Duty vs. Depletion

Utah Water Users Workshop

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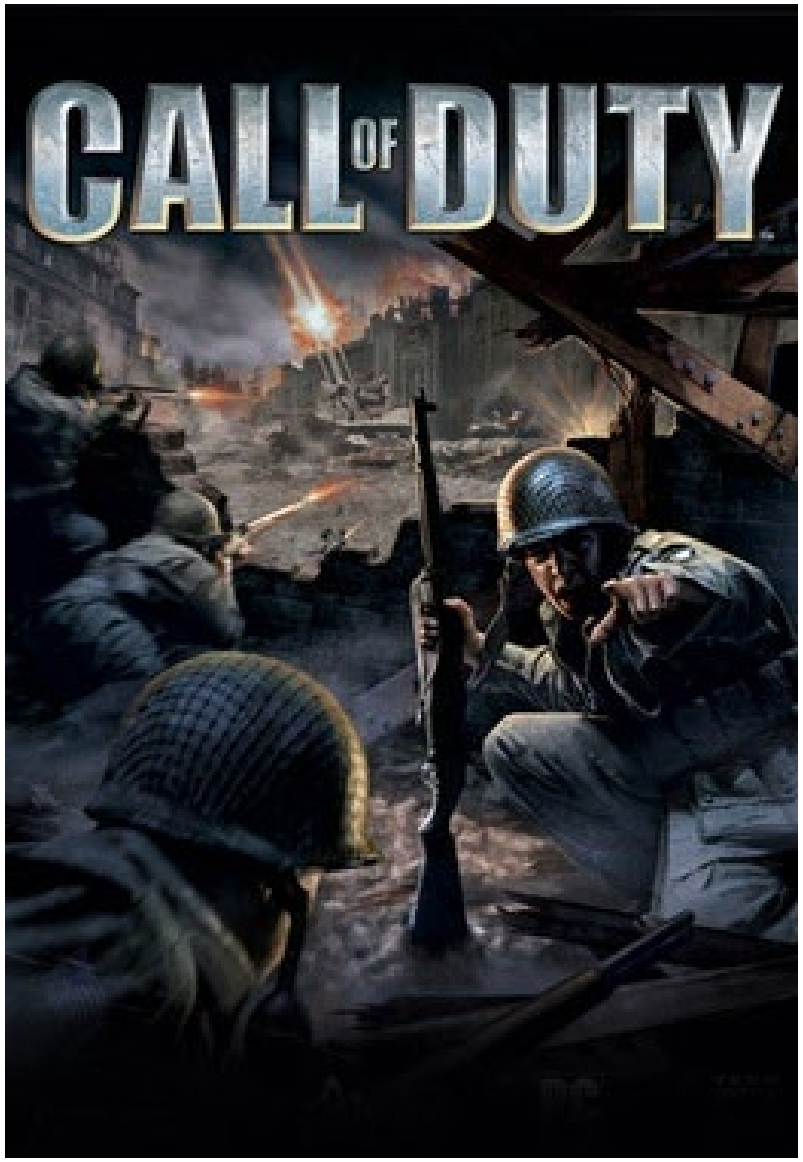
Utah Division of Water Rights

*“Everything in **[water rights]** is very simple. But the simplest thing is difficult.”*

- Carl von Clausewitz…probably

Why does Duty and Depletion Matter?

- Appropriations
  - *Quantifying new appropriations*
  - *Evaluating change applications*
- Adjudication
  - *Quantifying unevaluated claims/rights*
  - *Updating antiquated allocations*
- Distribution
  - *Apportioning diversions*
  - *Preventing waste*



Duty & Depletion Defined (DRAFT)

“Duty of Water” or **“Duty”** means the maximum amount of water reasonably required to accomplish a unit amount of Beneficial Use for a given period of time for a specified beneficial use.

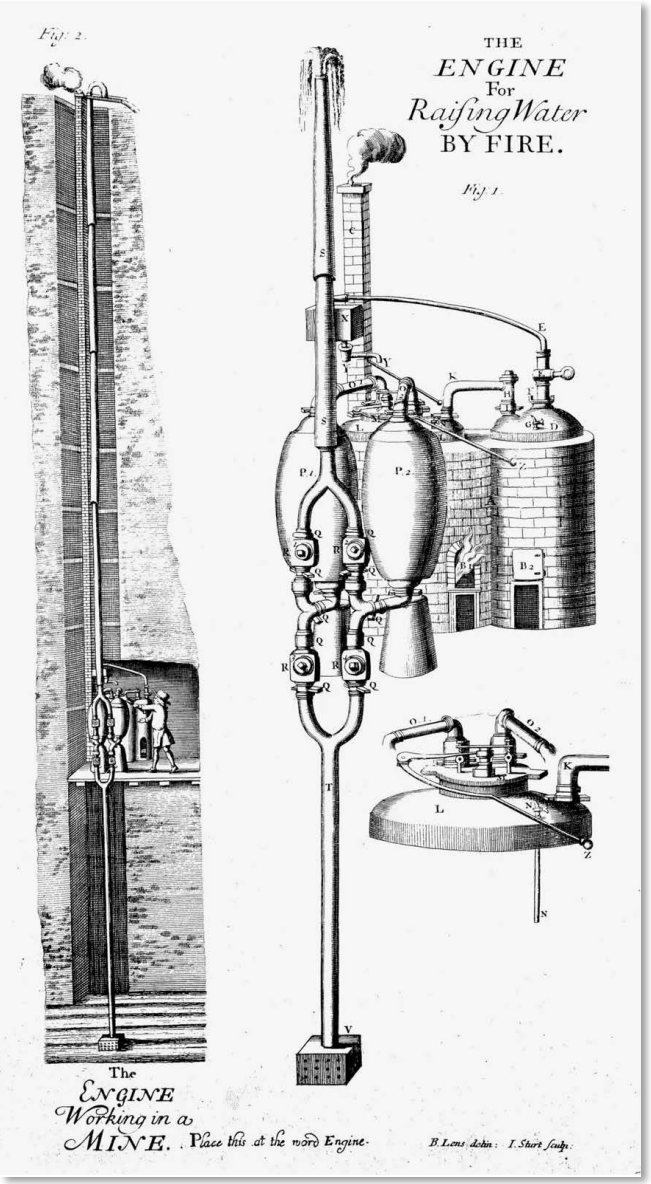
“Depletion” means the amount of water removed from the Hydrologic System.

Common Beneficial Uses, Duties, and Depletions

Common Beneficial Uses	*Unit of Use*	*Typical Duty*	*Typical Depletion*
Irrigation	acres	3 to 6 AF/acre/yr	40% - 50%
Domestic	Equivalent Domestic Unit (1 EDU = family of 5)	Full-time: 0.45 AF/yr Part-time: 0.25 AF/yr	20% - 100%
Livestock	Equivalent Livestock Unit (1 ELU = 1 horse or cow)	0.028 AF/yr	100%
Mining	Acre-feet or cfs	None established	Depends
Power (Hydro Electric)	cfs and kW	None established	0%
Municipal	Acre-feet	None established	100% (Depends)
Storage	Acre-feet	N/A	1 ft – 2 ft per year

The Early History of Duty

- The word “duty” as an engineering term was first introduced by James Watt in the 18th century to illustrate the efficiency of his steam engines in dewatering English coal mines in Cornwall.
- In order to promote his steam engine against the Newcomen engine, Watt had to standardize a way to compare the amount of work performed by an engine in relation to the amount of fuel consumed.
- Watt developed the concept of horsepower and described a steam engine’s “duty” as the amount of water that could be lifted per bushel of coal burned.
- Consequently, the concept of “duty” began as a measure of the amount of “work” an engine could perform per unit of fuel.
- During the colonial occupation of India, British engineers adapted the concept of “duty” to large-scale irrigation projects.
- Engineers assigned an “irrigative duty” to a particular region that described the number of acres that could be irrigated per cubic foot per second (cfs) of diverted water.



The Utah History of Duty

- When the Mormon Pioneers first settled in what is now Utah, they generally imposed a fractional apportionment of a stream based on the relative number of acres under cultivation.
- In the early 1860s, the "duty of water" concept began to be adopted by settlers to describe the amount of "work" a unit of water could perform to better administer the scarce resource in the arid West.
- Irrigation duties were often dependent on various factors (e.g., soil type, climate, crop type, etc.); consequently, duty values varied widely.
- Around the turn of the century, irrigation duties began to be expressed as a volume of water applied per acre (i.e., acre-feet per acre).

> *"The duty of water in irrigation is the area of crop which can be matured with a given volume….This practice has recently been adopted, but it is usual to give the number of acre-feet of water used on an acre of ground. This is in reality the reciprocal of the duty, but is a more convenient form…"*
>
> *– Irrigation Institutions, 1903*

Duty of water.

Name of canal.	Area served by 1 cubic foot per second.	Depth on land.
Jordan River:	*Acres.*	*Feet.*
Mousley Ditch	36.30	6.66
Beckstead Ditch	48.70	4.97
Galena Ditch	50.20	4.81
Provo River:		
Provo Bench	82.51	4.16
East Union	55.83	6.14
Upper East Union	37.23	9 48
Timpanogas	34.48	9.45
Parks & Roberts	8.15	a 42.06
Lake Bottom Canal	106	3.64
West Union	74	4.32
Roberts Ditch	19.36	12.43
Virgin River:		
St. George and Washington	.....	8.41
St. George Clara fields	.....	2.74

Table from "Report of Irrigation Investigations in Utah", USDA, 1903

The State Engineer History of Duty - Appropriation

- In 1903, the State Engineer was given authority to approve water rights appropriations and issue Certificates of Beneficial Use related to their quantification.
- Initially, flow rates (i.e., cfs) were used exclusively to define the amount of water associated with a particular water right (except for storage rights).
- In the 1920s, certificates began to include a sentence relating to volumetric limitations:

  "This certificate does not entitle the holder to exceed three acre feet of water per acre of land irrigated per annum."

- This three acre-foot duty was used for water rights across the entire state.
- This practice appears to have continued until the 1940s when it was abandoned.
- In the mid-1990s, certificates began listing flow rates and a corresponding volume or just a volume.

The State Engineer History of Duty - Adjudication

- In 1920, the State Engineer was statutorily directed to be a more active participant in the General Stream Adjudication process by evaluating rights and filing a determination in the respective court (i.e., Proposed Determination or "PD").

- Early adjudications relied on a flow rate duty (except for storage rights). The irrigation duties were often listed in the preamble as shown in the Weber River PD from 1924:

  "[A] duty of one second foot of water to 60 acres of land on the upper river areas, one second foot of water to 65 acres of land on the middle river areas and one second foot of water to 70 acres of land on the lower river areas during the high water stages has been determined. During the low water stages and before rights are cut off according to class the duty of water is raised to one second foot of water to 80 acres of land over the entire system."

- This practice changed in 1949 with the Escalante Valley PD wherein the State Engineer first published a volume duty along with an explanation for the shift:

  "In the instance of irrigation, the requirement of the land has been considered to be 3 ac ft. per acre per calendar year, regardless of the source of supply. So far as the State Engineer at this time is aware, this is the first attempt made to prepare a statutory adjudication on the basis of actual water diverted and used. Heretofore second feet has been the standard… but… second feet is only a rate of flow and the water actually consumed or beneficially used is a combination of rate of flow and time elapsed during which said flow is permitted, the combination of which results in an acre foot quantity of water."

- Later and contemporary proposed determinations generally add clarifying language that specifies whether the duty is to be measured at the diversion or field headgate.

The State Engineer History of Duty - Distribution

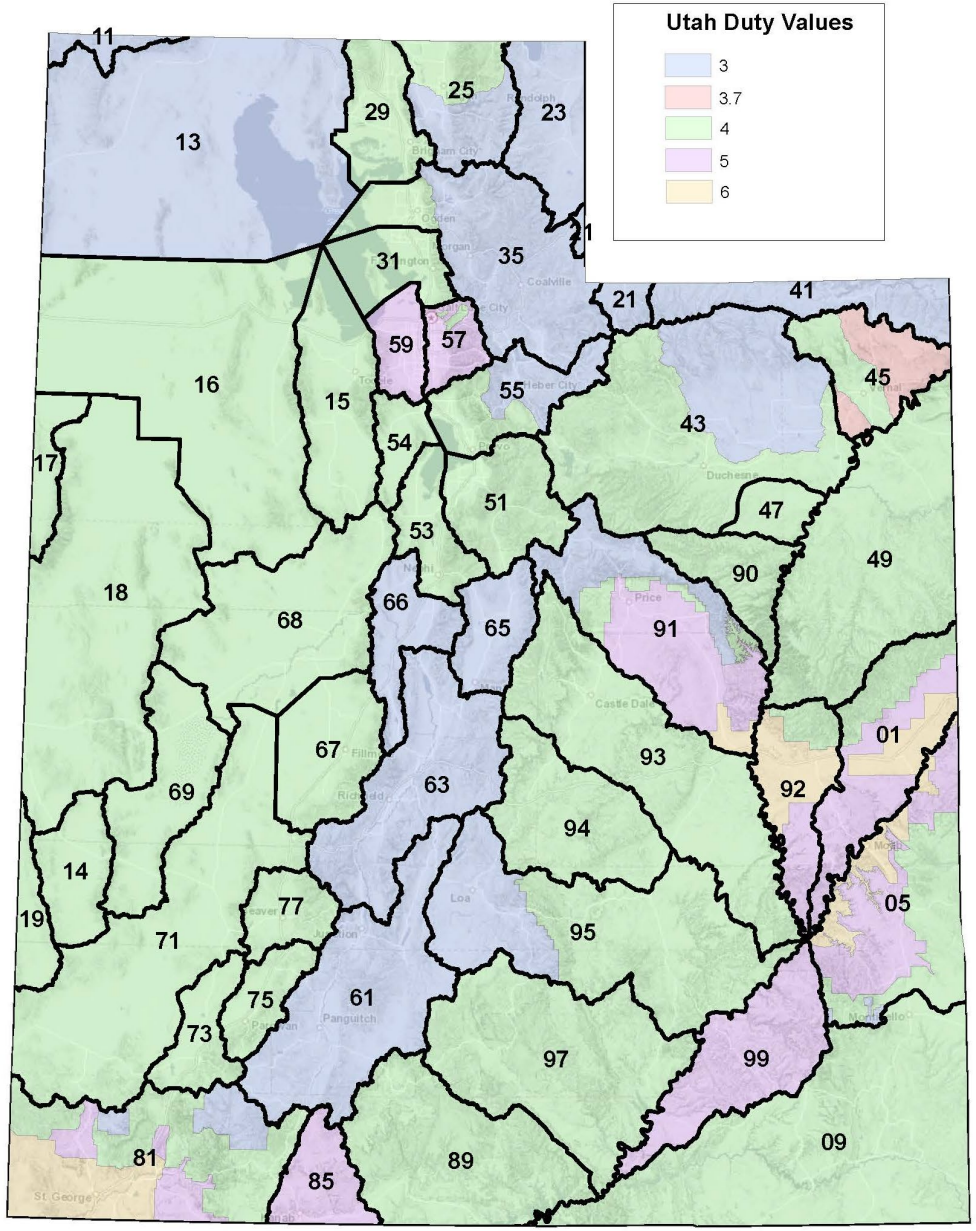
- Early appropriations (i.e., those pre-dating the State Engineer) were directly tied to distribution practices, which mirrored local customs of the pioneers.
- One custom that was codified in by the 1880 Territorial Legislature was the division of a stream into primary and secondary rights.
  - *Primary Rights: Pro rata diversion and use of the ordinary flow of the stream.*
  - *Secondary Rights: Pro rata diversion and use of water that is available once primary rights were satisfied.*
- The practice of distributing and/or apportioning rights based on their respective flow rates and relative priority remained unchanged due to the nature of the physical process of distributing water (i.e., flow measurement vs. volume totalizing) until relatively recently under specific circumstances.
- Volumetric duties have occasionally been imposed via delivery monthly schedules or annual limits to accommodate larger federal projects operating under a junior water right (e.g., Duchesne-Strawberry Distribution System, Utah Lake Distribution Plan, Lower Bear River).

Reliance on Volumetric Duty

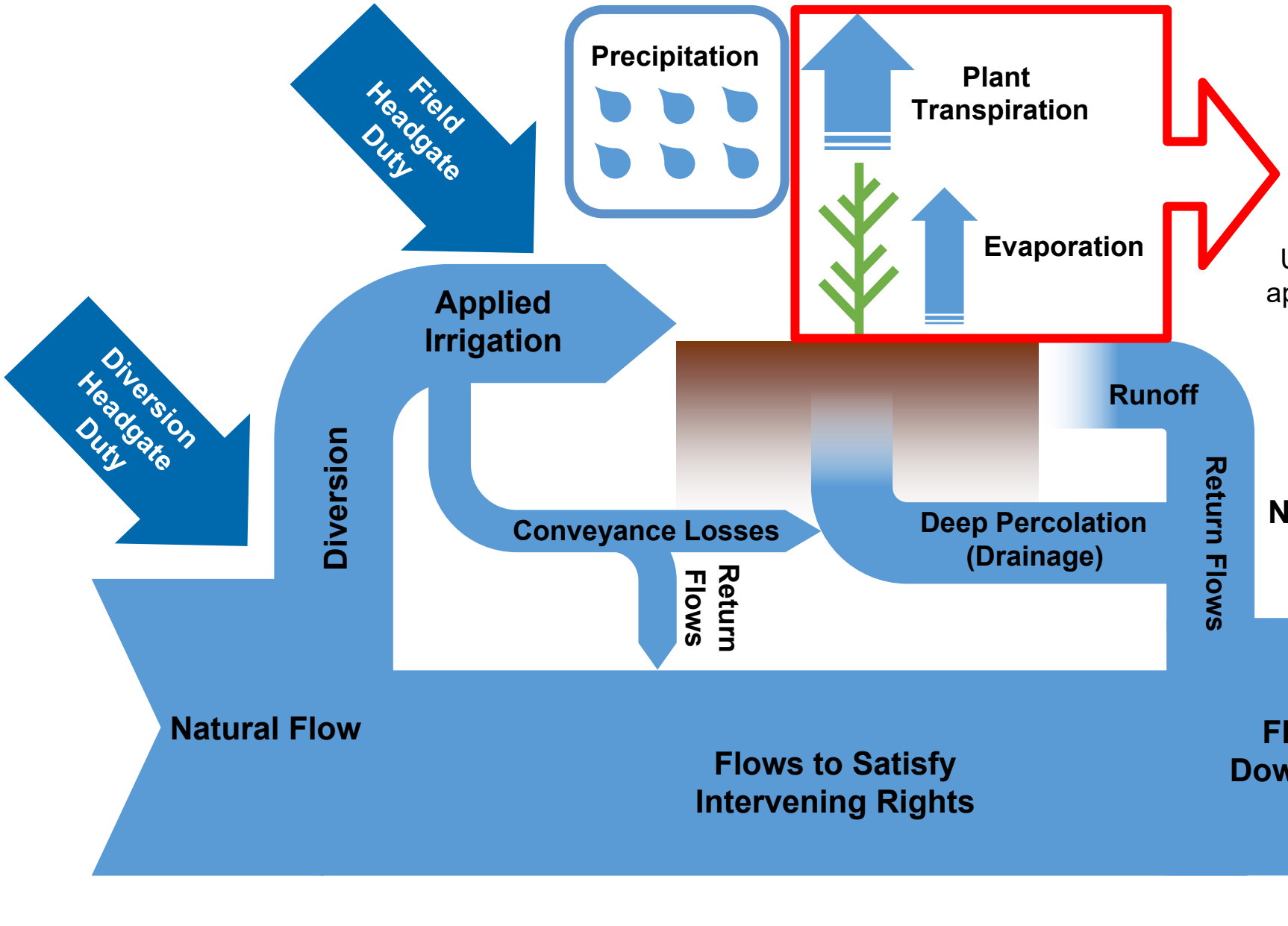
- The widespread use of large wells and the increasing number of change applications moving water from surface sources to underground sources has influenced the duty landscape.
- Although surface rights are typically quantified in terms of flow rate (cfs) to facilitate apportionment among other users on the source, movement of a surface right to groundwater reduced the potential for competing for the same flow.
- Since groundwater aquifers act more like a reservoir, surface rights that are moved to groundwater are quantified with a volumetric limitation to prevent waste and/or enlargement.
- This volumetric quantification process relies on the respective volumetric duty values established by regional policy or adjudication/court decree.
- Rapid urban development and the attendant increase of surface water moving to groundwater (e.g., changes on shares in irrigation companies) coupled with the increased concern relating to aquifer safe yield have reinforced the application of a volumetric duty by the State Engineer.

Duty Values Today

- Duties are established via administrative policy or adjudication decree throughout the state.
- Irrigation duties are typically based on the diversion requirements associated with flood irrigation for alfalfa.
- Duty values vary throughout the state, ranging from 3 AF/acre to 6 AF/acre.



Diversion, Depletion, & Return Flows



Evaporation + Transpiration

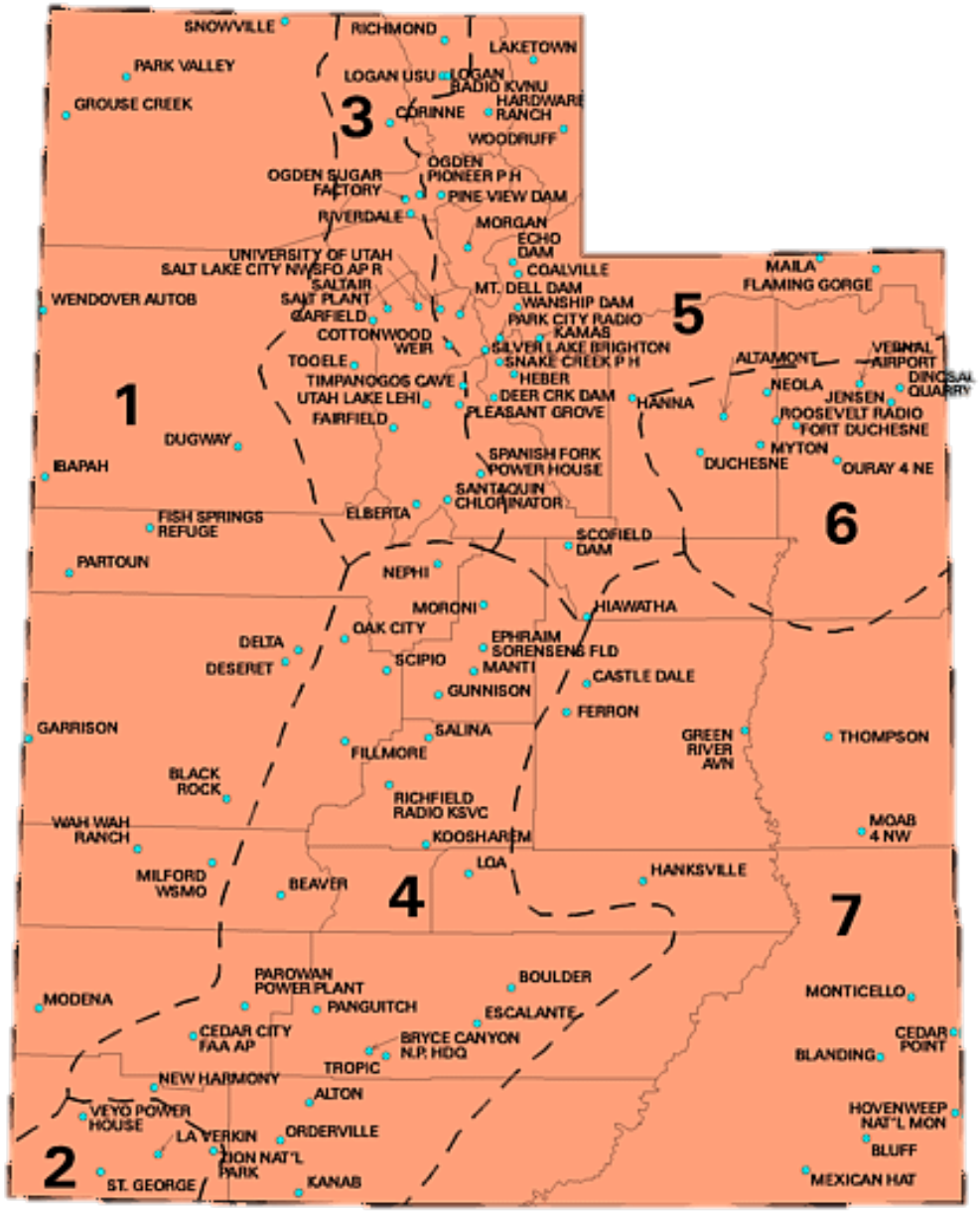
Evapotranspiration (Et)

Under the considerations of a change application involving irrigation, the State Engineer often uses the terms "Consumptive Use" or "Depletion" interchangeably to mean the **Net Irrigation Requirements (NIR)**

NIR = Et - Effective Precipitation

Calculating Depletion

- Consumptive Use of Irrigated Crops in Utah (Research Report 145, Utah Agricultural Experiment Station, 1994).
- SCS Modified Blaney-Criddle Equation: Et = kc × kt × (t × p)/100
  - Et = monthly consumptive use (inches)
  - kc = crop growth stage coefficient
  - kt = climatic coefficient
  - t = mean monthly temperature (°F)
  - p = percentage of annual daylight hours in the given month
- Used by the State Engineer due to availability of temperature data from National Weather Service stations located throughout the state.
- Does not account for carry-over soil moisture, elevation, localized wind effects, “frosty nights”, groundwater contribution (sub-irrigation), deficit irrigation, or water shortages.



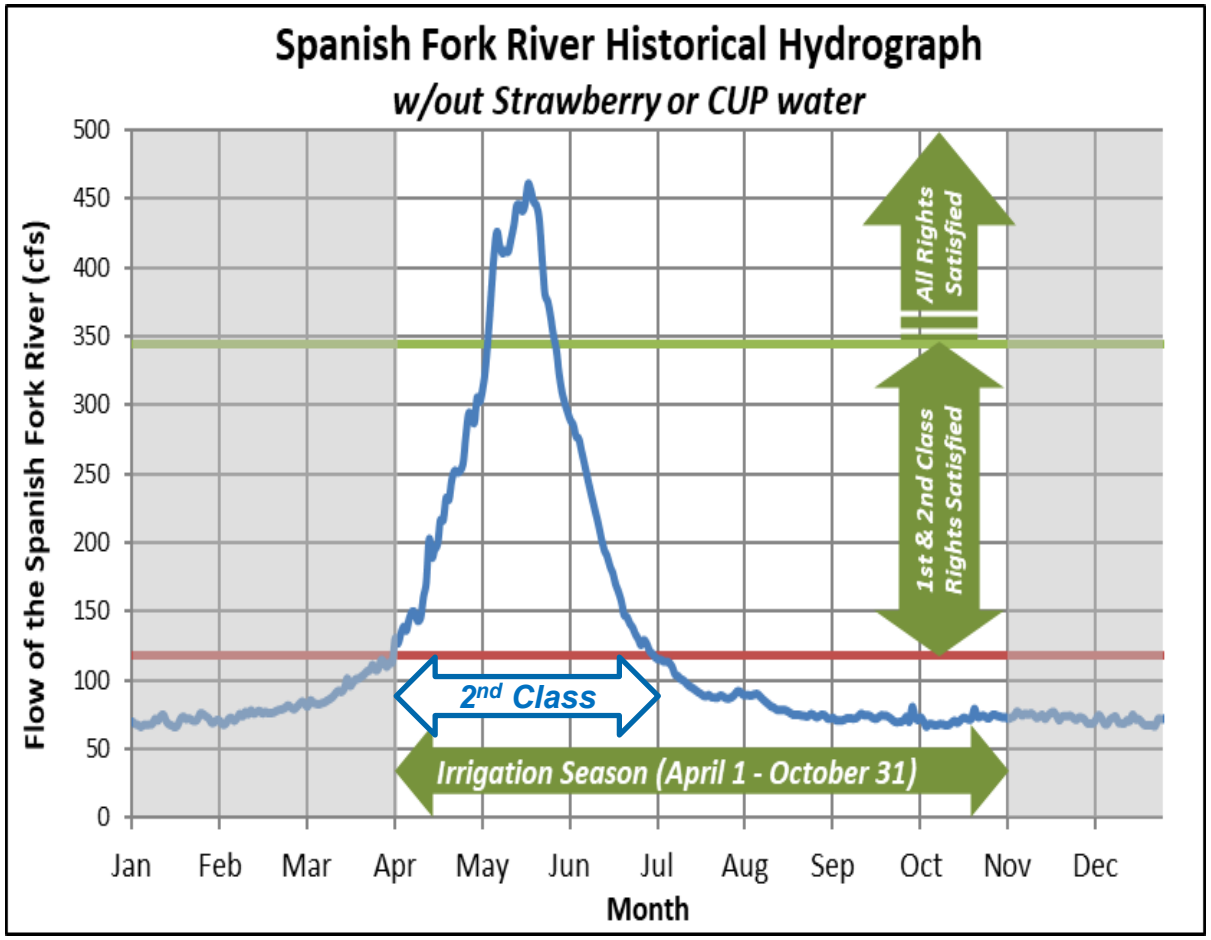
Irrigation Consumptive Use Methodology

- State Engineer relies on tables that relate to nearby NWS stations to identify the net irrigation requirements.
- Alfalfa is used to quantify the net irrigation requirements of applications regardless of existing/proposed crop type since it is considered among the most consumptive crop.
- Monthly Net Irrigation Requirements = Et - (0.8 × Avg Precip)
  - NIR May = 6.65 - (0.8 × 0.81) = **6.0 in**
- Add each month to get the total Net Irrigation Requirements
  - 0.6 + 6.0 + 5.63 + 7.27 + 7.21 + 3.73 + 0.57 = **31.0 in**

Table 25.(Continued) Estimated Consumptive Use for the NWS Station at MORONI
From a Calibrated SCS Blaney-Criddle Equation using data from MANTI / EPHRAIM 10-26-1994
Years of Data Available; NWS: 1961-1990 MANTI / EPHRAIM: 1987-1989 Elev. 5560 ft., Lat. 39.53

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
% Day Light	6.75	6.69	8.28	8.92	10.02	10.09	10.26	9.58	8.39	7.74	6.72	6.55	100.00
Avg Temp F	22.70	28.67	36.70	44.60	53.22	61.97	69.31	67.29	58.94	48.08	35.61	25.02	46.01
Std Dev Temp	4.68	4.57	3.54	3.14	2.42	2.47	1.51	1.98	2.74	3.08	3.05	4.30	1.24
Avg Prec in.	0.85	0.82	0.95	0.70	0.81	0.57	0.67	0.77	1.01	0.91	0.86	0.95	9.87
Std Dev Prec	0.77	0.80	0.61	0.57	0.52	0.62	0.47	0.63	0.91	0.70	0.65	0.69	2.80
SCS-BC f in.	0.46	0.58	1.03	1.84	3.24	4.75	6.30	5.49	3.50	1.94	0.78	0.49	30.39
Std Dev f	0.09	0.10	0.23	0.35	0.37	0.46	0.32	0.38	0.40	0.32	0.13	0.08	1.25
ALFALFA													
Cal SCS-BC k				0.63	2.05	1.28	1.24	1.43	1.29	0.67			
Cal SCS-BC Et				1.15	6.65	6.08	7.81	7.83	4.53	1.30			35.35
Std Dev Et				0.22	0.77	0.59	0.40	0.54	0.51	0.21			1.53
Net Irr in.				0.60	6.00	5.63	7.27	7.21	3.73	0.57			31.00
PASTURE													
Cal SCS-BC k				0.68	1.35	1.13	0.99	0.99	1.10	0.44			
Cal SCS-BC Et				1.25	4.39	5.35	6.21	5.41	3.85	0.84			27.32
Std Dev Et				0.24	0.51	0.52	0.32	0.38	0.44	0.14			1.20
Net Irr in.				0.69	3.74	4.89	5.67	4.80	3.05	0.11			22.96
SP GRAIN													
Cal SCS-BC k				0.51	1.78	1.73	0.96						
Cal SCS-BC Et				0.94	5.79	8.23	6.04						20.99
Std Dev Et				0.18	0.67	0.80	0.31						1.23
Net Irr in.				0.38	5.14	7.77	5.50						18.79

Full Supply Analysis



Class of Right	Stage when rights are available	Historic Period of Available Flow	Days of Available Flow per Irrigation Season	Prorated Irrigation Diversion Duty	Consumptive Use over Diverted Period
1st Class	N/A	Apr 1 – Oct 31	214	4.0 acft/ac	31 in (2.58 ft)
2nd Class	118.4 cfs	Apr 3 – Jul 3	92	1.72 acft/ac	12.23 in (1.02 ft)
3rd Class	344.5 cfs	May 6 – May 29	24	0.45 acft/ac	6 in (0.5 ft)

Table 25.(Continued) Estimated Consumptive Use for the NWS Station at MORONI
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Years of Data Available; NWS: 1961-1990 MANTI / EPHRAIM: 1987-1989 Elev. 5560 ft., Lat. 39.53

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Avg Temp F	22.70	28.67	36.70	44.60	53.22	61.97	69.31	67.29	58.94	48.08	35.61	25.02	46.01
Std Dev Temp	4.68	4.57	3.54	3.14	2.42	2.47	1.51	1.98	2.74	3.08	3.05	4.30	1.24
Avg Prec in.	0.85	0.82	0.95	0.70	0.81	0.57	0.67	0.77	1.01	0.91	0.86	0.95	9.87
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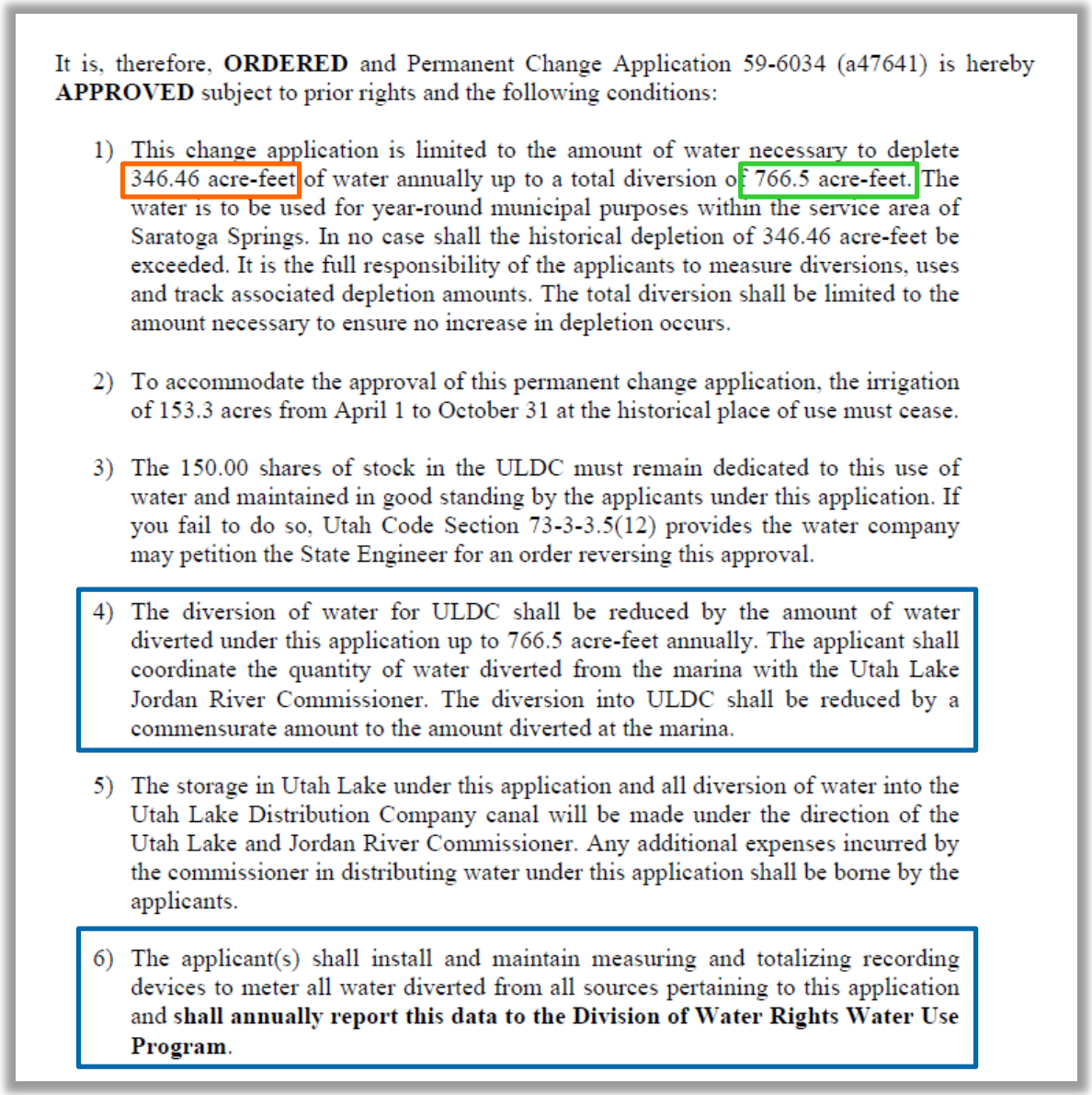
Agriculture to M&I Changes

- Conversion from agriculture (i.e., irrigation or stockwater) to municipal use is quantified using established diversion limitations and historical depletions.
- There is no diversion or depletion duty for municipal use.
- When a change application is approved that moves water from agricultural use, the municipal use is simply given both a depletion and diversion limitation.
- Where changes involve shares of stock in an irrigation company, the distribution is adjusted by the commissioner.
- Municipalities are required to measure all water diverted and report the data to the Water Use Program.



It is, therefore, **ORDERED** and Permanent Change Application 59-6034 (a47641) is hereby **APPROVED** subject to prior rights and the following conditions:

1) This change application is limited to the amount of water necessary to deplete 346.46 acre-feet of water annually up to a total diversion of 766.5 acre-feet. The water is to be used for year-round municipal purposes within the service area of Saratoga Springs. In no case shall the historical depletion of 346.46 acre-feet be exceeded. It is the full responsibility of the applicants to measure diversions, uses and track associated depletion amounts. The total diversion shall be limited to the amount necessary to ensure no increase in depletion occurs.

2) To accommodate the approval of this permanent change application, the irrigation of 153.3 acres from April 1 to October 31 at the historical place of use must cease.

3) The 150.00 shares of stock in the ULDC must remain dedicated to this use of water and maintained in good standing by the applicants under this application. If you fail to do so, Utah Code Section 73-3-3.5(12) provides the water company may petition the State Engineer for an order reversing this approval.

4) The diversion of water for ULDC shall be reduced by the amount of water diverted under this application up to 766.5 acre-feet annually. The applicant shall coordinate the quantity of water diverted from the marina with the Utah Lake Jordan River Commissioner. The diversion into ULDC shall be reduced by a commensurate amount to the amount diverted at the marina.

5) The storage in Utah Lake under this application and all diversion of water into the Utah Lake Distribution Company canal will be made under the direction of the Utah Lake and Jordan River Commissioner. Any additional expenses incurred by the commissioner in distributing water under this application shall be borne by the applicants.

6) The applicant(s) shall install and maintain measuring and totalizing recording devices to meter all water diverted from all sources pertaining to this application and **shall annually report this data to the Division of Water Rights Water Use Program**.

Other Approaches for Determining ET (i.e., Depletion)

GridET

- Potential ET
- ASCE Standardized Penman-Monteith
- Accounts for:
  - Crop Type
  - Effective Precipitation
  - Solar Radiation
  - Carry-over Soil Moisture
  - Humidity
  - Wind Speed
  - Air Temperature
- Used to estimate post-1976 irrigation depletions for the purposes of the Amended Bear River Compact.

OpenET

- Actual ET
- Surface Energy Balance (thermal remote sensing)
- Uses Landsat dataset and weather station measurements
- Six models
  - ALEXI/DisALEXI
  - eeMETRIC
  - geeSEBAL
  - PT-JPL
  - SIMS
  - SSEBop
- Adopted by the Upper Colorado River Commission (UCRC) for measuring and reporting consumptive water use for interstate purposes.

Duty of Water Rule Progress

- Utah Code 73-2-1(4)(g) directs the State Engineer to make a rule regarding the duty of water.
- Utah Water Task Force Subcommittee
- Draft Defined Terms:
  - *Irrigation Diversion Duty*
  - *Irrigation Flow Rate Duty*
  - *Domestic Diversion Duty*
  - *Depletion Accounting*
  - *Depletion Administration*
  - *Irrigation Depletion Duty*
  - *Delivery Schedule*
- Draft Concepts:
  - *Computation of a standard Domestic Duty*
  - *Computation of a standard Irrigation Duty*
  - *Computation of a standard Stockwatering Duty*
  - *The process of adopting and/or changing a duty*
  - *The process for administering a duty in a change application*
  - *The process for incorporating Delivery Schedules*

Questions?