



An Irrigation Scheduling Web
Application for Managing
Limited Water Supply

Next Generation Irrigation Scheduling

Going beyond field level ET demand/replacement

-- to --

Multi-Field Irrigation Optimization
(Deficit Irrigation)



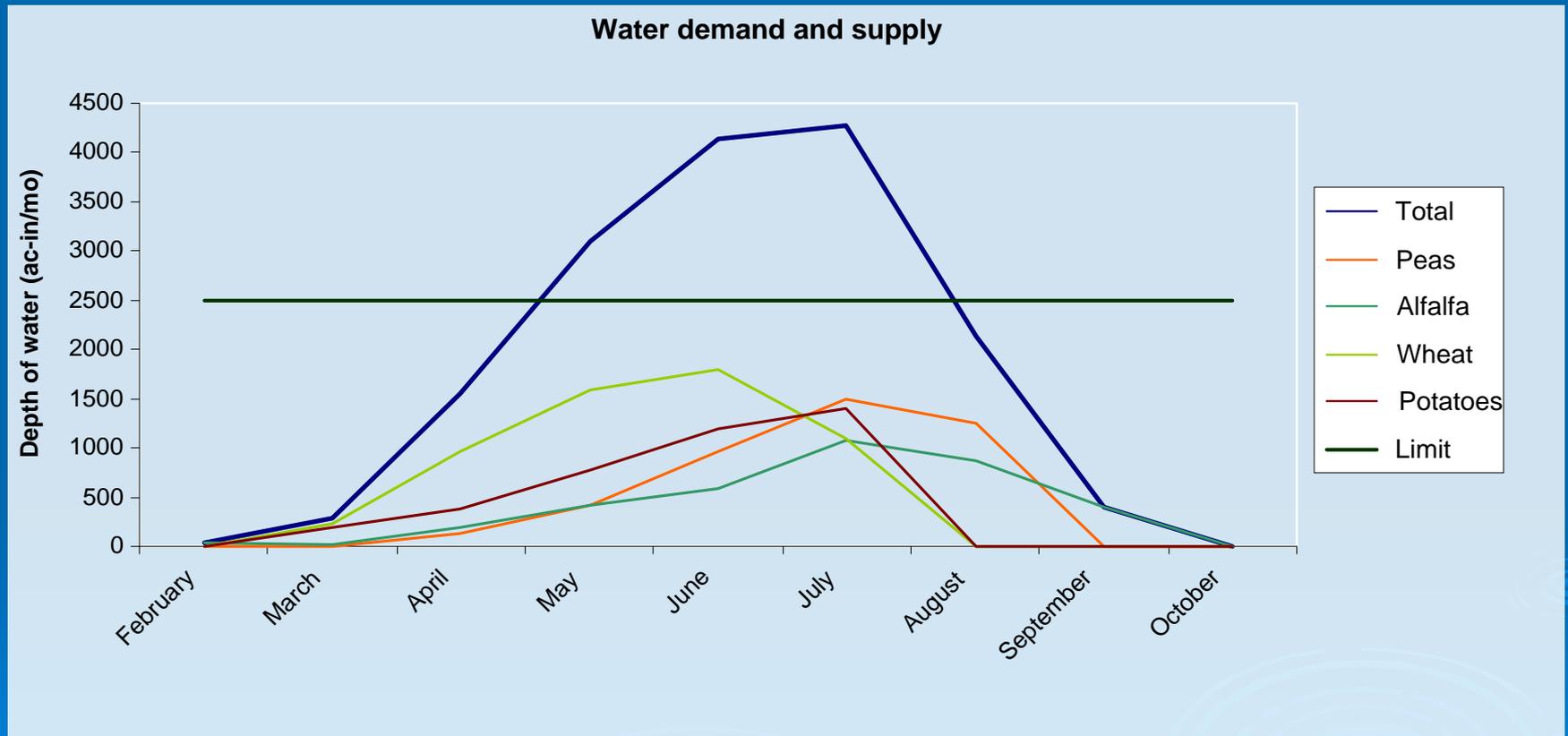
Key Challenges

- Efficiency is linked to irrigation intensity
 - Efficiency must be simulated explicitly
- Farm level optimization depends on all fields
 - Fields must be scheduled conjunctively
- Conjunctive scheduling must consider farm level irrigation capacity
 - Optimization must be sensitive to water supply & delivery constraints
- Optimization implies some level of deficit irrigation
 - Yield reductions must be simulated

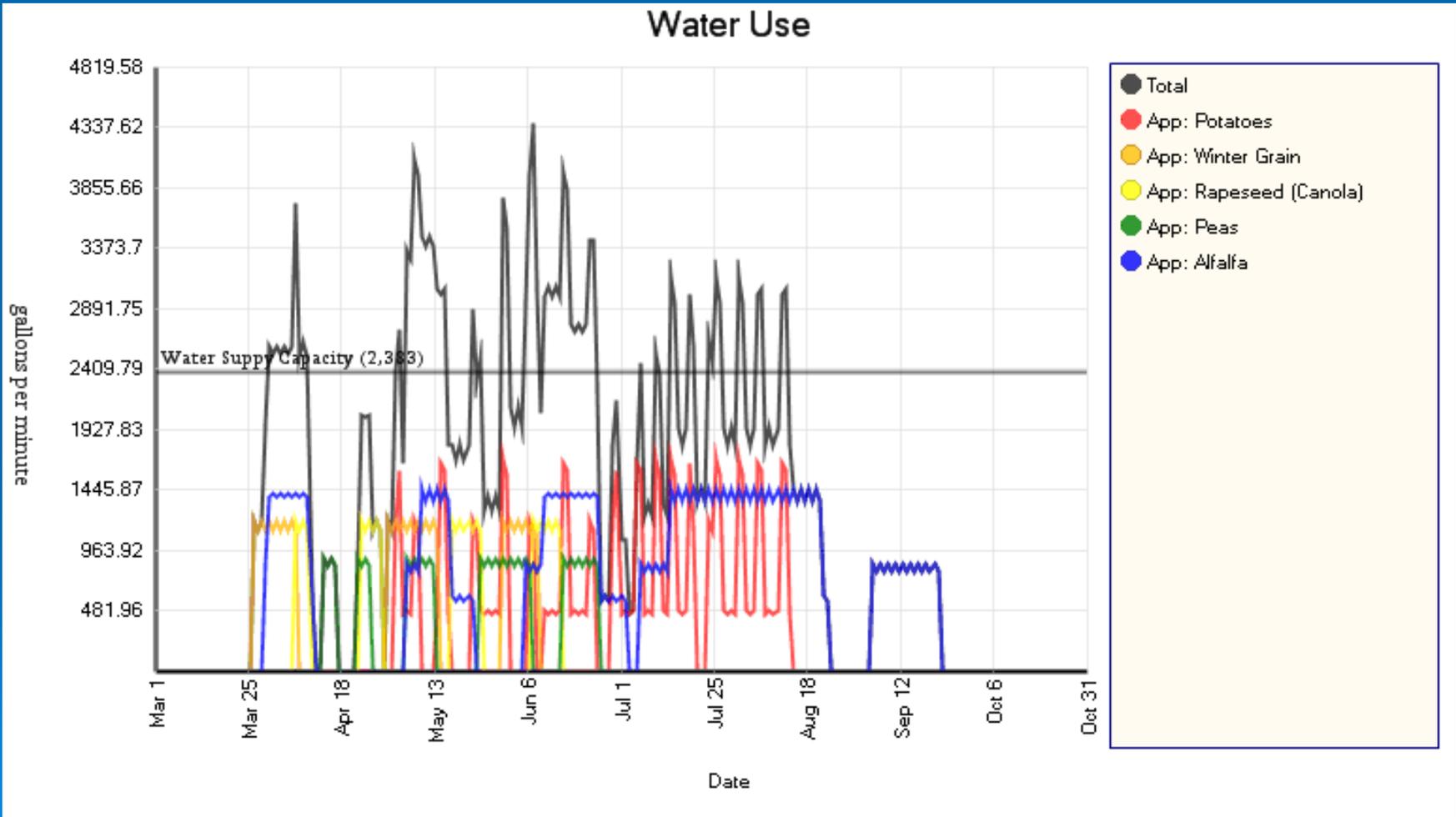
Irrigation Management with limited water supply

- *Irrigation Efficiency Model*: designed specifically for simulating consequences of less than full irrigation (deficit irrigation)
 - *Irrigation Management Online*: user interface components for managing limited water supply
 - Short term constraints
 - Long term constraints
- User is integral part of optimization process

Scheduling for Four Crops on Seven Fields



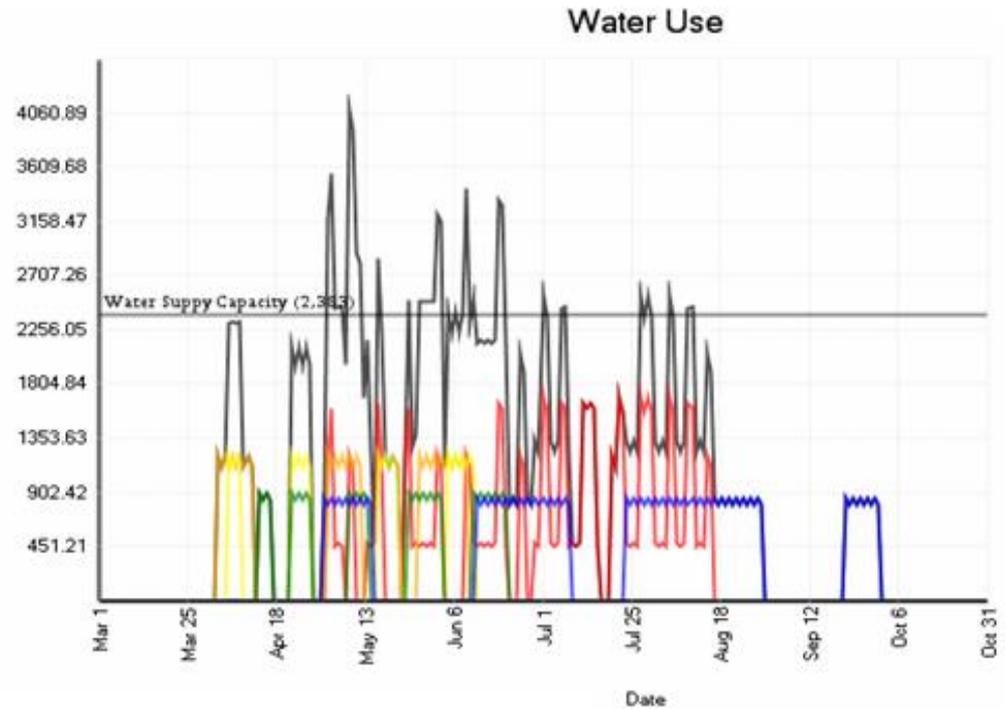
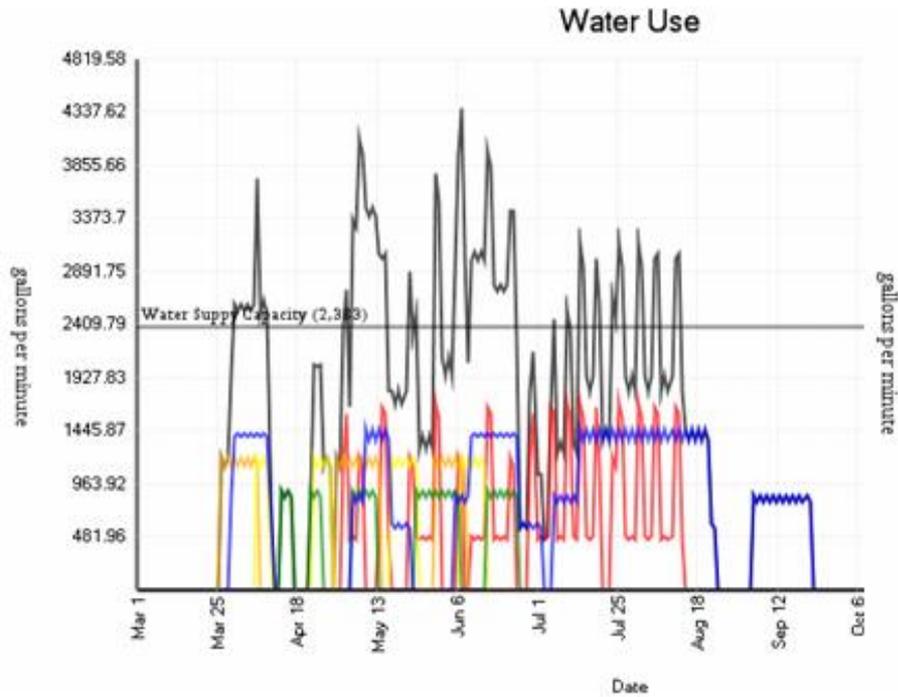
Example Seasonal Water Demand Output



Proposed Changes

- A small field of alfalfa in last year of production could be fallowed
- A second field of alfalfa could be deficit irrigated
- A circle of winter wheat could be deficit irrigated
- Alfalfa cutting dates could be shifted slightly

Original & Revised Water Demand



Oregon Irrigation Scheduling Online - Windows Internet Explorer

http://localhost/RealtimeIrrigationSchedule/EdittableCalendarSchedule.aspx

File Edit View Favorites Tools Help Links Oregon Irrigation Scheduling Online Rose Report Manager OISO DailyReport

Oregon Irrigation Scheduling Online

OREGON IRRIGATION SCHEDULING Online

Overview | Wizards | Run Analysis | Edit Farm Data | Input Measurements | Advanced Plots

Editable Calendar Schedule

← →

Field Name	Oct-7	Oct-8	Oct-9	Oct-10	Oct-11	Oct-12	Oct-13	Oct-14	Oct-15	Oct-16	Oct-17	Oct-18	Oct-19	Oct-20
single field	X ← → 36													
Barley	X ← → 36	X ← → 36	X ← → 36	X ← → 36										
Alfalfa							X ← → 36							
Flow Rate (gpm)	2000													

Display Options

Display Value:

System Run Time

Update Analysis

Clear All Provisional Events

Event Summary

Occuring in Field: Barley

Start Date: Thu Oct 16 11:00:00 PDT 2008

End Date: Fri Oct 17 23:00:00 PDT 2008

Gross Depth: 0.0 in.

Net Depth: 1.0 in.

Run Time: 36.0 hours

Event Type: ProvisionalUserModified

Information...

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Initial view, after running an analysis.

Events are displayed in the form of a modified Gantt chart with each event as a block in the chart.

Clicking these arrows moves the calendar start date one day forward or backward.

Red on Yellow indicates that Supply capacity has been exceeded. Notice that it is exceeded for 14 days.

Oregon Irrigation Scheduling Online - Windows Internet Explorer

http://localhost/RealtimeIrrigationSchedule/EditableCalendarSchedule.aspx

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Oregon Irrigation Scheduling Online

OREGON IRRIGATION SCHEDULING Online

Overview | Wizards | Run Analysis | Edit Farm Data | Input Measurements | Advanced Plots

Editable Calendar Schedule

Field Name	Oct-9	Oct-10	Oct-11	Oct-12	Oct-13	Oct-14	Oct-15	Oct-16	Oct-17	Oct-18	Oct-19	Oct-20	Oct-21	Oct-22
single field		X 36	X 36	X 36	X 36	X 36	X 36	X 36	X 36	X 36	X 36	X 36	X 36	X 36
Barley	X 36	X 36	X 36	X 36										
Alfalfa								X 36						
Flow Rate (gpm)	1200	2000			800	2000								

Display Options

Display Value:

System Run Time

Update Analysis

Clear All Provisional Events

Event Summary

Occuring in Field: Barley

Start Date: Mon Oct 13 12:00:00 PDT 2008

End Date: Wed Oct 15 00:00:00 PDT 2008

Gross Depth: 1.0 in.

Net Depth: 0.8 in.

Run Time: 36.0 hours

Event Type: Proposed.MAD

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OSU USDA NRCS

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Clicking on an event 'selects' the event. White on blue indicates selected event.

Clicking on an event also causes **Event Summary** to be updated with info about the event.

Oregon Irrigation Scheduling Online - Windows Internet Explorer

http://localhost/RealtimeIrrigationSchedule/EditableCalendarSchedule.aspx

File Edit View Favorites Tools Help Links Oregon Irrigation Scheduling Online Rose Report Manager OISO DailyReport

Oregon Irrigation Scheduling Online

OREGON IRRIGATION SCHEDULING Online

Overview | Wizards | Run Analysis | Edit Farm Data | Input Measurements | Advanced Plots

Editable Calendar Schedule

Field Name	Oct-9	Oct-10	Oct-11	Oct-12	Oct-13	Oct-14	Oct-15	Oct-16	Oct-17	Oct-18	Oct-19	Oct-20	Oct-21	Oct-22
single field		X ← → 0.4												
Barley	X ← → 1.0	X ← → 1.0	X ← → 1.0	X ← → 1.0										
Alfalfa								X ← → 1.0						
Flow Rate (gpm)	1200	2000			800	2000								

Display Options

Display Value:

Gross Application Depth

Update Analysis

Clear All Provisional Events

Event Summary

Occuring in Field: Barley

Start Date: Mon Oct 13 12:00:00 PDT 2008

End Date: Wed Oct 15 00:00:00 PDT 2008

Gross Depth: 1.0 in.

Net Depth: 0.8 in.

Run Time: 36.0 hours

Event Type: Proposed.MAD

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Value displayed in the event blocks can be Hours of operation (shown in previous screens), Gross application depth, Net application depth, or system flow rate.

Oregon Irrigation Scheduling Online - Windows Internet Explorer

http://localhost/RealtimeIrrigationSchedule/EditableCalendarSchedule.aspx

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Oregon Irrigation Scheduling Online

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OREGON IRRIGATION SCHEDULING Online

Overview | Wizards | Run Analysis | Edit Farm Data | Input Measurements | Advanced Plots

Editable Calendar Schedule

← →

Field Name	Oct-9	Oct-10	Oct-11	Oct-12	Oct-13	Oct-14	Oct-15	Oct-16	Oct-17	Oct-18	Oct-19	Oct-20	Oct-21	Oct-22
single field		X ← → 36												
Barley	X ← → 36	X ← → 36	X ← → 36	X ← → 36										
Alfalfa								X ← → 36						
Flow Rate (gpm)	1200	2000			800	2000								

Display Options

Display Value:

System Run Time

Update Analysis

[Clear All Provisional Events](#)

Event Summary

Occuring in Field: Barley

Start Date: Mon Oct 13 12:00:00 PDT 2008

End Date: Wed Oct 15 00:00:00 PDT 2008

Gross Depth: 1.0 in.

Net Depth: 0.8 in.

Run Time: 36.0 hours

Event Type: Proposed.MAD

Information...

Shift event 1.47 days.

OSU Oregon State | USDA | NRCS

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Buttons in the event blocks are used to edit the event.

X → delete the event

Arrows → shift the event 1 day forward or backward

Events can be dragged left or right to change their start date. Here, an event is being dragged as indicated by the green rectangle. The rectangle's color changes to red if the user drags the event to a date when it cannot occur.

Oregon Irrigation Scheduling Online - Windows Internet Explorer

http://localhost/RealtimeIrrigationSchedule/EdittableCalendarSchedule.aspx

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Oregon Irrigation Scheduling Online

OREGON IRRIGATION SCHEDULING Online

Overview | Wizards | Run Analysis | Edit Farm Data | Input Measurements | Advanced Plots

Editable Calendar Schedule

← →

Field Name	Oct-9	Oct-10	Oct-11	Oct-12	Oct-13	Oct-14	Oct-15	Oct-16	Oct-17	Oct-18	Oct-19	Oct-20	Oct-21	Oct-22
single field		X ← → 36												
Barley	X ← → 36	X ← → 36	X ← → 36				X ← → 36							
Alfalfa								X ← → 36						
Flow Rate (gpm)	1200	2000		800	2000	320		2000						

Display Options

Display Value:

System Run Time

Update Analysis

Clear All Provisional Events

Event Summary

Occuring in Field: Barley

Start Date: Mon Oct 13 12:00:00 PDT 2008

End Date: Wed Oct 15 00:00:00 PDT 2008

Gross Depth: 1.0 in.

Net Depth: 0.8 in.

Run Time: 36.0 hours

Event Type: Proposed.MAD

Information...

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A double click in the gray area will create a new event.

After an event is dragged, deleted, or added the Flow Rate row is updated automatically...

Oregon Irrigation Scheduling Online - Windows Internet Explorer

http://localhost/RealtimeIrrigationSchedule/EditableCalendarSchedule.aspx

File Edit View Favorites Tools Help Links Oregon Irrigation Scheduling Online Rose Report Manager OISO DailyReport

Oregon Irrigation Scheduling Online



Overview | Wizards | Run Analysis | Edit Farm Data | Input Measurements | Advanced Plots

Editable Calendar Schedule

← →

Field Name	Oct-7	Oct-8	Oct-9	Oct-10	Oct-11	Oct-12	Oct-13	Oct-14	Oct-15	Oct-16	Oct-17	Oct-18	Oct-19	Oct-20
single field	36				36					36				
Barley		36				36					36			
Alfalfa				36				36					36	
Flow Rate (gpm)	800	1200	1200	800	1200	1200	800	1200	1200	800	1200	1200		

Display Options

Display Value:

System Run Time

Update Analysis

[Clear All Provisional Events](#)

Event Summary

Occuring in Field: Barley

Start Date: Wed Oct 8 12:00:00 PDT 2008

End Date: Fri Oct 10 00:00:00 PDT 2008

Gross Depth: 1.0 in.

Net Depth: 0.8 in.

Run Time: 36.0 hours

Event Type: Provisional

Information...





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Final view, after editing.

After deleting, shifting, and adding several new events the supply capacity is not exceed during the 14 day interval.



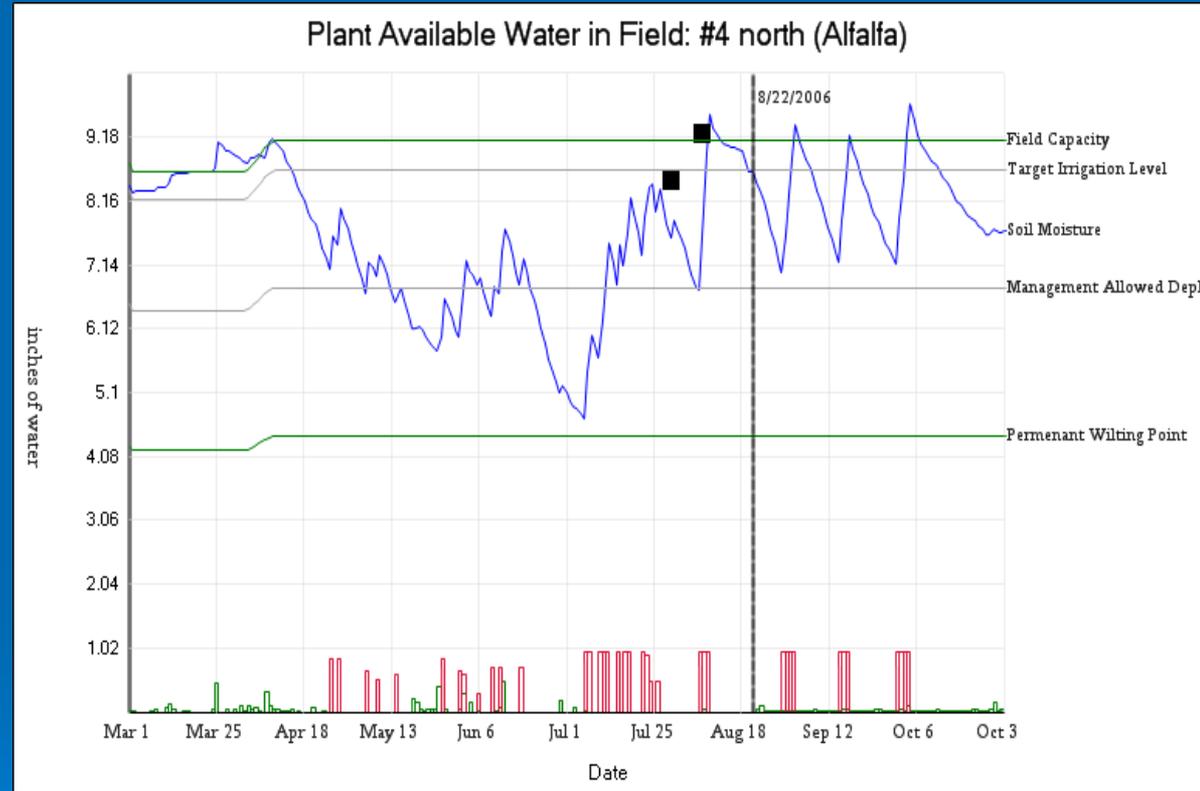
Full Season Output (single field)

➤ Soil moisture status

➤ Precipitation

➤ Application History

➤ Soil Moisture Measurements



➤ Recommendations for timing and duration of upcoming irrigations

Tabular Output

- List application dates and amounts
- Field level performance summary

Oregon Irrigation Scheduling Online - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://bre-rose.bioe.orst.edu/RealtimeIrrigationSchedule/OutputScheduleForm.aspx

O I S O OREGON IRRIGATION SCHEDULING Online

Overview | Wizards | Run Analysis | Edit Farm Data | Input Measurements | Advanced Plots

Irrigation Schedule for Farm : (Farm Name)

Water Management Unit

Selected Field

Weather Regime

Show Historical Irrigation Events

Show Soil Moisture Plot

Show cumulative ET plot

Show Water Management Unit Summary

Edit Irrigation Scheduling Options

Select Different Field

Performance Summary		Depth (inches)
Total Applied (gross)	38.716	
Total Applied (net)	34.393	
Cumulative ET	31.870	
Cumulative Precip	5.043	
Spray Loss	0.348	
Deep Percolation	1.739	
Run Off	2.293	
Water Balance	0.666	
Simulated Properties		
Field Capacity	0.2800	
Permenant Wilting Point	0.1810	
Avg Soil Depth	36.906 (in)	

Field Name	Start Date	Gross Application(inches)	Application Type	Time To Cover Field (hours)	Message
#4 north	8/26/2006	0.95	Proposed.MAD	24.0	
#4 north	8/27/2006	0.95	Proposed.MAD	24.0	
#4 north	8/28/2006	0.95	Proposed.MAD	24.0	
#4 north	9/6/2006	0.95	Proposed.MAD	24.0	
#4 north	9/7/2006	0.95	Proposed.MAD	24.0	
#4 north	9/8/2006	0.95	Proposed.MAD	24.0	
#4 north	9/19/2006	0.95	Proposed.MAD	24.0	
#4 north	9/20/2006	0.95	Proposed.MAD	24.0	
#4 north	9/21/2006	0.95	Proposed.MAD	24.0	
#4 north	10/6/2006	0.95	Proposed.MAD	24.0	
#4 north	10/7/2006	0.95	Proposed.MAD	24.0	
#4 north	10/26/2006	0.95	Proposed.MAD	24.0	
#4 north	10/27/2006	0.95	Proposed.MAD	24.0	

Local intranet

Links to Economic Analysis

- Excel spreadsheet based analysis
 - Spreadsheet contains macros to download farm data and recent analyses
 - Macros also upload revised yield parameters
- Facilitates maximum flexibility when enumerating operational costs

Microsoft Excel - EconomicsMacro_v3

File Edit View Insert Format Tools Data Window Help

Calculate Full Arial 10

FieldT.IrrSys... =('Irrigation System Template'!B16)

	A	B	C	D	E	F	G
1							
2							
3	GROSS INCOME Description						
4						Acres in Enterprise-->	130.0
5	PRODUCT	Yield (tn/ha)	Price (\$/Tn)	Gross Income (\$/ac)	Total Cost (\$/ac)	Gross Margin (\$/ac)	
6	Marcos Alfalfa Field	1.5	5.0	\$7.50	\$8.33	-\$0.83	
7	#####						
8	#####						
9	VARIABLE COST Description						
10	Operations						
11		Materials Details		Labor	Machinery	Materials	Total Cost
12		<i>quantity</i>	<i>\$/quantity</i>	<i>\$/acre</i>	<i>\$/acre</i>	<i>\$/acre</i>	<i>\$/acre</i>
13							
14	Tillage				50.0	0.0	50.0
15	Fertilizer						
16	Phosphate Fertilizers	50.0	1.5	0.0		75.0	75.0
17	Nitrate Fertilizers	0.0	1.0	0.0	0.0	0.0	0.0
18	Other Fertilizers	0.0	0.0			0.0	0.0
19	Herbicide						
20	Pre emergence	1.0	12.0	0.0	10.0	12.0	22.0
21	Post emergence	1.0	20.0	0.0	10.0	20.0	30.0
22	Seed						
23		1.0	25.0	0.0	30.0	25.0	55.0
24	Insecticide & fungicide						
25		2.0	6.0	0.0	20.0	12.0	32.0
26	Others (crop monitoring, soil moisture measurement, soil sample, etc)						
27		1.0	10.0	20.0	0.0	10.0	30.0
28	Total Operations						294.0
29	Irrigation						
30	Irrigation						
31	Electricity & motor mante	see irr page		\$/acre			0.0
32	Repair and maintenance	see irr page		\$/acre			2.3
33	Labor	see irr page		\$/acre			96.9
34	Total Irrigation						99.2
35	Harvest and Other Yield Varying Costs						
36	Harvest			%	10.0		0.7
37	depends on the yield. Is it usual in US to have a % a reference. See hidden sheet.						
38	Total Harvest and Other Yield Varying Costs						0.7
39	Other variable costs						
40							

Ready

Inputs / Outputs / Summary / Field Template / Irrigation System Template

Wizard driven setup

Water Management Unit

- Command area
- Delivery rate & volume

Weather Data Source

- USBR AGRIMET
- WyEast IFPNet

The screenshot shows a web browser window titled "Oregon Irrigation Scheduling Online - Microsoft Internet Explorer". The address bar shows the URL "http://bre-rose.bioe.orst.edu/RealtimeI...". The page features the "OREGON IRRIGATION SCHEDULING Online" logo and a banner image of a field. The main content area is titled "Wizard" and "Farm Setup", with the subtitle "Step by Step directions for creating a new farm".

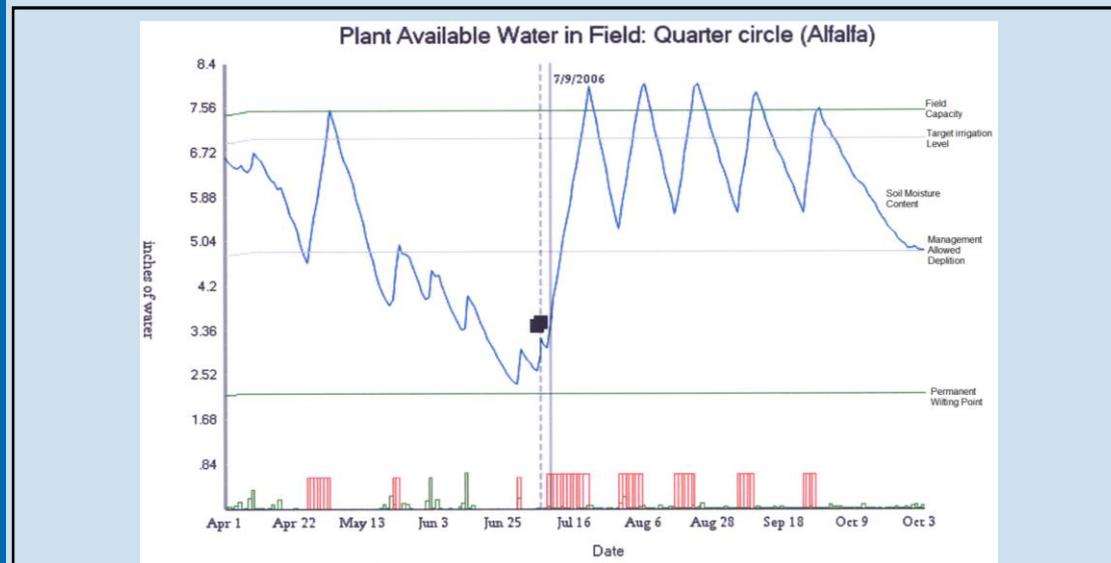
The text explains that the wizard guides the user through creating a farm and an associated water management unit, requiring historic and current weather data (AgriMet or similar). It notes that in OISO, farms consist of one or more Water Management Units (WMU), each with a specific irrigation application system. The wizard will create a farm with one WMU, which can be expanded later.

The diagram, titled "Farm", illustrates the structure of a Water Management Unit 1. It shows a central box labeled "Water Management Unit 1" containing a vertical list of "Field 1", "Field 2", "Field 3", and "Field n", each connected to an "Irrigation System 1", "Irrigation System 2", "Irrigation System 3", and "Irrigation System n" respectively. To the right of this unit is a "Weather Site(s)" box, which is connected to "Current Weather" and "Future Weather (Historical Averages)" boxes. Arrows indicate the flow of data from the weather sources to the irrigation systems within the WMU.

At the bottom of the wizard window, there are "Next" and "Cancel" buttons. The browser's status bar at the bottom shows "Done" and "Local intranet".

E-mail output

- Links to gather recent application information
- Motivates continued analysis of irrigation strategy



Field Name	Aug/20	Aug/21	Aug/22	Aug/23	Aug/24	Aug/25	Aug/26	Aug/27	Aug/28	Aug/29	Aug/30	Aug/31	Sep/1	Sep/2
#4 north					900	900	900	900						
#4 Southeast														
#4 southwest	900	900	900	900								900	900	900
Total	900	900	900	900	900	900	900	900				900	900	900

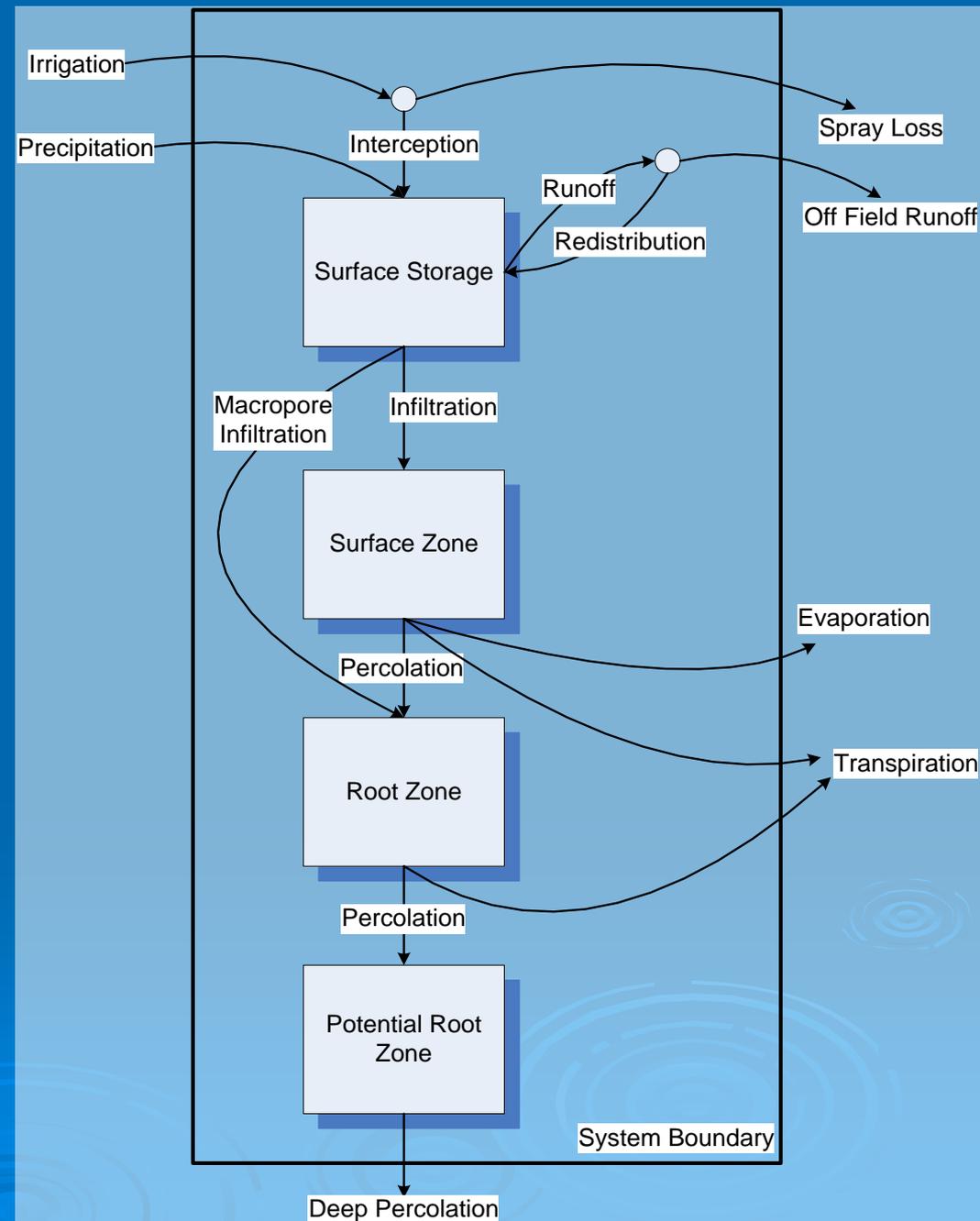
Dear Mr.

The above OISO analysis is a summary for July 8th. The last irrigation date entered was June 28th. The last cutting of alfalfa was June 10th and the next assumed alfalfa cutting date is July 15th. If there have been more recent irrigations, or soil moisture measurements please let us know by *reply email* or call 541-602 6845. For more complete details you can go directly to the web site:

<http://bre-rose.bioe.orst.edu/Realtimeirrigationschedule/index.htm>

Irrigation Efficiency Model

- Analysis of application efficiency
- Spatial variability
- Full season forecast
- Multiple levels of ET demand
- Conjunctive scheduling
- Alternative or Unconventional scheduling strategies



Yield Reduction Model

- Initially: FAO 33 (1979)
 - widely used
 - unsatisfactory under ordinary field conditions
- During the last few years, a team of scientists from various countries have been developing a new crop-water production model to replace FAO 33.

- The new FAO yield model “**AQUACROP**” will be available and ready for distribution in **2007-2008**.
- The model describes the effect of water stress occurring **at particular moments** in the growing period and it requires only a **minimum of input data** which are readily available or can easily be collected.



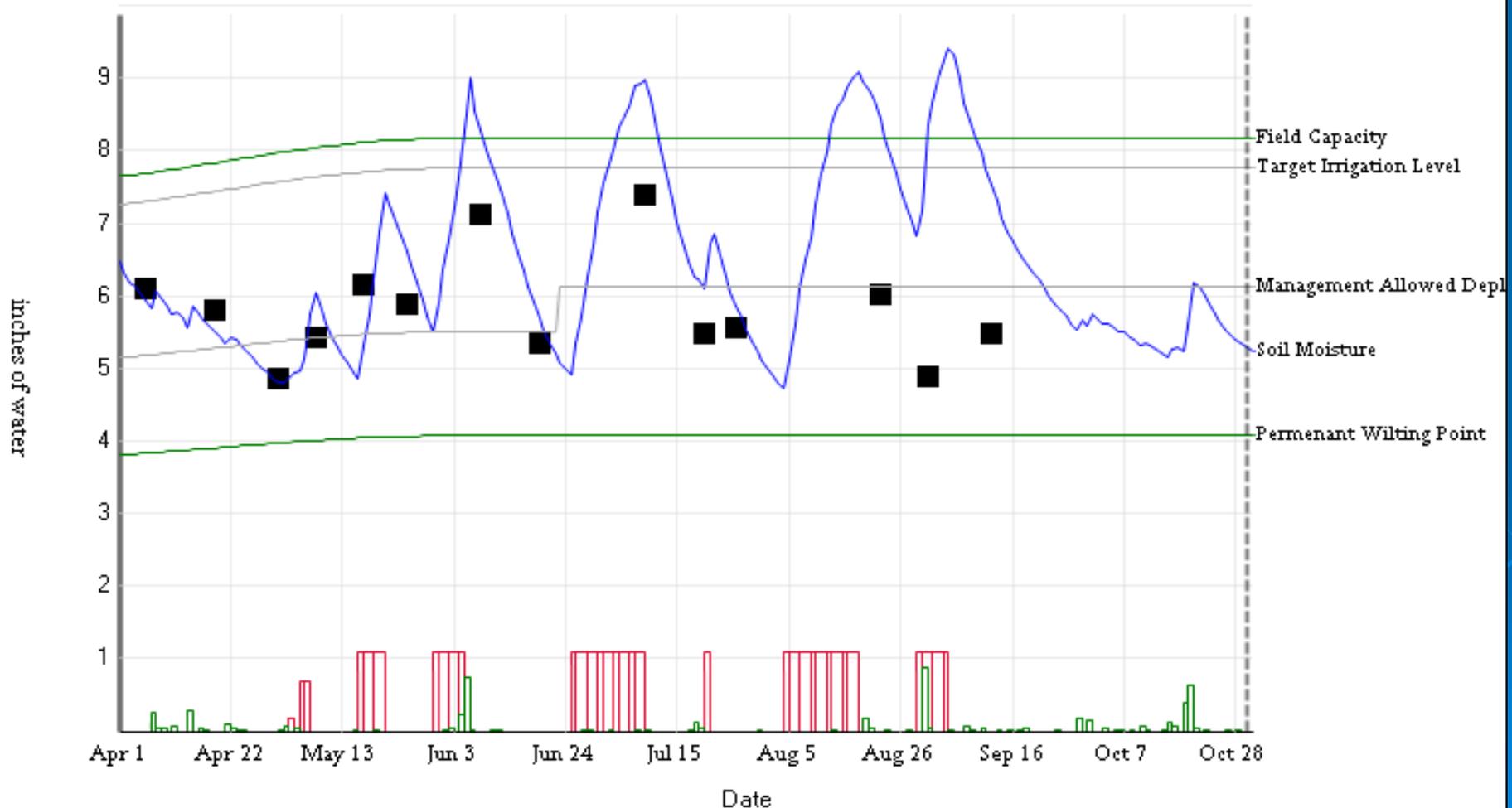
Reconciling Soil Moisture Estimates

- Accurate estimation of crop available water is critical for economic optimization
- Two estimators are commonly used:
 - calculated cumulative ET
 - direct measurements

Both of these estimators have some error...

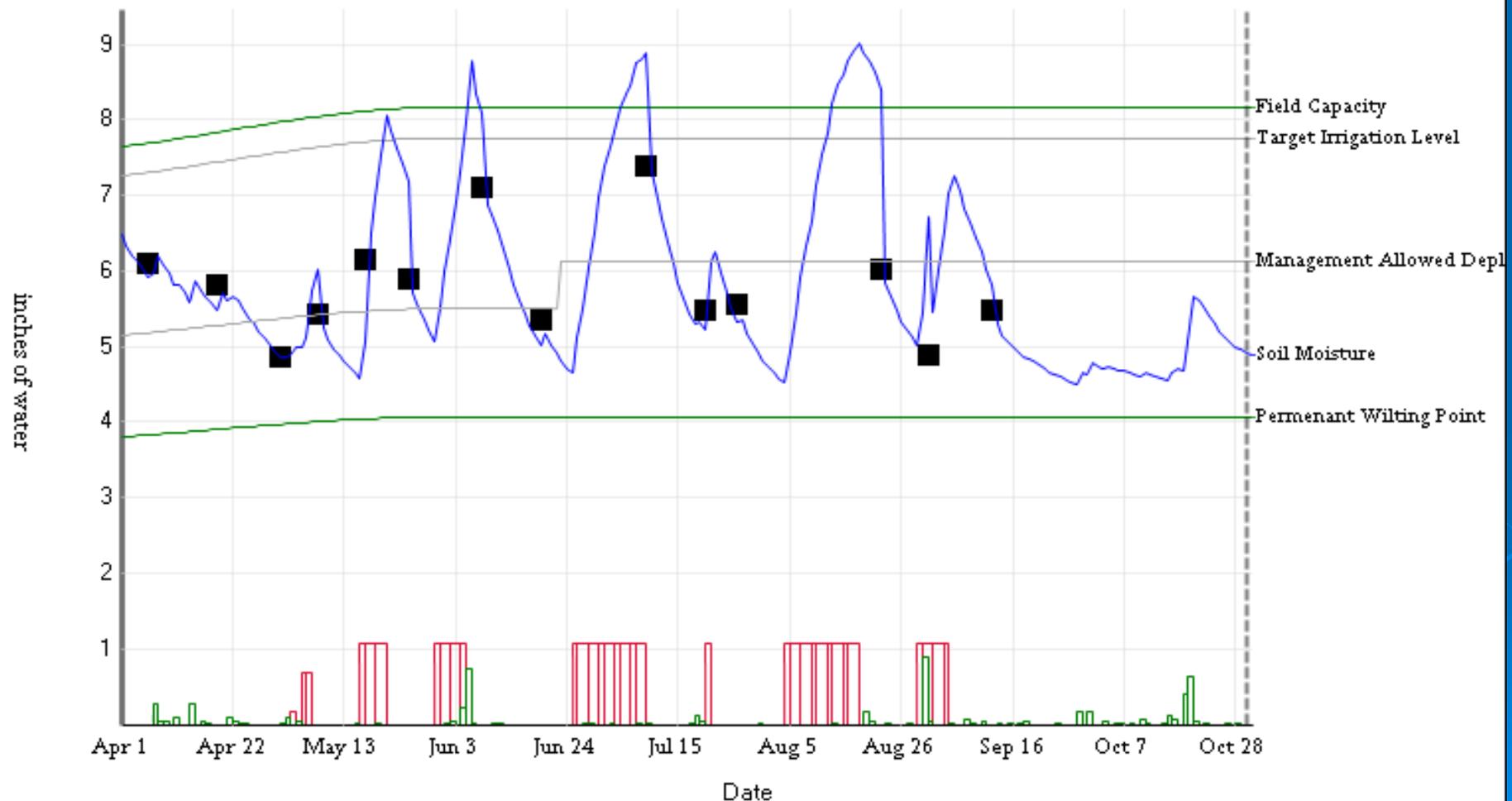
Uncorrected

Plant Available Water in Field: Quarter circle (Alfalfa)



Corrected

Plant Available Water in Field: Quarter circle (Alfalfa)



Current/Future Work

- Completed 3rd year of field trials
- Continued trials next year in:
OR, WA, ID, CA
- Adding Salinity Component
 - collaboration with Rick Snyder (UC Davis)
- Integration with SSURGO web service
- Negotiating hosting on NRCS web farm

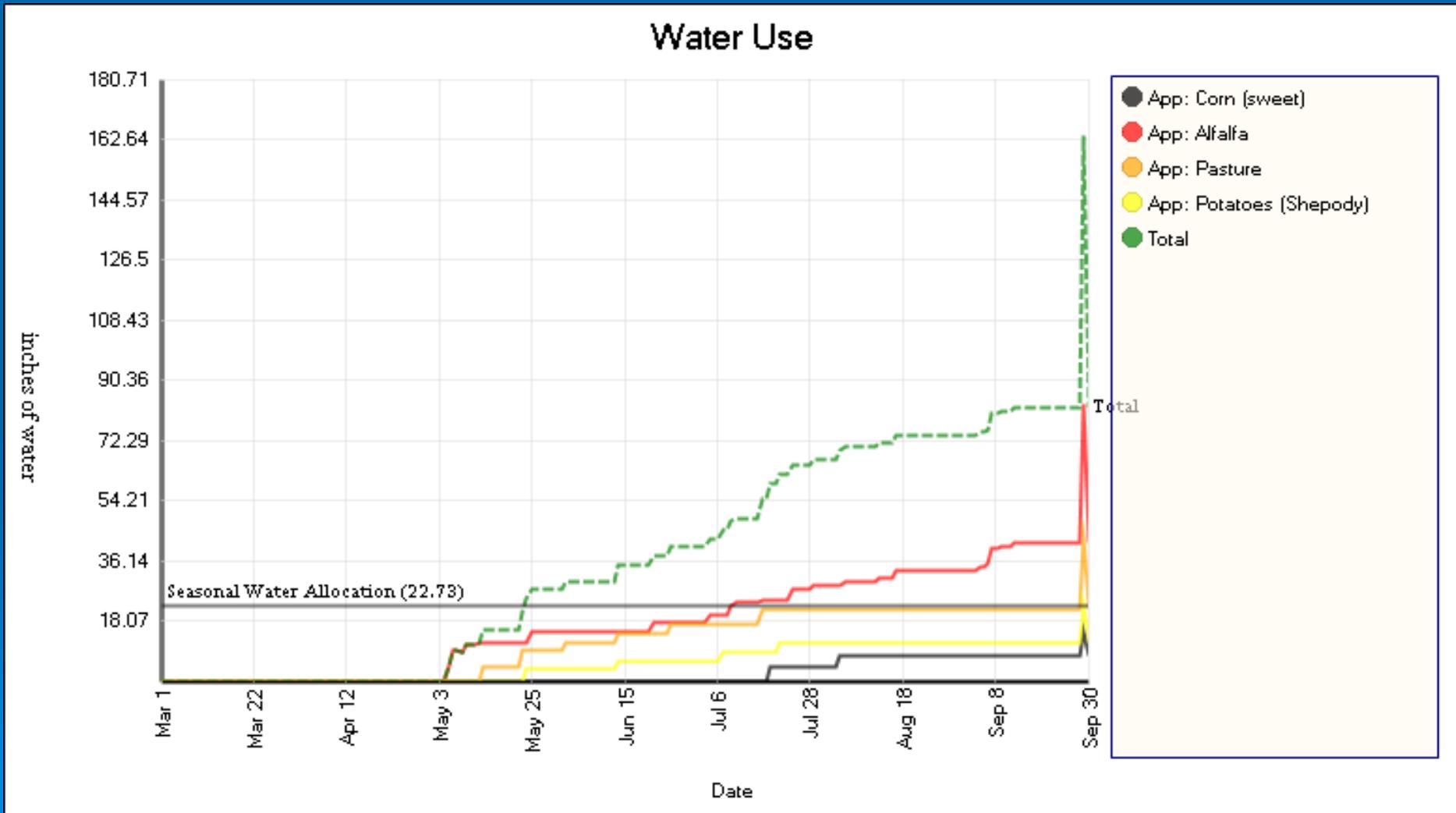
<http://oiso.bioe.orst.edu>



BIOENGINEERING
OREGON STATE UNIVERSITY



Full Season Output (multi field output)



IEM Overview

- Simultaneous scheduling of multiple fields
 - Simulates multiple levels of ET demand
 - Full season forecasting of irrigation requirements (historical averages)
 - Analysis of application efficiency
 - Allows for alternative or unconventional scheduling strategies
- 