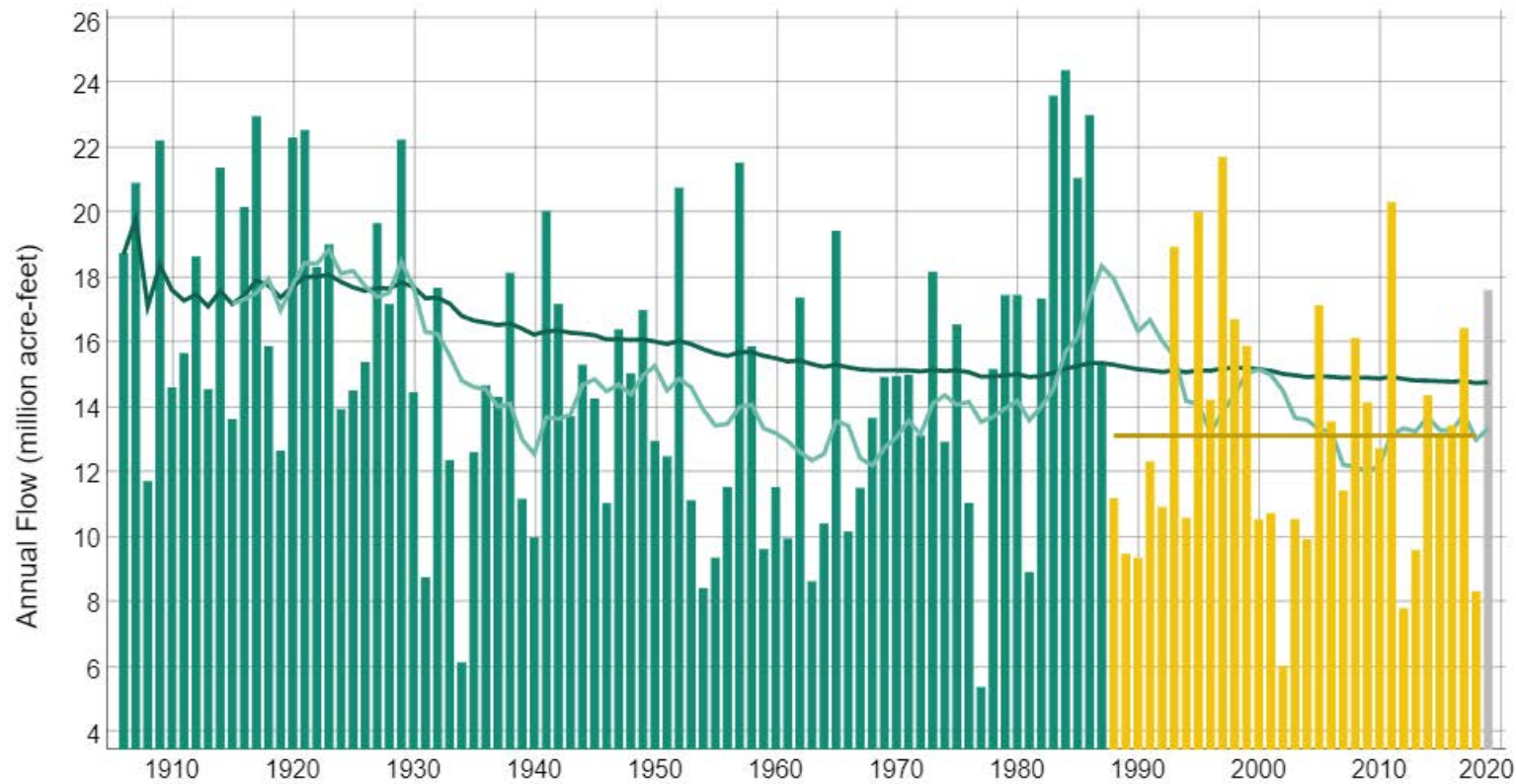


Colorado River Natural Flow at Lees Ferry Gaging Station, Arizona

— Annual — Provisional — Running Average — 10-year Moving Average — Annual (Stress Test) — Stress Test Average

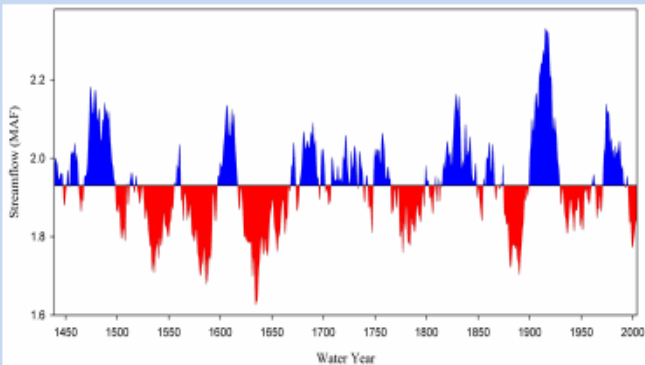


Multi-century droughts in the Green River Basin.

Climate Variability

Tree Ring analysis

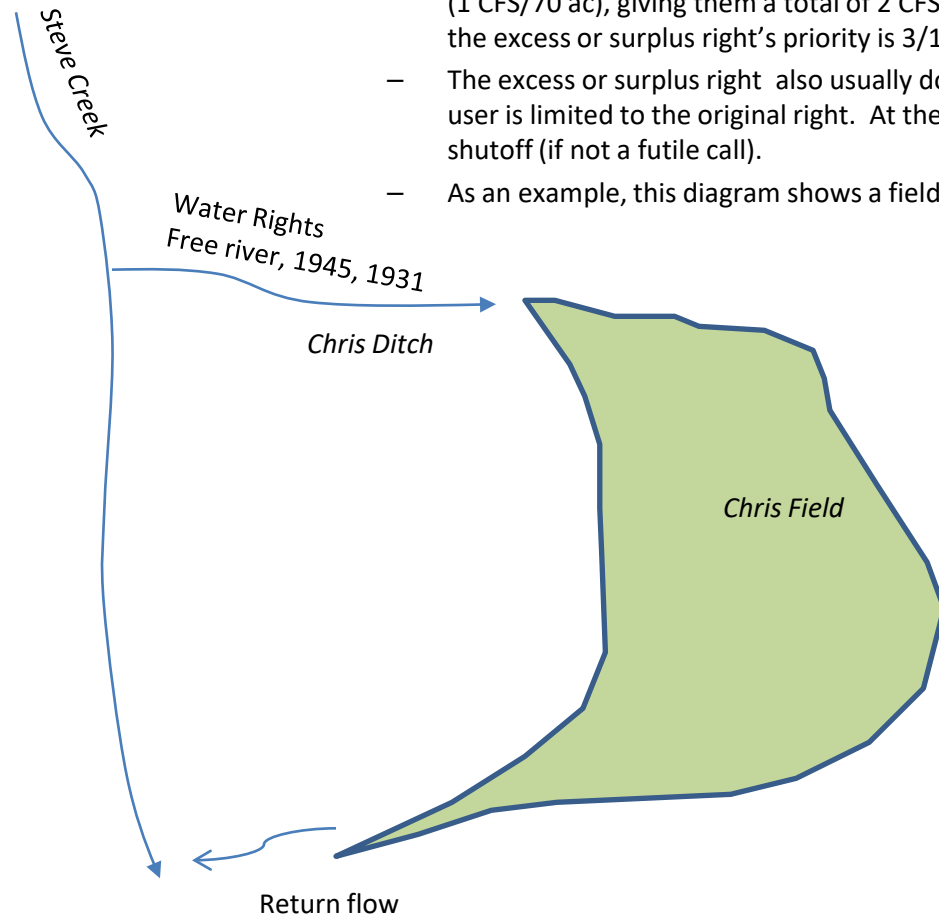
Lake Sediment analysis



Regulating Fields by Priority Date vs. Curtailing a Basin by Consumptive Use

A Conceptual Model that Combines the Two

- Conceptual model created by SEO - It is a tool created for demonstration and consideration purposes of irrigation rights, and is based on estimates only. It is not intended to be used for regulation purposes.
- Background: The State Engineer's Office (SEO) normally regulates fields by their water rights, in order of priority date. Most fields have multiple water rights.
 - Prior to regulation, ditches in most areas are allowed to fill to capacity (free river). This flow is short-lived, ending once the drainage goes into regulation or the river flow is not sufficient.
 - Most irrigators have two rights: an original right (1 CFS/70 acres) and a second, known as the excess or surplus right (1 CFS/70 ac), giving them a total of 2 CFS/70 acres. The original right priority date is the date of the permit, whereas the excess or surplus right's priority is 3/1/1985 or 3/1/1945, respectively.
 - The excess or surplus right also usually does not last the whole season due to water shortage, at which point the user is limited to the original right. At the time the drainage goes into regulation, upstream junior rights will be shutoff (if not a futile call).
 - As an example, this diagram shows a field's overlying free river flow, 1945 surplus right, and 1931 original right.



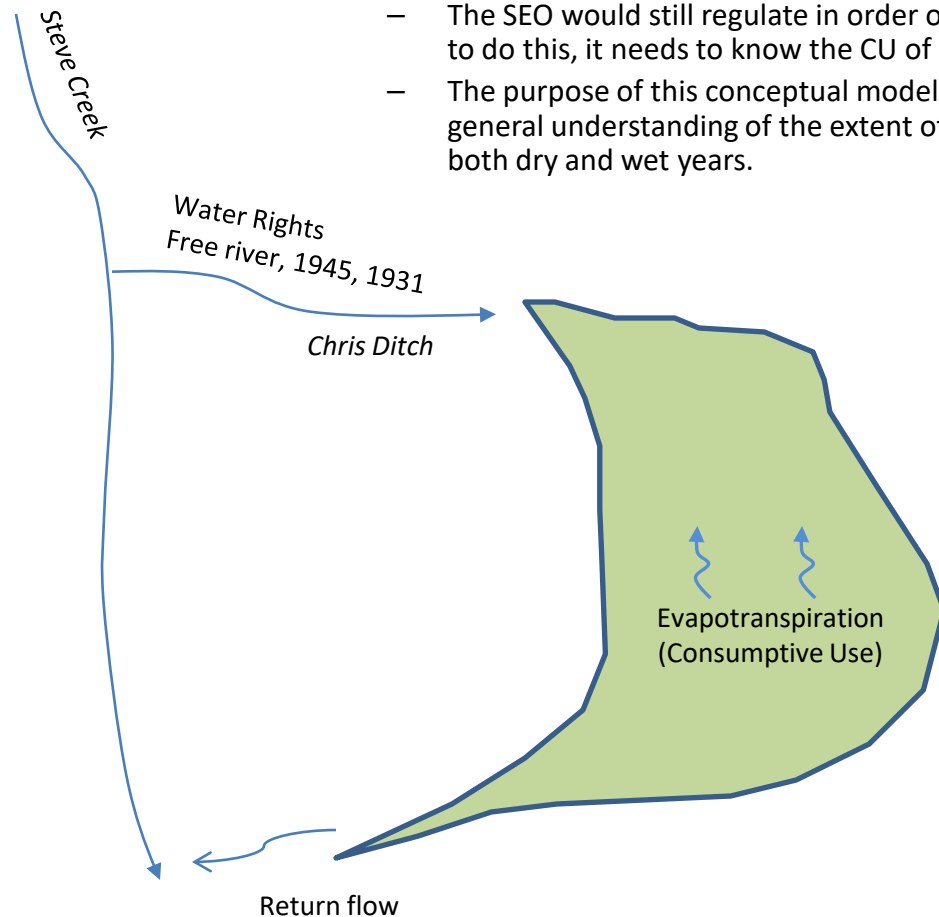
Example of overlying rights

Priority Date	Flow (CFS)	Est. Duration (dry – wet year)	Right's Name
Free River	Ditch capacity	0 days – 30 days	Free River
3/1/1945	1 CFS/70 ac	30 days – 60 days	Surplus Right
1/1/1931	1 CFS/70 ac	100 days – 150 days	Original Right
Total	2 CFS/70 ac	100 days – 150 days	-

Regulating Fields by Priority Date vs. Curtailing a Basin by Consumptive Use

A Conceptual Model that Combines the Two

- The 1948 Upper Colorado River Compact regulates in terms of consumptive use (CU).
 - The SEO annually reports the CU of the fields based on measurements of the field's evapotranspiration (ET) due solely to irrigation, regardless of the field's individual rights.
 - If there were a Compact curtailment, the SEO would have to regulate ditches until sufficient CU was "conserved".
 - The SEO would still regulate in order of the priority date (back to the Compact date). However, in order to do this, it needs to know the CU of each right.
 - The purpose of this conceptual model is to be able to calculate the CU of each right and provide a general understanding of the extent of regulation generated by hypothetical curtailment volumes, under both dry and wet years.



Example of overlying rights

Priority Date	Flow (CFS)	Est. Duration (dry – wet year)	CU (ac-ft)	Right's Name
Free River	Ditch capacity	0 days – 30 days	x	Free River
3/1/1945	1 CFS/ 70 ac	30 days – 60 days	y	Surplus Right
1/1/1931	1 CFS/ 70 ac	100 days – 150 days	z	Original Right
Total	2 CFS/ 70 ac	100 days – 150 days	x + y + z	

Workings of the Irrigation Conceptual Model

- The model divides each field's CU into percentages of: 1) free river, 2) excess or surplus right and 3) original water right. These total to 100%.
 - The % of free river and excess/surplus vary. In some areas of the model, these flows make up a large portion of the fields' CU. These parameters depend mainly on the year's water supply (wet year vs dry year), but also on the ditch, soil type, and if a large reservoir supplies the area.
 - Estimating these %s is based on info from field staff including understanding users' water needs and when these additional flows usually run out.
 - The time period of free river is dependent on the water supply and is just available in the first part of the season, and often will not exist in dry years.
 - Excess or surplus rights are usually only available the first part of the season, and in cases of certain districts/agreements, may be used only minimally.
- Annually, the SEO calculates a total ET for each District, which is applied to each field in that district.
 - ET is different every year and is affected by temperature, humidity, rainfall, solar radiation (cloud cover), wind, water supply and crop type.
 - In this model, each right's individual ET = Total ET of the field x % attributable to that right (AKA ET_{right})
- The amount of acres irrigated varies annually, depending on water supplies. Annually, this is measured by the SEO using remote sensing (Landsat) methods. The model incorporates this irrigated acreage, resulting in an "effective" area of each right. This may be smaller than the adjudicated area.
- Finally, each right's CU = $ET_{Right} \times$ "effective" area of the right. This is the value "conserved" by curtailing that right.
- Two years were tested up to this point:
 - 2013: Low water supply, above average ET, less land irrigated (*MORE LIKELY DURING CURTAILMENT*)
 - 2017: High water supply, below average ET, more land irrigated.

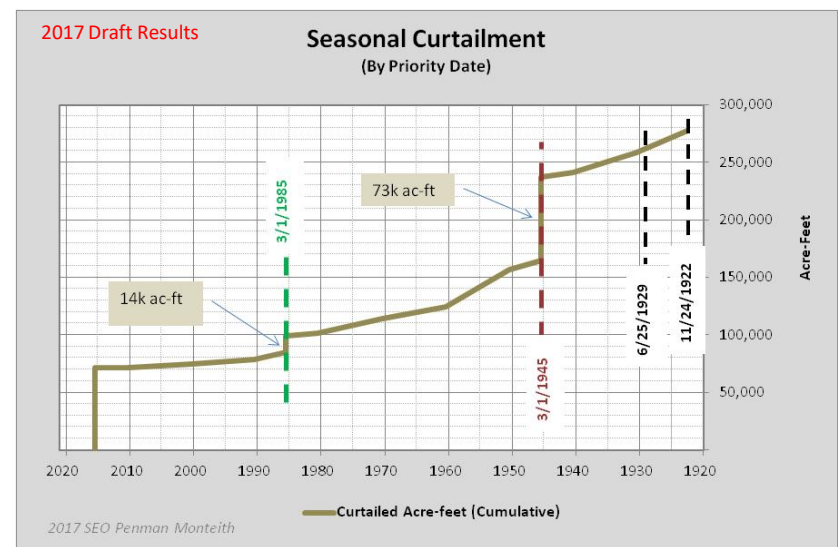
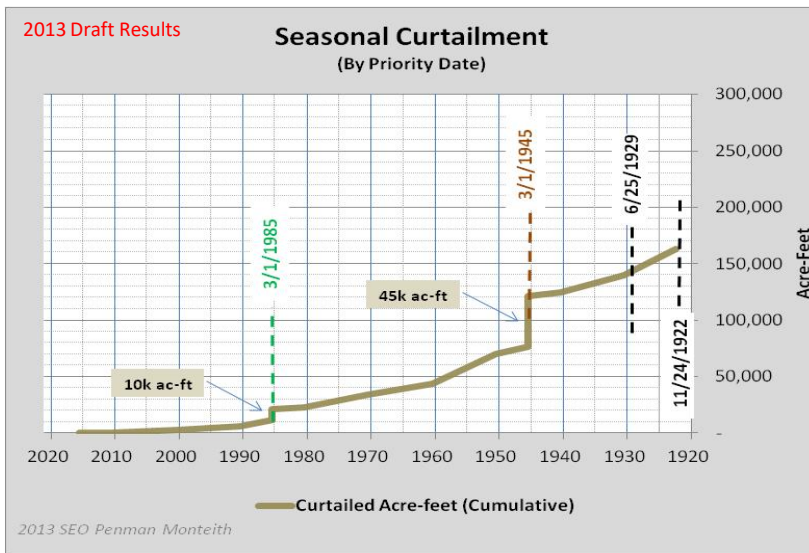
Irrigation Conceptual Model

2013

- Typical GRB hydrology of a dry period.
- ~75,000 ac-ft CU achieved prior to curtailing surplus rights.
- No free river available – cannot count toward conserved CU.
- Regulating during a dry period would require deeper regulation. This is mainly because each right has less CU potential.

2017

- Typical GRB hydrology of a wet, cooler year, with free river.
- ~165,000 ac-ft CU achieved prior to curtailing surplus rights.
- Significant CU from free river.
- Regulating during a high water supply year, like 2017, would require less regulation. This is mainly because each right has greater CU potential. In other words, would not likely regulate back as far.



Generalizations only; municipal and industrial CU NOT included

Uncertainties and Future Work

Uncertainties

- The simplicity of this conceptual model makes it appropriate to estimate CU conserved by curtailing free river, excess/surplus and original WRs (up to Compact date) of irrigation rights only. It is not designed for regulating individual water rights.
- The dataset is missing a small amount of water rights records. It is uncertain at this time how this would change the results.
- Lack of precise GIS mapping requires use of correlation factors that relate adjudicated areas to actual irrigated areas. This incorporates some error into the results.
- CU percentages due to free river, surplus and excess rights are estimated based on the best information available. Adjustments to these percentages have significant effects on the results.
- Additional testing of boundaries and error ranges should be done as part of future refinements.

Future Work

- Future improvements range in degrees of effort and complexity. Initial refinements might be done in-house by the SEO over the next year, or more, depending on their degree:
 - Refinements and testing of model parameters through work with field data, field staff and remote sensing CU data.
 - Possible improvements to the water rights dataset through work with WWDO.
- Additional useful enhancements may be worthwhile and increase the confidence and usefulness of the model, however, they are larger undertakings and the SEO currently lacks personnel and funding to accomplish these at this time:
 - Improving the mapping of adjudicated rights boundaries.
 - Incorporating available non-agricultural CU such as municipal and industrial rights.
 - Incorporating reservoir supply rights that are not tied to a specific point of use.

The SEO greatly welcomes information from individuals regarding the use and importance of free river and excess/surplus water rights