Water Management in Colorado
Changing a Water Right – The Process

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Engineering Support for Water Rights

- **Demand Analysis**
  - Filing on a New Water Right
  - Diligence on a Conditional Water Right
  - May be necessary on a Water Rights Change
- **Water Availability Analysis**
  - Filing on a New Water Right
  - Diligence on a Conditional Water Right
- **Water Rights Change Analysis**
  - Changing Type of Use
  - Changing Location of Use
- **Exchange Analysis**
  - If Change of Location is Upstream or on another Tributary

Purpose of Engineering Analyses

1. **Assure that no water right change injures other water users**
   - "Non-Injury" based on water rights change analysis

2. **Show that applicants "Can and Will" use their new water rights, conditional water rights, or changed water rights**
   - "Can" means water is physically and legally available based on a water availability analysis and exchange analysis
   - "Will" assures anti-speculation and shows beneficial use based on a demand analysis
3. **Provide method for accounting and administering**

Water Rights Change Analysis

- **Generally change irrigation to other uses**
  - Municipal use
  - Augmentation of junior municipal rights
- **Only the amount historically consumed by crops can be changed to other uses**
- **To assure non-injury, return flows have to be maintained/replaced**
  - Based on historical locations and timing
- **Often requires storage**

Typical Engineering Report Outline

1. **Introduction**
   - Water Right original decreed amount and uses
   - Definitions
2. **Water Rights Change Analysis**
   - Study Period Selection
   - Historical Irrigated Acreage and Crop Type
   - Historical Crop Irrigation Requirement
   - Historical Crop Consumptive Use
   - Historical Return Flows
   - Net Stream Depletions

Typical Engineering Report Outline

3. **Plan for Augmentation (or direct use)**
   - Replacement Sources for Stream Depletions
   - Operations to Assure Non-Injury
4. **Plan for Exchange (if new use is upstream)**
   - Exchange Analysis
   - Operations to Assure Non-Injury
5. **Accounting Procedures**
6. **Proposed Terms and Conditions**
7. **Summary and Opinions**
8. **List of Documents and Information Used**

Water Rights Change Analysis

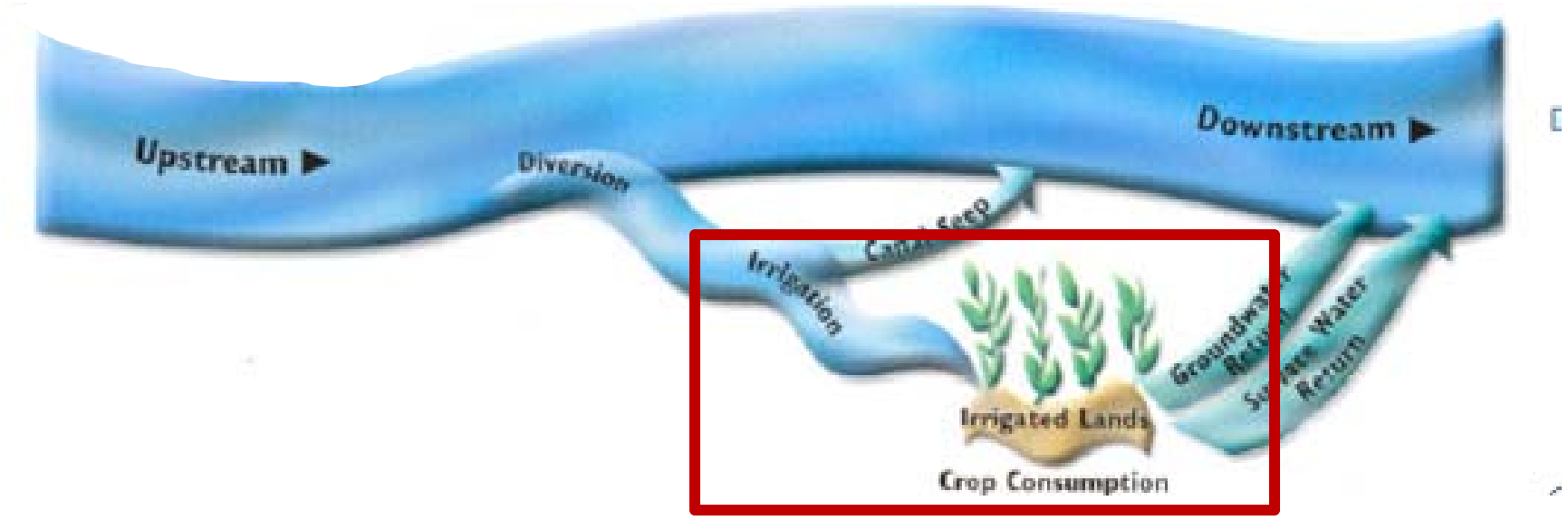
- **Essentially Two Mass-Balance Exercises**

Inflow = Outflow

1) Ditch Mass Balance (Crop CU and Return Flow Analyses):

Inflows are Diversions

Outflows are Crop CU and Return Flows



Water Rights Change Analysis

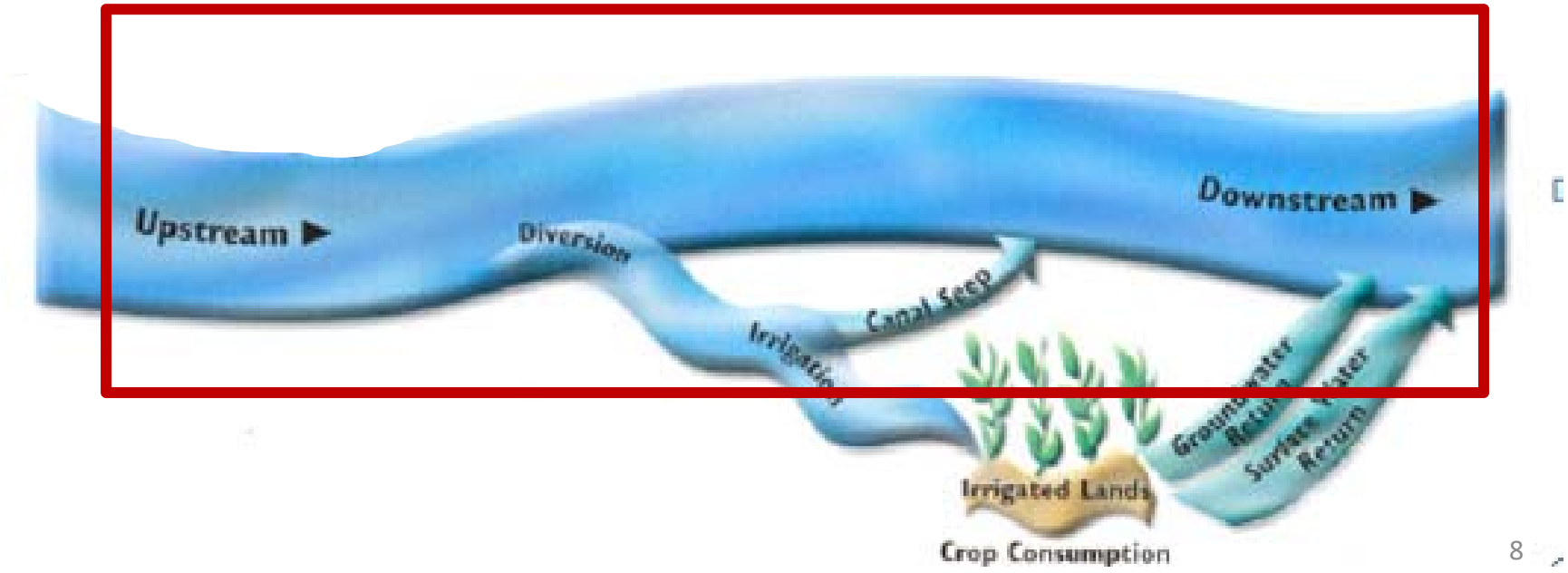
- **Essentially Two Mass-Balance Exercises**

  Inflow = Outflow

  2) River Mass Balance (Depletion Analysis)

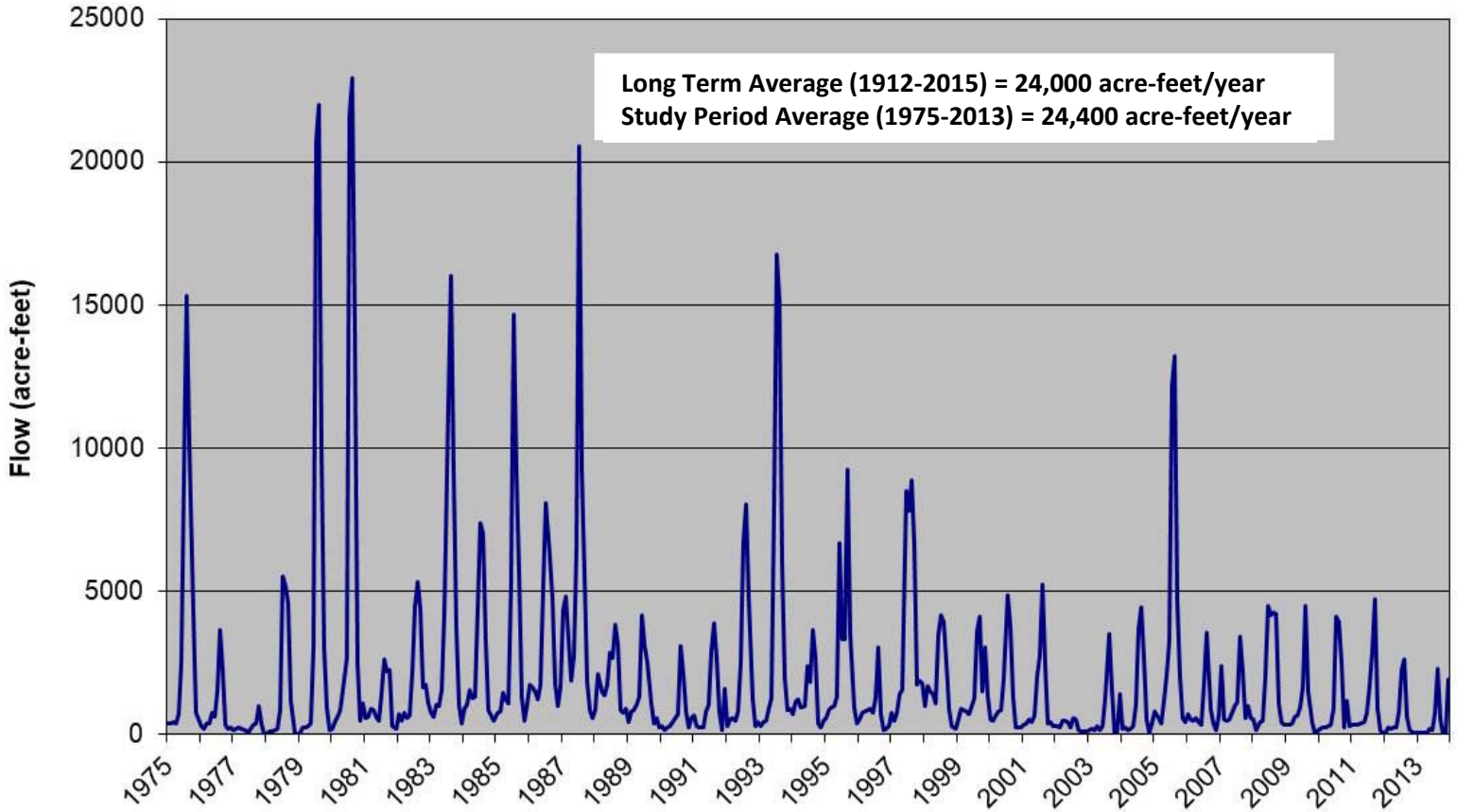
  Inflows are Upstream Flow and Return Flows

  Outflows are Diversions and Downstream Flow



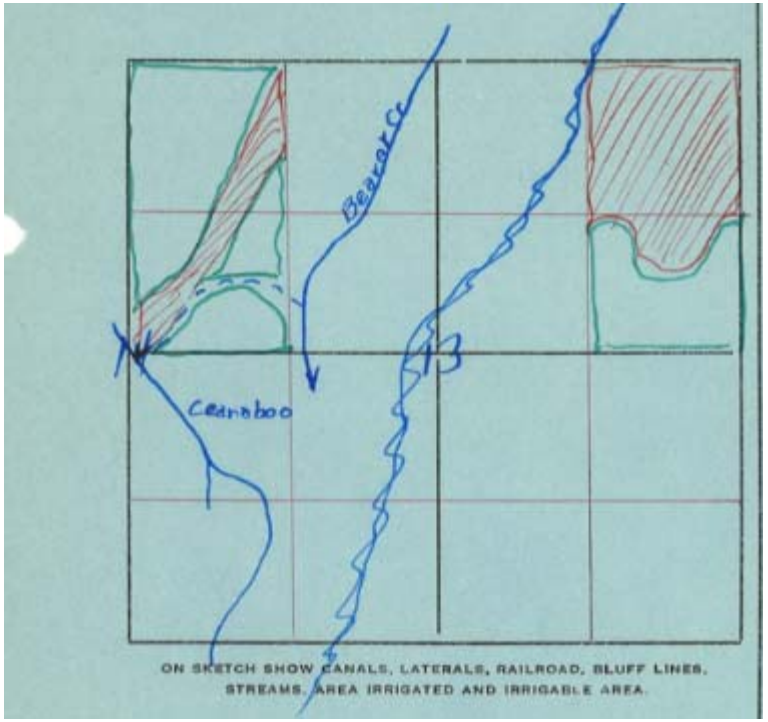
Study Period Selection

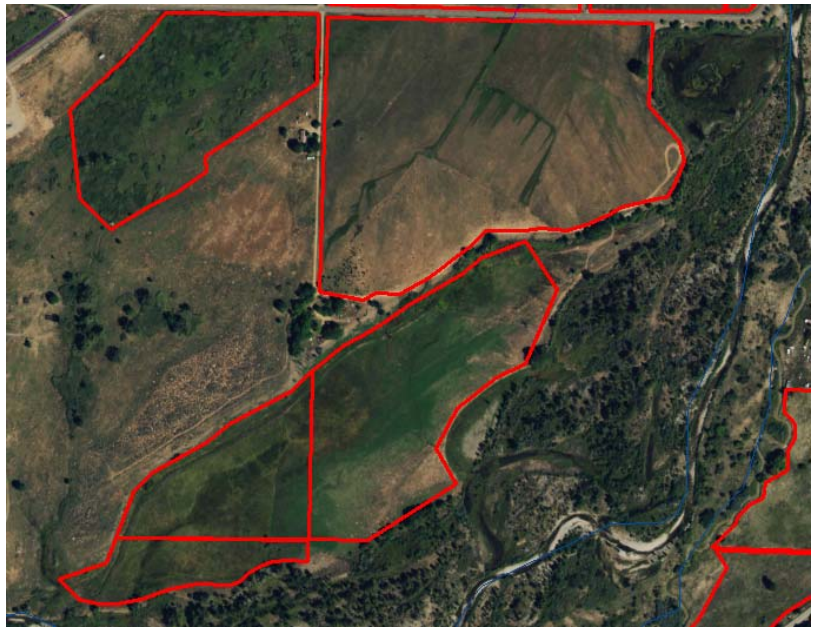
- **Period includes wet, dry, and average hydrologic years**
- **Period represents consistent use and administration**



Historical Irrigated Acreage and Crop Type

- **Aerial photos, satellite imagery, acreage delineation maps from original decree or other change cases**





Historical Crop Irrigation Requirement

- **Maximum Crops could Consume from Irrigation Supply**
- **CIR = Potential CU (ET) - Effective Precipitation**
- **Data Input Requirements**
  - Irrigated Acreage
  - Climate Data (Temperature, Precipitation, Solar Radiation, Wind Speed, Vapor Pressure)
- **Potential CU Methods Commonly Used**
  - Modified Blaney-Criddle monthly method
  - Standardized Penman daily method

Potential CU

Modified Blaney-Criddle – outlined in SCS Technical Release 21

PCU = k * f

$f = t * p/100$

$k = k_t * k_c$

where:

t = mean monthly air temperature

p = mean monthly percentage of annual daylight hours

k_t = temperature coefficient

k_c = crop coefficient

Used in most change cases because mean monthly temperature is readily available for the past 100 years

Potential CU

Daily Standardized Penman – outlined in ASCE Manual 70

$$ET_{sz} = \frac{.408\,\Delta(R_n - G) + \gamma(C_n/(T+273))\,U_2(e_s^{\circ} - e_a)}{\Delta + \gamma(1+C_d U_2)}$$

PCU = ET_{sz} * k_c

ET_{sz} = Reference ET
k_c = crop coefficient
Other parameters derived from
- Tmin, Tmax = daily minimum and maximum temperature
- Rad = daylight hours average solar radiation
- VP = daily average vapor pressure
- U = daily average wind speed

Daily Climate Data available in some areas since late 1980s, other areas not until more recently – can't cover representative study period

Colorado is "moving towards" this more accurate method as more climate data becomes available

Historical Crop Irrigation Requirement

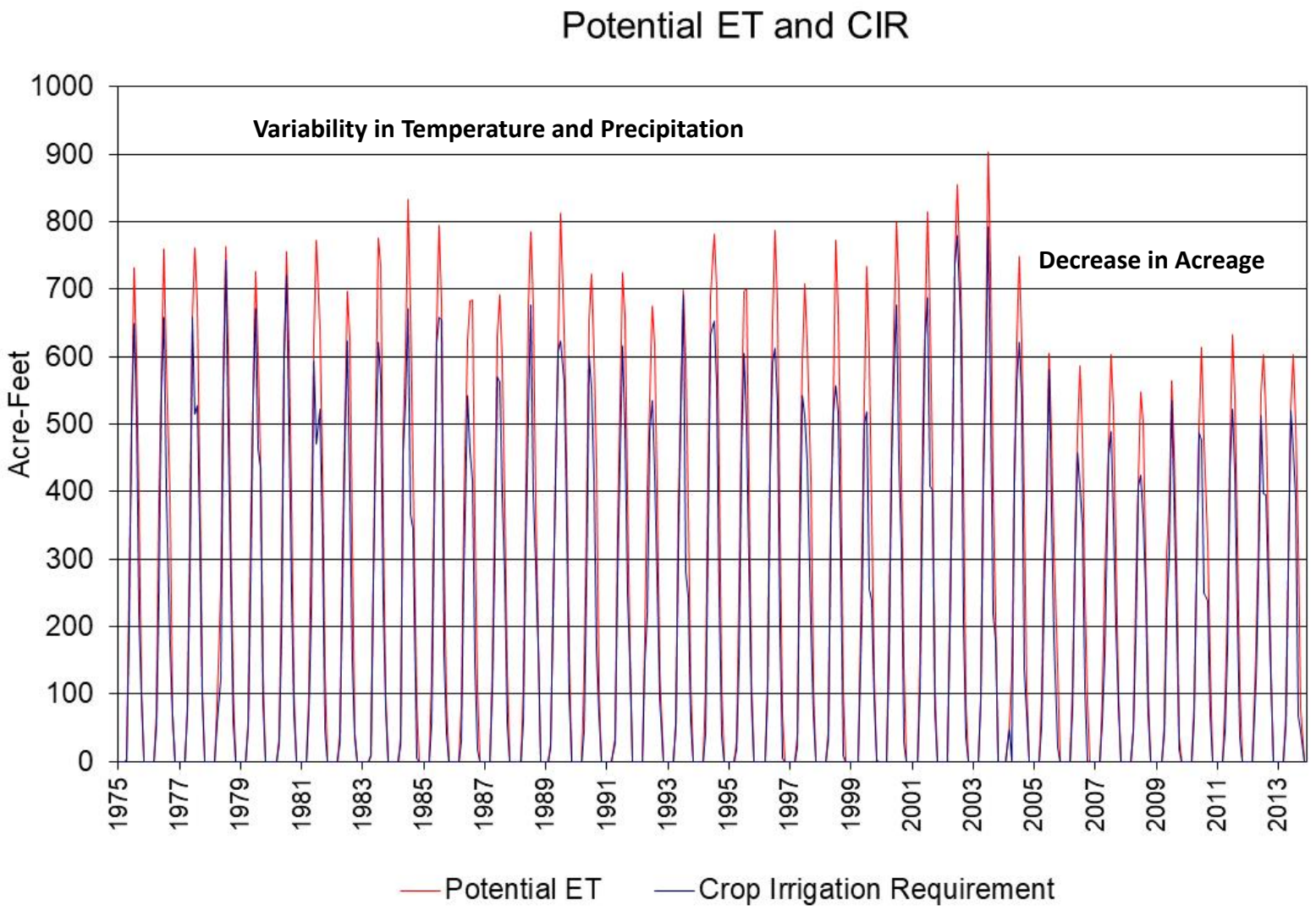
Crop Irrigation Requirement – Maximum crops can use from an irrigation supply

CIR = PCU – Effective Precipitation

Effective Precipitation = Portion of precipitation effective in meeting crop requirements

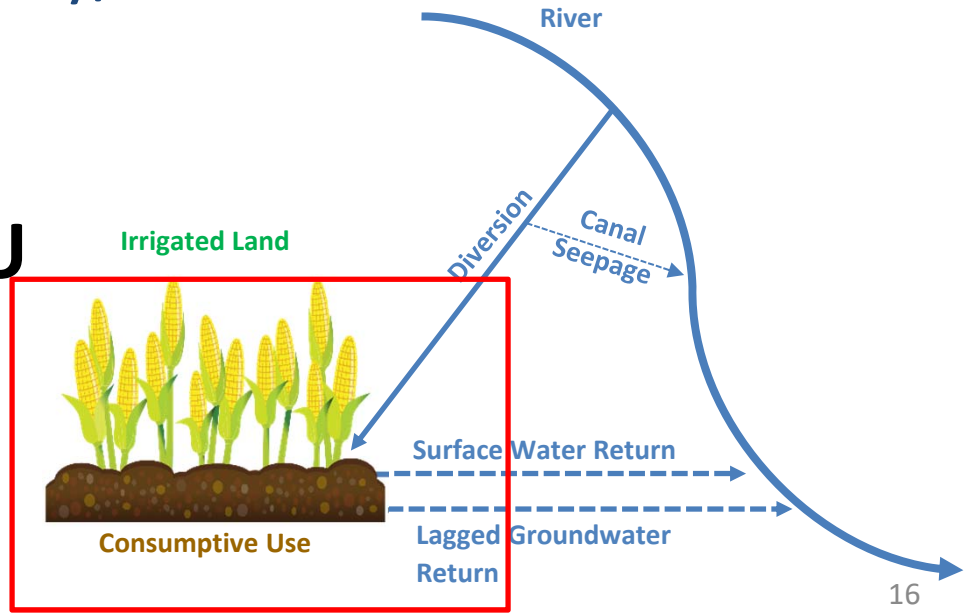
- Requires Daily or Monthly Total Precipitation data
- Often calculated using SCS Effective Precipitation Method outlined in SCS Technical Release 21 (TR-21)

Historical Crop Irrigation Requirement



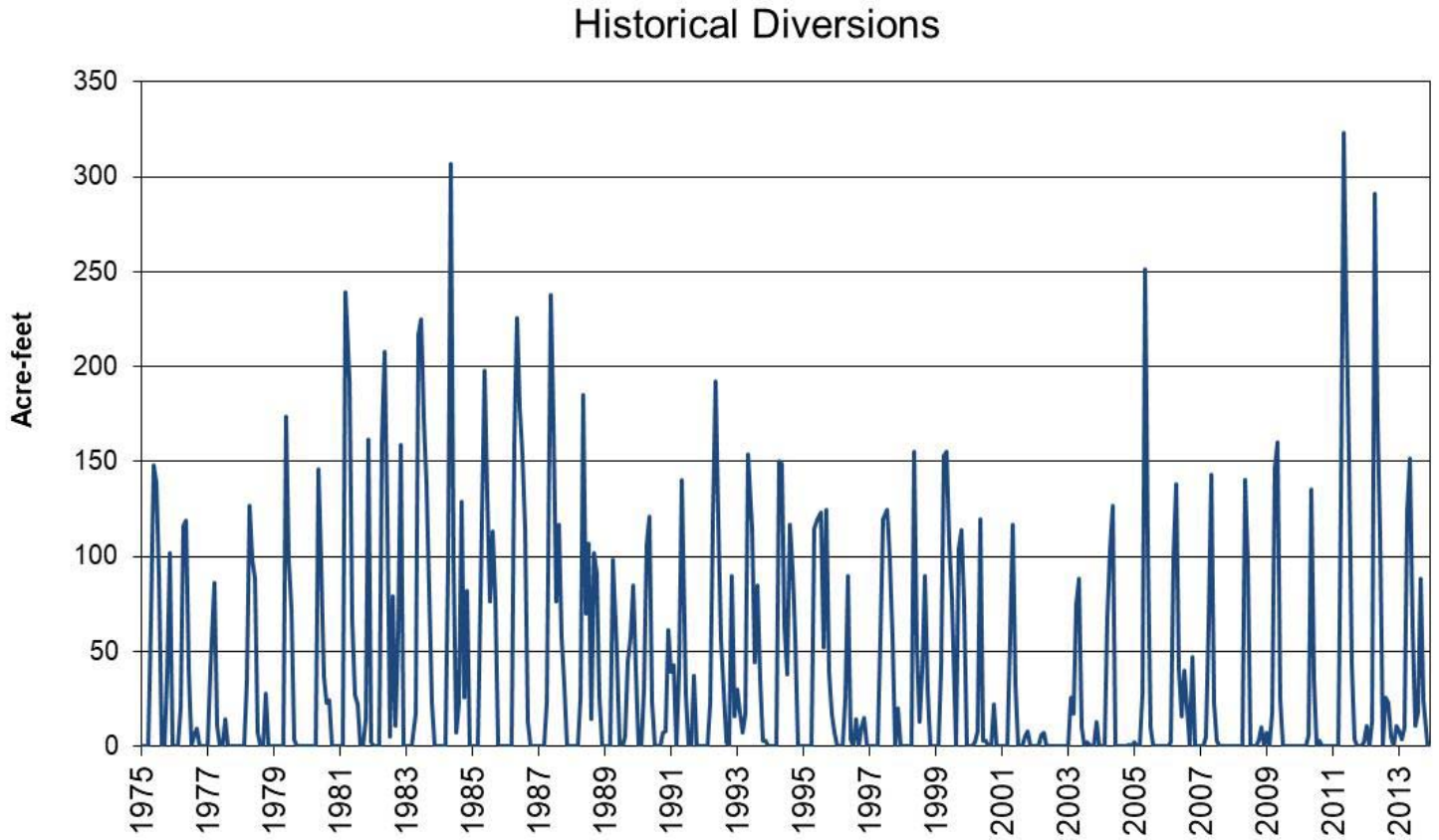
Historical Consumptive Use

- **Data Input Requirements**
  - Historical Crop Irrigation Requirement
  - Historical Irrigated Acreage
  - Historical Irrigation Diversions
  - Estimated Ditch Efficiency/Ditch Loss
  - Irrigation Method
  - Soil Parameters
- **Also termed Actual CU or Supply-Limited CU**



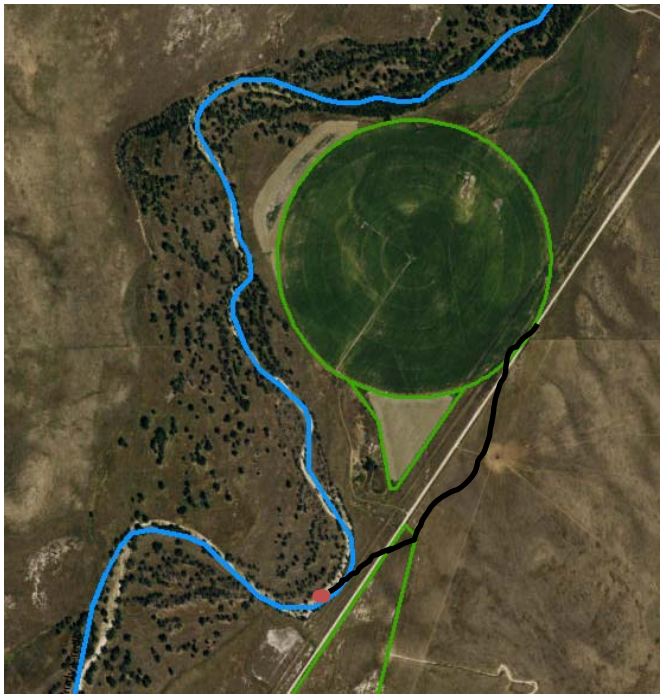
Historical Consumptive Use

- **Historical Diversions**
  - Reflect hydrology, primarily snowpack and runoff
  - Reflect seniority of water right



Historical Consumptive Use

- **Ditch Efficiency and Irrigation Method**
- **Determines Max Diversion that can meet CIR**



River Diversion = 20 cfs
Conveyance Efficiency = 90%

"Farm" Delivery to Irrigated Land = 18 cfs
(20 cfs * .90)

Maximum Application Efficiency for Sprinkler Irrigation Method = 85%

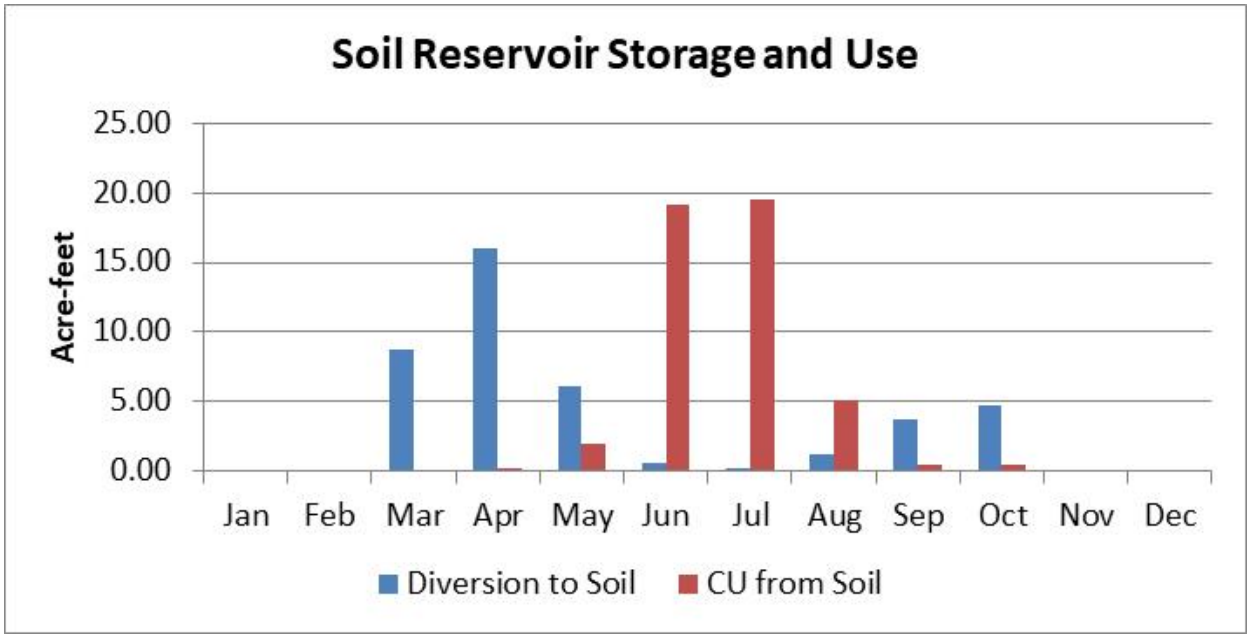
Maximum Diversion to meet CIR = 15.3 cfs
(18 cfs * .85)

- **Ditch Efficiency from Ditch Loss Studies, Length and Soil Parameters, or User Information**
- **Application Efficiency based on Irrigation Method (flood, sprinkler, etc.)**

Historical Consumptive Use

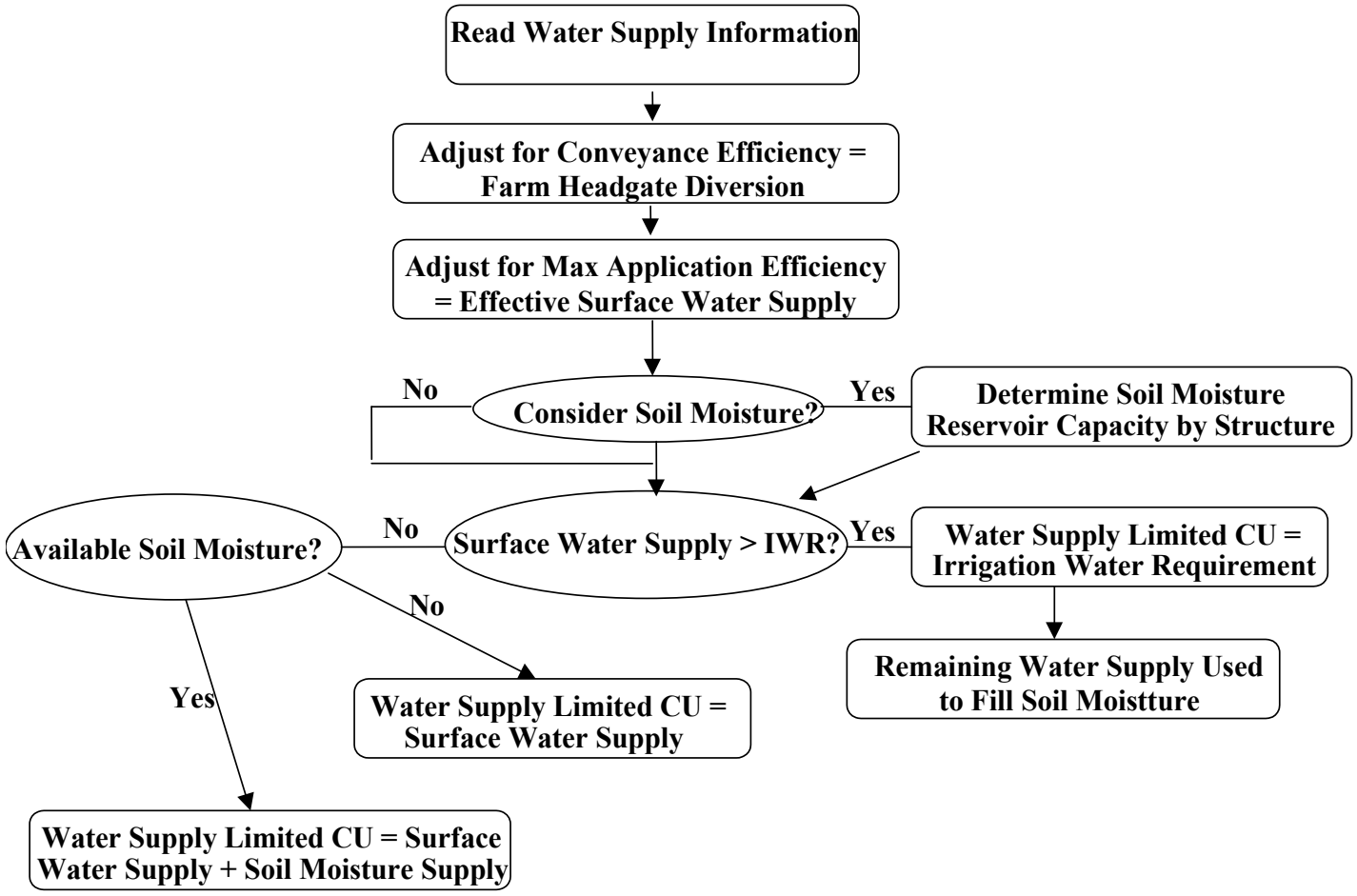
- **Soil Holding Capacity (Available Water Content)**
  - **Farm deliveries in excess of CU are "stored" in the soil root-zone and consumed in the late season**

AWC (in/in) x Root Depth (ft) x Acreage (acres) = Soil "Reservoir" Capacity (acre-feet)



Historical Consumptive Use

- **Actual (Supply-limited) Crop Consumptive Use**



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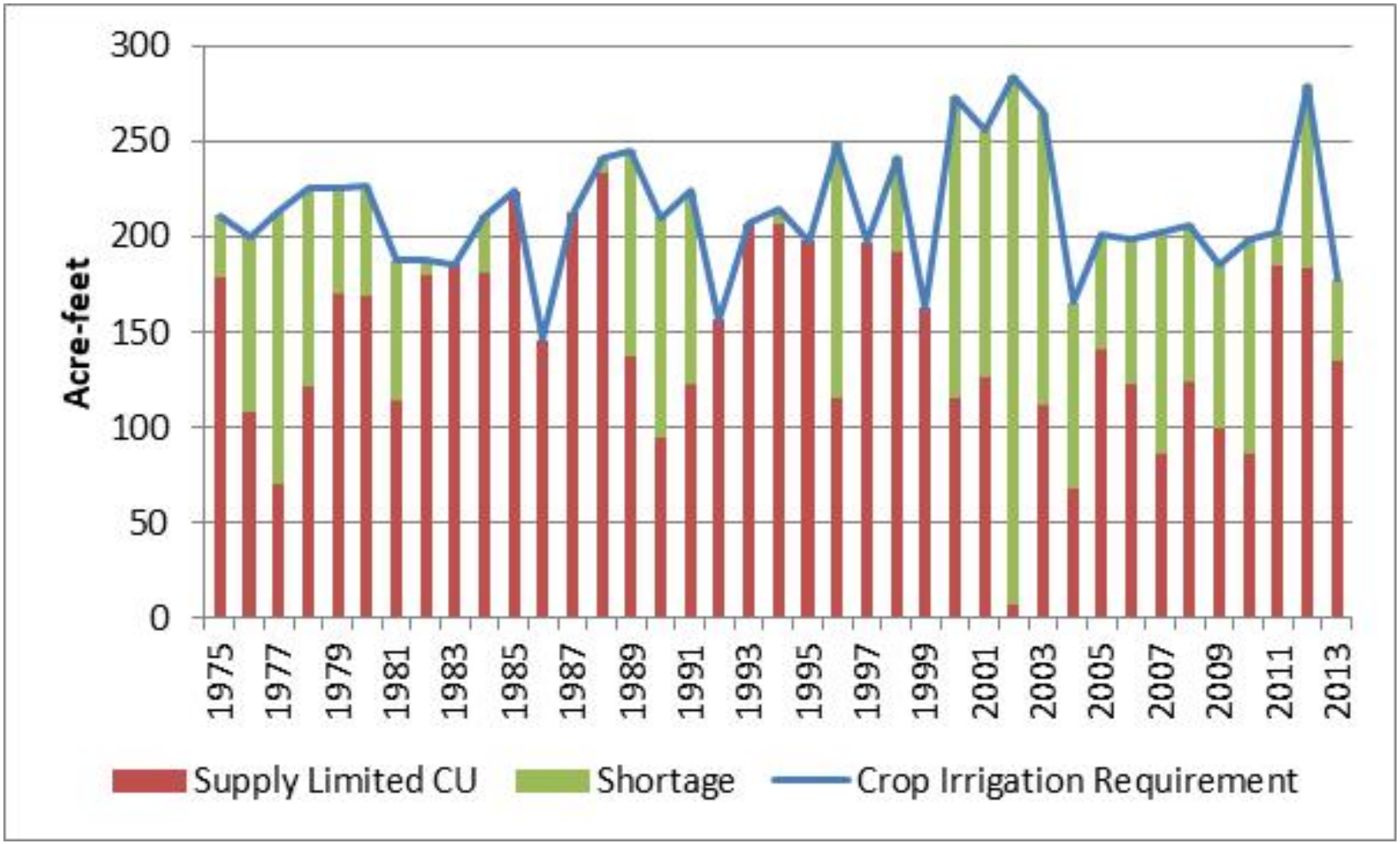
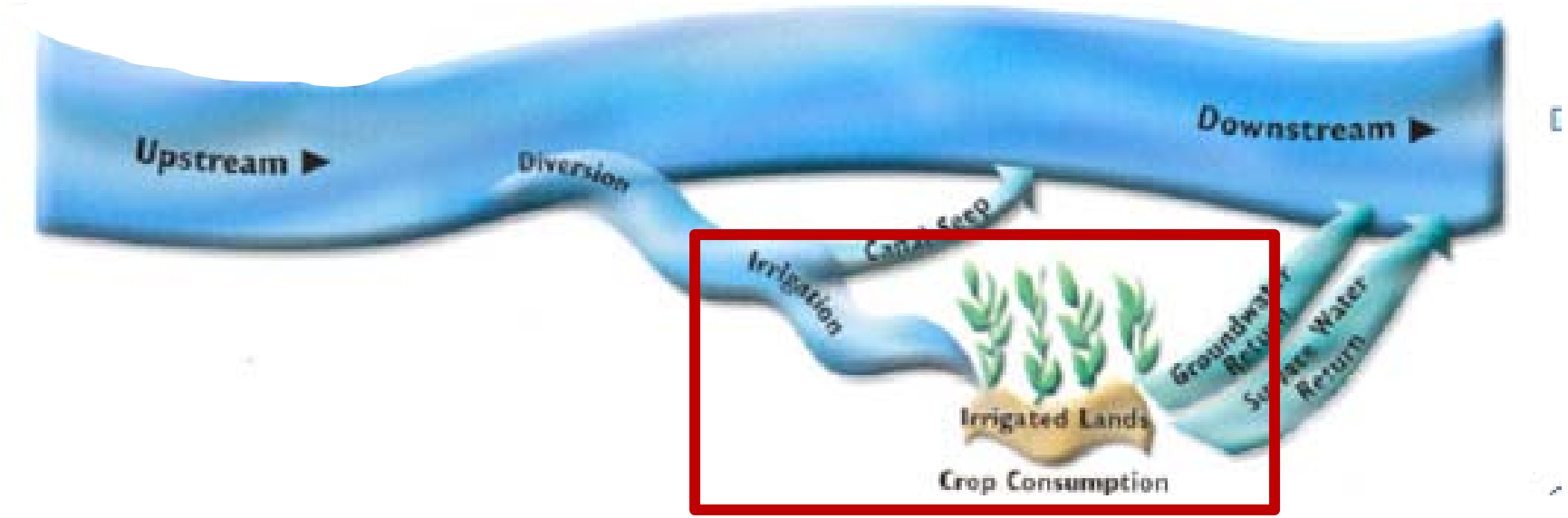


Historical Return Flows

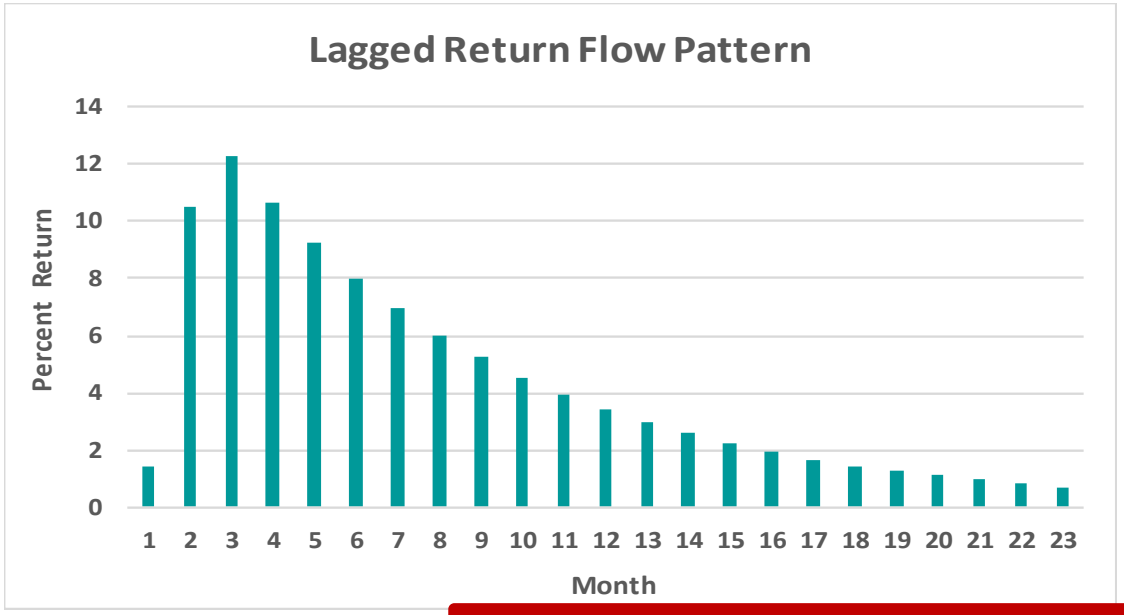
- **Total Returns = Diversions – Crop CU**
  - **Ditch Loss Returns (through GW Alluvium)**
  - **Irrigation Application Returns**
    - **Surface Runoff (returns quickly after irrigation)**
    - **Subsurface Returns (through GW Alluvium)**

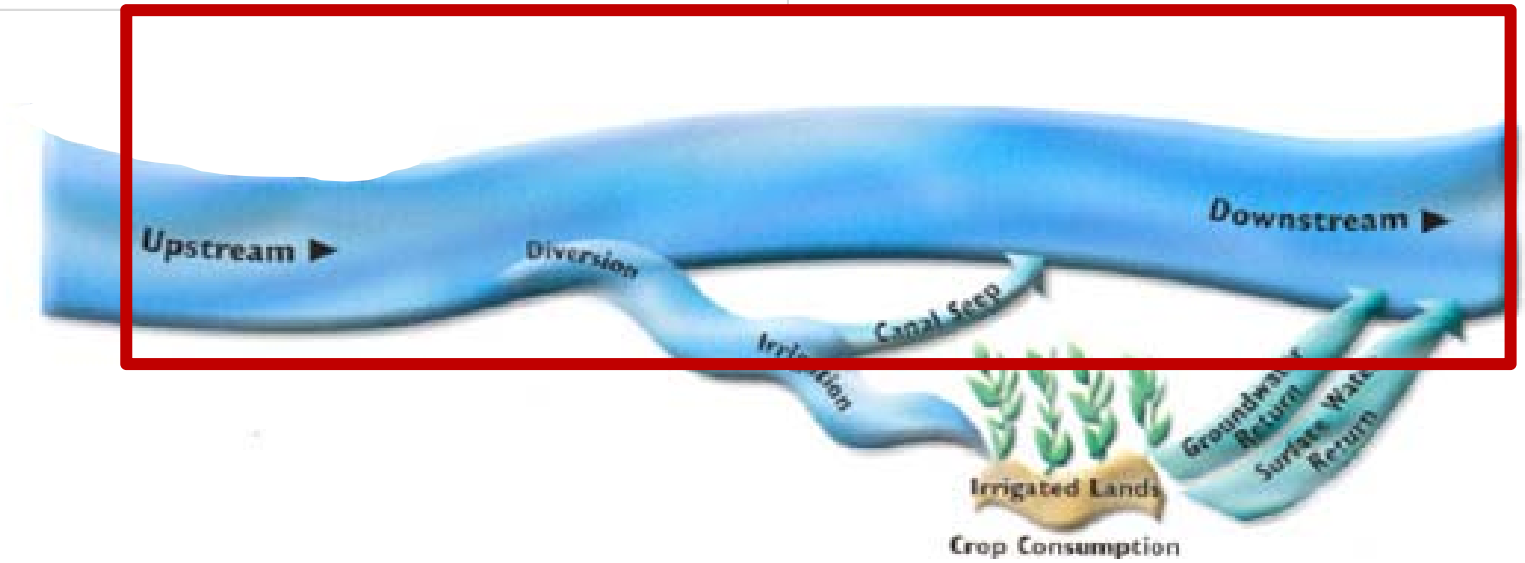


Historical Return Flows

- **Location of Return Flows Determined based on ditch alignment and location of irrigated lands**
  - **Subsurface Returns to nearest point on river or nearest drainage**
- **Timing of Subsurface Return Flows based on:**
  - **Distance from river to irrigated acreage and no-flow boundary**
  - **Aquifer transmissivity and specific yield**
  - **Aquifer parameters based on geologic maps or nearby well pump tests**
  - **Generally Glover analytical method used**

Net Stream Depletions





Net Stream Depletions

	(1)	(2)	(3)	(4)	(5)	(6)
Month	Diversion	Farm Headgate Delivery	Surface Water Runoff	Total Crop Consumptive Use	Lagged GW Return Flow	Net Stream Depetion/ Accretion
Jan	0.00	0.00	0.00	0.00	34.76	-34.76
Feb	0.00	0.00	0.00	0.00	31.53	-31.53
Mar	0.00	0.00	0.00	0.00	28.94	-28.94
Apr	77.70	64.49	6.45	24.00	27.41	43.84
May	101.40	84.16	8.42	34.88	28.23	64.75
Jun	114.60	95.12	9.51	52.96	30.43	74.66
Jul	126.70	105.16	10.52	58.24	32.74	83.44
Aug	124.20	103.09	10.31	46.40	35.30	78.59
Sep	109.20	90.64	9.06	35.52	38.00	62.13
Oct	75.90	63.00	6.30	10.88	40.08	29.52
Nov	0.00	0.00	0.00	0.00	40.56	-40.56
Dec	0.00	0.00	0.00	0.00	38.27	-38.27
Annual	**729.70**	**605.65**	**60.57**	**262.88**	**406.25**	**262.88**

(1) Average Monthly Diversions
(2) Column (2) = Column (1) x ditch efficency (1-ditch loss of 17% = 83%)
(3) Surface Runoff estimated to be 15% of Farm Headgate Deliver Column (3) = Column (2) x .15
(4) Crop consumptive use from surface diversions from Historical CU analysis
(5) Lagged return flow from ditch los and non-consumed surface water; lagging factors from Glover analysis
(6) Net depletions equal diversions minus lagged return flows Column (6) =Column (1) - Column (3) - Column (5)

Water Rights Change Analysis

- **Next Week - Perform a Historical Consumptive Use Analysis**
  - Discuss data sources and data management in more detail
  - Use on-line available tools
  - Walk through results, terms and conditions, and expert opinions

Water Rights Change Analysis

- **Questions?**

Water Availability Analysis

- **Physical Supply**
  - "Wet" Water
  - Generally determined based on streamflow gages
  - If there is physical supply, there are options
- **Legal Supply**
  - Portion of the Physical Supply that can't be claimed by downstream water rights - determined based on Call Records or Flow vs Calling Right relationship
- **Reliable Supply**
  - Will supply be there in Drought Years? If conditions change?

Water Availability Analysis

- **Call Relationship varies by location and season**

COLORADO
Decision Support Systems
Colorado Water Conservation Board / Division of Water Resources

Administrative Calls — Hide Filters | Export | Get Link | Help

Administrative Calls

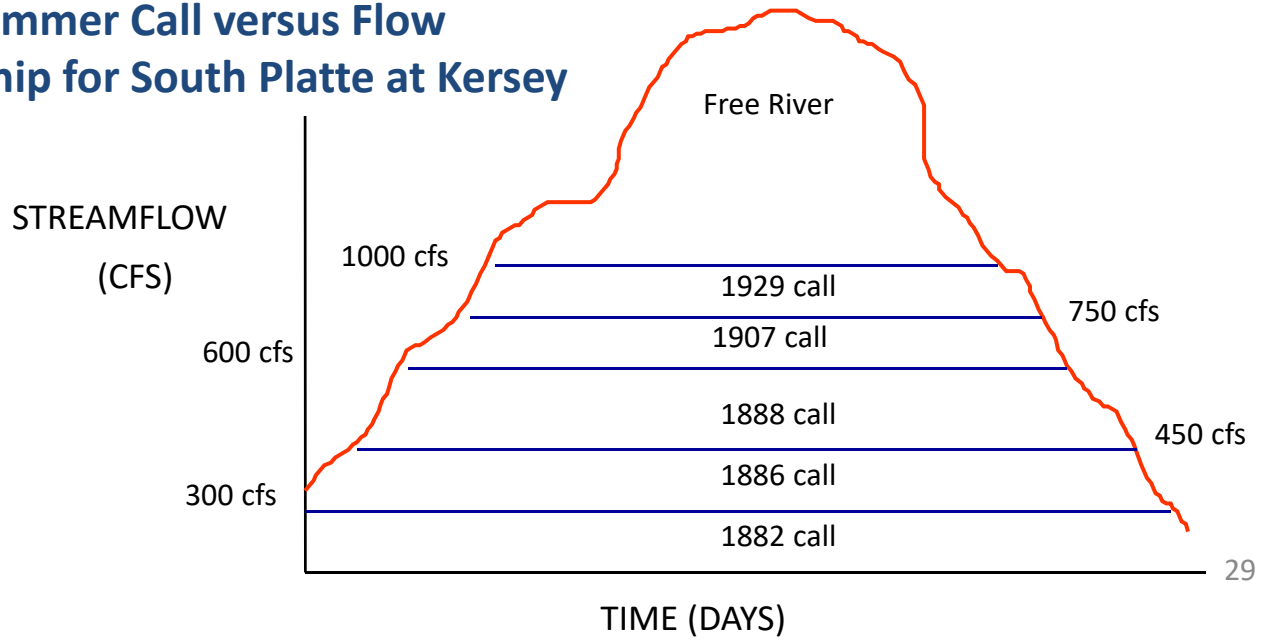
Filters

Active Historic

From: 09/10/2016 To: 09/24/2017

Admin Scenario	Date Time Set	Date Time Released	Water Source Name	Location WDID	Location Structure Name	Priority WDID	Priority Structure Name
CALL	9/23/2017 8:00 AM		CLEAR CREEK	0700569	FARMERS HIGHLINE CNL	0700569	FARMERS HIGHLINE CNL
CALL	9/23/2017 8:00 AM		RIO GRANDE	2499999	RIO GRANDE COMPACT - LOBATOS	2000812	RIO GRANDE CNL
CALL	9/22/2017 8:00 AM		SOUTH PLATTE RIVER	0100687	NORTH STERLING CANAL	0100687	NORTH STERLING CANAL

Typical Summer Call versus Flow Relationship for South Platte at Kersey



Water Availability Analysis