FARM IRRIGATION CASE STUDIES

OKANAGAN WATER SCARCITY

Four Case Studies to Improve Irrigation Efficiency in the Okanagan: A Ranch, Two Orchards, and a Vegetable Farm

Bruce Naka, CID

Sound Water Advise

Andrew Bennett, MSc PAg CID

LIVING LANDS AGROECOLOGY

Funding for this project has been provided in part by the Regional District of Okanagan Similkameen, the Regional District of North Okanagan and the Okanagan Basin Water Board, and in part by the governments of Canada and British Columbia under the Canadian Agricultural Partnership, a federal-provincial-territorial initiative. The program is delivered by the Investment Agriculture Foundation of BC.

19 March 2023

Water Scarcity

In semi-arid regions like BC's Okanagan Valley, summer rains are typically infrequent and light, so irrigation is vital to sustain crops. Climate change has shifted weather patterns toward greater extremes and the impacts on agricultural crops we already feel are likely to press harder in the future. In particular, water may become more scarce in summer at the same time as crops' water demands increase.

For agriculture to flourish in the Okanagan in the face of water scarcity, we must operate our irrigation systems as efficiently as possible.

Case Studies

In 2022, irrigation designers Bruce Naka and Andrew Bennett visited and assessed the irrigation systems of a vegetable farm, a ranch growing hay, and two fruit orchards. Discussions with producers focused attention on irrigation weaknesses in the face of potential droughts, and the limitations posed by labour, maintenance, and the cost of new equipment.

The case studies presented here consider a few ways that new irrigation methods and equipment might assist these farms.

Case study topics include:

- Assessments of current systems
- Opportunities for improvement
- Options for new equipment
- Maps and tables for new designs
- Schedules to meet peak demand
- Seasonal adjustments to adapt to varying crop and weather conditions

FARM IRRIGATION CASE STUDIES

CASE: VEGETABLE FARM

Replacing Aluminum Handlines with Automatic Solid-Set Sprinklers in North Okanagan, BC

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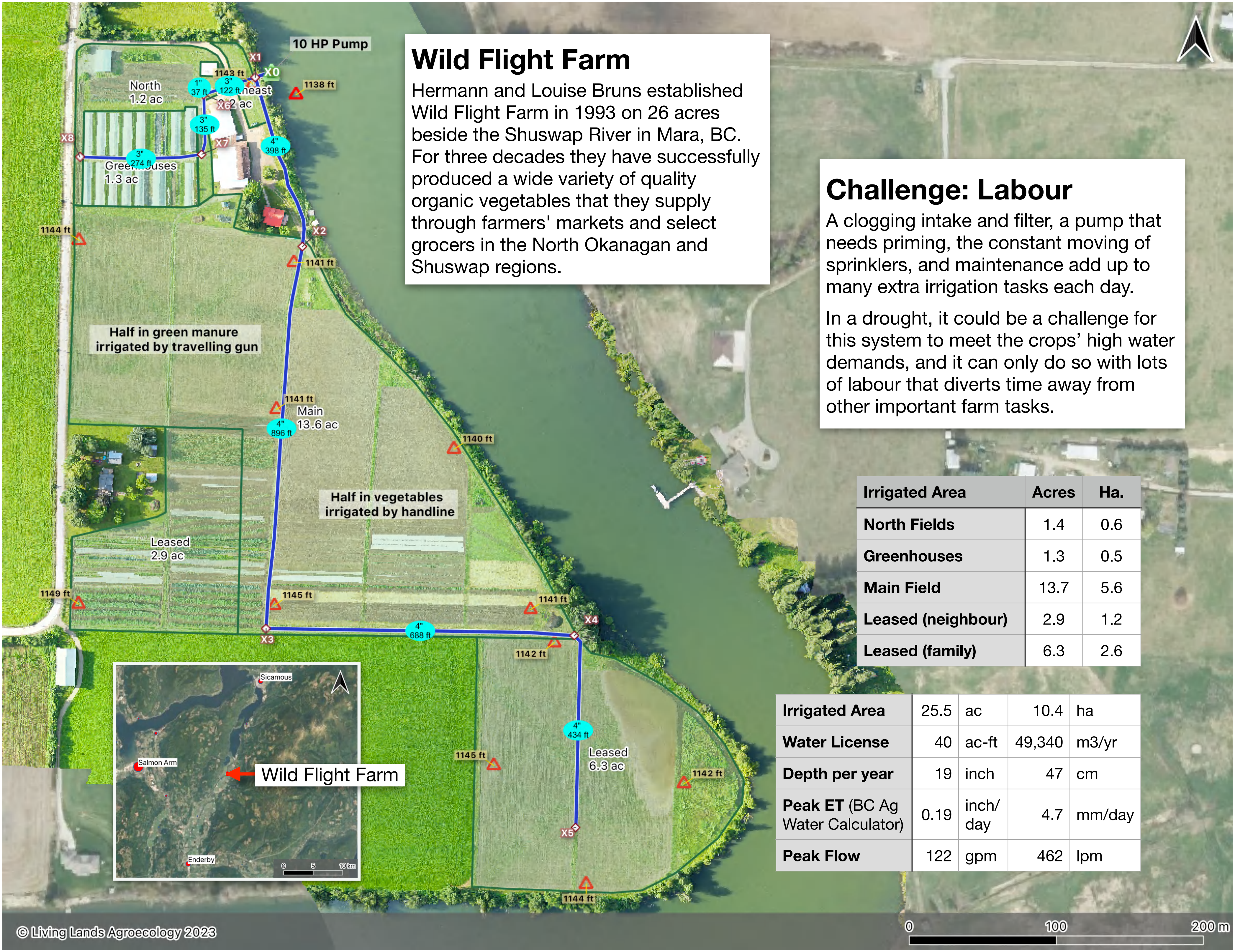


Wild Flight Farm

Hermann and Louise Bruns established Wild Flight Farm in 1993 on 26 acres beside the Shuswap River in Mara, BC. For three decades they have successfully produced a wide variety of quality organic vegetables that they supply through farmers' markets and select grocers in the North Okanagan and Shuswap regions.

Challenge: Labour

A clogging intake and filter, a pump that needs priming, the constant moving of sprinklers, and maintenance add up to many extra irrigation tasks each day.

In a drought, it could be a challenge for this system to meet the crops' high water demands, and it can only do so with lots of labour that diverts time away from other important farm tasks.

Irrigated Area	Acres	Ha.
North Fields	1.4	0.6
Greenhouses	1.3	0.5
Main Field	13.7	5.6
Leased (neighbour)	2.9	1.2
Leased (family)	6.3	2.6

Irrigated Area	25.5	ac	10.4	ha
Water License	40	ac-ft	49,340	m3/yr
Depth per year	19	inch	47	cm
Peak ET (BC Ag Water Calculator)	0.19	inch/ day	4.7	mm/day
Peak Flow	122	gpm	462	lpm

Crops & Fields

At the north end of the farm there is a one-acre vegetable field and 15 hoophouses. The other 23 acres to the south are rotated annually to improve soil health, with half the area in vegetable production and the other half in a “green manure" cover crop, often a mix of peas, oats, rye, and vetch.

Soils

The farm is on very fine soils that hold a lot of water, which is good in a drought. But fine soils can also pool water, leading to erosion, mud, and compaction. And fine soils do not easily absorb water, especially if they dry out.

Roots

Every crop has different water requirements at different times. Rooting depth varies between crop types as well, and younger crops have shorter roots than mature crops. Crops only have access to water in soil near roots.

Max. Irrigation Intervals (ET = 0.19”/day)

Crop Rooting Depth (inch)	3	6	12	18	24	36
Total Soil Water Storage (inch)	0.5	1.0	2.1	3.3	4.5	6.7
Plant Available Water (40%)	0.2	0.4	0.8	1.3	1.8	2.7
Max Irrigation Interval (days)	1	2	4	6	9	14

Growing Beds

Wild Flight uses consistent bed dimensions for every crop to match the size and spacing of the tractors' cultivation implements: 3-foot wide rows with 3-foot wide paths. The length of rows varies according to field shapes, ranging from 200 feet up to more than 600 feet. Crops are planted in one row, or several adjacent rows.

“Nisconlith” Soil — BC Soil Survey Code: BCNTH~~~~~A

LAYER	Total Depth (inch)	Layer Depth (inch)	Texture	Water (inch)	Sand (%)	Silt (%)	Clay (%)	Org. (%)	Rock (%)	Dom. Sand	Very Fine (%)
1	9	9	Loam	1.47	43	35	22	2.6	0	Fine	11
2	17	8	Clay Loam	1.57	27	44	29	2.5	0	Fine	7
3	21	4	Clay Loam	0.87	22	50	28	1.6	0	Fine	6
4	34	13	Silty Clay Loam	2.52	18	46	36	0.8	0	Fine	5
5	49	15	Sandy Loam	2.30	66	18	16	0.6	0	Fine	17

Water Source

The farm gets its water from a license on the Shuswap River, but water levels can fluctuate significantly (playing havoc with the pump) and water quality can be very turbid, plugging screens and creating maintenance problems.

Water is currently pumped from a suction line into a centrifugal pump that requires priming, which prevents it from being used for automatic operation.

Mainlines

From the pump, water either flows through a 4" PVC mainline to the fields in the south, or through a 3" PVC mainline to the hoophouses and one-acre field in the north.

Filtration

The 3" mainline is first diverted through a 3" disc filter with fine rings. Water quality is often so turbid that the filter needs cleaning within hours of operation.

Microsprinklers

Filtration is required for the inverted microsprinklers that irrigate each hoophouse, and the small-nozzled “Meganets” that irrigate the 1-acre field and fields between houses.

There is no automation, so each house is turned on and off individually. There is sufficient flow from the pump that a single main valve can be used to turn all the hoophouses on together at one time.

Aluminum Handlines and Brass Impact Sprinklers

The 4" mainline heads south for more than 2400 feet (750m) to service 22 acres of vegetables irrigated by 3" by 30-foot aluminum handlines.

These must be moved twice per day, which is tedious and time-consuming over such a large area of land.

Irrigation Gun

The green manure is usually irrigated by a small travelling (reel) irrigation gun that must also be moved twice per day.

R2000 Windfighter at 50 psi

	Size	Flow (gpm)	Throw (feet)	Note
Gold	9/64	4.1	43	40' space standard
Tan	15/128	2.8	39	30' space handlines
Yellow	13/128	2.1	37	Road guards at 40'
Orange	11/128	1.5	34	Road guards at 30'
Blue	5/64	1.3	33	Road guards at 20'

Zone	Laterals	Total Flow (gpm)	App Rate ("/hr)	Rate to Roots ("/hr)	Peak Daily Hours
1	1-2	100	0.17	0.13	1.5
2	3-4	96	0.17	0.13	1.5
3	5-6	96	0.17	0.13	1.5
4	7-8	94	0.17	0.13	1.5
5	9-12	96	0.17	0.13	1.5
6	13-14	84	0.16	0.12	1.5
7	15-16	84	0.16	0.12	1.5
8	17-21	78	0.17	0.13	1.5
9	22-24	111	0.17	0.13	1.5
10	25-26	94	0.17	0.13	1.5
11	27-28	109	0.16	0.12	1.5
12	29-30	118	0.16	0.12	1.5
13	31-35	105	0.16	0.12	1.5
14	36-40	105	0.16	0.12	1.5
15	42-45	68	0.16	0.12	1.5
16	46-50	105	0.16	0.12	1.5

Solid Set Sprinklers

A "solid set" system — where sprinklers are permanently located throughout the fields — saves a lot of labour, but there are two major problems:

1) It is expensive to purchase the many sprinkler heads, risers, and pipes that are required.
2) Many production practices are easier without pipes and risers in the way, such as whole-field cultivation.

Here, careful attention was paid to current production practices so they can continue relatively unchanged.

The material expense can usually be justified in terms of a few years of reduced labour, decreased water use, and improved crop health.

Aluminum handlines must be moved regularly. Besides labour, it is difficult to fine-tune how much water crops get.

Automation

Automation is the key to really benefit from solid set labour savings and water efficiency. With minimal effort, automation makes it possible to fine tune irrigation to the weather and the crop throughout the season.

A good solution is the "two-wire decoder" system, in which a network of 2-wire (one out, one return) follows the mainlines. "Decoders" are wired to individual automatic valves (AC solenoid) and the central "controller" sends coded signals down the wire to tell decoders to turn valves on or off.

The main advantage is flexibility: If more zones are required, then just splice in new decoders anywhere along the 2-wire network. If the system needs to expand into new land, then more 2-wire can be spliced into the network at any point.

Decoder

Pump

The pump should also operate automatically. The existing centrifugal should be replaced with a self-priming or submersible pump, with a pressure switch that turns on based on demand.

Additional energy-saving features that could be considered include variable frequency drives and cycle stop valves.


Riverscreen raft

Intake

To deal with water level changes in the river, and as a first line of defence against turbidity, a self-flushing intake is a good idea.

For example, “Riverscreen” intake rafts work in as little as 6 inches of water with a centrifugal pump, or in 24 to 36 inches of water with a submersible pump or a gravity intake.

A flexible connection to the shoreline allows the raft to adapt to water level changes, while screening as fine as 120-mesh can be selected for the rolling drum kept clean by small water jets.

As with any intake screen, a large screen area is needed to keep water speeds near the screen low and fish fry safe.

Before winter (or a flash flood), the raft can be disconnected and pulled to shore.

Hydrant

Mainlines

The existing 4" PVC mainlines can be re-used and have very little pressure loss at the 120 gpm peak flow. Water moves slowly in them, reducing the risk of water hammer which can break PVC as it becomes more brittle over time.

Automatic and manual zone valves can be aboveground in “manifolds” near the mainline at the start of a lateral in the uncultivated buffer strip. These manifolds can connect by 3” PVC to the existing hydrants on the mainline.

Headers

From each zone valve, new PVC "headers" run to laterals. Here it is crucial that pipes are sized to accommodate the flow, and that tees are also sized for the total flow.

Lateral Layout

Wild Flight opted to run laterals mostly aboveground down the middle of 3-foot-wide “buffer strips” of land taken out of production. Compared to burial, this makes it easier to maintain the laterals or remove them entirely, if required.

It is most economical to use the fewest laterals and sprinklers to cover the most land. Typical sprinklers with a 40-foot throw (80-foot diameter) require laterals no further than 60 feet apart, and only then if the prevailing winds are gentle and run across (perpendicular to) the laterals.

Wild Flight's east-west rows run perpendicular to the prevailing up-and-down-valley winds. They opted to have 9 rows of crops between each lateral, plus the buffer strips, for a span of 57 feet between laterals.

The lowest acceptable pipe pressure (P) is calculated along the full length (L) from the filter at the pump house (X1) to the far end of the leased field (X5).

Flow is 122 gpm in the 4” inner-diameter (ID) PVC pipe. Elevation changes (Elev) in the field are added to total friction losses in both pipes and fittings (H_{tot}) to determine that the pipe loses about 18% of its pressure from start to finish.

Water velocity (V_{pipe}) is 3.1 ft/s, well below the 5 ft/s limit where water hammer risks rapidly rise.

Higher flows would increase both water velocity and pressure loss to friction.

			2410				10.6	17.6%	3.1
MAINLINE	**Comment**	**Flow (gpm)**	**L (ft)**	**ID (in)**	**Type**	**Elev (ft)**	**H_{tot} (psi)**	**P (psi)**	**V_{pipe} (ft/s)**
X1	**Filter (after Pump)**	**122**				0		**60**	
X1-X2	**North end Main Field**	122	420	4	PVC	-2	1.8	**59**	3.1
X2-X3	**South end Main Field**	122	870	4	PVC	2	3.8	**53**	3.1
X3-X4	**North end Lease Field**	122	680	4	PVC	-1	3.0	**52**	3.1
X4-X5	**South end Lease Field**	122	440	4	PVC	1	1.9	**49**	3.1

Polyethylene Laterals

With 57 feet between rows, sprinklers with a 40-foot throw shouldn't be more than 40 feet apart in the lateral. Any further apart might reduce the "evenness" of the water application.

Laterals are 2" polyethylene (PE) for the first 240 feet, and step down to 1.5" PE for the last 240 feet. This keeps the difference in pressure from the first sprinkler to the last within about 10% of each other so application rates are consistent.

Manual valves at the beginning of each lateral allow them to be turned off, even if they are part of a larger zone that has other laterals that continue to operate automatically on the regular schedule.

Drain valves at the end of each lateral make it easy to flush and drain the pipes.

Aluminum Laterals

Wildflight will re-use its aluminum handlines as laterals. The design takes advantage of the 3" aluminum pipes to reduce friction losses and water hammer risks on the long 500 to 600-foot rows in zones 11 and 12.

The aluminum lines have sprinklers spaced at 30 feet, so smaller nozzles must be used to keep the application rate consistent.

Sprinklers

The old brass impacts have worn nozzles, often leak from bearings, and tend to jam easily. It is least expensive to replace brass impacts with durable, parts-swappable "rotator" sprinklers, such as the R2000 Windfighters.

Sprinkler nozzles were chosen to keep flows low enough for 2" laterals up to 480 feet long (wider polyethylene is harder to use and often unavailable) and, crucially, to keep the application rate the same throughout the system, in this case around 0.16 to 0.17"/hr.

Road Guards limit the sprinkler to a semi-circle (technically 190°) at the edge of roads, so smaller nozzles are needed to maintain the rate of about 0.17"/hr.

					0.16		500				5.33	11.1%	4.4
Zone 7 Lateral 16	**Comment**	**190° Road Guard**	**Noz Size**	**Noz Flow (gpm)**	**App Rate ("/hr)**	**Flow (gpm)**	**L (ft)**	**ID (in)**	**Type**	**Elev (ft)**	**H_{tot} (psi)**	**P (psi)**	**V_{pipe} (ft/s)**
Valve	**1.5" (5 psi loss)**					**42.0**				**0**	5	**53**	
Header	**60' x 3" PVC**					42.0	60	**3**	**PVC**	0	0.15	**48**	**1.9**
Sprinkler 1	**200' x 2" PE**	✓	**Yellow**	2.07	0.17	42.0	0	**2**	**PE**	0	0.00	**48**	**4.3**
Sprinkler 2			Gold	3.93	0.17	39.9	40	**2**	**PE**	1	0.69	**47**	**4.1**
Sprinkler 3			Gold	3.89	0.16	36.0	40	**2**	**PE**	1	0.57	**46**	**3.7**
Sprinkler 4			Gold	3.89	0.16	32.1	40	**2**	**PE**	1	0.46	**46**	**3.3**
Sprinkler 5			Gold	3.89	0.16	28.2	40	**2**	**PE**	1	0.36	**45**	**2.9**
Sprinkler 6	**240' x 1.5" PE**		Gold	3.8	0.16	24.3	40	**1.5**	**PE**	2	1.11	**44**	**4.4**
Sprinkler 7			Gold	3.76	0.16	20.5	40	**1.5**	**PE**	2	0.81	**43**	**3.7**
Sprinkler 8			Gold	3.72	0.16	16.7	40	**1.5**	**PE**	2	0.56	**42**	**3.0**
Sprinkler 9			Gold	3.72	0.16	13.0	40	**1.5**	**PE**	2	0.35	**42**	**2.4**
Sprinkler 10			Gold	3.68	0.16	9.3	40	**1.5**	**PE**	3	0.19	**41**	**1.7**
Sprinkler 11			Gold	3.68	0.16	5.6	40	**1.5**	**PE**	3	0.07	**41**	**1.0**
Sprinkler 12		✓	**Yellow**	1.92	0.15	1.9	40	**1.5**	**PE**	3	0.01	**41**	**0.3**

Friction losses drop the pressure (P) by 11% along the lateral, from 48 to 41 psi. This reduces the application rate, but it remains in the range of 0.16 to 0.17"/hr.

Peak Schedule

Schedules are set up to irrigate 24-hours per day in “peak” conditions.

The BC Agriculture Water Calculator can give “Peak Evapotranspiration”, which for Mara is 4.7mm/day.

Application Efficiency and Run Times

Typically only 70 to 75% of sprinkled water makes it to the roots, so more water is applied to account for these inefficiencies.

For example, to get 4.7mm to the crop each day requires about 6.3mm of water to be applied. At 4.15 mm/hr (0.165”/hr) that’s 1.5 hours per day.

Run times are adjusted week-to-week by a “percentage of peak” based on the weather, the crop, and the soil. (The next page has an example with cabbage.)

Fewer, Larger Zones

As mapped here, laterals are tied by headers into large zones — a zone is run by a single automatic valve. Laterals can be added so long as the total flow doesn’t exceed the farm's 122 gpm limit.

The schedule on the map shows this approach for 16 large zones. This is the simplest to program and has the fewest upfront expenses in decoders, solenoid valves, fittings, and installation.

Many Smaller Zones

Alternatively, laterals can be split up and run as smaller zones. Here, the scheduling system is programmed so multiple small zones run simultaneously so the total flow is close to 122 gpm.

At the extreme, each lateral can be its own zone — 50 zones instead of 16. Wild Flight chose this option, determining that the increased cost will pay for itself in management flexibility.

A middle ground is charted here, with some of the shorter laterals split off into small zones (20 to 40 gpm) that can be run at the same time as the larger (80 to 100 gpm) zones, bringing the total flow at any time close to 122 gpm.

Climate Change Renos

If a system is built with just a few, large zones, decoder controllers make it easy to split them into smaller zones.

Such splits may be needed as climate change takes hold. Most zones in this plan run well below the 122 gpm limit, but when crops are mature and thirsty, extremely hot and dry periods will demand the full flow 24-hours per day.

Schedule for 23 zones

Schedule	Zones	Laterals	Flow (gpm)	Peak Daily Hours
1	1	1-2	100	1.5
1	15B	44	21	1.5
2	2	3-4	96	1.5
2	15A	42-43	26	1.5
3	3	5-6	96	1.5
3	15C	45	21	1.5
4	4	7-8	94	1.5
4	4	4	21	1.5
5	5	9-12	96	1.5
5	14B	37	21	1.5
6	6	13-14	84	1.5
6	16A	46-47	42	1.5
7	7	15-16	84	1.5
7	16C	49-50	42	1.5
8	8	17-21	78	1.5
8	14D	39-40	42	1.5
9	9	22-24	111	1.5
10	10	25-26	94	1.5
10	14C	38	21	1.5
11	11	27-28	109	1.5
11	16B	48	17	1.5
12	12	29-30	118	1.5
13	13	31-35	105	1.5

This 23-zone schedule has 13 time slots of 1.5 hours each at “peak”, completing the cycle in just 19.5 hours. This leaves 4.5 hours to spare in case extra irrigation is required in extreme conditions.

Example Adjustments

Evapotranspiration data from the Grindrod weather station for 2021 and 2022 was adjusted 5% lower to account for the higher Peak ET in Grindrod (4.9mm/day) over Mara (4.7mm/day), as defined by the BC Agriculture Water Calculator, the online tool used to determine water license limits.

Crop coefficients for a full season of cabbage (Washington State University) were used to estimate how much water a typical vegetable might use.

The graph is shown as a "percentage of Peak ET". A peak schedule (100%) run time of 1.5 hours means "133%" equates to a 2-hour run time, and "66%" equates to a 1-hour run time.

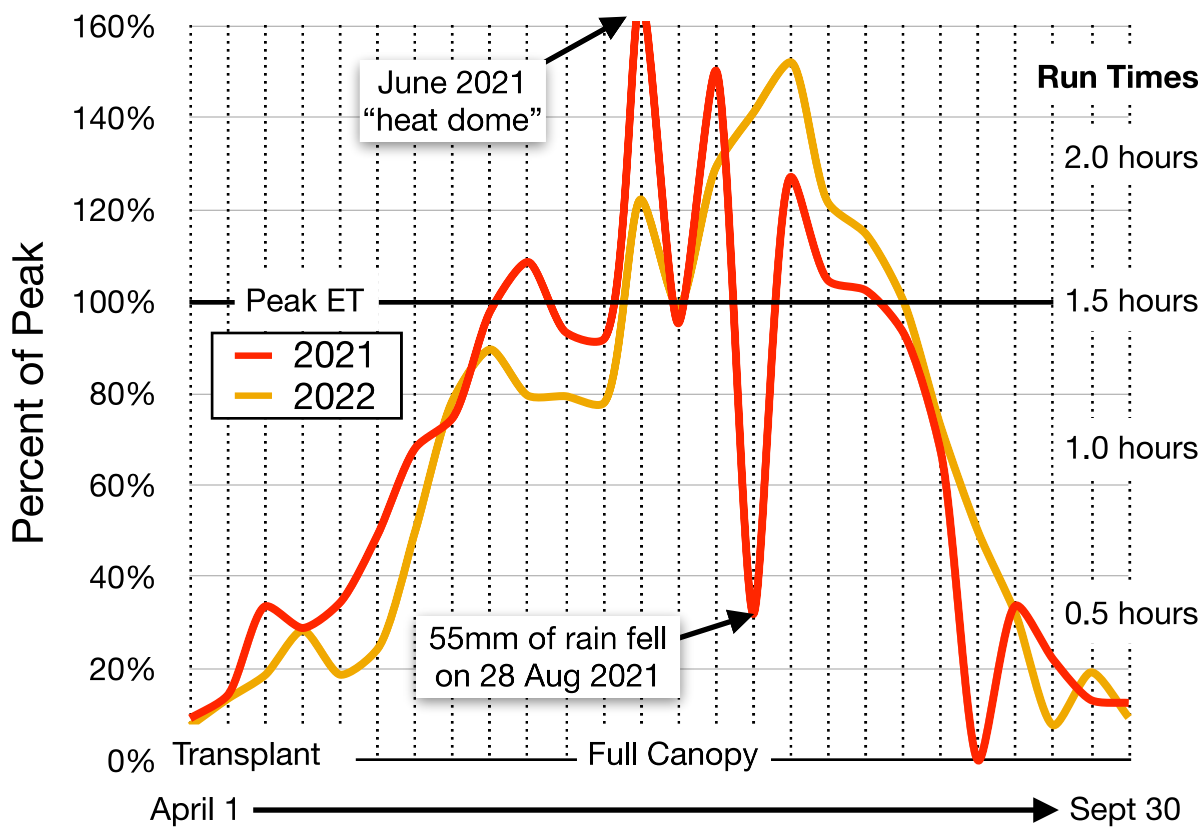
Uncertainties

It is unusual to see schedules going so far above Peak ET (100%), especially for weeks at a time.

We could question the microclimate of the Grindrod station relative to Wild Flight Farm, 10km to the north, and we already reduced values by 5%.

There may also be an argument that the BC Ag Water Calculator's Peak ET for Mara could be reconsidered in light of newly available data for the region.

In a market garden, high water demand from mature crops is often balanced by low demand on recently planted ground or from younger crops.



Soil Monitoring

It is important to check soil moisture to "ground truth" weather-based scheduling assumptions.

Soil moisture sensors help to see when and at what depth a particular combination of soil, crop, and irrigation is drying out, or getting saturated.

A 6" tensiometer is easily moved and is ideal for shallow-rooted crops. Deeper probes are also available.

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CASE: HAY PRODUCTION

Efficiency Improvements for Hay Irrigated by Wheelmoves, Travelling Guns and Pivots on a South Okanagan Ranch

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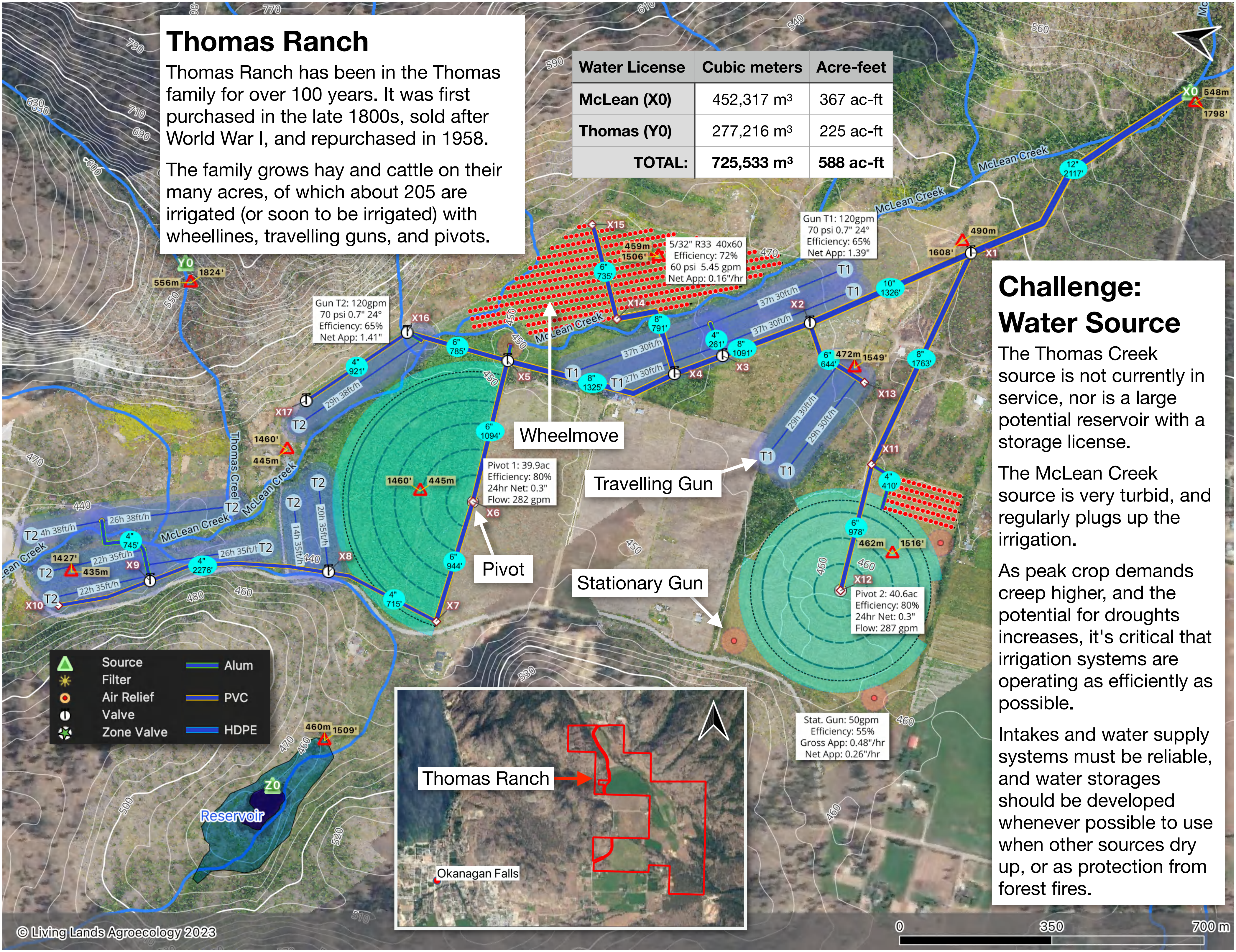
Thomas Ranch

Thomas Ranch has been in the Thomas family for over 100 years. It was first purchased in the late 1800s, sold after World War I, and repurchased in 1958.

The family grows hay and cattle on their many acres, of which about 205 are irrigated (or soon to be irrigated) with wheellines, travelling guns, and pivots.

Water License	Cubic meters	Acre-feet
McLean (X0)	452,317 m³	367 ac-ft
Thomas (Y0)	277,216 m³	225 ac-ft
TOTAL:	725,533 m³	588 ac-ft



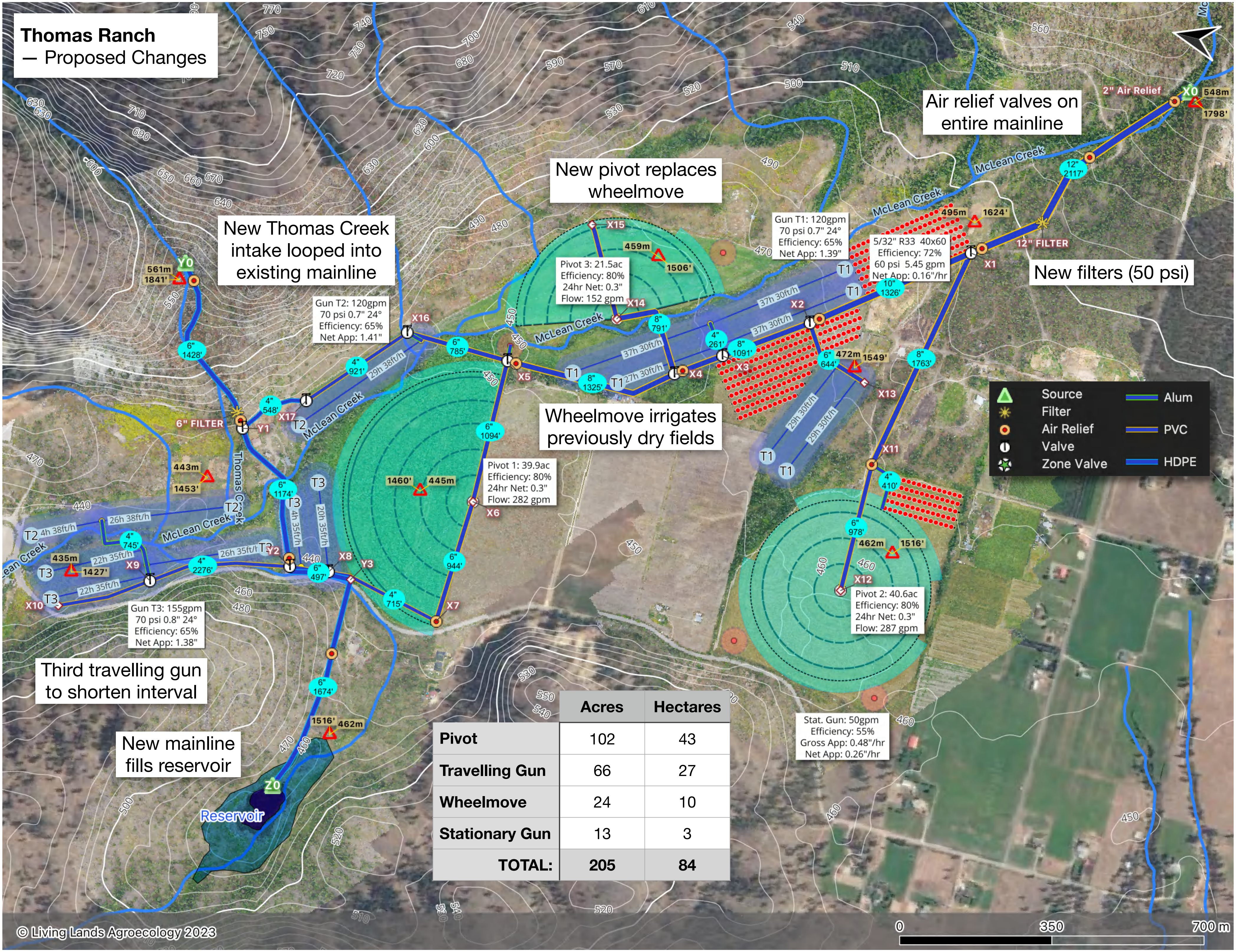
Challenge: Water Source

The Thomas Creek source is not currently in service, nor is a large potential reservoir with a storage license.

The McLean Creek source is very turbid, and regularly plugs up the irrigation.

As peak crop demands creep higher, and the potential for droughts increases, it's critical that irrigation systems are operating as efficiently as possible.

Intakes and water supply systems must be reliable, and water storages should be developed whenever possible to use when other sources dry up, or as protection from forest fires.



	Acres	Hectares
Pivot	102	43
Travelling Gun	66	27
Wheelmove	24	10
Stationary Gun	13	3
TOTAL:	205	84

Forest Fire Protection

A forest fire in 2021 started just north of the ranch near Thomas Creek, and could have been disastrous if not for the ranch's large travelling guns. The guns went back and forth parallel to the fire's path saving both the Thomas Ranch and other nearby farms. Irrigation systems can provide benefits beyond growing crops in our fire-prone ecosystems.

Water Sources

The ranch has a long-standing water license on McLean Creek, which is fed from McLean Lake and receives water from snow melt collected in the mountains between Carmi and Okanagan Falls.

A second water license on Thomas Creek is fed from a canyon east of the property. Both water sources are reliable and serve the ranch with lots of pressure from gravity.

Thomas Creek

The Thomas Creek source is not in service, but it makes up almost 40% of the farm's licensed water. In peak demand, particularly with climate change, there could be a serious water shortage for the farm.

So far, this has not been critical as several irrigable areas are also under development and not yet in service. But as the farm re-establishes full use of its land, it will also need full use of its available water.

Existing Mainline

The gravity feed mainline from McLean Creek begins as 12" PVC. This is well-sized for the licensed flow of 1350 gpm (6.6 gpm/acre).

Moving north, pipe diameters reduce after intersections where water is diverted to different fields. By the time the mainline reaches Thomas Creek in the north, it terminates in two branches of 4" piping.

Pipe Size

This mainline works well if the farm were only irrigating from McLean Creek, but 4" pipe is too small to bring large flows from Thomas Creek back in the other direction.

Fortunately, the farm can connect to both 4" branches to create a loop. When mainlines are looped, water is able to travel down both branches at once, doubling the potential flow. In this case, one 4" pipe can only carry 200 gpm, but the loop doubles the flow to 400 gpm.

New Thomas Connection

A 6" line from Thomas Creek can be connected to the existing McLean Creek mainline on both 4" branches (Y1 and Y2 on the map).

The 6" Thomas line can then continue up to the reservoir. When the water is not used for irrigation, closing two isolation valves and opening a third can start filling the reservoir.

Reservoir

The ranch has water storage licenses and should use them to hedge against extreme weather and for potential fire protection for the ranch and surrounding neighbourhoods.

The low elevation of the reservoir means it can only be used to feed back into the irrigation mainline with a booster pump.

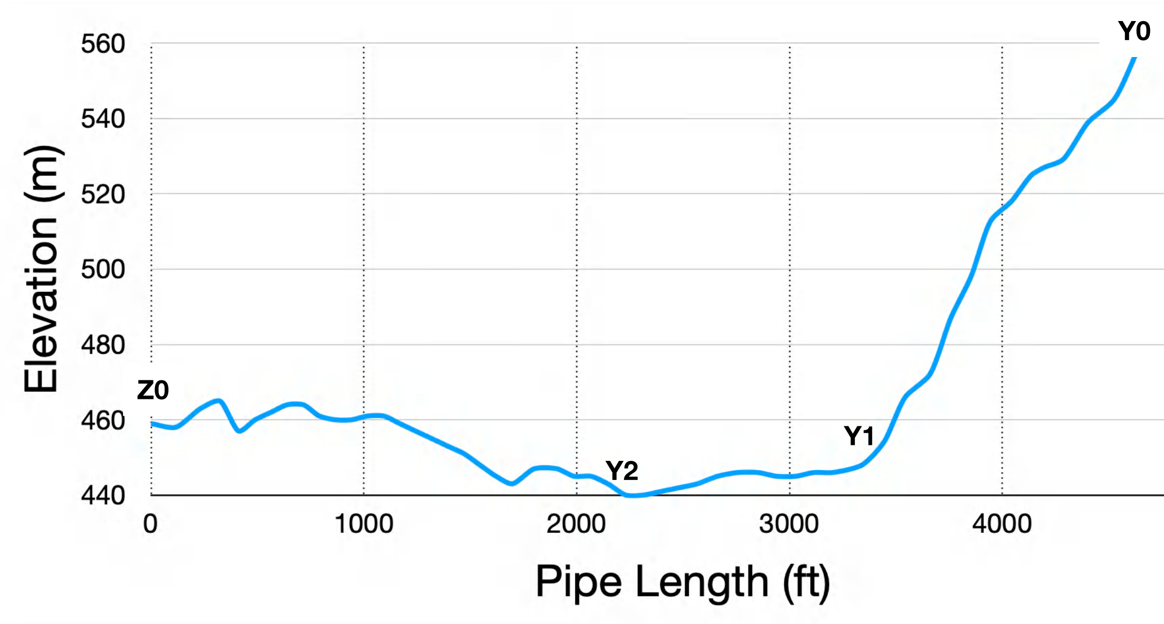
The reservoir currently stores about 8 ac-ft of water in an area about 1.5 to 2 acres, but up to 11 acres might be available to hold up to 130 ac-ft. Critically, the reservoir's ability to store the water without infiltrating into the surrounding soil is not tested.

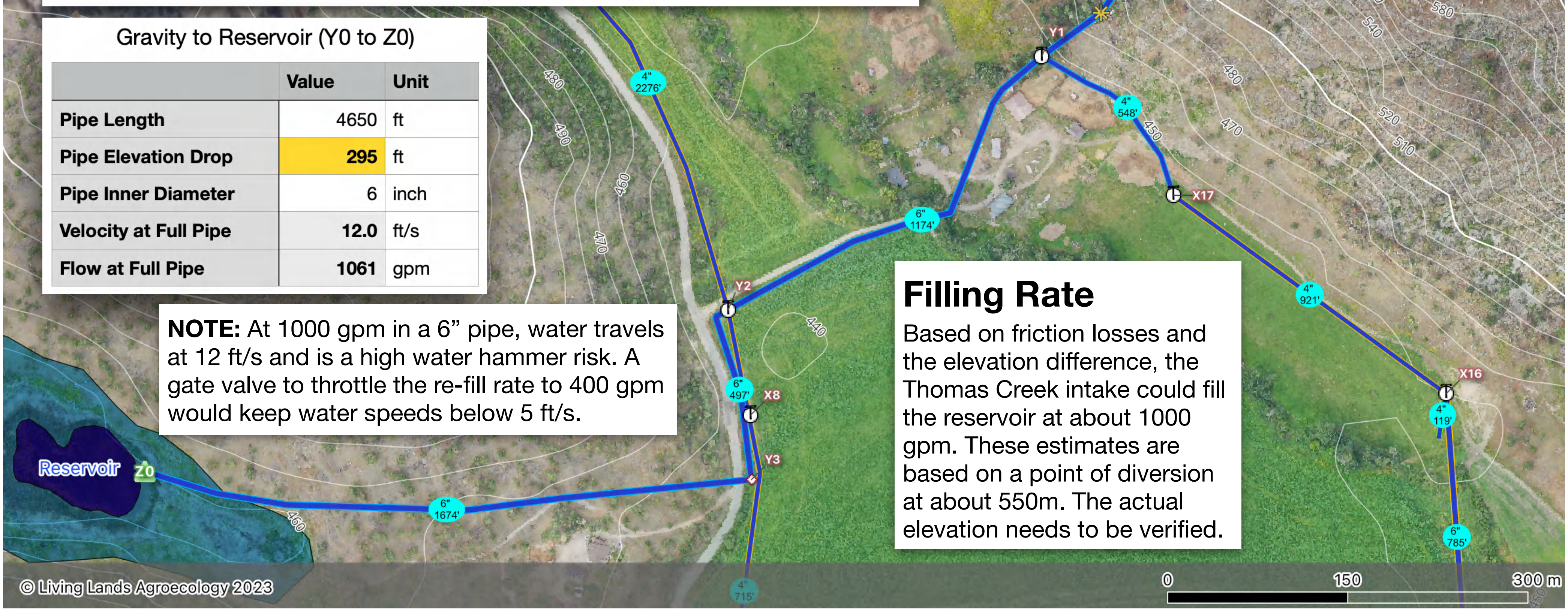
The higher estimates depend on the dam wall being reliable, and there are signs that water is already leaking through its base. The dam would have to be tested and likely renovated.

Reservoir

6” Pipe from Thomas Creek (Y0) to Reservoir (Z0)

▼ Fish Screen		
Max Screen Flow	1060	gpm
Max Flow Velocity	0.1	ft/s
Mesh Size	8	mesh
Open Area	60%	
Min Total Area	39.2	sqft





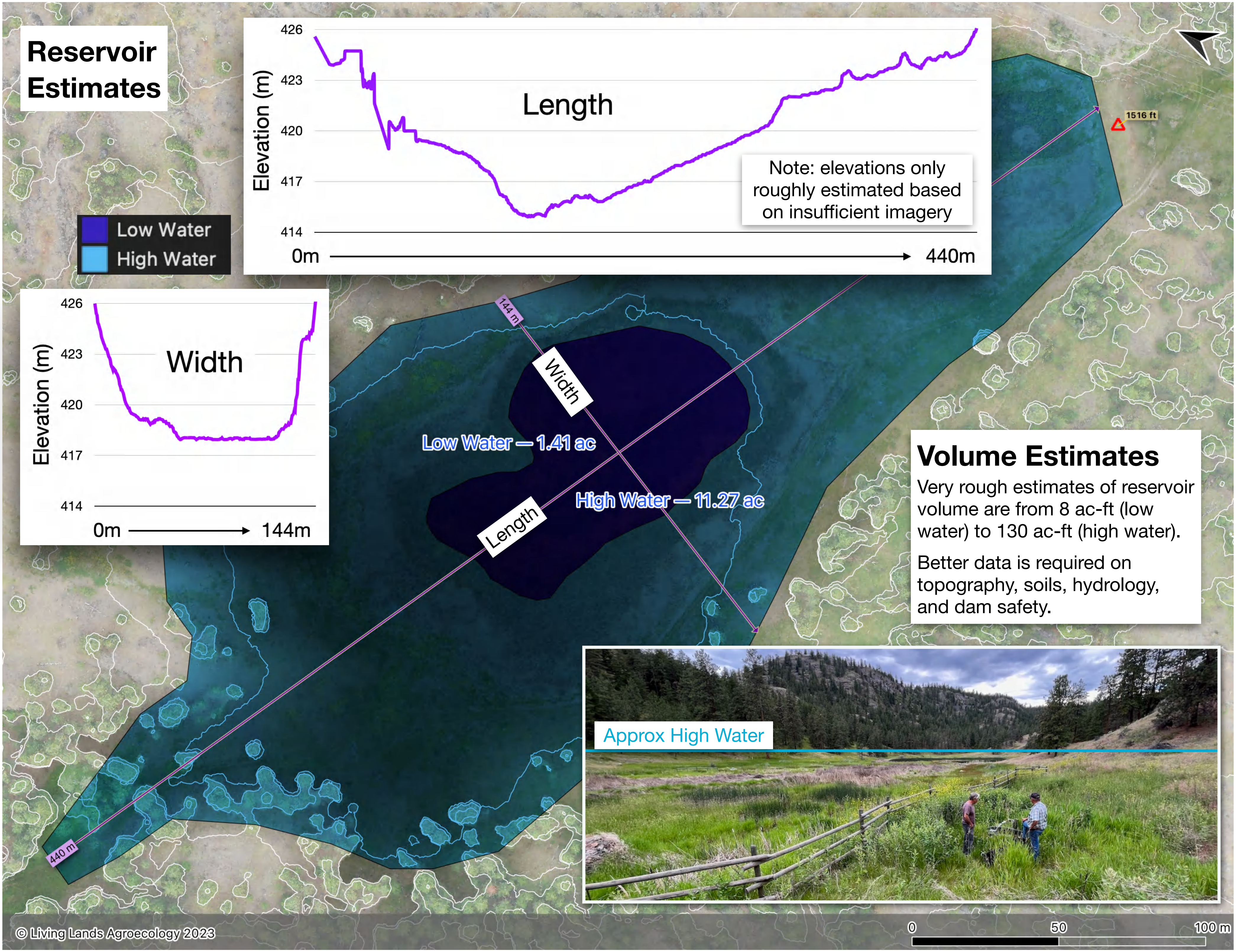
Gravity to Reservoir (Y0 to Z0)

	Value	Unit
Pipe Length	4650	ft
Pipe Elevation Drop	295	ft
Pipe Inner Diameter	6	inch
Velocity at Full Pipe	12.0	ft/s
Flow at Full Pipe	1061	gpm

NOTE: At 1000 gpm in a 6” pipe, water travels at 12 ft/s and is a high water hammer risk. A gate valve to throttle the re-fill rate to 400 gpm would keep water speeds below 5 ft/s.

Filling Rate

Based on friction losses and the elevation difference, the Thomas Creek intake could fill the reservoir at about 1000 gpm. These estimates are based on a point of diversion at about 550m. The actual elevation needs to be verified.


Reservoir Estimates
Low Water
High Water
Length
Elevation (m)
426
423
420
417
414
0m
440m
Note: elevations only roughly estimated based on insufficient imagery
Width
144m
1516 ft
144 m
440 m
Low Water — 1.41 ac
High Water — 11.27 ac
Volume Estimates
Very rough estimates of reservoir volume are from 8 ac-ft (low water) to 130 ac-ft (high water).
Better data is required on topography, soils, hydrology, and dam safety.
Approx High Water
© Living Lands Agroecology 2023
0
50
100 m

Air Vents

Many irrigation systems suffer from air pockets that build up at high points, or over long runs. If air isn't evacuated, flows and pressures can be significantly reduced and water hammer risks increased.

Gravity systems are particularly prone to the error of too-few air relief valves. Even with a consistent drop in elevation along the full length of this pipe (no high spots), air vents are still needed about every 1000 feet.

It is important to install air relief valves that are capable of air relief, vacuum relief, and continuous action.

Continuous action air and vacuum relief

Turbid Water

McLean Creek is very turbid, with large amounts of suspended matter frequently plugging key irrigation components, including stopping the turbines from operating in the two guns' traveller units.

McLean Creek Intake

Filters

A 12" self-flushing filter should be installed on the McLean Creek mainline downhill from the point of diversion. A minimum of 50 psi is required to operate the flush valve, so at approximately 130-feet lower elevation than the intake.

An "orifice plate" in the filter directs jets of water that wash off the screen and force debris into a catch basin. Opening a flush valve drains the back to the creek. Due to the high level of turbidity, the flush valve would be kept open continuously.

A 6" filter should be installed on the new Thomas Creek gravity mainline at an elevation where 50 psi is available.

Spin-Down Filter

Soils

There are many soil types on the property, but mostly sandy loam and sand. Some layers have more silt and clay, but the layers are typically thin.

The amount of gravel and rock also varies a lot. This has a significant impact as gravel doesn't store water.

Winslow Soil Survey Data

Total Depth (inch)	Layer Depth (inch)	Texture	Water (inch)	Sand (%)	Silt (%)	Clay (%)	Rock (%)
4	4	Sandy Loam	0.53	65	25	10	10
13	9	Sandy Loam	1.10	55	33	12	15
16	4	Loamy Sand	0.16	50	40	10	70
20	4	Sandy Loam	0.58	52	38	10	10
25	5	Loamy Sand	0.14	75	20	5	70
42	17	Sand	0.25	90	5	5	85

Soil Water Storage

We dug into soil in one area where the survey called for a "Winslow" soil, with sandy loam to sand, and 10 to 85% coarse fragments (rock and gravel). This soil would only store about 2.8" of water, of which only 1.4" is available to plants.

Instead we found very little rock and considerably more loam in the upper layers. We estimated closer to 5.8" of water storage, of which 2.9" would be available to plants.

There's no substitute for digging holes and taking a look.

Loam to sand transition

Irrigation Interval

Irrigation planning for moveable irrigation like wheelmoves and guns depends on the amount of water the soil can store that is available to the plants.

The irrigation interval — how long until you return to the same place again — depends on the number of days it takes a vigorous crop to use up the available water during "peak" weather.

What we found did not match the survey

The soil we dug into may have stored about 2.9" of plant-available water. With 0.26"/day peak evapotranspiration, that gives an irrigation interval of 11 days.

This seems reasonable based on the farm's experience, but it should be reassessed with a closer look at the soils. According to the survey, many soils might only have 1.5" of available soil storage, or less, with a maximum irrigation interval closer to 5 or 6 days.

Soil Sensors

Install soil moisture sensors in at least one location in each field, with sensors at two depths — e.g. one at 12" and one at 36" — at each location.

Soil moisture sensors can help identify patterns in how and when the soil dries to improve each field's irrigation schedule.

Some fields may be able to operate with very heavy but infrequent irrigations, where others need to be irrigated a smaller amount more frequently.

Travelling guns

The McLean Creek intake is at 540 meters elevation, and the higher irrigated fields in the south are at about 470 m. After friction loss, there is about 90 psi available in the mainline. Using guns in these fields is just barely acceptable, with about 70 psi at the nozzle.

Two travelling guns are currently in use, but a third travelling gun could improve water use by shortening the irrigation interval length. If irrigation intervals are too long, the soil can dry out and leave the crop stressed or dormant.

Pivots

Both pivots are working well, but they share a single gas generator so only one pivot can operate at a time.

Pivots are designed to be used 24-hours per day in peak periods, so this issue is being resolved with a new power supply.

Wheelmove Problems

Two wheelmoves used on the east side of the property have very worn nozzles and pressures that are too high (80+ psi).

Heavily worn nozzles create inconsistent flows and distribute the water poorly.

High pressure causes “misting”. Water was visibly affected by gentle winds, and strong winds are common in the valley.

A catch-can test found very low distribution uniformity, with excess water applied near the heads, and insufficient water applied far from the heads.

Pressure

Pressure regulation is important for all types of irrigation. In this case, either a 3” pressure regulator needs to be installed on the mainline, or install small in-line flow control valves under each sprinkler head. The latter option gives the best uniformity as friction losses inevitably result in lower pressures at the far end of a wheel line.

New Sprinkler Heads

All sprinkler heads should be replaced with plastic rotators (e.g. R33) with 5/32" nozzles. These heads are durable, have better uniformity than brass heads, have readily changed parts, and are less expensive.

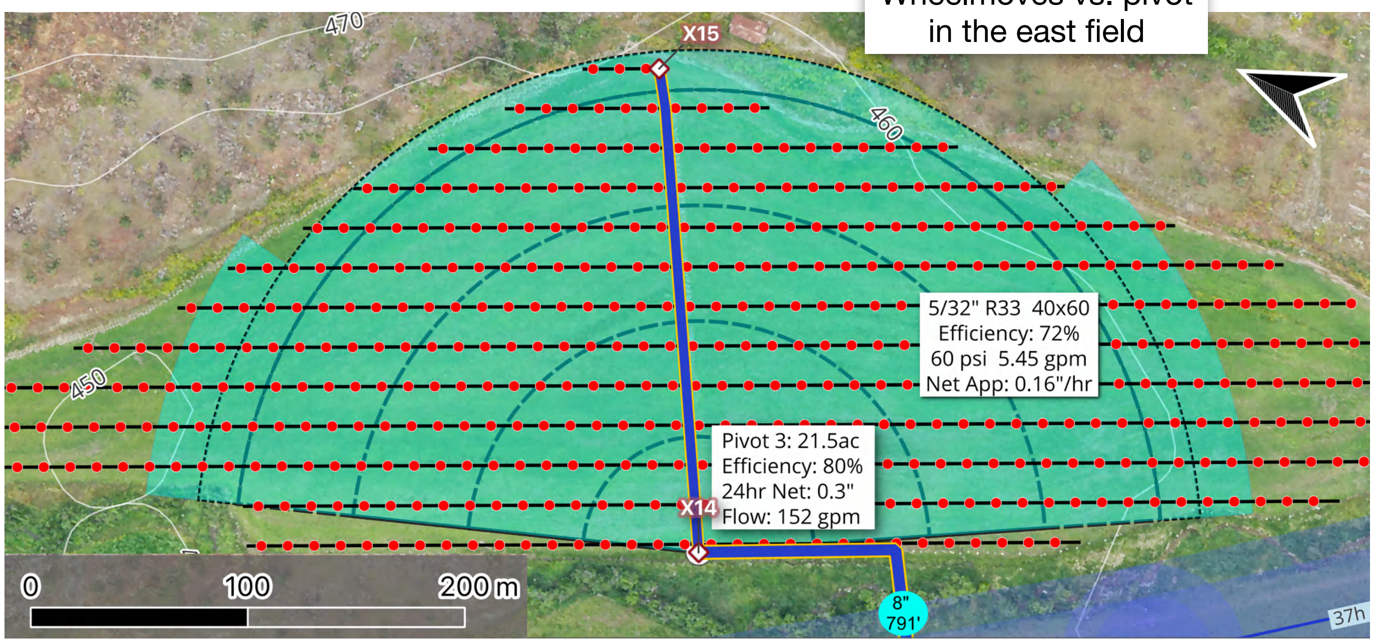
To address wind effects on sprinkler performance, consider staggering line spacing. For example, with 60 feet changes between wheel line positions, offset the next moves by 30 feet.

New Pivot

Alternatively, the farm is a considering a third pivot to replace these wheelmoves.

The (renovated) wheelmoves can then be moved to the currently unirrigated centre and south fields, or set up as permanent "solid set" installations, for example in the corners around pivots.

Wheelmoves vs. pivot in the east field



FARM IRRIGATION CASE STUDIES

CASE: APPLE ORCHARD

Upgrading Old Drip Emitters in an Apple Orchard on a Steep Slope with Hard Soils in Central Okanagan, BC

Bruce Naka, CID

Sound Water Advise

Andrew Bennett, MSc PAg CID

LIVING LANDS AGROECOLOGY

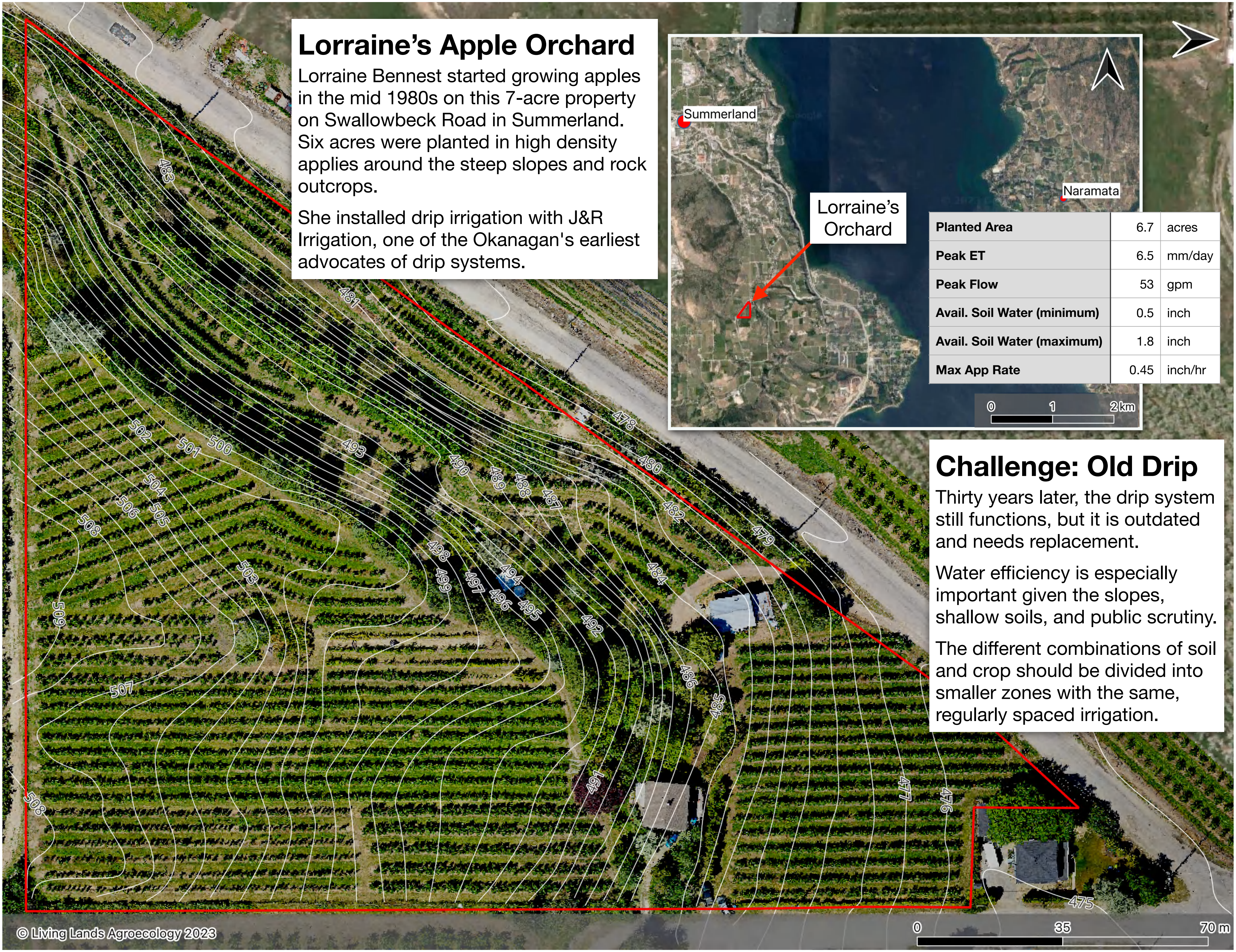
Funding for this project has been provided in part by the Regional District of Okanagan Similkameen, the Regional District of North Okanagan and the Okanagan Basin Water Board, and in part by the governments of Canada and British Columbia under the Canadian Agricultural Partnership, a federal-provincial-territorial initiative. The program is delivered by the Investment Agriculture Foundation of BC.

19 March 2023

Lorraine's Apple Orchard

Lorraine Bennest started growing apples in the mid 1980s on this 7-acre property on Swallowbeck Road in Summerland. Six acres were planted in high density applies around the steep slopes and rock outcrops.

She installed drip irrigation with J&R Irrigation, one of the Okanagan's earliest advocates of drip systems.



Planted Area	6.7	acres
Peak ET	6.5	mm/day
Peak Flow	53	gpm
Avail. Soil Water (minimum)	0.5	inch
Avail. Soil Water (maximum)	1.8	inch
Max App Rate	0.45	inch/hr

Challenge: Old Drip

Thirty years later, the drip system still functions, but it is outdated and needs replacement.

Water efficiency is especially important given the slopes, shallow soils, and public scrutiny.

The different combinations of soil and crop should be divided into smaller zones with the same, regularly spaced irrigation.

Elevation and Soils

From top to bottom, elevation changes by more than 100 feet. Bedrock is often only 12" below the surface, especially at the top of the property, and there are wide variations in soil types.

Uphill Neighbours

Immediately uphill (south) of the top of Lorraine's property is a cherry orchard from which excess water flows downhill (north) onto her property into the area with shallow bedrock. Combined with run-off from rain, steep slopes, and thin soils with limited water storage, there is potential to saturate soils lower down. Puddling and soil saturation can be detrimental, or even deadly, to trees.

Downhill Neighbours

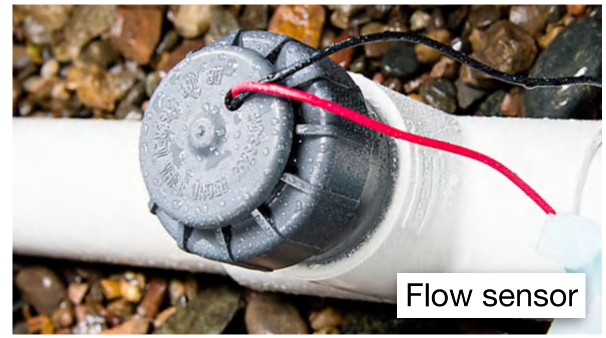
Lorraine's orchard is relatively small (under 10 acres) and surrounded by housing developments. This very common situation can exacerbate water conflicts.

If an orchard has leaks and irrigates excessively, the water losses could be high, and the public visibility great. In these cases, irrigation efficiency is not only important to address water demands in drought conditions, but to remain on good terms with neighbours.

The top (south end) of Lorraine's Orchard

Point of Connection

The orchard is supplied with purveyed water from the lowest point of property with a mainline feeding up to the top. There are many connections and possible points of failure. If a leak were to occur in the mainline and run for a significant length of time, serious flooding could occur.



Flow sensor

Flow Sensors

When new irrigation is installed, it is very useful to have a flow sensor to measure how much water each zone uses. Over time, if flows decrease it could indicate clogging, or if flows increase there could be leaks.

Here, we also recommend connecting the flow sensor to the main shut-off valve, so the system will automatically turn off if unusually high flows are detected. This is some insurance against a blow-out and the potential water damage that could result.


Soils
Lots of coarse fragments
Uphill neighbour's orchard
Totally saturated soil on hardpan or bedrock 2-feet below surface
Mix of drip and microsprinklers in poor condition and very leaky

Irrigation Inefficiency

As a result of repairs and replacements over the years, several different irrigation products are used, often in the same zone, and often at different flow rates and spacings.

When many types of drip irrigation are mixed like this, some areas get overwatered while others are underwatered.

This mis-irrigation is both very common and puts to rest the myth that drip irrigation is necessarily more efficient than other forms of irrigation.

Inline Drip

Some areas have inline drip irrigation, where pressure-compensated emitters are built into polyethylene pipe at specific spacings. Unless it's clogged or damaged, this type of irrigation is usually quite predictable in its output.

Inline drip

On-line drip leaking

On-line Drip

Other areas have on-line drip irrigation, where emitters are punched into poly pipe. In many cases in Lorraine's orchard, there are emitters of different spacings and different flows all in the same zone, which makes it difficult (or impossible) to determine how long to run the system to properly irrigate the crop.

On-line drip

Microsprays

Some areas have microsprays of different types and spacing, often at different elevations without being pressure compensated. Again, this leads to great variability in water output within a single zone.

Microsprays

Old Zones

The orchard only has 5 irrigation zones, despite many unique combinations of tree varieties, spacings, and soil types.

Many early drip irrigation systems aimed to maximize water allotments and minimize infrastructure by making zones as big as possible. But different varieties, spacings, and soil types require different amounts and frequencies of irrigation. The "one-size-fits-all" approach can both underwater and overwater within a zone.

New Zones

A better approach breaks these big zones into smaller, more uniform zones with the same tree variety, size, and spacing, on the same soil type, all irrigated by the same irrigation product.

Several smaller zones are run together, simultaneously, so the sum of their flows is close to the maximum allotment.

Automation

Centralized irrigation control — rather than individual battery-operated stations — makes management easier when there are many zones. Unfortunately, the current irrigation controller isn't suited to the retrofit.

In standard controllers like the orchard currently owns, each zone requires a wire to be run from the controller to the zone valve, and at Lorraine's, most wires are run on top of the ground.

Variety and Current Zones	Space (ft)	Row (ft)	Area (sqft)
Zone 1			
Spartan / Ambrosia (M9)	5	15	75
Spartan / Ambrosia (M26)	6	15	90
Zone 2			
Jonagold / Ambrosia (M9)	3	12	36
Royal Gala (M9)	4	12	48
Zone 3			
Ambrosia (M9)	3	12	36
Royal Gala (M9)	4	12	48
Spartan / Ambrosia (M9)	5	14	70
Zone 4			
Royal Gala / Silken (M9)	1.5	9	13.5
Zone 5			
Jonagold / Ambrosia (M9)	4	12	48

The only way to increase the number of zones is to run additional wires, which isn't practical for so many new zones.

Two-Wire Decoder

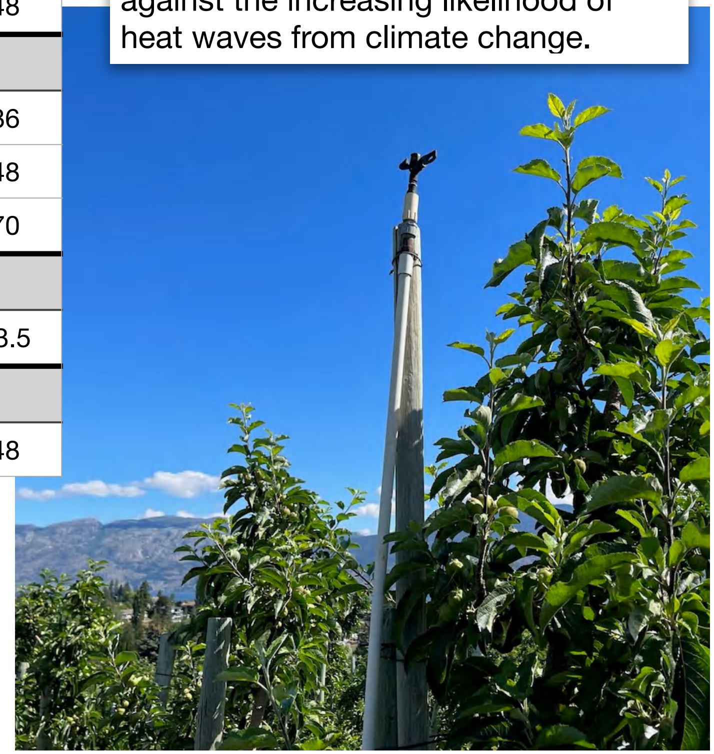
Instead, a "two-wire decoder" controller is a better choice. Each valve has a "decoder" wired to it that receives messages from the controller telling the valve to turn on or off. This way, only two wires are needed for the entire system — one out, one back — to carry the codes.

Old Cooling System

Overhead sprinklers were installed in many areas of the orchard for cooling.

Unfortunately, due to wear, most of the overhead system is inoperable today.

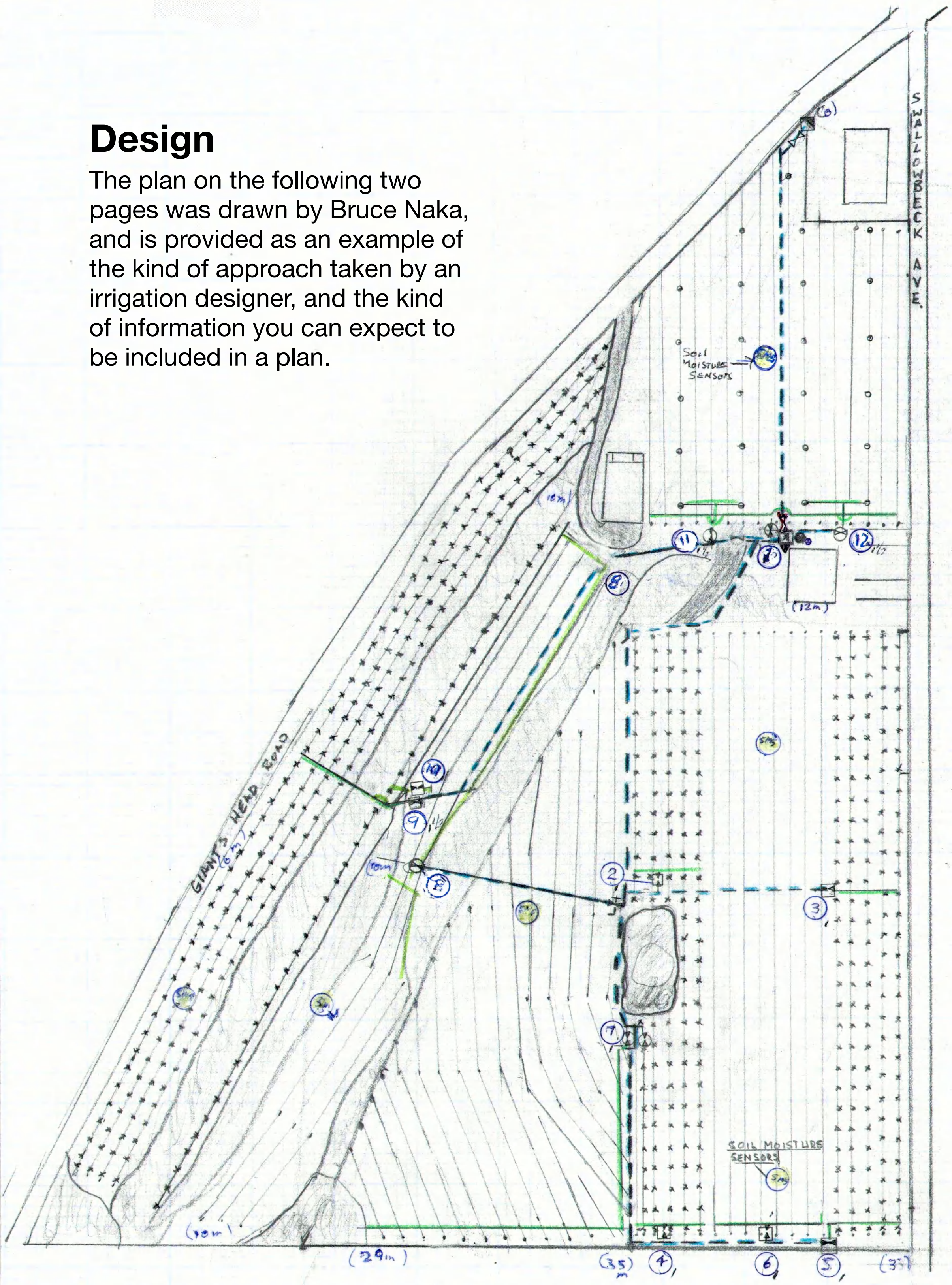
Many orchards are currently installing overhead sprinklers as protection against the increasing likelihood of heat waves from climate change.



Two-wire systems are easy to expand into new areas and to add new zones just by splicing in. This flexibility could be particularly helpful if the changes to Lorraine's orchard are to take place in several phases.

Design

The plan on the following two pages was drawn by Bruce Naka, and is provided as an example of the kind of approach taken by an irrigation designer, and the kind of information you can expect to be included in a plan.



DESIGN CALCULATIONS

DATA

- CROPS – APPLES, PEARS / ACREAGE – 7.40
  SPACING – 12' x 4' / 15 x 15'
- ET – .26"/DAY 6.6 mm
- SOURCE OF WATER – DISTRICT OF SUMMERLAND – 53.28 GPM
- ALLOCATION – 6 Imp gallons / Min. or 7.25 US GPM

SYSTEM REQUIREMENTS

MICRO SPRINKLER: PEARS — MICRO VI TORO 19 AROON NOZZLE .049" ORIFICE – 100 MESH FILTRATION
20 PSI 19 gph – 25' DIA
SPACING 15 x 15

APPLICATION RATE: $\frac{96.3 \times .32}{15 \times 15}$ = .14"/hr x .80% = .12"/hr

→ $\frac{.26 (ET)}{.12}$ = 2.17 hr / Day

DRIP IRRIGATION: APPLES — DRIP IRRIGATION 24" SPACING, .6 gph PC – FILTRATION 120 MESH

$\frac{.623 \times .75 \times .26 \times 48^2 \times 1 \times 1.10}{.90}$

= 7.13 gals / day / Tree

→ 7.13 / $\frac{1.2}{(2 \times .60)}$ = 5.95 hr / Day Peak

SYSTEM REQUIREMENT

75 PSI – 53.28 GPM – 20.48 hours / Day

*** NOTES:**

- 75 PSI REQUIRED TO OPERATE ZONES 4, 6 + OVERHEAD COOLING ZONES 11, 12
- ZONE 9 MICRO SPRINKLERS EXCEED ALLOCATION OF 53.28 GPM BY 4.35 GPM, CONNECTING 1 ROW OF ZONE 9 TO ZONE 10 COULD RESOLVE IF REQUIRED.
- PEAK DEMAND FLOW / DAY = 53.28 GPM x 20.48 hrs. = 65,470.46 US GALLONS OR 247.83 M3
- DUE TO 30 METER OF ELEVATION CHANGE, EXTREMELY SHALLOW BEDROCK, SIGNIFICANT SOIL VARIATIONS, MONITORING SOIL MOISTURE LEVELS IS IMPORTANT. CIRCLE WITH LABEL SMS INDICATE POTENTIAL LOCATIONS OF PAIRS OF SENSORS.
- DRIP IRRIGATION INSTALLED IS A MIXTURE OF VARIOUS FLOWS + SPACINGS THROUGHOUT, ALL ZONES MAINTAINING DRIP IRRIGATION TO BE CHANGED TO A CONSISTANT FLOW OF EMITTERS + SPACINGS. ALL CALCULATIONS BASED ON 24" SPACING + .6 gph EMITTERS.

IRRIGATION SCHEDULE

ZONE #	TYPE OF IRRIGATION	ZONE FLOW	RUN TIME / DAY
1	DRIP ONLINE / INLINE	4545' - 22.73 GPM	5.95 hr.
2	MICRO SPRINKLER - 75	75 - 23.75 GPM	2.17 hr
3	MICRO SPRINKLER	75 - 23.75 GPM	2.17 hr
4	MICRO SPRINKLER	85 - 26.91 GPM	2.17 hr
5	MICRO SPRINKLER	90 - 28.50 GPM	2.17 hr
6	DRIP ONLINE	3520' - 17.60 GPM	2.17 hr
7	DRIP ONLINE	5047' - 25.24 GPM	5.95 hr
8	DRIP ONLINE / INLINE	2080' 10.40 GPM	5.95 hr
9	MICRO SPRINKLER	182 - 57.63 GPM	2.17 hr
10	MICRO SPRINKLER	45 - 14.25 GPM	2.17 hr
11	OVERHEAD SPRINKLER	11 - 44 GPM	AS REQUIRED
12	OVERHEAD SPRINKLER	13 - 52 GPM	AS REQUIRED

TOTALS – 15,250' – 24" .60 DRIP, 370 – MICRO SPRINKLERS

CONTROLLER PROGRAM

	PROG A	PROG B	TOTAL GPM	TOTAL RUN TIME
START TIME	6am	6am		
ZONE #	1	6	40.33	5.90 hr
	7	8	35.64	5.90 hr
END TIME	5:48pm	5:48pm		11.80 hr
	PROG C	PROG D		
START TIME	6pm	6pm		
ZONE #	2	4	50.66	2.17 hr.
	3	5	52.25	2.17 hr.
	9		57.63	2.17 hr
	10		14.25	2.17 hr.
END TIME	2:29am	2:29am		8.68 hr.

FARM IRRIGATION CASE STUDIES

CASE: CHERRY ORCHARD

Water Scarcity and Extreme Weather in a Cherry Orchard with Microsprinklers in Central Okanagan, BC

Funding for this project has been provided in part by the Regional District of Okanagan Similkameen, the Regional District of North Okanagan and the Okanagan Basin Water Board, and in part by the governments of Canada and British Columbia under the Canadian Agricultural Partnership, a federal-provincial-territorial initiative. The program is delivered by the Investment Agriculture Foundation of BC.

Bruce Naka, CID

Sound Water Advise

Andrew Bennett, MSc PAg CID

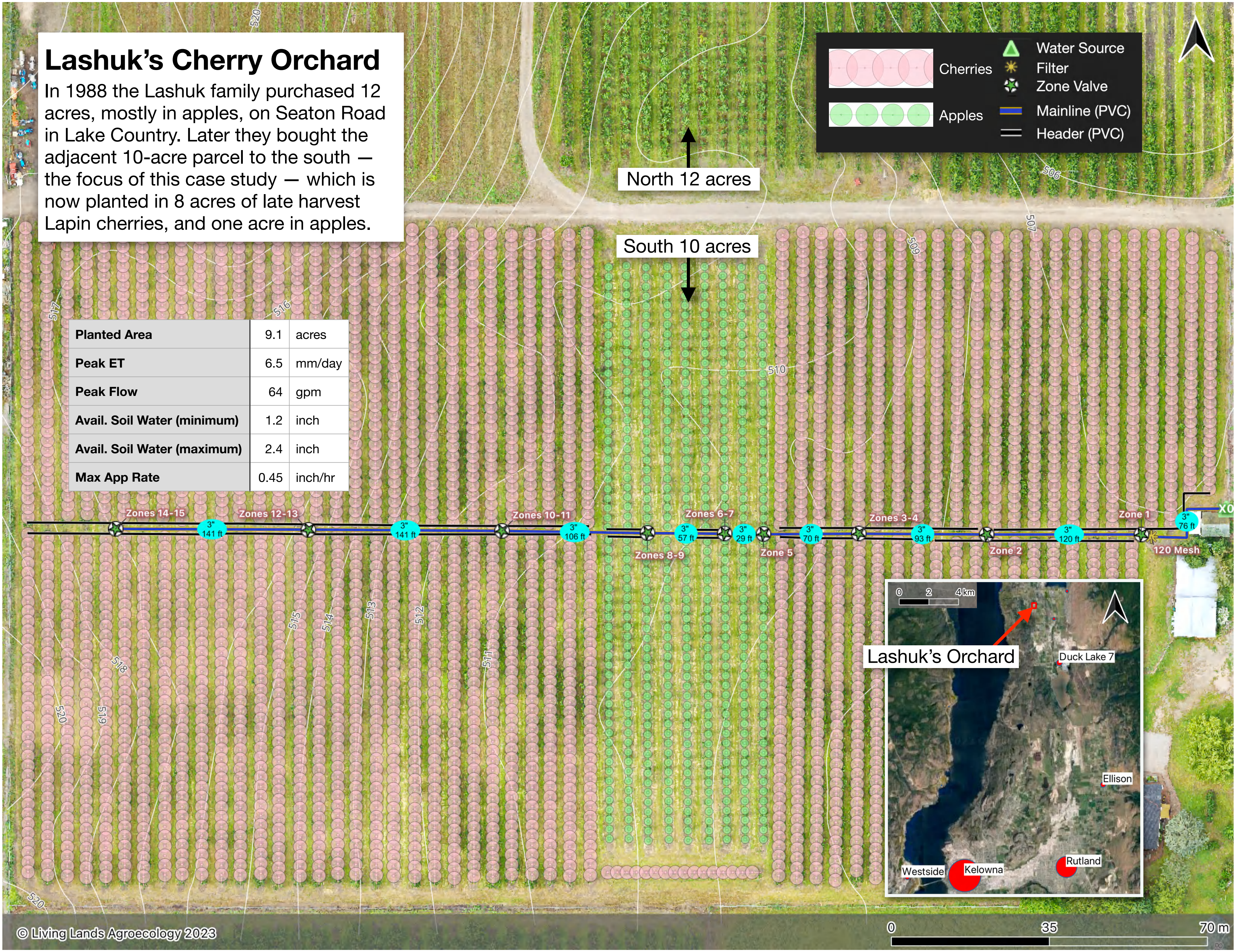
LIVING LANDS AGROECOLOGY

19 March 2023

Lashuk's Cherry Orchard

In 1988 the Lashuk family purchased 12 acres, mostly in apples, on Seaton Road in Lake Country. Later they bought the adjacent 10-acre parcel to the south — the focus of this case study — which is now planted in 8 acres of late harvest Lapin cherries, and one acre in apples.

Planted Area	9.1	acres
Peak ET	6.5	mm/day
Peak Flow	64	gpm
Avail. Soil Water (minimum)	1.2	inch
Avail. Soil Water (maximum)	2.4	inch
Max App Rate	0.45	inch/hr

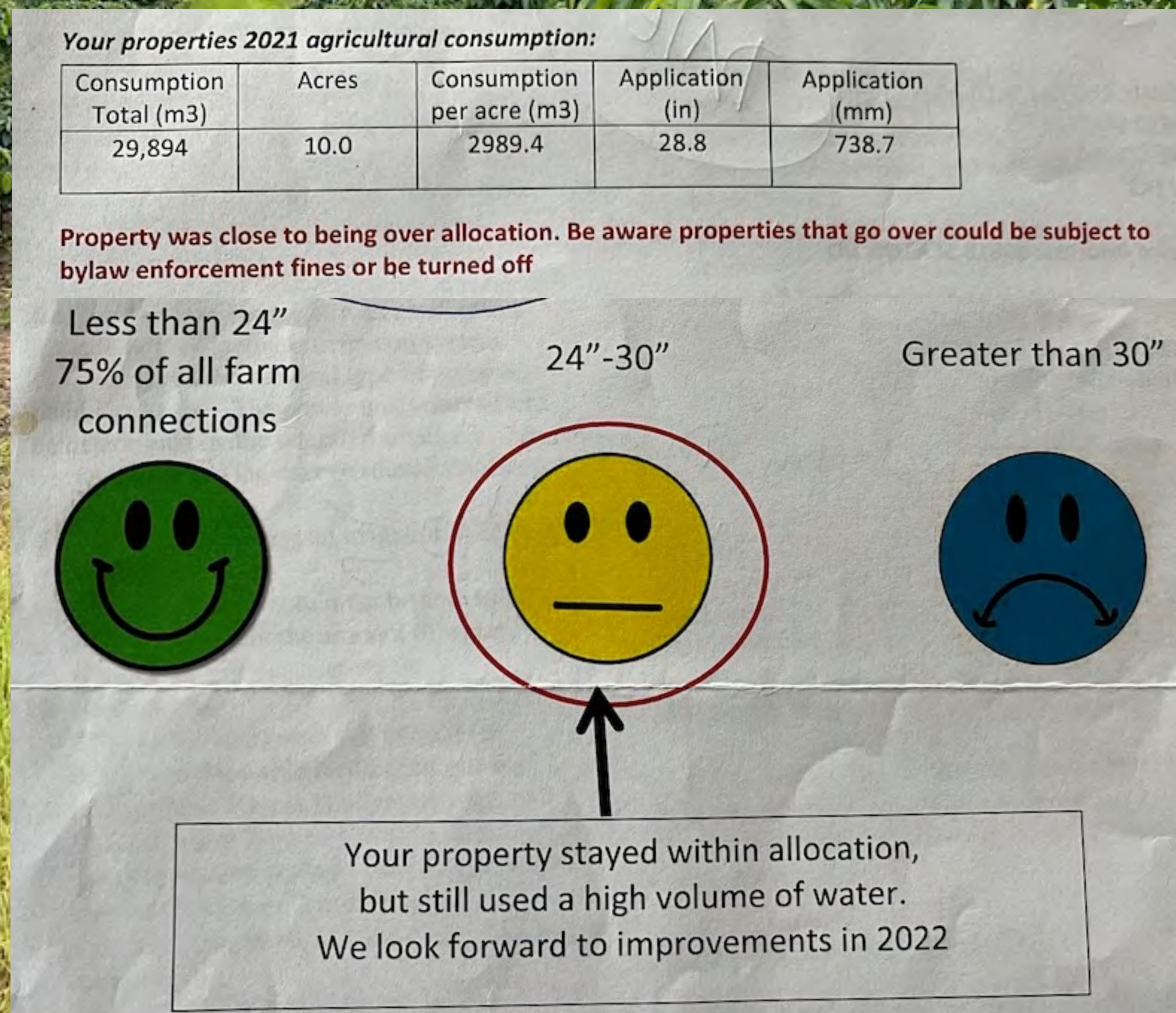


Challenge: Water Scarcity

The Lashuk's and the lease holder who operates the orchard need to optimize their water use efficiency.

In 2021, they received a series of letters from the water utility expressing concern that the 10-acre parcel was close to the 30" (3083 m3/acre) maximum seasonal water allocation.

They acknowledged a hot year could demand 26" of water, but said most growers were under 24" (2464 m3/acre) and encouraged the Lashuk's to also reduce their water use below 24".



Your properties 2021 agricultural consumption:

Consumption Total (m3)	Acres	Consumption per acre (m3)	Application (in)	Application (mm)
29,894	10.0	2989.4	28.8	738.7

Property was close to being over allocation. Be aware properties that go over could be subject to bylaw enforcement fines or be turned off

Your property stayed within allocation,
but still used a high volume of water.
We look forward to improvements in 2022

Soils

The soils vary significantly from a coarse sand in the northwest section to fine sandy loams and loams on the lower slopes in the south and east.

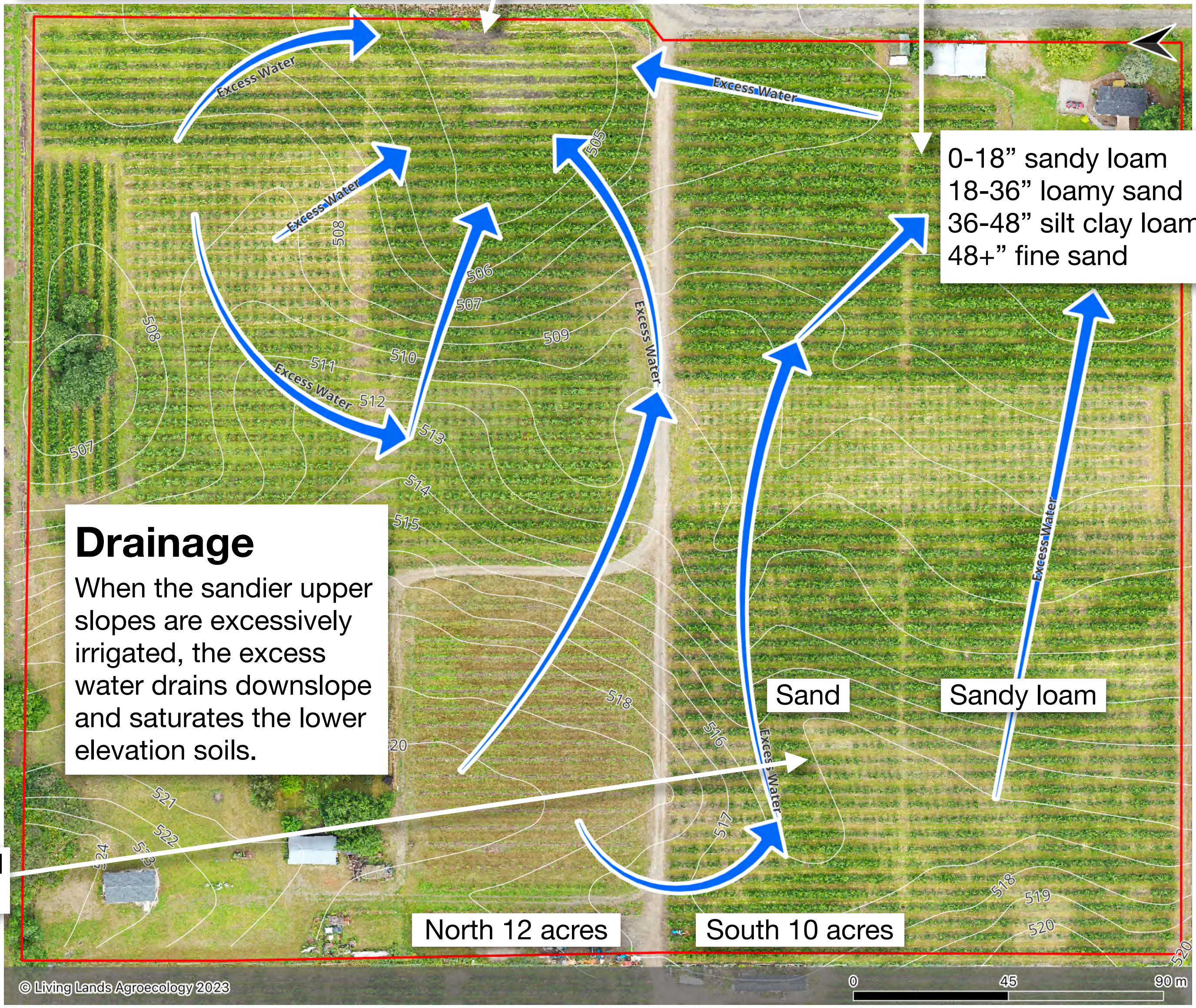
Fortunately, the irrigation zones were divided in the middle of the block, roughly along the transition in soil types, so there are separate zones for the sands in the northwest and the loamier southeast.

When digging holes in the southeast, we also found a layer high in silt and clay about 3 to 4 feet below the surface. In the lowest areas, the layer came out very wet.

Coarse sand at 0-48”

Trees died from water saturation.

Silt clay loam at 36-48”



Drainage

When the sandier upper slopes are excessively irrigated, the excess water drains downslope and saturates the lower elevation soils.

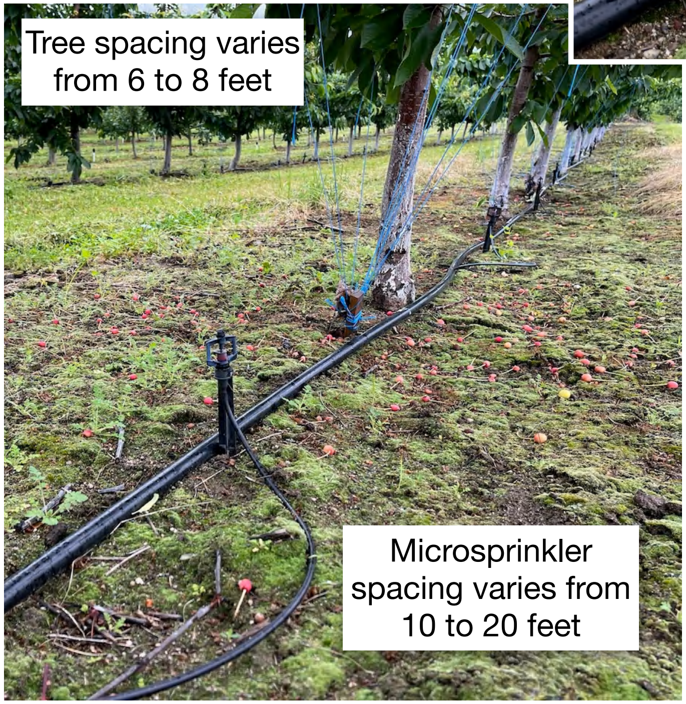
Tree Health

When we assessed the orchard in July 2022, the cherries were growing well except on the sandy slopes in the northwest where plants appeared stressed from under-watering.

Erratic Spacing

Tree spacing within rows varies a lot, which has also led to inconsistent spacing between microsprinklers.

Erratic sprinkler spacing causes application rates to vary significantly within a zone, so some areas get overwatered while others are underwatered.



Schedule Problems

Most cherry zones were likely being run too long, based on the run times displayed on the irrigation controller.

Moreover, the same program ran from system start-up until early September, long after harvest was complete, with no variation to account for varying weather or crop needs. “One-size-fits-all” strategies like this often overwater in the spring and late summer, but come up short in a heat wave.

Microjets

Erratically spaced microsprinklers in Zone 12 and Zone 14 create very uneven watering. Remove all microsprinklers and replace them with a spray-type irrigation, one per tree.

If the trunks should stay dry, use two 180° sprays at the base of each tree, both pointed away from the trunk.

Schedule

A schedule that is better matched to conditions — rather than running at high demand from start-up to September — would dramatically improve irrigation efficiency. But adjusting the schedule requires a change in management that can be difficult for a lease operator who is often off-site.

Connected Controller

The lease operator would benefit from a new irrigation controller with a LAN connection so adjustments can be made remotely by cell phone or tablet. This convenience could make it much easier and more likely to schedule the orchard.

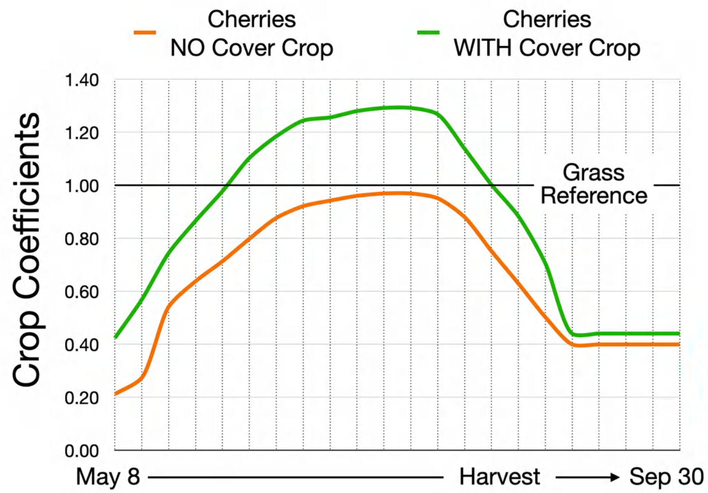
Weekly Adjustments

The schedule should be set for peak demand, with zones or combinations of zones that add up to close to the peak flow of 60 gpm.

Run times should be adjusted on a weekly basis. This is often done as a percentage of peak demand.

Seasonal Programs

If weekly adjustments are too much effort for the operator, an alternative would be to use two programs: 1) A summer program, for peak periods, and 2) A spring/post-harvest program at 50% of peak demand.



Apple Program

Currently, the 1-acre apple planting is also running on the cherry schedule.

The apple trees are still quite small and, regardless of size or stage, apples have different needs than cherries.

Ideally, a separate program is used for the apple block to allow for different crop requirements and harvest times.

Soil Sensors

Monitoring the soil is very important to ensure that scheduling assumptions are checked against the reality in the soil.

At a minimum, install soil sensors at 3 locations — one for each of the major soil type areas — at two depths per location (e.g. 12" and 30").

With experience reading moisture levels, the manager can identify trigger points to adjust irrigation run times for each area.

Grower Supply's "Winfield South" weather station is less than 1 kilometre from the Lashuk's orchard.

Crop Coefficients

Crop coefficients were drawn from the USDA's AgriMet service, with values specific to Washington State's northeast counties.

The growing season for the coefficients used first leaf on May 8, full canopy towards the end of June, and harvest in the first two weeks of August.

Working Together

Everyone needs to work together to better understand crop water requirements: water purveyors, land owners, lease holders, and land managers.

With climate change, water allocations for agriculture may need to be reconsidered, but growers must also streamline their irrigation efficiency.

Scheduling Exercise

The following scheduling exercise based on local weather data and crop water demand curves examines the uncertainty behind the question: “How much water does my crop need?” Is it 24” or less, or 30” or more?

Cherries, May 8 to Sept 30

BC Agriculture Water Calculator

Volume and Inches Applied

Efficiency:	m3/acre	inches
Microsprinkler	**2670**	**26.0**
May	160	1.6
June	620	6.0
July	830	8.1
August	680	6.6
September	380	3.7

Data: 2020 to 2022

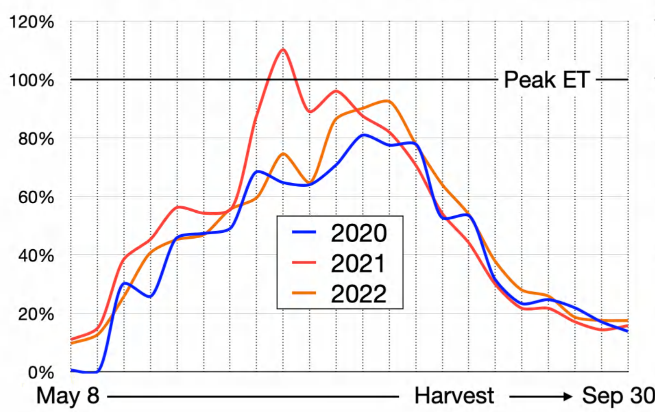
Evapotranspiration and precipitation data from the 2020, 2021, and 2022 growing seasons (defined as May 8 to Sept 30) were pulled from the Winfield South weather station on Farmwest.com

Crop coefficients were used from two scenarios using tables from Washington State University: 1) Cherries grown with a cover crop, and 2) Cherries grown *without* a cover crop (see previous page).

This was compared with the output for cherries with microsprinklers from the BC Agriculture Water Calculator.

Peak ET, also from the calculator, is 6.4 mm/day.

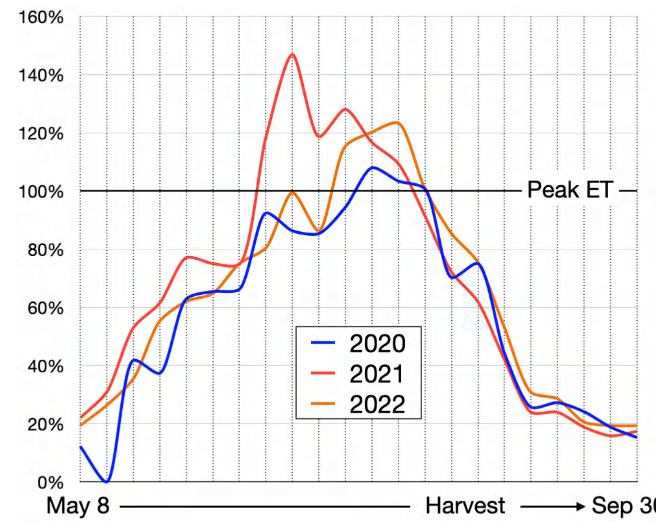
Cherries — No cover crop



Inches Applied (NO cover crop)

Efficiency:	2020	2021	2022
80%	**20.4**	**24.0**	**22.4**
May	1.4	2.2	1.8
June	5.4	7.3	5.6
July	7.2	8.7	8.2
August	4.7	4.3	5.1
September	1.8	1.6	1.8

Cherries — With cover crop



Inches Applied (WITH cover crop)

Efficiency:	2020	2021	2022
80%	**27.0**	**32.0**	**29.8**
May	2.0	3.2	2.6
June	7.3	9.8	7.6
July	9.5	11.5	10.9
August	6.2	5.7	6.7
September	2.0	1.7	2.0

How Much Water?

Whether 24” or 30” (or less, or more) depends heavily on the weather, the crop, and even on the cover crop growing between the rows.

Cover crops are recognized for many soil benefits, from carbon sequestration to increased water- and nutrient-holding capacity, plus other benefits such as habitat for biodiversity. But growing more biomass in an area takes more water.

In years of plenty, perhaps more water should be allocated to help grow the soil. Encouraging soil life and carbon storage is the basis of “regenerative” farming.

In years of drought, cover crops might be sacrificed to reduce water use, and hopefully the benefits from previous years’ cover crops will help carry the crop through.

Future Outlook

Every year, especially as climate change takes hold, water efficiency should be the goal.

This requires irrigation systems that apply water evenly, in zones with consistent water requirements, using schedules that match the weather and soil conditions.