Ministry of Agriculture

Efficient Irrigation

Andrew Petersen, P.Ag., CID.
Water Management Specialist

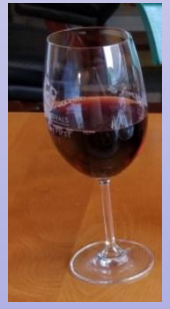
CANADIAN AGRICULTURAL PARTNERSHIP
Innovate. Grow. Prosper.

BRITISH COLUMBIA

Canada

Agriculture and Water

- Livestock
- Crops
- Processing



Importance of water for agriculture

- Life requires water
  - Livestock
  - Plants
  - Value of water
  - What if we don't have it?
- Where do we get our water?
  - Precipitation – rain, snow
  - Streams - rivers, lakes, creeks, springs
  - Groundwater – wells, dugouts

What Right do we have to Water

- First water licences 1864
- *Water Act* – 1909
  - Surface water
- *Water Sustainability Act* – 2016
  - Groundwater
- First in Time - First in Right (FITFIR)
  - Purpose – irrigation, stock-watering, domestic

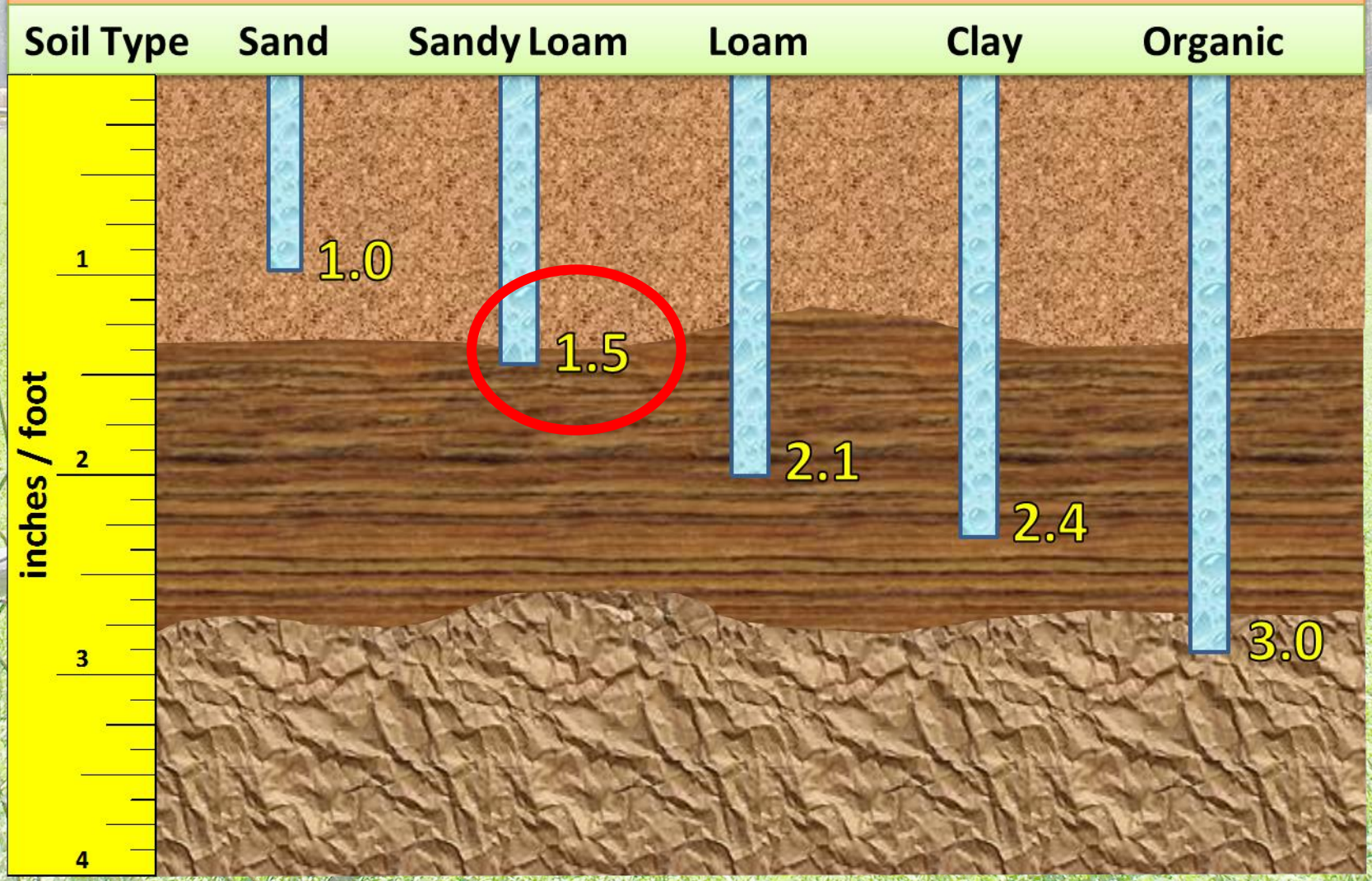
Why do we Irrigate?

- To grow a productive crop
- To replenish Soil Moisture
- Soil is our storage tank for water
- Soil structure is very important

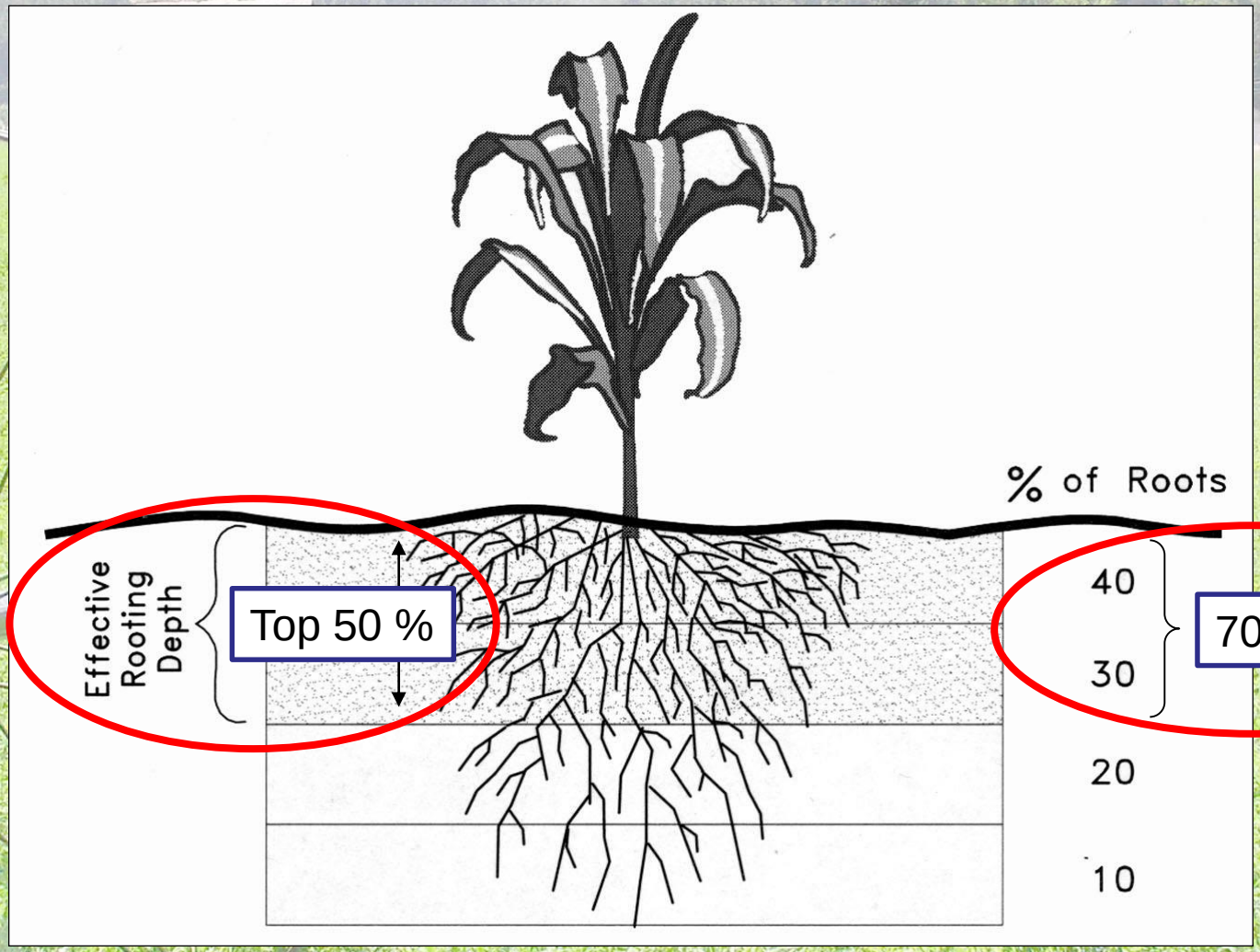
Soil Structure

Water Storage Capacity

Available Water Storage Capacity (AWSC)



Effective Rooting Depth

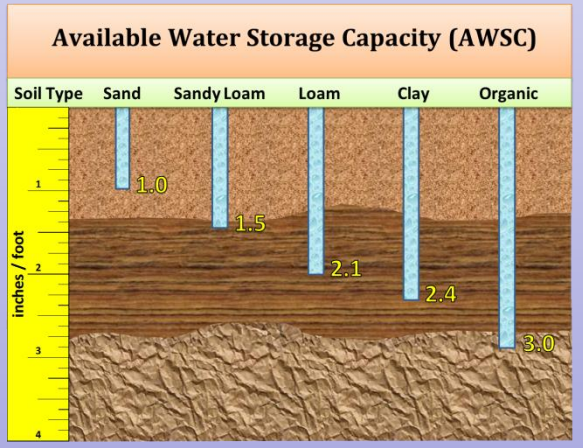


Effective Rooting Depth

Shallow 0.45 m (1.5 ft)	Medium Shallow 0.6 m (2 ft)	Medium Deep 0.9 m (3 ft)	Deep 1.2 m (4 ft)
Cabbages	Beans	Brussels Sprouts	Alfalfa
Cauliflowers	Beets	Cereal	Asparagus
Cucumbers	Blueberries	Clover (red)	Blackberries
Lettuce	Broccoli	Corn (sweet)	Corn (field)
Onions	Carrots	Eggplant	Grapes
Radishes	Celery	Kiwifruit	Loganberries
Turnips	Peas	Peppers	Raspberries
Grass	Potatoes	Squash	Sugar beets
Conifer Tree Shallow	Spinach	Saskatoons	Tree Fruits (12′ x 18′)
	Strawberries	Tree Fruits (6′ x 12′)	
	Tomatoes		
	Tree Fruits (3′ x 10′)		
	Conifer Tree		

How much water can the soil store?

- Depends on soil type and tree rooting depth.
- Field Corn = 4.0 ft root depth
- Sandy loam = 1.5 in water / ft
- Total AWSC = 4.0 x 1.5
- = 6.0 in



Shallow Rooted Crop

- If grass is grown instead:
- Grass = 1.5 ft root depth
- Sandy loam = 1.5 in water / foot
- Total AWSC = 1.5 x 1.5
- = 2.25 in

Availability Coefficient, (AC)

Maximum percentage of the total AWSC that the crop can remove before irrigation should occur again.

Crop	Maximum Percent
Peas	35
Potatoes	35
Tree Fruits	40
Grapes	40
Others	50
Conifer Tree	70

How much water can be applied at one time?

- Maximum Soil Water Deficit is the amount of water that is readily available to the crop.

MSWD = AWSC x AC

Example

MSWD (Corn) = 6.0 x 0.50

= 3.0 **inch**

What if it was shallow rooted crop?

- Maximum Soil Water Deficit:

  MSWD (Grass) = 2.25 x 0.50

  = 1.3 inch

- Same field but need to manage the irrigation system differently.

How do we apply this water?

- Irrigation systems types

  Application Rates (AR)

  - Is the depth of water applied by the irrigation system per hour

  Application Efficiency (AE)

  - Is an indication of the percentage of water applied by an irrigation system that is actually available to the crop

Stationary Gun

AE = 58%

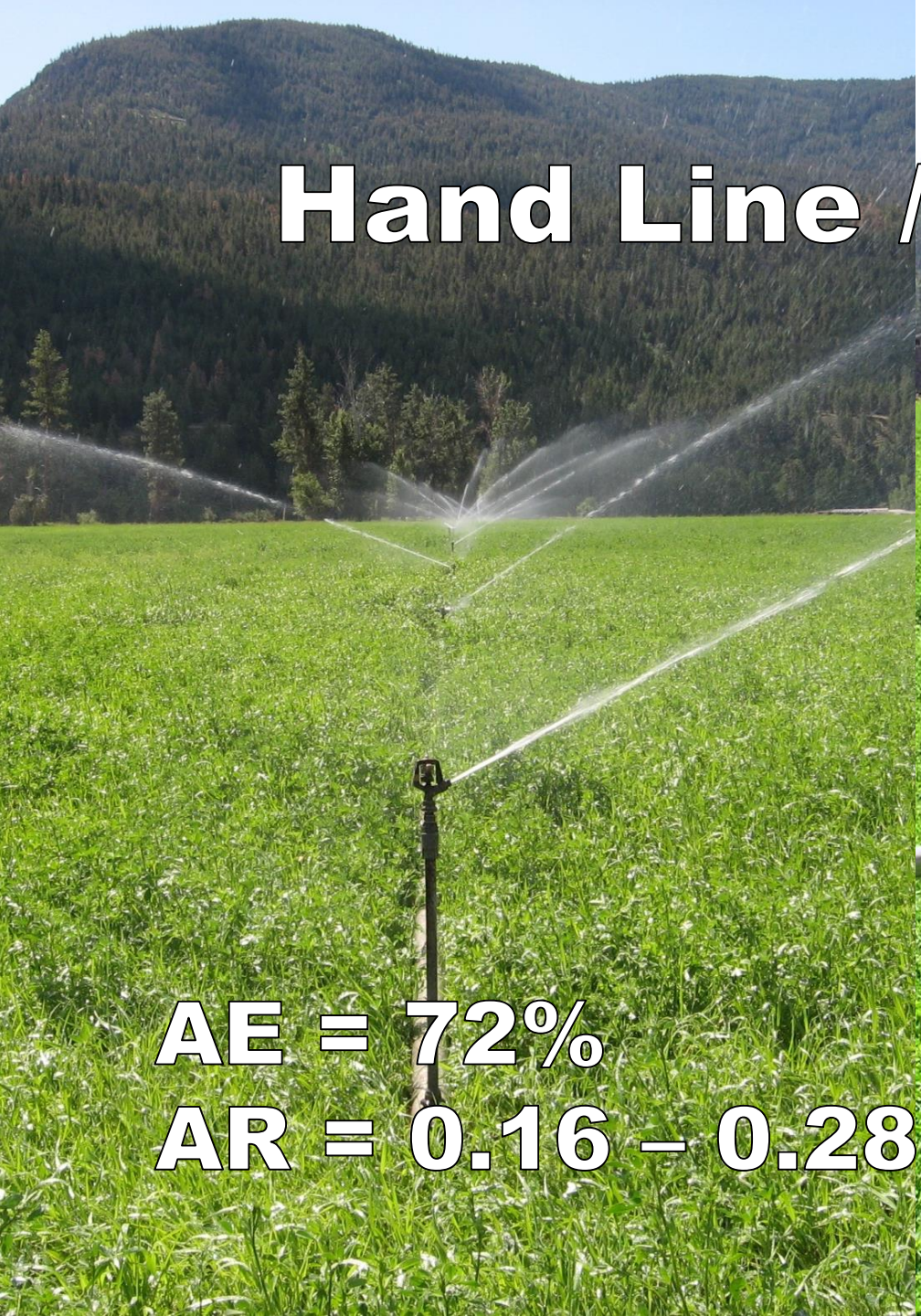
AR = 0.5 – 0.75 in/hr

Travelling Gun

AE = 65%

AR = 0.75 – 1.0 in/hr

Hand Line / Wheel Line



AE = 72%

AR = 0.16 – 0.28 in/hr

Micro Sprinkler

AE = 80%

AR = 0.15 – 0.5 in/hr

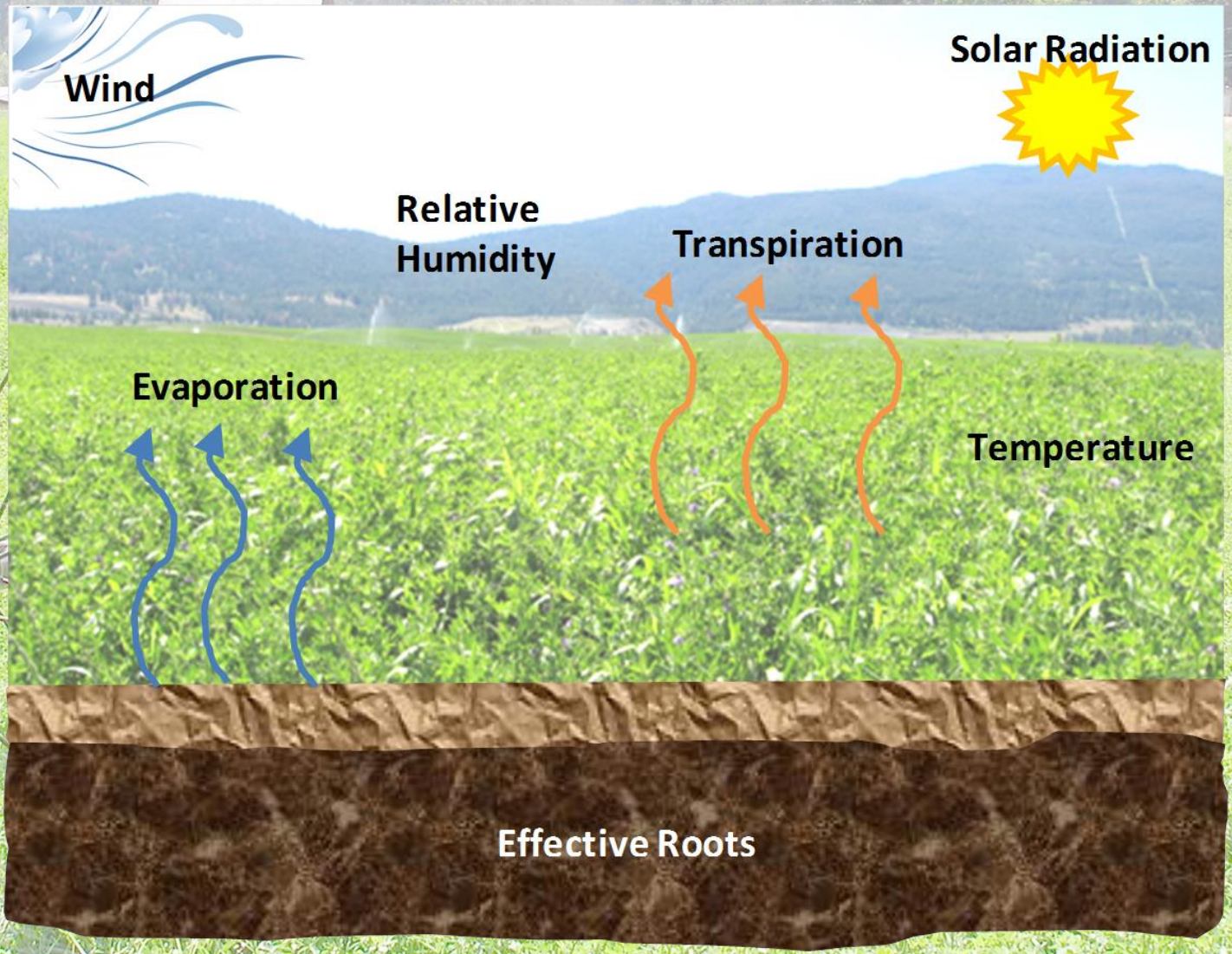
Drip or Trickle

AE = 90%

AR = 0.1 -0.2 in/hr

How is this water consumed?

- Evapotranspiration: (ET)



Evapotranspiration

Peak Evapotranspiration Rates for Various B.C. Locations

Location	MSWD 2 in ln/d	MSWD 3 in in/d	Location	MSWD 2 in ln/d	MSWD 3 in in/d	Location	MSWD 2 in ln/d	MSWD 3 in in/d
Abbotsford	0.16	0.15	Golden	0.15	0.15	Oliver	0.26	0.24
Agassiz	0.16	0.15	Grand Forks	0.19	0.19	100 Mile House	0.24	0.23
Alexis Creek	0.16	0.15	Grandview Flats	0.27	0.25	Osoyoos	0.3	0.28
Armstrong	0.23	0.21	Grasmere	0.23	0.22	Oyster River	0.13	0.12
Ashcroft								0.16
Aspen Grove								0.13
Barriere								0.2
Baynes Lake								0.15
Campbell River								0.25
Canal Flats								0.26
Castlegar								0.2
Cawston								0.28
Chase								0.16
Cherryville								0.17
Chilliwack								0.15
Clinton								0.19
Cloverdale								0.17
Comox								0.26
Creston								0.3
Dawson Creek								0.18
Douglas Lake								0.2
Duncan								0.22
Ellison								0.29
Fort Fraser	0.2	0.19	Natal	0.19	0.18	Westwold	0.28	0.27
Fort Steele	0.23	0.22	Notch Hill	0.21	0.2	Williams Lake	0.29	0.28
Fort St. John	0.19	0.19	Oliver	0.26	0.24			

Location	MSWD 2 in ln/d	MSWD 3 in in/d
Golden	0.15	0.15
Grand Forks	0.19	0.19
Grandview Flats	0.27	0.25
Grasmere	0.23	0.22
Grindrod	0.16	0.14

Irrigation Interval, II

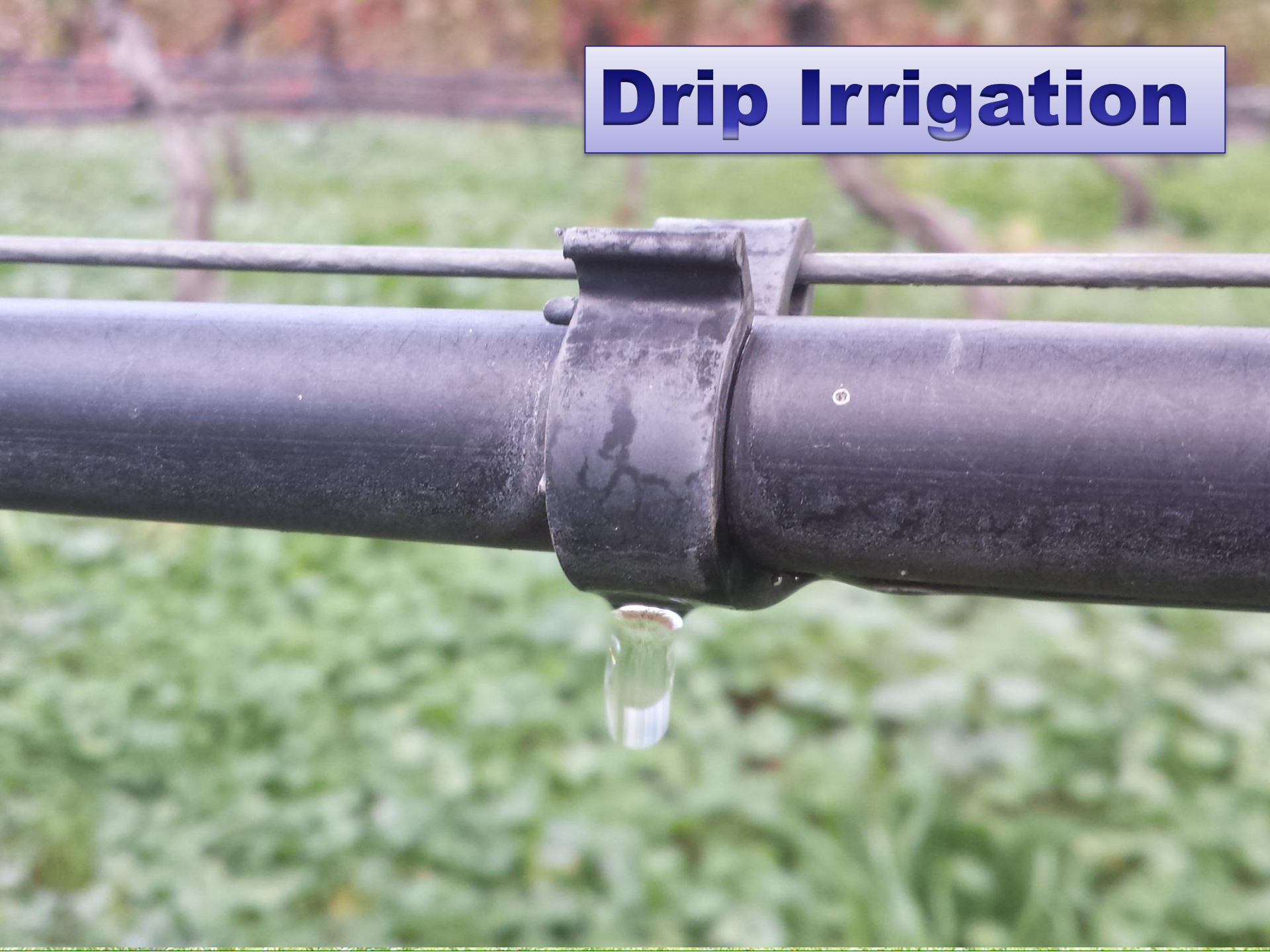
Irrigation Interval = MSWD / ET

For crops in Grand Forks (ET = 0.19 in/day)

- II (Corn) = 3.0 / 0.19 = 16 days
- II (Grass) = 1.3 / 0.19 = 7 days

For crops in Osoyoos (ET = 0.3 in/day)

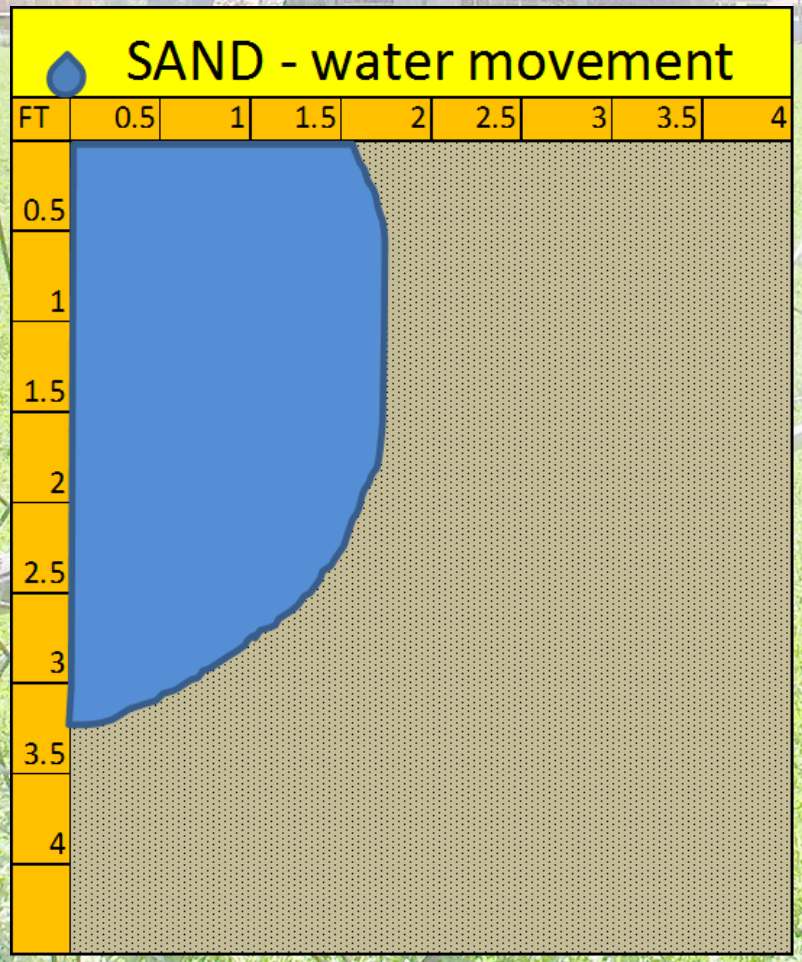
- II (Deep RD) = 3.0 / 0.3 = 10 days
- II (Shallow RD) = 1.3 / 0.3 = 4 days

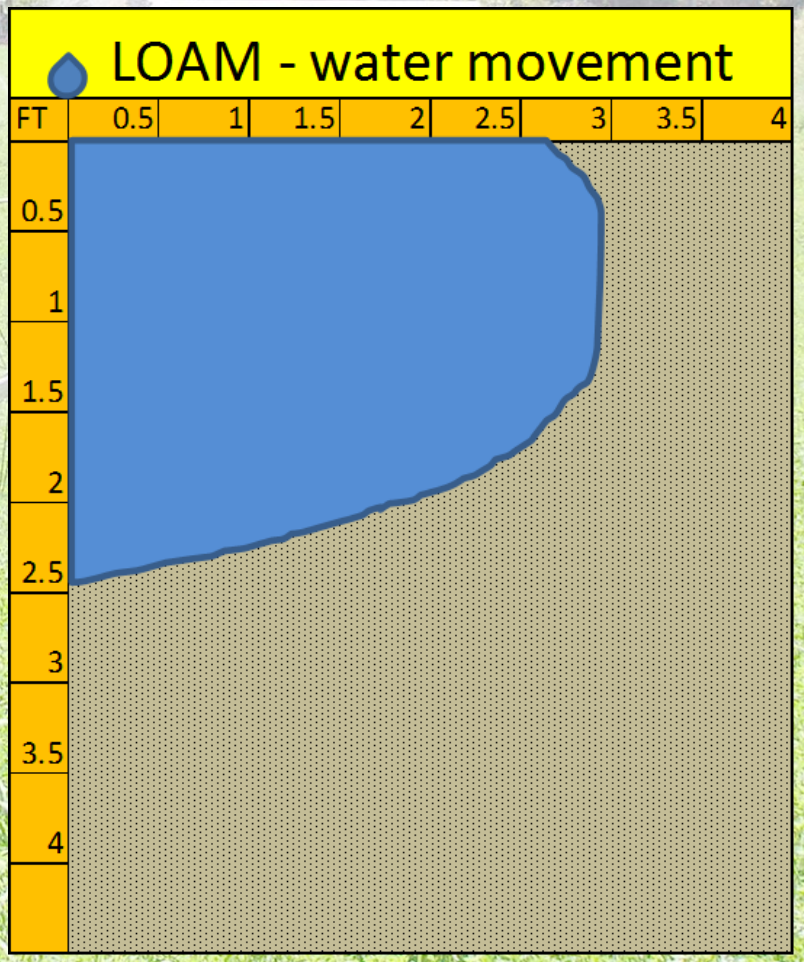

Drip Irrigation

For Drip Systems

- For point source trickle systems
  - water requirement is calculated per plant
  - US Gallons or Litres per Plant per Day
- For linear tape systems
  - water requirement is calculated per row
  - US Gallons or Litres per Row per Day

Lateral Movement of Water in Soil





Plant Water Requirement

G/P/D = 0.623 x ET x S x A x K

ET	-	Peak evapotranspiration
S	-	Soil water storage factor
A	-	Area per plant
K	-	Crop coefficient factor

Drip Irrigation Design

Example

- Tree Fruit Orchard
  - Spacing 7.5’ x 15’
    - Area = 112.5’
  - Sandy Loam Soil
    - MSWD = 3.0 inch

Evapotranspiration, ET

Location	MSWD	
	2 in In/d	3 in in/d
Golden	0.15	0.15
Grand Forks	0.19	0.19
Grandview Flats	0.27	0.25
Grasmere	0.23	0.22
Grindrod	0.16	0.14

Soil Water Storage Factor, S

Effective Soil Water Storage Factor		
MSWD	**Peak ET (in/day)**	**S Factor**
3.0 inches +	0.3	0.8
	0.25	0.75
	0.2	0.75
2.0 inches	0.3	0.85
	0.25	0.8
	0.2	0.75
1.0 inches	0.3	0.95
	0.25	0.9
	0.2	0.85

Crop Coefficient Factor, K

Crop Coefficient Factor (K)			
Crop	**Crop Coefficient**	**Approximate Spacing**	
Apples	0.9	Grapes	0.7
Apricots	0.8	Blueberries	0.8
Cherries	0.9	Blackberries	0.6
Peaches	0.8	Kiwi Fruit	1
Pears	0.8	Logan Berries	0.6
Plums	0.8	Raspberries	0.7
Tree Fruits – High Density	1	Strawberries	0.75
		Tomatoes	0.9
		Vegetables	0.75

Plant Water Requirement

- Gallons per Plant per Day (G/P/D)
- G/P/D = 0.623 x ET x S x A x K

  = 0.623 x 0.19 x 0.75 x 112.5 x 0.9

  = 9.0 USgpd (daily)

Trickle System Design Capacity

$$TC = \frac{G/P/D \times L}{E \times Eu}$$

- GPD - gallons per plant per day
- L - leaching factor
- E - application efficiency
- Eu - emission uniformity

Leaching Factor, L

Leaching Factors for Trickle Irrigation System Design		
Region	**Rooting Depth**	**Leaching Factor**
Okanagan, Kootneys, Thompson	Less than 2 ft	1.05
	Greater than 2 ft	1.10
South Coastal	All	1.00
Fertigation System	All	1.10

Trickle System Design Capacity, TC

- For orchard in Grand Forks

$$TC = \frac{G/P/D \times L}{E \times Eu}$$

$$= \frac{9.0 \times 1.1}{0.92 \times 0.9}$$

$$= 12 \text{ USgpd}$$

(adds about 1/3 more water)

Water Storage

- How big does it need to be?
  - Total storage for season
  - Partial storage with recharge
- Storage = Duty x Field Area
  - Depth of Duty
  - How many acres

Licenced Water Duty

- Grand Forks = 18 inch
- Creston = 24 inch
- Malakwa = 12 inch
- Invermere = 24 inch

Field Size

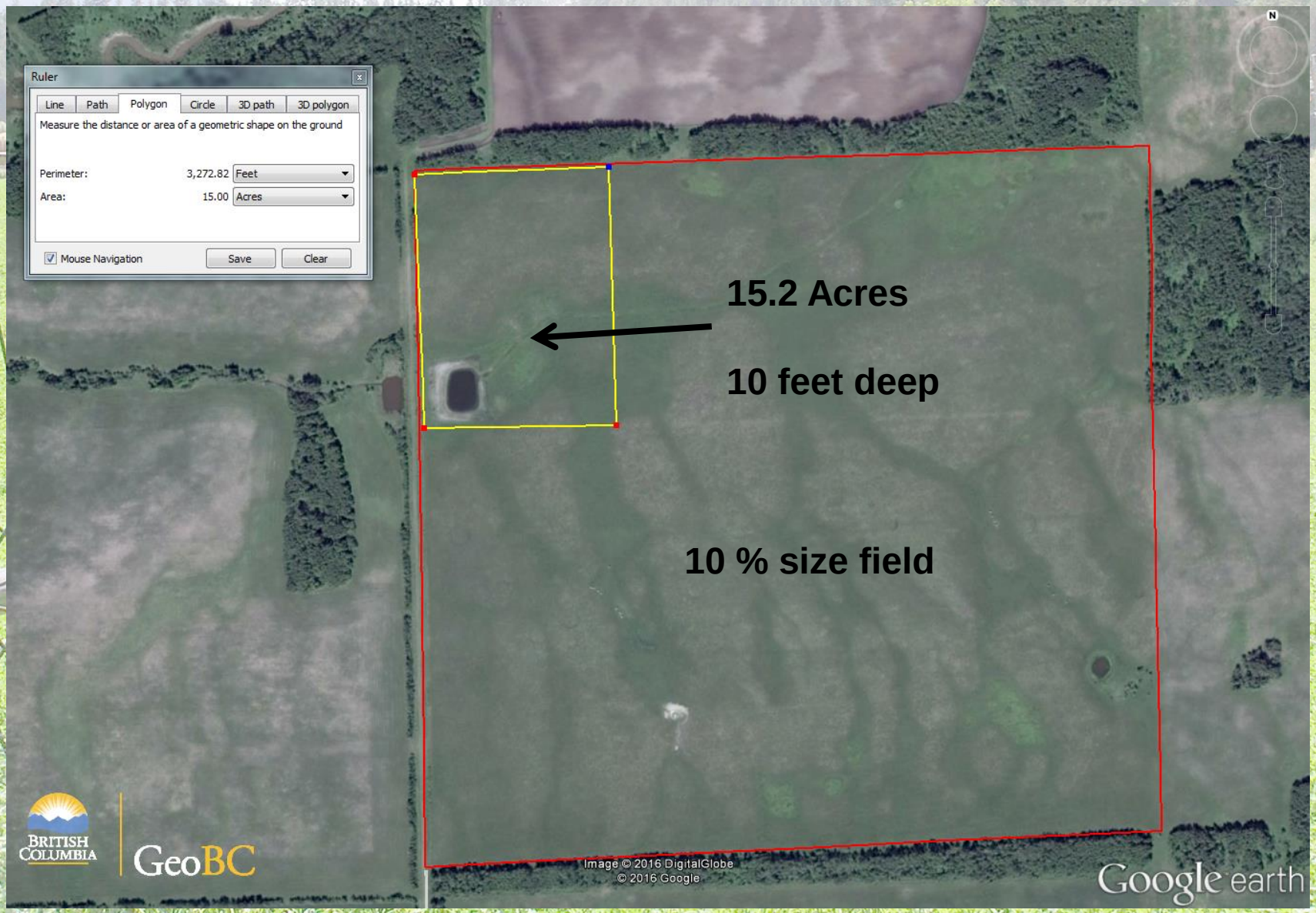

Ruler
Line
Path
Polygon
Circle
3D path
3D polygon
Measure the distance or area of a geometric shape on the ground
Perimeter: 10,340.60 Feet
Area: 152.50 Acres
Mouse Navigation
Save
Clear
152 acres
BRITISH COLUMBIA
GeoBC
Image © 2016 DigitalGlobe
© 2016 Google
Google earth

Irrigation Water Required

- Storage = Duty x Field Area
  - Duty = 12 inch or 1 foot
  - Area = 152 acres
  - Storage = 1 x 152 = 152 acre feet
  - Dugout 10 feet deep = 15 acres

Dugout Size - Irrigation

Required dugout size



Stockwatering Dugout

Stock Watering

TABLE 1 ESTIMATED AVERAGE DAILY WATER CONSUMPTION FOR LIVESTOCK (US GALLONS PER DAY)

TYPE OF ANIMAL	DESCRIPTION	US GPD
BEEF		
cow with calf *	1,300 lb	12
dry cow/mature cow *	1,300 lb	10
calf *	250 lb	3
feeder – growing **	400-800 lb	6 - 9
feeder – finishing **	600-1,200 lb	9 - 12
bull	--	12
DAIRY		
milking * (with wash water)	holstein	36
dry cow/replacement	holstein	12
calf	to 550 lb	3.5
SHEEP AND GOATS		
ewe/doe	--	2.5
milking ewe/doe	--	3.5
feeder lamb/kid	--	2
BISON, HORSE, MULE	--	12

TYPE OF ANIMAL	DESCRIPTION	US GPD
SWINE (with wash water)		
farrow - finish	--	24 / sow
farrow - late wean	50 lb	8 / sow
farrow - early wean	15 lb	6.5 / sow
feeder	50 - 250 lb	2 / pig
weaner	15 - 50 lb	0.6 / pig
POULTRY		
broiler	per 100	4.2
roaster/pullet	per 100	4.8
layer	per 100	6.5
breeder	per 100	8.5
turkey - grower	per 100	15.5
turkey - heavy	per 100	19
OSTRICH	--	1.2
DEER, LLAMA, ALPACA	--	2.5
ELK, DONKEY	--	6

Livestock Water Storage

- Beef – 100 Cows
  - 12 US gpd
  - 100 x 12 = 1200 US gpd
- Dairy – 100 Cows
  - 36 US gpd
  - 100 x 36 = 3600 US gpd
- Poultry – 10,000 Layers
  - 6.5 US gpd / 100 birds
  - 6.5 x 100 = 650 US gpd

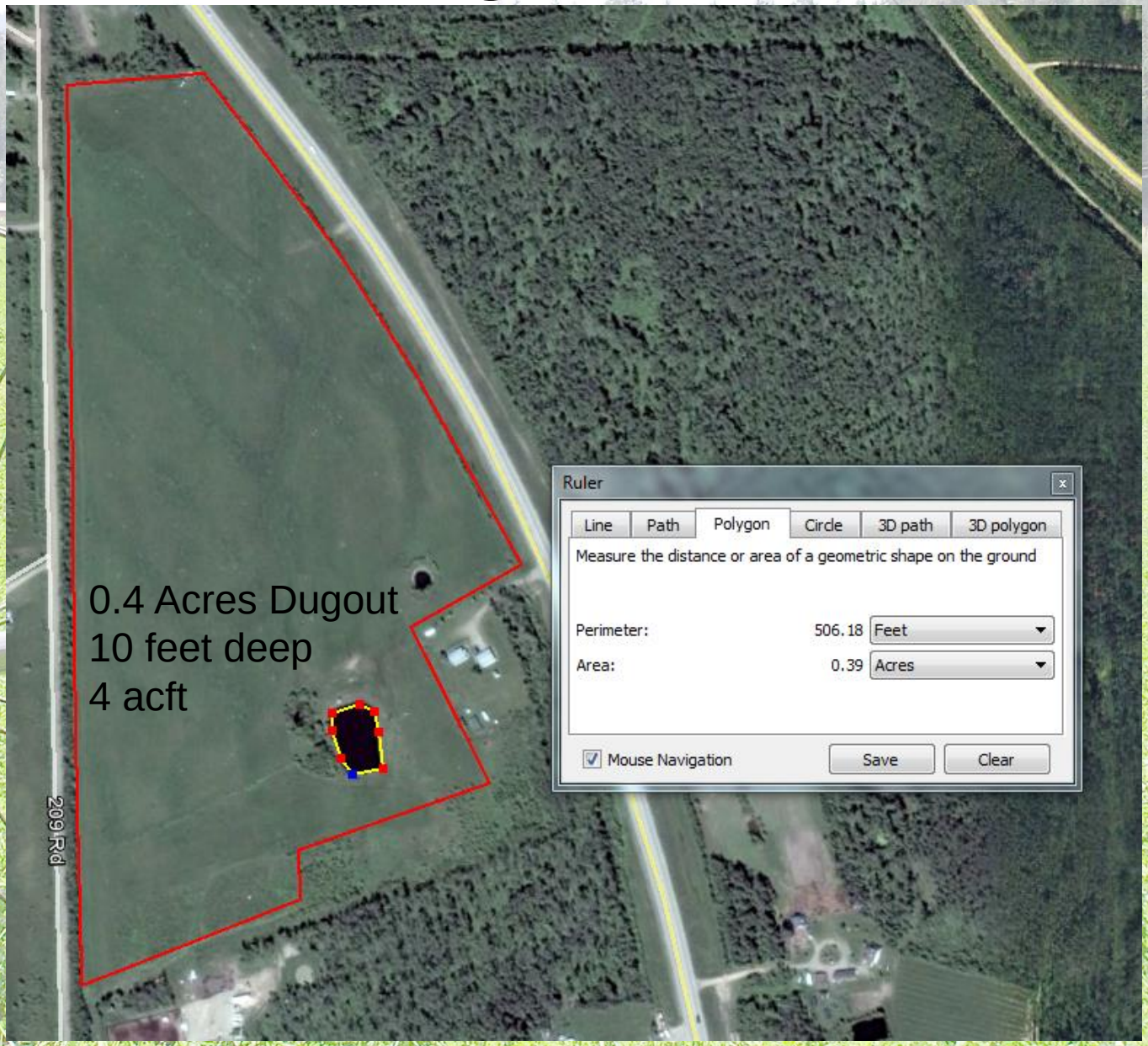
Livestock Water Storage

- Dairy Example
  - Annual water use = 3600 USgpd x 365 day/yr

    = 1.3 million USG

    = 4 acft

Current Dugout - Livestock

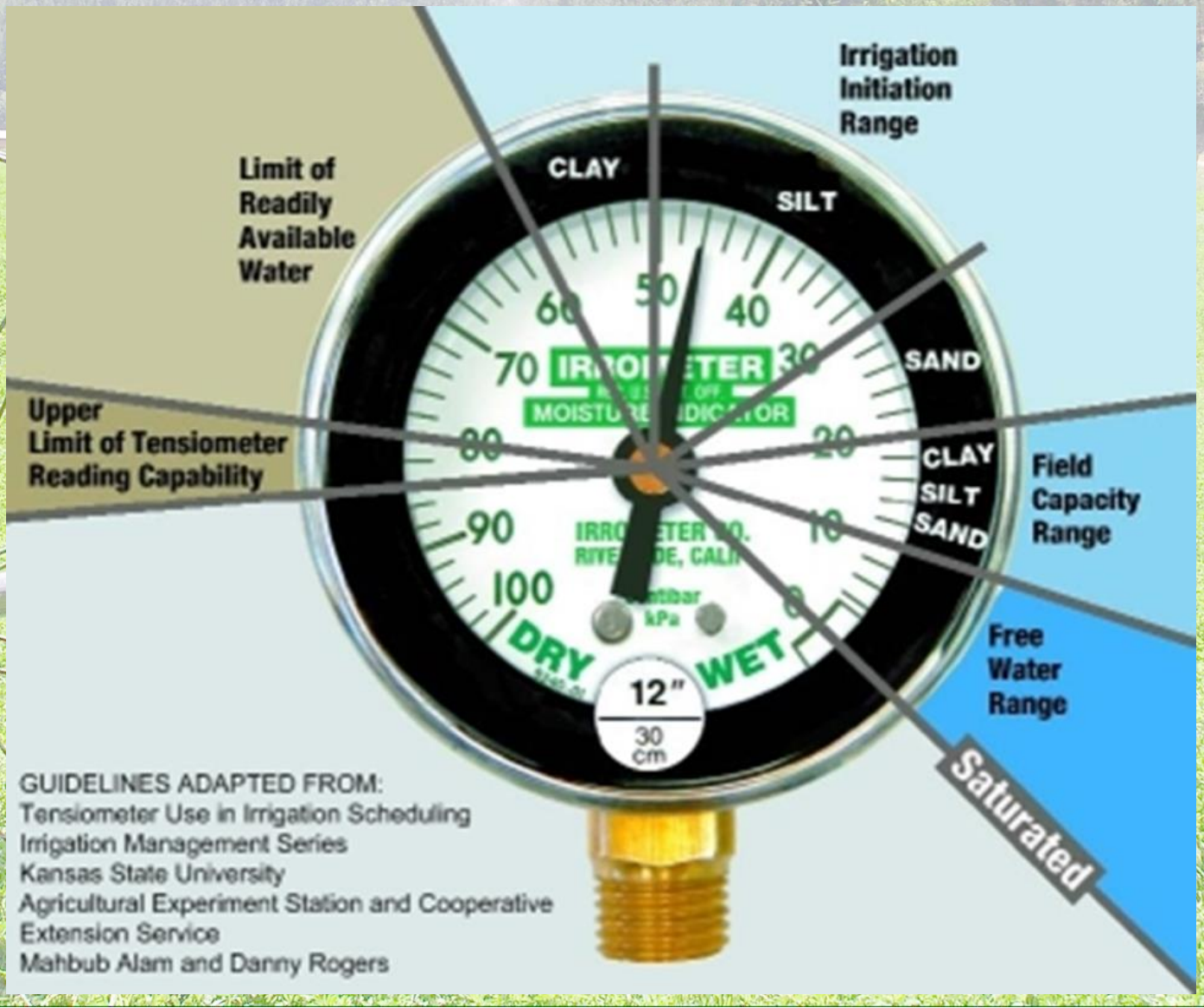


Irrigation Scheduling Methods

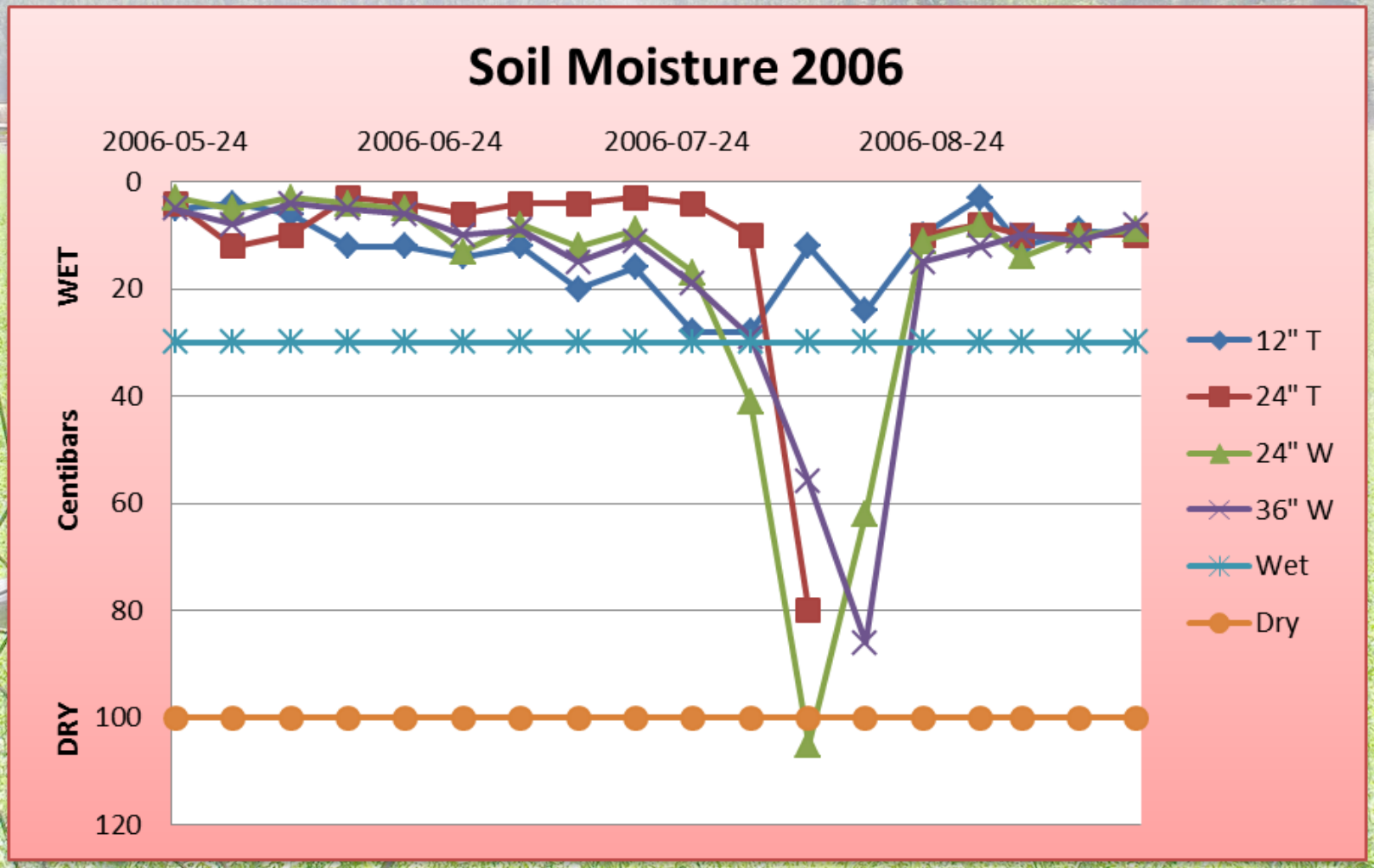
Soil Method

Climatic Method

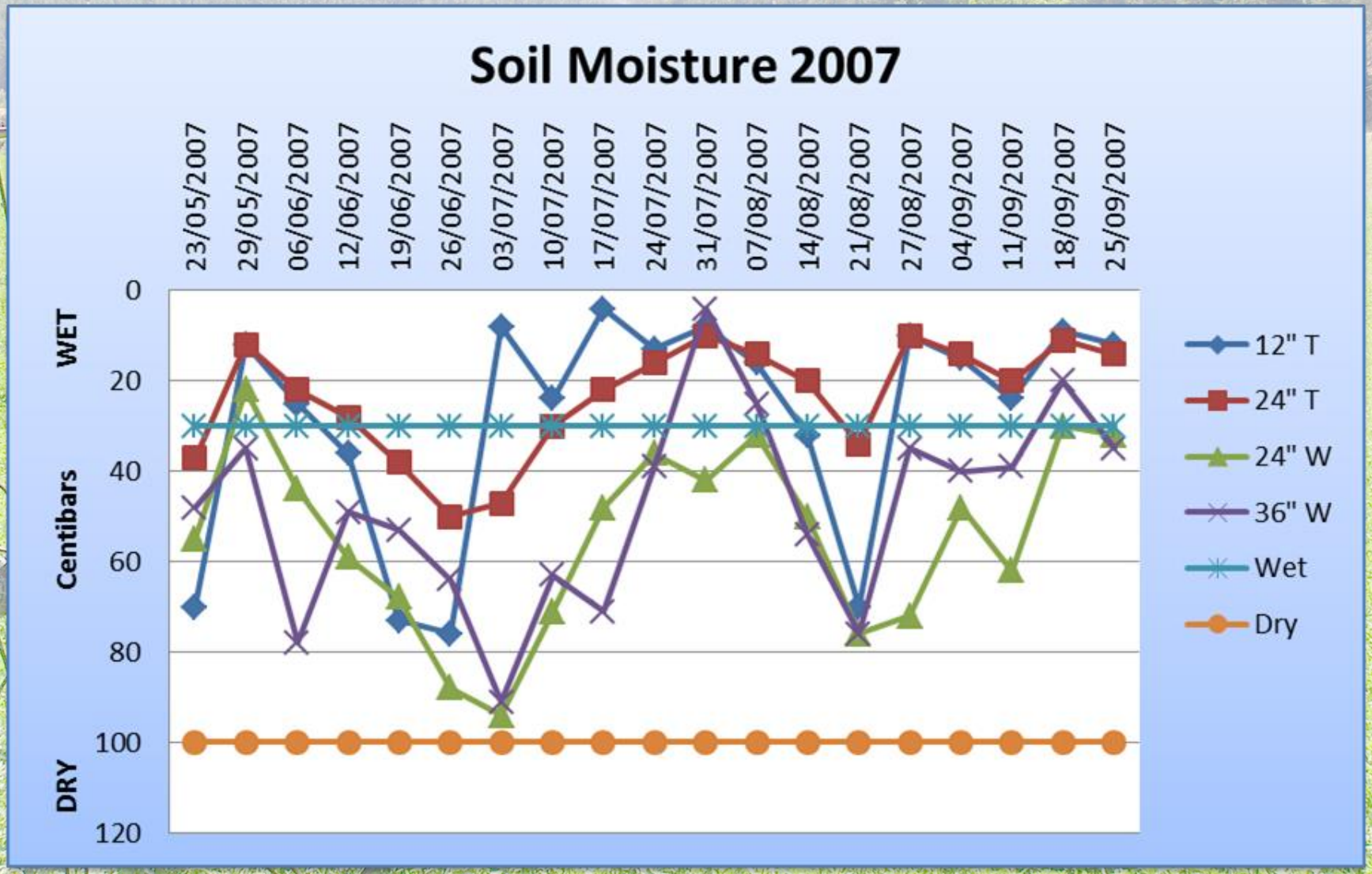
Soil Moisture Method



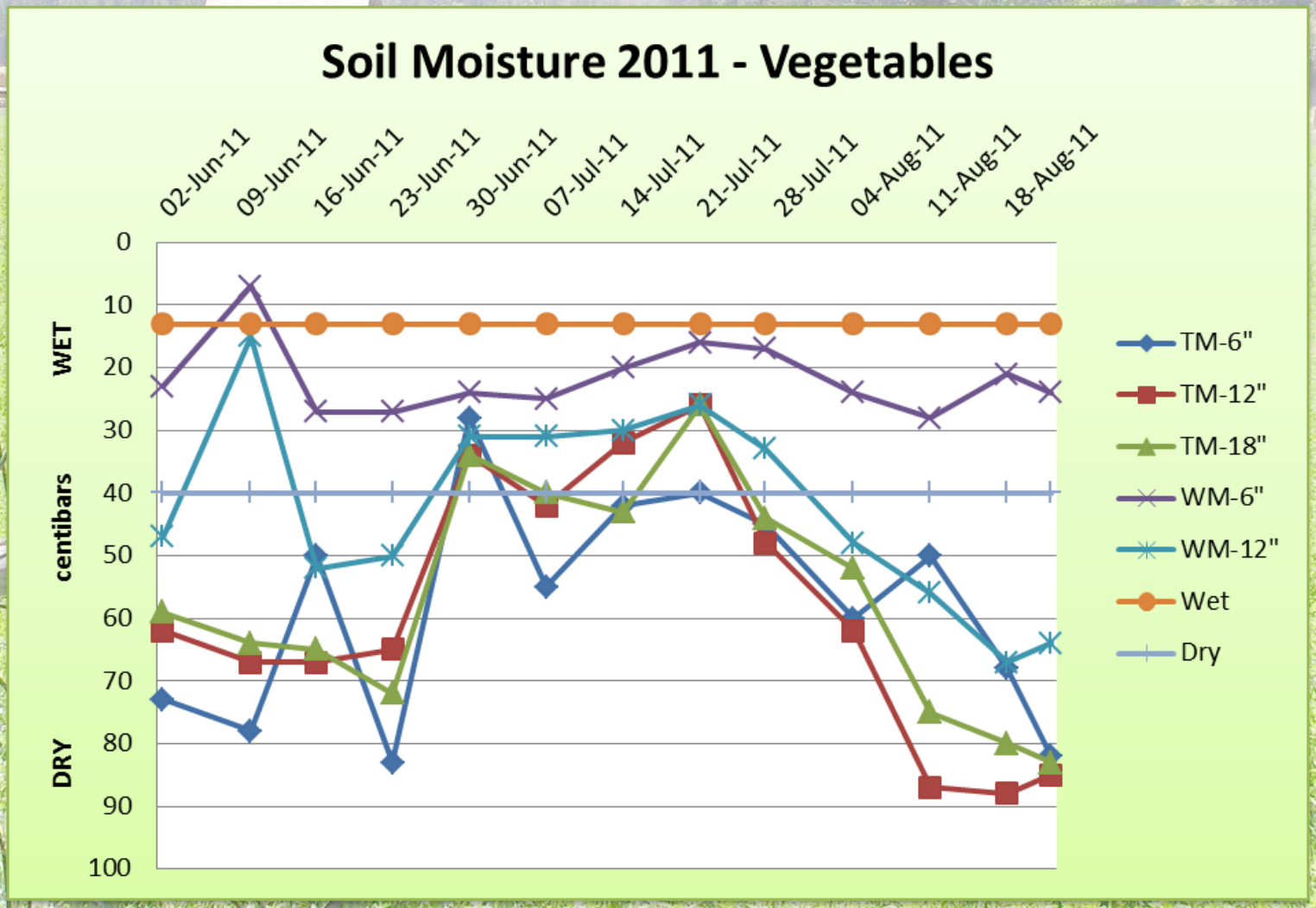
Soil Moisture Study Forage



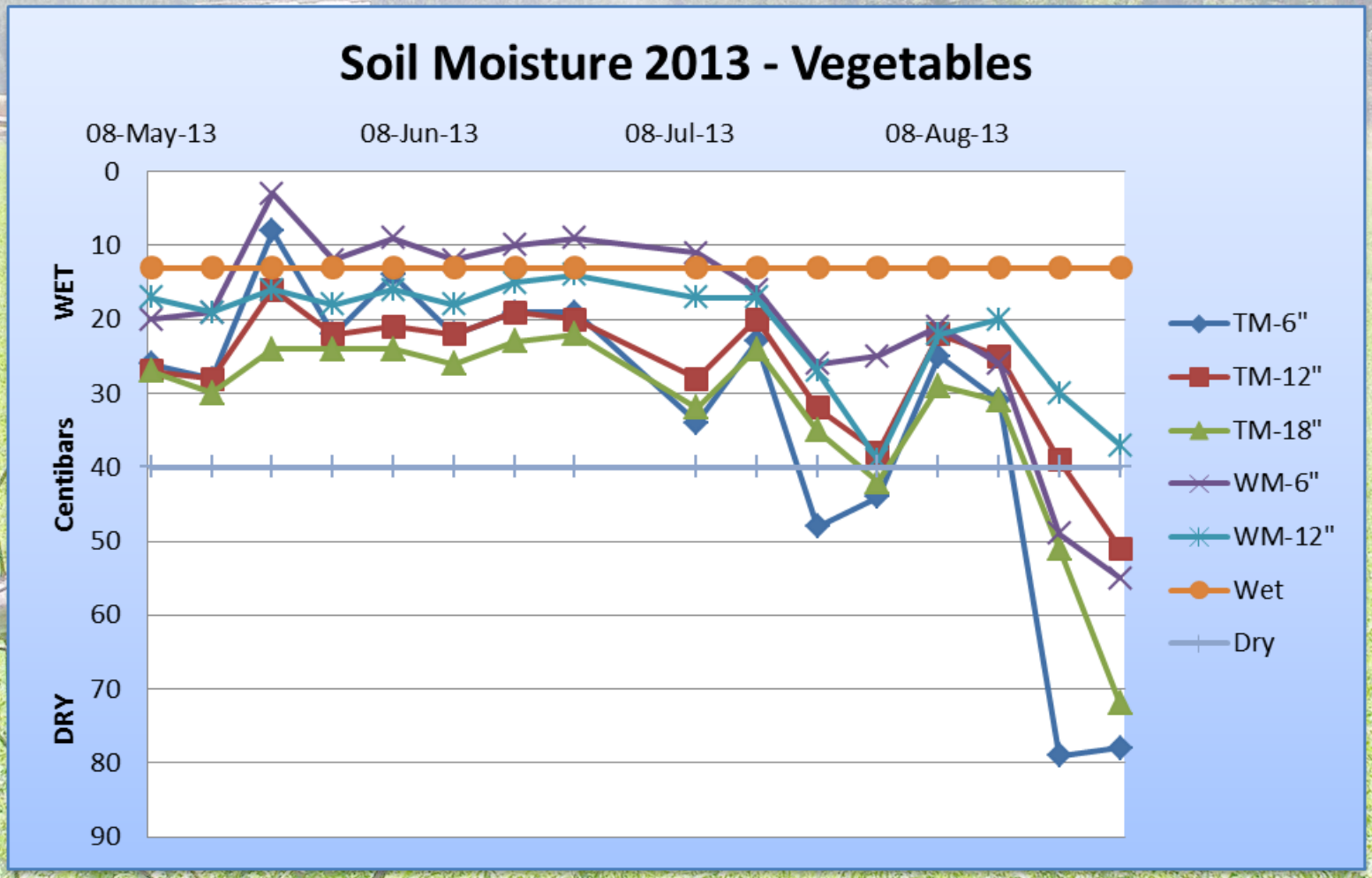
Soil Moisture Study Forage



Soil Moisture Study Vegetables



Soil Moisture Study



Climatic Irrigation Scheduling

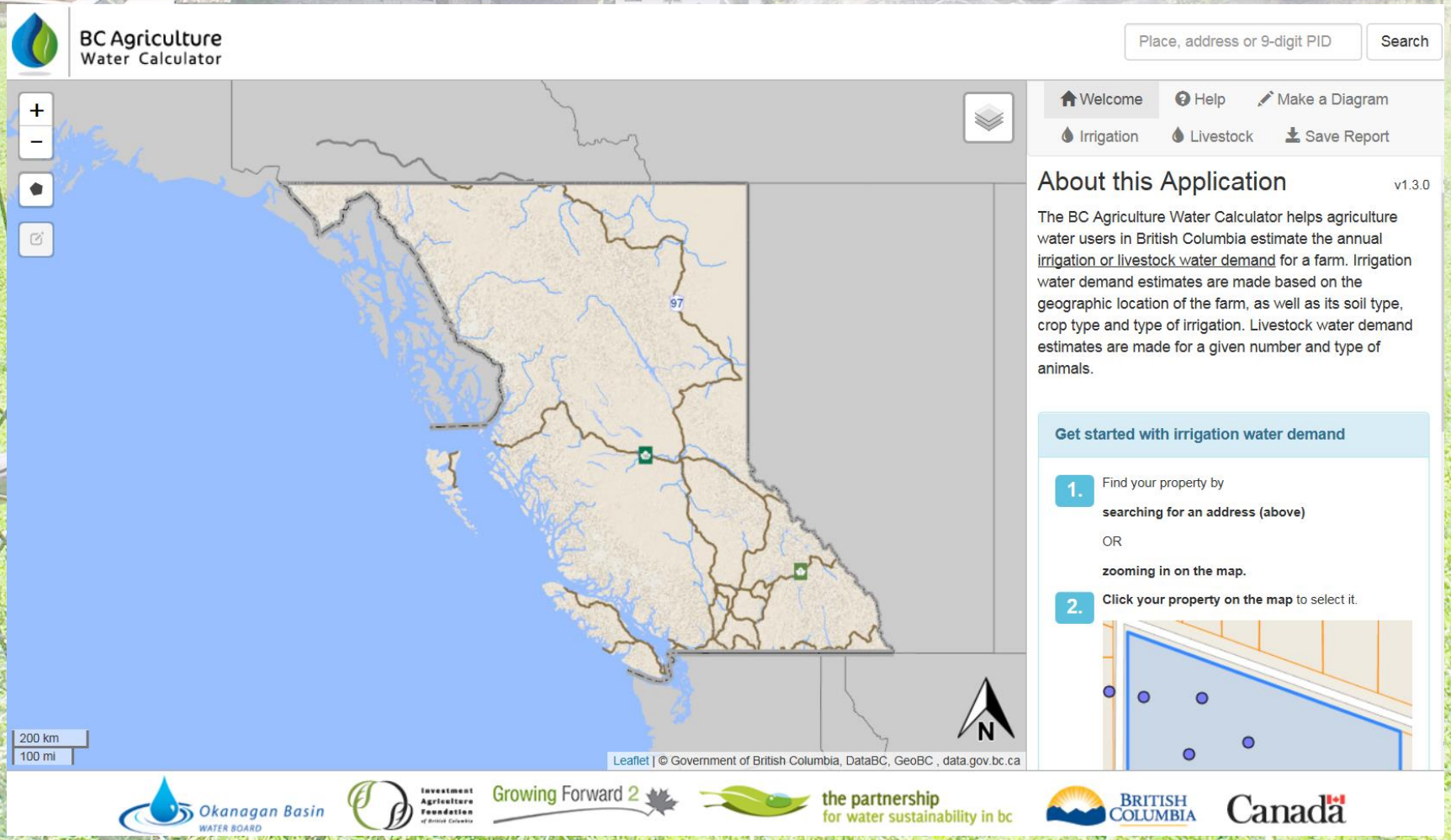
- Using weather station data to track Actual ET.
- Remember that irrigation systems are designed using Peak ET.
- When Actual ET consumes all of the water stored in the soil it is time to irrigate.

Online Tools

- http://ag-calc.irrigationbc.com/

Online Tools

- http://www.bcagriculturewatercalculator.ca/



Questions