Improving runoff simulation for sub-watersheds in the Lower Laguna Madre: *an assessment of the need incorporate land use-land cover information in rainfall-runoff model calibration*

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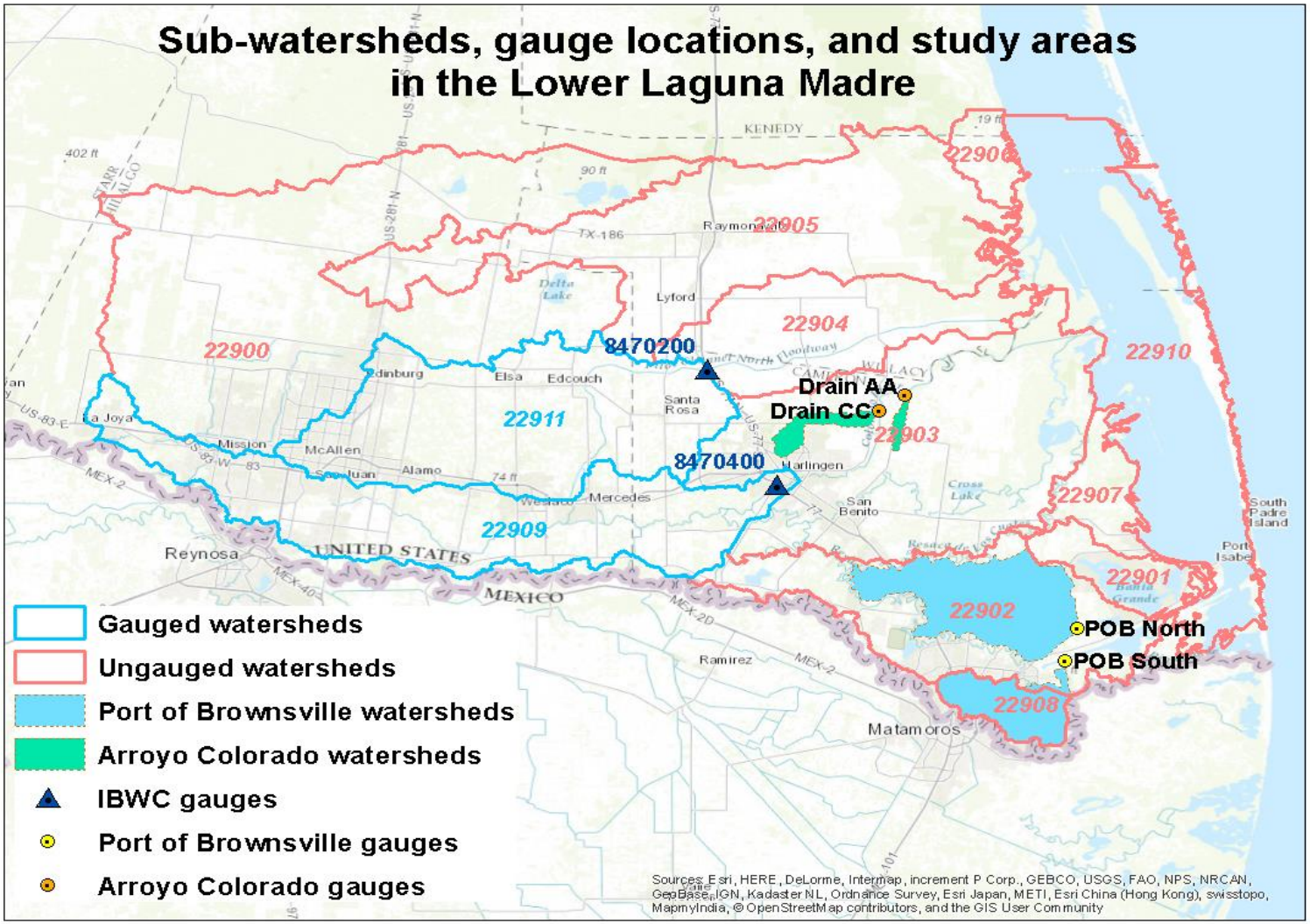
Outline

1. Problem statement: need for improved runoff simulation
2. Performance of the Texas Water Development Board's Texas Rainfall-Runoff model
3. Incorporating land use-land cover data in runoff simulation
4. Land cover calibration results
5. Future work

Need for improved runoff simulation

- Ungauged runoff from the Arroyo Colorado West and the Brownsville watersheds contribute large pulses of inflow to the Lower Laguna Madre.
- Sea grass decreases in the Lower Laguna Madre have been attributed to these large inflow pulses.
- Land cover and land use change in the region could affect runoff and should ideally be accounted for.

Study sites in the Lower Laguna Madre



Texas Rainfall-Runoff (TxRR) Model: model specifications

- TWDB's in-house model used to simulate runoff in ungauged watersheds
- Runoff computed for rainfall events
- Keeps a continuous track of soil moisture conditions
- Calibration done using gauged streamflow and precipitation records
- Calibrated model applied to simulate runoff in nearby catchments (*with parameter adjustment to account for soil type/land cover if needed*)

Key parameters in calibration

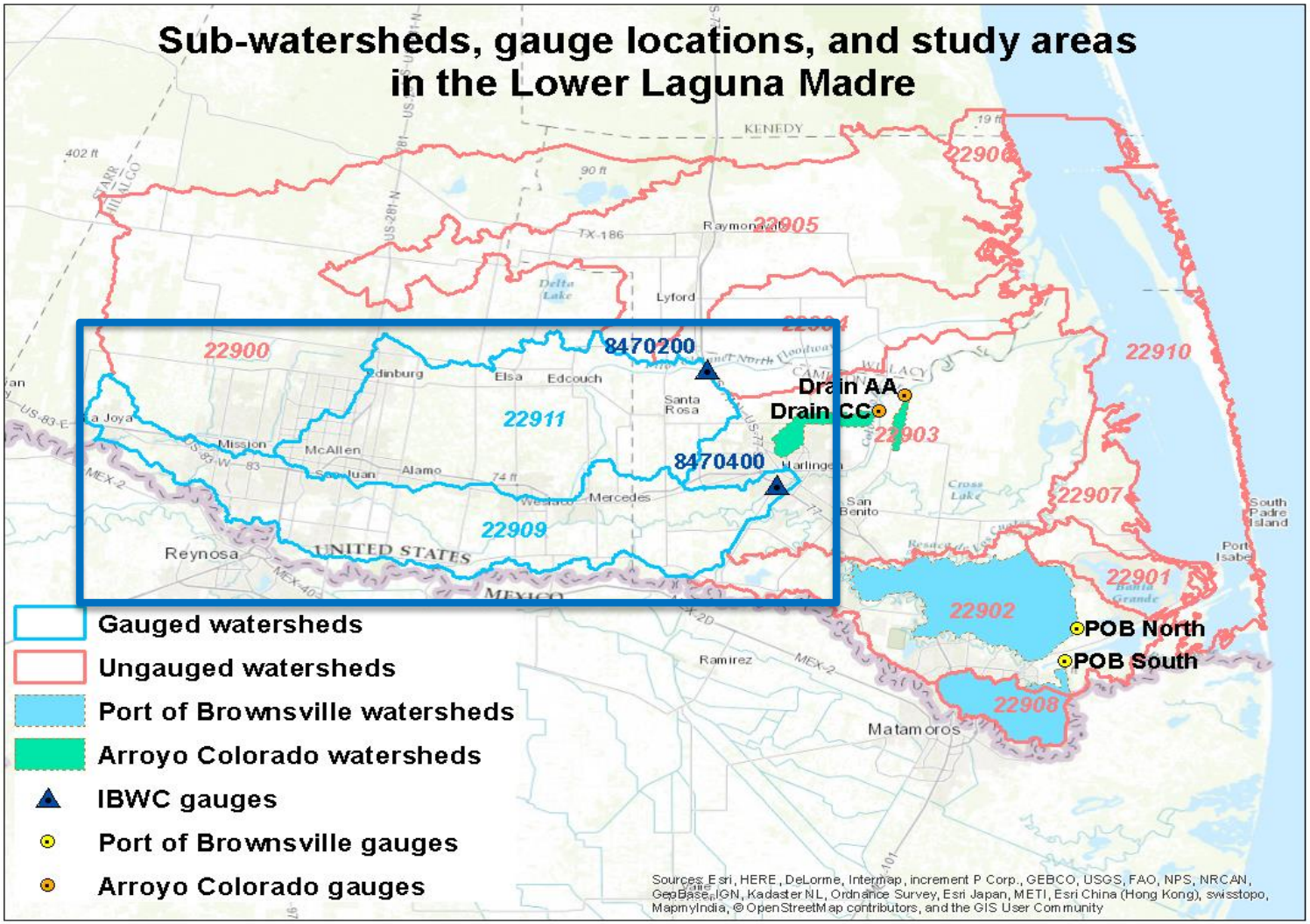
```
/T/baysestuaries/Data/Hydrology/U201501/laguna_madre/inputfiles/pcp/22999.pcp
This line skipped as watershed 22999 is ungaged
LAGUNA BASIN 22999
22999,1940,5,5.72,2.35,37.47
.0073,.0074,.0087,.0091,.0125,.0121
.0118,.0141,.0111,.0107,.0099,.0094
0,1940,1,2016,12,1.00,0.1,0.97,0.0010,.05
```

Base flow constant

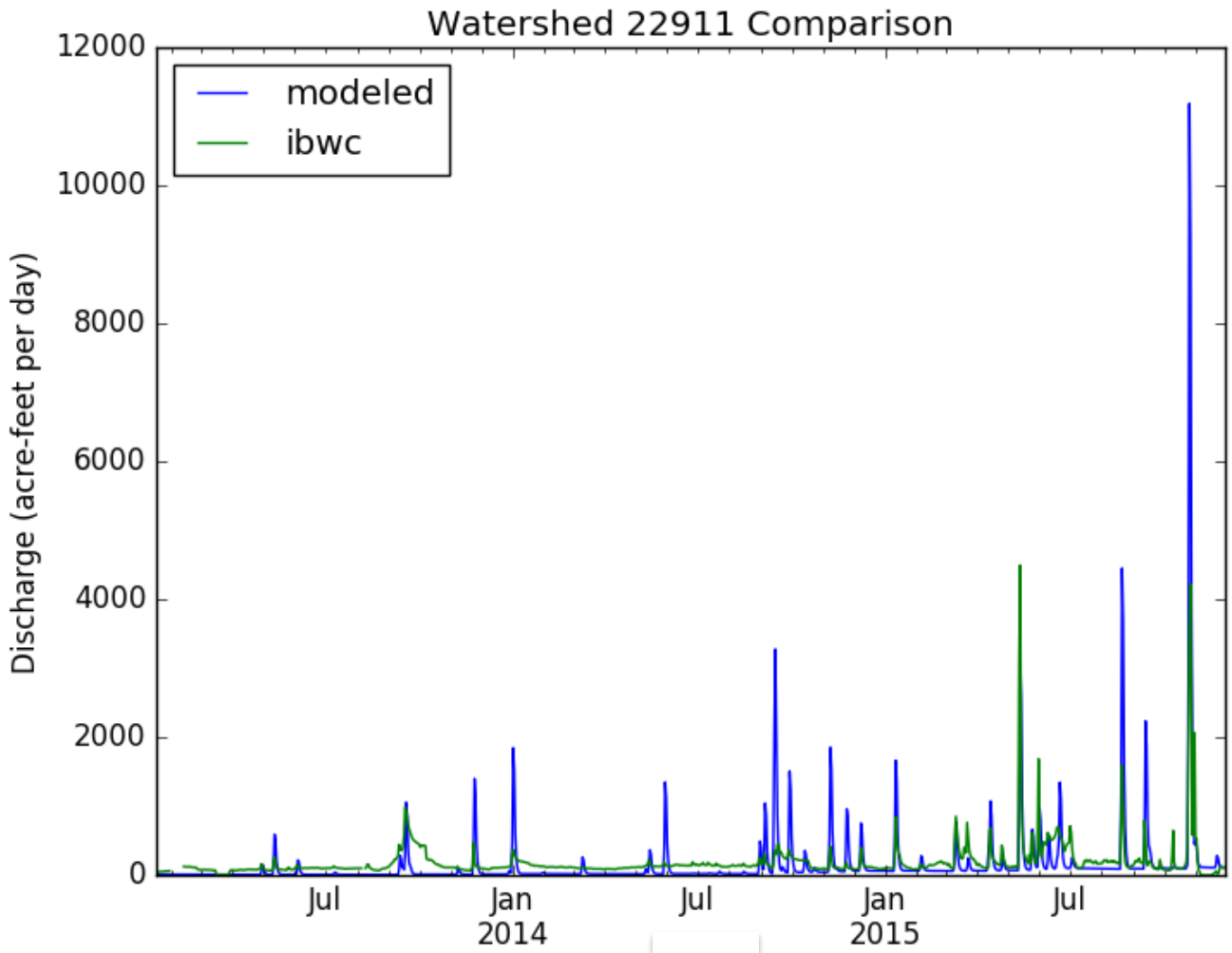
Watershed area

Maximum soil moisture (SMMAX)

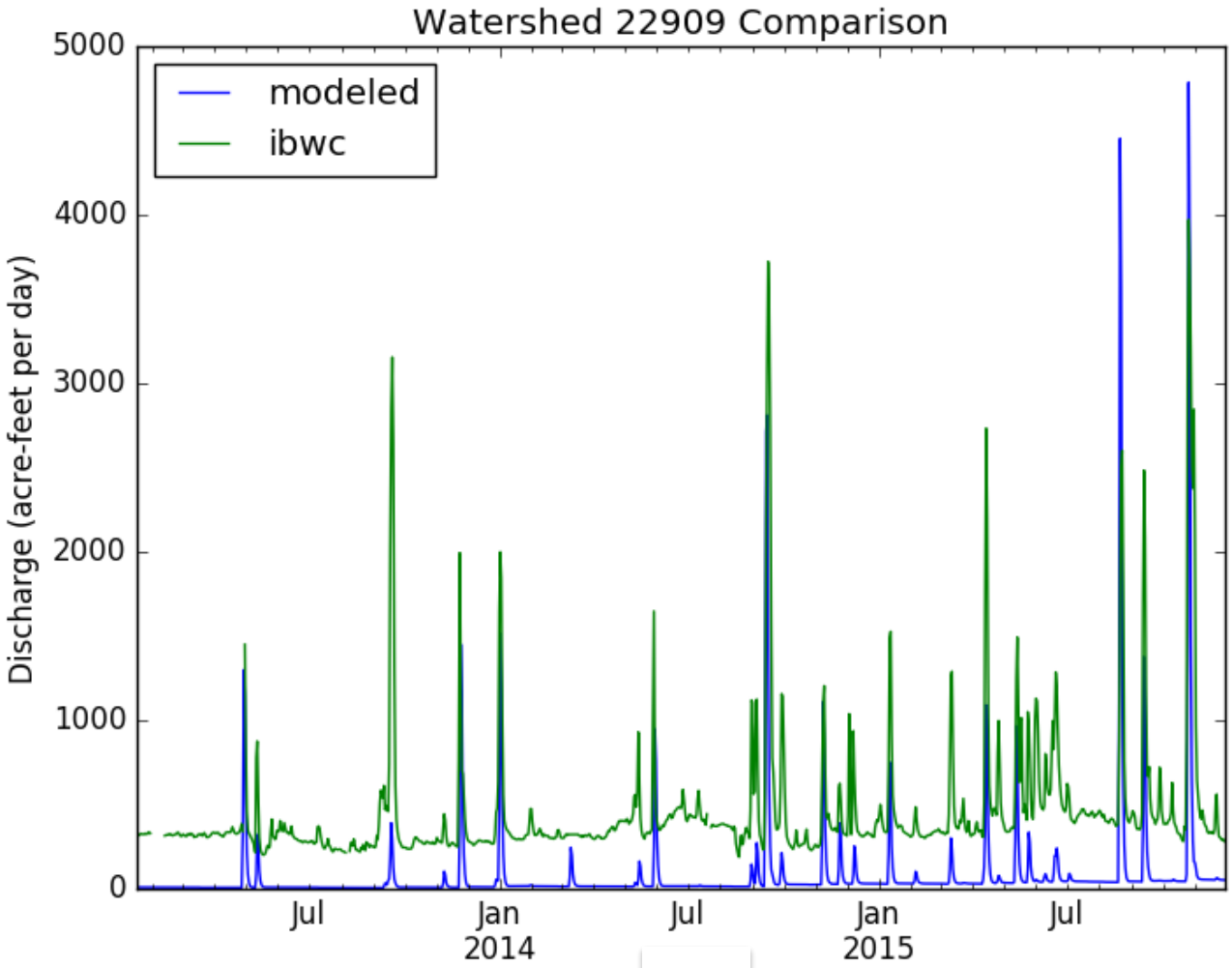
Gauged watersheds in the Lower Laguna Madre



TxRR performance: gauged watershed 1



TxRR performance: gauged watershed 2



How can land use be factored in?

- Adjust SMMAX to reflect existing land use-land cover in watersheds

  SMMAX is derived using the following equation:

$$\boldsymbol{SMMAX = -0.1x + 21.2}$$

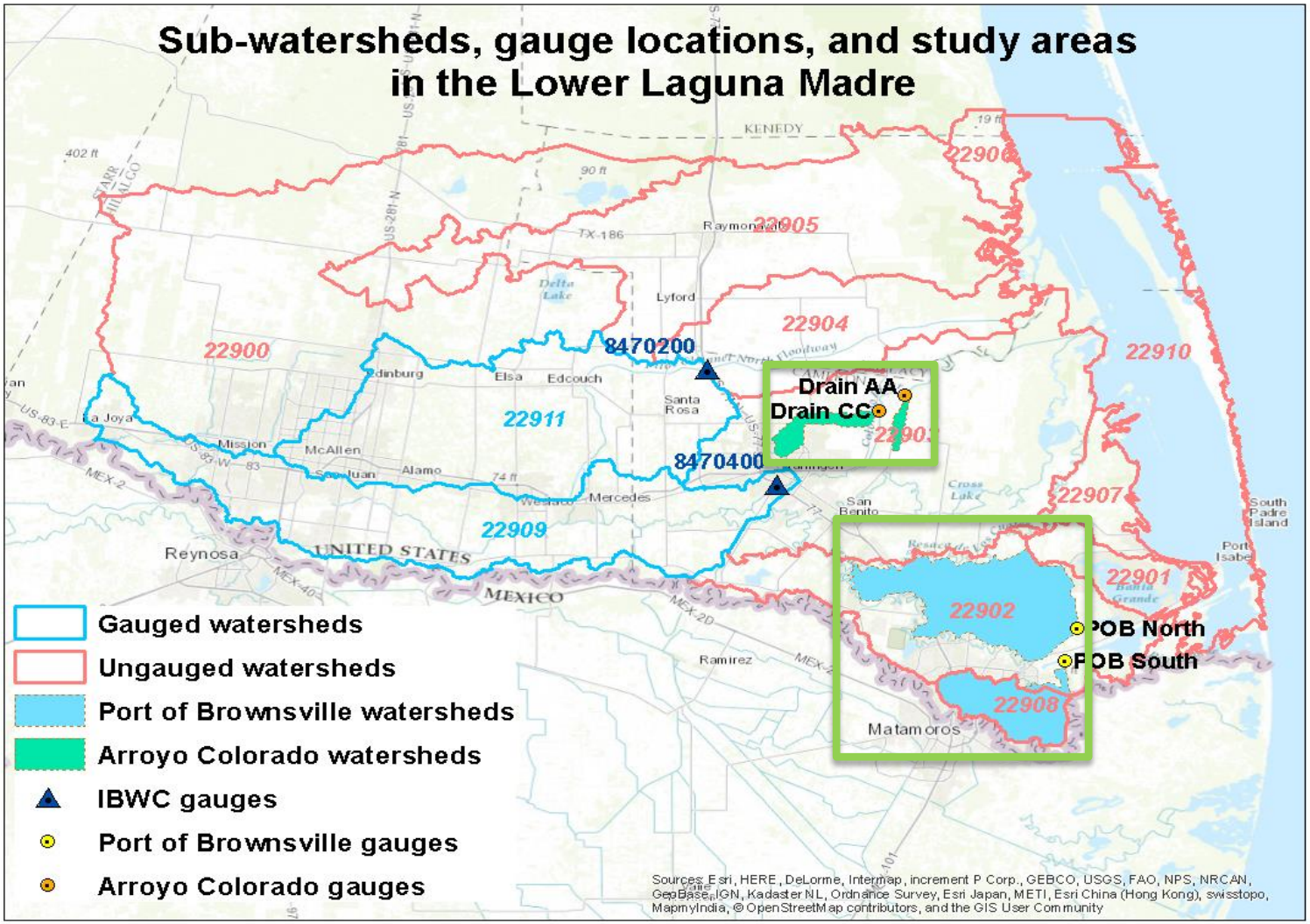
  Where, $x = Curve\ number$

- Curve numbers are from the U.S. Department of Agriculture – Natural Resources Conservation Service report TR-55 titled '***Urban Hydrology for Small Watersheds***' (Cronshey, 1986).

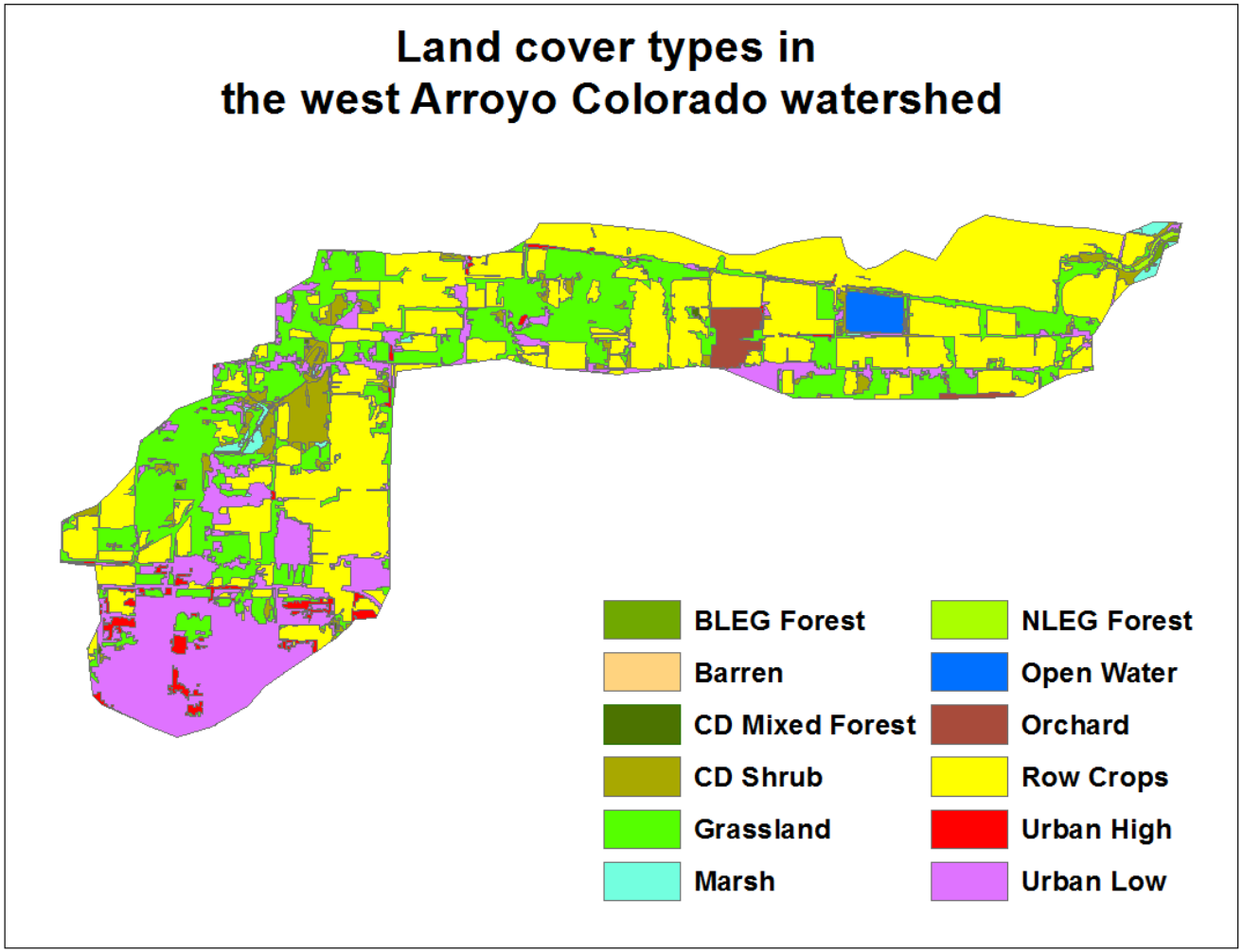
Selection of curve number

- Requires determining Hydrological Soil Groups (HSGs) within a watershed.
- We used soil data for Cameron County from the Soil Survey Geographic (SSURGO) database to obtain HSGs in the sub-watersheds.
- HSGs within dominant land cover types found in the sub-watersheds are used to obtain the runoff curve number associated with each HSG.

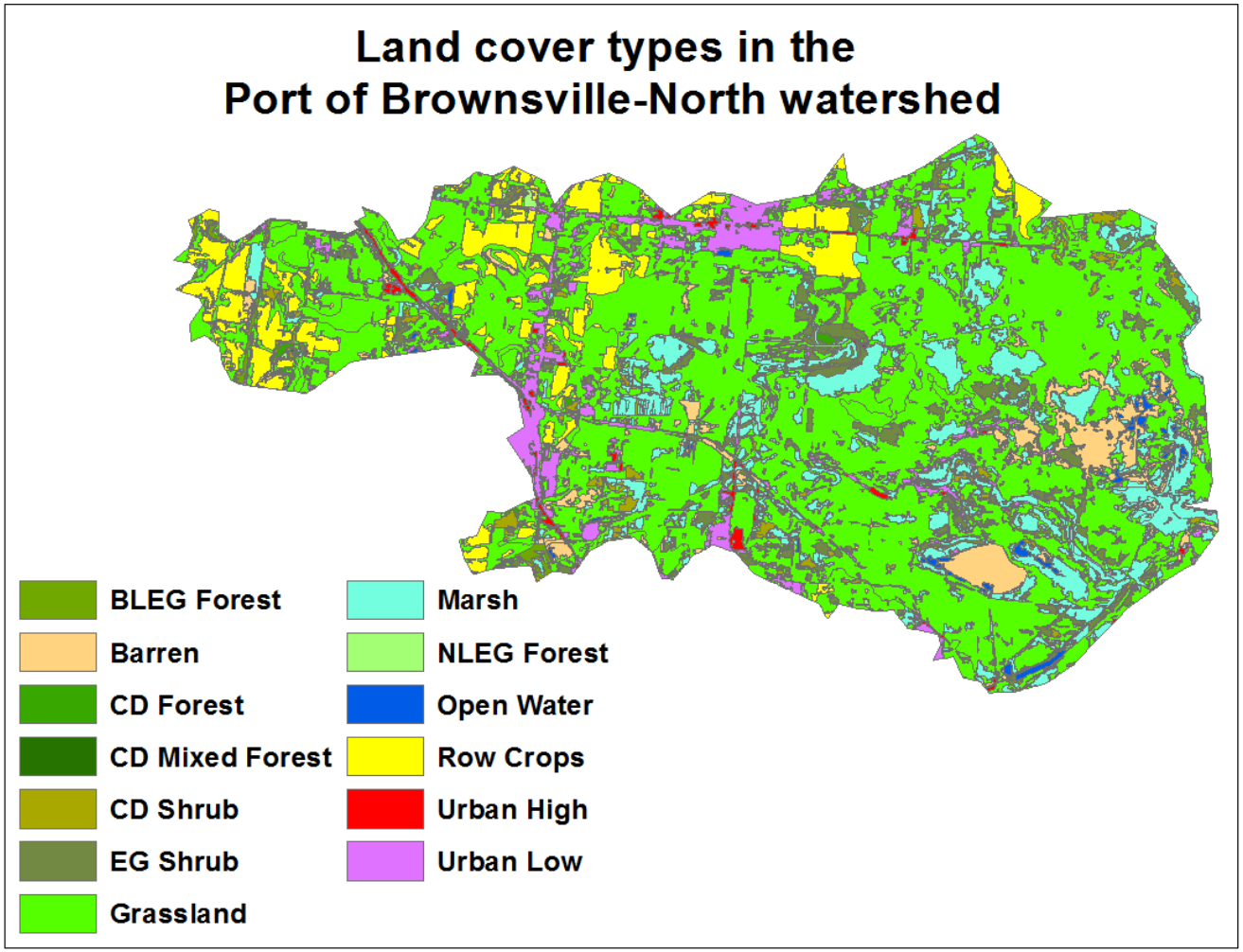
Study sites in the Lower Laguna Madre



Land cover: West Arroyo Colorado



Land cover: Port of Brownsville-North



Dominant land cover, HSG and SMMAX

West Arroyo Colorado	Land cover type	Area (%)	HSG	hydrologic condition/average impervious percentage	Curve Number	SMMAX
	row crops	44	C	poor	88	5.36
	grassland	25	B	good	61	10.22
	urban low intensity	25	C	commercial/business	94	4.28
Average SMMAX						**6.62**

East Arroyo Colorado	Land cover type	Area (%)	HSG	hydrologic condition/average impervious percentage	Curve Number	SMMAX
	grassland	61	C	good	74	7.88
	row crops	35	C	poor	88	5.36
Average SMMAX						**6.62**

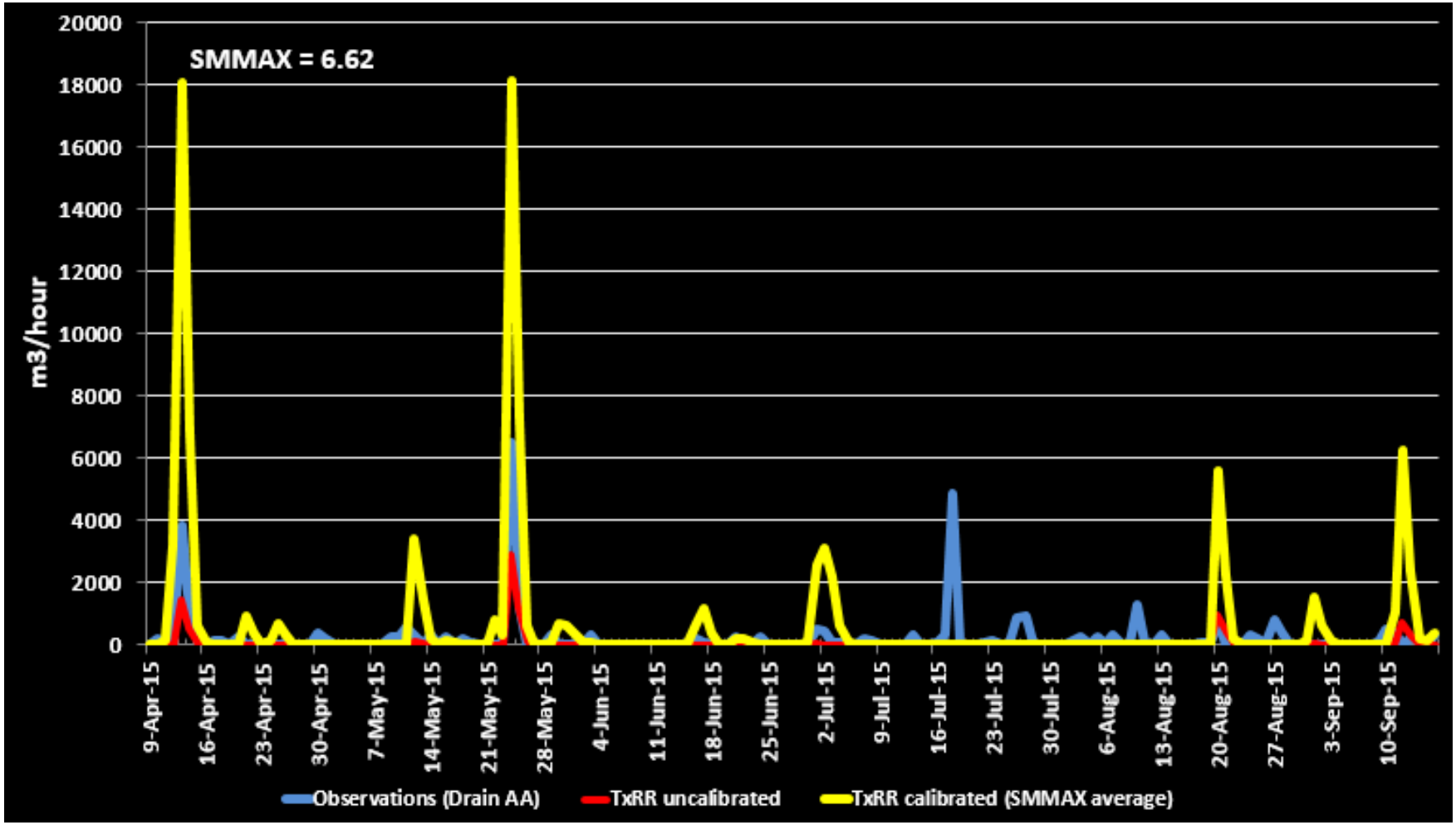
Port of Brownsville-North	Land cover type	Area (%)	HSG	hydrologic condition/average impervious percentage	Curve Number	SMMAX
	grassland	60	D	good	80	6.8
	marshland	12	D	good (used herbaceous)	85	5.9
Average SMMAX						**6.35**

Port of Brownsville-South	Land cover type	Area (%)	HSG	hydrologic condition/average impervious percentage	Curve Number	SMMAX
	urban low intensity	36	B	commercial/business	92	4.64
	grassland	33	D	good	80	6.8
Average SMMAX						**5.72**

Calibration tests: West Arroyo Colorado

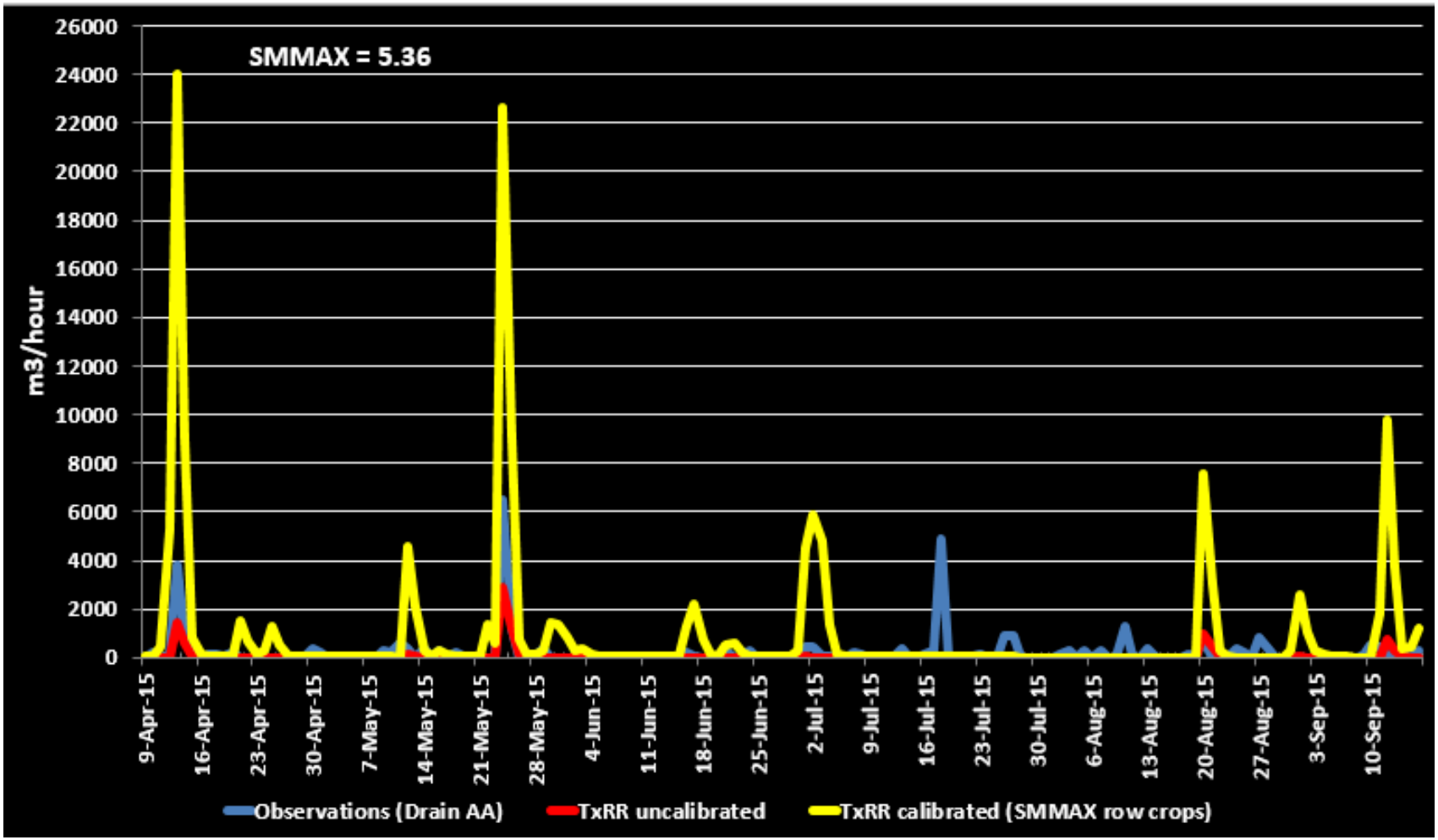
- We ran simulations using:
  1. Average SMMAX (6.62) of the dominant land cover types
     - *Row crops, grassland, urban low intensity*
  2. SMMAX (5.36) for marshland (2nd major land cover type)
  3. SMMAX (10.22) for grassland

West Arroyo Colorado results: average SMMAX



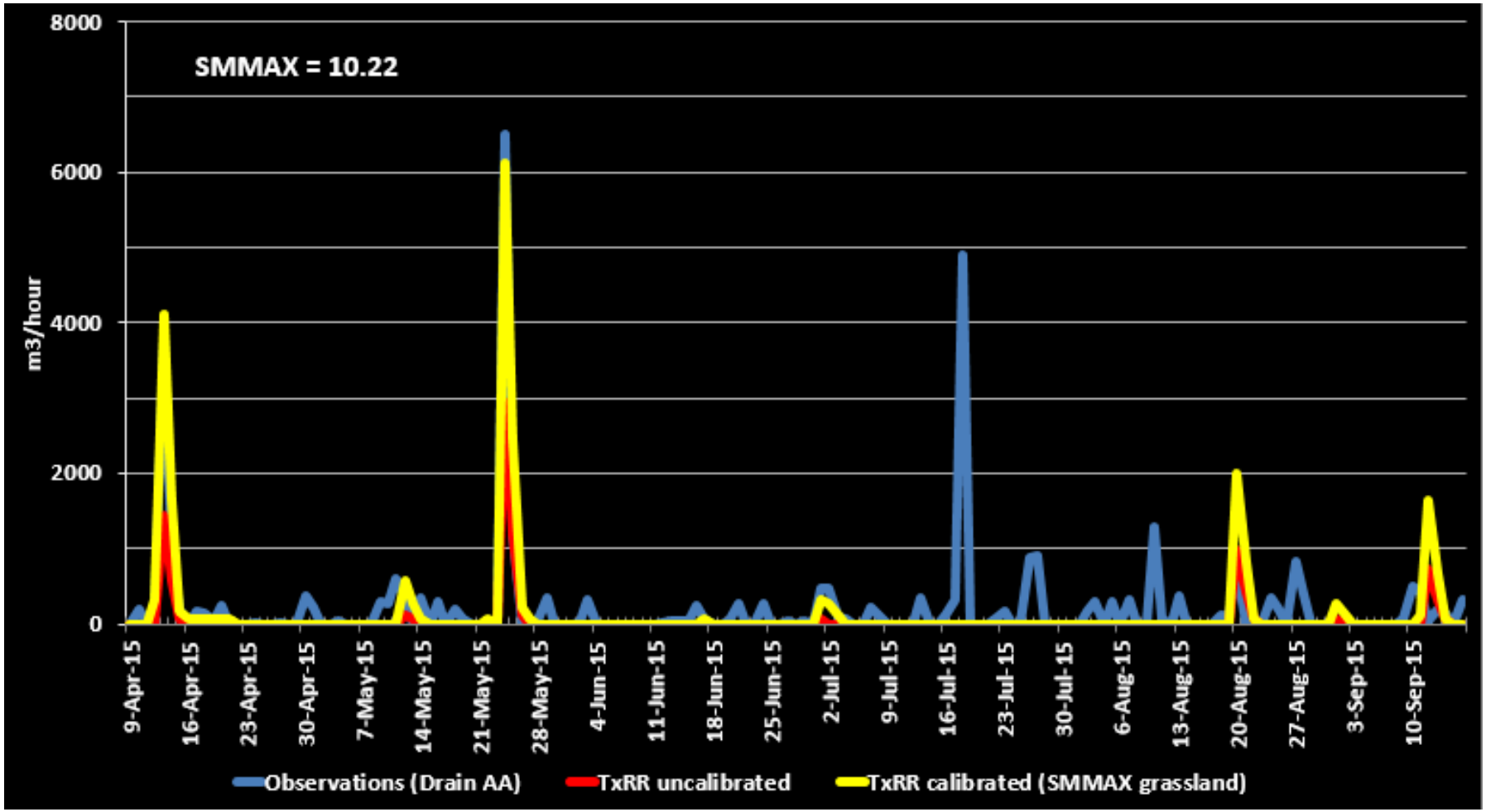
Red: uncalibrated run **Yellow: calibrated run** **Blue: observed**

West Arroyo Colorado results: row crops



Red: uncalibrated run **Yellow: calibrated run** **Blue: observed**

West Arroyo Colorado results: grassland



Red: uncalibrated run **Yellow: calibrated run** **Blue: observed**

Calibration results: Arroyo Colorado West

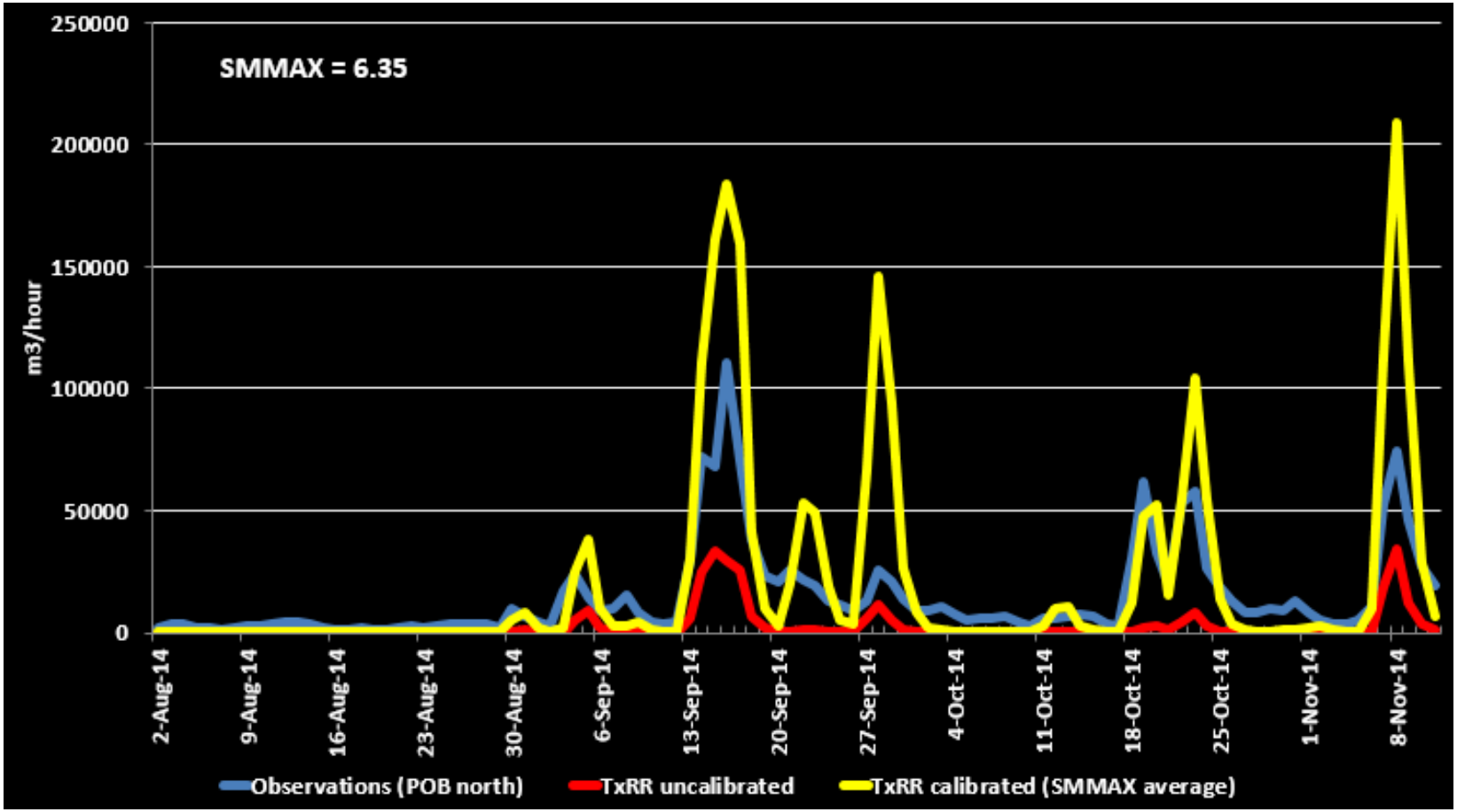
Test	SMMAX	RMSE (m3/hour)	NSE
Uncalibrated	10.59	560.4	-2.155
Dominant land cover (average)	6.62	1859.04	0.3511
Row crops	5.36	2659.02	0.2643
Grassland	10.22	489	0.4378

RMSE: Root Mean Squared Error
NSE: Nash Sutcliffe Efficiency

Calibration tests: Port of Brownsville-North

- We ran simulations using:
  1. Average SMMAX (6.35) of the dominant land cover types
     - *Grassland and marshland*
  2. SMMAX (5.9) for marshland (major land cover type)
  3. SMMAX (6.8) for grassland

Port of Brownsville-North results: SMMAX average

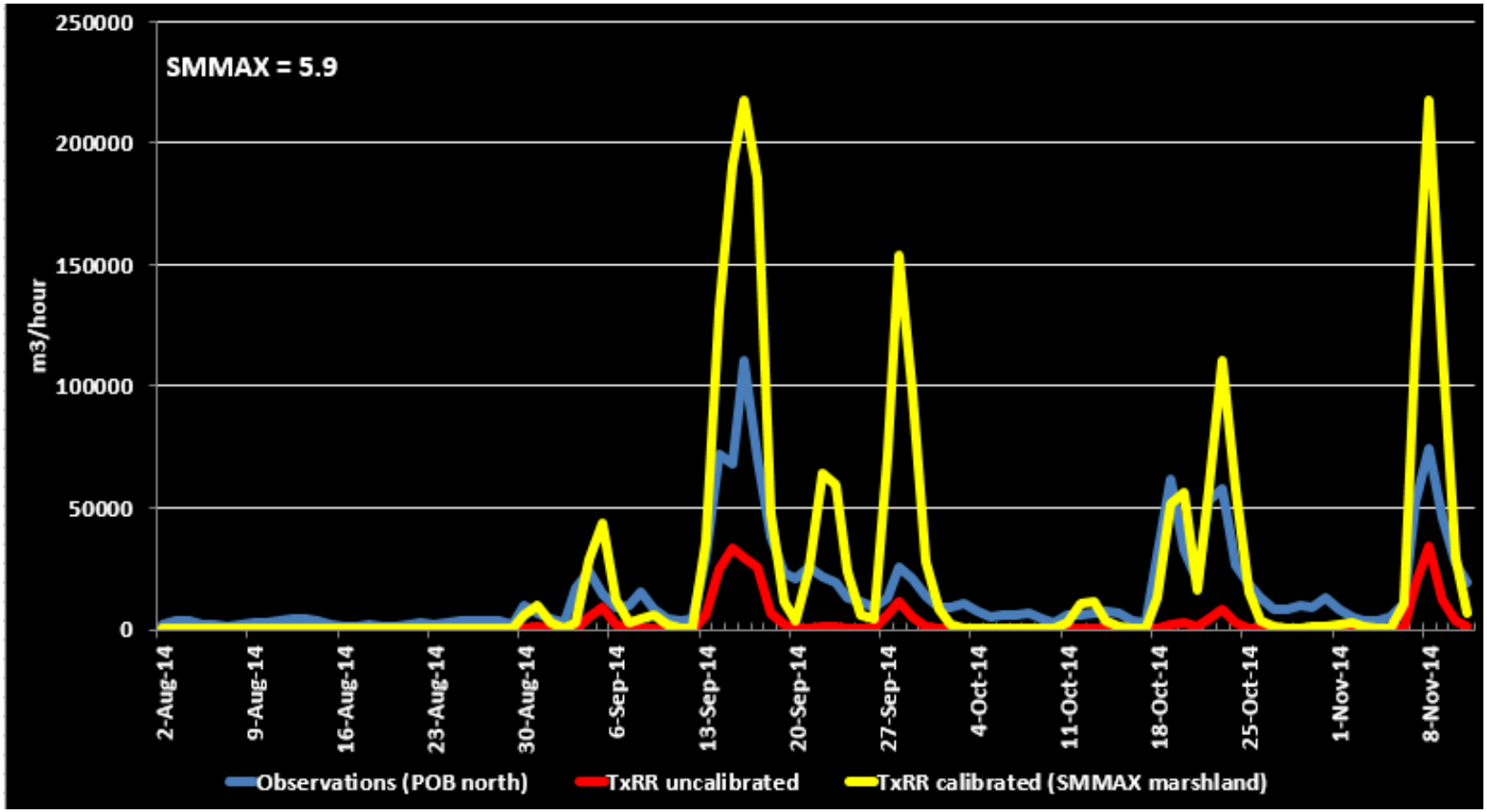


Red: uncalibrated run

Yellow: calibrated run

Blue: observed

Port of Brownsville-North results: marshland

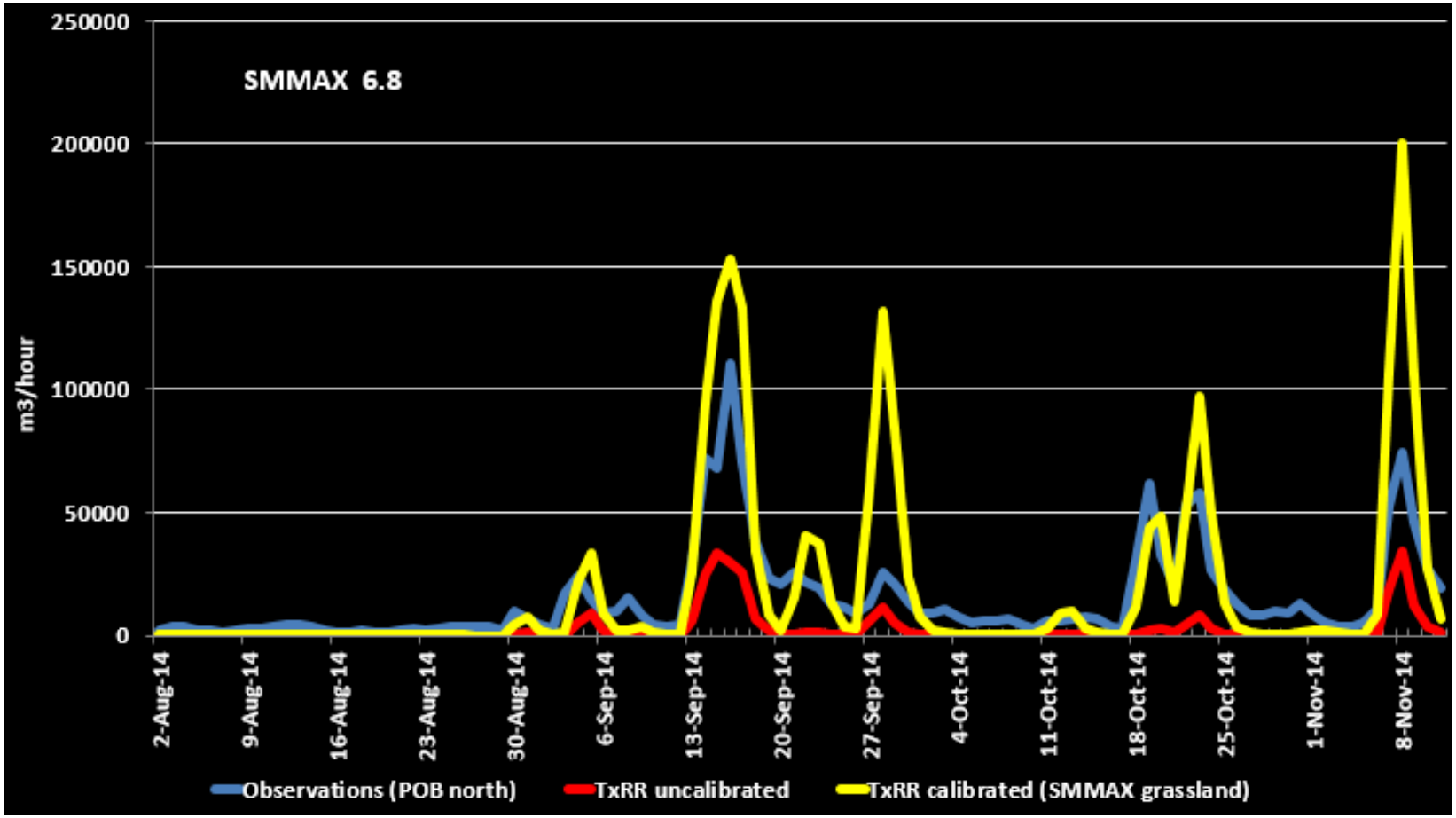


Red: uncalibrated run

Yellow: calibrated run

Blue: observed

Port of Brownsville-North results: grassland



Red: uncalibrated run **Yellow: calibrated run** **Blue: observed**

Calibration results: Port Brownsville North

Test	SMMAX	RMSE (m3/hour)	NSE
Uncalibrated	10.59	18805.14	0.002
Dominant land cover (average)	6.35	28253.44	0.54
Marshland	5.9	32962.1	0.5012
Grassland	6.8	23782.2	0.5834

RMSE: Root Mean Squared Error
NSE: Nash Sutcliffe Efficiency

Conclusion

- Calibrating for existing land cover appears to improve runoff estimates during large runoff events.
  - Particularly so when using SMMAX for grassland
- Some flow pulses, particularly in the Arroyo Colorado watershed, are not captured.
  - May be agricultural releases
  - Upstream flow
- Need to incorporate updated land use/land cover information in TxRR model calibration
  - Update at least every 5 years if not more frequently (data availability a critical issue)

Work planned

- Undertake a similar analysis for two more sub-watersheds:
  - Arroyo Colorado East
  - Port of Brownsville South
- Compare gauged flow at a sub-watershed north of Arroyo Colorado West and Port of Brownsville-North
  - Is there a flow pulse going downstream?
  - Does adding upstream gauged flow from upstream to estimated runoff change the calibration result? (i.e. would SMMAX average work better?)
- Assess calibration results with improved watershed delineations

Questions?

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