CEWS Center for Energy Water Sustainability
Colorado State University

Certification of Freshwater Resource Use as Part of a Responsibly Sourced Gas ESG Strategy

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PROJECT CANARY

Contents

Acknowledgements 3
1. Introduction 4
2. Methodology 5
   Fresh Water Replacement Ratio (FR2) 5
   Water Stress Index (WSI) 7
   WSI Weighted Fresh Water Replacement Ratio (WSI FR2) 11
3. PA case study 11
4. References 15

List of Tables

Table 1. Sample operator data input spreadsheet. 6
Table 2. WSI Rolling Average for State of Pennsylvania, 2019-2020. 12
Table 3. WSI Weighted Fresh Water Replacement Ratio for State of Pennsylvania. 13
Table 4. Summary Statistics for WSI Weighted Fresh Water Replacement Ratio 15

List of Figures

Figure 1. Example of USDM dataset (Weld County) 8
Figure 2. Time Series WSI for Weld County 9
Figure 3. Map of quarterly averaged 2020 OG-related WSI 10
Figure 4. WSI for the State of Pennsylvania over selected timespan. 12
Figure 5. Time series data of WSI FR2 for selected operators and period. 14

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List of Acronyms

CC	Conservation Credits
CEWS	Center for Energy Water Sustainability
CO	Colorado
CSU	Colorado State University
DSCI	Drought Severity and Coverage Index
DWP	Drought Weighted Population
ESG	Environmental Social Governance
FR2	Freshwater Replacement Ratio
NDMC	National Drought Mitigation Center
NOAA	National Oceanic and Atmospheric Administration
OG	Oil & Gas
PW D	Produced Water Discharged
PA DEP	Pennsylvania Department of Environmental Protection
PW R	Produced Water Recycled
RSG	Responsibly Sourced Gas
UOG	Unconventional Oil & Gas
US	United States
USDA	U.S. Department of Agriculture
USDM	U.S. Drought Monitor
WSI	Water Stress Index
WW C	Water Withdrawn from Competitive Freshwater Sources
WW NC	Water Withdrawn from Non-Competitive Sources

Acknowledgements

The Center for Energy Water Sustainability at Colorado State University worked closely with the Project Canary team to develop the proposed methodology for assessing and certifying freshwater stewardship as part of a RSG program throughout the oil and gas industry. Dr. Ken Carlson led the effort from the CEWS team with significant contributions from Dr. Huishu Li, Asma Hanif and Fin Carlson. Josh Zier led the Project Canary contributions to this project with support from Shayna Sims.

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1. Introduction

The development of the US unconventional oil and gas (UOG) industry has had transformative impacts on the energy outlook both nationally and internationally. At the same time, the growing threat of climate change and its relationship to fossil fuel use is receiving increased amounts of attention, casting doubt on the sustainability of current levels of natural gas extraction and use. Another issue related to the environmental sustainability of the UOG industry is the impact on water resources, particularly in semi-arid regions of the US where several major UOG basins are located.

Compounding the perceived unsustainability of the UOG industry with respect to water is the severe drought that is impacting much of the US. As of August 17, 2021, greater than 47% of the area of the lower 48 states in the US was affected by some level of drought (NOAA, 2021). Drought conditions were impacting almost 75 million people, including populations that are in many of the of the most productive UOG basins (NOAA, 2021).

Considering the central role of water in oil and gas production, developing freshwater acquisition, and produced water disposal methods with minimal environmental and social impacts are an important part of an overall Responsibly Sourced Gas (RSG) program. In general, the companies that will be considered the best stewards of water in the UOG industry will be those that minimize or eliminate freshwater usage, thus providing no competition with other societal uses in a basin. In addition, companies that treat wastewater as a resource that can be reused or recycled internal or external to UOG operations will be considered more responsive to Environmental Social Governance (ESG) objectives (Produced Water Society, 2021).

The Center for Energy Water Sustainability at Colorado State University has been partnering with Project Canary to develop and deploy quantitative methods to assess water stewardship in the UOG industry and ultimately award certification levels to companies that can meet sustainability metrics. This document describes an important component of the certification methodology, responsible freshwater stewardship, and presents a case study of this approach with data retrieved from the Pennsylvania Department of Environmental Protection.

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2. Methodology

Fresh Water Replacement Ratio (FR2)

The Fresh Water Replacement Ratio (FR2) is a holistic metric that accounts for oil and gas operators' use of water both in the initial drilling/fracturing phase as well as flowback and produced water in the production phase. The goal is to develop methods to evaluate the responsible water stewardship of oil and gas operators in a world that is prioritizing sustainable practices while continuing to supply essential energy resources. The method and resultant metrics described here will be important components in the TrustWell Freshwater Friendly certification process in the future.

The key part of this process was defining the Fresh Water Replacement Ratio as a comprehensive measure of sustainable water usage. The metric (shown in the equation below) in its simplest terms aims to sum all positive or sustainable uses of water utilized by operators divided by the amount of fresh water withdrawn.

$$Fresh\,Water\;Replacment\;Ratio\;(FR2) = \frac{WW\;NC + PW\;R + PW\;D + CC}{WW\;C}$$

*WW NC is water withdrawn from non-competitive sources

*PW R is produced water that is recycled

*PW D is produced water that is treated and then discharged to surface bodies

*CC is conservation credits that are awarded for work that restores freshwater resources

*WW C is water withdrawn from competitive freshwater sources

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The specific parameters used to calculate the FR2 as shown above will possibly change depending on the basin as strategies for managing water vary widely across the country, but the general concept will remain the same. Oil and gas production is very much a cycle that fluctuates between extensive drilling requiring lots of water and times of managing the flowback leading to large amounts of produced water. For this reason, FR2 will be calculated using quarterly data as kept by operators but it will be a rolling average of the last four quarters. This is done to try and manage the cyclic nature of oil and gas production as measuring single quarters can lead to deceptively high variability. To tabulate the data required, operators are being asked to enter their data into a spreadsheet similar to Table 1.

	A	B	C	D	E	F	G	H	I
1	**Area Designation**	Operator, Region (Year)							
2			**INPUT DATA**						
3		**Water Withdrawn (WW) Competitive Use**	**Water Withdrawn (WW) Non-Competitive Use**	**PW Recycled**	**PW Recycled Discharged**	**SWD Well Injection**	**Waste Residual Storage**	**Surface Impoundment**	**Freshwater conservation credit**
4		bbl	bbl	bbl	bbl	bbl	bbl	bbl	bbl
5	Jan - Mar (Q1)	2652335.9	0	111628.99	0	16837.95	36949.99	408398.74	0
6	Apr - Jun (Q2)	5220964	0	156752.24	0	4971.07	24830.08	266394.78	0
7	Jul - Sep (Q3)	5903810	0	320002.49	0	48894.27	46298.01	676388.82	0
8	Oct - Dec (Q4)	3879091.7	0	130741.98	0	15533.18	17546.38	341955.86	0
9									
10	Annual avaerage	4414050.4	0	179781.43	0	21559.118	31406.115	423284.55	0
11									
12									
13	WW Competitive Use represents freshwater taken from providers or ground/surface freshwater								
14	WW Non-Competitve Use represents water recylced from other operators or from non-potable								
15	PW recycled represents water resused or supplied to other operators								
16	PW Recycled Discharged is produced water reused or recycled outside of oilfield								
17	PW in Waste Residual Storage is the amount of produced water that goes to waste residual storage								
18	Freshwater Conservation Credit is water added to hydologic cycle through conservation projects. Details should be archived.								

Table 1. Sample operator data input spreadsheet.

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With this data, the relevant metrics will then be calculated, and this will be used for TrustWell certification. To ensure operator integrity, the data will be verified either through checks against state reported data or operator audits. The spreadsheet was designed around ease of use and created to easily integrate with data already kept by operators to lessen the burden of participation. To this end, the data collection parameters are subject to change to best represent the operators who use them although the intent of the data will be equivalent to assure that the calculated metrics remain the same.

Water Stress Index (WSI)

Water stress index is often used to assess the scarcity, or the deficit of water and it represents the relationship between water use and water availability. Methods used to calculate the water stress index vary because different indices use different inputs and therefore have different optimal applications. Falkenmark et al. (1989) was one of the first to use water supply per capita per year to measure water scarcity but the limit of traditional established water stress indices is that they represent the water stress at a large spatial scale, such as basin or country, and these indices are not robust enough to measure the water stress in shorter timeframes. Since in the UOG industry, standard practice and water regulations can vary from county to county, a water stress index with large spatial and temporal scales might not be a good representation of impacts on a local scale.

Water availability usually changes significantly throughout the year with some seasonal trends or regular patterns and therefore to estimate the local water stress and its impacts on oil and gas activities requires an index with temporal flexibility. The U.S. Drought Monitor (USDM) is a unified drought indicator used by federal agencies to trigger drought responses. The USDM is produced by NDMC (the National Drought Mitigation Center at the University of Nebraska-Lincoln), NOAA (the National Oceanic and Atmospheric Administration), and USDA (the U.S. Department of Agriculture). Bi-weekly (updated every other Tuesday) and the data indicates drought conditions throughout the country based on several numeric and climatological models.

For the water stress index discussed in this paper, we use USDM data but supplement with population estimation data to assess a county-level drought-based water stress index applicable to UOG operations. There are three major components in our UOG-related WSI (Water Stress Index): DSCI (USDM) (the Drought Severity and Coverage Index), severity drought (duration of D3 plus D4), and drought weighted population.

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1) $DSCI = 1 \times D_0 + 2 \times D_1 + 3 \times D_2 + 4 \times D_3 + 5 \times D_4$

2) $Severity\ Drought = Duration\ of\ D_3 + Duration\ of\ D_4\ (in\ weeks)$

3) $Drought\ weighted\ population\ (DWP) =$

$$(None_{pop} * 1 + D0_{pop} * 1.2 + D1_{pop} * 1.4 + D2_{pop} * 1.6 + D3_{pop} * 1.8 + D4_{pop} * 2) * population$$

4) $WSI = (Score_{DSCI} + Score_{Severity\ Duration} + Score_{DWP})/3$

Five classifications including four levels of drought (D1-D4) and abnormally dry (D0) are used in the U.S. Drought Monitor dataset. The USDM dataset has two different types of data, one is based on area and the other is based on population. Values of D0- D4, $D0_{pop}$ - $D4_{pop}$ represent the normalized area and population percentages (to the total area) of the corresponding categories, respectively.

Figure 1 is an example of USDM data for Weld County, CO during the week of 02-23-2021. The numbers shown in Figure 1 are the categorical area percentage. "28.31" in "D1" means 28.31% of the total area of Weld County is in D1 drought. None means no drought conditions. Therefore, during this week, more than 99% of the area of Weld County was either in D1 or D2 drought conditions.

Week	None	D0	D1	D2	D3	D4	DSCI
2021-02-23	0.00	0.00	28.31	70.93	0.77	0.00	272

Figure 1. Example of USDM dataset (Weld County)

Each of the three components, DSCI, severity drought and drought weighted population (DWP) will be transformed to a score from 1-5 by quintile. A scale of 5 equals values ranking in the range of 80%-100% of the total data (quintile 80%-100%), 4 equals quintile of 60% to 80% and so on. The final UOG-related WSI ranges from 0-5 and can be aggregated in different timescales (e.g., monthly, quarterly or annually).

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Figure 2 shows the temporal changes of UOG-WSI for Weld County in Colorado. On the left of the first three rows are the three WSI components, the score of DSCI, the score of severity and the score of DWP (drought weighted population). The right axis of the top three rows are the actual numbers of DSCI, duration of the severe drought in weeks and the drought weighted population.

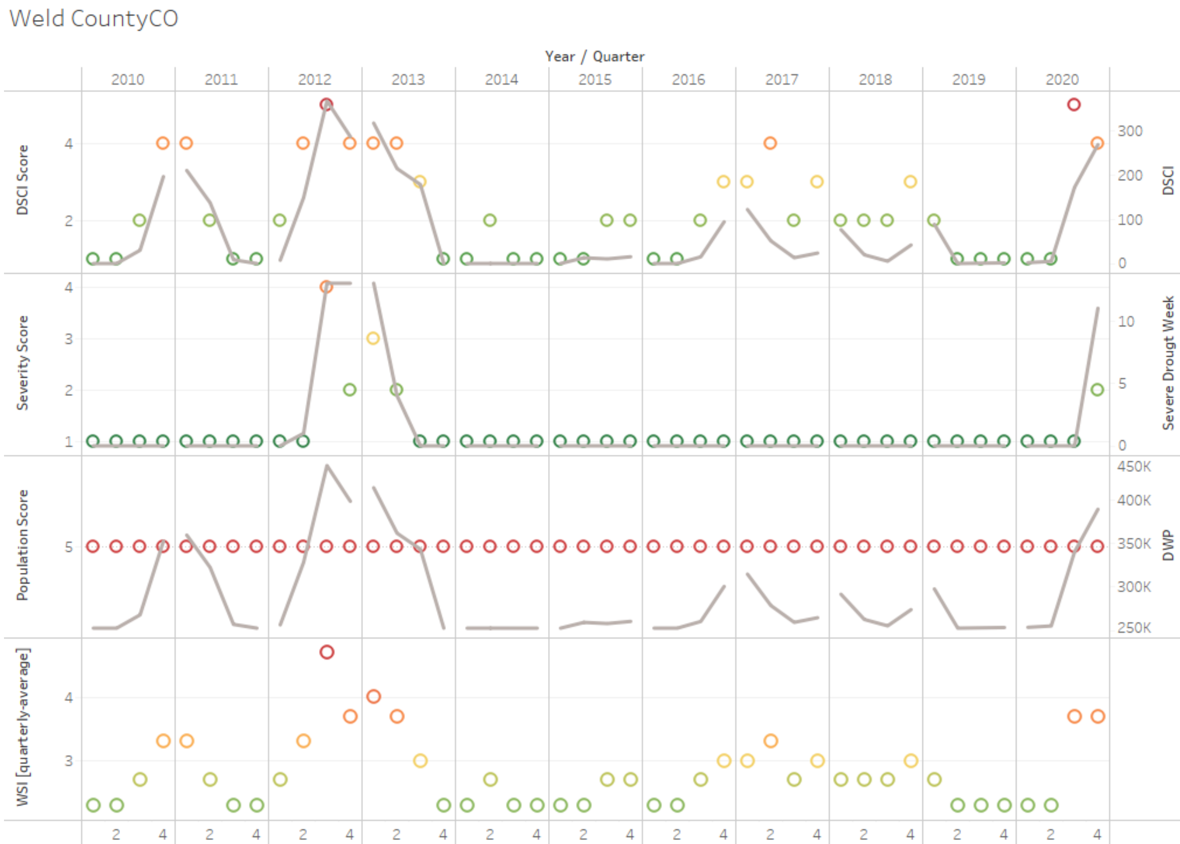

Figure 2. Time Series WSI for Weld County

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Figure 3 shows how the quarterly averaged WSI varied nationwide in 2020. There is an increasing WSI in the western US from Q1 to Q4 in 2020.

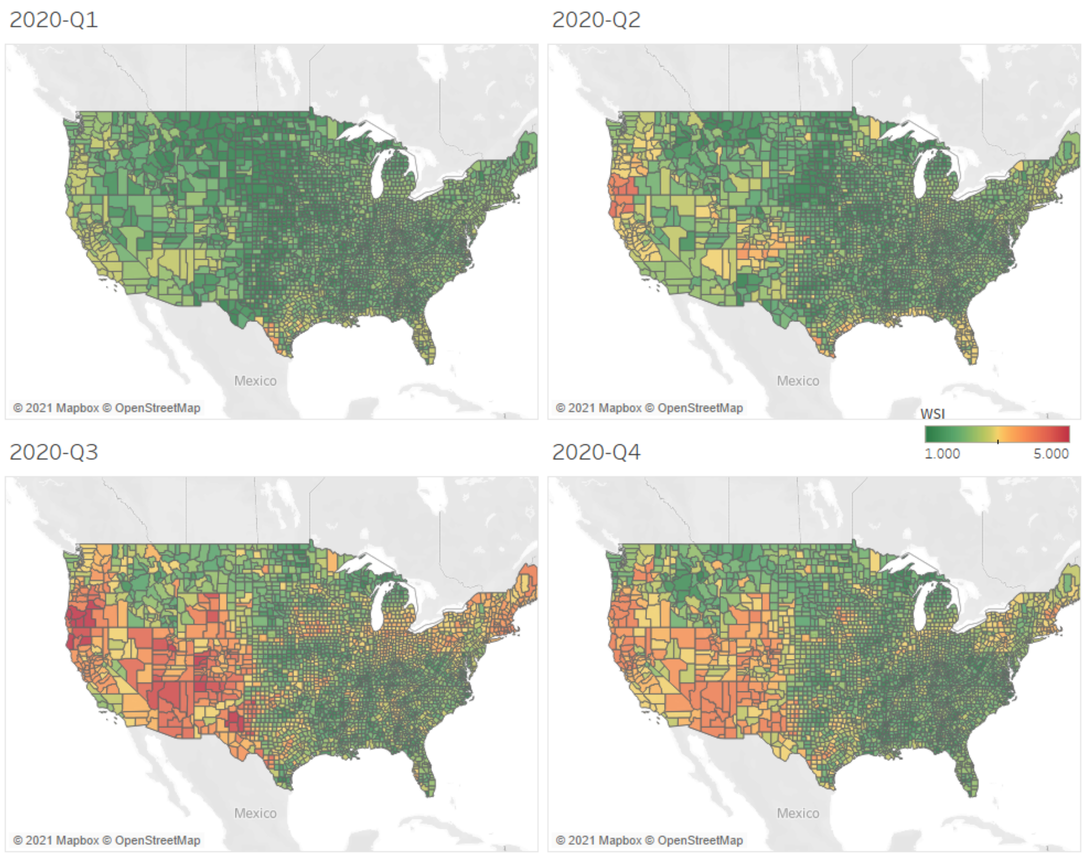

Figure 3. Map of quarterly averaged 2020 OG-related WSI

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WSI Weighted Fresh Water Replacement Ratio (WSI FR2)

Accounting for the levels of water stress at a basin level is a key goal of this process. To do this the already introduced Fresh Water Replacement Ratio will be weighted using the WSI to give an even more accurate representation of an operator's impact on the water usage and stress in a particular basin or county.

$$WSI\ Weighted\ Fresh\ Water\ Replacment\ Ratio = \frac{WW\ NC + PW\ R + PW\ D + CC}{WW\ C * WSI}$$

*WSI will be adapted to a scale of 1-2 with spacing of .2

For those operating in regions of elevated water stress it is important to be cognizant of current conditions. To this length, as water stress increases operators need to do more to mitigate their impact on freshwater availability in the region whether this means drawing less freshwater or being more resourceful with their produced water. This metric will also be calculated on a 4-quarter rolling average with the WSI for the given area being incorporated into the rolling average for the desired period.

3. PA case study

To test the methods outlined in this paper, a case study was developed using data from The Pennsylvania Department of Environmental Protection (PA DEP). To conduct this study, state-wide waste reports and water management plans were downloaded for ten operators for the years 2019 and 2020. The operators were primarily selected due to their status as large producers of natural gas in the state of Pennsylvania. The data available was then rolled into quarterly totals and used in conjunction with the FR2 and the WSI to determine the water stress weighted FR2. For the purposes of this study, only produced fluid was considered as waste and other types of waste such as drilling fluid and drill casings were omitted. This was done as the scope of both metrics and this study are primarily focused on water and while some water may be found in other types of waste, it is not a significant source when compared to produced water. The WSI while originally done at a county level was also aggregated to reflect the entire state's water stress. Shown in Figure 4 is the calculated WSI for the State of Pennsylvania for 2019 and 2020. The accompanying Table 2 gives the calculated Rolling Average to be used with the WSI FR2.

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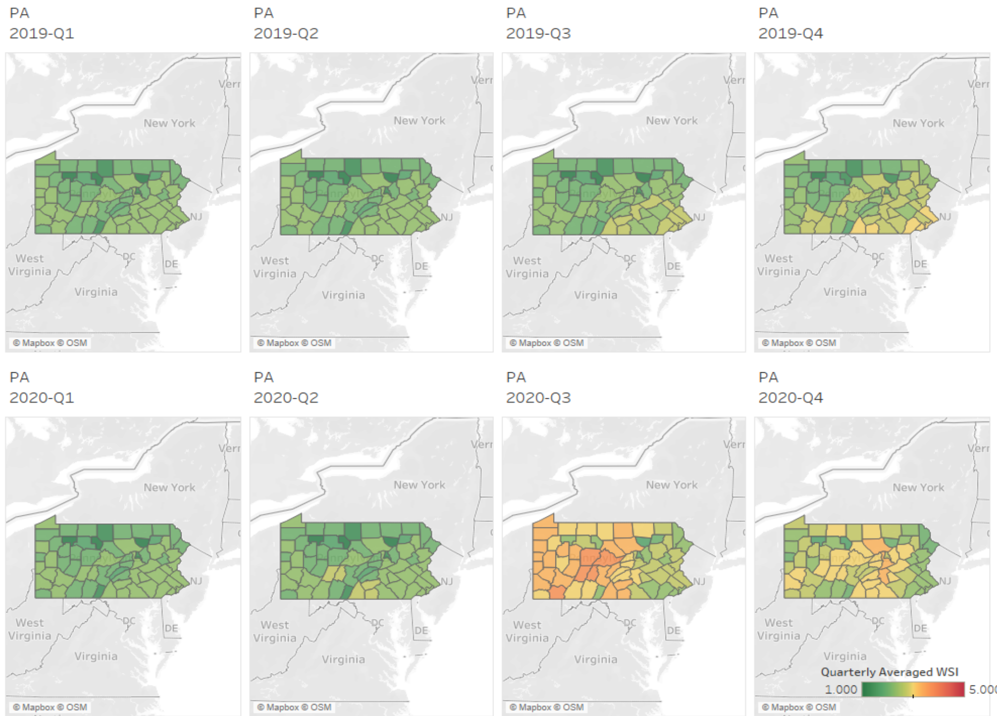

Figure 4. WSI for the State of Pennsylvania over selected timespan.

Table 2. WSI Rolling Average for State of Pennsylvania, 2019-2020.

	Rolling Average 1 (19Q1-19Q4)	Rolling Average 2 (19Q2-20Q1)	Rolling Average 3 (19Q3-20Q2)	Rolling Average 4 (19Q4-20Q3)	Rolling Average 5 (20Q1-20Q4)
WSI Rolling Average	2.1	2.1	2.2	2.3	2.4

When aggregating the quarterly data there were a few challenges that needed to be addressed to fully understand the data presented. On the water withdrawal side, some difficulty arose when trying to determine competitive use vs. non-competitive use as the reporting does not make it explicitly clear the nature of the water being used. This will be easily solved when working directly with operators as more nuance will be available. When summing the uses of produced water, it was found that many operators use storage techniques such as surface impoundment and residual waste storage. Through conversations with operators, it was learned that these storage techniques are a part of a unique water sharing arrangement that is most prevalent in Pennsylvania. Because of lack of further reporting requirements, it is difficult to discover the end use of this stored water. As a result, it was treated as positive water usage and summed along with the other positive uses when calculating the FR2. We are currently treating the data collection and analysis as preliminary until we have more direct input from the operators that are part of the TrustWell certification process. Nevertheless, the analyses presented in the case study is a first of its kind and demonstrates the value of a freshwater stewardship certification program as part of an overall ESG strategy.

Table 3 and Figure 4 show the calculated values WSI FR2 for ten operators studied in the Marcellus Basin in Pennsylvania.

Table 3. WSI Weighted Fresh Water Replacement Ratio for State of Pennsylvania.

Operator	Rolling Average 1 (19Q1-19Q4)	Rolling Average 2 (19Q2-20Q1)	Rolling Average 3 (19Q3-20Q2)	Rolling Average 4 (19Q4-20Q3)	Rolling Average 5 (20Q1-20Q4)
1	1.5	2.7	3.0	15	1.9
2	0.41	0.64	0.89	2.0	1.5
3	0.29	0.31	0.27	0.29	0.24
4	0.20	0.22	0.21	0.23	0.22
5	0.31	0.35	0.33	0.37	0.30
6	1.2	1.3	1.3	1.2	1.9
7	0.18	0.18	0.72	0.94	0.13
8	0.19	0.17	0.15	0.21	0.10
9	0.06	0.06	0.04	0.06	0.03
10	0.07	0.07	0.07	0.10	0.07

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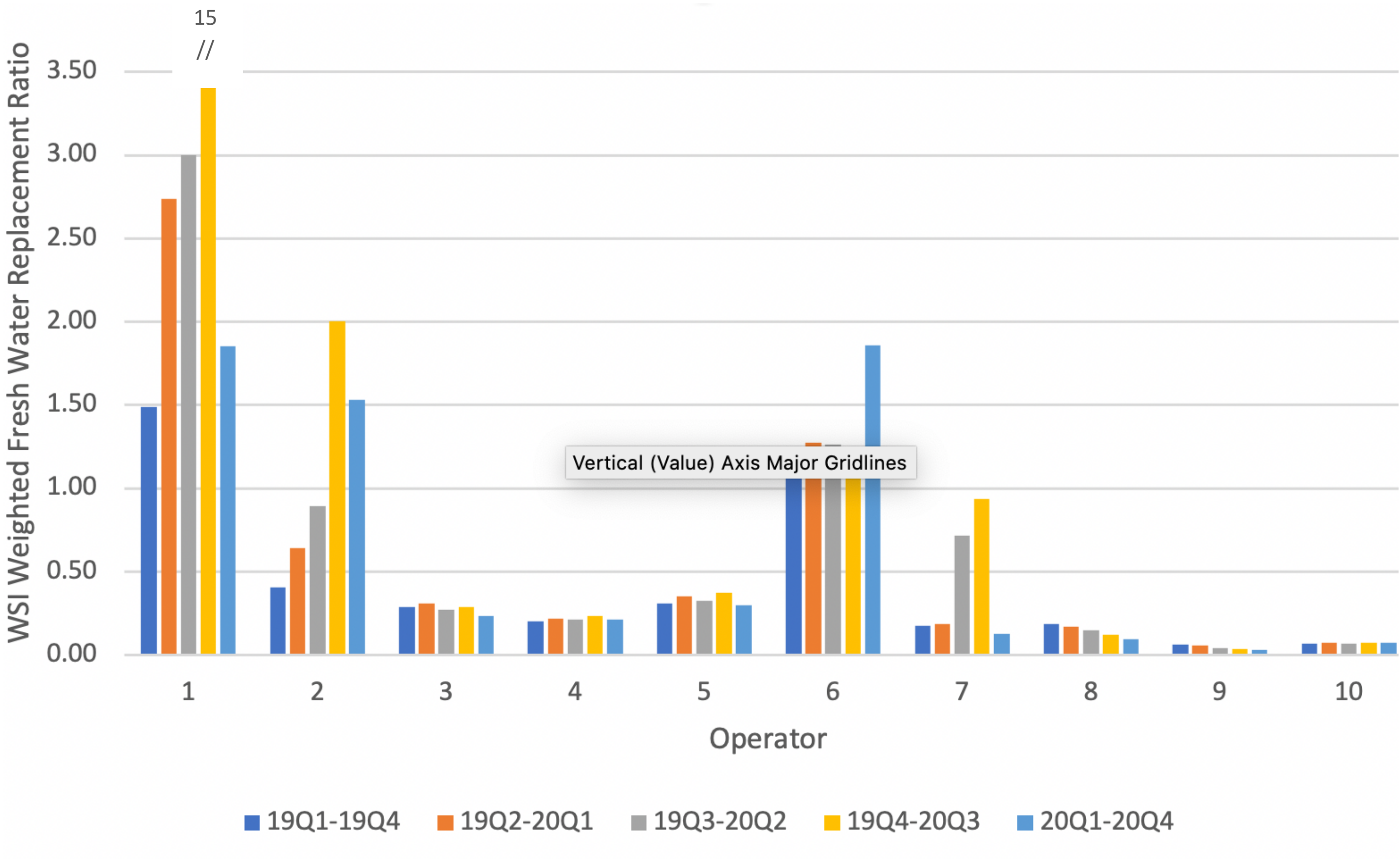

Figure 5. Time series data of WSI FR2 for selected operators and period.

This data shows that significant variability exists between operator practices leading to very different levels of the freshwater replacement variable. Some operators have already begun to limit their freshwater use by recycling either their own water or using non-fresh sources for drilling operations. Others still rely heavily on freshwater and could do more to recycle or reuse the water they receive as flow back. The goal of highlighting these differences is to allow operators to understand where they stand in terms of their individual freshwater footprint such that changes can be made to be more responsible stewards of this valuable resource.

To better understand the differences in water stewardship as well as to potentially begin to address certifications, summary statistics were calculated and are show in Table 4.

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Table 4. Summary Statistics for WSI Weighted Fresh Water Replacement Ratio.

	Rolling Average 1 (19Q1-19Q4)	Rolling Average 2 (19Q2-20Q1)	Rolling Average 3 (19Q3-20Q2)	Rolling Average 4 (19Q4-20Q3)	Rolling Average 5 (20Q1-20Q4)
10th Percentile	0.07	0.07	0.07	0.07	0.07
1st quartile	0.18	0.17	0.16	0.15	0.10
Median	0.25	0.26	0.30	0.33	0.23
3rd quartile	0.38	0.57	0.85	1.1	1.2
90th Percentile	1.2	1.4	1.4	3.3	1.9
Average	0.44	0.60	0.69	2.0	0.63

It should be noted that while those on the bottom of the spectrum (< median) have seen little change over the past 2 years, those who have committed to water stewardship (3rd quartile and 90th percentile) have seen consistent positive change over this same period.

4. References

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