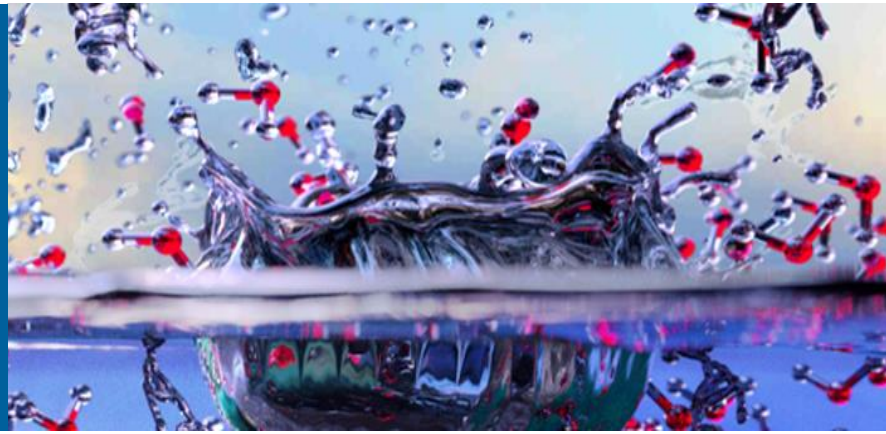
GWPC ANNUAL FORUM VIRTUAL 2020

Argonne NATIONAL LABORATORY

IMPLICATIONS OF REGIONAL PRODUCED WATER USE IN CRUDE PRODUCTION WATER FOOTPRINT

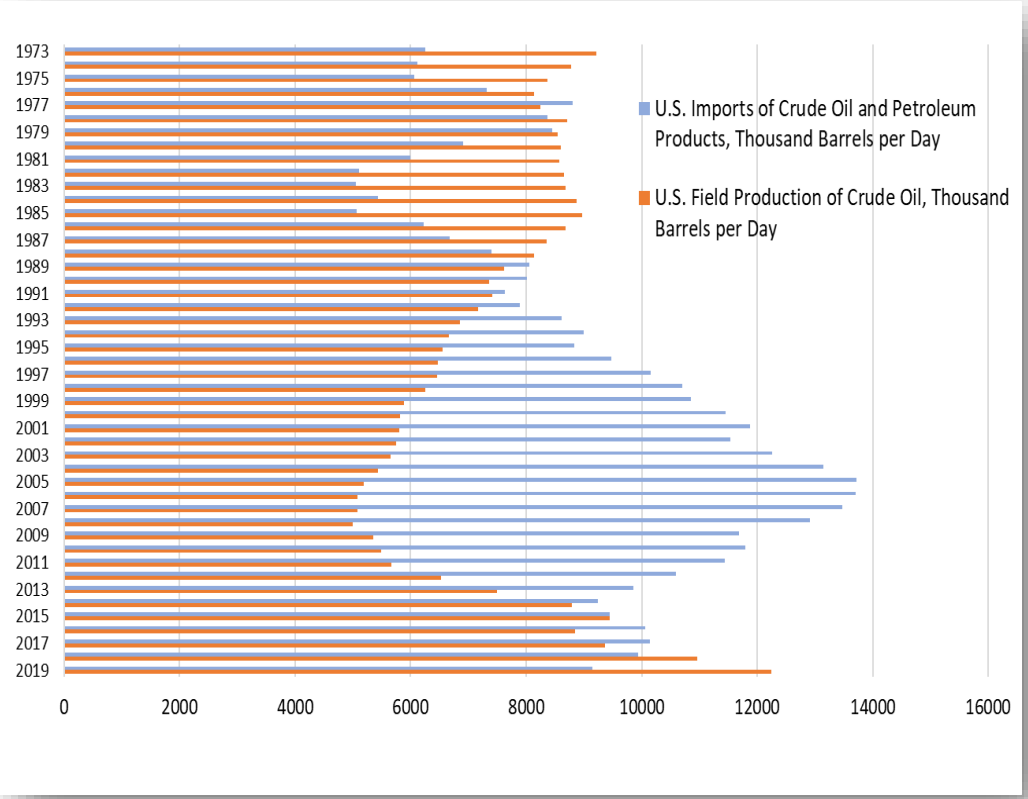


MAY WU

Argonne National Laboratory

Water Reuse: Research Showcase
Sept. 28-30, 2020

INTRODUCTION



- Domestic crude oil production from onshore wells grew steadily for more than a decade.
  - Increased from 3466 thousand bl/d (2005) to 7660 thousand bl/d (2017).
  - The production accounts for 44% of total supply in 2017, doubled that of 2005.
- Crude imports decreased during the period from 10.1 million bl/d to 7.9 million bl/d.

WATER MANAGEMENT IN PETROLEUM PRODUCTION

- The production of petroleum involves substantial water and wastewater in multiple stages. The water use is closely related to and affected by technology advancement and management programs and constraint by regional characteristics.
- A change of crude sources and the proportion of total supply would bring changes in water management and potentially shift the overall water footprint of the petroleum products.
- Produced water is a non-conventional water resource and a key feature in the water footprint of petroleum production.

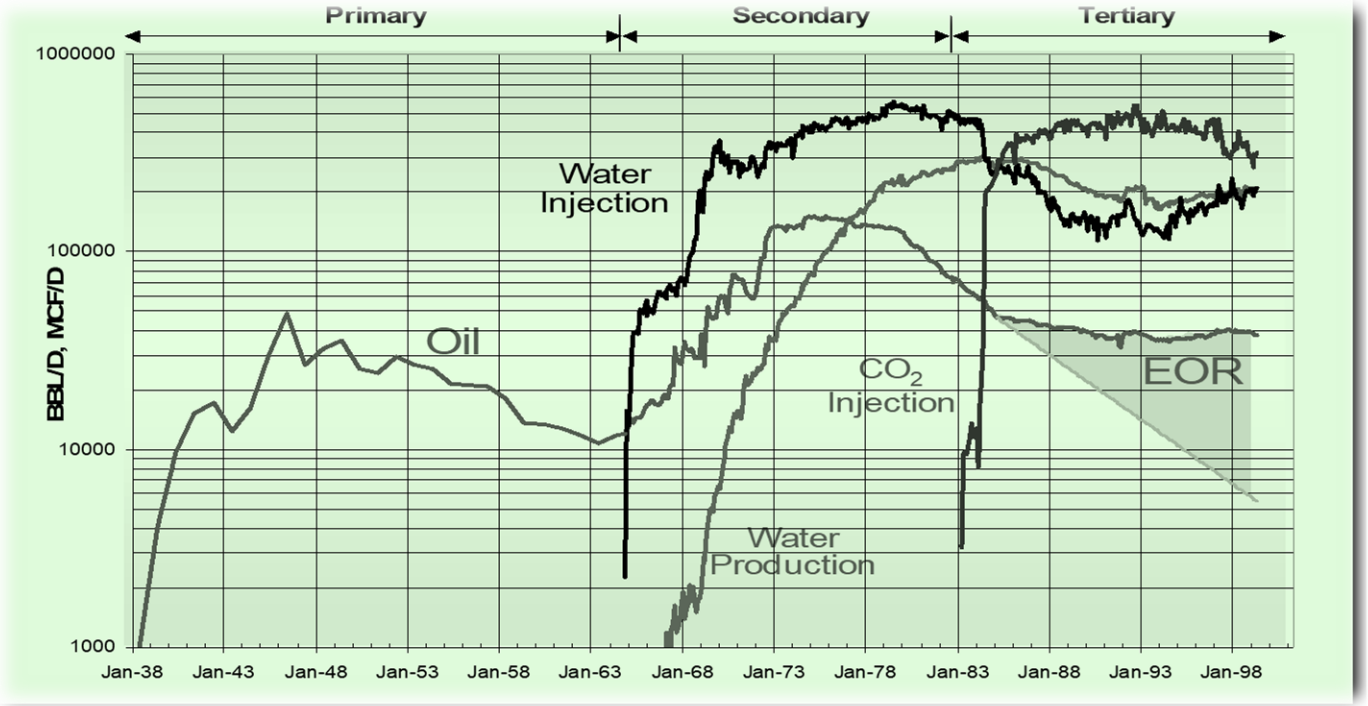
SCOPE

- Examine produced water management in the conventional crude production from onshore wells.
- Adopt a water footprint approach.
- Conduct national and regional analysis.
- Develop analysis based on surveys, published literature, and various inputs from industry.

Understand the impacts of production dynamics, management practices, and regional characteristics on water use.

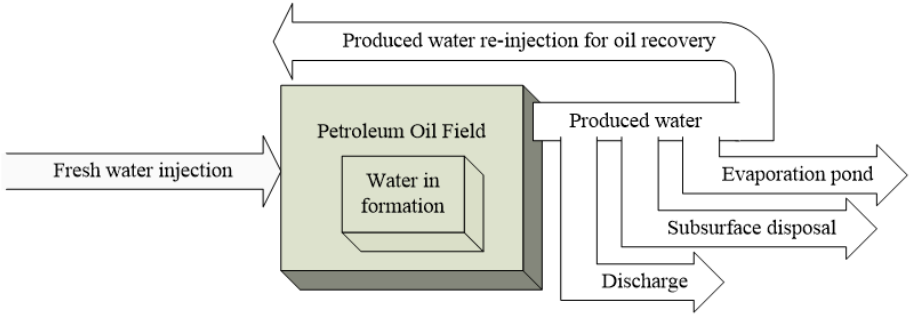
Source: ANL/ESD/09-1 Rev.2.
https://water.es.anl.gov/documents/ANL_ESD_09-1_Update%202018.pdf

WATER USE & PRODUCTION IN THE LIFE–TIME OF WELLS



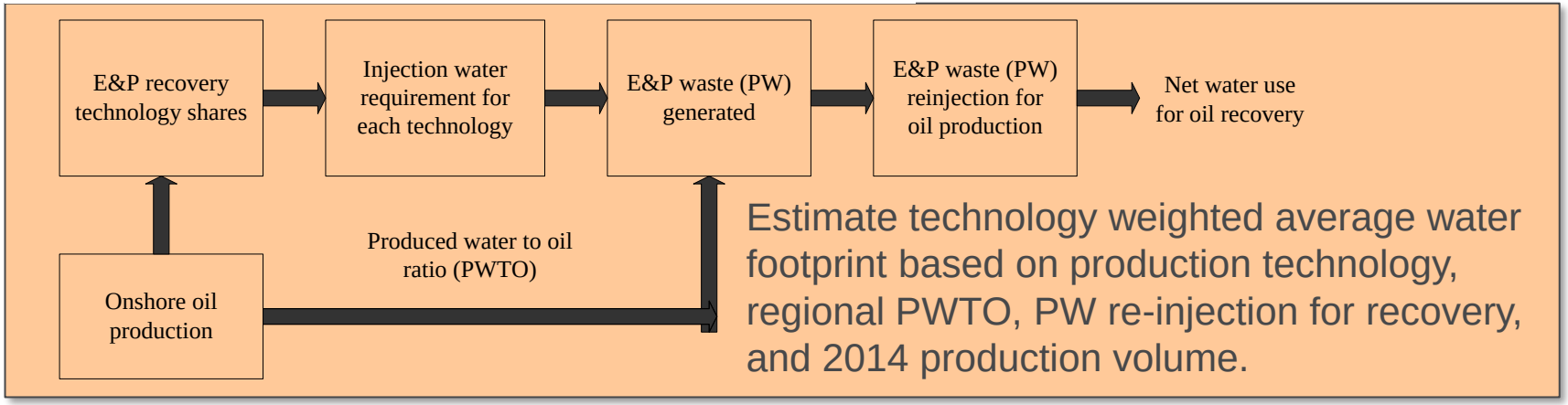
Source: ANL/ESD/09-1 Rev.2. https://water.es.anl.gov/documents/ANL_ESD_09-1_Update%202018.pdf

METHODOLOGY



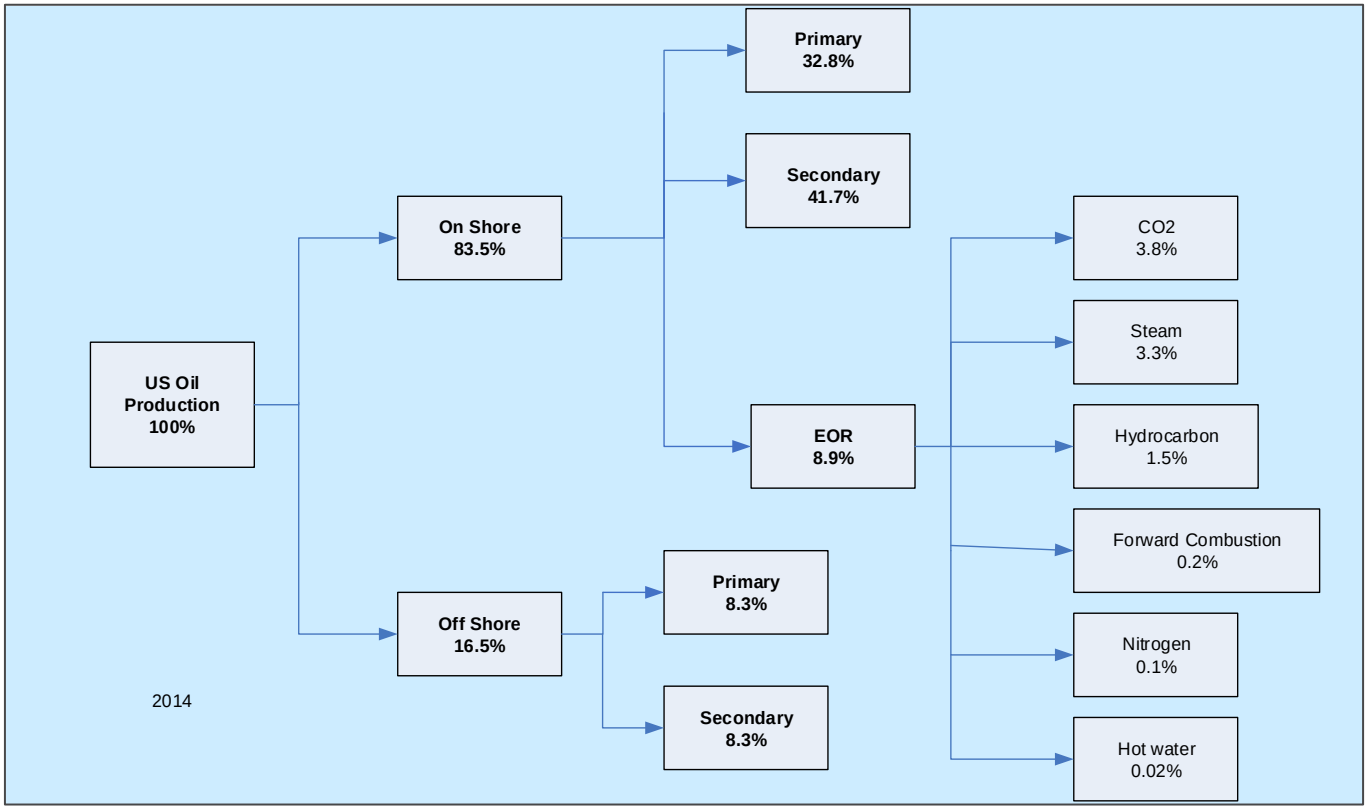
Factors considered

- Water inputs and outputs in E&P
- Technologies
- Oil production
- Produced water management



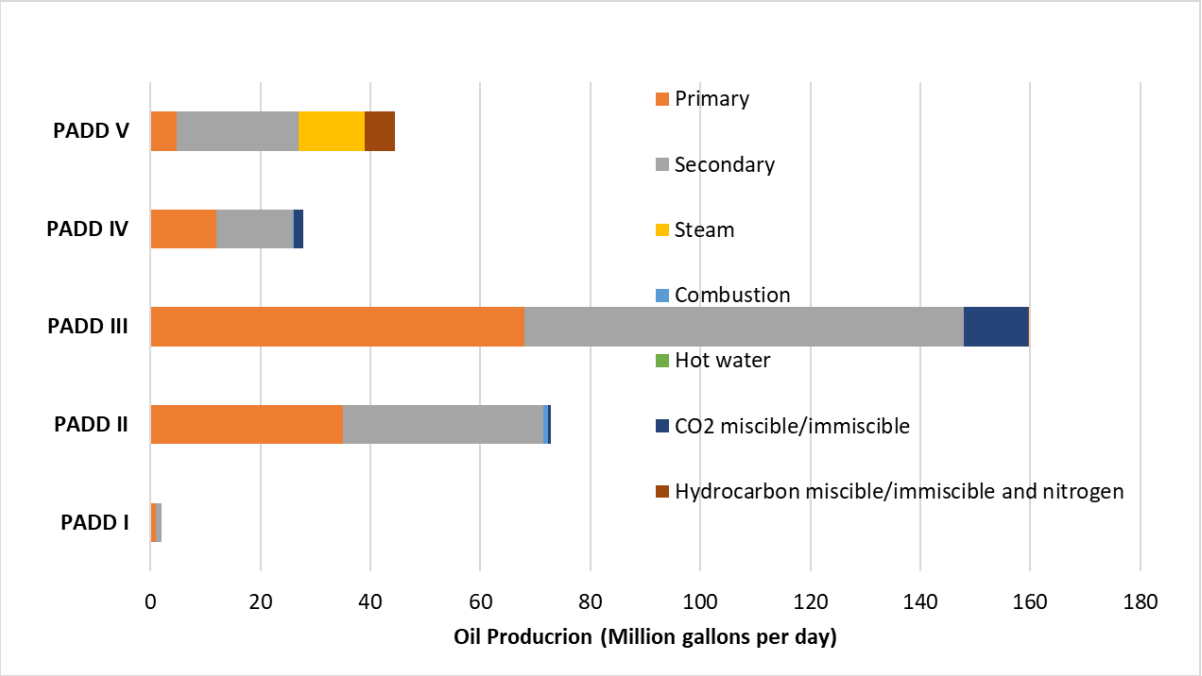
Estimate technology weighted average water footprint based on production technology, regional PWTO, PW re-injection for recovery, and 2014 production volume.

CRUDE PRODUCTION BREAKDOWN BY TECHNOLOGY

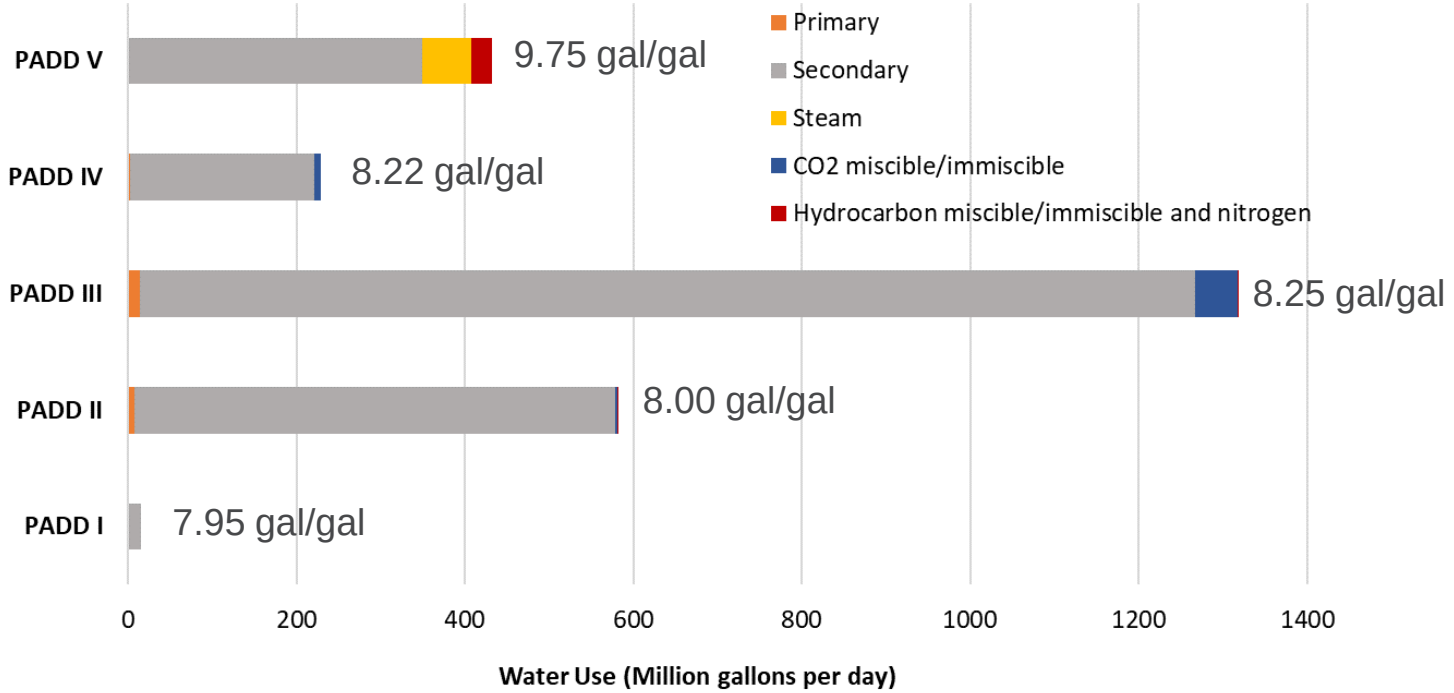


INJECTION WATER USE BY RECOVERY TECHNOLOGY

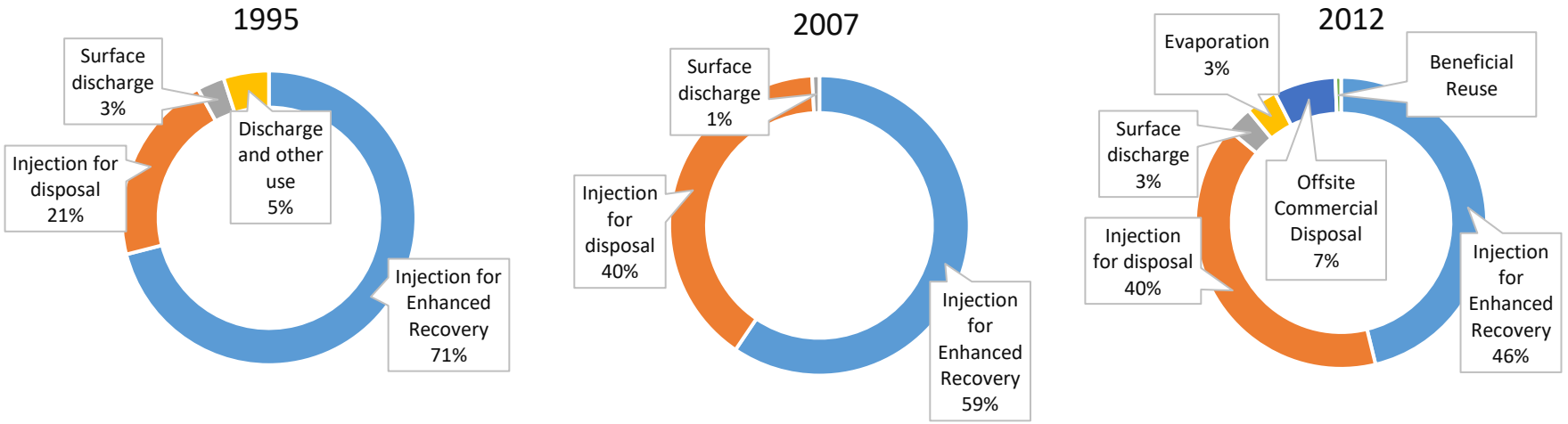
Recovery Technology	Water Intensity (gal/gal)
E&P, Drilling	0.005
Primary	0.21
Water flooding	15.69
Steam	4.90
Combustion	1.93
Hot water	4.55
Hydrocarbon miscible/immiscible	4.55
CO_2 miscible/immiscible	4.26
Nitrogen	4.55



PRODUCTION TECHNOLOGY BASED WATER FOOTPRINT



FATE OF PRODUCED WATER FROM U.S. OIL RECOVERY



Nationally, produce water re-injection for enhanced oil recovery decreased from 71% in 1995 to 46% in 2012 while injection for disposal doubled during the period.

PRODUCED WATER–TO–OIL (PWTO) RATIO

- Significant regional variations in PWTO.
- The range of PWTO widens over time.
- PWTO changes over time.
  - The ratio for PADD IV increased about three-fold from 1995 to 2012.
  - Those of PADDs II and I decreased by a half and more than 90%, respectively, over the same period.

	Produced water (1000 bl)	Oil Production (1000 bl)	PWTO Ratio, National average
1985	20,608,505	3,274,553	6.3
1995	17,922,200	2,394,268	7.5
2002	14,160,325	2,097,124	6.8
2012	21,180,646	2,264,241	9.2

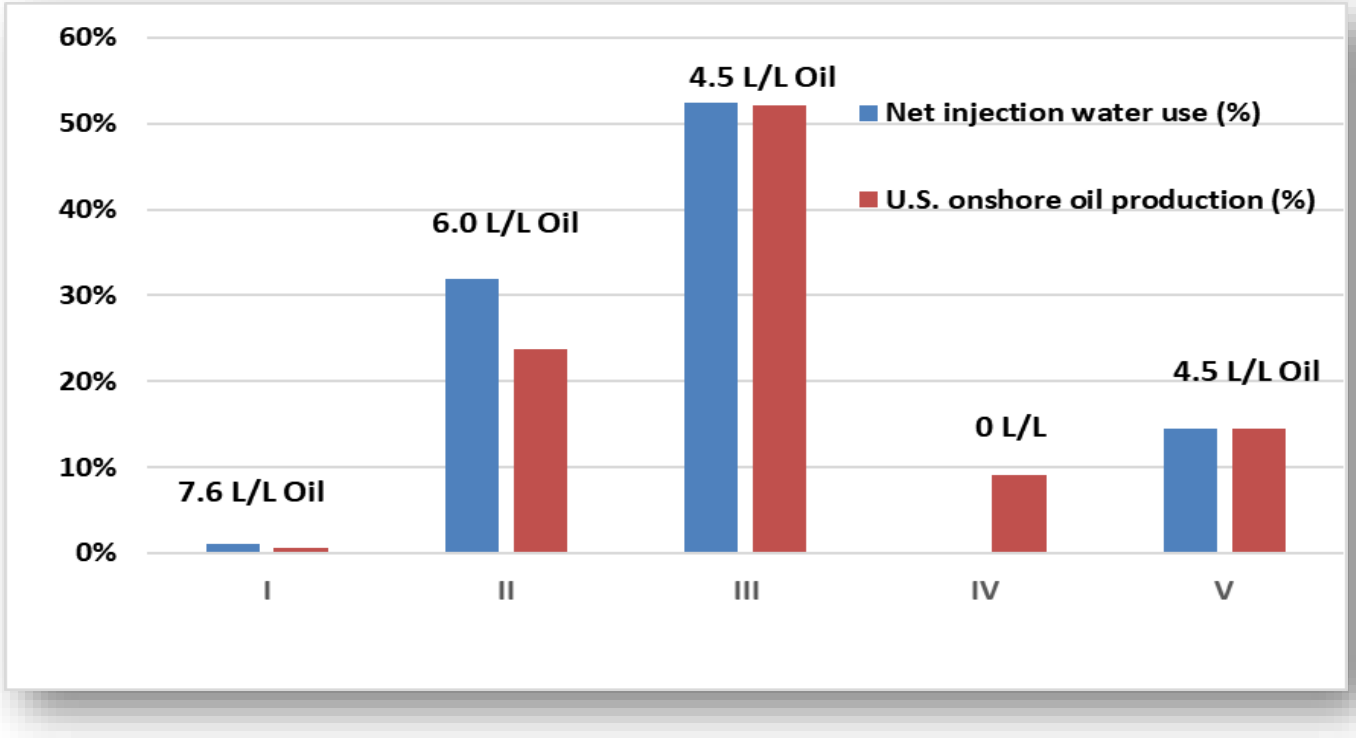
PADD Region	PWTO 1995	PWTO 2002	PWTO 2017, Field data	PWTO 2012
I	8.7	9.8		0.7
II	8.3	11.1		4.8
III	11.3	10.9		8.7
IV	9.4	14.7		25.4
V	3.3	3.4	5.2, 3.0	9.8

REGIONAL AND NATIONAL WATER FOOTPRINT

Add PW reinjection to the water footprint equation.

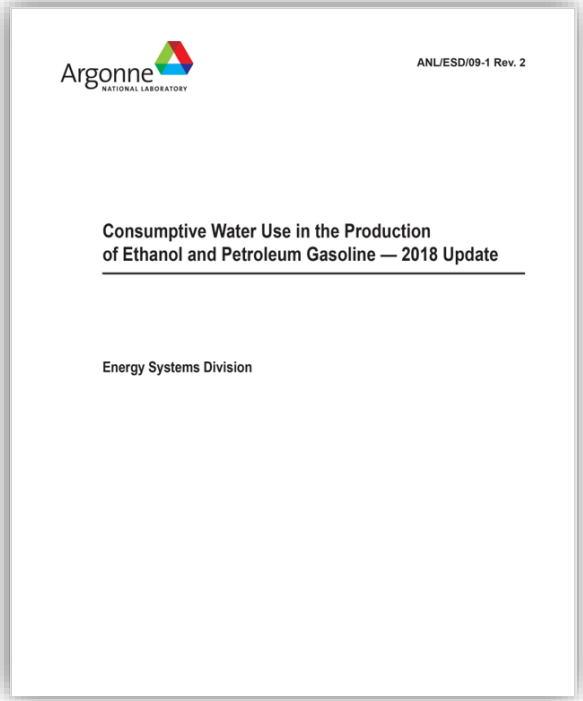
PADD Region	Technology Weighted Average Injection Water Use (gal/gal)	PW-to-Oil Ratio	% of PW Reinjection for Oil Recovery	PW Used for Reinjection (gal/gal)	Net Water Footprint (gal/gal)
I	7.95	0.7	45	0.3	7.62
II	8.00	4.8	41	2.0	6.05
III	8.25	8.7	43	3.7	4.52
IV	8.22	25.4	60	15.3	0.00
V	9.74	9.8	54	5.3	4.49
			U.S. onshore weighted average		4.5

SHARES OF PRODUCTION AND WATER USE IN PADD REGIONS



CONCLUSION

- Produced water management that emphasizes water reuse and recycle drives a sustainable water footprint for crude production.
- PWTO in PADD regions widened in last two decades and ranged from 0.7 – 25.4 in 2012.
- The degree of produced water reinjection for oil recovery has significant impact on the net water footprint.
  - Wells that with modest to large PWTO can lower net water use by increasing PW reinjection when feasible.
- The type of recovery technology and the production share in a region play an equally critical role in the national net water footprint.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ANL/ESD/09-1 Rev. 2

Consumptive Water Use in the Production of Ethanol and Petroleum Gasoline — 2018 Update

Energy Systems Division

Source: Wu et al. ANL/ESD/09-1 Rev.2. https://water.es.anl.gov/documents/ANL_ESD_09-1_Update%202018.pdf

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