Water Commissioner Training

Title 85-5
Montana Code Annotated

Bozeman, Montana
April 17, 2019

Department of Natural Resources
and Conservation (DNRC)

Handouts

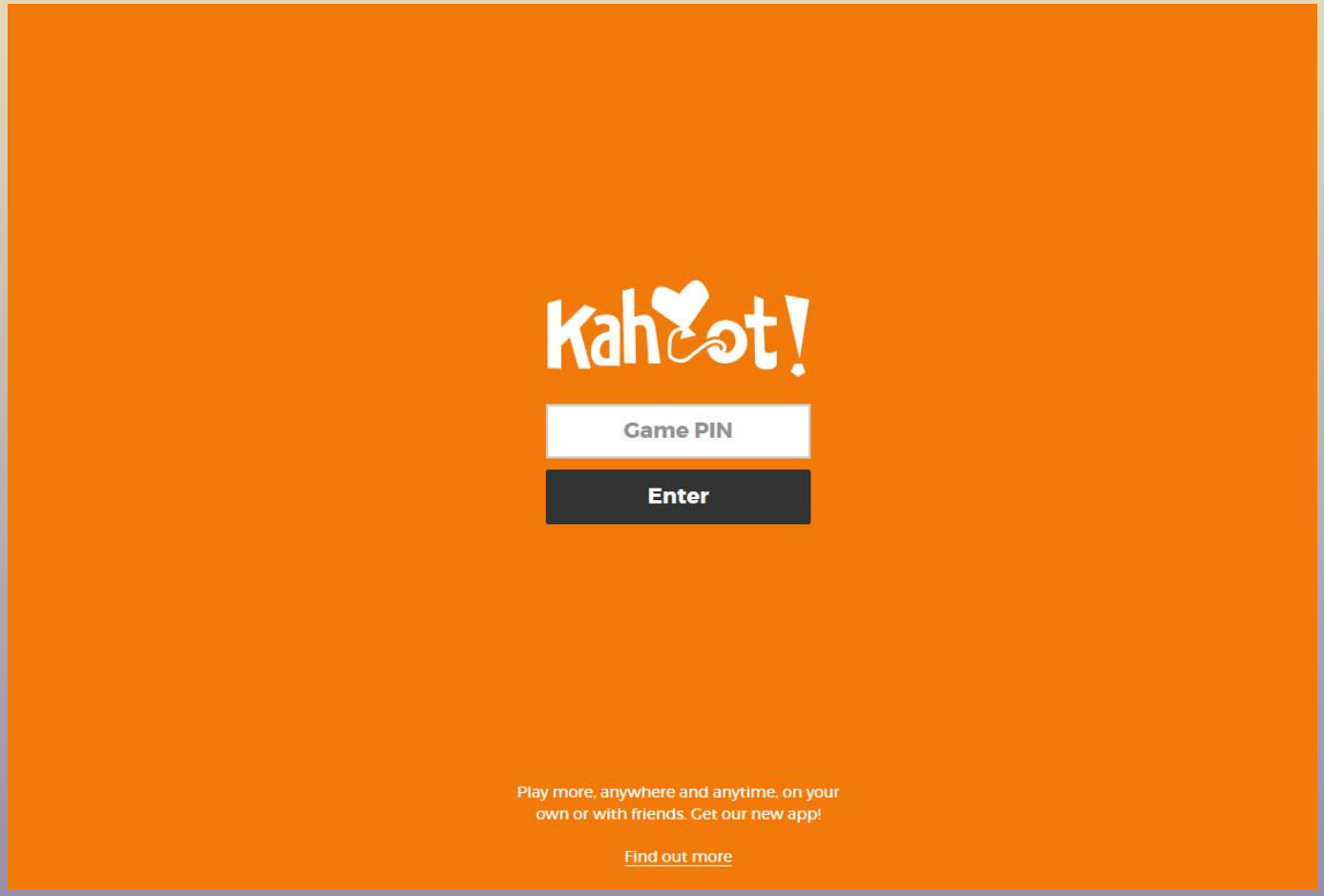
- Water Commissioner Training Manual (2019)
- Irrigation Water Measurement (Wyoming Pocket Guide)
- Water Rights in Montana 2018
- *Draft* Implementation Guide for Water Distribution in Montana (2019)
- Problem Sets

Speakers

Dr. Chris Hahn, Constructive Agreement, LLC
Julie Nordlund, Water Master, Montana Water Court
Ben Sudduth, Water Master, Montana Water Court
Matt Norberg, Hydrologist, DNRC Water Resources Division
Mike Roberts, Hydrologist, DNRC Water Resources Division
Jim Beck, Retired DNRC Engineer

On your Smart Phone

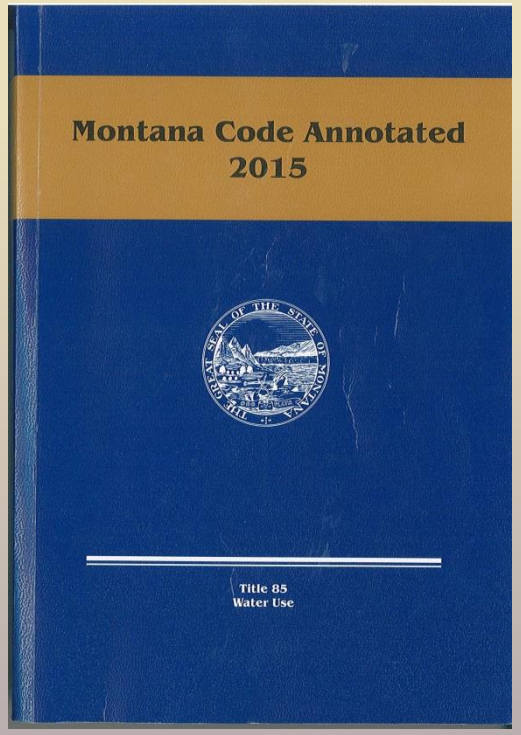
1) Go to: Kahoot.it
2) Enter Game PIN
3) Enter Nickname

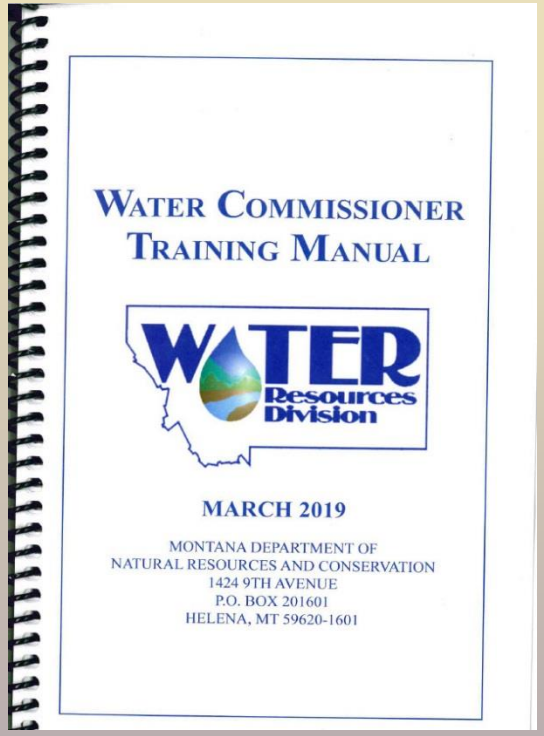


Why do we train Water Commissioners?

1989 Montana Legislature

MCA 85-5-111





Heightened awareness of water management:

- adjudication – Water Court Decrees
- drought
- water right hearings

Department of Natural Resources & Conservation

Water Resources Division

Water Commissioner Training
Certificate of Attendance

awarded to

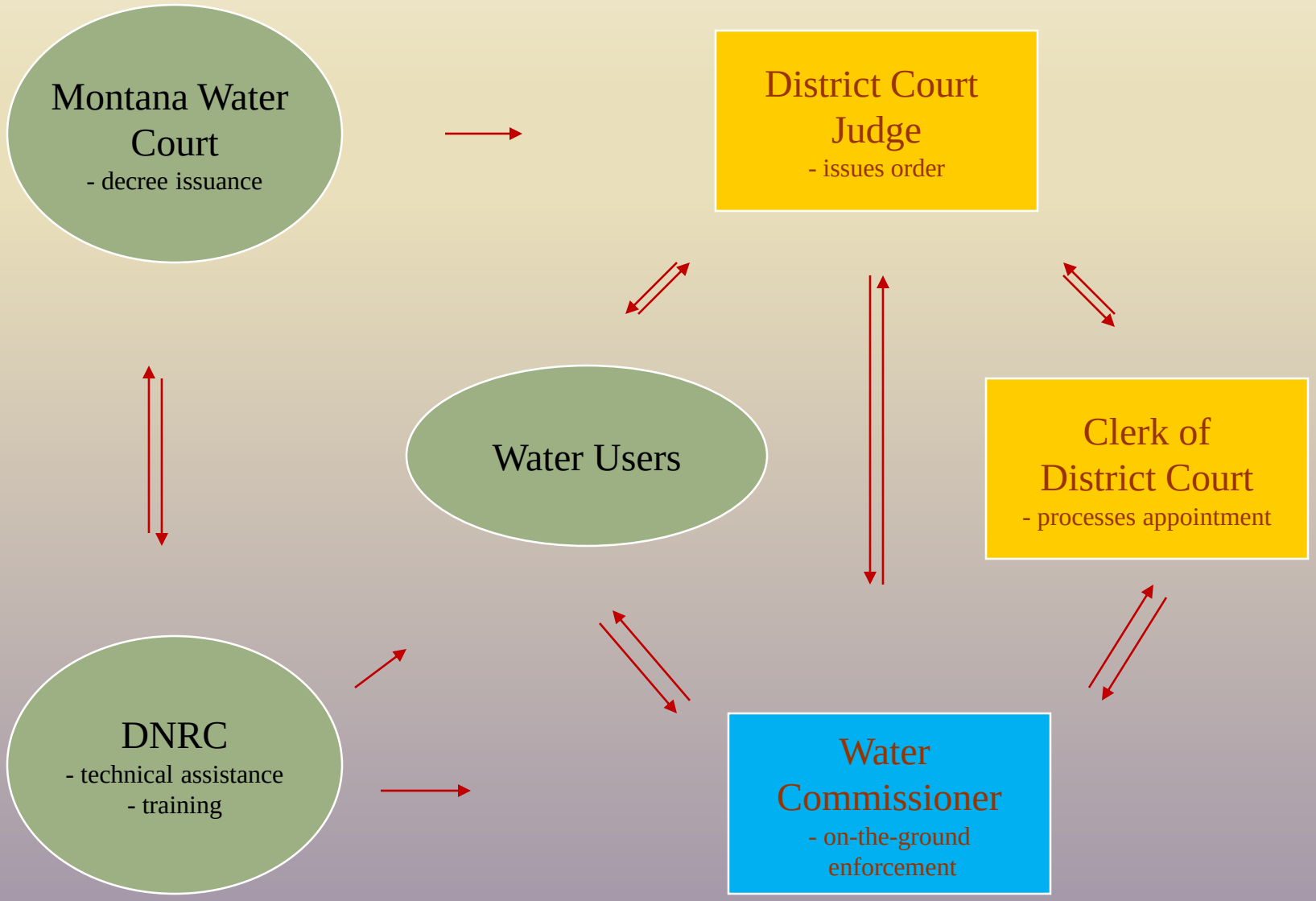
March 29-30, 2017

In recognition of your attendance and participation in the 2017 Water Commissioner Training held in Helena, Montana pursuant to §85-5-111, MCA.

Jan Langel
Division Administrator

Mike Roberts
Hydrologist - Trainer

Key Players



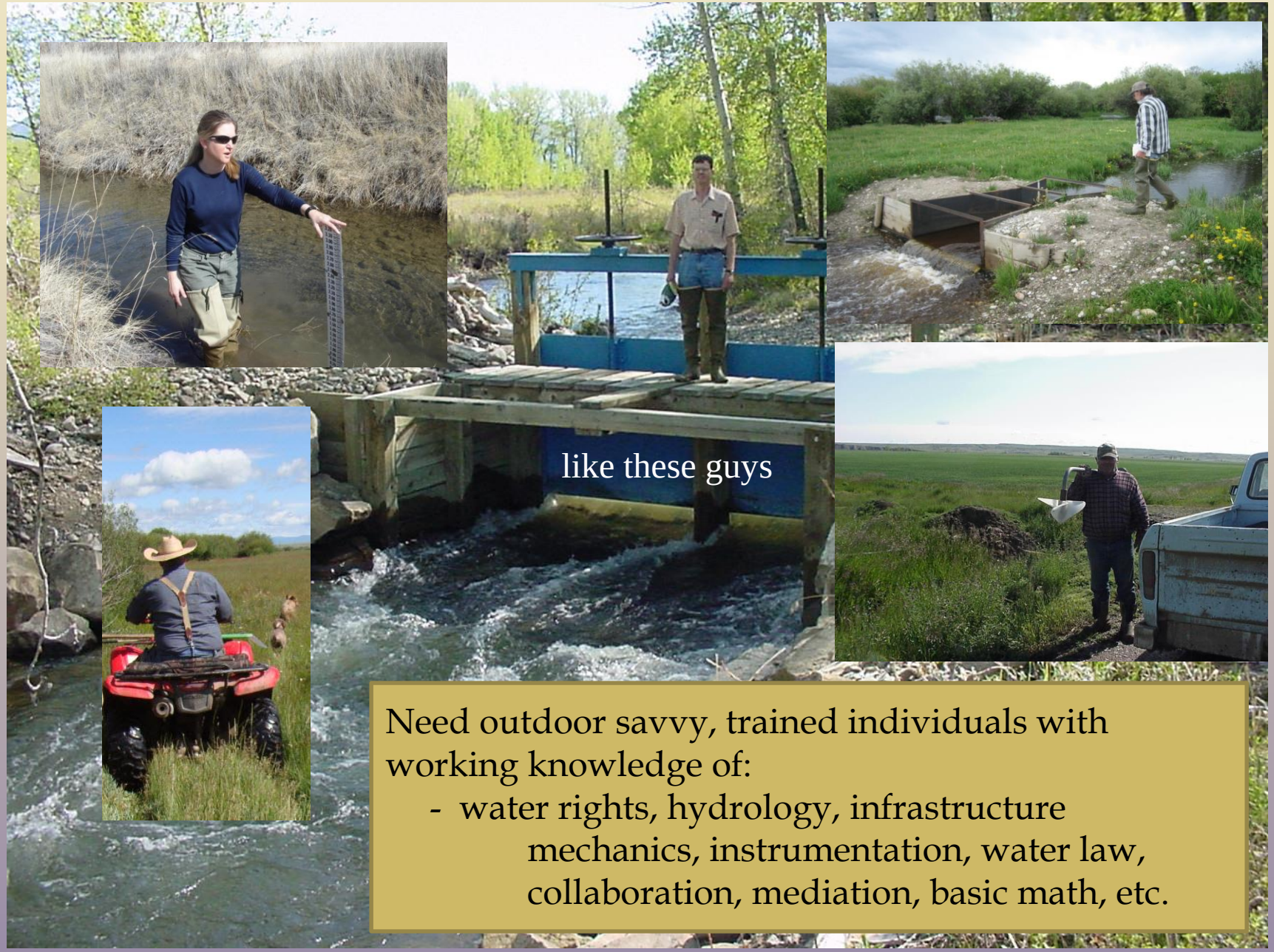
DNRC Examines, Water Court Adjudicates, District Court enforces…..

What is a Water Commissioner?

An appointee of the District Court responsible for the measurement and delivery of water based upon the priority of water rights for a specific stream, ditch, reservoir, or other watercourse.

Skills Required….

Skills Required…



Need outdoor savvy, trained individuals with working knowledge of:

- water rights, hydrology, infrastructure mechanics, instrumentation, water law, collaboration, mediation, basic math, etc.

Typical Water Commissioner: local, agriculture background, water user (appx. 50%), has multiple jobs, hands-on*, communication skills

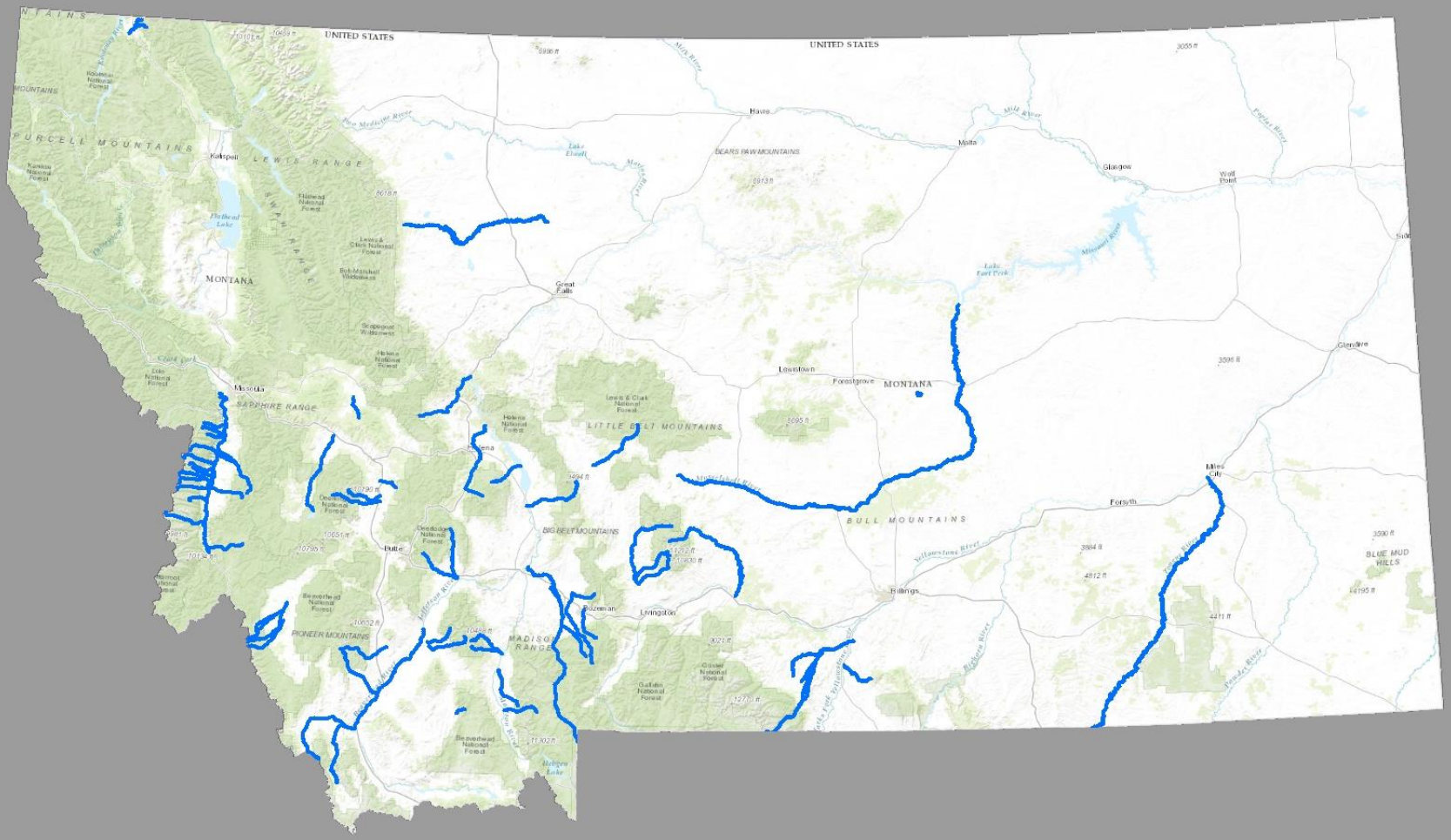
Ditch Rider? Dam Tender? Water Commissioner? Mediator?

MCA 85-5-101 Applies to any stream, ditch, watercourse, spring, lake, reservoir, or other source of supply which has been determined by a decree of a court of competent jurisdiction (including temporary preliminary, preliminary, and final decrees).

Water Commissioner is a private contractor

(not employee of District Court, DNRC, or Water Users) MCA 85-5-101(6)

Sources With Active Water Commissioners 2019



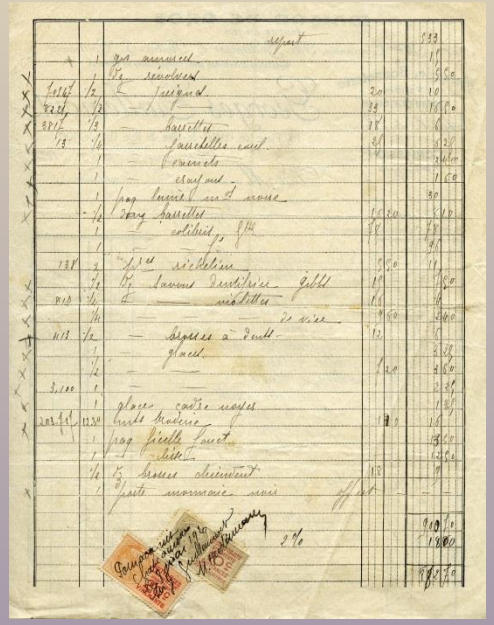
2019 Appointees: appx. 70

District Court Decree vs. Water Court Decree

- Typically includes all water rights dated before Decree Issued

- Does not reflect newer water rights, permits, or changes

- Typically includes all water rights, permits, changes in appropriation, and is updated annually.



2014 Priority Date Index - Shields River Enforcement Area

Enforceable Priority Date	Water Right #	Owner	Type	Use	Acres	Pod ID	Means	Qtr Sec	Section	Twp Rge	Source	Enf #	Diversion Name	From - To	Cfs	Total Flow
18800601	43A W 11572 00	PORCUPINE CREEK RANCH INC	USE	ST		1	LS	N2SW	34	5N9E	SHIELDS RIVER	LS010	LS010	01 01 12 31		0.00
18830415	43A W 137659 00	MONTANA, STATE OF BOARD OF LAND COMMISSIONERS	USE	ST		1	DT	NWSENE	25	5N9E	SHIELDS RIVER	018	BECKER DITCH	01 01 12 31		0.00
18830425	43A W 193075 00	BRIGHT, GORDON L	DECR	IR	30.8	1	HG	SENWSW	9	4N9E	SHIELDS RIVER	012	BIG CANAL	05 01 10 04	0.43	0.43
18830425		BRIGHT, JACQUELINE J	DECR	IR	30.8	1	HG	SENWSW	9	4N9E	SHIELDS RIVER	012	BIG CANAL	05 01 10 04		0.43
18830425	43A W 31162 00	ADAMS, DIRK S	DECR	IR	104	1*	HG		4	4N9E	SHIELDS RIVER	012	BIG CANAL	05 15 10 19	3.33	3.76
18830425		ADAMS, DIRK S	DECR	IR	104	2*	HG	NWNWNW	3	4N9E	SHIELDS RIVER	014P	ADAMS PUMP SITE	05 15 10 19		3.76
18830425	43A W 33140 00	ADAMS, DIRK S	DECR	ST		1	LS	SESW	16	4N9E	SHIELDS RIVER	LS006	LS006	01 01 12 31		3.76
18830610	43A W 113381 00	ADAMS, ANITA L	DECR	IR	212	1*	HG	SWSWSE	4	4N9E	SHIELDS RIVER	011	UPPER SWANDAL DITCH	04 15 10 31	1.69	5.45
18830610		ADAMS, ANITA L	DECR	IR	212	2*	HG	SESENW	9	4N9E	SHIELDS RIVER	010	MIDDLE SWANDAL DITCH	04 15 10 31		5.45
18830610		ADAMS, ANITA L	DECR	IR	212	3*	HG	SENWSE	9	4N9E	SHIELDS RIVER	009	LOWER SWANDAL DITCH	04 15 10 31		5.45
18830610		ADAMS, DIRK S	DECR	IR	212	1*	HG	SWSWSE	4	4N9E	SHIELDS RIVER	011	UPPER SWANDAL DITCH	04 15 10 31		5.45
18830610		ADAMS, DIRK S	DECR	IR	212	2*	HG	SESENW	9	4N9E	SHIELDS RIVER	010	MIDDLE SWANDAL DITCH	04 15 10 31		5.45
18830610		ADAMS, DIRK S	DECR	IR	212	3*	HG	SENWSE	9	4N9E	SHIELDS RIVER	009	LOWER SWANDAL DITCH	04 15 10 31		5.45
18830610	43A W 11582 00	PORCUPINE CREEK RANCH INC	DECR	IR	425	1	HG	NWSENE	25	5N9E	SHIELDS RIVER	018	BECKER DITCH	05 15 09 19	0.56	6.01
18830610	43A W 191857 00	ADAMS, ANITA L	USE	ST		1*	DT	SWSWSE	4	4N9E	SHIELDS RIVER	011	UPPER SWANDAL DITCH	01 01 12 31		6.01
18830610		ADAMS, ANITA L	USE	ST		2*	DT	SESENW	9	4N9E	SHIELDS RIVER	010	MIDDLE SWANDAL DITCH	01 01 12 31		6.01
18830610		ADAMS, ANITA L	USE	ST		3*	DT	SENWSE	9	4N9E	SHIELDS RIVER	009	LOWER SWANDAL DITCH	01 01 12 31		6.01

How do Water Commissioners Enforce Decrees?

- Distribute water by priority date
- Monitor headgates and measuring devices
- Keep daily records

Why are Water Commissioners important?

- Distribute water according to law
- Protect all water users from illegal diversions
- Provide documentation of water use

Water Commissioner Appointment – Clerk of Court

- Petition (15%)

("owners of at least 15% of water rights and flow rate affected" MCA 85-5-101)

- Order
- Oath of Office
- Bond

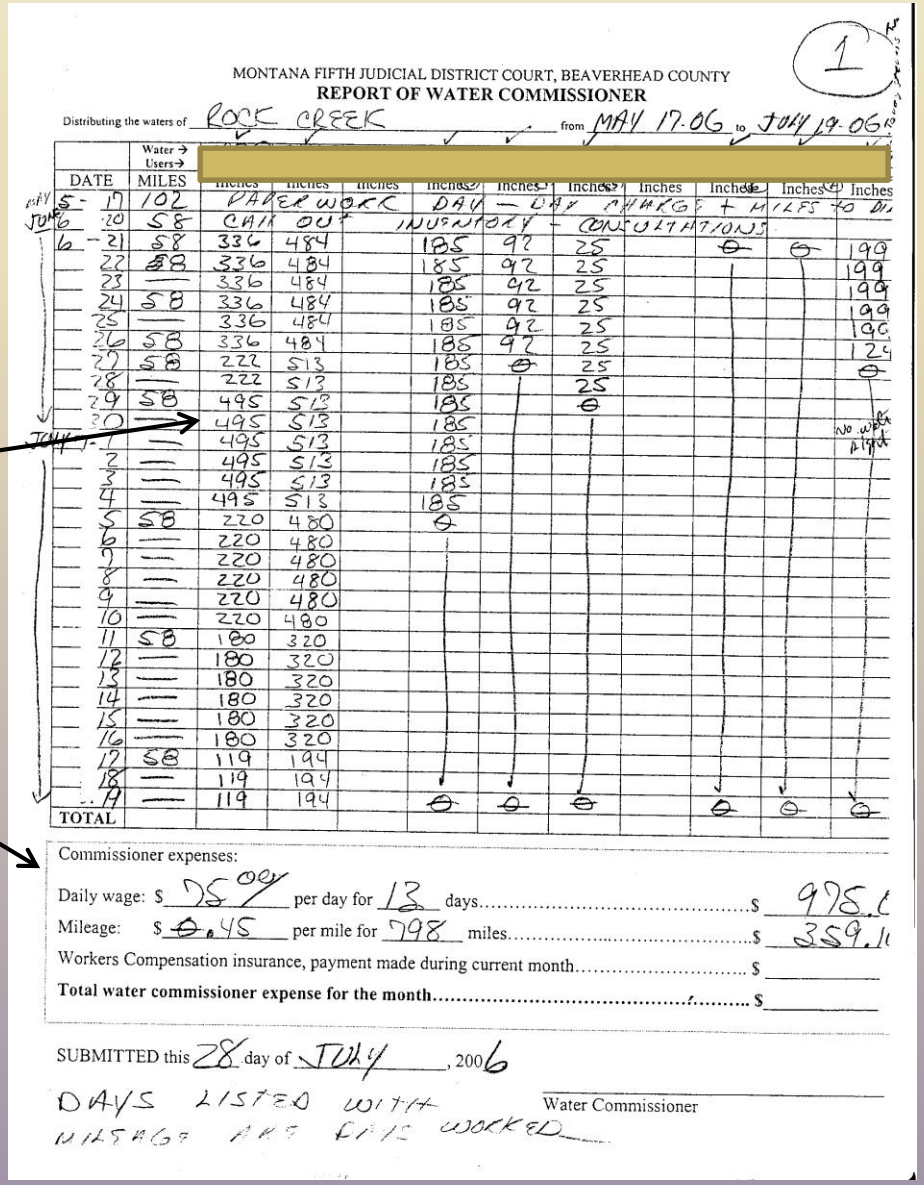
Once Appointed, now what??

- Attend DNRC Water Commissioner Training
- Clerk will notify water users
- Purchase worker's compensation
- Get copy of decree or list of water users
- Meet with (if possible):
  - previous commissioner
  - water users
- Inspect headgates and measuring devices

Daily Record of Water Distribution

Daily allotment (inches)

Payment (wage and mileage)



MONTANA FIFTH JUDICIAL DISTRICT COURT, BEAVERHEAD COUNTY

REPORT OF WATER COMMISSIONER

Distributing the waters of ROCK CREEK from MAY 17-06 to JULY 19-06

DATE	MILES	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
MAY 5-17	102	PAPER WORK			DAY — DAY CHARGE + MILES TO DI						
JUNE 6-20	58	CAIR OUT			INVENTORY - CONSULTATIONS						
6-21	58	336	484		185	92	25		0	0	199
22	58	336	484		185	92	25				199
23	—	336	484		185	92	25				199
24	58	336	484		185	92	25				199
25	—	336	484		185	92	25				199
26	58	336	484		185	92	25				196
27	58	222	513		185	0	25				124
28	—	222	513		185		25				0
29	58	495	513		185		0				
30	—	495	513		185						No work
JULY 1	—	495	513		185						
2	—	495	513		185						
3	—	495	513		185						
4	—	495	513		185						
5	58	220	480		0						
6	—	220	480								
7	—	220	480								
8	—	220	480								
9	—	220	480								
10	—	220	480								
11	58	180	320								
12	—	180	320								
13	—	180	320								
14	—	180	320								
15	—	180	320								
16	—	180	320								
17	58	119	194								
18	—	119	194								
19	—	119	194		0	0	0		0	0	0
TOTAL											

Commissioner expenses:

Daily wage: $ 75.00 per day for 13 days ..... $ 975.0

Mileage: $ 0.45 per mile for 798 miles ..... $ 359.1

Workers Compensation insurance, payment made during current month ..... $ _____

Total water commissioner expense for the month ..... $ _____

SUBMITTED this 28 day of JULY, 2006

Water Commissioner

DAYS LISTED WITH MILEAGE ARE DAYS WORKED

Water Commissioner Report

Judicial District #_____ County_____Clerk of Court_____
Water Commissioner_____Water Body_____

July 2017 DATE	Water User Ditch MILES	Smith Big Inches	Smith Middle Inches	Jones Small Inches	Davis Pasture Inches	Williams Farm1 Inches	Williams Farm2 Inches
7/1	45	40	40	80	160	60	20
7/2	45	40	40	80	160	60	20
7/3		40	40	80	160	60	20
7/4		40	40	80	160	60	20
7/5		40	40	80	160	60	20
7/6		40	40	80	160	60	20
7/7		40	40	80	160	60	20
7/8		40	40	80	160	60	20
7/9		40	40	80	160	60	20
7/10	45	25	80	120	160	60	20
7/11	45	25	80	120	160	60	20
7/12		25	80	120	160	60	20
7/13		25	80	120	160	60	20
7/14		25	80	120	160	60	20
7/15		25	80	120	160	60	20
7/16	75	25	80	120	160	60	20
7/17	45	25	80	120	160	60	20
7/18		0	80	0	160	60	20
7/19		0	80	0	160	60	20
7/20		0	80	0	160	60	20
7/21		0	80	0	160	60	20
7/22	75	0	80	0	160	60	20
7/23	75	0	80	0	160	60	20
7/24		0	80	0	80	0	20
7/25		0	80	0	80	0	20
7/26		0	80	0	80	0	20
7/27		0	20	0	80	0	20
7/28	45	0	20	0	80	0	20
7/29	45	0	20	0	80	0	20
7/30		0	20	0	80	0	20
7/31		0	20	0	80	0	20
TOTAL	540	560	1820	1680	4320	1380	620

Commissioner Expenses:						
Daily Wage:	100	per day	10	days	$	1000
Mileage:	0.75	per mile	540	miles	$	405
Workers Comp:	281.81	per month			$	281.81
Other Expenses (list):			phone, log books		$	100
Total Commissioner Expenses for the month					**$**	**1787**

Water Commissioner Report

Monthly Billing Summary

Water User	Total Inches	Percent of Total	Monthly Bill	Annual Bill to Date
Smith	560	7%	$119.40	
Smith	1820	22%	$388.07	
Jones	1680	20%	$358.21	
Davis	4320	52%	$921.12	
Williams	1380	16%	$294.25	
Williams	620	7%	$132.20	

Comments:

SUBMITTED the day of 20__

Why is filing Water Commissioner records important?

1) It's the Law

2) Provides accountability/transparency of water commissioner.

3) Provides a public record of water distribution for water user's, general public, government agencies, etc.

4) May preclude a Dissatisfied Water User's complaint

5) It's how the WC gets paid.

$$$ Payment

- Proportionate (mileage, training, worker's comp, etc.)
- Payment system (MCA 85-5-204, 2007)
- Water Commissioner is paid directly through Clerk of Courts office
- If user does not pay, water can be shut off (MCA 85-5-206)

WORKERS COM ARRANGEMENT FOR WATER COMMISSIONERS
07/1/2018 *

1. Term: Two options:

a. Short term: Policy will only run for the period requested for coverage for the water commissioner. Policy will cancel and not renew & if commissioner is appointed for another period, a new application will have to be completed & submitted.

b. Regular 12 month term: Policy will run for 12 months with coverage for the water commissioner being only for the months given. The application needs to be specific on the time frame required for coverage on the owner of the policy. The policy will automatically renew in 12 months as long as payrolls & payments are kept up to date.

2. Binding Effective date: This will be the day following the date when 3 items have been received in MSF office:

a. Any prior policy reconciled (payroll reports received & payment received) if applicable.

b. Completed application.

c. Deposit & expense constant or 1st installment.

3. Coverage for water commissioner: The covered period will be from no sooner than the effective date of the policy (can use a later date) to the last date the commissioner thinks he/she will need coverage. Ex: policy starts June 1 & coverage is needed from June 1 to the end of Oct. So the last day of coverage would be October 31. If the commissioner stops earlier, it is his/her responsibility to contact MSF to request the coverage stop sooner. If the coverage is needed longer, again it is the responsibility of the commissioner to notify MSF PRIOR to ending coverage date for an extension.

4. The 2 options of policies:

a. Installment method:

i. This will require a payment of at least $431.38 down (includes the $180.00 expense constant) & 2 more monthly payments to pay off the premium in advance. Usually has an annual payroll reporting frequency.

b. Deposit method:

i. This will require the payment of the expense constant $180.00 plus a 20% of the estimated premium.

ii. The payroll reporting will be semi-annually.

The rates for the water commissioners this year will be: $7.30 per $100.00.

The lowest wages that commissioners can elect is $900 per month for sole proprietors. The approximate annual premium charge will be $455.35 to bind coverage and 2 monthly installments of $271.35 which would be prorated when coverage is removed or cancelled as stated above. Other options may be considered.

Your contact with the select team is Karen Beddow 1-800-332-3102 ex 5112.

Through July 1, 2018
(MCA 85-5-101(7))

Document

- date and time of anything you do
- daily record of water distribution
- mileage
- any repairs (photo document, date)
- correspondence with users, Judge, DNRC, Water Court
- worker's compensation insurance
- training

Tools: shovel, hand level, maps, field book, cell phone, reference materials, field notebook

Frequently Asked Questions?

Frequently Asked Questions?

How frequent are Water Commissioners Paid?

How many days a week do Water Commissioners work?

How many months during the season?

Term of Office?

How many Water Commissioner's per stream?

Water Commissioners: Do's

- Measure and Distribute water based on priority and decree.
- Inspect Headgates and Measuring devices.
- Record daily distribution.
- Shut water off based on:
  - > priority
  - > lack of payment
  - > non-cooperation regarding infrastructure
- Administer water at source unless otherwise ordered

Water Commissioners: Don'ts

- Change PODs, change periods of use, flow rates, place of use, or priority dates.
- Deliver water based on use
- Deliver water to non-water right holders
- Deliver water outside of priority*
- Be exempt from 310 permitting

(Natural Streambed and Preservation Act)

Water Commissioners: Do's

- Measure and Distribute water based on priority and decree.
- Inspect Headgates and Measuring devices
- Record daily distribution
- Shut water off based on:
  - > priority
  - > lack of payment
  - > non-cooperation regarding infrastructure

Water Commissioners: Don'ts

- Change PODs, change periods of use, flow rates, place of use, or priority dates.
- Deliver water based on use
- Add water for ditch carriage
- Deliver water to non-water right holders
- Deliver water outside of priority*
- Perform construction in or near a stream without a 310 permit

(National Streambed and Preservation Act)

Rights and Duties of Water Users:

- Required to have suitable and functioning headgate and measuring device.
- Required to allow access
- Right to view water commissioner records
- Right to file dissatisfied user complaint with judge

(Failure of Water Commissioner to perform duty is Contempt of Court)

Water Commissioners

What is a Water Commissioner?

An appointee of the District Court with legal authority to measure and distribute water by priority as defined by a decree.

How are they appointed?

When petitioned to the District Court by owners of 15% of the water rights or flow rate affected on a stream.

Who pays for the Water Commissioner?

The water users pay based on the proportion of water they receive.

Why are they important?

They protect water users from unlawful use of water. They provide legal documentation of water use on a stream that can be helpful if disputes arrive.

What are my legal responsibilities as a water user?

- To have a proper functioning headgate and state-approved measuring device.
- To allow access to my headgates and measuring devices.
- To pay the Water Commissioner based on the amount of water I receive.
- To not interfere with the Water Commissioners duties.

What if I am dissatisfied with the Water Commissioner's performance?

You may file a dissatisfied user complaint with the District Court.

Questions:

District Clerk of Court: Beaverhead County, (406) 683-3725

Montana DNRC Regional Office: Helena (406) 444-6999

Montana DNRC: Mike Roberts (406) 444-6641

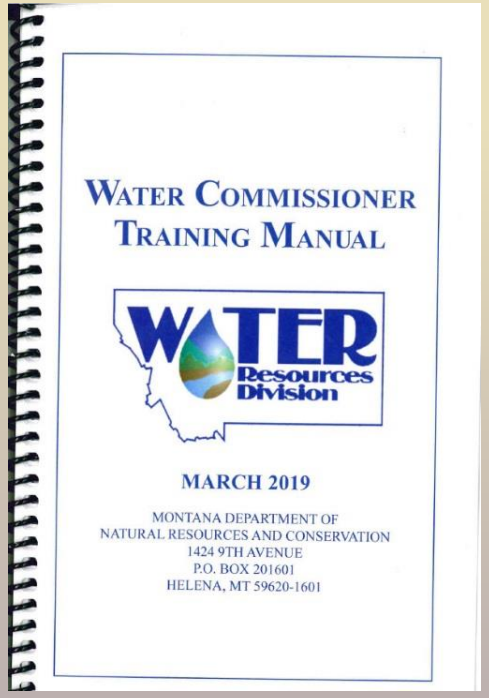
State Laws pertaining to Water Commissioners:

Water Users do not always understand

Handout for Water Users

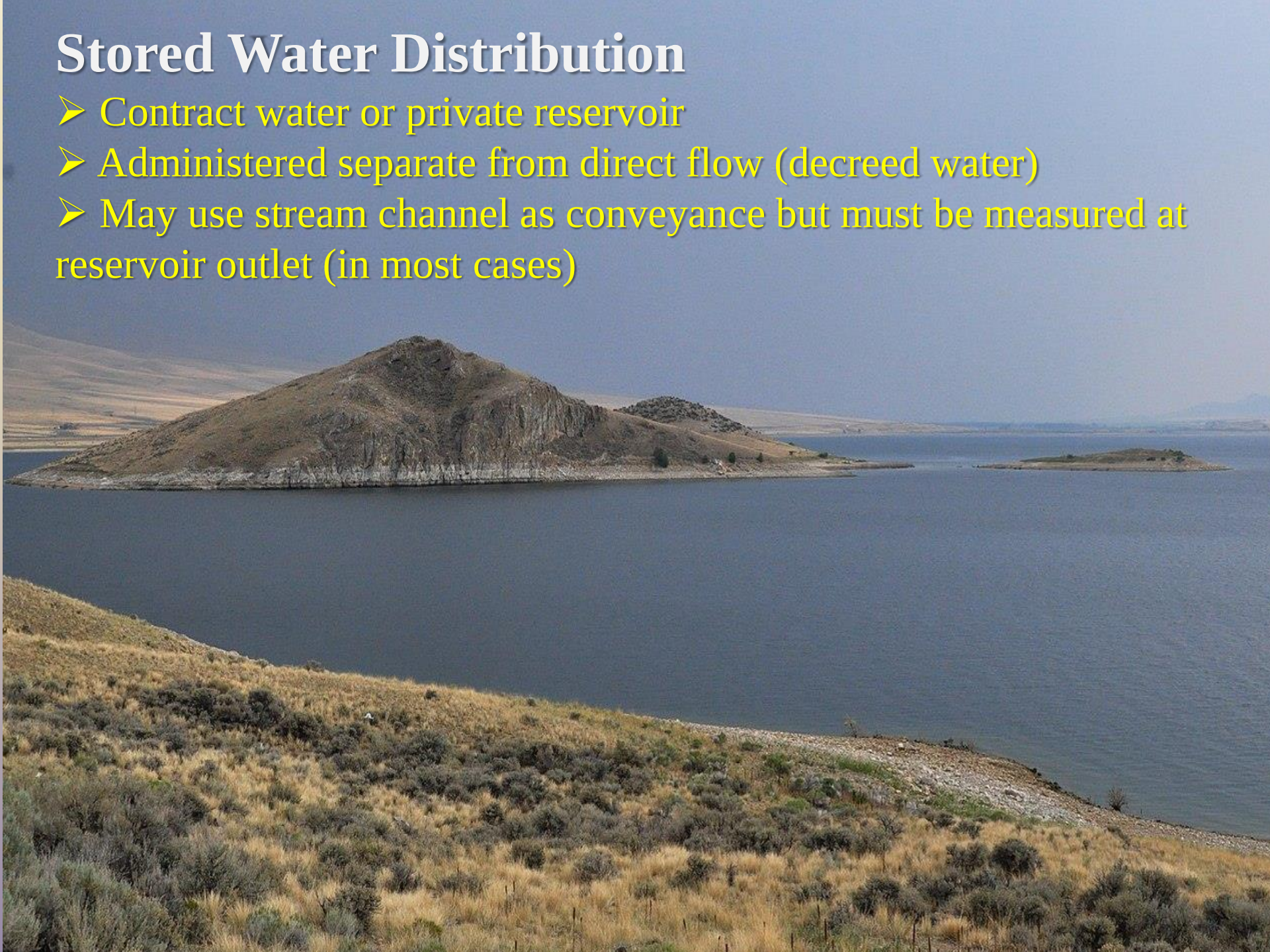
Special Circumstances

- water rights not in decree
- carriage water
- gaining/losing streams, “shrink”
- temporary changes
- instream flow/lease enforcement
- return flow
- seepage rights
- futile call (Teton Prairie decision)



Stored Water Distribution

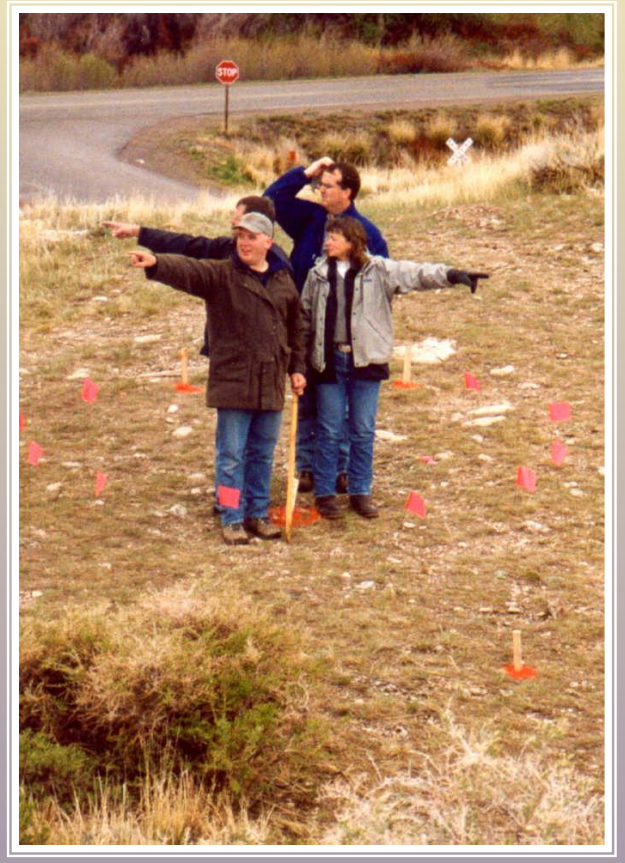
- Contract water or private reservoir
- Administered separate from direct flow (decreed water)
- May use stream channel as conveyance but must be measured at reservoir outlet (in most cases)



Instream Flow

1. Pre 1973
   - Murphy Rights
   - Public Recreation Claims
   - Statements of Claim for Fish and Wildlife Uses
   - Storage
2. Post 1973 Water Reservations
3. Water Leasing

Questions & Contacts



Instream Flow Specialists

- Andy Brummond
  - 538-2445 FWP - Lewistown
  - ext 224
  - abrummond@mt.gov
- Stephen Begley
  - FWP – Helena
  - 444-1229
  - Sbegley@mt.gov
- Mike McLane
  - FWP - Helena
  - 444-1563
  - mmclane@mt.gov

Communication

Water Commissioner and Water User Water Commissioner and District Court

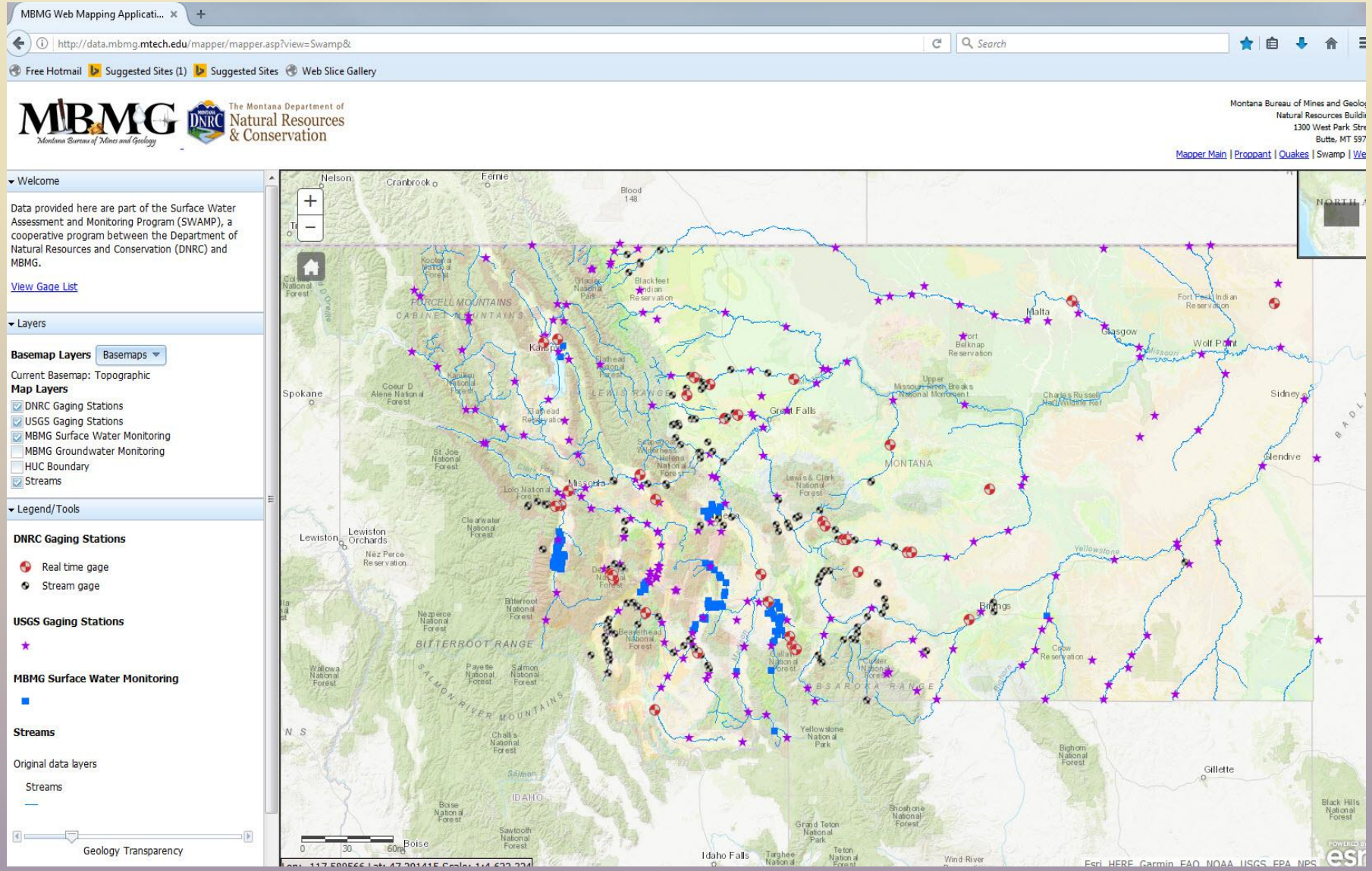
Issues that require Communication include:

- New water commissioner
- Beginning of season
- Turning on/off
- Headgate adjustment
- Access
- Repair/Replacement
- Payment Issues

STREAM GAGE PROGRAM

Montana Department of Natural Resources
and Conservation
Water Management Bureau

STREAM GAGE PROGRAM



Montana Department of Natural Resources and Conservation

Water Management Bureau

http://mbmg.mtech.edu/swamp/

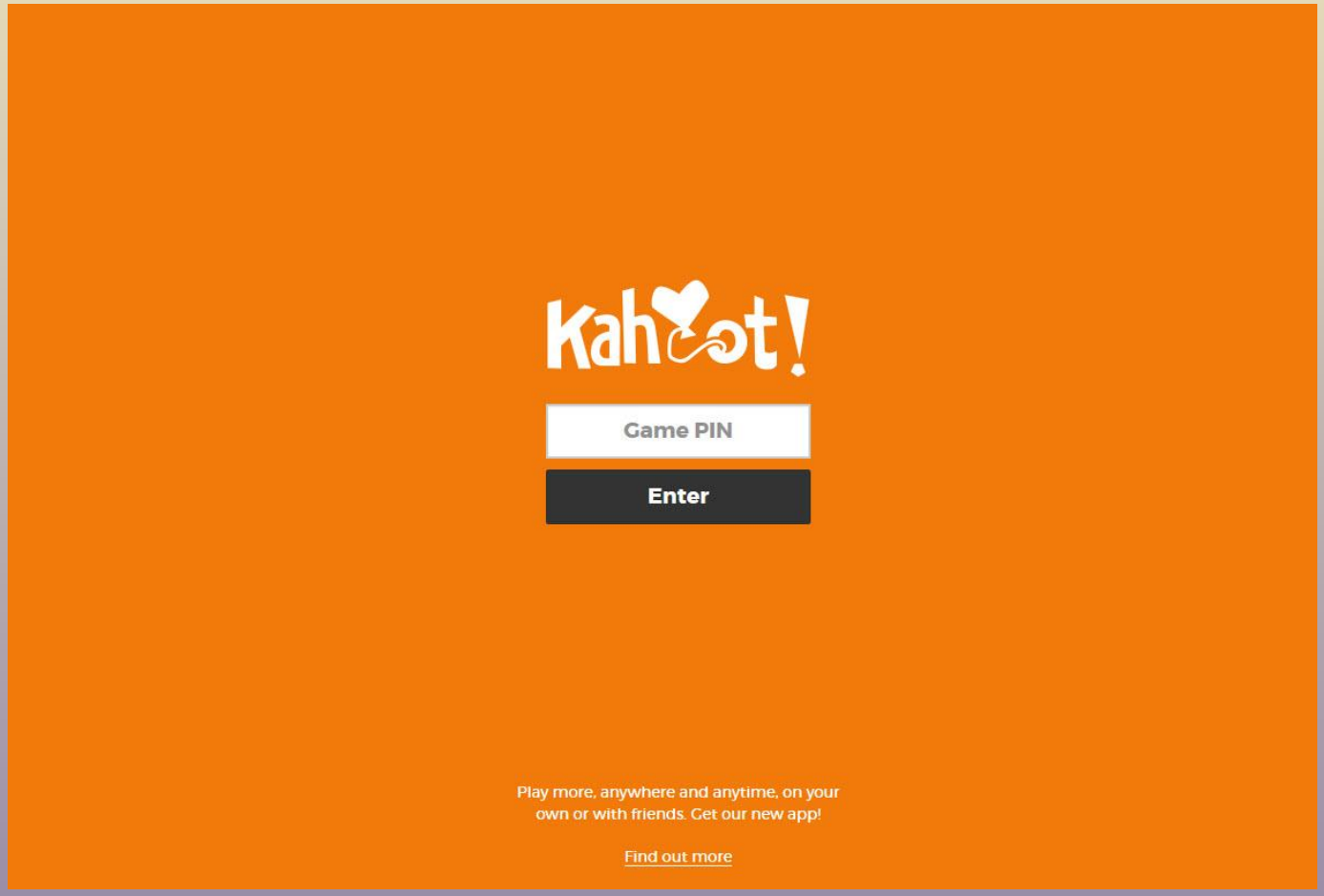
Property of
Water Resources Division
Stream Gaging Program
2018. 11. 1 16:28

2016. 9. 29 13:18

Questions?

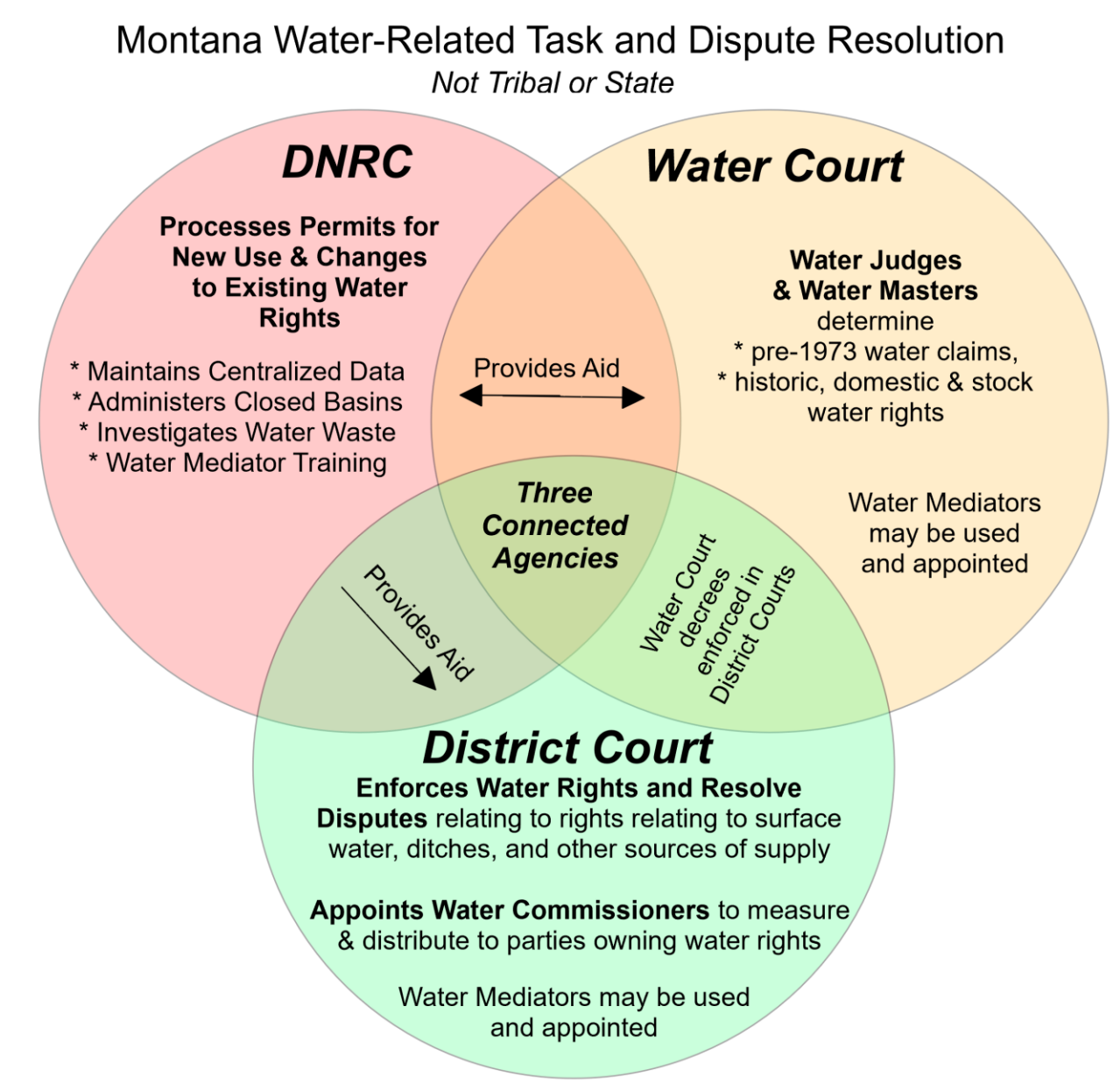
On your Smart Phone

1) Go to: Kahoot.it
2) Enter Game PIN
3) Enter Nickname



Water Mediation Training

MCA 85-5-110
MCA 85-5-111



Distinct but Overlapping Water Resources Roles in Montana

Illustration by Chris Hahn, Ph.D., MBA

http://dnrc.mt.gov/divisions/water/management/training-education/water-commissioner-information

The Montana Department of Natural Resources & Conservation

DNRC Headquarters
1539 Eleventh Ave. Helena, MT 59601
Phone: (406) 444-2074 | Fax: (406) 444-2684
Questions? Email us

Water Adjudication
Water Management
- State Water Plan
- Regional River Basin Information
- Programs, Projects, and Studies
- Reports & Technical Information
- Training & Education
  - Water Commissioner Information
- Transboundary Water Information
- Water Compact Information
- St. Mary Rehabilitation Project

Water Operations
Water Projects
Water Rights Bureau
Drought Management

Water Commissioner Information

DNRC has developed an educational program for water commissioners that provides annual training on commissioner responsibilities and water measurement techniques. This free training is available to **anyone** interested in the accurate measurement and distribution of water in Montana including state and federal water managers, water commissioners, ditch riders and dam tenders, District Court and Water Court personnel.

Training Materials | Decree Status | FAQs

Streamflow and Water Right Data | Forecasting | Active Water Commissioners

District Court Information | Water Commissioner Law | Glossary

Educational Materials

Water Rights and Historical Beneficial Use

- Water Rights and Historical Beneficial Use (PDF)
- Water Rights and Historical Beneficial Use (Video)

Facts About Montana's Water

1. Who Owns the Water in Montana?
2. Who Manages Montana's Water?
3. How Much Water is There and How is it Used?
4. Can Groundwater Meet the Demand for New Water Uses in Montana?
5. What is the History of Water Planning in Montana?
6. How is Water Managed in the Event of Water Shortages?
7. What is Water Rights Adjudication?
8. How Are Instream Flows Protected?
9. What Are Federal Reserved Water Rights?
10. Water Fact Sheets Terminology

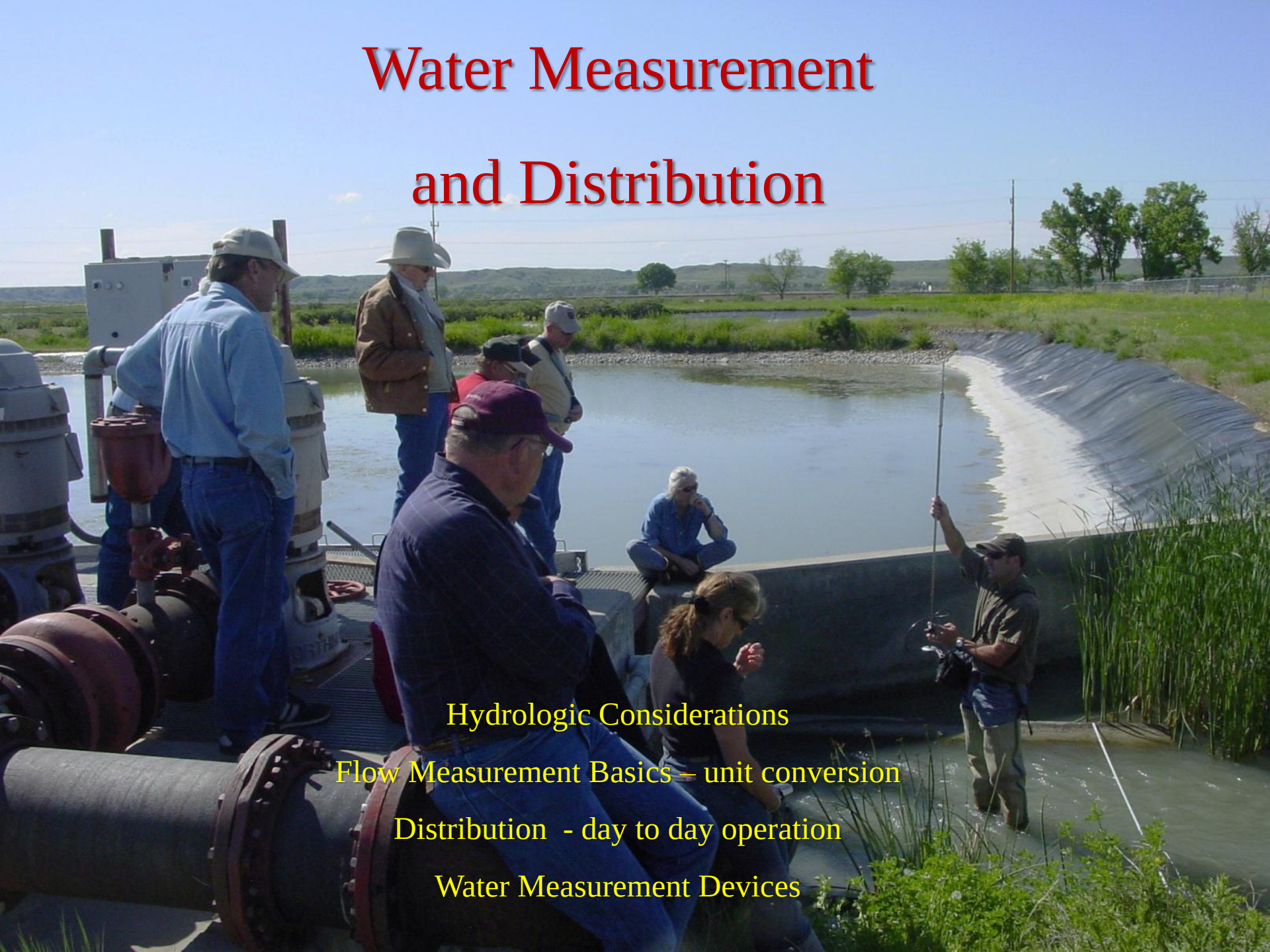
Guide to Montana Water Management

Who Does What with Montana's Water Resources?

Take Precautions

Safety First

Water Measurement and Distribution



Hydrologic Considerations

Flow Measurement Basics – unit conversion

Distribution - day to day operation

Water Measurement Devices

Hydrologic Considerations

- **Seepage gains and losses**
- **Tailwater Runoff and Return Flow**
- **Snowpack and Precipitation**

How do Water Commissioners address seepage gains and losses in source streams?

Tailwater Runoff (wastewater) and Return Flow Considerations

Surface Returns

Groundwater Returns

Basin Snowpack

2019

MONTANA SNOTEL Snow Water Equivalent Update Graph

As of MONDAY: APRIL 15 , 2019

Basin	Snow Water Equivalent Percent of Median
KOOTENAI RIVER BASIN	88%
FLATHEAD RIVER BASIN	91%
UPPER CLARK FORK RIVER BASIN	107%
BITTERROOT RIVER BASIN	115%
LOWER CLARK FORK RIVER BASIN	105%
JEFFERSON RIVER BASIN	110%
MADISON RIVER BASIN	123%
GALLATIN RIVER BASIN	119%
MISSOURI HEADWATERS	116%
HEADWATERS MISSOURI MAINSTEM	117%
SMITH, JUDITH, AND MUSSELSHELL RIVER BASINS	114%
SUN, TETON AND MARIAS RIVER BASINS	98%
MISSOURI MAINSTEM RIVER BASIN	109%
ST MARY AND MILK RIVER BASINS	83%
UPPER YELLOWSTONE RIVER BASIN	118%
WIND RIVER BASIN (WYOMING)	110%
SHOSHONE RIVER BASIN (WYOMING)	110%
BIGHORN RIVER BASIN (WYOMING)	97%
TONGUE RIVER BASIN (WYOMING)	77%
POWDER RIVER BASIN (WYOMING)	86%
LOWER YELLOWSTONE RIVER BASIN	97%

Legend:	<70%	70-90%	91-110%	111-130%	>130%

* = Data are not available or data may not provide a valid measure of conditions for over half of the sites within the basin.

2018

MONTANA SNOTEL Snow Water Equivalent Update Graph

As of THURSDAY: APRIL 12 , 2018

Basin	Snow Water Equivalent Percent of Median
KOOTENAI RIVER BASIN	135%
FLATHEAD RIVER BASIN	148%
UPPER CLARK FORK RIVER BASIN	165%
BITTERROOT RIVER BASIN	157%
LOWER CLARK FORK RIVER BASIN	137%
JEFFERSON RIVER BASIN	137%
MADISON RIVER BASIN	128%
GALLATIN RIVER BASIN	145%
MISSOURI HEADWATERS	136%
HEADWATERS MISSOURI MAINSTEM	164%
SMITH, JUDITH, AND MUSSELSHELL RIVER BASINS	141%
SUN, TETON AND MARIAS RIVER BASINS	164%
MISSOURI MAINSTEM RIVER BASIN	154%
ST MARY AND MILK RIVER BASINS	150%
UPPER YELLOWSTONE RIVER BASIN	168%
WIND RIVER BASIN (WYOMING)	126%
SHOSHONE RIVER BASIN (WYOMING)	161%
BIGHORN RIVER BASIN (WYOMING)	141%
TONGUE RIVER BASIN (WYOMING)	112%
POWDER RIVER BASIN (WYOMING)	116%
LOWER YELLOWSTONE RIVER BASIN	129%

Legend:	<70%	70-90%	91-110%	111-130%	>130%

* = Data are not available or data may not provide a valid measure of conditions for over half of the sites within the basin.

Flow Measurement Basics

- Flow Rate or discharge is the volume of water passing a flow section per unit time

- Standard units of ***cubic feet per second*** (cfs)

Flow Measurement Basics

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- Standard units of ***cubic feet per second*** (cfs)

1 cfs is equivalent to:

40 miner's inches in Montana
448.8 gallons per minute (gpm)
1.98 ac-ft per day

Flow Measurement Basics

- Basic flow equation
  - Flow Rate (discharge) = Area · Velocity
  - $Q = A \cdot V$

$$30\ ft^2 \bullet 3\frac{ft}{\sec} = ?$$

Flow Measurement Basics

- Basic flow equation
  - Flow Rate (discharge) = Area · Velocity
  - Q = A · V

$$30\ ft^2 \bullet 3\frac{ft}{\sec} = ?$$

90 ft^3/sec
or
90 cfs

Flow Measurement Basics

- Volume Units
  - Standard unit of volume is acre-feet (ac-ft)
  - An ac-ft is equivalent to a foot of water on one acre.

1 ac-ft is equivalent to:	325,851 gallons
	43,560 cubic feet

Flow Measurement Basics

Example Problems

WCT Manual: inside cover
or page 55

Based on the Water Court decree, an irrigator has the right to divert 500 inches of water.

1) What is their water right in cubic feet per second (cfs)?

2) Convert their water right to gallons per minute (gpm).

3) How many acre-feet (af) is the irrigator entitled to in 10 days?

4) A different irrigator is entitled to 600 acre-feet over a period of 20 days. Assuming irrigation is non-stop, what is their flow rate in cfs?

1 cfs = 40 m.i.
1 cfs = 448.8 gpm
1 cfs for 24 hrs = 1.983 acre-feet

Based on the Water Court decree, an irrigator has the right to divert 500 inches of water.

1) What is their water right in cubic feet per second (cfs)?

500 in. / 40 in. = **<u>12.5 cfs</u>**

2) Convert their water right to gallons per minute (gpm).

3) How many acre-feet (af) is the irrigator entitled to in 10 days?

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1) What is their water right in cubic feet per second (cfs)?

500 in. / 40 in. = 12.5 cfs

2) Convert their water right to gallons per minute (gpm).

12.5 cfs * 448.8 gpm = **5610 gpm**

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500 in. / 40 in. = 12.5 cfs

2) Convert their water right to gallons per minute (gpm).

12.5 cfs * 448.8 gpm = 5610 gpm

3) How many acre-feet (af) is the irrigator entitled to in 10 days?

12.5 cfs * 1.986 acre-feet/cfs * 10 days = **248 acre feet**

4) A different irrigator is entitled to 600 acre-feet over a period of 20 days. Assuming irrigation is non-stop, what is their flow rate in cfs?

1 cfs = 40 m.i.
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12.5 cfs * 1.986 acre-feet/cfs * 10 days = 248 acre feet

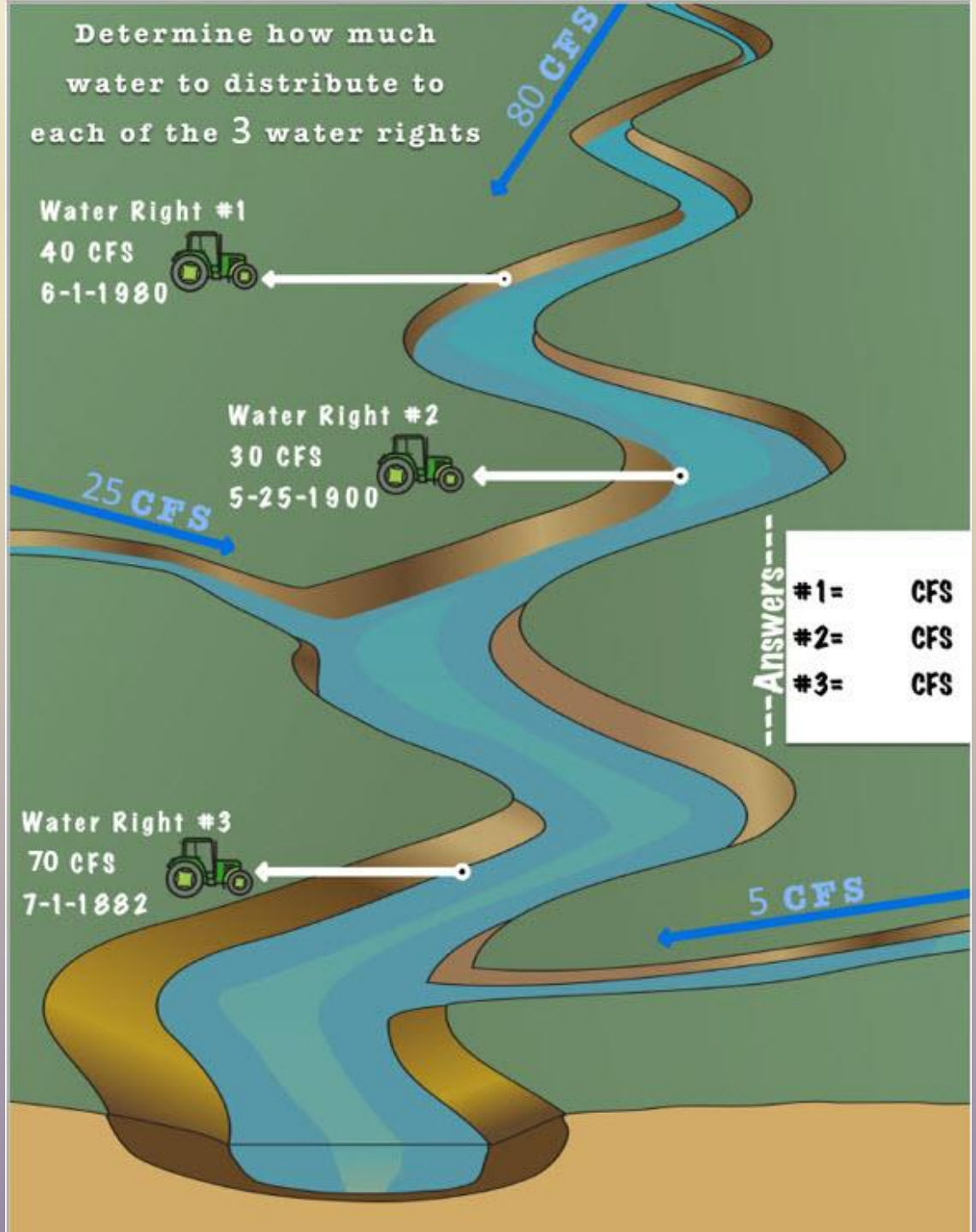
4) A different irrigator is entitled to 600 acre-feet over a period of 20 days. Assuming irrigation is non-stop, what is their flow rate in cfs?

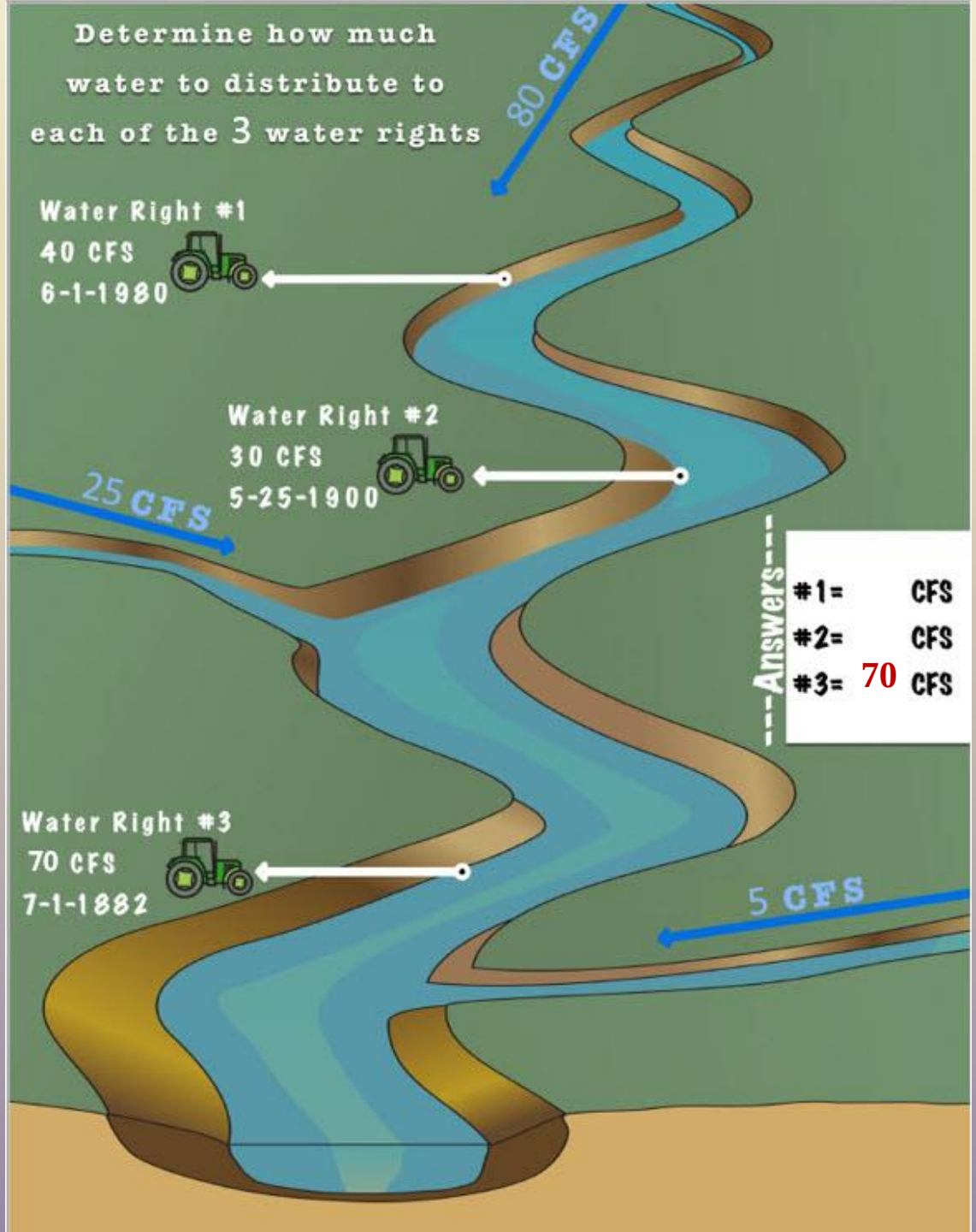
600 ac-ft divided by 20 days = 30 ac-ft/d
30 ac-ft divided by 1.983 ac-ft/cfs = **15.1 cfs**

1 cfs = 40 m.i.
1 cfs = 448.8 gpm
1 cfs for 24 hrs = 1.983 acre-feet

Water Distribution

- Priority and Instream Flow
- Direct Flow vs. Stored Waters


Determine how much water to distribute to each of the 3 water rights
80 CFS
Water Right #1
40 CFS
6-1-1980
Water Right #2
30 CFS
5-25-1900
25 CFS
---Answers---
#1= CFS
#2= CFS
#3= CFS
Water Right #3
70 CFS
7-1-1882
5 CFS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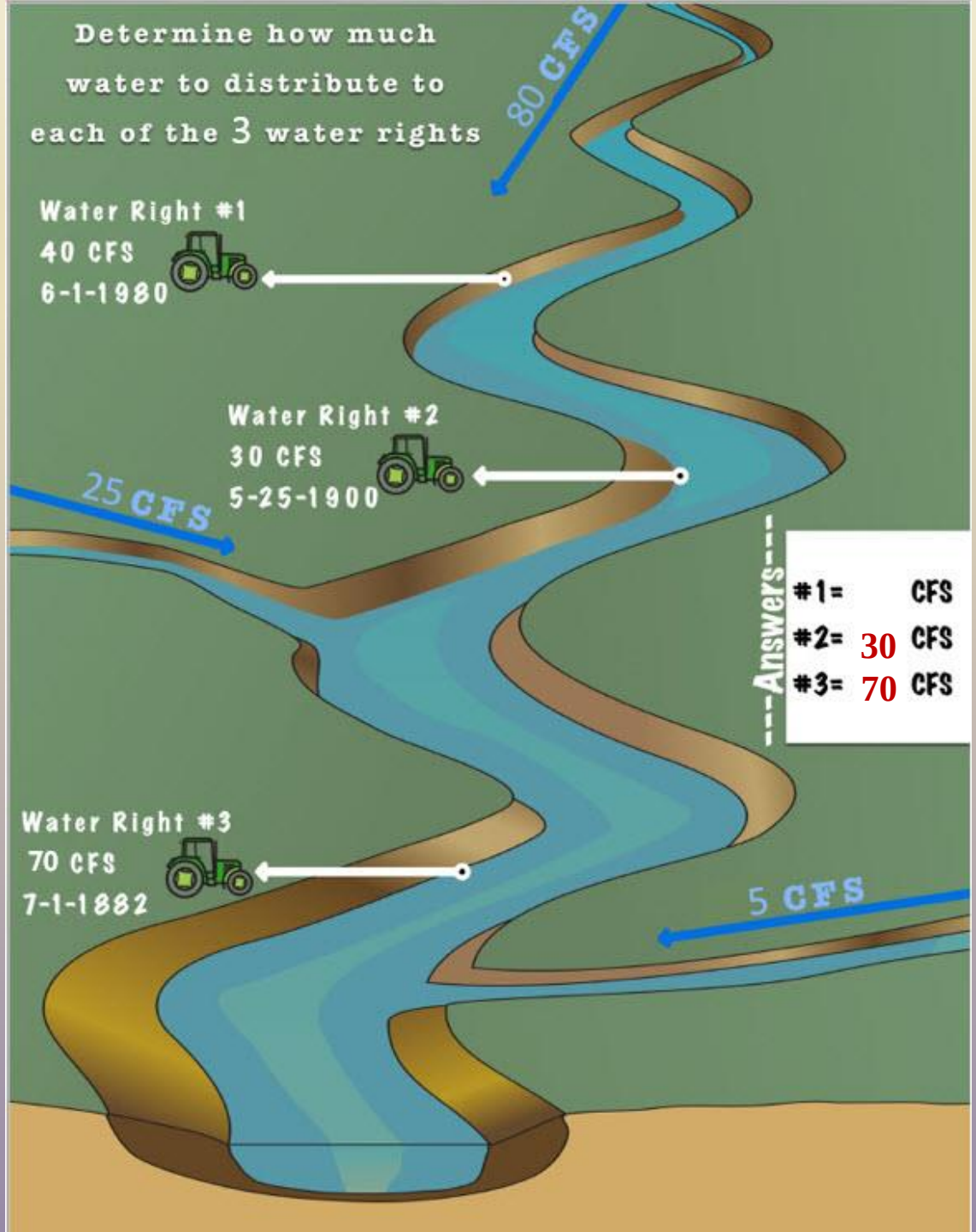
Water Right #1
40 CFS
6-1-1980
Water Right #2
30 CFS
5-25-1900
25 CFS
---Answers---
#1= CFS
#2= CFS
#3= 70 CFS
Water Right #3
70 CFS
7-1-1882
5 CFS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6-1-1980
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30 CFS
5-25-1900
25 CFS
---Answers---
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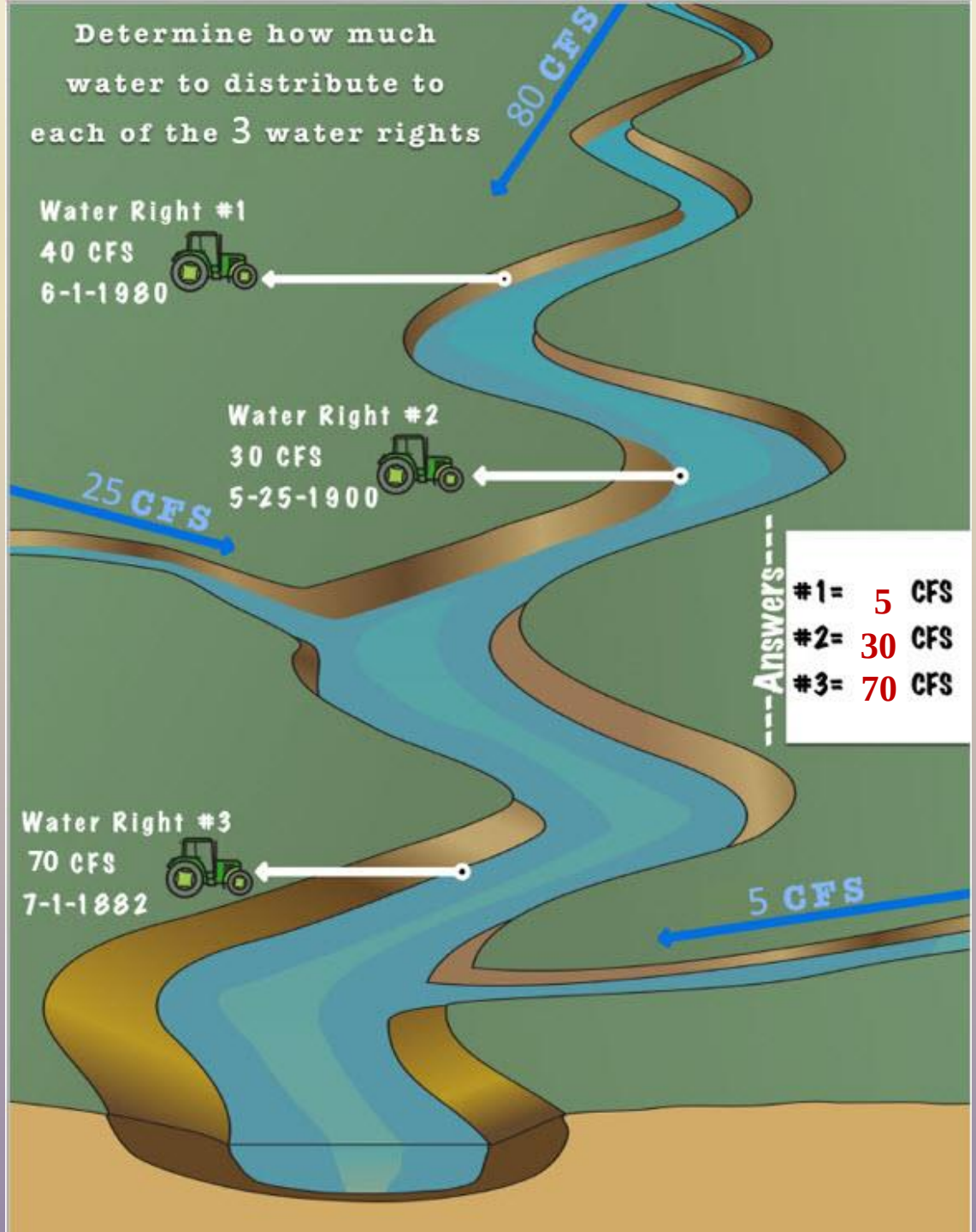
#2= 30 CFS
#3= 70 CFS
Water Right #3
70 CFS
7-1-1882
5 CFS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25 CFS
---Answers---
#1= 5 CFS
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#3= 70 CFS
Water Right #3
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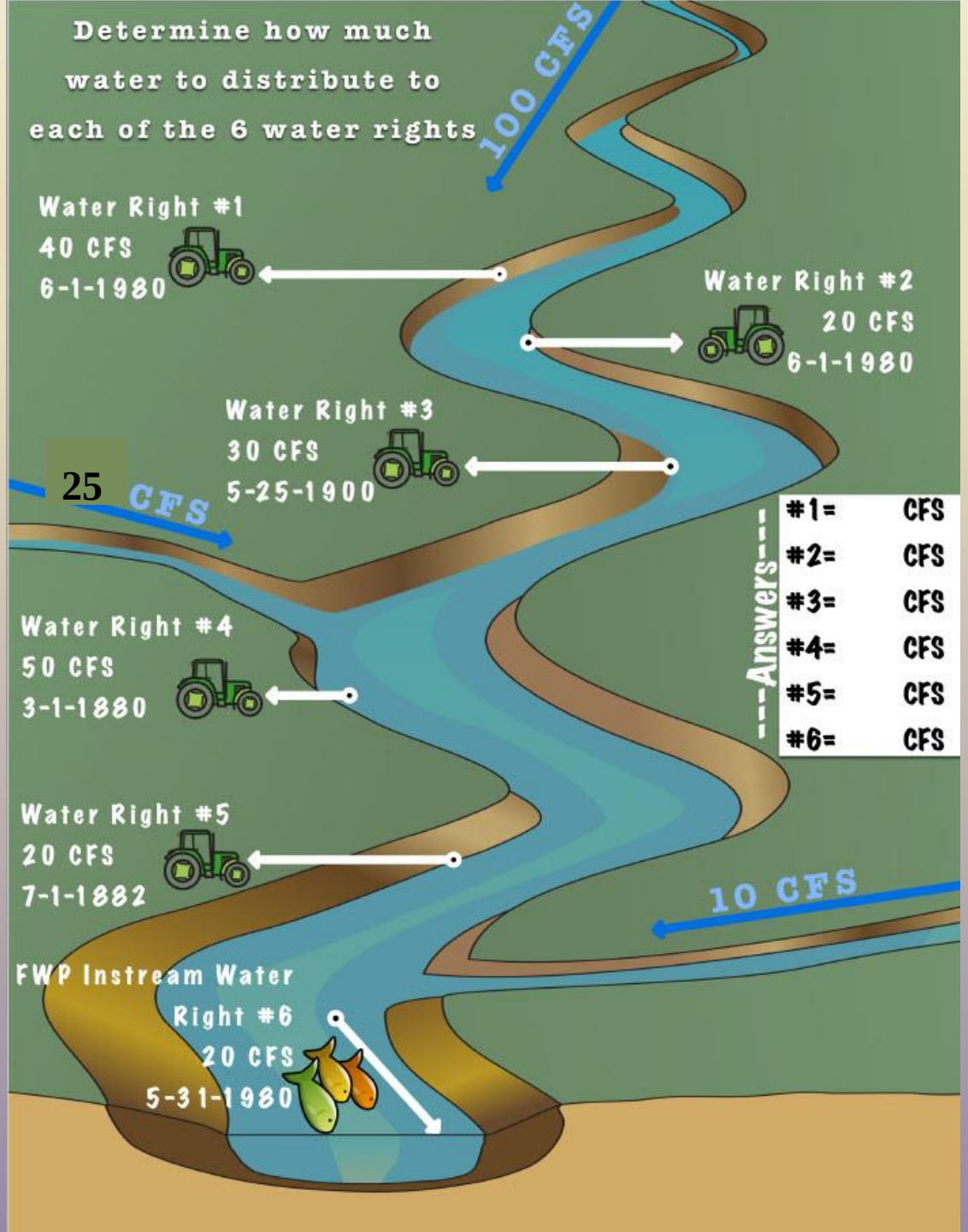
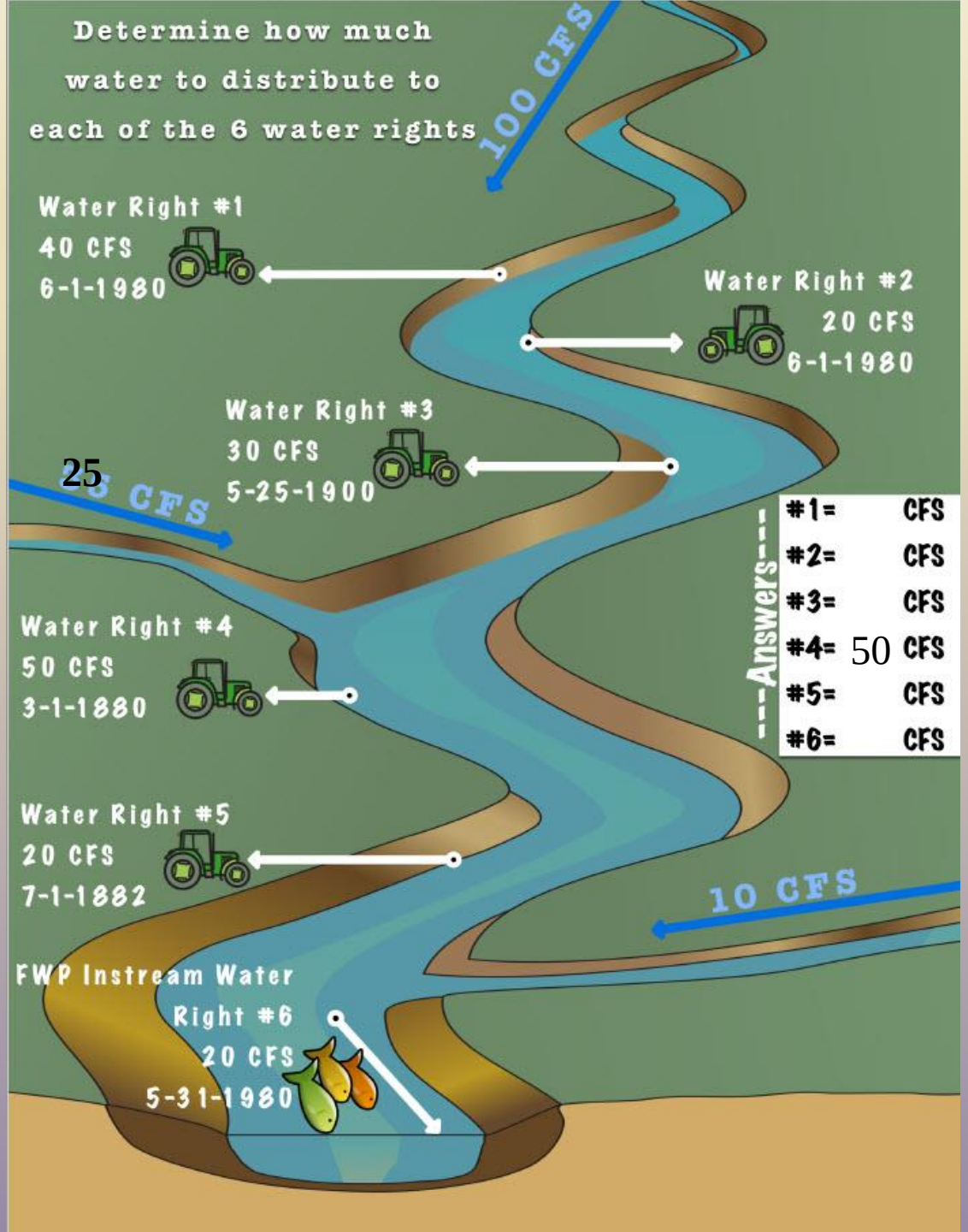

Determine how much water to distribute to each of the 6 water rights
100 CFS
Water Right #1
40 CFS
6-1-1980
Water Right #2
20 CFS
6-1-1980
Water Right #3
30 CFS
5-25-1900
25
CFS
Water Right #4
50 CFS
3-1-1880
Water Right #5
20 CFS
7-1-1882
10 CFS
FWP Instream Water Right #6
20 CFS
5-31-1980
---Answers---
#1= CFS
#2= CFS
#3= CFS
#4= CFS
#5= CFS
#6= CFS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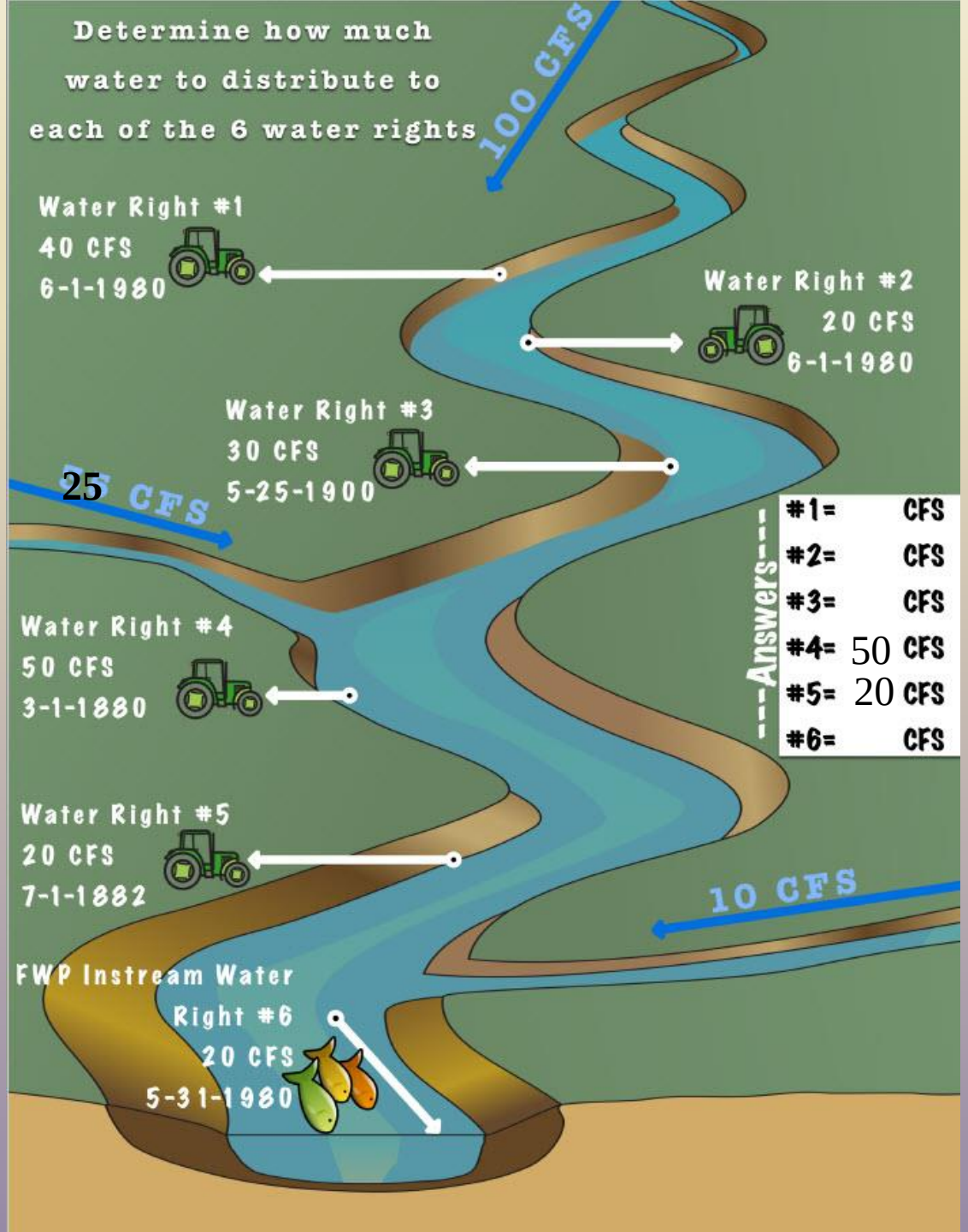
5-25-1900
25
25 CFS
Water Right #4
50 CFS
3-1-1880
Water Right #5
20 CFS
7-1-1882
10 CFS
FWP Instream Water Right #6
20 CFS
5-31-1980
---Answers---
#1= CFS
#2= CFS
#3= CFS
#4= 50 CFS
#5= CFS
#6= CFS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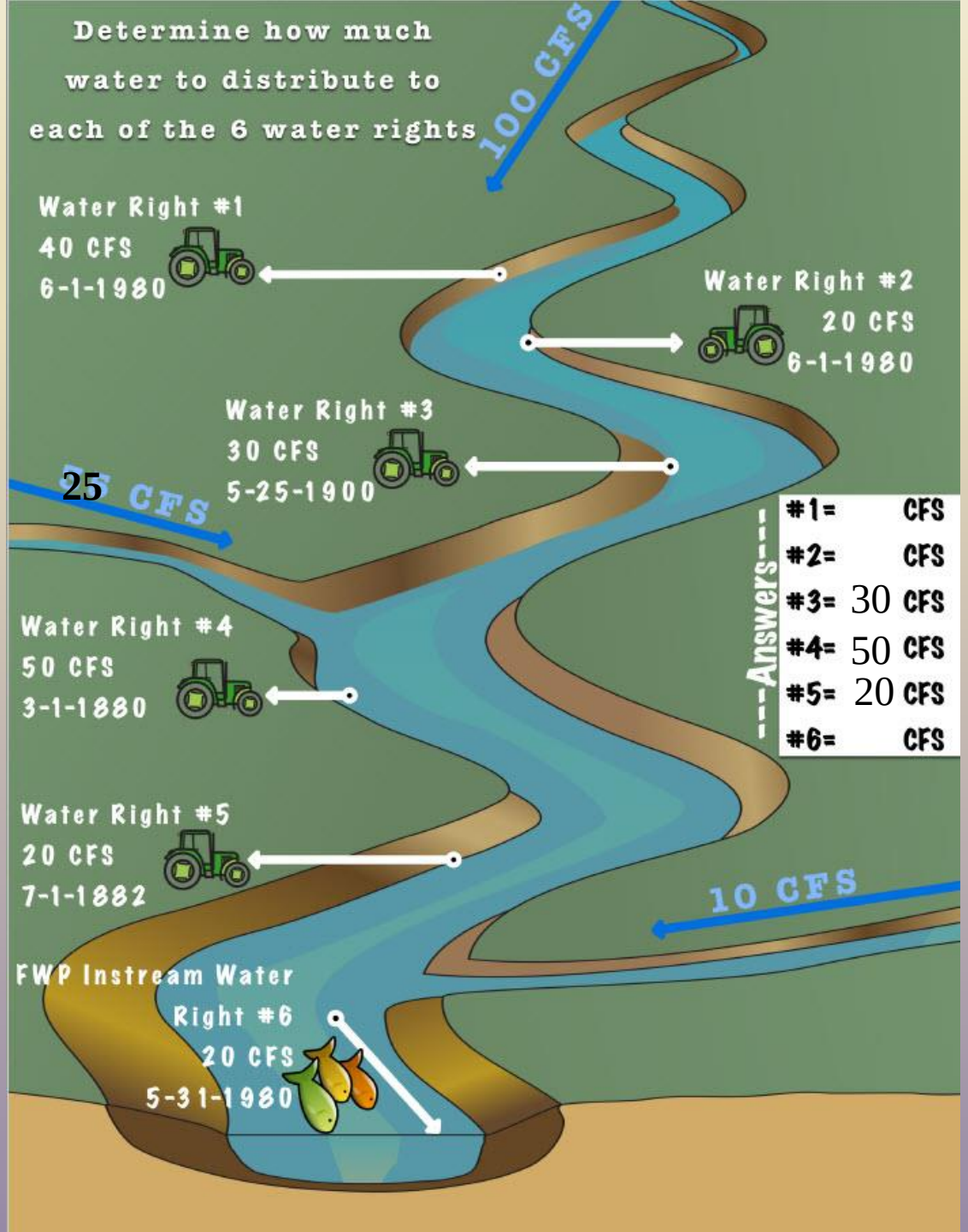
#3= CFS
#4= 50 CFS
#5= 20 CFS
#6= CFS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Water Right #5
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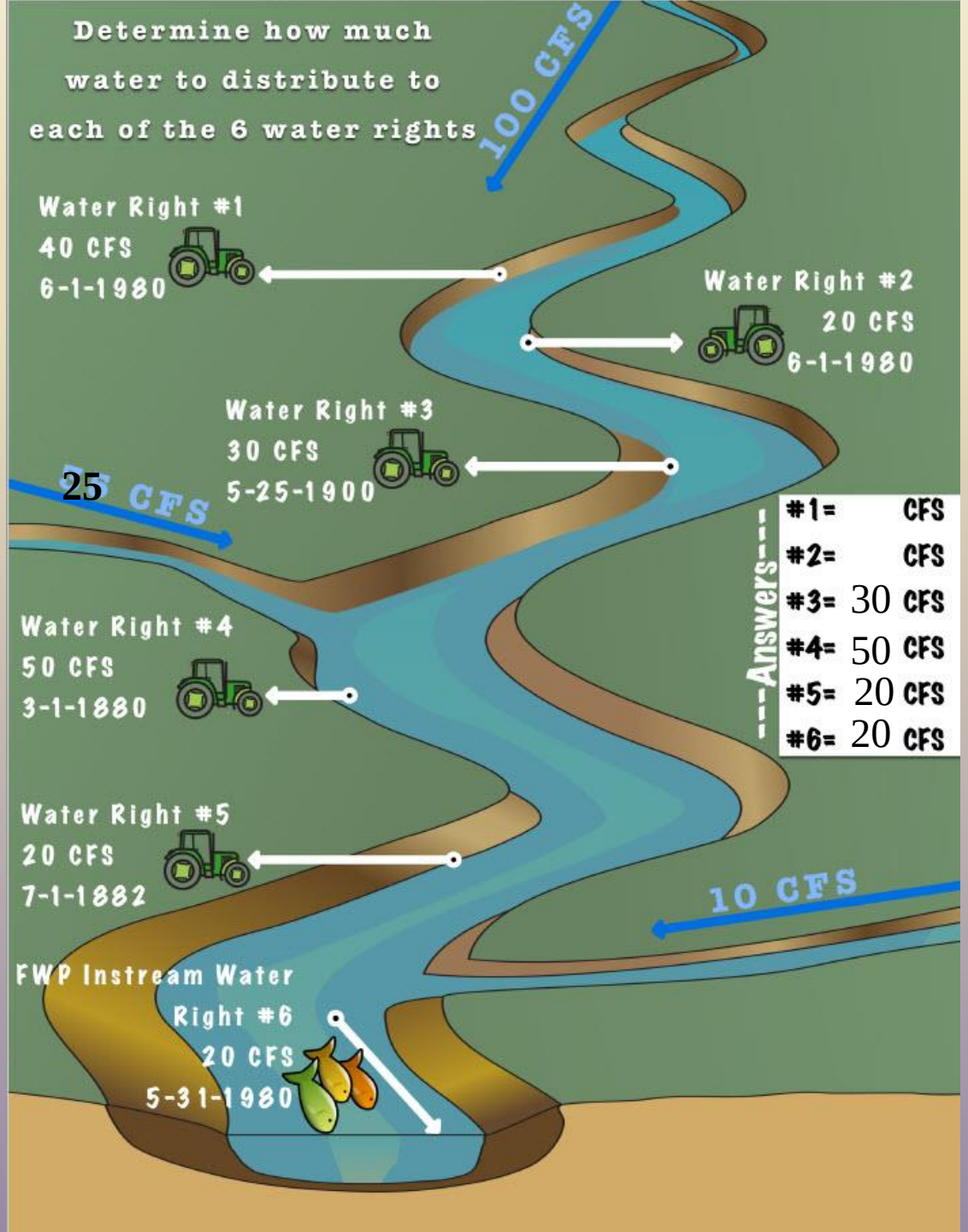
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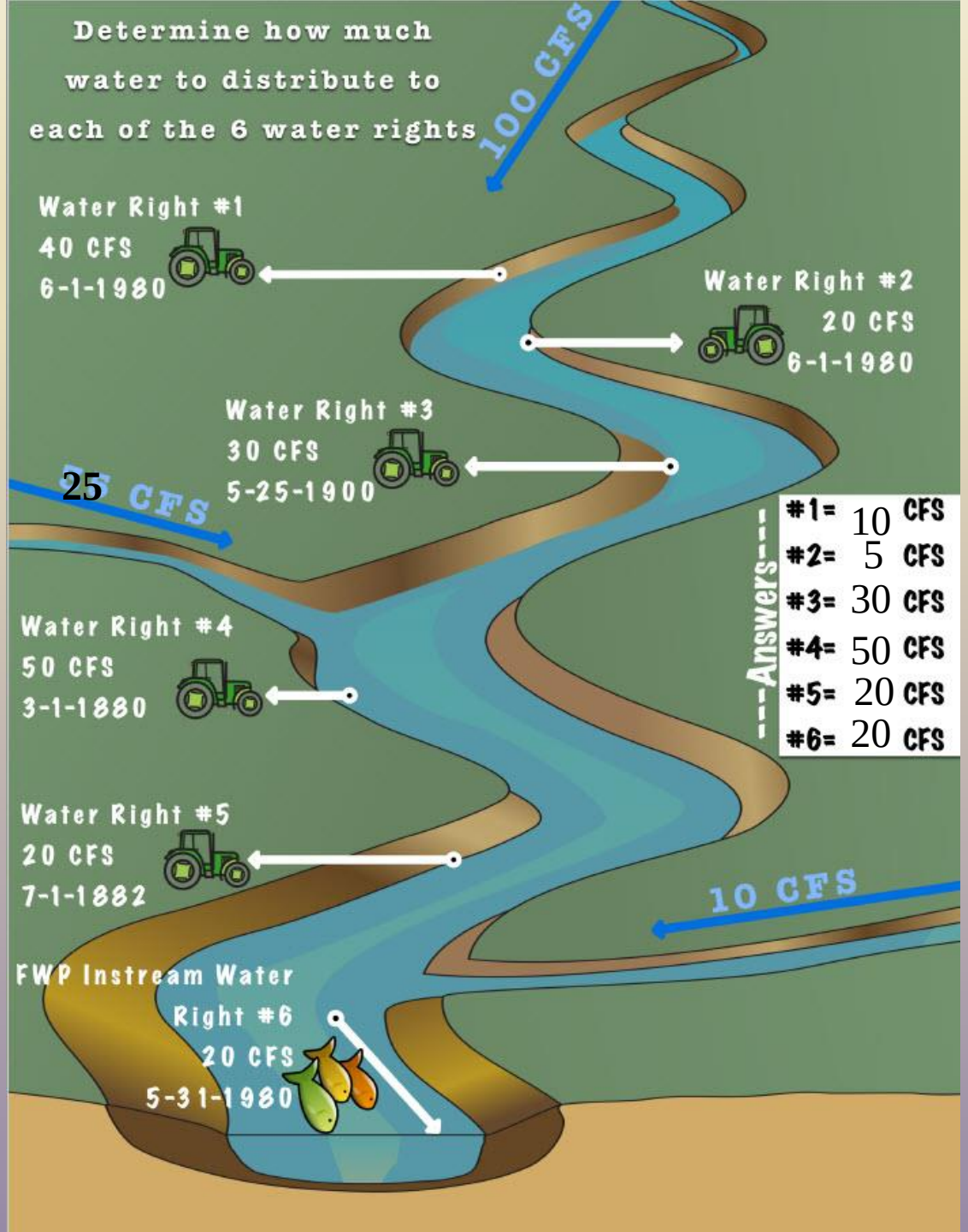
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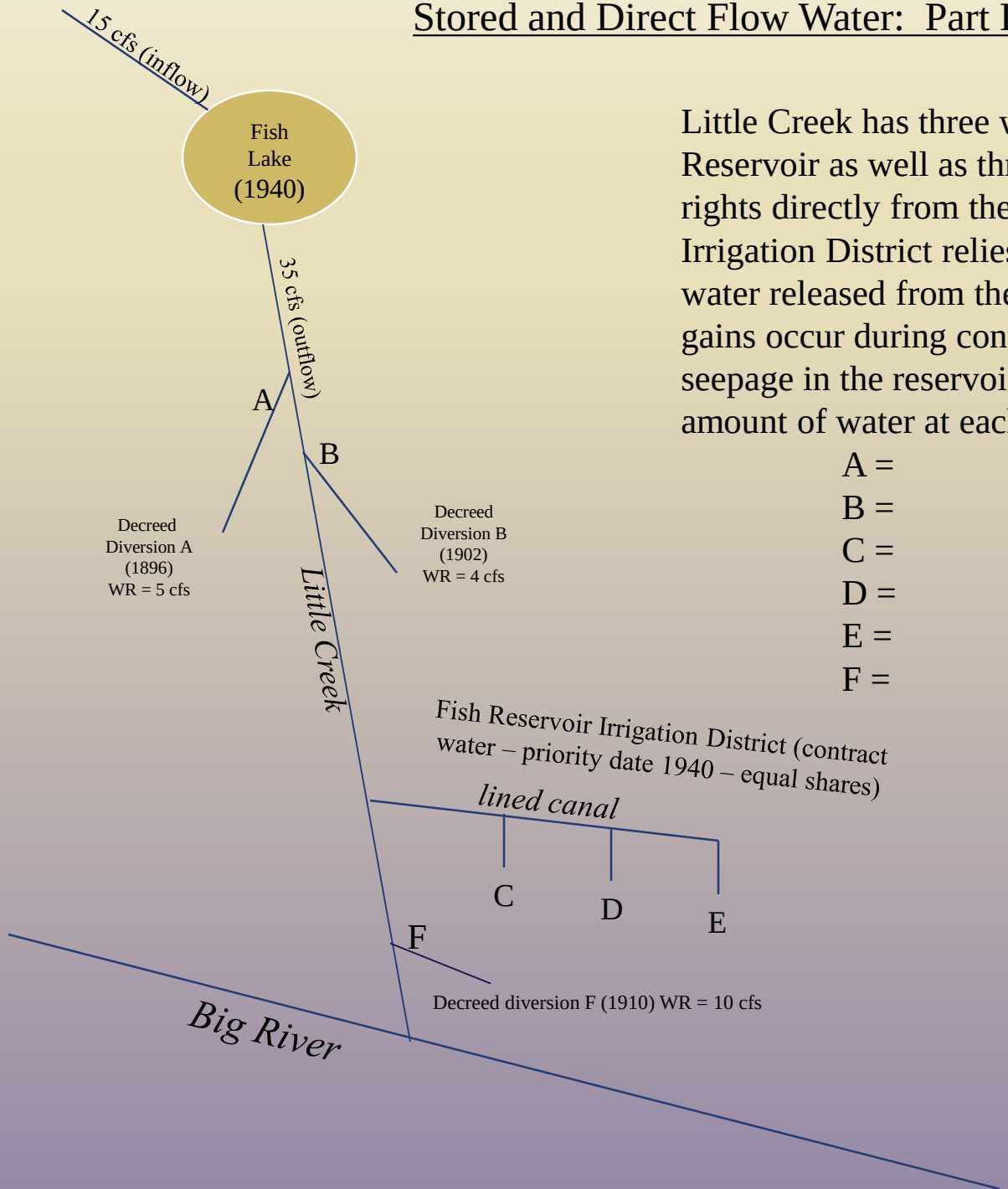
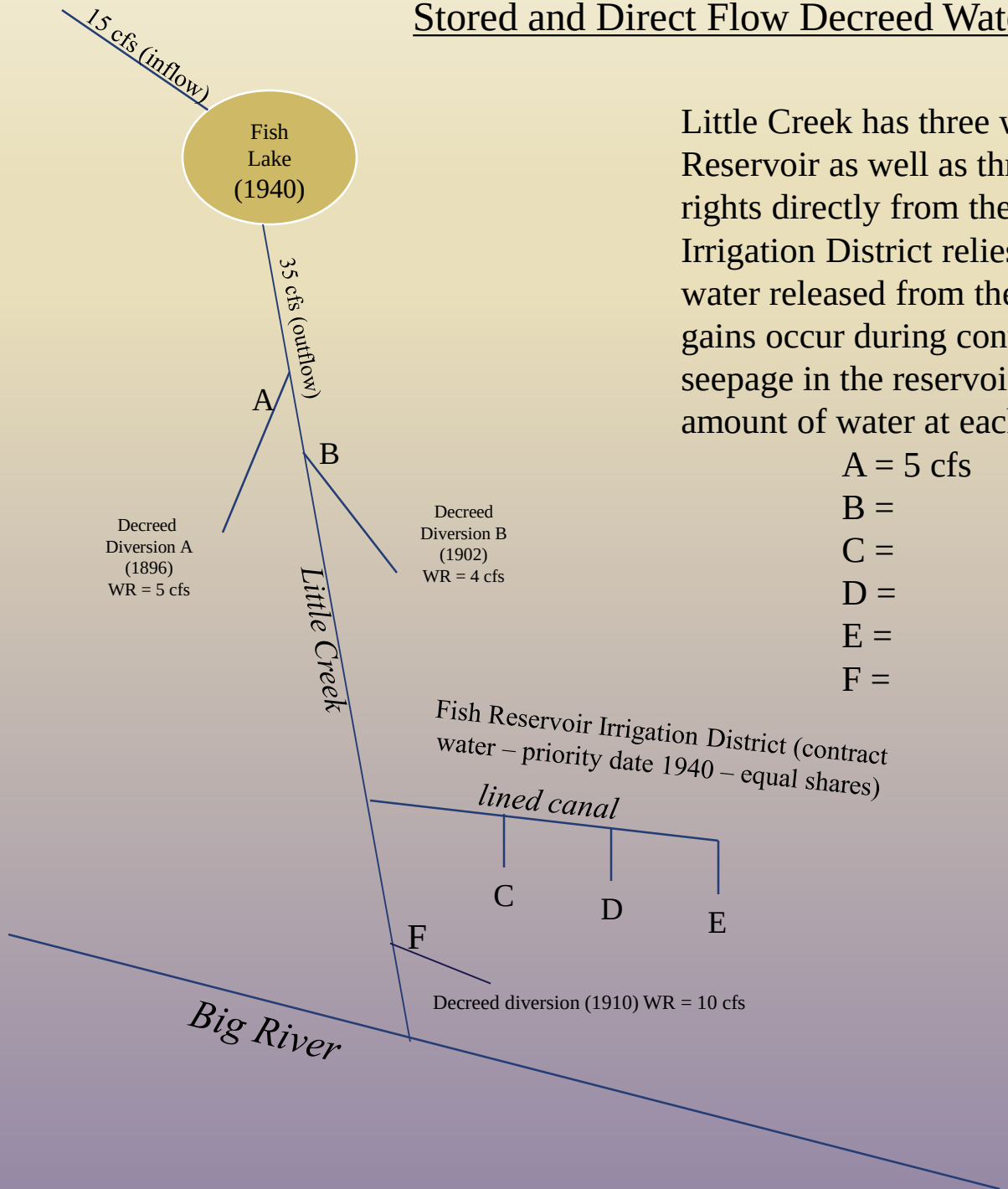
Stored and Direct Flow Water: Part I



Little Creek has three water right contracts from Fish Reservoir as well as three direct flow decreed water rights directly from the stream. The Fish Lake Irrigation District relies solely on the 20 cfs of stored water released from the dam. No seepage losses or gains occur during conveyance. If evaporation and seepage in the reservoir are negligible, determine the amount of water at each location.

A =
B =
C =
D =
E =
F =

Stored and Direct Flow Decreed Water: Part I



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A = 5 cfs
B =
C =
D =
E =
F =

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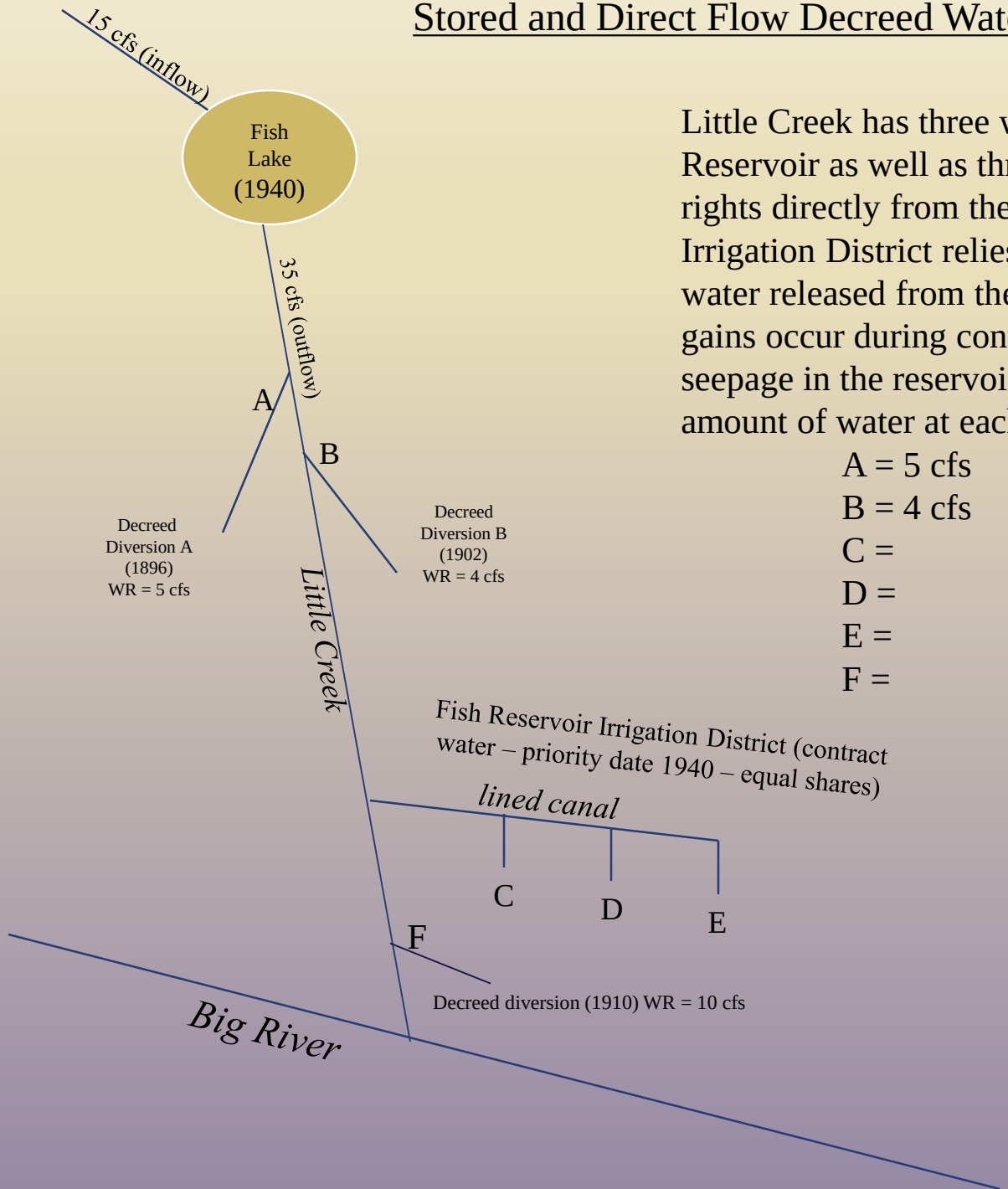

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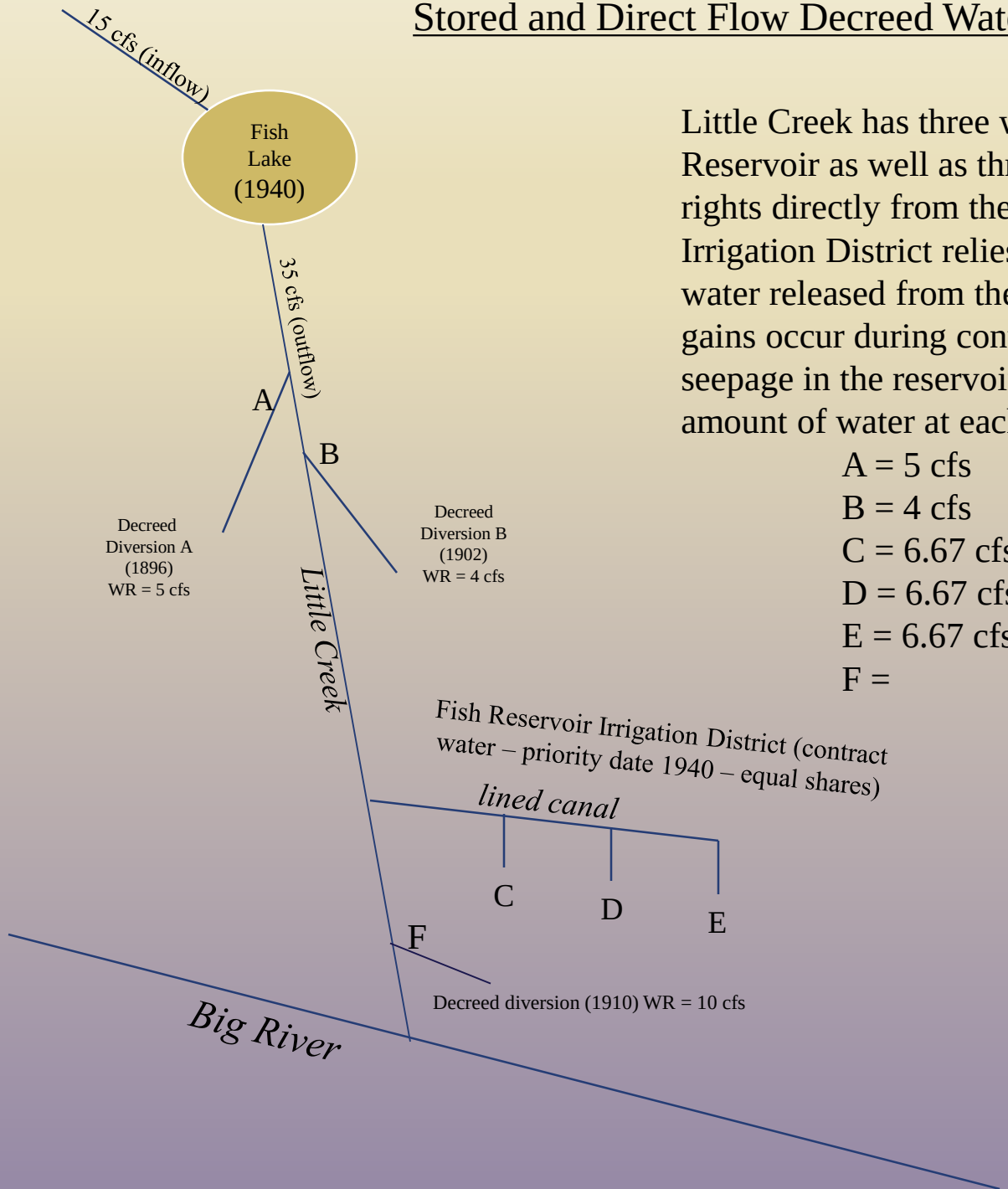
A = 5 cfs
B = 4 cfs
C =
D =
E =
F =

Stored and Direct Flow Decreed Water: Part I



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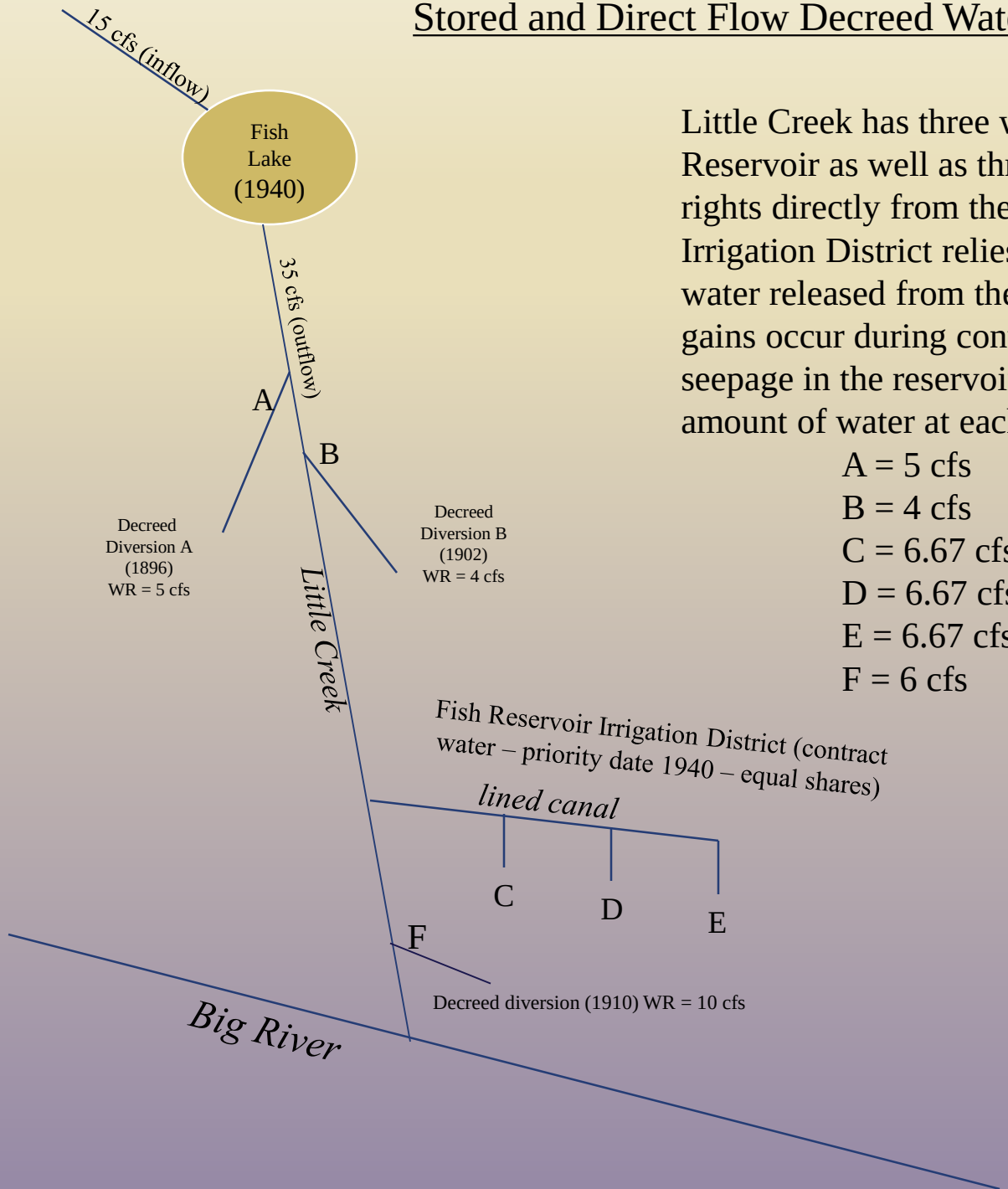
A = 5 cfs
B = 4 cfs
C = 6.67 cfs
D = 6.67 cfs
E = 6.67 cfs
F =

Stored and Direct Flow Decreed Water: Part I



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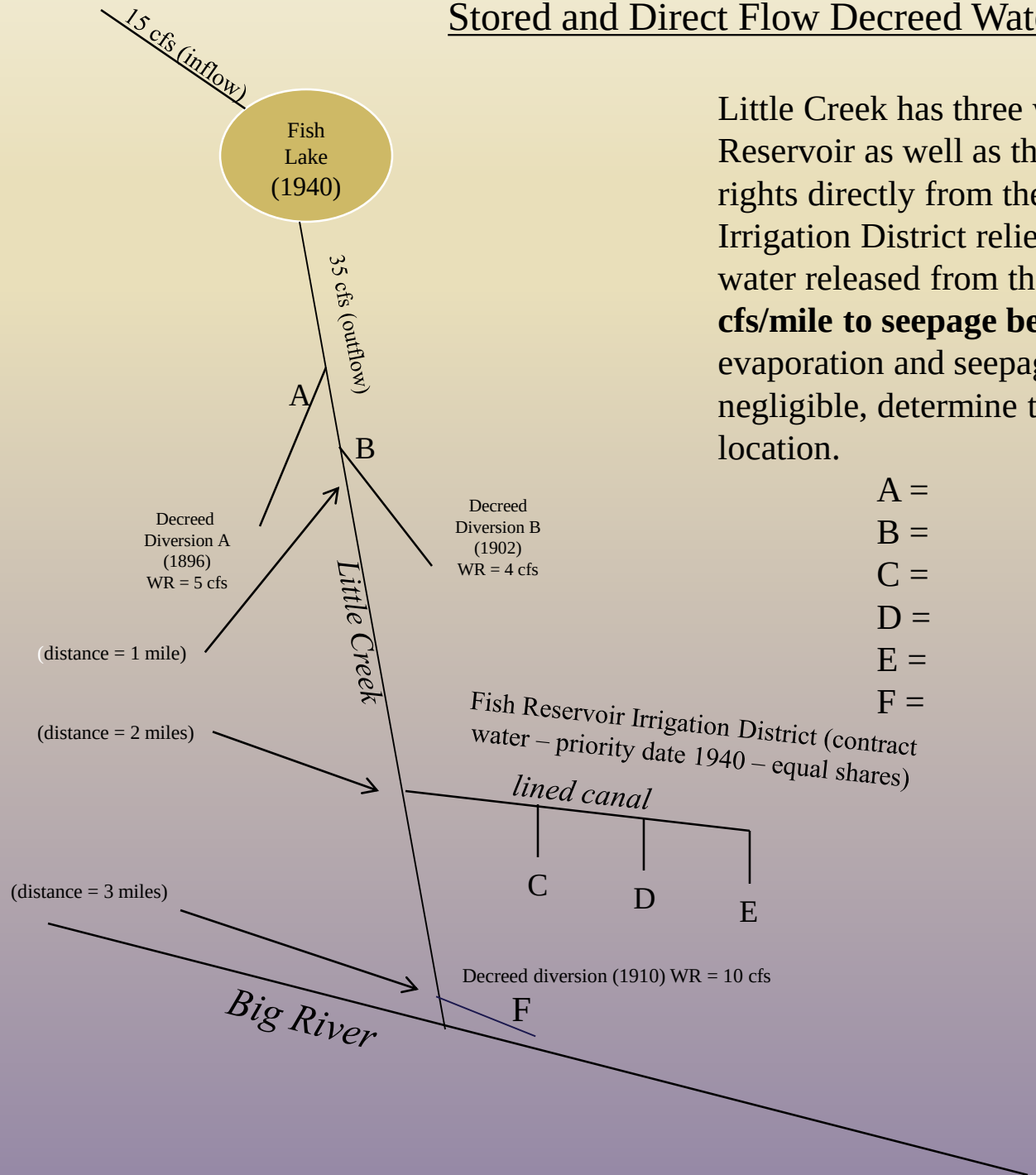
A = 5 cfs
B = 4 cfs
C = 6.67 cfs
D = 6.67 cfs
E = 6.67 cfs
F = 6 cfs

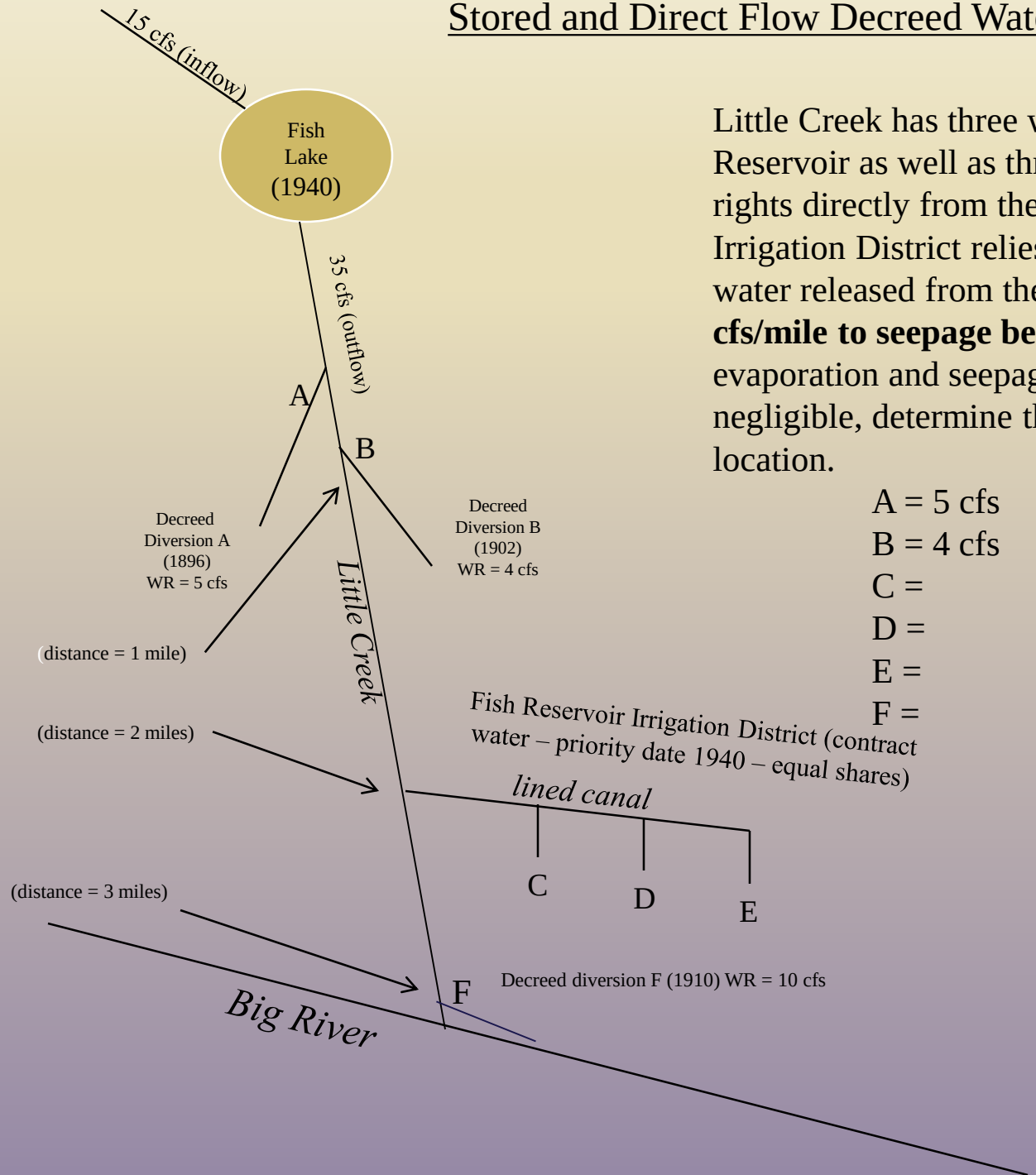
Stored and Direct Flow Decreed Water: Part II



Little Creek has three water right contracts from Fish Reservoir as well as three direct flow decreed water rights directly from the stream. The Fish Lake Irrigation District relies solely on the 20 cfs of stored water released from the dam. **The channel loses 1 cfs/mile to seepage below the reservoir**. If evaporation and seepage in the reservoir are negligible, determine the amount of water at each location.

A =
B =
C =
D =
E =
F =

Stored and Direct Flow Decreed Water: Part II



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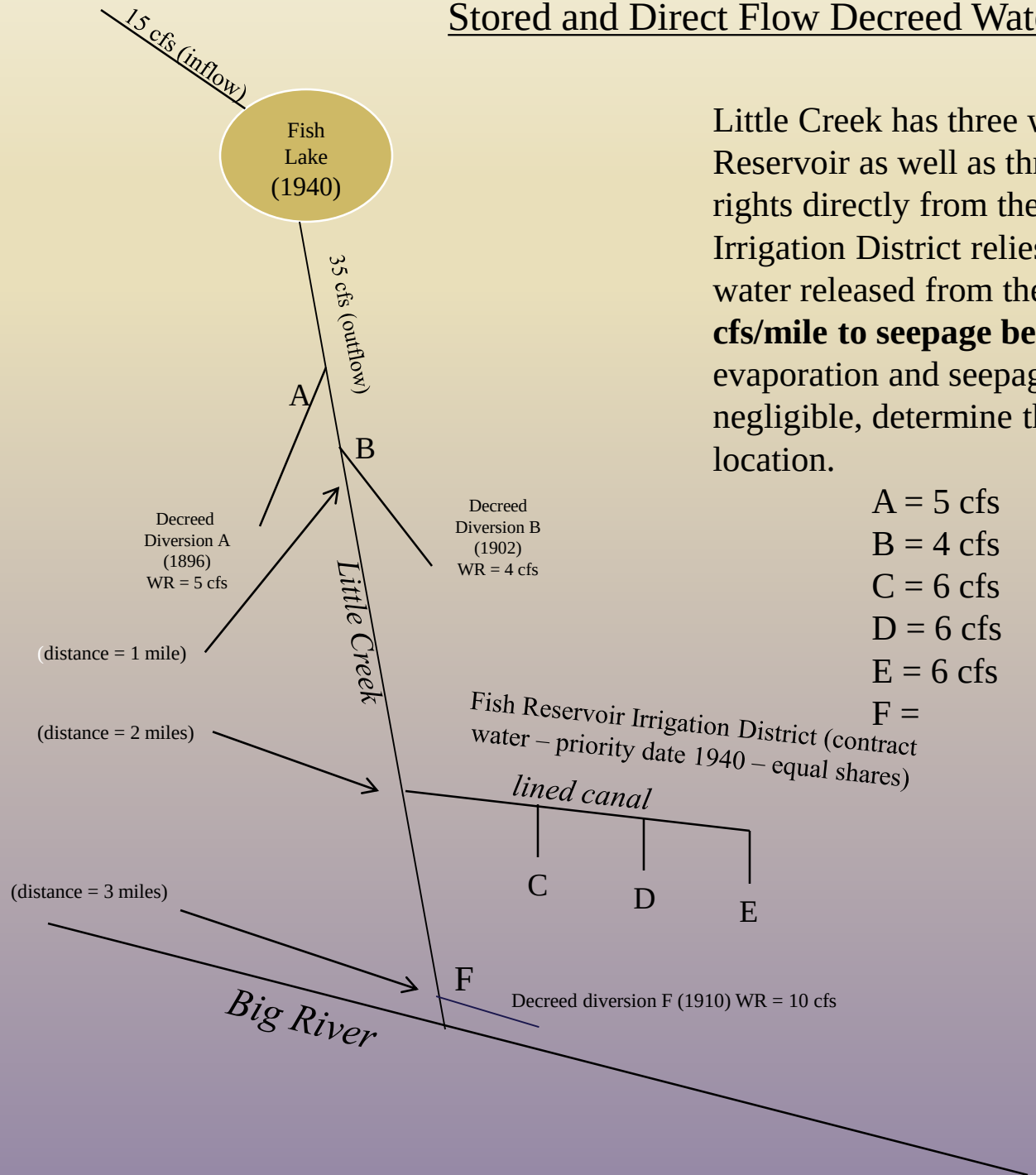
A = 5 cfs
B = 4 cfs
C =
D =
E =
F =

Stored and Direct Flow Decreed Water: Part II



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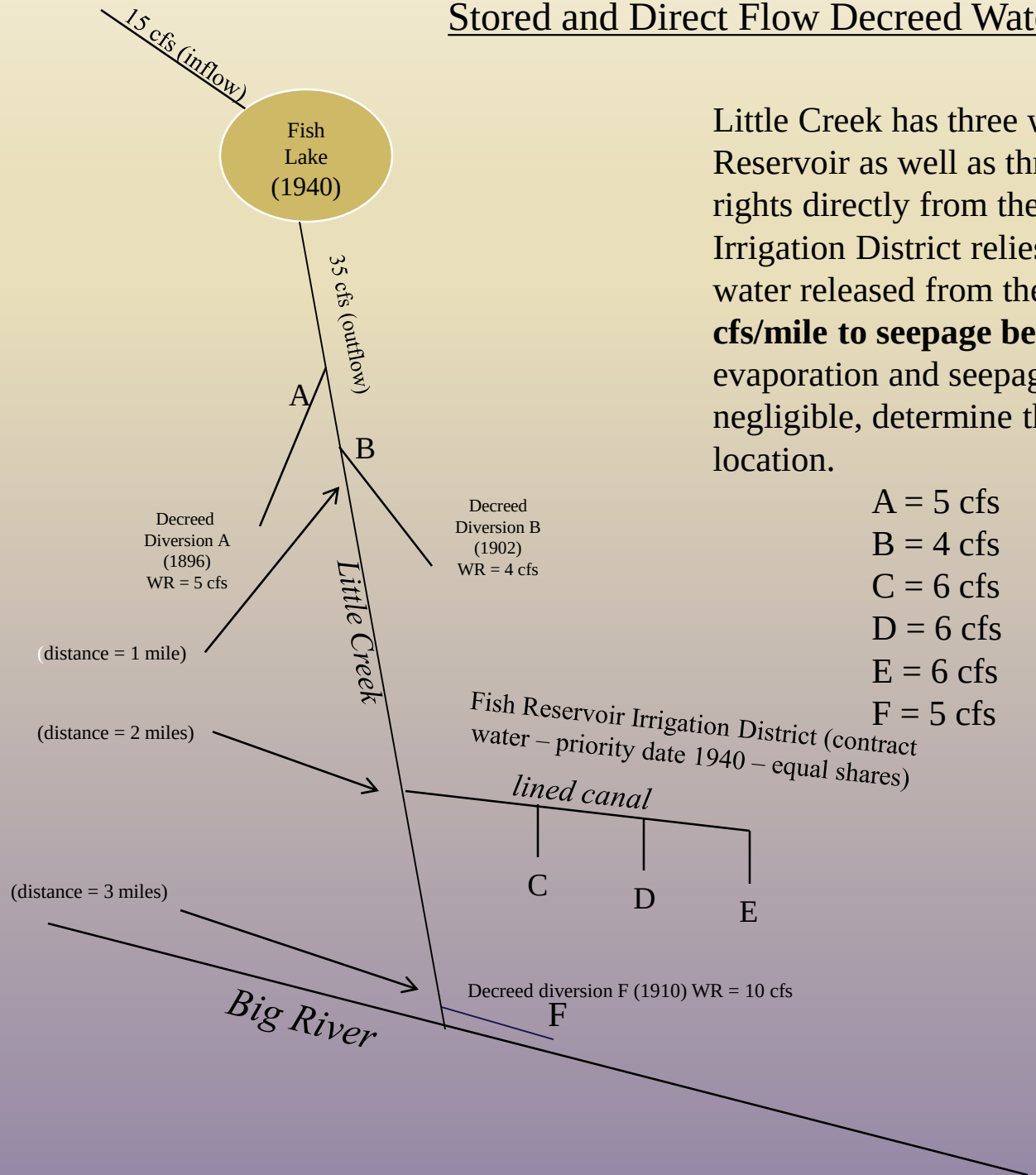
B = 4 cfs
C = 6 cfs
D = 6 cfs
E = 6 cfs
F =

Stored and Direct Flow Decreed Water: Part II



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A = 5 cfs
B = 4 cfs
C = 6 cfs
D = 6 cfs
E = 6 cfs
F = 5 cfs

A small reservoir has 25,000 acre-feet of water in storage on July 1. For the sake of this problem, assume no seepage or evaporation occurs. Between July 1 and August 31, average reservoir inflows equal 15 cfs. Irrigators require 3200 inches, 24 hours a day, from the reservoir. Lakeside residents constantly pump 2750 gpm from the reservoir for domestic water supply and water must be released from the dam at a rate of 7.5 cfs to satisfy FWP's in-stream flow lease for west-slope cutthroat. **How many acre-feet of water are left in the reservoir on September 1?**

A small reservoir has 25,000 acre-feet of water in storage on July 1. For the sake of this problem, assume no seepage or evaporation occurs. Between July 1 and August 31, average reservoir inflows equal 15 cfs. Irrigators require 3200 inches, 24 hours a day, from the reservoir. Lakeside residents constantly pump 2750 gpm from the reservoir for domestic water supply and water must be released from the dam at a rate of 7.5 cfs to satisfy FWP's in-stream flow lease for west-slope cutthroat. **How many acre-feet of water are left in the reservoir on September 1?**

September 1 storage = (July storage + Inflows) – (Outflows)

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September 1 storage = (July 1 storage + Inflows) – (Outflows)

Inflows: 15 cfs * 1.983 acre-feet/day/cfs * 62 days = **1844 acre-feet**

Outflows: Irrigators = 3200 in/40 in = 80 cfs * 1.983 af/d/cfs = 158.6 af/d * 62 days = **9836 acre-feet**

Residents = 2750 gpm/448.8 gpm/cfs = 6.13 cfs*1.983 af/d/cfs = 12.2 af/d * 62 days = **753 acre-feet**

West-Slope Cutthroat = 7.5 cfs * 1.983 af/d/cfs * 62 d = **922 acre-feet**

September 1 storage = (July storage + Inflows) – (Outflows)

(25,000 af + 1844 af) – (9836 af + 753 af + 922 af)

= 15,333 acre-feet

Flow Measurement Basics

Open Channel Flow

Closed Conduit Flow

Water Measurement

- headgates
- flow measurement basics
- rated devices
- flumes and weirs
- automated devices
- manual measurements

- sample problems

MCA 85-5-302

....All persons using water from any stream or ditch whereon a water commissioner is appointed are required to have <u>suitable</u> headgates at the point where the ditch taps a stream and shall also, at some <u>suitable</u> place on the ditch and as near the headgate as practicable, place and maintain a <u>proper</u> measuring box, weir, or other appliance for the measurement of the waters flowing in the ditch.

What is a suitable headgate?

“Suitable” Headgate

per ARM 36.13.101(9)

- Can be closed completely
- Adequately vary amount diverted

And, not in ARM

- Can be operated by one person

Suitable headgate?

Solution: Replace

Suitable Headgate??

MAR 30 2004

Rock Headgate – not properly functioning, hard on the back

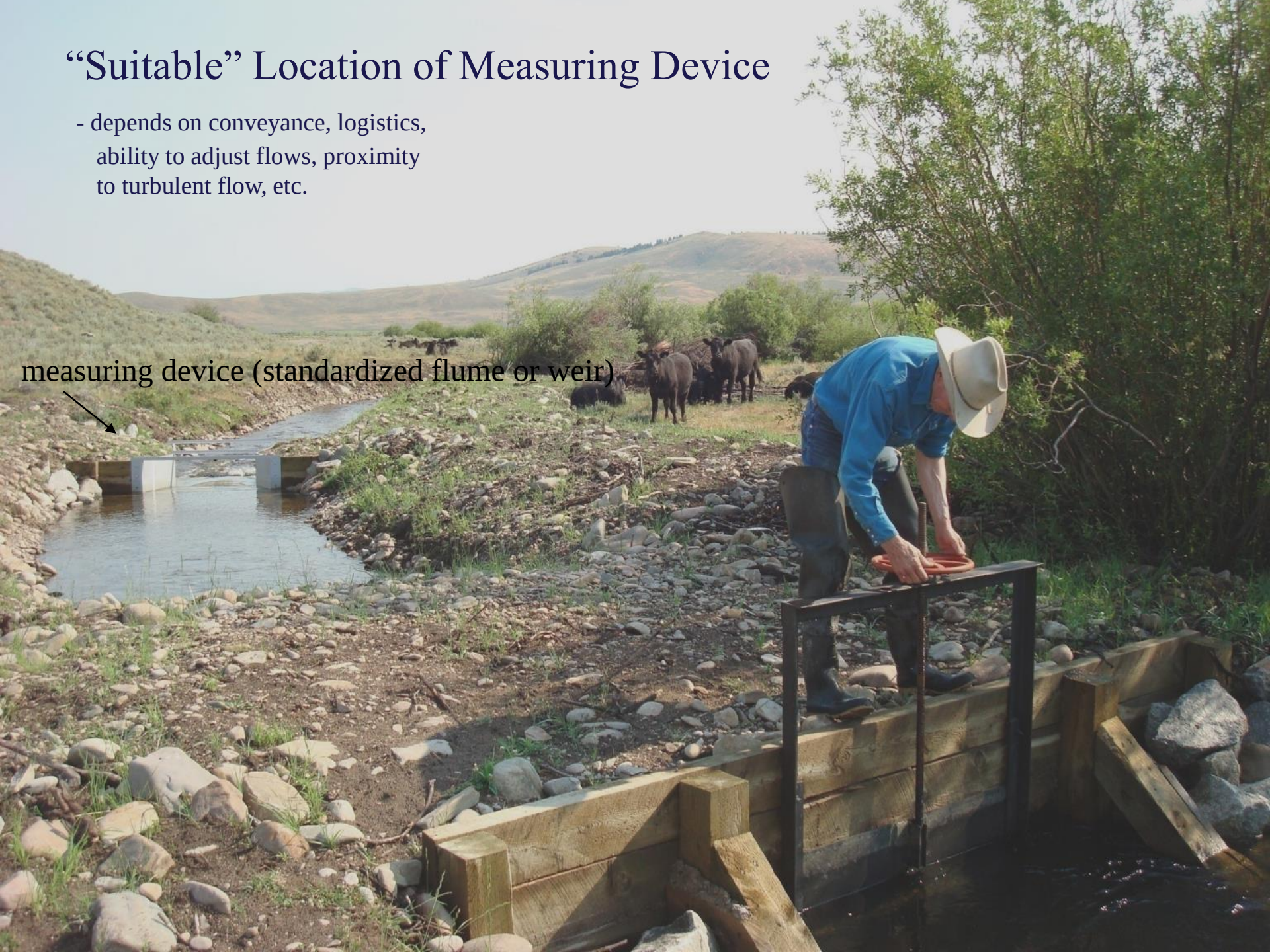
functional

not so functional

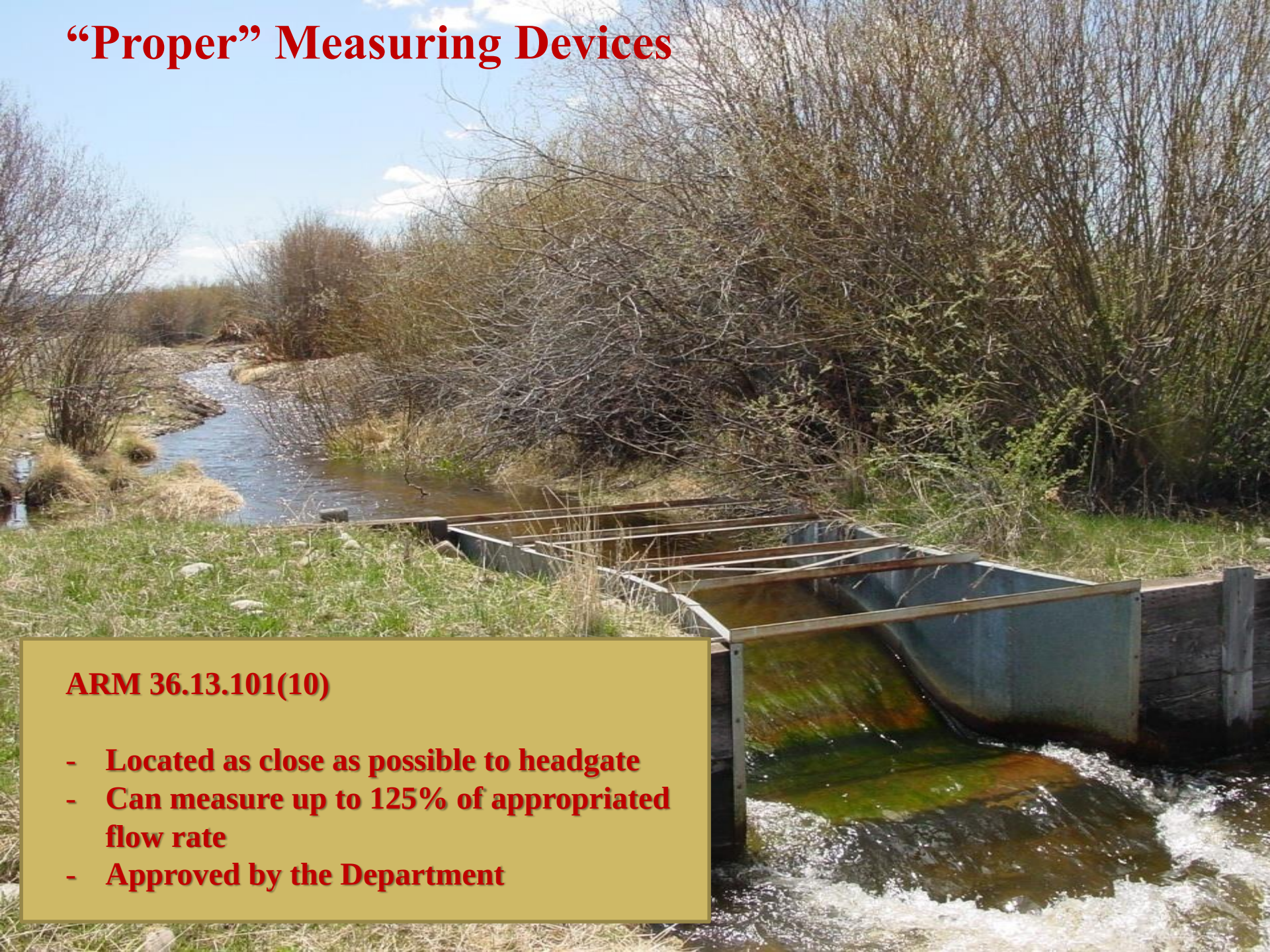
Diversion Dams

“Suitable” Location of Measuring Device

- depends on conveyance, logistics, ability to adjust flows, proximity to turbulent flow, etc.



“Proper” Measuring Devices



ARM 36.13.101(10)

- Located as close as possible to headgate
- Can measure up to 125% of appropriated flow rate
- Approved by the Department

pin and plank diversion dam
Waterman screwgate
Parshall flume measuring device
fish ladder

measuring device
MAR 30 2004

Water Measurement Devices

- Rated and standard devices - staff gages, flumes, weirs, orifices, weir sticks

- Automated devices - gaging station, propeller meters, in-line meters, ultra-sonic meters, totalizers

- Manual measurement - current meters, estimation tech-niques (float-area method)

Open Channel Rated Devices

Staff Gages

Flumes

Weirs

Weir Sticks

The presence of a flume, weir, staff gage, or other measuring device does not ensure proper functioning or accuracy of measurement
5 29 '03

definitions

Stage - height of water surface above an established datum
ex. staff gage reading

Discharge - volume of flow passing a point usually expressed
(flow rate) in cubic feet per second (cfs) or inches.

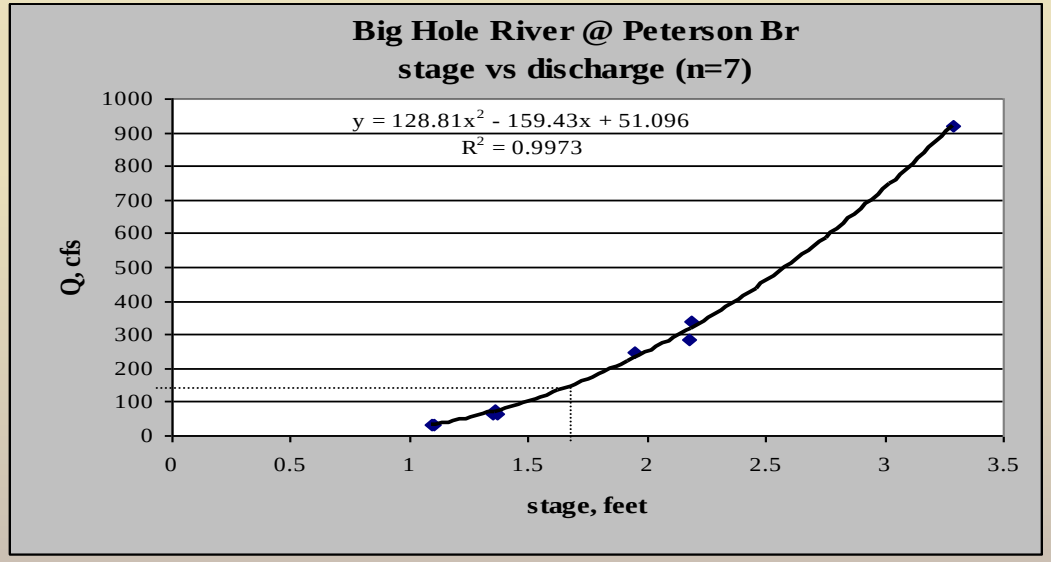
Rating – relationship between the stage of the stream/canal and
the discharge.

Staff Gages

Stage = 1.16 feet

Stage = 0.67 feet

wire weight gage



stage	discharge	stage	discharge	stage	discharge
1.5	102	1.56	116	1.62	131
1.51	104	1.57	118	1.63	133
1.52	106	1.58	121	1.64	136
1.53	109	1.59	123	1.65	139
1.54	111	1.6	126	1.66	141
1.55	113	1.61	128	1.67	144

staff gage rating

Table A8-12. Free-flow discharges in ft^3/sec through 1- to 8-foot Parshall flumes. Discharges for 2- to 8-ft flumes computed from the formula $Q = 4.00Wh_a^{1.522(W^{0.026})}$. Discharges for 1-ft flume computed from the formula $Q = 3.95h_a^{1.55}$.

Upper Head h_a, ft	Discharge for flumes of various throat widths, W 1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
0.20	0.33	0.66	0.96	1.26	-----	-----	-----	-----
.21	.35	.71	1.04	1.36	-----	-----	-----	-----
.22	.38	.77	1.12	1.47	-----	-----	-----	-----
.23	.40	.82	1.20	1.57	-----	-----	-----	-----
.24	.43	.88	1.28	1.68	-----	-----	-----	-----
.25	.46	.93	1.37	1.80	2.22	2.63	-----	-----
.26	.49	.99	1.46	1.91	2.36	2.80	-----	-----
.27	.52	1.05	1.54	2.03	2.50	2.97	-----	-----
.28	.55	1.11	1.63	2.15	2.65	3.15	-----	-----
.29	.58	1.17	1.73	2.27	2.80	3.33	-----	-----
.30	.61	1.24	1.82	2.39	2.96	3.52	4.07	4.63
.31	.64	1.30	1.92	2.52	3.12	3.71	4.29	4.88
.32	.68	1.37	2.01	2.65	3.28	3.90	4.52	5.13
.33	.71	1.44	2.11	2.78	3.44	4.10	4.75	5.39
.34	.74	1.50	2.22	2.92	3.61	4.30	4.98	5.66
.35	.78	1.57	2.32	3.05	3.78	4.50	5.21	5.92
.36	.81	1.64	2.42	3.19	3.95	4.71	5.46	6.20
.37	.85	1.71	2.53	3.33	4.13	4.92	5.70	6.48
.38	.88	1.79	2.64	3.48	4.31	5.13	5.95	6.76
.39	.92	1.86	2.75	3.62	4.49	5.35	6.20	7.05
.40	.95	1.93	2.86	3.77	4.67	5.57	6.46	7.34
.41	.99	2.01	2.97	3.92	4.86	5.79	6.72	7.64
.42	1.03	2.09	3.08	4.07	5.05	6.02	6.98	7.94
.43	1.07	2.16	3.20	4.22	5.24	6.25	7.25	8.25
.44	1.11	2.24	3.32	4.38	5.43	6.48	7.52	8.56
.45	1.15	2.32	3.44	4.54	5.63	6.72	7.80	8.87
.46	1.19	2.40	3.56	4.70	5.83	6.96	8.08	9.19
.47	1.23	2.48	3.68	4.86	6.03	7.20	8.36	9.51
.48	1.27	2.57	3.80	5.03	6.24	7.45	8.65	9.84
.49	1.31	2.65	3.93	5.19	6.45	7.69	8.94	10.2
.50	1.35	2.73	4.05	5.36	6.66	7.95	9.23	10.5
.51	1.39	2.82	4.18	5.53	6.87	8.20	9.53	10.8
.52	1.43	2.90	4.31	5.70	7.08	8.46	9.83	11.2
.53	1.48	2.99	4.44	5.88	7.30	8.72	10.1	11.5
.54	1.52	3.08	4.57	6.05	7.52	8.98	10.4	11.9
.55	1.56	3.17	4.71	6.23	7.74	9.25	10.8	12.2
.56	1.61	3.26	4.84	6.41	7.97	9.52	11.1	12.6
.57	1.65	3.35	4.98	6.59	8.20	9.79	11.4	13.0
.58	1.70	3.44	5.11	6.77	8.43	10.1	11.7	13.3
.59	1.74	3.53	5.25	6.96	8.66	10.3	12.0	13.7

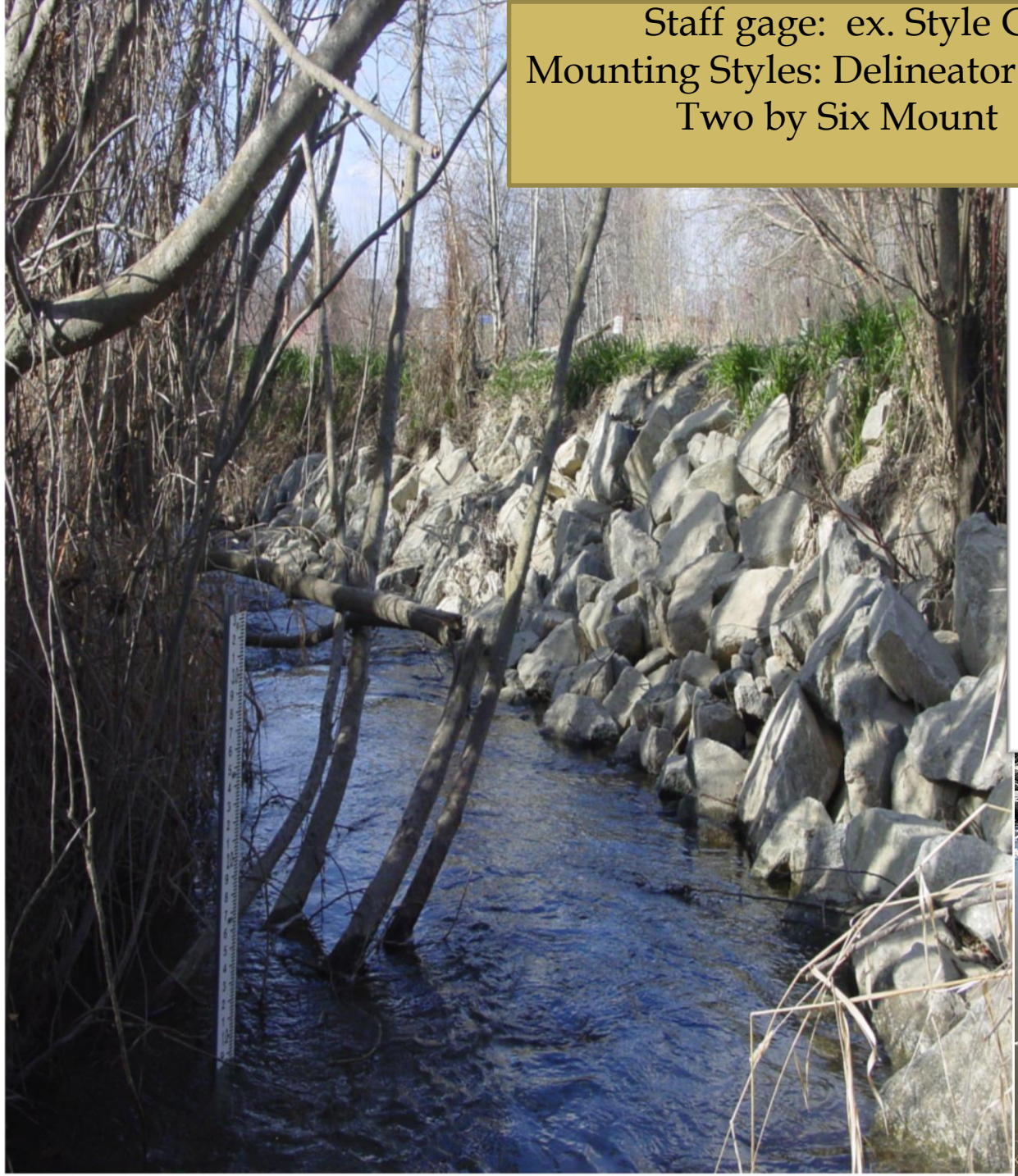
A-17

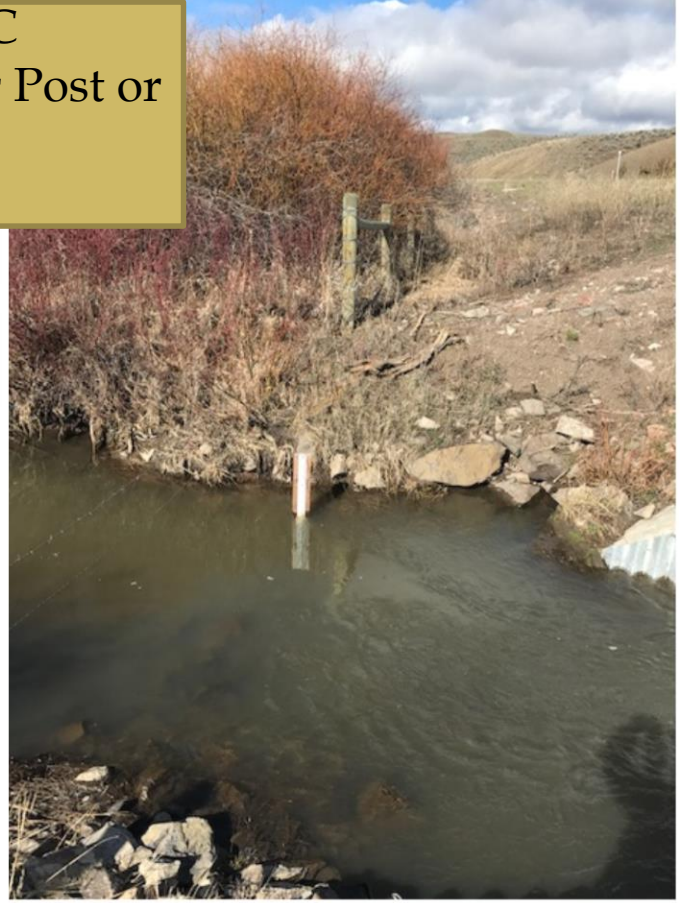
parshall flume

Staff Gage Installation

- Gage pool with control if possible
- Tranquil flow
- Close to cross section
- Set datum below zero flow
- Easily accessible/viewable

Staff gage: ex. Style C
Mounting Styles: Delineator Post or Two by Six Mount





Mule Shoe Ditch Rating		Measurements: Russ Gates (DNRC)	4/26/2017
		Rating: Mike Roberts/Russ Gates (DNRC)	5/8/2017

SG (ft)	Q (cfs)
0.44	10.9
0.7	22.6
0.9	36.4
1.1	47.9

Stage (ft)	Flow (cfs)	Stage (ft)	Flow (cfs)	Stage (ft)	Flow (cfs)	Stage (ft)	Flow (cfs)
0.3	4.6	0.62	19.4	0.94	37.7	1.26	59.8
0.31	5.0	0.63	19.9	0.95	38.4	1.27	60.5
0.32	5.4	0.64	20.4	0.96	39.0	1.28	61.3
0.33	5.9	0.65	20.9	0.97	39.7	1.29	62.0
0.34	6.3	0.66	21.5	0.98	40.3	1.3	62.8
0.35	6.7	0.67	22.0	0.99	40.9	1.31	63.5
0.36	7.1	0.68	22.5	1	41.6	1.32	64.3
0.37	7.5	0.69	23.1	1.01	42.3	1.33	65.1
0.38	8.0	0.7	23.6	1.02	42.9	1.34	65.8
0.39	8.4	0.71	24.2	1.03	43.6	1.35	66.6
0.4	8.8	0.72	24.7	1.04	44.2	1.36	67.4
0.41	9.3	0.73	25.3	1.05	44.9	1.37	68.2
0.42	9.7	0.74	25.8	1.06	45.6	1.38	69.0
0.43	10.2	0.75	26.4	1.07	46.3	1.39	69.8
0.44	10.6	0.76	27.0	1.08	46.9	1.4	70.6
0.45	11.1	0.77	27.5	1.09	47.6	1.41	71.3
0.46	11.5	0.78	28.1	1.1	48.3	1.42	72.1
0.47	12.0	0.79	28.7	1.11	49.0	1.43	73.0
0.48	12.5	0.8	29.3	1.12	49.7	1.44	73.8
0.49	12.9	0.81	29.8	1.13	50.4	1.45	74.6
0.5	13.4	0.82	30.4	1.14	51.1	1.46	75.4
0.51	13.9	0.83	31.0	1.15	51.8	1.47	76.2
0.52	14.4	0.84	31.6	1.16	52.5	1.48	77.0
0.53	14.9	0.85	32.2	1.17	53.2	1.49	77.9
0.54	15.3	0.86	32.8	1.18	53.9		
0.55	15.8	0.87	33.4	1.19	54.6		
0.56	16.3	0.88	34.0	1.2	55.4		
0.57	16.8	0.89	34.6	1.21	56.1		
0.58	17.3	0.9	35.2	1.22	56.8		
0.59	17.8	0.91	35.9	1.23	57.5		
0.6	18.3	0.92	36.5	1.24	58.3		
0.61	18.9	0.93	37.1	1.25	59.0		

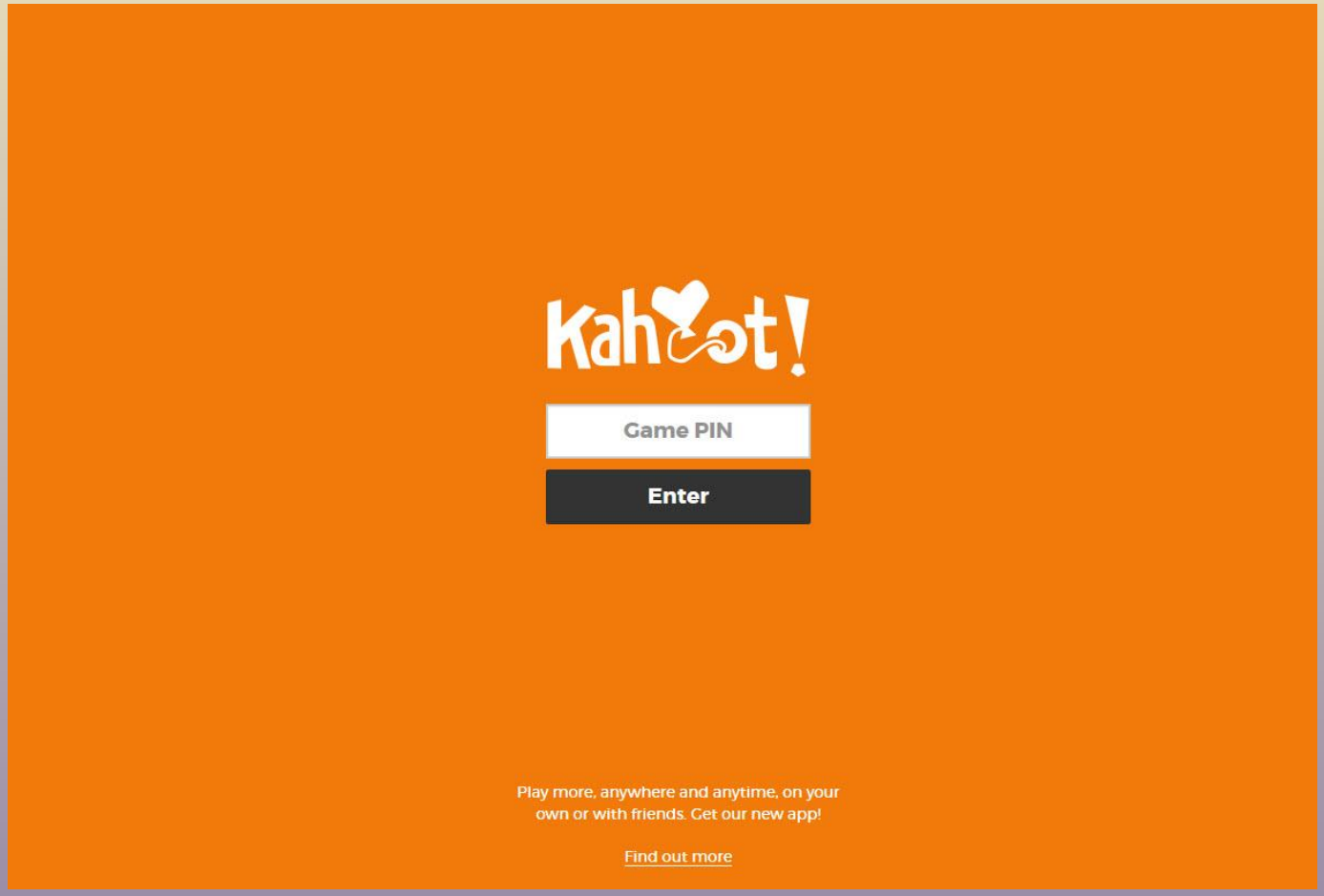
Photo: Ethan Mace

Staff gages are not adequate stand-alone measuring devices for water commissioners
(unless you have a flow meter)
Too much maintenance

mudgman

On your Smart Phone

1) Go to: Kahoot.it
2) Enter Game PIN
3) Enter Nickname



Flumes and Weirs

Flume – shaped, open-channel flow sections that force flow to accelerate.

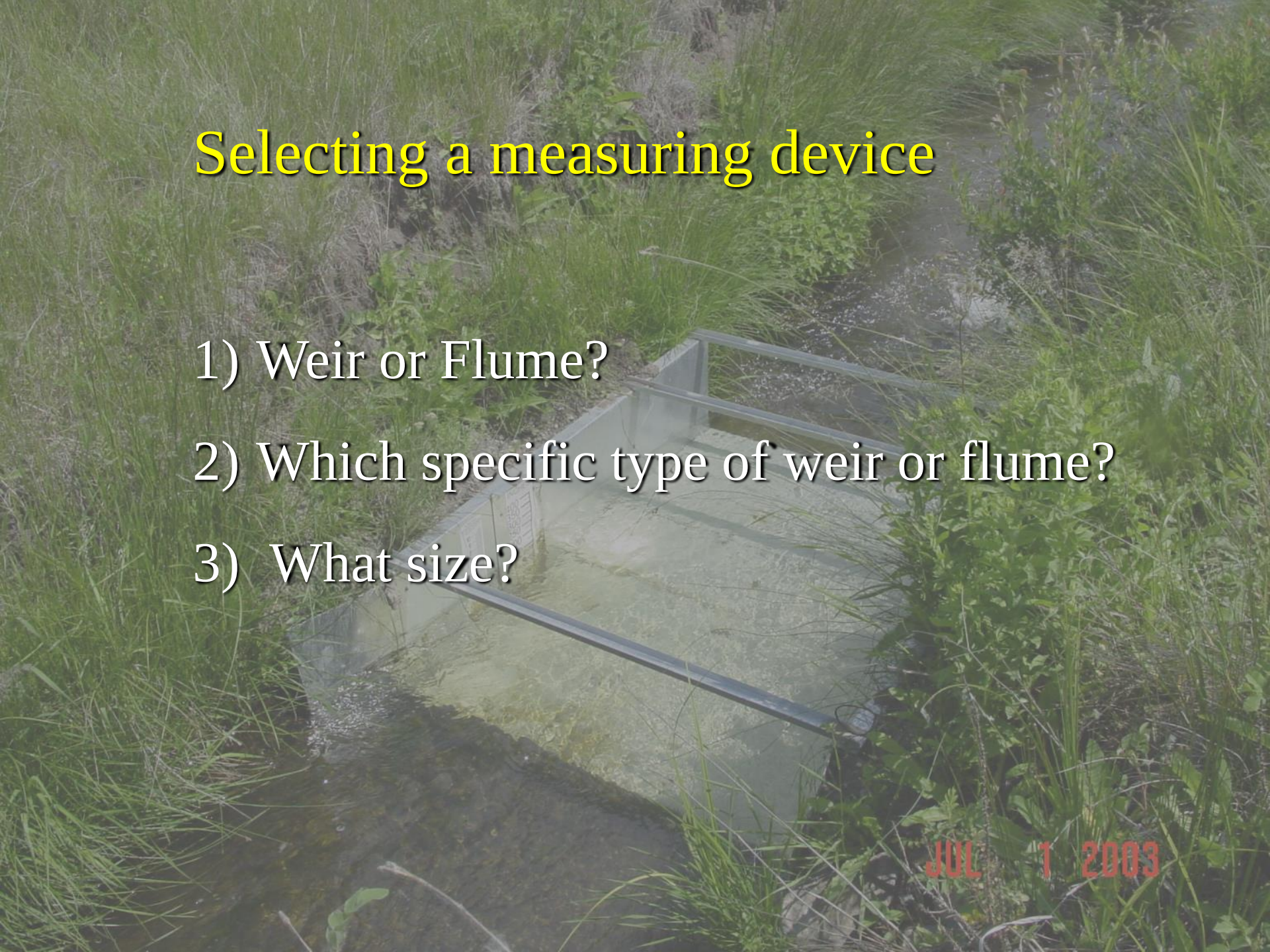
Weir – an overflow structure built perpendicular to an open channel axis to measure the rate of flow.
Slope > 0.5%

Selecting a measuring device

1) Weir or Flume?

2) Which specific type of weir or flume?

3) What size?



Flumes

- Parshall
- Montana
- Cutthroat
- Ramp

Parshall Flume

- low head loss requirement
- facilitates sand and silt
- can be measured under some submerged conditions

But..

- difficult to build
- expensive (2.5’ throat = $2000 to $3000)

level

Staff Gage Placement

cut-off wall
flume set above
bottom of ditch
straight section
of ditch

Free Flow

- Elevation of flume set to create “hydraulic” in throat
- No backwater restricting flow through flume
- Standing wave present

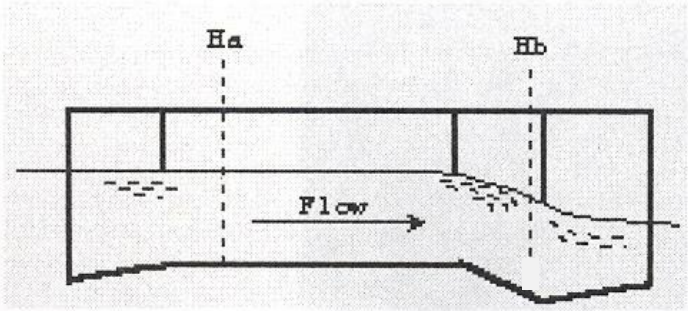


Figure 1

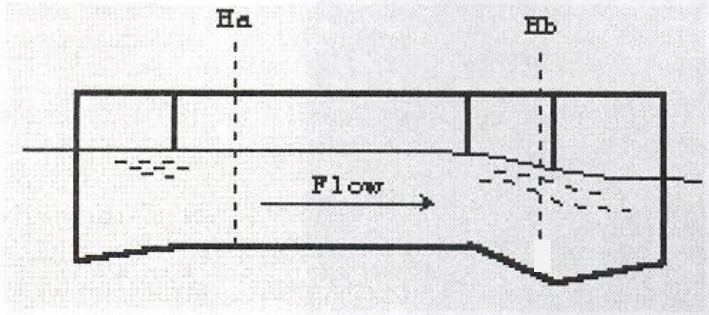


Figure 2

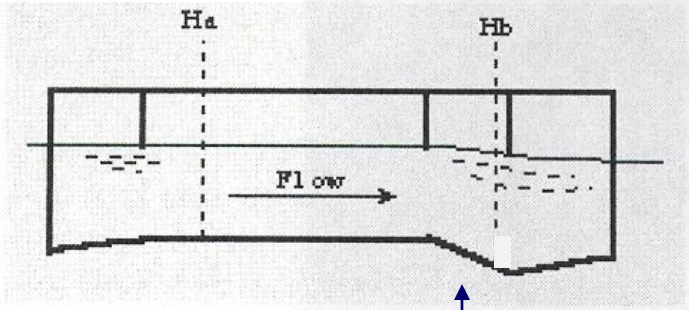


Figure 3

throat

Free Flow

Defn. When the downstream water elevation does not influence flow through the measuring device.

Submerged Flow

Determined by Ratio: H_b/H_a

Defn. Occurs when the downstream elevation of the water surface of the flume or weir is high enough to retard flow.

Typical Max Flow Determination

1.5’ Parshall Flume
Typical Maximum Flow = 5.1 cfs
high water mark

Throat width = 3 feet Q = ?

Stage = 0.45 feet

Water Measurement Manual

A Water Resources Technical Publication

U.S. Department of the Interior
Bureau of Reclamation
Third edition

Table A8-12. Free-flow discharges in ft^3/sec through 1- to 8-foot Parshall flumes. Discharges for 2- to 8-ft flumes computed from the formula $Q = 4.00Wh_a^{1.522(W^{0.026})}$. Discharges for 1-ft flume computed from the formula $Q = 3.95h_a^{1.55}$.

Upper Head h_a, ft	Discharge for flumes of various throat widths, W							
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
0.20	0.33	0.66	0.96	1.26	-----	-----	-----	-----
.21	.35	.71	1.04	1.36	-----	-----	-----	-----
.22	.38	.77	1.12	1.47	-----	-----	-----	-----
.23	.40	.82	1.20	1.57	-----	-----	-----	-----
.24	.43	.88	1.28	1.68	-----	-----	-----	-----
.25	.46	.93	1.37	1.80	2.22	2.63	-----	-----
.26	.49	.99	1.46	1.91	2.36	2.80	-----	-----
.27	.52	1.05	1.54	2.03	2.50	2.97	-----	-----
.28	.55	1.11	1.63	2.15	2.65	3.15	-----	-----
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.31	.64	1.30	1.92	2.52	3.12	3.71	4.29	4.88
.32	.68	1.37	2.01	2.65	3.28	3.90	4.52	5.13
.33	.71	1.44	2.11	2.78	3.44	4.10	4.75	5.39
.34	.74	1.50	2.22	2.92	3.61	4.30	4.98	5.66
.35	.78	1.57	2.32	3.05	3.78	4.50	5.21	5.92
.36	.81	1.64	2.42	3.19	3.95	4.71	5.46	6.20
.37	.85	1.71	2.53	3.33	4.13	4.92	5.70	6.48
.38	.88	1.79	2.64	3.48	4.31	5.13	5.95	6.76
.39	.92	1.86	2.75	3.62	4.49	5.35	6.20	7.05
.40	.95	1.93	2.86	3.77	4.67	5.57	6.46	7.34
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.42	1.03	2.09	3.08	4.07	5.05	6.02	6.98	7.94
.43	1.07	2.16	3.20	4.22	5.24	6.25	7.25	8.25
.44	1.11	2.24	3.32	4.38	5.43	6.48	7.52	8.56
.45	1.15	2.32	3.44	4.54	5.63	6.72	7.80	8.87
.46	1.19	2.40	3.56	4.70	5.83	6.96	8.08	9.19
.47	1.23	2.48	3.68	4.86	6.03	7.20	8.36	9.51
.48	1.27	2.57	3.80	5.03	6.24	7.45	8.65	9.84
.49	1.31	2.65	3.93	5.19	6.45	7.69	8.94	10.2
.50	1.35	2.73	4.05	5.36	6.66	7.95	9.23	10.5
.51	1.39	2.82	4.18	5.53	6.87	8.20	9.53	10.8
.52	1.43	2.90	4.31	5.70	7.08	8.46	9.83	11.2
.53	1.48	2.99	4.44	5.88	7.30	8.72	10.1	11.5
.54	1.52	3.08	4.57	6.05	7.52	8.98	10.4	11.9
.55	1.56	3.17	4.71	6.23	7.74	9.25	10.8	12.2
.56	1.61	3.26	4.84	6.41	7.97	9.52	11.1	12.6
.57	1.65	3.35	4.98	6.59	8.20	9.79	11.4	13.0
.58	1.70	3.44	5.11	6.77	8.43	10.1	11.7	13.3
.59	1.74	3.53	5.25	6.96	8.66	10.3	12.0	13.7

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.26	.49	.99	1.46	1.91	2.36	2.80	-----	-----
.27	.52	1.05	1.54	2.03	2.50	2.97	-----	-----
.28	.55	1.11	1.63	2.15	2.65	3.15	-----	-----
.29	.58	1.17	1.73	2.27	2.80	3.33	-----	-----
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.31	.64	1.30	1.92	2.52	3.12	3.71	4.29	4.88
.32	.68	1.37	2.01	2.65	3.28	3.90	4.52	5.13
.33	.71	1.44	2.11	2.78	3.44	4.10	4.75	5.39
.34	.74	1.50	2.22	2.92	3.61	4.30	4.98	5.66
.35	.78	1.57	2.32	3.05	3.78	4.50	5.21	5.92
.36	.81	1.64	2.42	3.19	3.95	4.71	5.46	6.20
.37	.85	1.71	2.53	3.33	4.13	4.92	5.70	6.48
.38	.88	1.79	2.64	3.48	4.31	5.13	5.95	6.76
.39	.92	1.86	2.75	3.62	4.49	5.35	6.20	7.05
.40	.95	1.93	2.86	3.77	4.67	5.57	6.46	7.34
.41	.99	2.01	2.97	3.92	4.86	5.79	6.72	7.64
.42	1.03	2.09	3.08	4.07	5.05	6.02	6.98	7.94
.43	1.07	2.16	3.20	4.22	5.24	6.25	7.25	8.25
.44	1.11	2.24	3.32	4.38	5.43	6.48	7.52	8.56
.45	1.15	2.32	3.44	4.54	5.63	6.72	7.80	8.87
.46	1.19	2.40	3.56	4.70	5.83	6.96	8.08	9.19
.47	1.23	2.48	3.68	4.86	6.03	7.20	8.36	9.51
.48	1.27	2.57	3.80	5.03	6.24	7.45	8.65	9.84
.49	1.31	2.65	3.93	5.19	6.45	7.69	8.94	10.2
.50	1.35	2.73	4.05	5.36	6.66	7.95	9.23	10.5
.51	1.39	2.82	4.18	5.53	6.87	8.20	9.53	10.8
.52	1.43	2.90	4.31	5.70	7.08	8.46	9.83	11.2
.53	1.48	2.99	4.44	5.88	7.30	8.72	10.1	11.5
.54	1.52	3.08	4.57	6.05	7.52	8.98	10.4	11.9
.55	1.56	3.17	4.71	6.23	7.74	9.25	10.8	12.2
.56	1.61	3.26	4.84	6.41	7.97	9.52	11.1	12.6
.57	1.65	3.35	4.98	6.59	8.20	9.79	11.4	13.0
.58	1.70	3.44	5.11	6.77	8.43	10.1	11.7	13.3
.59	1.74	3.53	5.25	6.96	8.66	10.3	12.0	13.7

Q = 3.44 cfs

Rating Table = 3.44 cfs
Measured flow (below) = 4.5 cfs
?

- out of level
- water flowing around or underneath
- staff gage improperly set

Montana Flume (short parshall)

- low head loss requirement
- facilitates sediment
- no approach velocity requirement
- wide range of flows
- easy to build

- cannot measure submergence, must have free flow

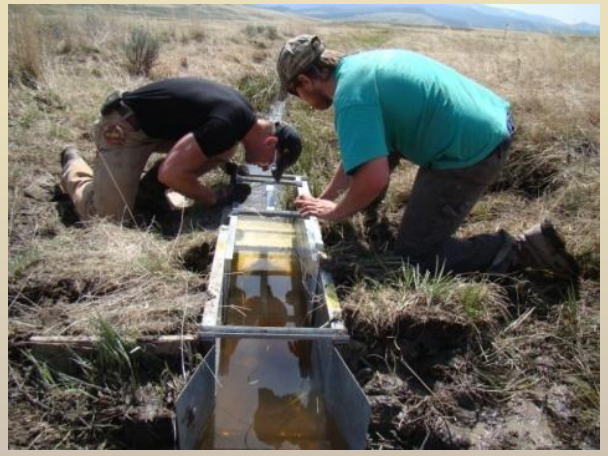
Cutthroat Flume

- flat bottom
- easy installation
- less expensive than parshalls
- easy to construct
- variable hydraulic conditions
- difficult to tell submergence

Long Throated Flumes

Ramp Flume
Replogle Flume
Broad-Crested Weir
(all very similar)

Long-Throated Flumes



Common Issues with Flumes

- Poor condition or no measuring device
- Bad Location
- Improper Function
  - accuracy/condition
  - submergence
  - not level crosswise
  - not level lengthwise
- Non-Standard Structure

Common Issues with Flumes

Solution?
1) Re-set, if flume integrity maintained.
Level, cut-off seepage and flow-around at
upper end of flume.
2) New flume

Location

Location
Too close
Poor angle
Poor Condition

Location
Too close
Poor angle
Poor Condition
Solution?
1) New flume
2) Move downstream

Location

Too Close to Headgate?

- Flume floor must be below elevation of headgate or diversion dam.
- Flat ditches (low head loss)
- Water right = >100 cfs

Solution?
Survey grade of ditch. Move flume downstream far enough to avoid water backing up to headgate.

Flume Placement Calculators available

4 Foot Parshall Flume	
Approximate max channel discharge (cfs)	25
Flume Size (based on flow rate and ditch dimensions)	4
Max Flow Depth in Ditch (est.)	1.5
Upper Staff Gage (H_a) at Max Flow Depth	1.2
Allowable Submergence Rate	0.7
Distance flume crest set below Max Flow rate	0.84
Flume height set abv Channnel Bottom	0.66
Net Rise in upstream water due to constriction	0.36
Water Depth in channel above Flume	1.86

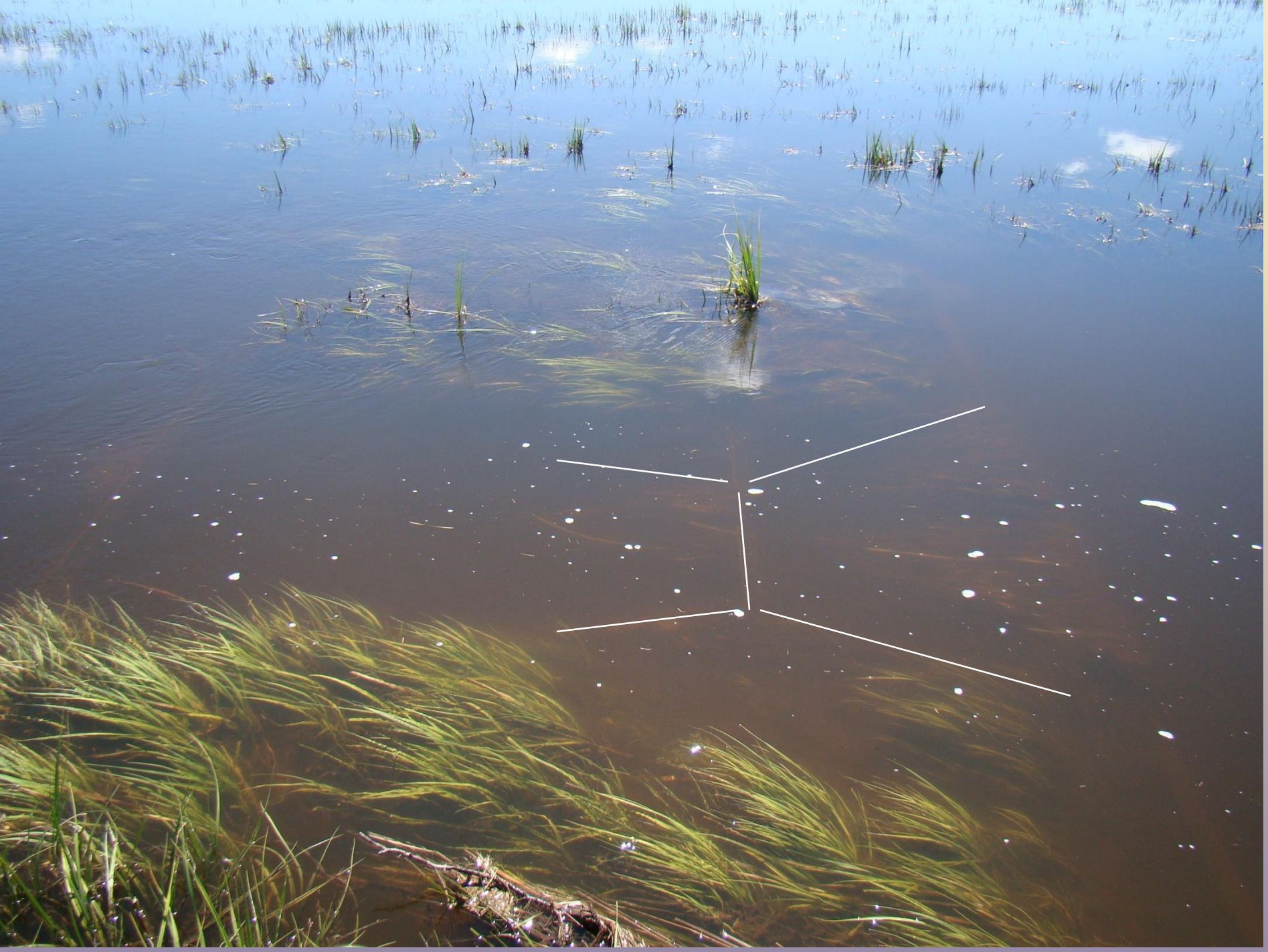
Also: Water Commissioner Training Manual has installation specifications

Too Far?

Location of original measuring device
ditch
scale 1 mile = 3.5 "
Pointof Diversion

Solution: Move flume closer to headgate

Too close to downstream culvert



Too close to downstream culvert

Solution?

1) **Move flume below culvert or**
2) **Replace existing culvert with larger culvert or bridge.**

Out of Level?

Solution:
1) Use two staff gages and a average stage, or
2) Re-set
Out of Level?

Poor staff gage placement

proper location = 2/3 from throat
Velocity Head
reducing stage

Submerged Flow

- Not free-flow
- Set too low or downstream restriction backing water up
- Will not accurately measure flow rate

Submerged Flow

Solution: Raise flume 0.5′ above channel bottom

Same cutthroat flume under free flow conditions

Non-Standard Structure

Non-Standard Structure

Solution:

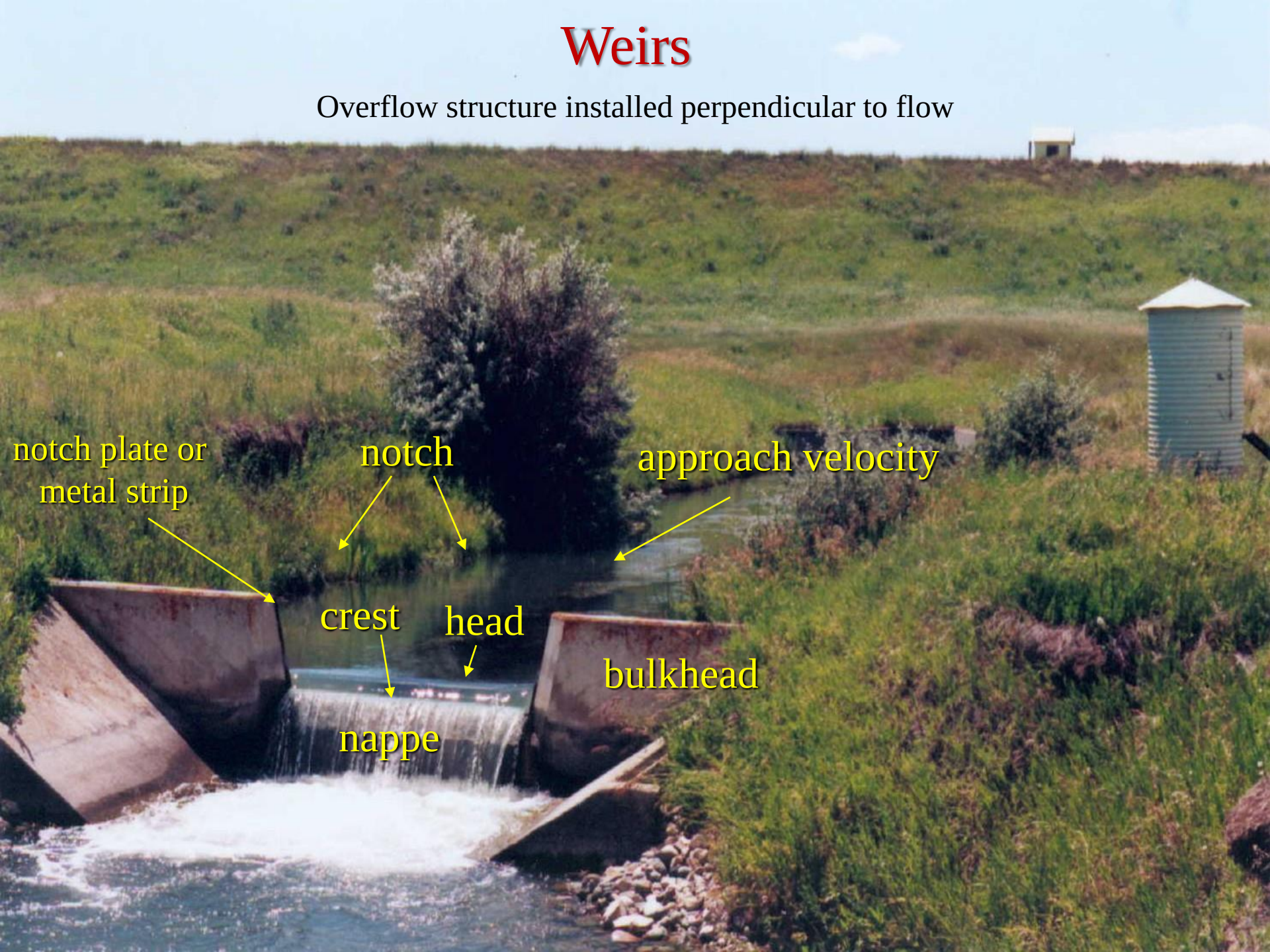
- Remove board, raise flume

Solution: Turn-around and Re-set.

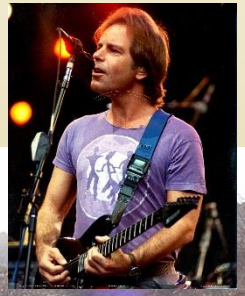
Flume Questions?

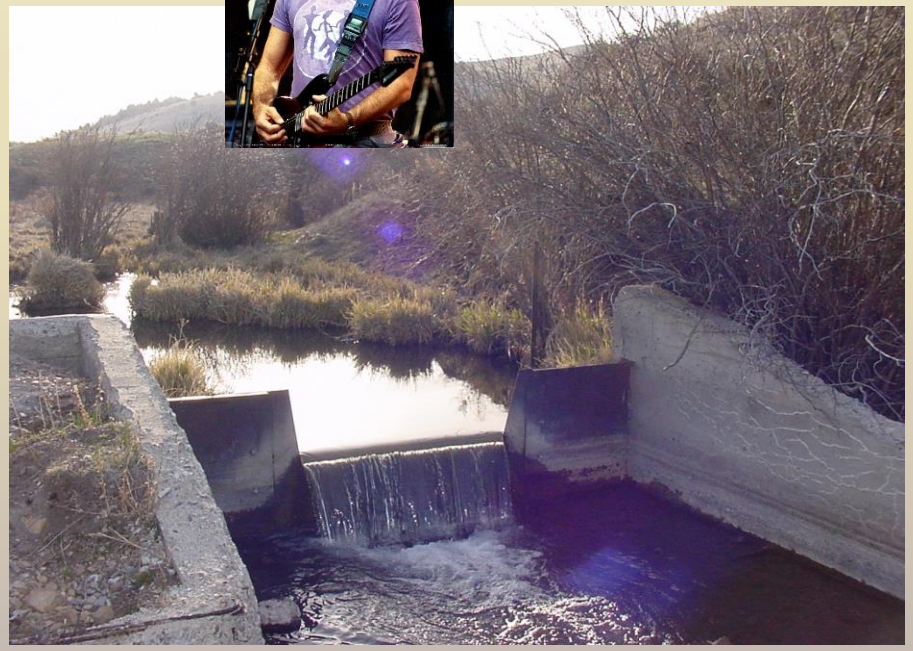
Weirs

Overflow structure installed perpendicular to flow



Weir vs. Flume





- head loss requirement (flume = 25% * weir)
- weirs have approach velocity requirement
- weirs can be easier to build
- weirs can collect sediment and debris

  (require more maintenance)

Sharp-Crested Weir

3 Standard Types

Contracted Rectangular

Cipolletti Contracted

Contracted Triangular or V-Notch

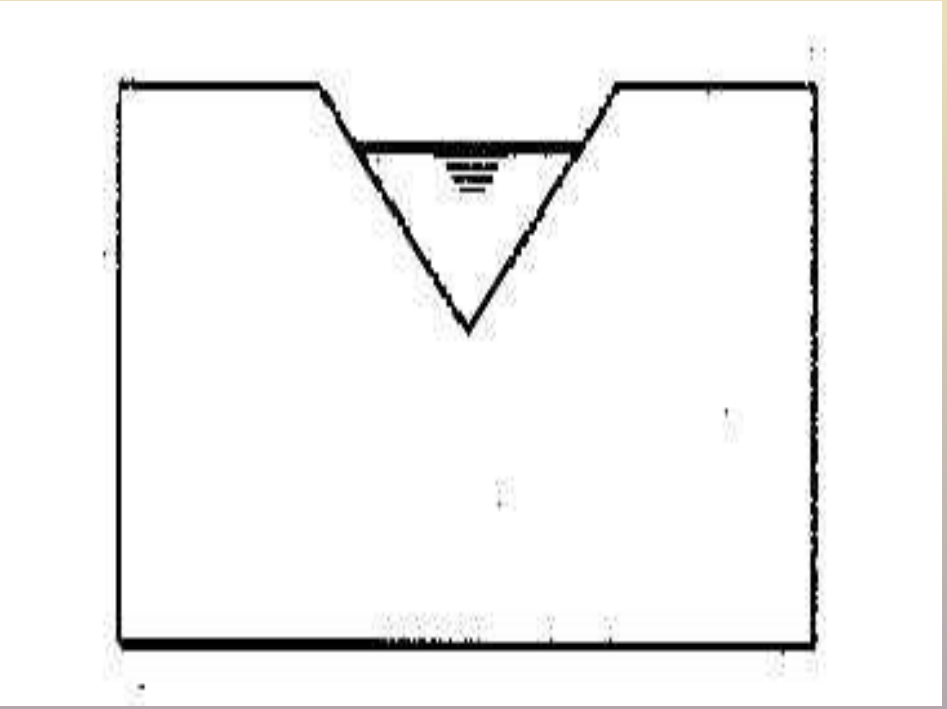
Sharp-Crested Weir

Contracted Rectangular

Sharp Crested Weir

Cipolletti Contracted - Trapezoidal in shape with sides that incline outwardly at a slope of 1 horizontal to 4 vertical. May be more accurate at lower stages than rectangular weir.

Sharp Crested Weir



Contracted Triangular or V-Notch

Measures flows up to 4.3 cfs or 1.25 feet of head

Conditions needed for all types of Sharp-Crested Weirs

- Weir should be installed in straight section of ditch/canal.
- Upstream face of the weir plates and bulkhead should be plumb, smooth, and normal to the axis of the channel.
- Approach velocity <= 0.5 feet/second (appear still).

APR 7 2004

ventilated nappe
APR 7 2004

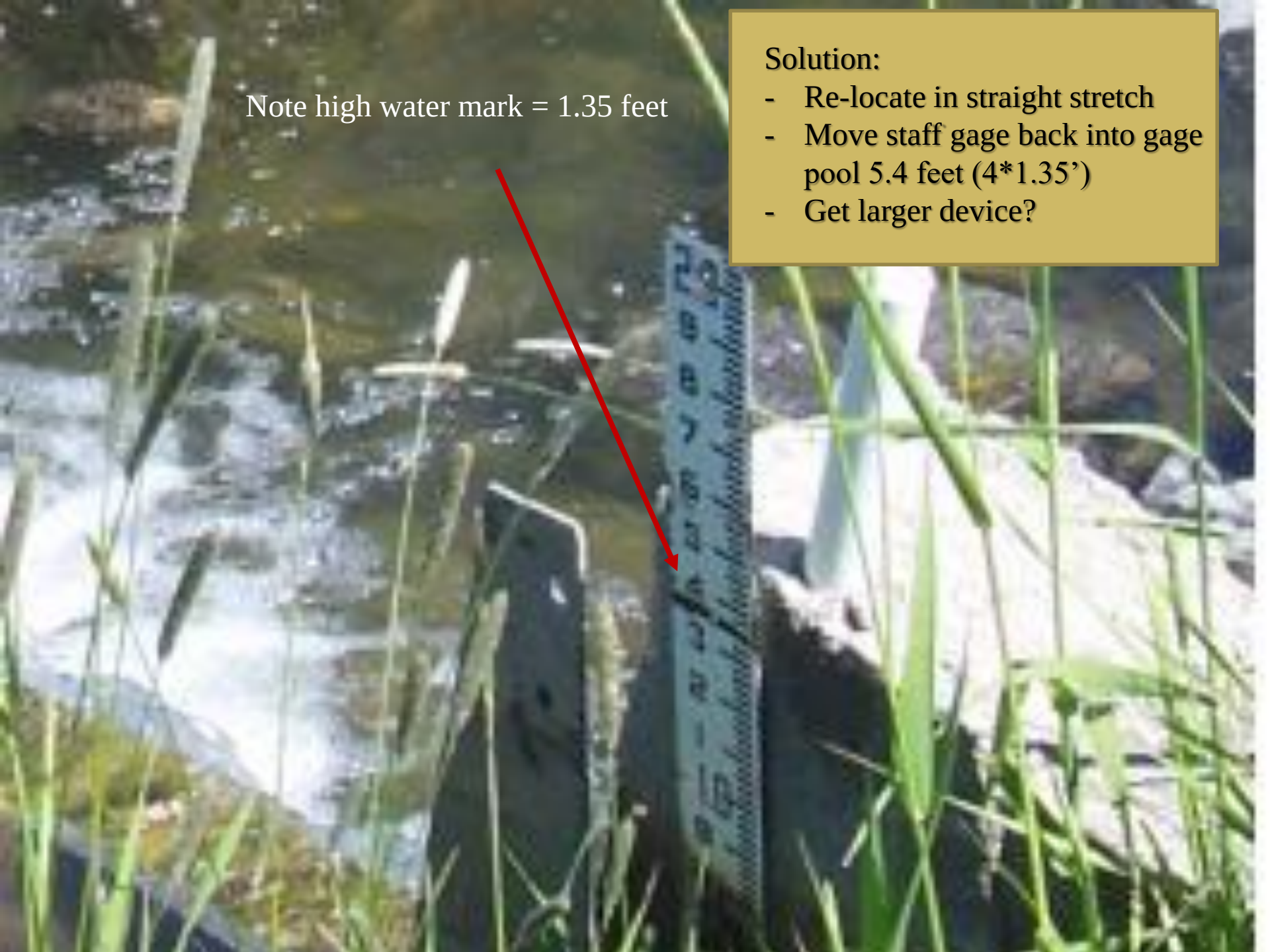
Weir Installation Specifications

05/07/2014

Solution: Raise weir plate appx. 0.5 feet, extend approach pool (10x width)

06/17/2008

Note high water mark = 1.35 feet

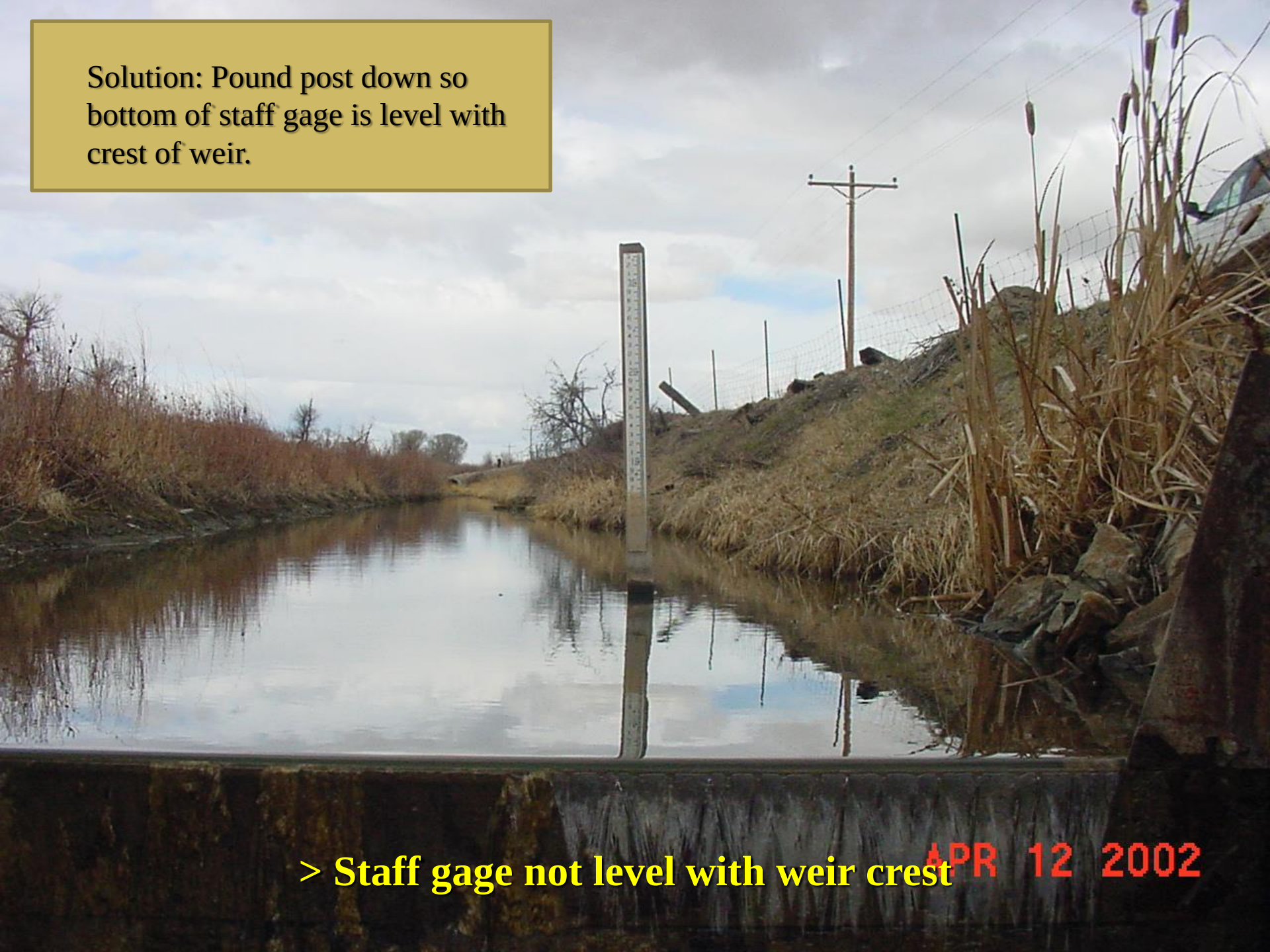


Solution:

- Re-locate in straight stretch
- Move staff gage back into gage pool 5.4 feet (4*1.35’)
- Get larger device?

Problem?

> Staff gage not level with weir crest


Solution: Pound post down so bottom of staff gage is level with crest of weir.
> Staff gage not level with weir crest
APR 12 2002

Weir Questions?

Accurate Water Measurement is dependent on:

- Measuring device selection
- Installation
- Correct use of measuring device
- Maintenance and quality control

Using your Irrigation Water Measurement Guide, determine flow in cfs for the following measuring devices.

1) Parshall flume, throat width = 5 feet, gage reading

2) Montana Flume, throat width = 2.5 feet, gage reading

3) Cipoletti weir, crest length = 5 feet, gage reading

4) V-notch weir, gage reading

5) Parshall flume, throat size = 12 feet, gage reading = 0.05 feet

Using your favorite Irrigation Water Measurement Guide, determine flow in cfs for the following measuring devices.

1) Parshall flume, throat width = 5 feet, gage reading
gh = 1.16, Q = 25.3 cfs

2) Montana Flume, throat width = 2.5 feet, gage reading

3) Cipoletti weir, crest length = 5 feet, gage reading

4) V-notch weir, gage reading

5) Parshall flume, throat size = 12 feet, gage reading = 0.05 feet

Using your favorite Irrigation Water Measurement Guide, determine flow in cfs for the following measuring devices.

1) Parshall flume, throat width = 5 feet, gage reading
gh = 1.16’ Q = 25.3 cfs

2) Montana Flume, throat width = 2.5 feet, gage reading
gh = 0.65’ Q = 5.11 cfs

3) Cipoletti weir, crest length = 5 feet, gage reading

4) V-notch weir, gage reading

5) Parshall flume, throat size = 12 feet, gage reading = 0.05 feet

Using your favorite Irrigation Water Measurement Guide, determine flow in cfs for the following measuring devices.

1) Parshall flume, throat width = 5 feet, gage reading
gh = 1.16’ Q = 25.3 cfs

2) Montana Flume, throat width = 2.5 feet, gage reading
gh = 0.65’ Q = 5.11 cfs

3) Cipoletti weir, crest length = 5 feet, gage reading

gh = 0.51’ Q = 6.13 cfs

4) V-notch weir, gage reading

5) Parshall flume, throat size = 12 feet, gage reading = 0.05 feet

Using your favorite Irrigation Water Measurement Guide, determine flow in cfs for the following measuring devices.

1) Parshall flume, throat width = 5 feet, gage reading
gh = 1.16’ Q = 25.3 cfs

2) Montana Flume, throat width = 2.5 feet, gage reading
gh = 0.65’ Q = 5.11 cfs

3) Cipoletti weir, crest length = 5 feet, gage reading

gh = 0.51’ Q = 6.13 cfs

4) V-notch weir, gage reading

gh = 0.43’ Q = 0.31 cfs

5) Parshall flume, throat size = 12 feet, gage reading = 0.05 feet

Using your favorite Irrigation Water Measurement Guide, determine flow in cfs for the following measuring devices.

1) Parshall flume, throat width = 5 feet, gage reading
gh = 1.16’ Q = 25.3 cfs

2) Montana Flume, throat width = 2.5 feet, gage reading
gh = 0.65’ Q = 5.11 cfs

3) Cipoletti weir, crest length = 5 feet, gage reading

gh = 0.51’ Q = 6.13 cfs

4) V-notch weir, gage reading

gh = 0.43’ Q = 0.31 cfs

5) Parshall flume, throat size = 12 feet, gage reading = 0.05 feet

flow too low to accurately measure

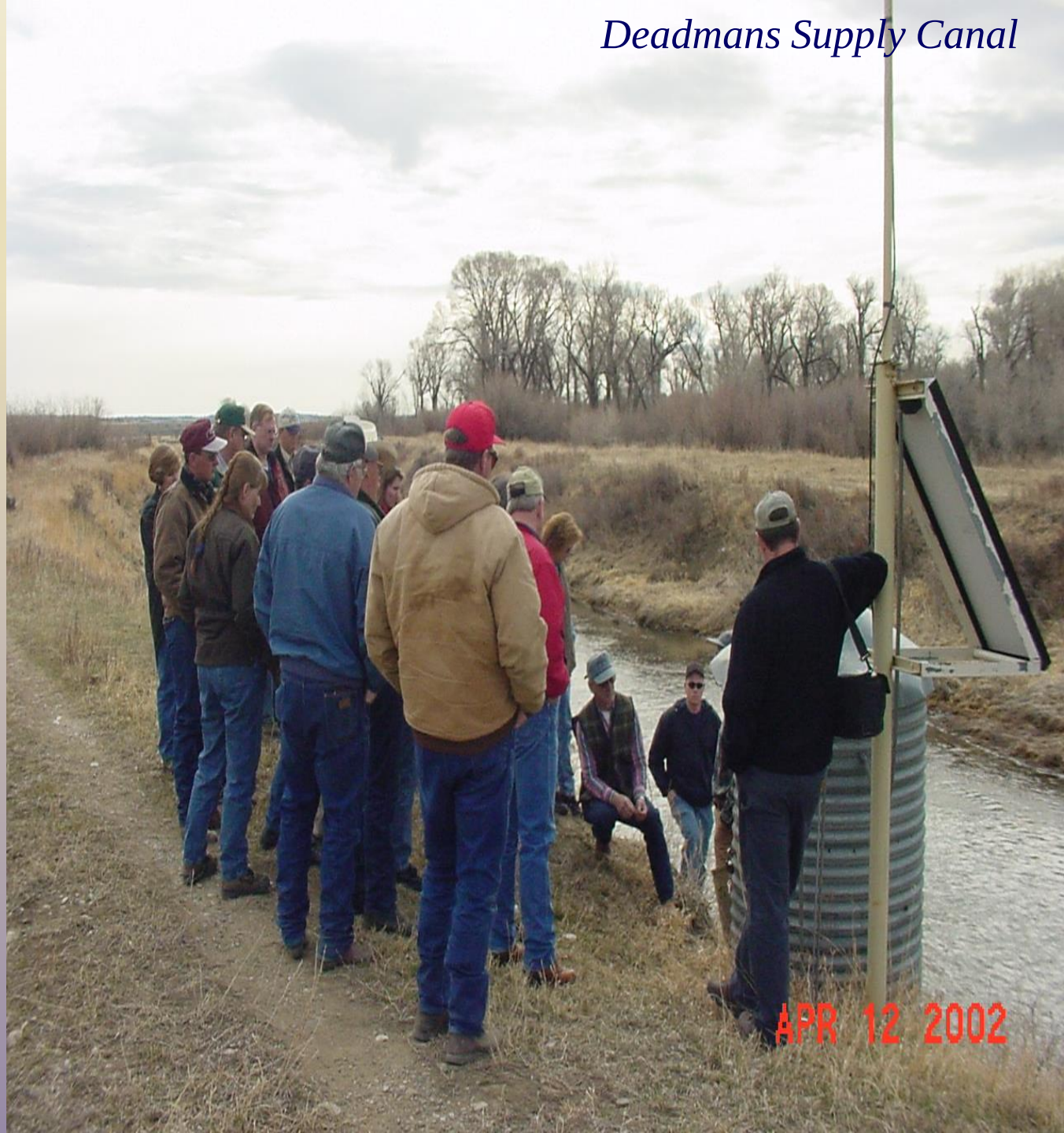
Most Common Ditch/Canal Measuring Devices in Montana

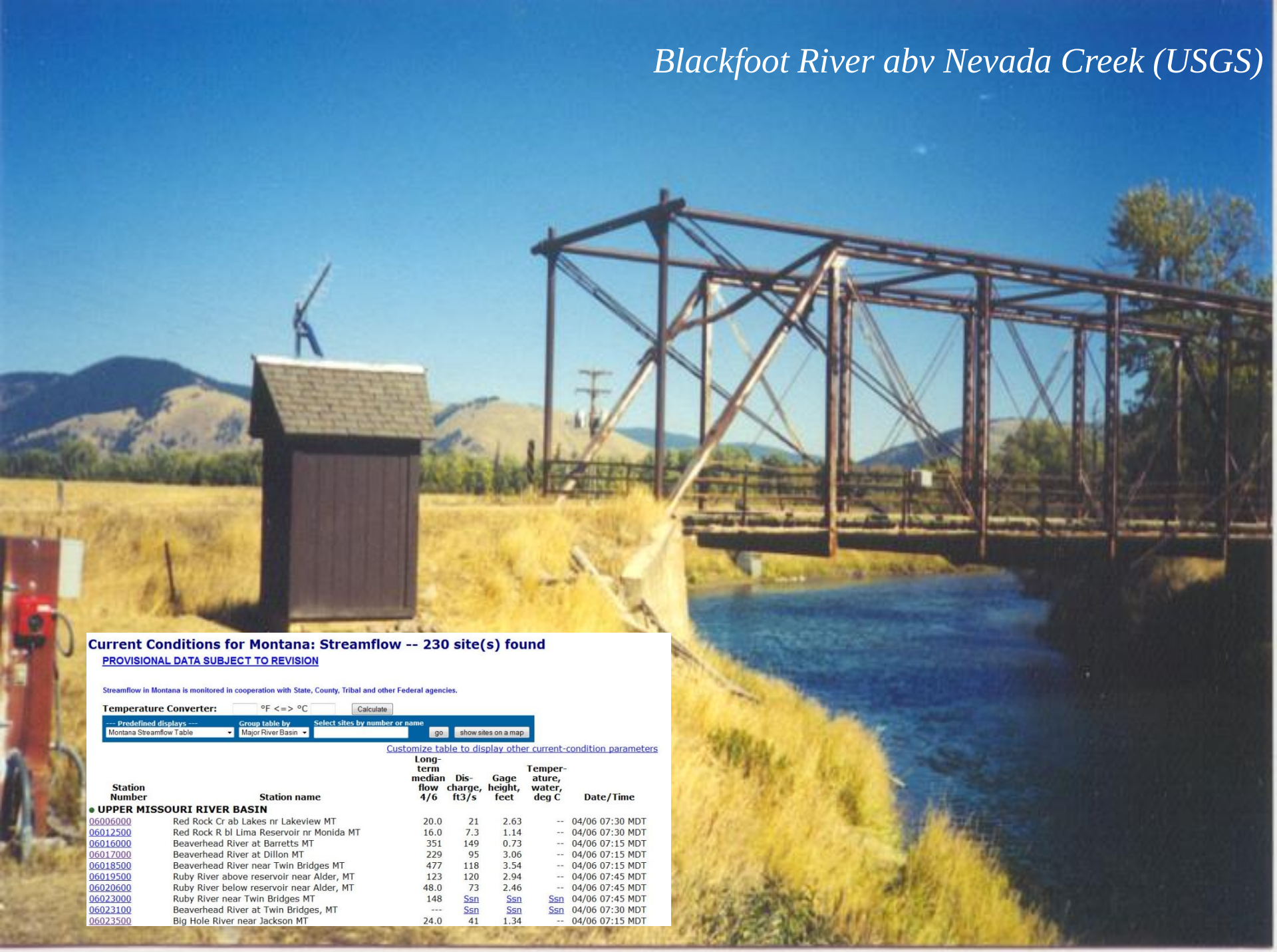
If properly installed, maintained and operated, the following are acceptable measuring devices for Water Commissioners:

Flumes	Weirs
Parshall	Contracted rectangular
Montana	Cipolleti
Ramp	V-Notch
Cutthroat	

Automated Devices

Streamflow Gaging Stations





Blackfoot River abv Nevada Creek (USGS)

Current Conditions for Montana: Streamflow -- 230 site(s) found

PROVISIONAL DATA SUBJECT TO REVISION

Streamflow in Montana is monitored in cooperation with State, County, Tribal and other Federal agencies.

Temperature Converter: °F <=> °C Calculate

--- Predefined displays --- Montana Streamflow Table | Group table by Major River Basin | Select sites by number or name go show sites on a map

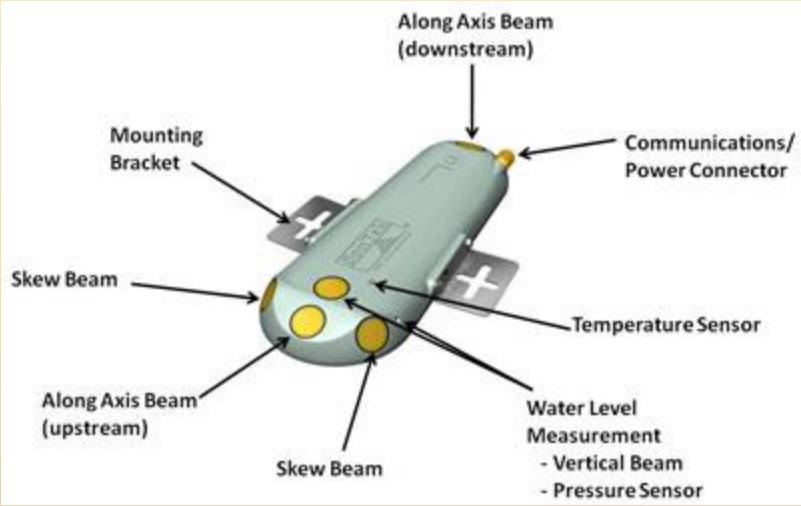
Customize table to display other current-condition parameters

Station Number	Station name	Long-term median flow 4/6	Dis-charge, ft3/s	Gage height, feet	Temper-ature, water, deg C	Date/Time
UPPER MISSOURI RIVER BASIN						
06006000	Red Rock Cr ab Lakes nr Lakeview MT	20.0	21	2.63	--	04/06 07:30 MDT
06012500	Red Rock R bl Lima Reservoir nr Monida MT	16.0	7.3	1.14	--	04/06 07:30 MDT
06016000	Beaverhead River at Barretts MT	351	149	0.73	--	04/06 07:15 MDT
06017000	Beaverhead River at Dillon MT	229	95	3.06	--	04/06 07:15 MDT
06018500	Beaverhead River near Twin Bridges MT	477	118	3.54	--	04/06 07:15 MDT
06019500	Ruby River above reservoir near Alder, MT	123	120	2.94	--	04/06 07:45 MDT
06020600	Ruby River below reservoir near Alder, MT	48.0	73	2.46	--	04/06 07:45 MDT
06023000	Ruby River near Twin Bridges MT	148	Ssn	Ssn	Ssn	04/06 07:45 MDT
06023100	Beaverhead River at Twin Bridges, MT	---	Ssn	Ssn	Ssn	04/06 07:30 MDT
06023500	Big Hole River near Jackson MT	24.0	41	1.34	--	04/06 07:15 MDT

Continuous Water Level Sensors

- TruTracks
- Pressure Transducers

Bottom Mounted Doppler Meters



In-Line Meters and Flow Totalizers

Ultra-Sonic Meters

Weir Sticks

• Commercially calibrated stick that shows depth of flow plus velocity head when placed on weir crest. In this case velocity head would be equal to the run up of water on the stick (Clausen Rule)

• May be calibrated to be read at an angle.

MAR 30 2004

Needs:
• cleaning
• clearing of debris
MAR 30 2004

Good location
Proper sizing
JUN 2 2004

Submerged Flow
No hydraulic jump
Needs Re-setting
JUN 2 2004

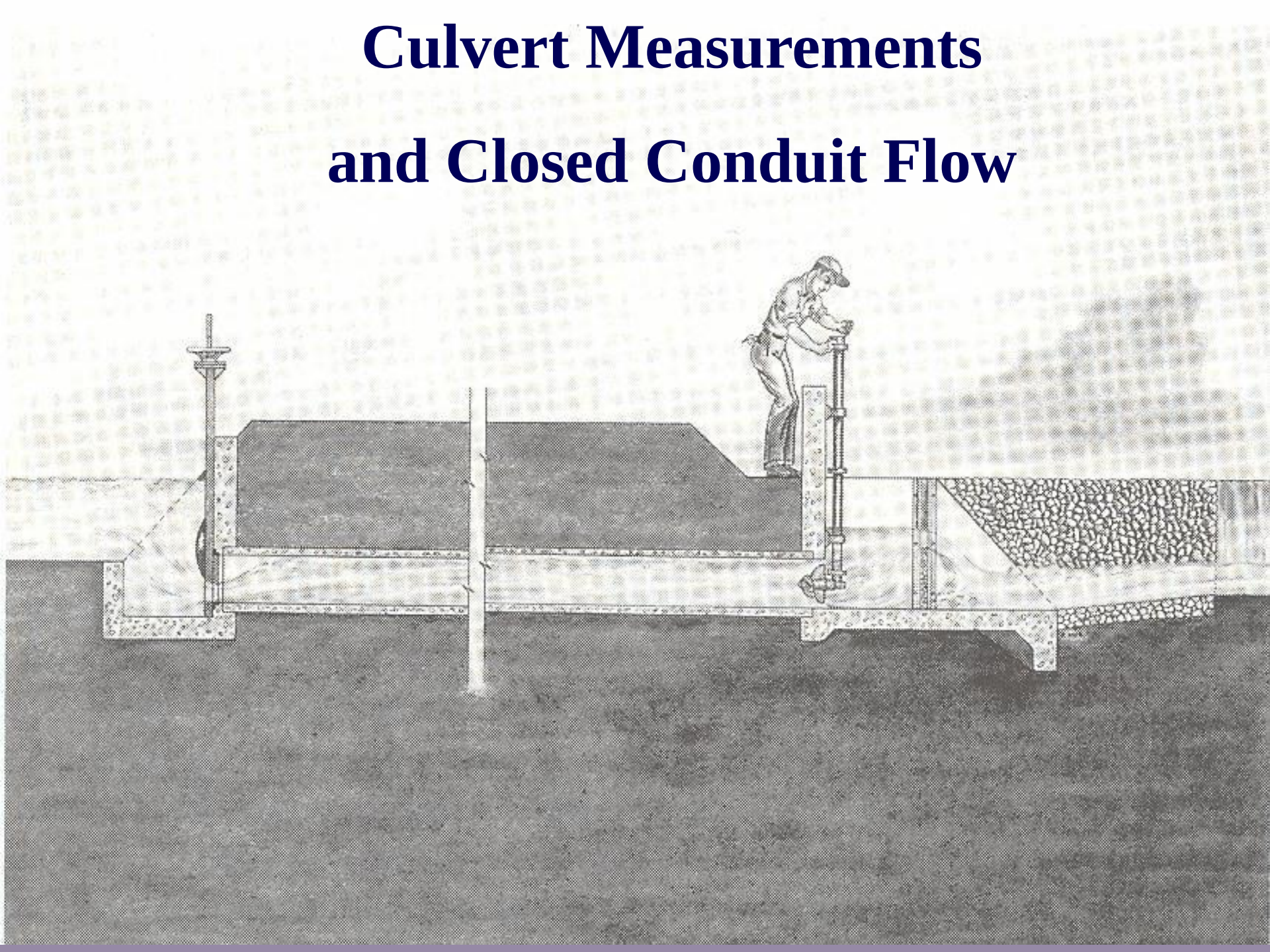
3' Parshall Flume

Flow direction?
Over- or underestimating flow?

Grazing impacts

Closed Conduit Flow

Culvert Measurements and Closed Conduit Flow

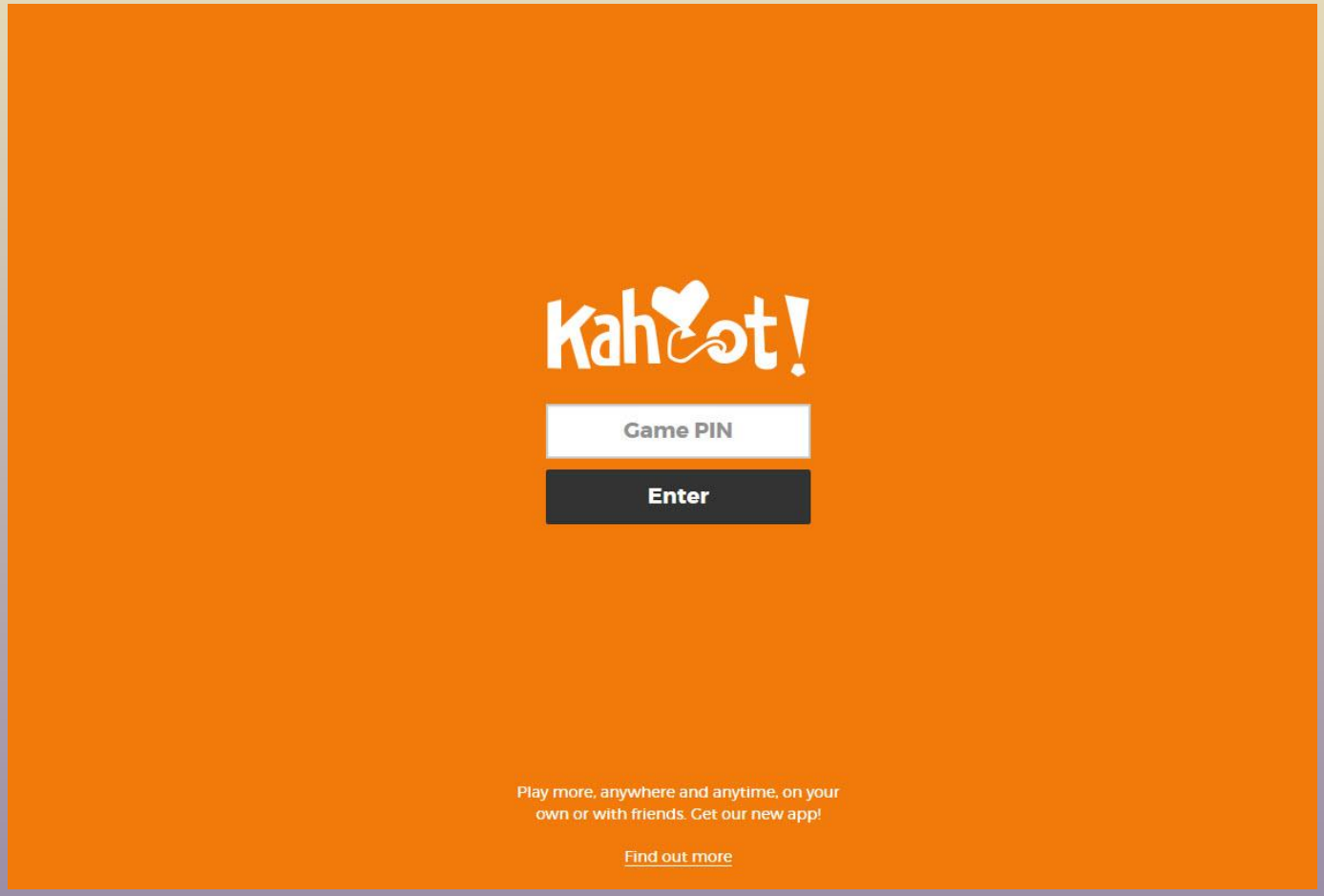


CUBIC FEET PER SECOND

BLUE-WHITE® INDUSTRIES
MODE
RESET
523523
GALLONS PER MINUTE
Rate - Totalizer
F-1000-RT

On your Smart Phone

1) Go to: Kahoot.it
2) Enter Game PIN
3) Enter Nickname



EC 1369 • Reprinted September 1994

Estimating Water Flow Rates

W.L. Trimmer

Increasing competition for water resources has made water conservation a high priority. Measuring the flow rate of water is the first step to good water management. All water right holders in the State of Oregon must be able to measure the flow rate of the water being diverted.

If a flow meter, flume, or weir isn't available, there are several methods available to estimate flow rate that you can do with available tools like stopwatches, rulers, and buckets.

The usual unit measuring flow rate for irrigation water rights is a cubic foot per second (cfs). This is water flowing through a cross-sectional area of 1 ft^2 at a velocity of 1 foot per second, and it's sometimes called a second-foot.

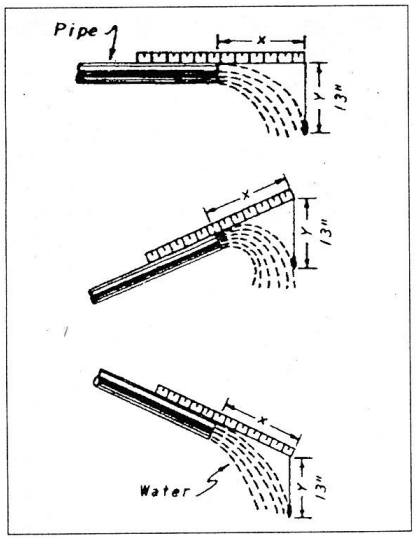


Figure 1.—Measuring horizontal distance (X) of a pipe flowing full with vertical drop Y=13".

A common diversion rate in eastern Oregon might be 1 cfs/40 acres. Here are some handy conversions (see page 4 for others): 1 cfs is about 450 gallons per minute; 1 cfs is about 1 acre-inch per hour; 1 cfs is about 2 acre-feet per day.

Propeller flow meters, weirs, and flumes provide the most accurate measures of flow rate, but in many instances you must make an estimate without them. Here are four methods to estimate irrigation diversions.

Method 1
Discharge from a pipe

If water can freely drop from a pipe, you can estimate the flow rate by measuring length with nothing more than a carpenter's rule. When the pipe is flowing full, place the rule as shown in Figure 1 and measure a horizontal distance when the vertical drop Y = 13 inches.

Find the proper pipe size in Table 1, and the discharge is in gallons per minute (gpm). If the pipe isn't level, use a plumb bob to measure the vertical drop Y.

Example 1. An 8-inch-diameter pipe is flowing full, and the horizontal distance X is measured to be 20 inches. From Table 1, the flow rate is 1,005 gpm.

If the pipe is flowing only partially full, find the ratio of the unfilled portion of pipe to the diameter of the pipe to estimate flow rate in gallons per minute, as shown in Table 2.

Example 2. A 10-inch-diameter pipe is flowing only partially full. The measured distance U is 2 inches. The ratio U ÷ D in Table 2 is 2 ÷ 10 = 0.2. The flow rate is 825 gpm.

Walter L. Trimmer, former Extension irrigation specialist, Oregon State University.

OREGON STATE UNIVERSITY EXTENSION SERVICE

Table 1.—Discharge (gallons per minute) from pipes flowing full, with vertical drop Y = 13" and variable horizontal distances X.

Pipe size		Horizontal distance X (in inches)												
Inside diam.	Area (sq in)	12	14	16	18	20	22	24	26	28	30	32	34	36
2.0	3.14	38	44	50	57	63	69	75	82	88	94	100	107	113
2.5	4.91	59	69	79	88	98	108	118	128	137	147	157	167	177
3.0	7.07	85	99	113	127	141	156	170	184	198	212	226	240	255
4.0	12.57	151	176	201	226	251	277	302	327	352	377	402	427	453
5.0	19.64	236	275	314	354	393	432	471	511	550	589	628	668	707
6.0	28.27	339	396	452	509	565	622	678	735	792	848	905	961	1013
7.0	38.48	462	539	616	693	770	847	924	1000	1077	1154	1231	1308	1385
8.0	50.27	603	704	804	905	1005	1106	1206	1307	1408	1508	1609	1709	1810
9.0	63.62	763	891	1018	1145	1272	1400	1527	1654	1781	1909	2036	2163	2290
10.0	78.54	942	1100	1257	1414	1471	1728	1885	2042	2199	2356	2513	2670	2827
11.0	95.03	1140	1330	1520	1711	1901	2091	2281	2471	2661	2851	3041	3231	3421
12.0	113.10	1357	1583	1809	2036	2262	2488	2714	2941	3167	3393	3619	3845	4072

$Q = \frac{3.61\ AX}{\sqrt{Y}}$, where:

A = Cross-sectional area of discharge pipe in square inches
X = Horizontal distance in inches
Y = Vertical distance in inches

Table 2.—An approximate method of estimating discharge from pipes flowing partially full.

	Inside diameter of pipe = D in inches				
$\frac{U}{D}$	4	6	8	10	12
0.1	142	334	379	912	1310
0.2	128	302	524	825	1185
0.3	112	264	457	720	1034
0.4	94	222	384	605	868
0.5	75	176	305	480	689
0.6	55	130	226	355	510
0.7	37	88	152	240	345
0.8	21	49	85	134	194
0.9	8	17	30	52	74
1.0	0	0	0	0	0

Questions?

Manual Measurements

-Current meters

- Float-area method

Current Meters

Classes of current meters

- Mechanical: Anemometer and propeller velocity meters
  (not discussed)
- Electromagnetic velocity meters
- Doppler velocity meters

Current Meters

- Electromagnetic

Example: Marsh-McBirney Velocity Meter with digital read-out

Current meter probe produces a magnetic field, water moving through that field generates a voltage which is proportional to the velocity of the water

Current Meters

Maintenance (Marsh-McBirney)

- zero test every two weeks (depending on usage) or prior to going to field
- clean probe when necessary (400-600 grit sandpaper)
- May need laboratory calibration

Doppler-Style Current Meters

Example: Flow-Tracker Acoustic Doppler Meter

- Sound is generated by transmitter
- Sound bounces off suspended particles in the water
- Doppler effect is used to compute velocity

Keypad and Discharge Computer

Doppler-Style Current Meters

Acoustic Doppler Current Profiler (ADCP)

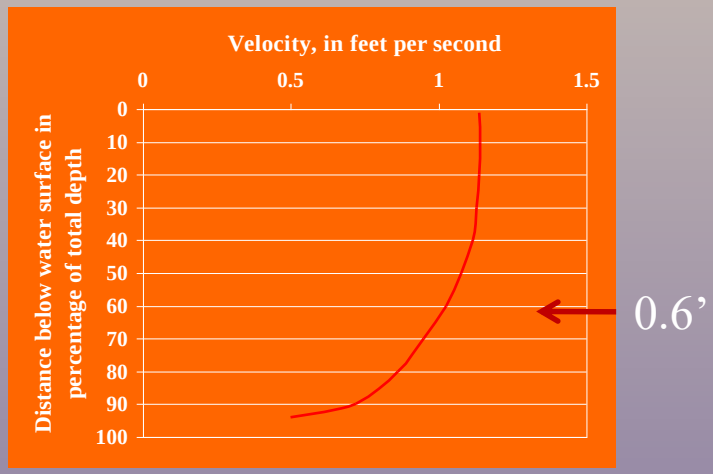
Measuring Flow with Current Meters

- Current meters measure velocity at a point.
- USGS Methodology

  (Rantz, 1982 USGS WSP 2175
  Nolan and Shields WRI 00-4036)
- Typically 20 points across section

  Accuracy Goal per section = 5%

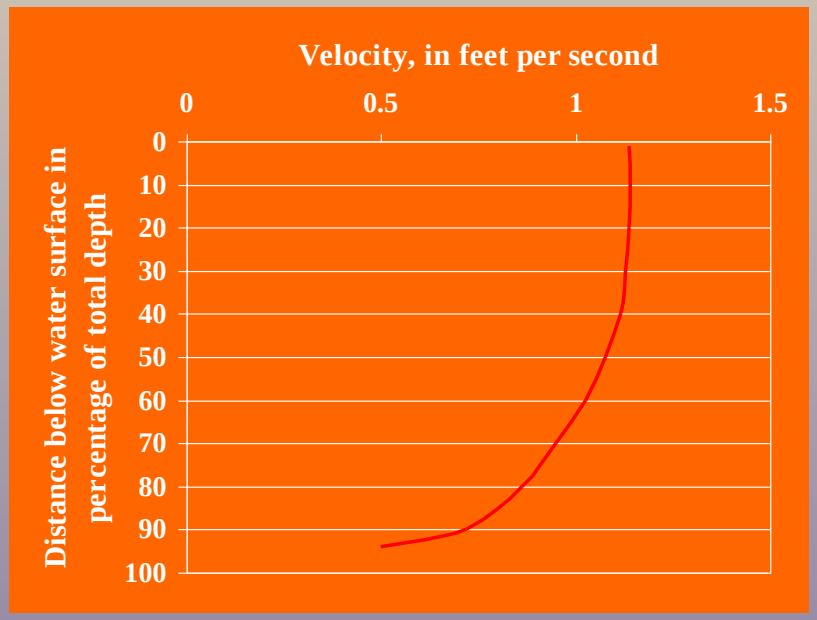
  Re-measure if > 10%
- Meter is placed six-tenths depth from the surface (mean V)
- 40 second intervals



Measuring Flow with Current Meters

- If depth greater than 2.5 feet, 2-point measurement
  - average 0.2 and 0.8 depths

- If velocity profile is “abnormal”, 3-point measurement
  - average 0.6 with average of 0.2 and 0.8



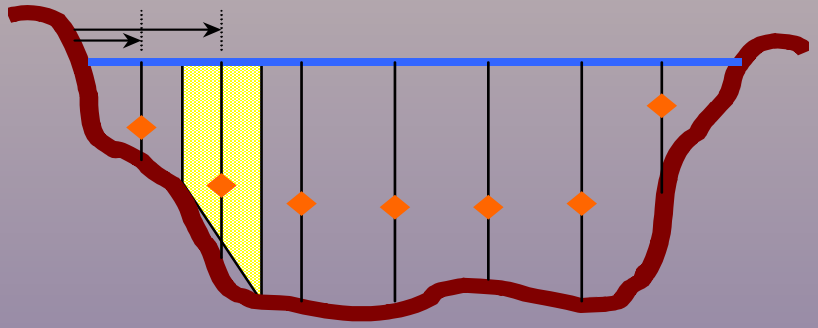
Current Meters

- Velocity-Area principle used to compute discharge

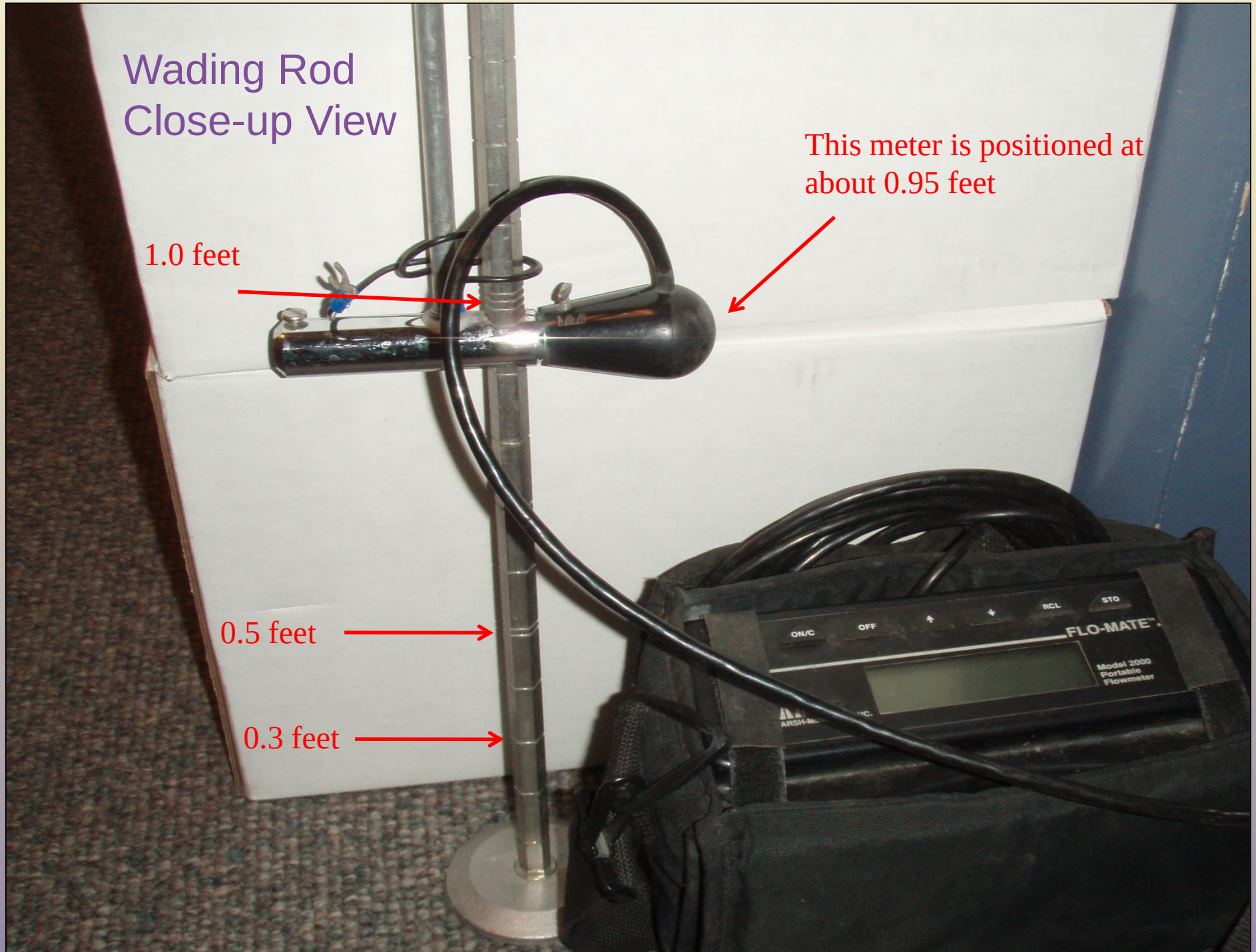
$$Q = A \cdot V$$

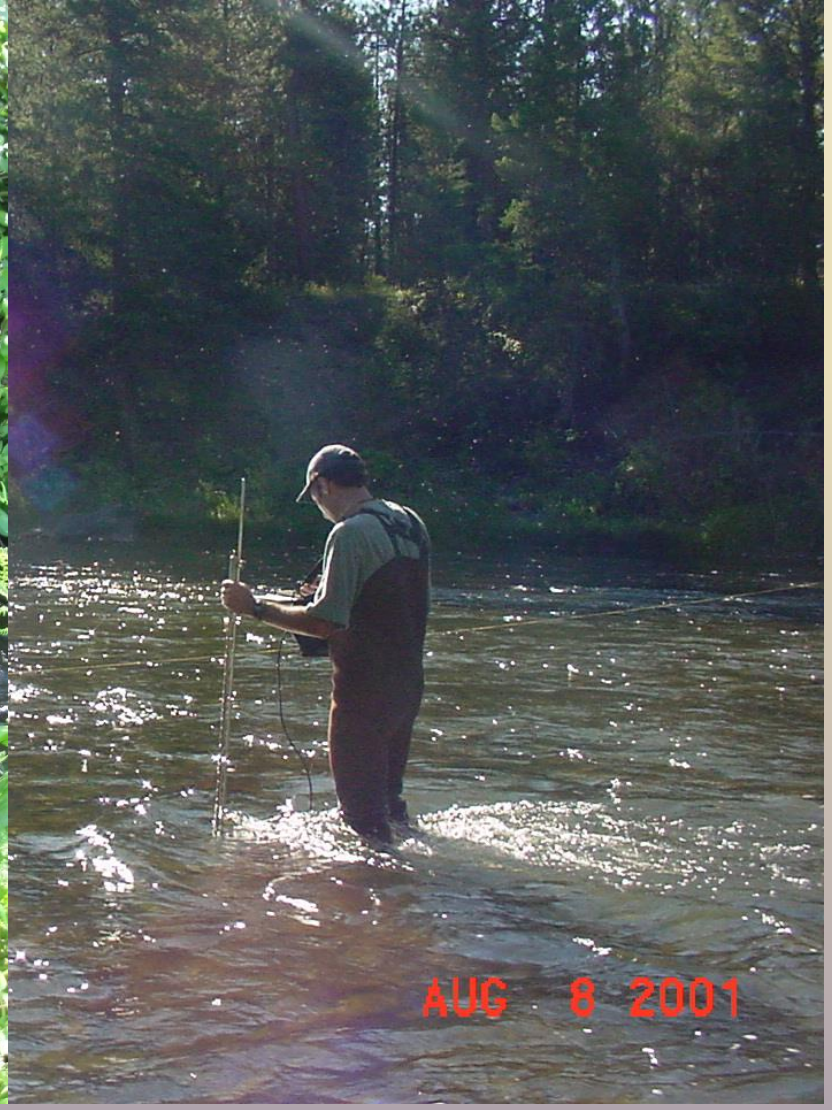
Total discharge is a summation of the partial discharges in measurement sections

$$Q_{Total} = A_1 \cdot V_1 + A_2 \cdot V_2 + \ldots + A_n \cdot V_n$$



Wading Rod Close-up View





Technique: Hold rod perpendicular to channel bottom
Hold instrument parallel to current
Stand behind and to the side of probe
Wear a cool hat

Current Meters

Selection of cross section for conventional current metering

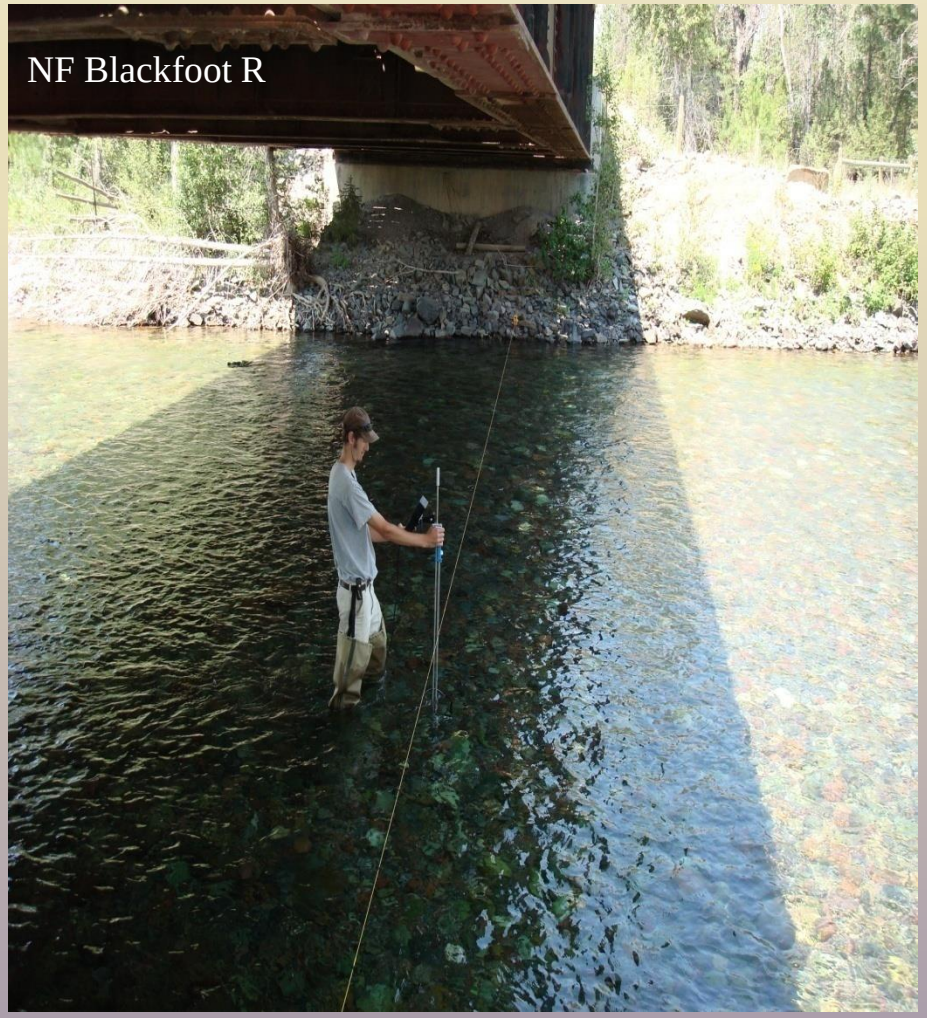
- Cross section should lie within a straight reach, where stream flow lines are parallel to each other
- Velocities should be greater than 0.25 ft/s and depths greater than 0.25 ft
- Streambed should be relatively uniform and free of numerous boulders and heavy aquatic growth

Current Meters

Selection of cross section for conventional current metering (cont)

- Flow in cross section should be relatively uniform and free of eddies, slack water, and excessive turbulence
- Measurement section should be relatively close to the gaging station; there should be no tributary inflows or water diversions between the measurement section and the gage

Site Selection - Q



Good cross-section

Bad cross-section

Sometimes you have no choice

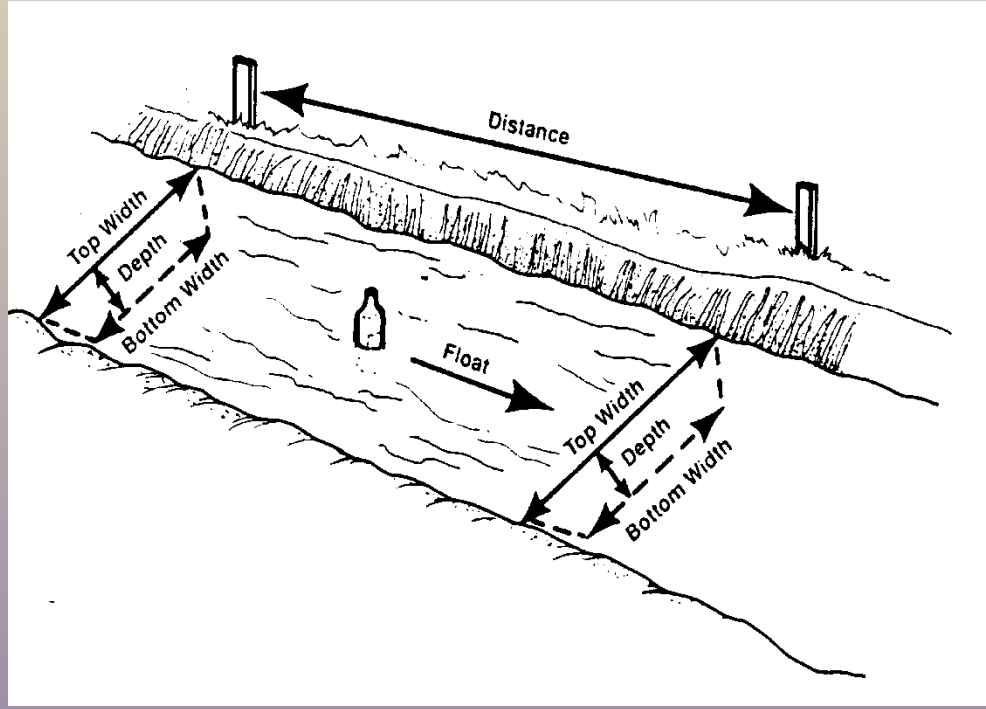
Float-Area Method

- Advantages
  - Useful when elaborate methods not warranted (ballpark assessment)
  - Useful for demonstrating flow-area concept
  - Recognized by DNRC as estimation in water right physical availability analysis

- Disadvantages
  - difficulty in determining average cross section
  - susceptible to wind currents, surface disturbances, and cross currents
  - least accurate of all other methods, not applicable for enforcement
  - Susceptible to criticism in a legal proceeding.

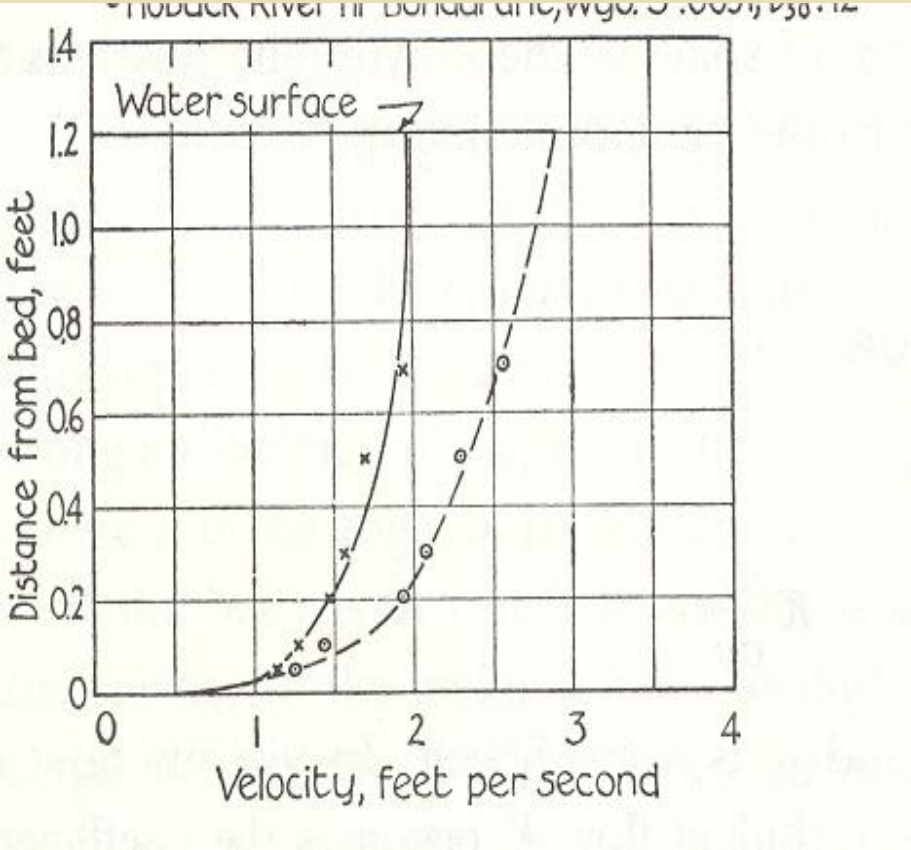
Float-Area Method

- Utilizes Basic Flow Equation to determine discharge
  - $Q = A_{average} \cdot V_{average}$



Float-Area Method

Coefficients for Converting Float Velocity to Water Velocity	
Average Depth (ft)	Coefficient
1	0.66
2	0.68
3	0.70
4	0.72
5	0.74
6	0.76
9	0.77
12	0.78
15	0.79
20 and above	0.80



Quiz for Discussion at end of Class

1) Assuming the priority dates are the same, which purpose of use gets delivered first?

stock irrigation municipal instream flow for fisheries all at the same time

2) An irrigator is using a junior water right that is not in your District Court decree ahead of senior users that are in your decree. What course of action can you take to ensure water is properly diverted in priority?

3) An irrigator has a water right out of Willow Creek for 10 cfs. By the time water travels down a leaky ditch to their field, only 5 cfs remains. What is the maximum amount of water you, as water commissioner, can divert from Willow Creek?

4) A 2' parshall flume reads 1.64'. This equals _____ cfs or _____miners inches

5) Name two things you would check when assessing the proper functioning of a flume or weir in the field?

6) What course of action would you take as a water commissioner if a water user's measuring device is not properly functioning?

Water Supply Organizations

Irrigation Districts

Quasi-governmental organizations authorized by Montana District Courts. Many are associated with USBR Projects. Ex. Helena Valley Irrigation District, Bitterroot Irrigation District, Daly Ditches Irrigation District

Water Users Associations

Associated with State Water projects. Ex. Broadwater-Missouri Water Users Assn, Deadmans Basin Water Users Assn

Ditch or Canal Companies

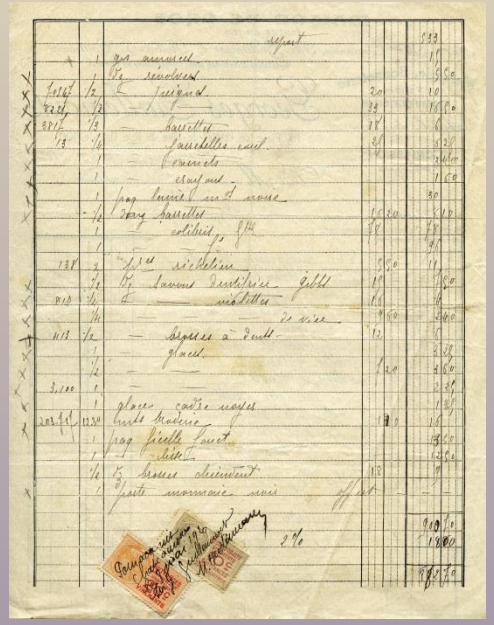
Privately held. Ex. Dearborn Canal and Water Co.

District Court Decree vs. Water Court Decree

- Typically includes all water rights dated before Decree Issued

- Does not reflect newer water rights, permits, or changes

- Typically includes all water rights, permits, changes in appropriation, and is updated annually.



2014 Priority Date Index - Shields River Enforcement Area

Enforceable Priority Date	Water Right #	Owner	Type	Use	Acres	Pod ID	Means	Qtr Sec	Section	Twp Rge	Source	Enf #	Diversion Name	From - To	Cfs	Total Flow
18800601	43A W 11572 00	PORCUPINE CREEK RANCH INC	USE	ST		1	LS	N2SW	34	5N9E	SHIELDS RIVER	LS010	LS010	01 01 12 31		0.00
18830415	43A W 137659 00	MONTANA, STATE OF BOARD OF LAND COMMISSIONERS	USE	ST		1	DT	NWSENE	25	5N9E	SHIELDS RIVER	018	BECKER DITCH	01 01 12 31		0.00
18830425	43A W 193075 00	BRIGHT, GORDON L	DECR	IR	30.8	1	HG	SENWSW	9	4N9E	SHIELDS RIVER	012	BIG CANAL	05 01 10 04	0.43	0.43
18830425		BRIGHT, JACQUELINE J	DECR	IR	30.8	1	HG	SENWSW	9	4N9E	SHIELDS RIVER	012	BIG CANAL	05 01 10 04		0.43
18830425	43A W 31162 00	ADAMS, DIRK S	DECR	IR	104	1*	HG		4	4N9E	SHIELDS RIVER	012	BIG CANAL	05 15 10 19	3.33	3.76
18830425		ADAMS, DIRK S	DECR	IR	104	2*	HG	NWNWNW	3	4N9E	SHIELDS RIVER	014P	ADAMS PUMP SITE	05 15 10 19		3.76
18830425	43A W 33140 00	ADAMS, DIRK S	DECR	ST		1	LS	SESW	16	4N9E	SHIELDS RIVER	LS006	LS006	01 01 12 31		3.76
18830610	43A W 113381 00	ADAMS, ANITA L	DECR	IR	212	1*	HG	SWSWSE	4	4N9E	SHIELDS RIVER	011	UPPER SWANDAL DITCH	04 15 10 31	1.69	5.45
18830610		ADAMS, ANITA L	DECR	IR	212	2*	HG	SESENW	9	4N9E	SHIELDS RIVER	010	MIDDLE SWANDAL DITCH	04 15 10 31		5.45
18830610		ADAMS, ANITA L	DECR	IR	212	3*	HG	SENWSE	9	4N9E	SHIELDS RIVER	009	LOWER SWANDAL DITCH	04 15 10 31		5.45
18830610		ADAMS, DIRK S	DECR	IR	212	1*	HG	SWSWSE	4	4N9E	SHIELDS RIVER	011	UPPER SWANDAL DITCH	04 15 10 31		5.45
18830610		ADAMS, DIRK S	DECR	IR	212	2*	HG	SESENW	9	4N9E	SHIELDS RIVER	010	MIDDLE SWANDAL DITCH	04 15 10 31		5.45
18830610		ADAMS, DIRK S	DECR	IR	212	3*	HG	SENWSE	9	4N9E	SHIELDS RIVER	009	LOWER SWANDAL DITCH	04 15 10 31		5.45
18830610	43A W 11582 00	PORCUPINE CREEK RANCH INC	DECR	IR	425	1	HG	NWSENE	25	5N9E	SHIELDS RIVER	018	BECKER DITCH	05 15 09 19	0.56	6.01
18830610	43A W 191857 00	ADAMS, ANITA L	USE	ST		1*	DT	SWSWSE	4	4N9E	SHIELDS RIVER	011	UPPER SWANDAL DITCH	01 01 12 31		6.01
18830610		ADAMS, ANITA L	USE	ST		2*	DT	SESENW	9	4N9E	SHIELDS RIVER	010	MIDDLE SWANDAL DITCH	01 01 12 31		6.01
18830610		ADAMS, ANITA L	USE	ST		3*	DT	SENWSE	9	4N9E	SHIELDS RIVER	009	LOWER SWANDAL DITCH	01 01 12 31		6.01

Open channel measuring device selection: Choose the type of measuring device you the water commissioner would most likely recommend under the following conditions.

1) Moderate to high head loss, low sediment load.

2) High sediment load, trapezoidal ditch, potential for submerged conditions.

3) Need to measure seepage below a dam. Expected flows 0.5-2 cfs.

4) Low head loss, moderate to high sediment load, wide range of flows.

5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible.

6) Water right is contract water that is administered based on volume.

7) A ditch has a number of standard outlets through pipe conduits.

8) DNRC hydrologist is on-site and you want to check accuracy of your weir.

Open channel measuring Device Selection: Choose the type of measuring device you the water commissioner would most likely recommend under the following conditions.

1) Moderate to high head loss, low sediment load. weir

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Open channel measuring Device Selection: Choose the type of measuring device you the water commissioner would most likely recommend under the following conditions.

1) Moderate to high head loss, low sediment load. weir

2) High sediment load, trapezoidal ditch, potential for submerged conditions. broad-crested weir or ramp flume

3) Need to measure seepage below a dam. Expected flows 0.5-2 cfs.

4) Low head loss, moderate to high sediment load, wide range of flows.

5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible.

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2) High sediment load, trapezoidal ditch, potential for submerged conditions. broad-crested weir or ramp flume

3) Need to measure seepage below a dam. Expected flows 0.5-2 cfs. **V-notch or small rectangular weir**

4) Low head loss, moderate to high sediment load, wide range of flows.

5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible.

6) Water right is contract water that is administered based on volume.

7) A ditch has a number of standard outlets through pipe conduits.

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3) Need to measure seepage below a dam. Expected flows 0.5-2 cfs. V-notch or small rectangular weir

4) Low head loss, moderate to high sediment load, wide range of flows. flume

5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible.

6) Water right is contract water that is administered based on volume.

7) A ditch has a number of standard outlets through pipe conduits

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4) Low head loss, moderate to high sediment load, wide range of flows. flume

5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible. **bucket, stop watch**

6) Water right is contract water that is administered based on volume.

7) A ditch has a number of standard outlets through pipe conduits.

8) DNRC hydrologist is on-site and you want to check accuracy of your weir.

Open channel measuring Device Selection: Choose the type of measuring device you the water commissioner would most likely recommend under the following conditions.

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2) High sediment load, trapezoidal ditch, potential for submerged conditions. broad-crested weir or ramp flume

3) Need to measure seepage below a dam. Expected flows 0.5-2 cfs. V-notch or small rectangular weir

4) Low head loss, moderate to high sediment load, wide range of flows. flume

5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible. bucket, stop watch

6) Water right is contract water that is administered based on volume. **flume with totalizer**

7) A ditch has a number of standard outlets through pipe conduits.

8) DNRC hydrologist is on-site and you want to check accuracy of your weir.

Open channel measuring Device Selection: Choose the type of measuring device you the water commissioner would most likely recommend under the following conditions.

1) Moderate to high head loss, low sediment load. weir

2) High sediment load, trapezoidal ditch, potential for submerged conditions. broad-crested weir or ramp flume

3) Need to measure seepage below a dam. Expected flows 0.5-2 cfs. V-notch or small rectangular weir

4) Low head loss, moderate to high sediment load, wide range of flows. flume

5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible. bucket, stop watch

6) Water right is contract water that is administered based on volume. flume, totalizer

7) A ditch has a number of standard outlets through pipe conduits. **portable propeller, ultra sonic meter**

8) DNRC hydrologist is on-site and you want to check accuracy of your weir.

Open channel measuring Device Selection: Choose the type of measuring device you the water commissioner would most likely recommend under the following conditions.

1) Moderate to high head loss, low sediment load. weir

2) High sediment load, trapezoidal ditch, potential for submerged conditions. broad-crested weir or ramp flume

3) Need to measure seepage below a dam. Expected flows 0.5-2 cfs. V-notch or small rectangular weir

4) Low head loss, moderate to high sediment load, wide range of flows. flume

5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible. bucket, stop watch

6) Water right is contract water that is administered based on volume. flume, rated section, totalizer

7) A ditch has a number of standard outlets through pipe conduits. portable propeller, ultra sonic meter

8) DNRC hydrologist is on-site and you want to check accuracy of your weir. **current meter**