

CONSUMPTIVE USE ANALYSIS: WHAT IT IS AND HOW IT IS QUANTIFIED

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PRESENTED TO:

ADVISORY COMMITTEE FOR MIDDLE COLORADO IWMP

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COLORADO WATER USAGE (DIVERSION)

Statewide Water Withdrawals

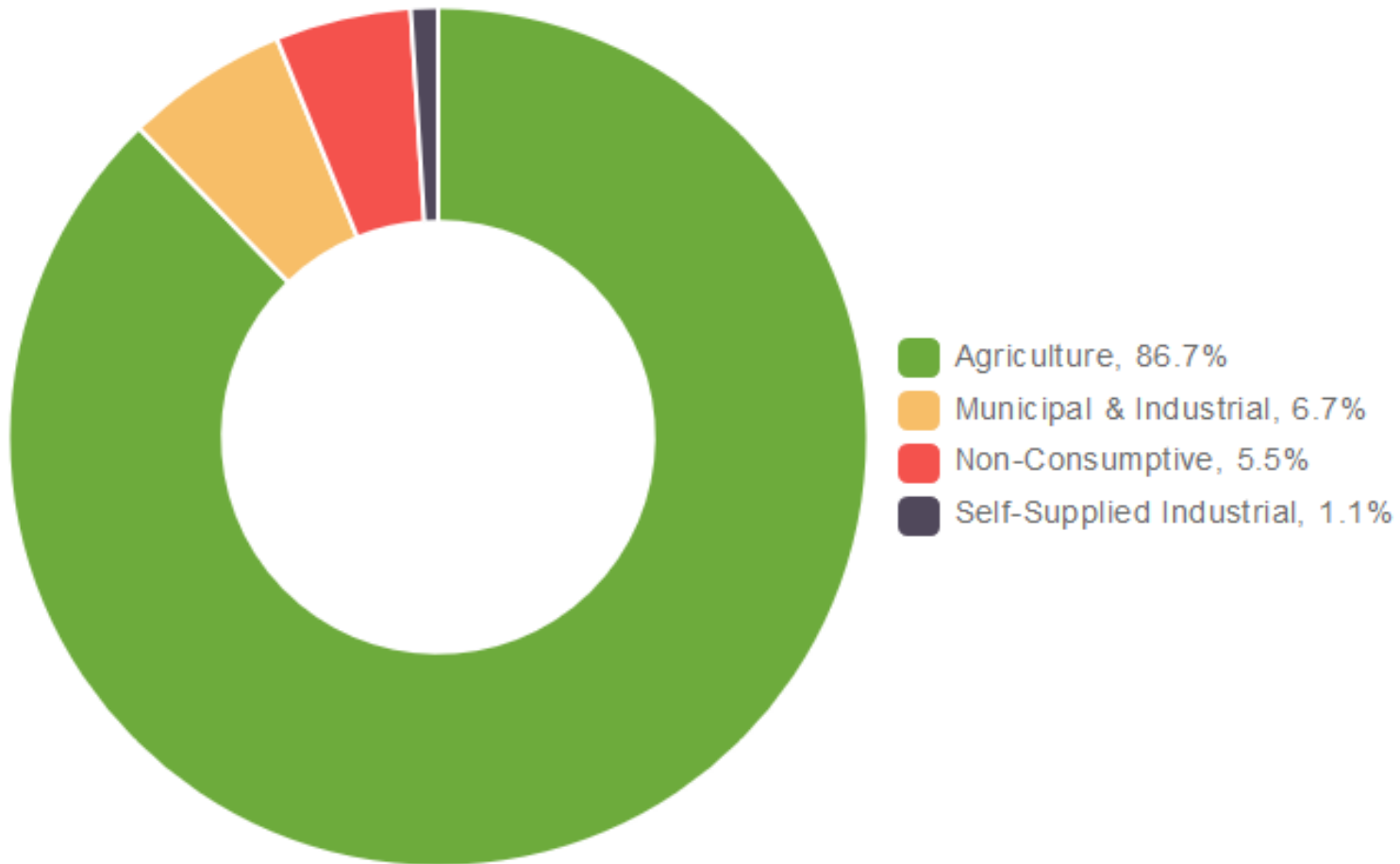


Chart recreated from Colorado Water Plan (2015).

AGRICULTURAL CONSUMPTIVE USE ANALYSIS: WHAT DO WE USE?

- Water Court Decrees
- Water Right - Proof of Ownership
- Diversion Records
- Irrigated Acreage Through Time
- Representative Climate Data
- Soil Information
- Irrigation Method

WATER COURT DECREES

- Original decrees are utilized to understand the water right.
 - Were specific lands identified in the decree (statement maps)?
 - Was there a duty of water defined in the decree?
 - i.e. 1 cfs for the irrigation of 50 acres
 - Any other limitations included in the decree that should be considered?
- Understand the relative seniority of priorities decreed to a structure.

WATER RIGHT PROOF OF OWNERSHIP

- Sometimes, there are multiple users and multiple priorities decreed for a structure.
 - Which Priority is your ownership included in?
- How to find changes associated with the water right?
 - Track changes in Title
 - Research Special Warranty Deeds
 - Interviews (ranchers, water commissioners, etc.)
 - Other records indicating ownership in the water rights?
- Unless a change of water right has been decreed, the water must be utilized on the lands and for the uses originally specified in the decree.

DIVERSION RECORDS

- Diversion records maintained through Division of Water Resources
 - Available through CDSS (Colorado Decision Support System)
 - <https://www.colorado.gov/cdss>
 - Research Water Commissioner Notebooks for Older Records.
 - Laserfiche archives of records
 - <http://water.state.co.us/DWRDocs/ImagedDocs/Pages/default.aspx>
- Total Diversions can be pro-rated by ownership when only considering a portion of the water right.

WATER COMMISSIONER'S

FIELD BOOK

District No. 11

STATE OF COLORADO

Year 1960

Signed Fred J. Montgomery

PUBLISHED BY
STATE ENGINEER
DENVER

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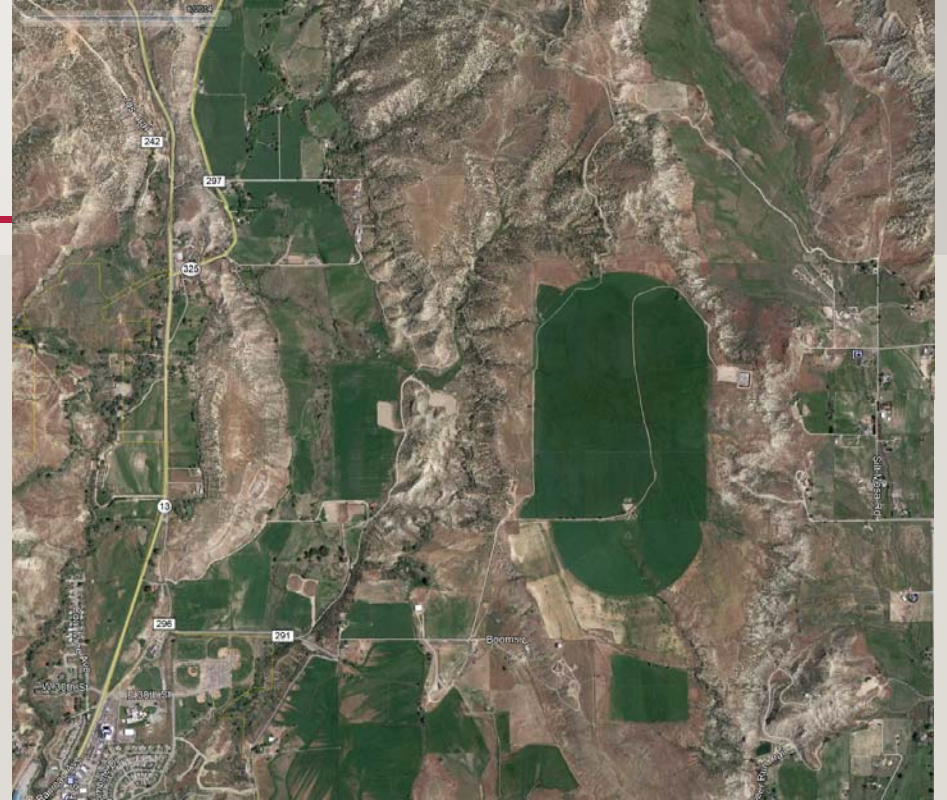
IRRIGATED ACREAGE AND CROP TYPE

- Historic aerial imagery is examined to quantify the irrigated acreage on subject parcels.
- Any acreage beyond the originally decreed area or duty of water does NOT count toward the historical consumptive use.
- The crop type (or mix) is also required as water usage varies by crop type.

1993

vs.

2014



- Aerial imagery provides information into irrigated area and irrigation methods.
- Older aerials can still be ordered online (USGS Earth Explorer)

REPRESENTATIVE CLIMATE DATA

- Reference Evapotranspiration (ET)
 - The amount of water utilized by a well watered alfalfa (tall) or grass (short) crop.
 - No stress to the plant; water is not limited.
 - Crop Coefficients are then applied to the Reference values to obtain Crop Potential ET (PET).
 - Multiple stations or adjustments to data can be made to make the measurements more representative of the location being quantified.
 - Orographic elevation adjustment to temperature = $3.6 \text{ F}/1,000 \text{ feet}$
 - Blaney-Criddle increase 10%/1,000 meters above sea level (accounts for low overnight temperatures which decreases mean temperature)



Typical CoAgMet Station: Temperature, Humidity, Solar Radiation, Wind Speed/Direction and Precipitation.

REPRESENTATIVE CLIMATE DATA

- Several methods to estimate Reference Evapotranspiration (will discuss 2 major)
- Blaney-Criddle (SCS TR-21) – widely accepted by Water Court
 - Utilizes long-term climate temperature records from NOAA Cooperative Stations
 - Inputs include:
 - % of sunshine hours (latitudinally based)
 - Monthly Mean Temperature
 - Requires locally calibrated Crop Coefficients which are not always available



Typical NOAA COOP Station: Temperature and Precipitation Only

REPRESENTATIVE CLIMATE DATA

- Standardized ASCE Penman
 - A physically-based approach to estimate Reference ET using daily or hourly:
 - Temperature
 - Solar Radiation
 - Wind Speed
 - Vapor Pressure (humidity)
 - This method requires more data parameters than the long term NOAA stations collect. This is where CoAgMet data comes in!
 - State efforts are being made to incorporate CoAgMet data in State Tools (Lease-Fallow Tool).
 - ASCE has developed methodology to simulate CoAgMet data back in time using NOAA temperature data.

Equation 1 - ASCE Standardized Reference ET Equation: (ASCE/EWRI 2005)

$$ET_{ref} = \frac{0.408\Delta(Rn - G) + \gamma \frac{Cn}{T + 273} u^2 (es - ea)}{\Delta + \gamma(1 - Cd u^2)}$$

ET_{ref} = standardized reference ET for short (ET_os) or tall (ET_rs) surfaces

R_n = calculated net radiation at the crop surface MJ/m²/d (function of solar data)

G = soil heat flux density at the soil surface (0 for daily timestep)

T = mean air temperature, °C

u² = mean wind speed at 2-m height, m/s

es = saturation vapor pressure, kPa (function of temperature data)

ea = mean actual vapor pressure, kPa (function of humidity and temperature data)

Δ = slope of the saturation vapor pressure-temperature curve, kPa/°C (function of temperature data)

γ = the psychrometric constant, kPa/°C

C_n = a numerator constant that changes with reference type and timestep

C_d = a denominator constant that changes with reference type and timestep

Note: Coefficients and additional calculations are explained in detail in ASCE/EWRI 2005

IRRIGATION WATER REQUIREMENT

- PET allows us to understand the amount of water a certain crop would use **if water was not limited.**
- IWR (Irrigation Water Requirement) or CIR (Crop Irrigation Requirement) represents $PET - \text{Effective Precipitation}$.
 - In other words, after considering precipitation, what amount of water was required for the crop of interest to be fully watered.

SOIL INFORMATION

- NRCs Web Soil Survey
 - Detailed soil type with soil properties available online:
 - <https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>
- Soil properties are used determine:
 - Available soil moisture reservoir over the root zone
 - Available water capacity
 - Tendency of runoff to determine the likelihood of irrigation to go to surface runoff vs. deep percolation
 - Soil Hydrologic Group



IRRIGATION METHOD

- Type of Irrigation Determines the Efficiency
 - What percentage of the water applied makes it to the field?

Table WA6-2 Application efficiency range for various irrigation systems¹

Type	Range	Avg (%)
Surface Irrigation		
Level Basin	80-95	85
Graded Border	50-80	65
Furrow or Corrugations	50-80	65
Surge	60-90	75
Micro Irrigation		
Point Source Emitter	70-95	88
Line Source Emitter	75-95	90
Spray Emitter	70-95	85
Sprinkler Irrigation		
Handline/Wheeline	60-85	75
Traveling Big Gun	55-75	65
Solid Set (Above Canopy)	60-75	60
Solid Set (Below Canopy)	70-85	75
Center Pivot		
Impact Sprinkler w/end gun	75-90	80
Drops, spray heads w/o end gun	75-95	85
Lateral Move		
Spray heads		
w/ hose feed	75-95	90
w/ canal feed	75-95	85

Typical Values from the
NRCS National
Engineering Handbook:
Irrigation Guide

HCU ANALYSIS

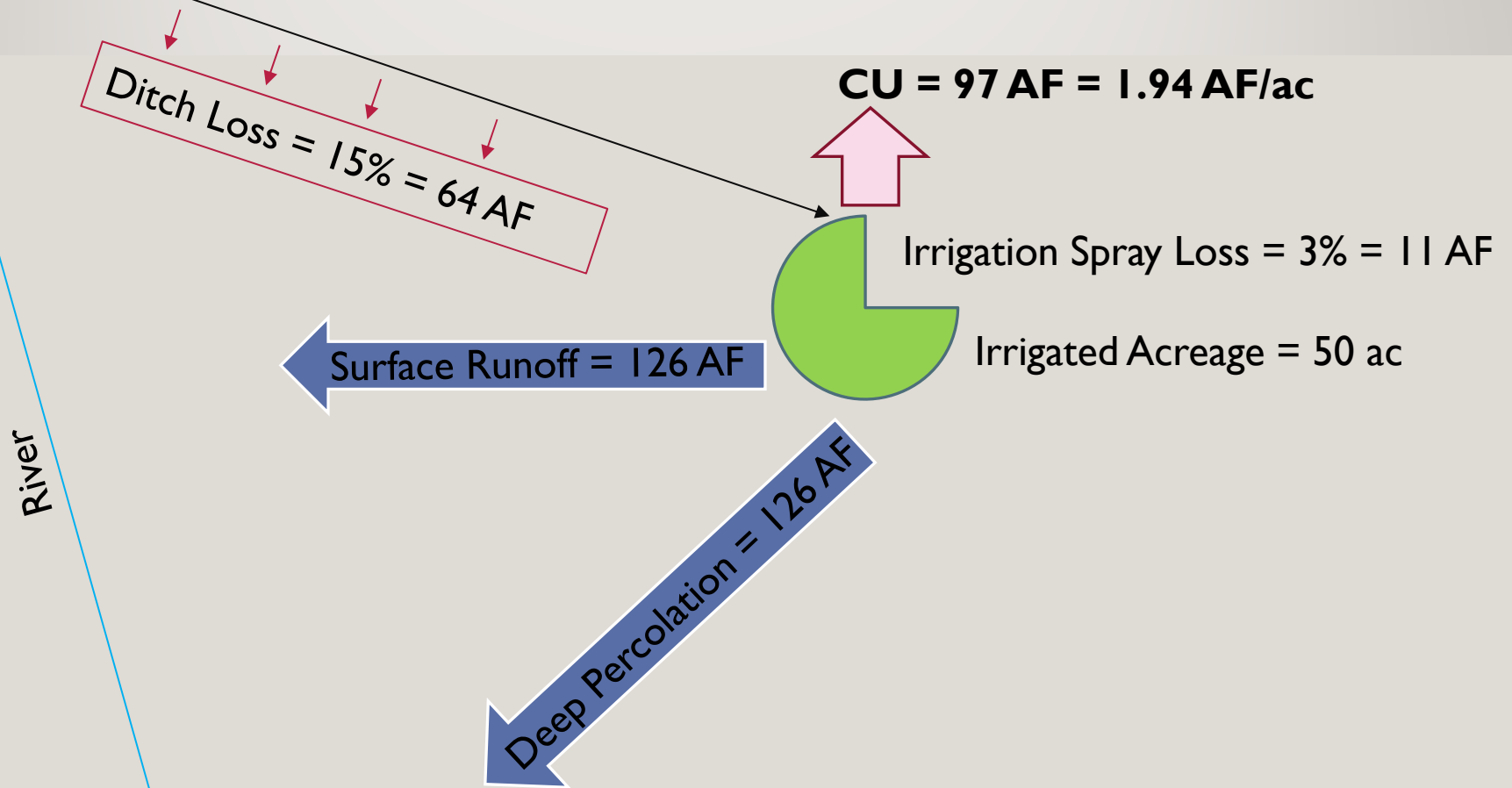
- A water balance approach to determine what was historically consumed by the crops on a given acreage over a time period representing wet, average and dry conditions.
- The IWR is calculated for the entire season; however, quantified consumptive use only takes into account what was consumed given the water applied using diversion records.
 - Also called “Water Supply Limited Consumptive Use”

HCU ANALYSIS

- As part of the analysis, the following are quantified:
 - Consumptive Use – Amount of applied irrigation water consumed by the crops
 - Surface Runoff
 - Deep Percolation/Delayed Return Flows (the amount that goes to deep percolation taking into account the lagged nature of these returns to the river).
 - This can get pretty complex.
 - Conveyance Losses

Example Outcome (Annual Values)

Headgate Diversion = 424 AF; 1 cfs: 50 acres with full supply



BASIN-WIDE ESTIMATES – SWSI (SURFACE WATER SUPPLY INITIATIVE)

- StateCU and StateMOD allow the consumptive use analysis to be expanded over larger regions using the available data in CDSS.
 - They are NOT verifying every decree to ensure duty of water, etc.
- The 2018 SWSI Update uses the following methodology:
 - Use Crop Type, Acreage and Climate Data to Quantify the IWR
 - On-farm irrigation and conveyance efficiencies are utilized to estimate the total agricultural DIVERSION needed.
 - The Diversion amount is entered into the water allocation model to determine amount of water available to meet these demands under various planning scenarios.
 - This method is more consistent with Municipal quantification.

MUNICIPAL DEMANDS

- Demand = Population * Water Usage (gpcd)
- CU = Metered Water Use – Return Flows
- Current and future demands rely on population and associated projections.
 - Quantify Future Population and Urban Growth
 - Apply Climate Impacts to Outdoor Usage
 - Adjust future gpcd rates and delivery loss assumptions
 - Calculate Future Municipal Water Demands