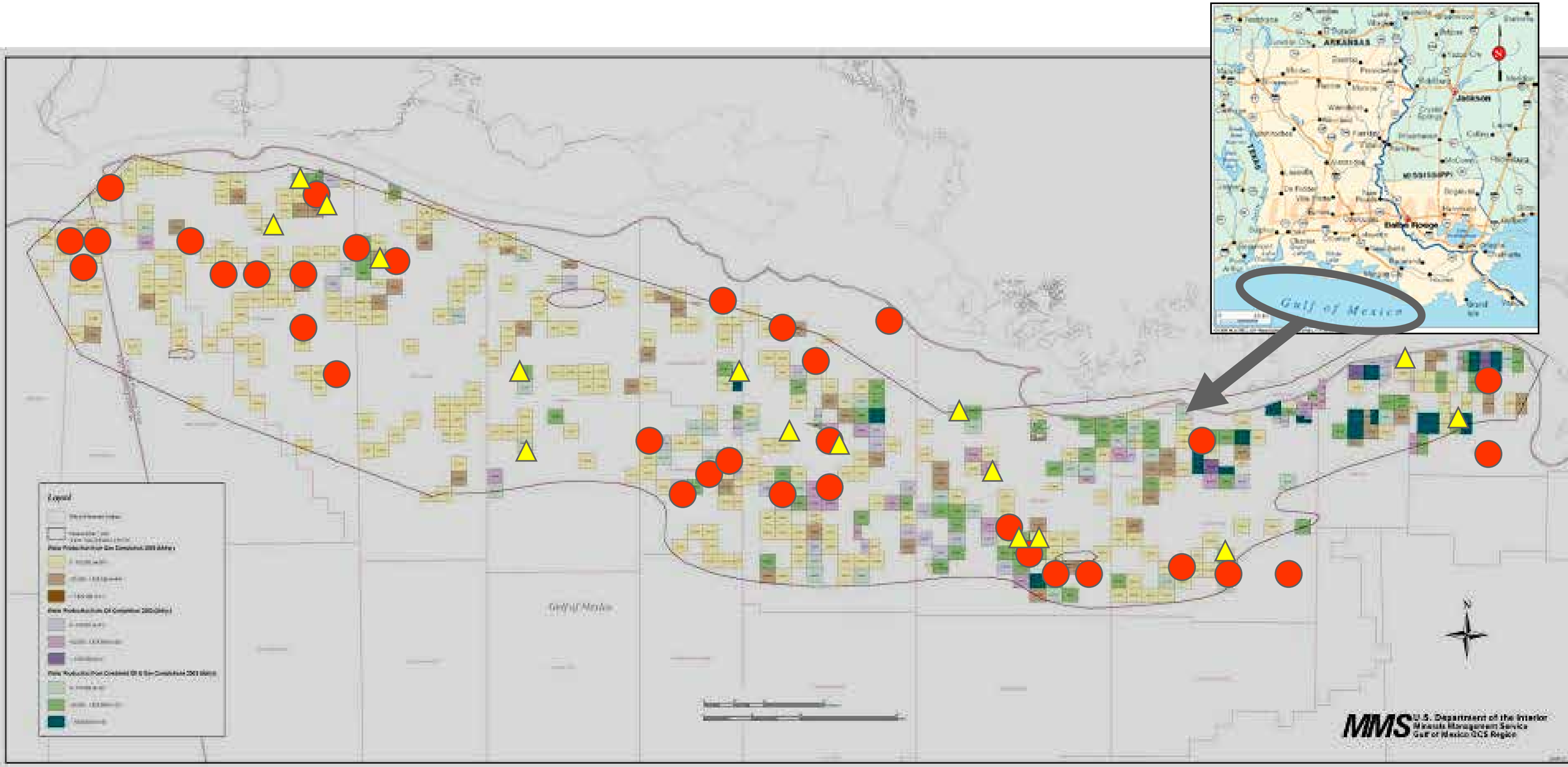
salinity

temperature

Selection of Sampling Sites

- For the 16 sites tested 3 times, subdivide hypoxic zone lease blocks into 3 water production rate classes (< 500 bbl/day, 500 – 5,000 bbl/day, >5,000 bbl/day) and 3 hydrocarbon production type classes (oil completions, gas completions, both types of completions)
  - Select at least 1 facility from each of the 9 subcategories
- For the 34 sites tested one time, select locations at random

Location of Platforms Sampled for Hypoxic Zone Produced Water Study



- ● Platforms sampled one time and selected at random
- △ Platforms sampled three times and selected based on discharge volume and type of hydrocarbon produced

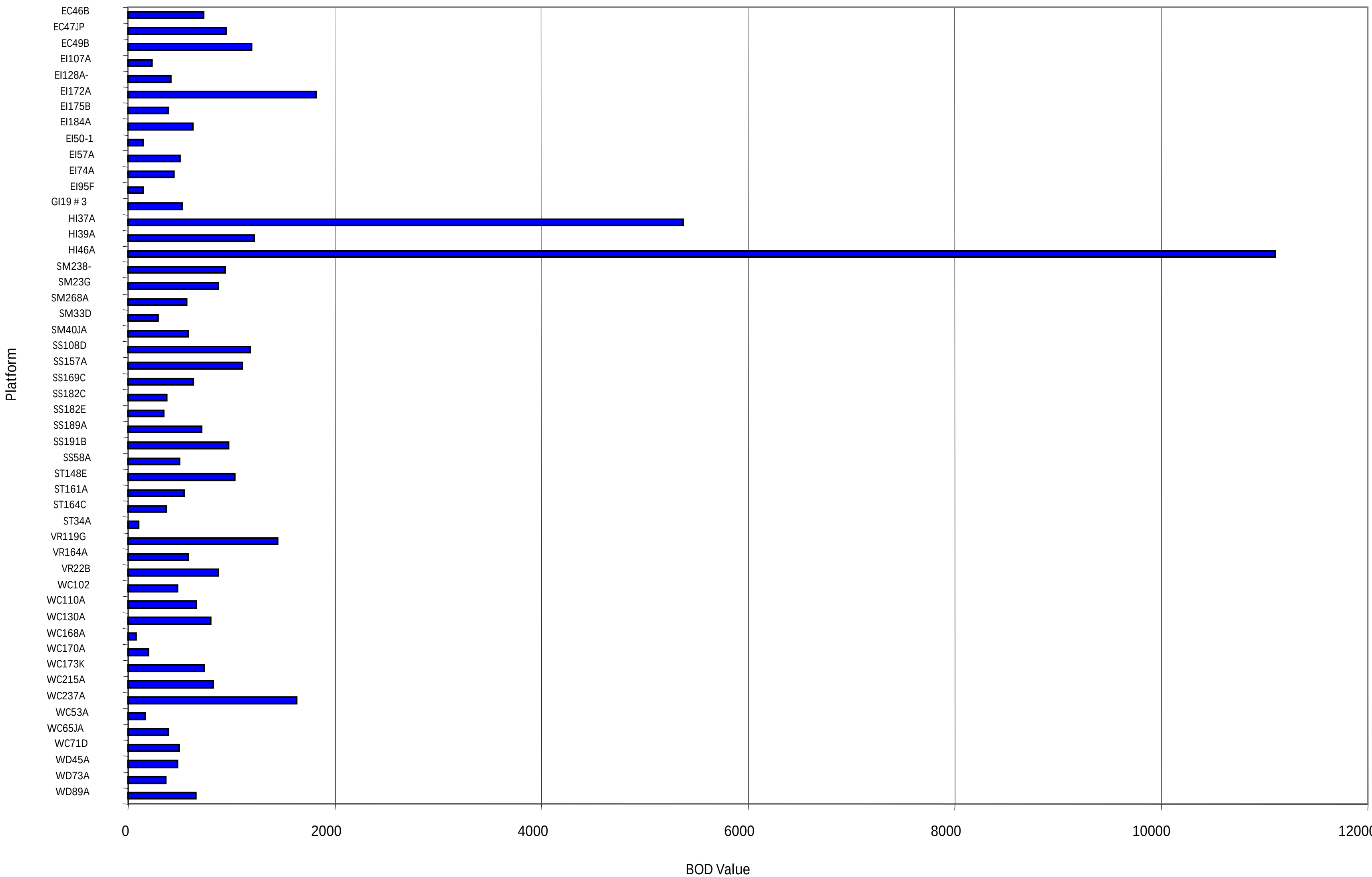
QA/QC Measures

- QA plan was developed before sampling begins
  - Sampling measures
    - Blanks
    - Duplicates
  - Analytical measures
    - Calibration
    - Matrix samples
    - Blanks

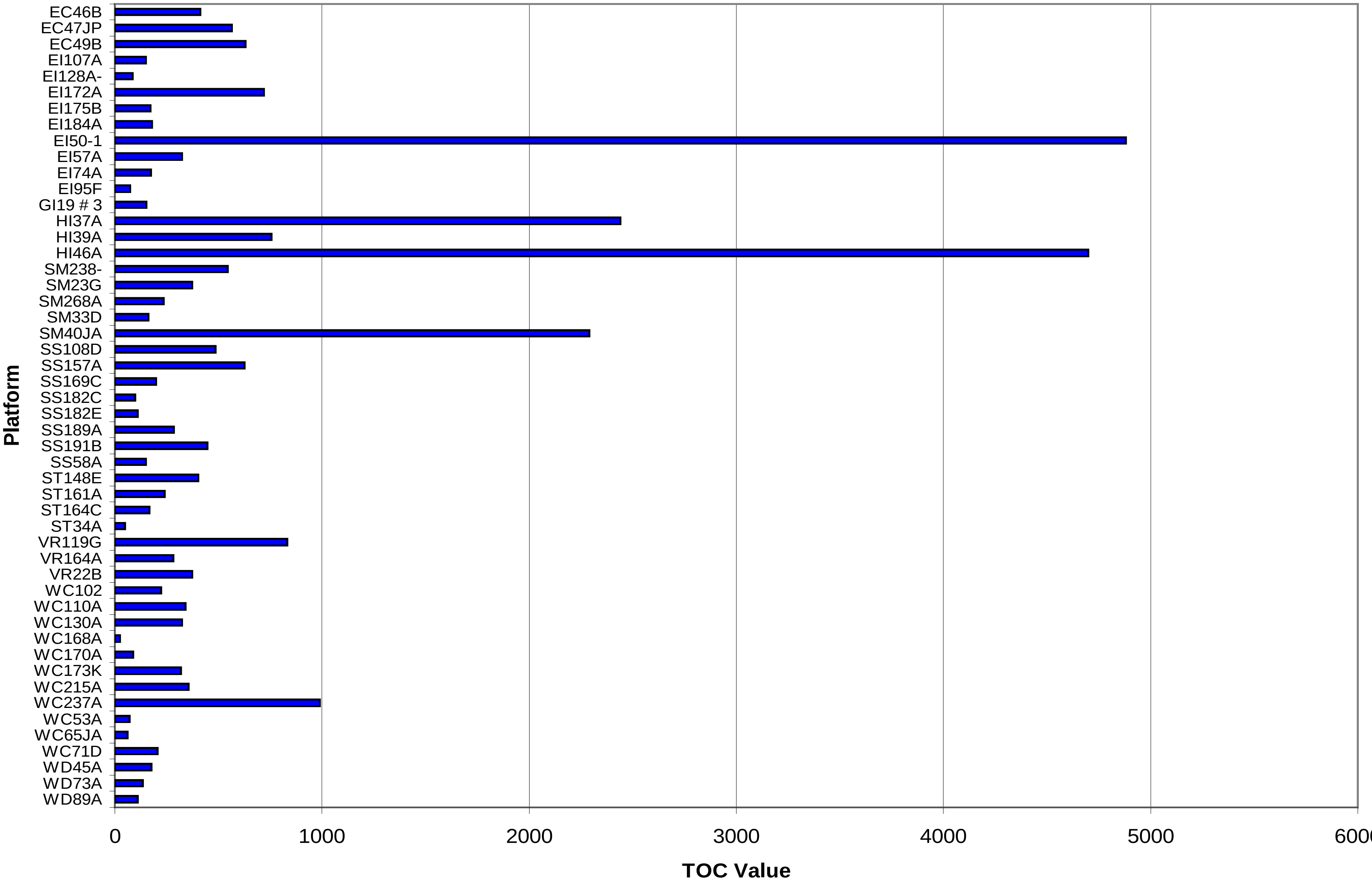
Summary of Analytical Data

Parameter	Mean	Median	Maximum	Minimum
BOD, mg/L	957	583	11,108	80
Dissolved BOD, mg/L	498	432	1,128	132
Suspended BOD, mg/L	76	57	146	16
TOC, mg/L	564	261	4,880	26
Dissolved TOC, mg/L	216	147	620	67
Suspended TOC, mg/L	32	13	127	5
Nitrate, mg/L	2.15	1.15	15.80	0.60
Nitrite, mg/L	0.05	0.05	0.06	0.05
Ammonia, mg/L	74	74	246	14
TKN, mg/L	83	81	216	17
Orthophosphate, mg/L	0.43	0.14	6.60	0.10
Total phosphorus, mg/L	0.71	0.28	7.90	0.10
Conductivity, umhos/cm	87,452	86,480	165,000	360
Salinity, ppt	100	84	251	0
Temperature, ^{o}C	38	32	80	20
pH, SU	6.29	6.50	7.25	1.77

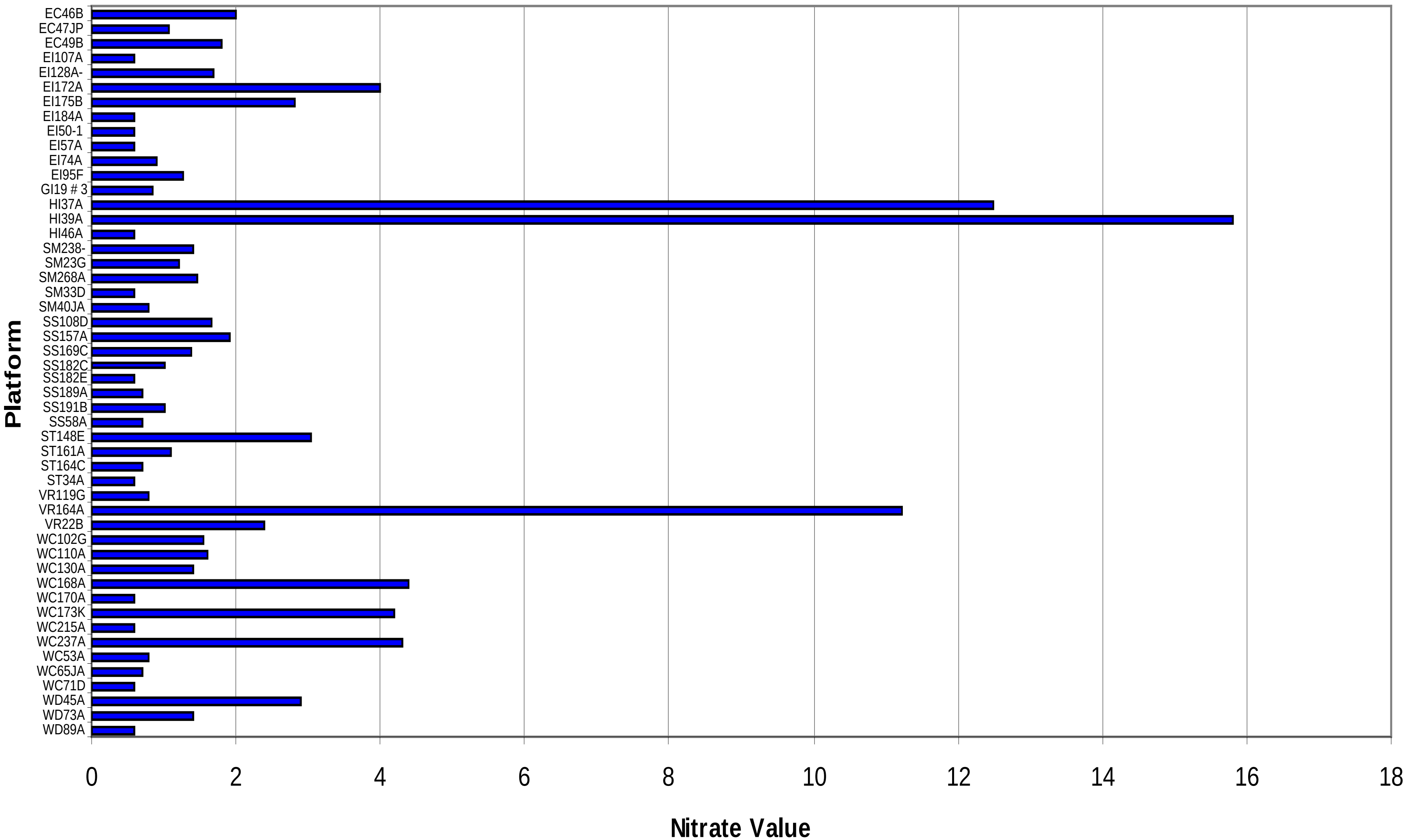
BOD Results from All Platforms (in mg/L)



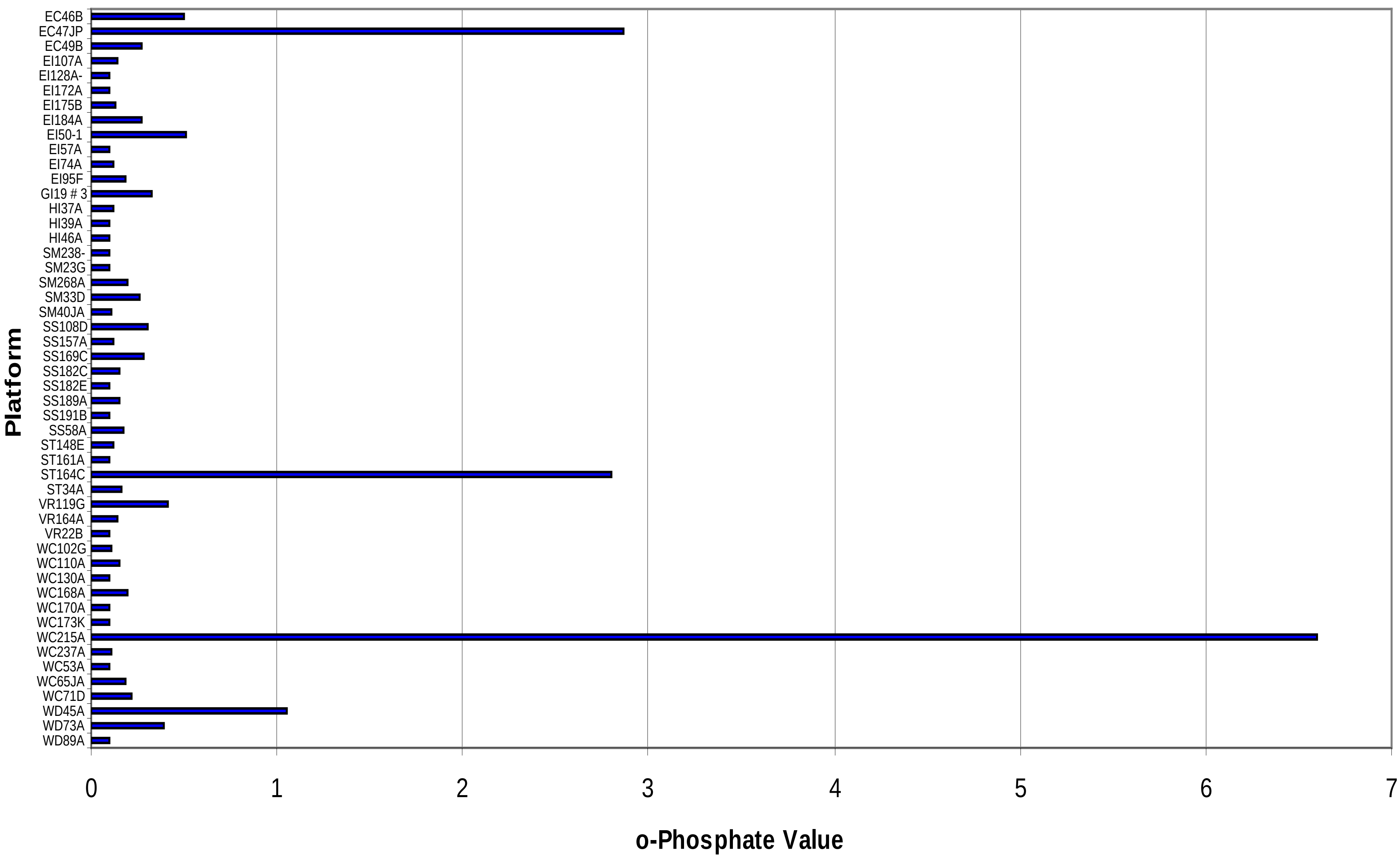
TOC Results from All Platforms (in mg/L)



Nitrate Results from All Platforms (in mg/L)



Orthophosphate Results from All Platforms (in mg/L)



Total Phosphorus Results from All Platforms (in mg/L)

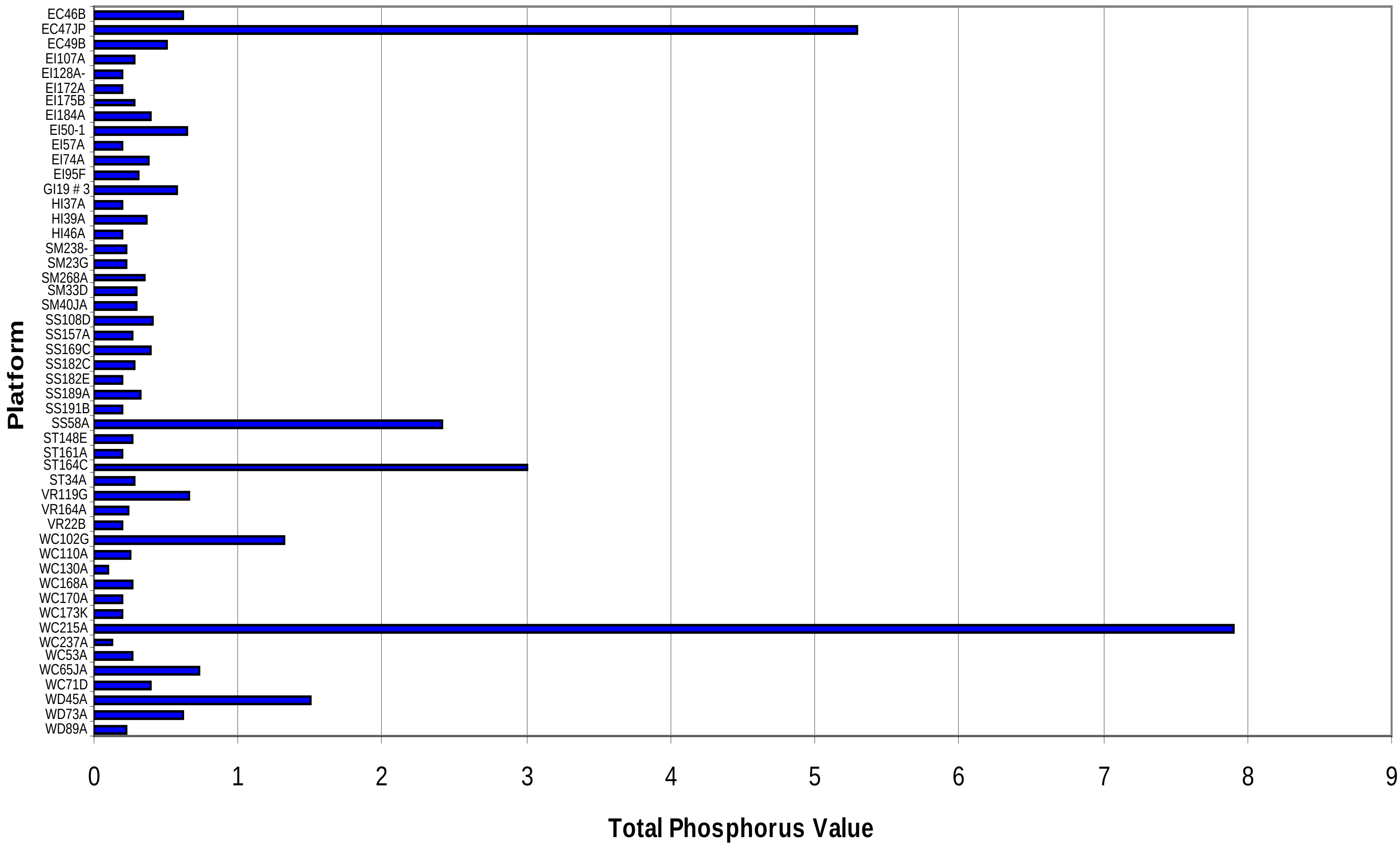


Table ES-2 – Loading Estimates for 50 Platforms and Entire Hypoxic Zone

Parameter	Loading from Sampled Platforms (lb/day)	Estimated Loading for Entire Hypoxic Zone (lb/day)
BOD	36,000	104,000
TOC	14,100	40,700
Nitrate	68.3	197
Nitrite	3.07	9
Ammonia	4,770	13,800
TKN	5,140	14,900
Orthophosphate	22.6	65
Total phosphorus	37.6	109

- The mass loadings from offshore oil and gas discharges to the entire hypoxic zone were estimated by multiplying the 50-platform loadings by the ratio of total water generated to 50-platform discharge volume.

Table 23 – Comparison of Nutrient Loadings from Produced Water Discharges and Riverine Inputs

Nutrient	Mean Flux (lb/yr) from Mississippi and Atchafalaya Rivers (Goolsby et al. 1999)	Estimated Annual Mass Loading (lb/yr) from Produced Water Discharges to the Hypoxic Zone	Ratio of Produced Water Loading to Riverine Loading
Ammonia	68,355,000	5,030,000	a
Organic N	1,278,900,000	389,000 (calculated as TKN – ammonia)	a
Nitrate	2,100,000,000	71,900	a
Nitrite	0	3,285	a
Total N	3,460,000,000	5,500,000	0.00159
Orthophosphate	92,100,000	23,700	a
Particulate phosphate	209,000,000	0	a
Total P	301,000,000	39,800	0.00013

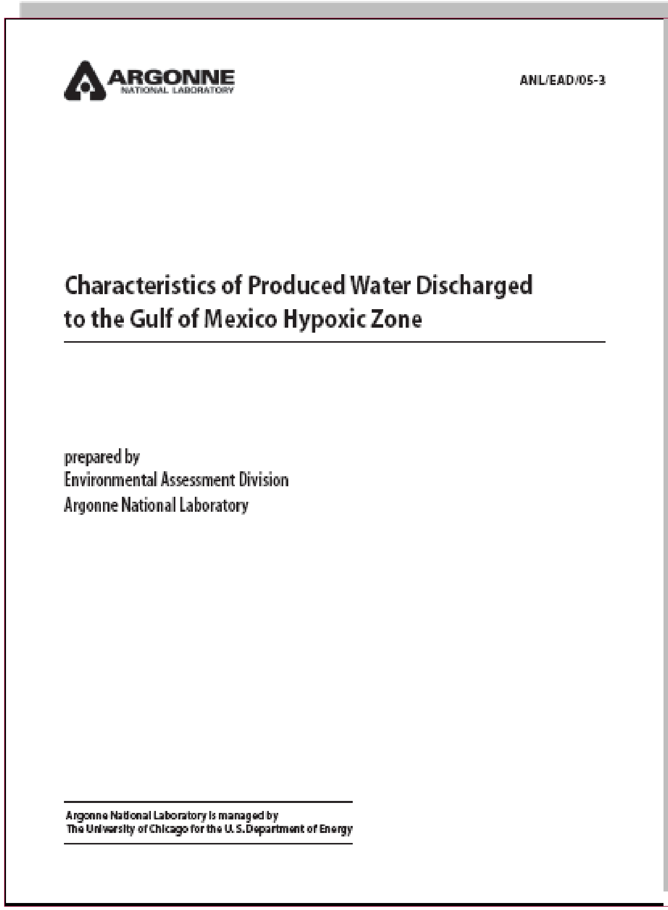
[a] The key ratios are total nitrogen and total phosphorus. Ratios for the other component comparisons are not shown.

nitrogen - 0.16%

phosphorus 0.013%

The Report Was Completed

- The hypoxic zone report was completed in August 2005 and submitted to EPA
- These data from 50 platforms represent the most complete and comprehensive effort ever undertaken to characterize the amount and potential sources of the oxygen demand in offshore oil and gas produced water discharges.
- Discharges of oxygen-demanding pollutants and nutrients are collectively large, but they represent less than 1% of the contribution of the same pollutants from the Mississippi and Atchafalaya Rivers



ARGONNE NATIONAL LABORATORY

ANL/EAD/05-3

Characteristics of Produced Water Discharged to the Gulf of Mexico Hypoxic Zone

prepared by
Environmental Assessment Division
Argonne National Laboratory

Argonne National Laboratory is managed by
The University of Chicago for the U.S. Department of Energy

Download report at: http://www.veilenvironmental.com/publications/pw/ANL-hypoxia-report.pdf

What Happened Next?

- EPA hired three experienced water quality modelers to run different water quality models
- Used the data from the Argonne report as inputs

Attribute	MODEL		
	Bierman	Justić	Scavia
General Description	Moderately complex mechanistic eutrophication model	Simple two-layer dissolved oxygen model	Simple dissolved oxygen model for bottom waters
Spatial Scale	3D with 21 spatial segments in hypoxic zone	1D vertical at Station C6 in core of hypoxic zone	1D horizontal in subpycnocline downstream of river inputs
Temporal Scale	Summer Steady-State	Monthly Time-Variable	Summer Steady-State
Nutrients	Phosphorus, nitrogen and silicon	Nitrogen	Nitrogen
Hypoxia Characterization	3D structure of summer-average dissolved oxygen concentrations in hypoxic zone	Seasonal dynamics of dissolved oxygen concentrations in core of hypoxic zone	Interannual variability in hypoxic zone length and area
Calibration Time Periods	1985, 1988 and 1990	1985-1993	1985-2002

Source: SPE 106814

Sensitivity Analysis to Determine which Data Points to Include

BOD5 (mg/L)
80
103
147
148
167
198
234
289
344
365
372
376
389
392
415
442
477
479
494
499
503
521
543
569
582
583
628
632
654
663
711
732
738
804
826
878
879
940
954
974
1,038
1,108
1,186
1,200
1,224
1,448
1,632
1,821
5,378
11,108

Step 1: Calculate the flow weighted mean.

total loading	36,000 lb/day
total flow	175,000 bbl/day
flow-weighted average concentration	588 mg/L

Step 2: The 50 data values are ordered from lowest to highest (see list to the left).

Step 3: The quartile values are calculated.

lowest value	80
lower quartile	390
median	583
Upper quartile	925
highest value	11,108
outlier threshold (upper quartile plus 3 times the ICR)	2,529

Step 4: Any data values exceeding 2,529 mg/L are dropped from the data set. In this case, the two highest values are dropped.

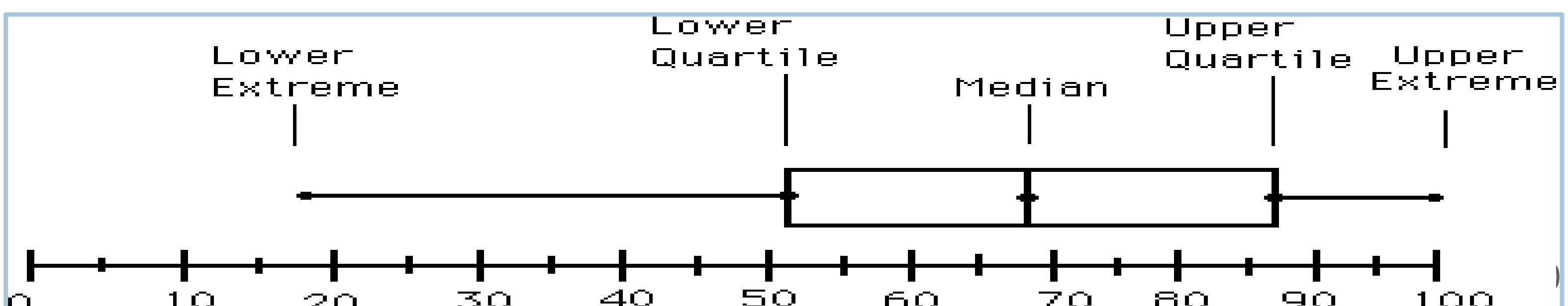
Step 5: Calculate the 95th percent confidence interval.

Standard Deviation	394
No. of data values	48
95% Conf. Int.	112

Step 6: Calculate the upper and lower ends of the range = flow-weighted average plus or minus the 95th percent confidence interval.

Range = 476 – 700 mg/L

Box and Whiskers Plot



Conclusions of Modeling Work

- A peer-reviewed article summarizing the work concluded:

> ***"All of the predictive results in this study contain uncertainties inherent in each of the original models, in addition to the uncertainties explicitly considered for the produced water loads. Despite uncertainties in model results for absolute magnitudes of dissolved oxygen concentrations and hypoxic areas, relative differences between baseline and predictive simulations have higher degrees of confidence because the absolute uncertainties tend to be self-cancelling. The predicted incremental impacts of produced water loads on dissolved oxygen conditions in the northern Gulf of Mexico from all three models were small."***

EPA's Reaction

- EPA circulated a draft of the next discharge permit:

> ***"EPA has also recently completed a study of the effects of produced water discharges on the hypoxia in the northern Gulf of Mexico and found that these <u>discharges do not have a significant impact</u>."***
>
> ***"The Region finds that discharges proposed to be authorized by the reissued general permit <u>will not cause unreasonable degradation of the marine environment</u>"***

- The Fact Sheet accompanying the permit notes:

> ***"EPA finds that the potential impact on the hypoxia from produced water discharges is insignificant. Therefore, <u>no additional permit requirements are proposed at this time</u>"***

Final Thoughts

- Environmental reports, permits, and other documents are abundant and important
- When documents do not use good data, valid and clearly stated assumptions, and appropriate analyses, they can result in less-than-accurate conclusions that may cause significant financial implications to the industry or unintended environmental impacts
- While many documents are intended to be unbiased, some documents prepared by advocacy groups or material presented by the media (on both sides) are often slanted to promote an agenda
- Thorough review and critique of documents can help to avoid “bad science” or “fake news”