Using GIS for Rural Fire Protection Planning

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Bellefontaine Fire & EMS

Ohio GIS Conference

September 24 – 26, 2018

Hyatt Regency Columbus

Columbus, Ohio

Rural Fire Protection Planning

What's so special about it?

- Most emergency services oriented GIS work is focused on urban areas
- There are nearly 1,200 fire departments in Ohio – most of them are small and rural
- Rural environment is characterized by:
  - Long response distances and times
  - Volunteer staffing
  - Limited funding & antiquated equipment
  - **Reliance on alternative water supplies**
  - Limited planning support – no county-level coordinating authority

Water Supply: *What is the Goal?*

Example Property:

- Two-story rural residence
- Wood-frame construction, built in ~1900
- Not sprinklered

Area:

- 26 ft x 30 ft = 780 sq ft

Height:

- 2 floors @ 10 ft
- Basement @ 10 ft
- Pitched roof @ 5 ft
- Total = 35 ft

Exposure:

- 725 sq ft outbuilding @ 17 ft

Water Supply: *What is the Goal?*

Needed Fire Flow (NFF)

- Initial attack water for **first-due apparatus**
- Minimum needed to control flaming combustion
- Using Iowa Rate of Flow (ROF) formula:

ROF = Volume / 100

26 ft x 30 ft x 35 ft = 27,300 cu ft

27,300 / 100 = **273 gpm**

delivered for 30 seconds = **136 gallons**

Water Delivery Rate (WDR)

- Extended attack water for **overhaul and exposure protection**
- Rate needed to supply flows over extended periods (2 hours or longer)
- Using NFPA 1142 formula:

$WS_{min} = (VS_{tot} / OHC) \times CC \times 1.5$

OHC = 7 (light); CC = 1.5 (Type 5 / wood frame)

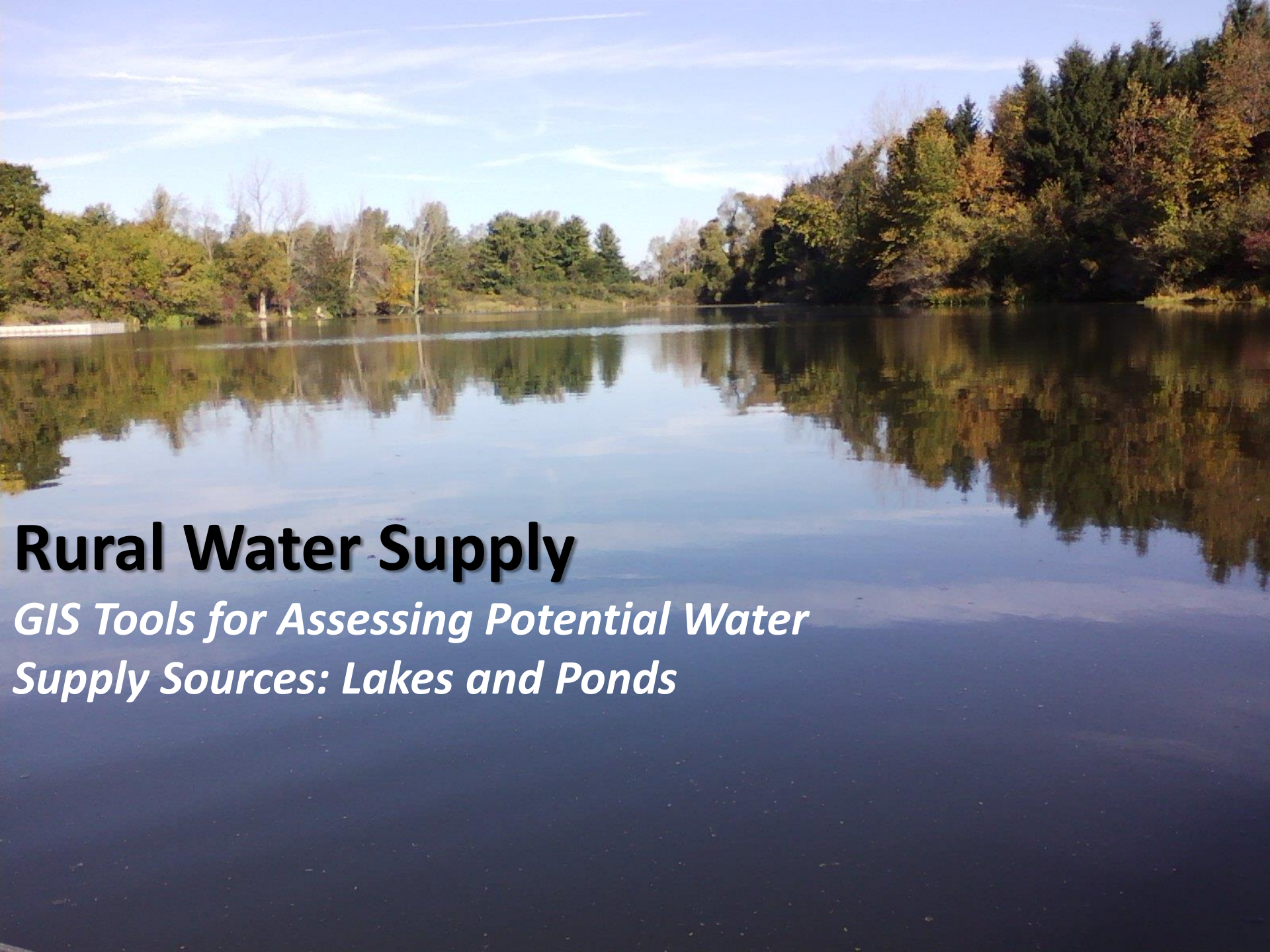
(27,300 / 7) x 1.5 x 1.5 = **8,775 gallons**

WDR = **500 gpm**

Eckman's Rules of Thumb

The following will cover 90% of fires in non-hydranted residential areas:

- **2,000 gallons** on first due apparatus (pumper/tanker or pumper + tanker combo)
- Ability to deliver **500 gpm** minimum via shuttle or other means



Rural Water Supply

GIS Tools for Assessing Potential Water Supply Sources: Lakes and Ponds

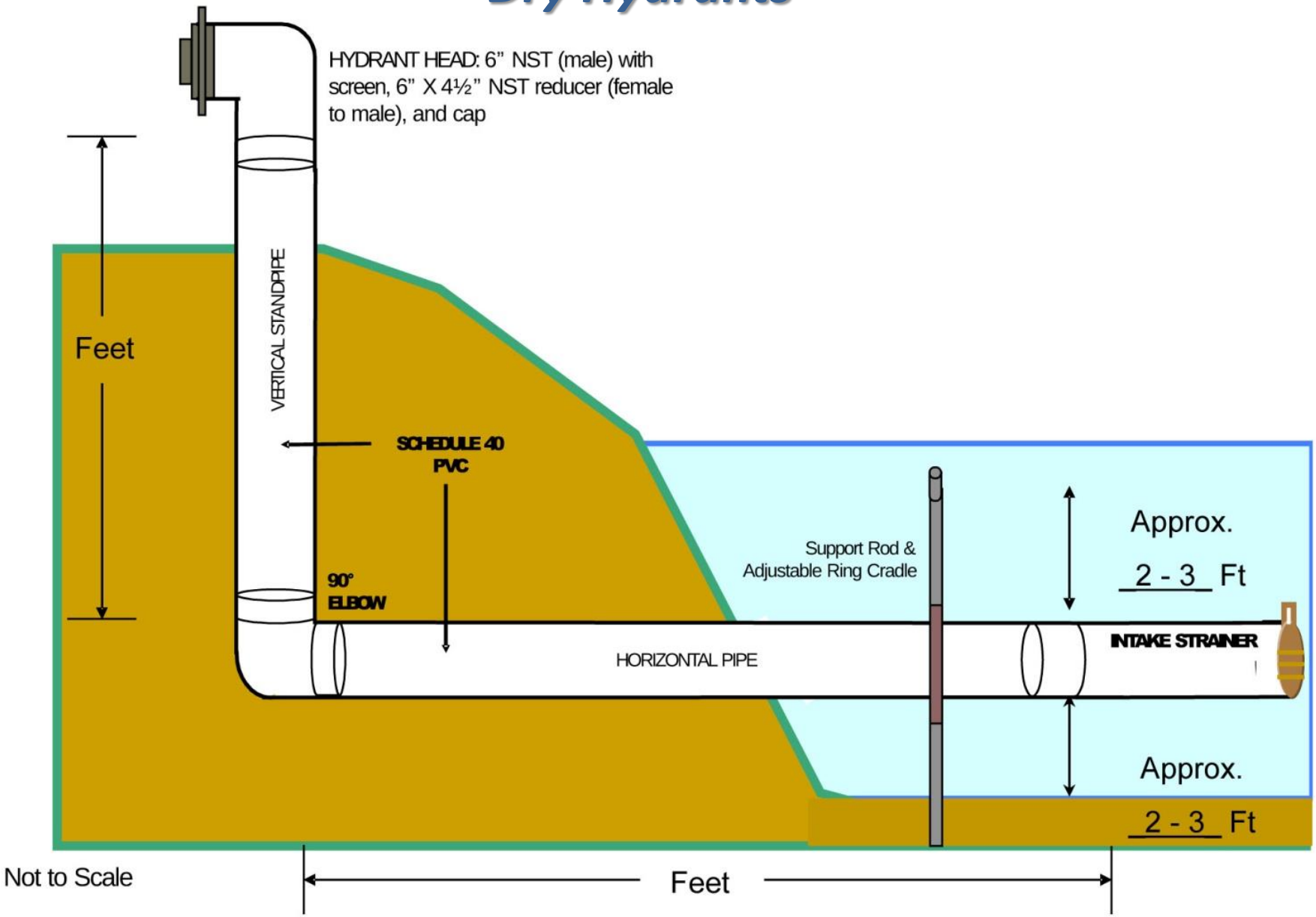
NFPA 1142: Alternative Water Supply

Minimum requirements for water supply source:

- ≥ 30,000 gallons usable year-round
- ≥ 250 gpm flow rate for two hours
- Lift ≤ 15 feet (≤ 12 feet desirable)
- All at 50-yr drought condition (2% chance in given year) ... In Ohio, this is covered by a 4-ft “sacrifice” depth
- Certified by hydrologist, engineer, or “similarly qualified person”
- Ref: NFPA 1142 (2017), sec. A.7.1.7 & USDA NRCS CP432 Dry Hydrants

Alternative Water Supply

Dry Hydrants



BERLIN
E-382

Ohio Dry Hydrant Installations *(ODNR as derived from NFPA 1142)*

Total Depth & Volume Estimates

- Developed from depth readings taken during representative dry period
- Minimum total depth for creditable area around inlet must be 8.5 ft (for 6-in inlet)

Surface

Unusable Overhead Volume

Freezing/Drought Allowance

4-ft Depth from Surface

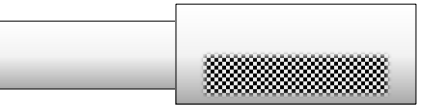
Creditable Volume

- Minimum 2-ft depth at creditable area around inlet; *and*
- Minimum 30,000 gallons volume

At 2-ft minimum depth, 2,005 sq ft (or approx. 0.05 acres) of surface area needed to make 30,000 gallons

Creditable Volume

Dry Hydrant Inlet



Non-Creditable Volume

dry hydrant strainer diameter allowance

6-12 inches
(depends on inlet diameter)

Flow Rate

Dry hydrant design must allow for minimum of 250 gpm flow for 2 hours

Non-Creditable Volume

inlet clearance above pond bottom silt

2-ft Depth from Bottom

Bottom

How Much Pond is Enough?

Remember ... An acre-foot is a LOT of water

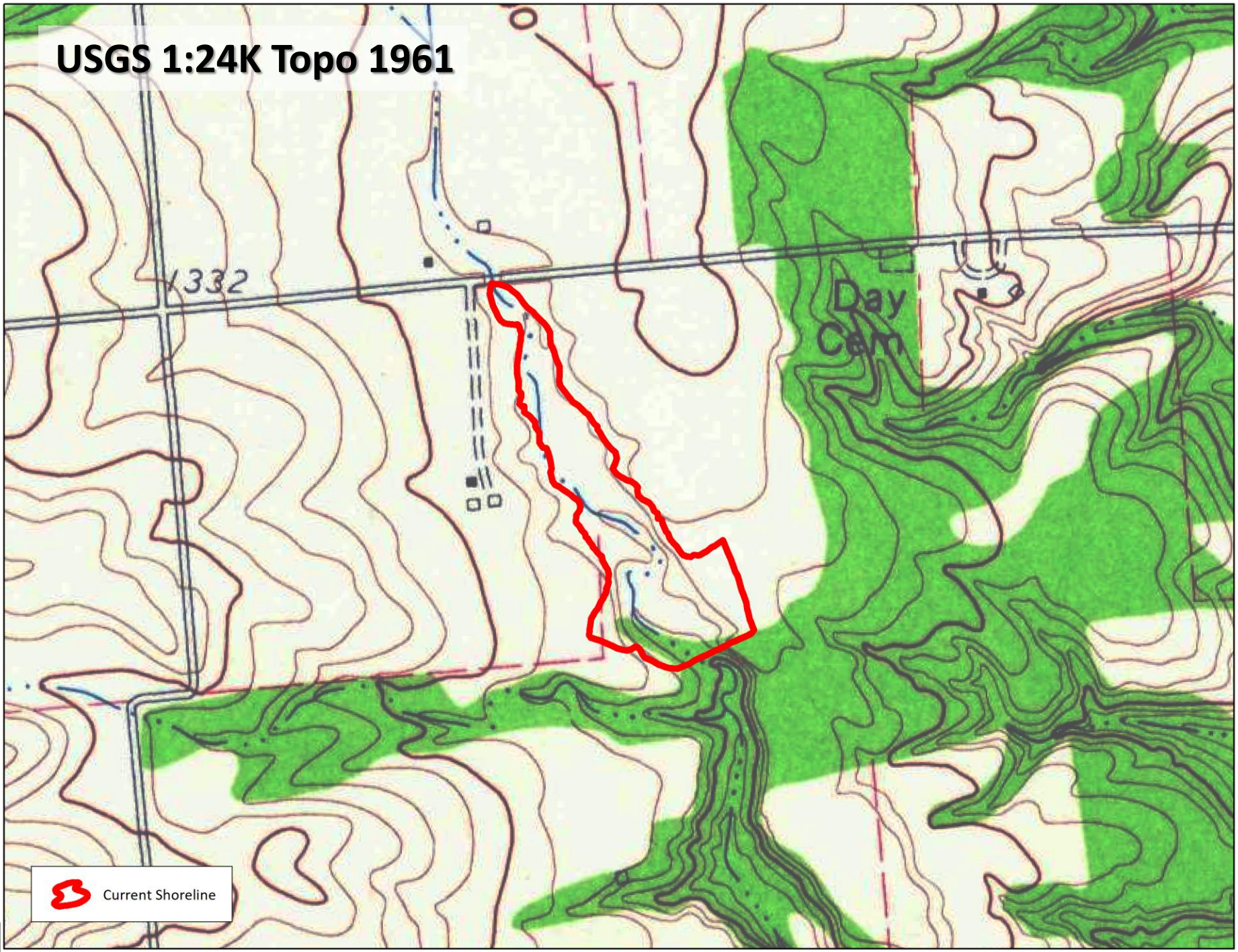
Potentially Exploitable Volume		
Surface Area (acres)	*Usable Depth (feet)*	*Exploitable Volume (gallons)*
5.0	1.0	1,629,257
5.0	0.5	814,628
2.5	0.5	407,314
1.0	*1.0*	*325,851*
0.5	0.5	81,463
0.1	0.5	16,293

Example: Lake McDowell

Myeerah Nature Preserve, Logan County OH

- 13-acre impounded reservoir
- Sediment trapping structure; built in 1960s

USGS 1:24K Topo 1961



USDA NAIP 1-m
9/6/2013
0 100 200 300 Feet

USDA NAIP 1-m
7/11/2015
0 100 200 300 Feet

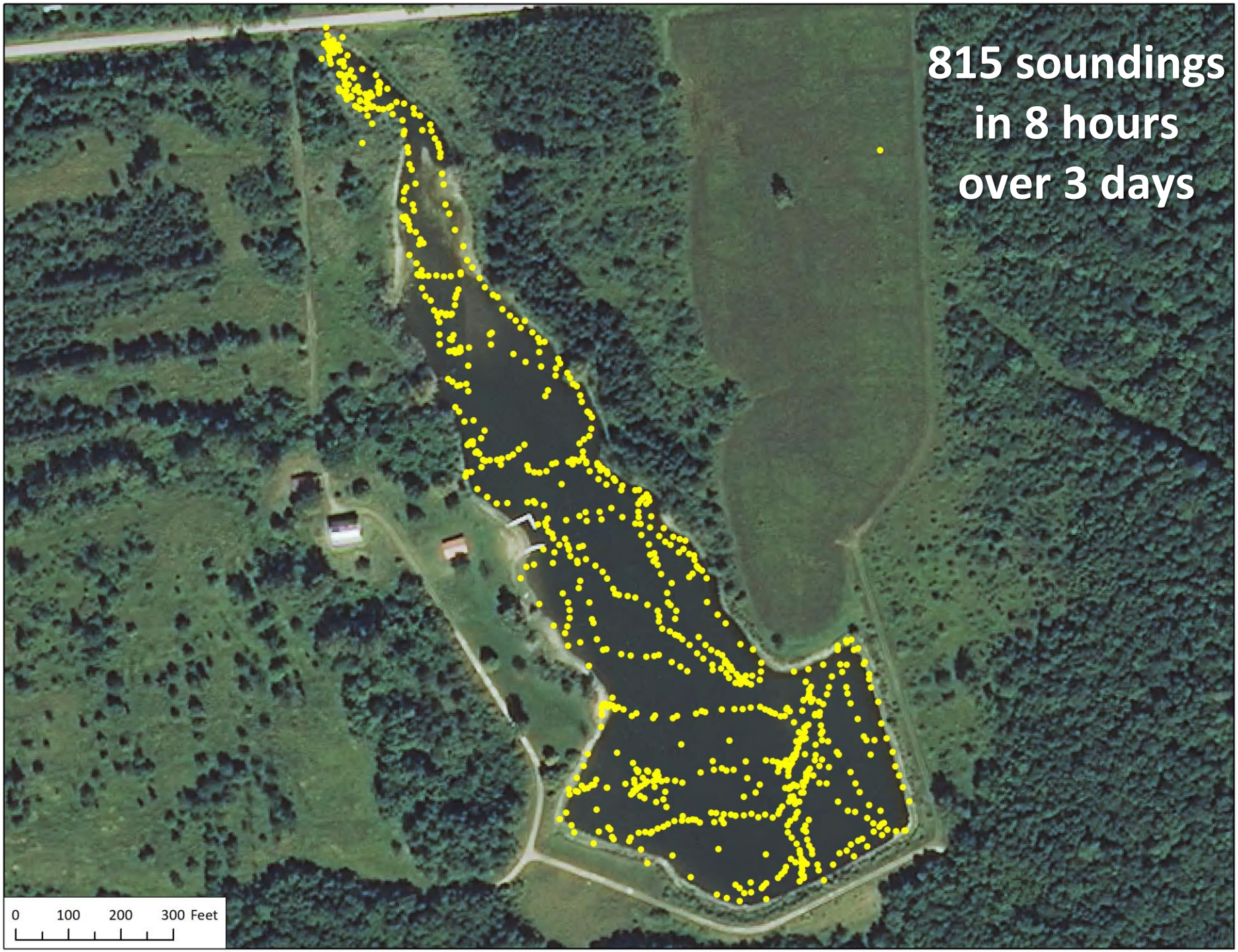
Google Earth
6/13/2014

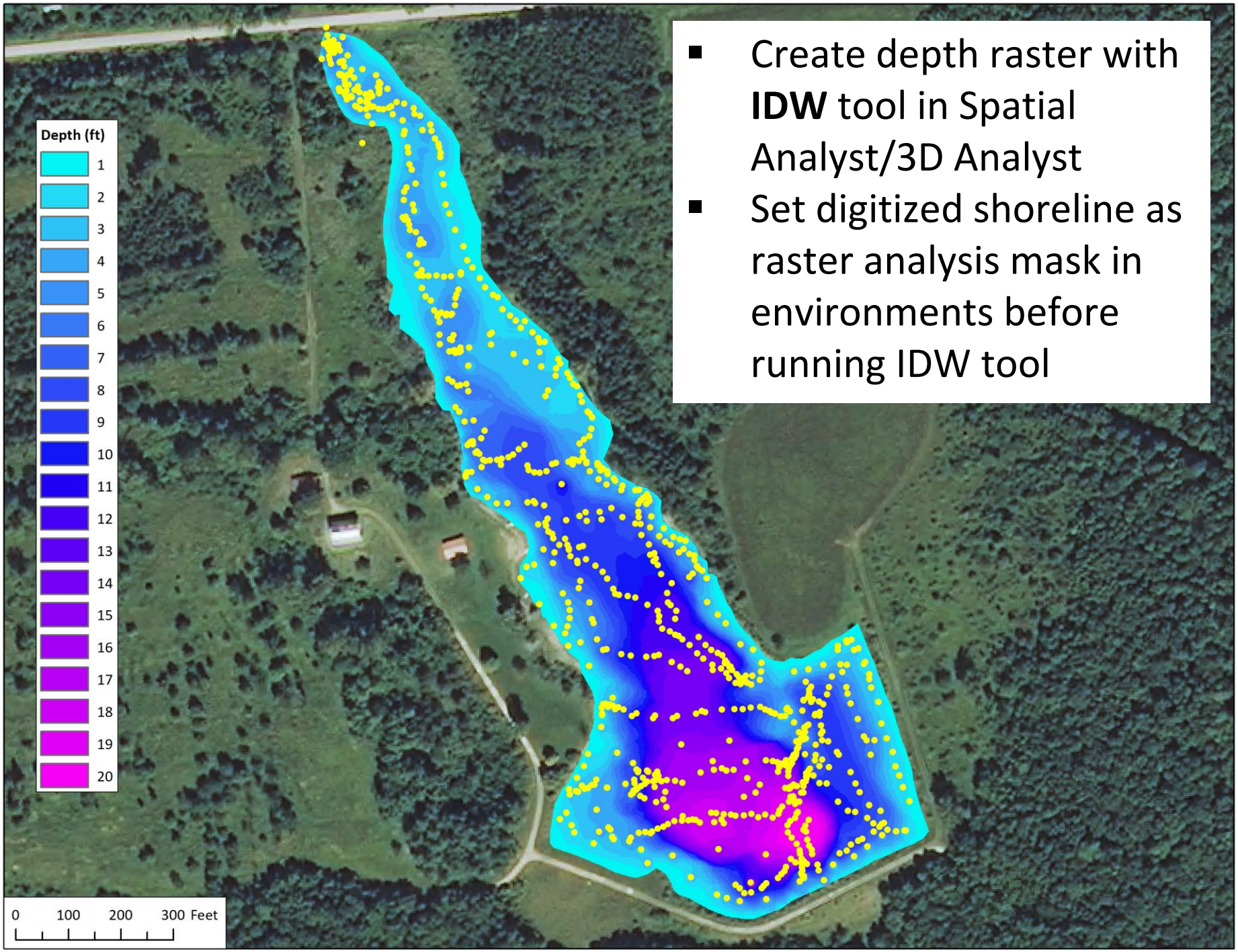
Data Collection:

- 9/25-27/2014
- 815 depth points collected
- SONAR + depth pole

Data Collection:

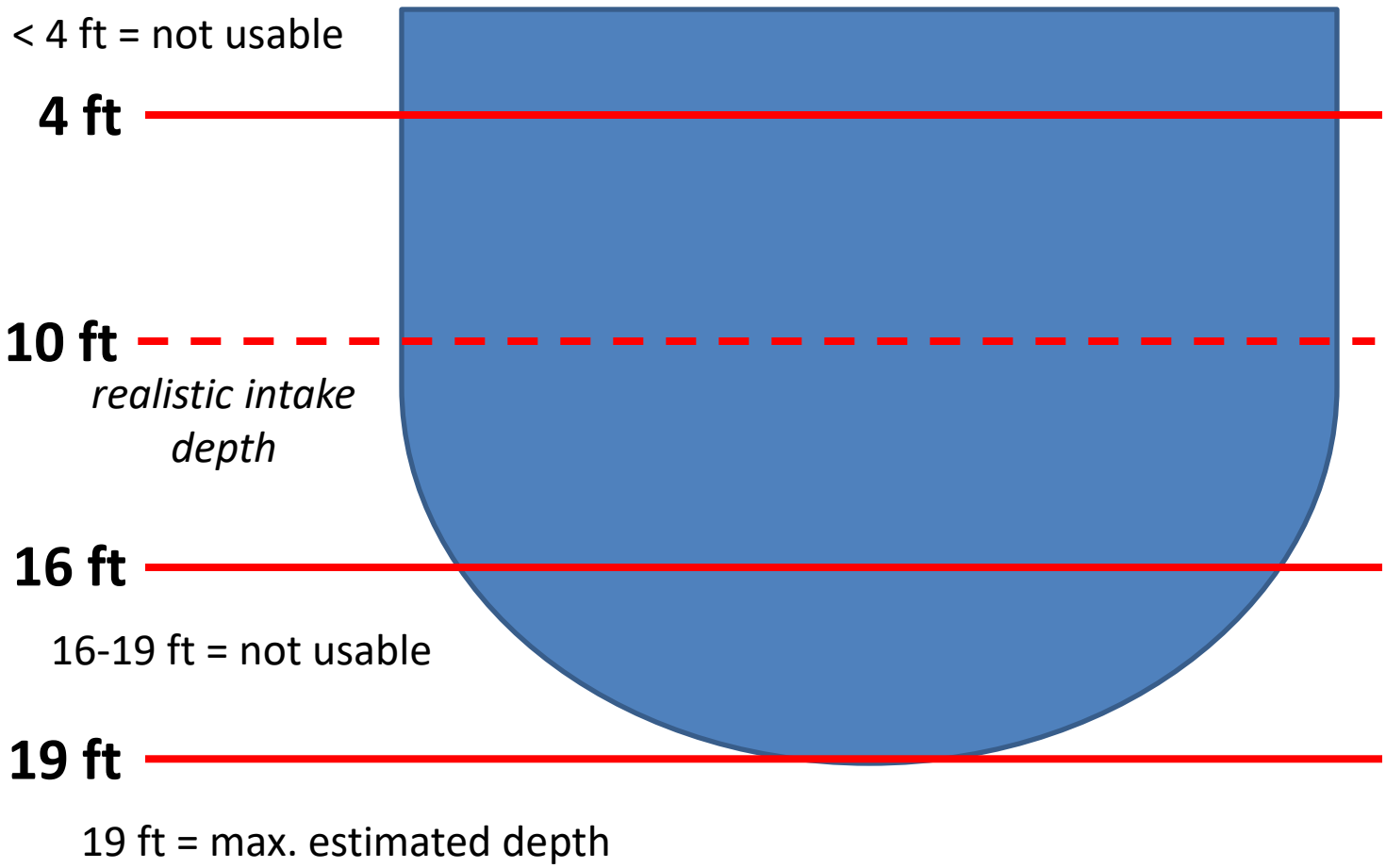
- SONAR worked well in depths > 4 feet
- In depths < 4 feet, used pole due to vegetation
- Used recreational SONAR ("fish finder") plus GPS
- Integrated SONAR/GPS would be more efficient, but higher cost


815 soundings
in 8 hours
over 3 days
0 100 200 300 Feet



- Create depth raster with **IDW** tool in Spatial Analyst/3D Analyst
- Set digitized shoreline as raster analysis mask in environments before running IDW tool

- Use **Surface Volume** tool (3D Analyst) to estimate volumes from depth raster
- Critical depths: 4, 10, 16 feet (for this example)
- *Select projection carefully – volumes in cubic units*



Potentially Exploitable Volume

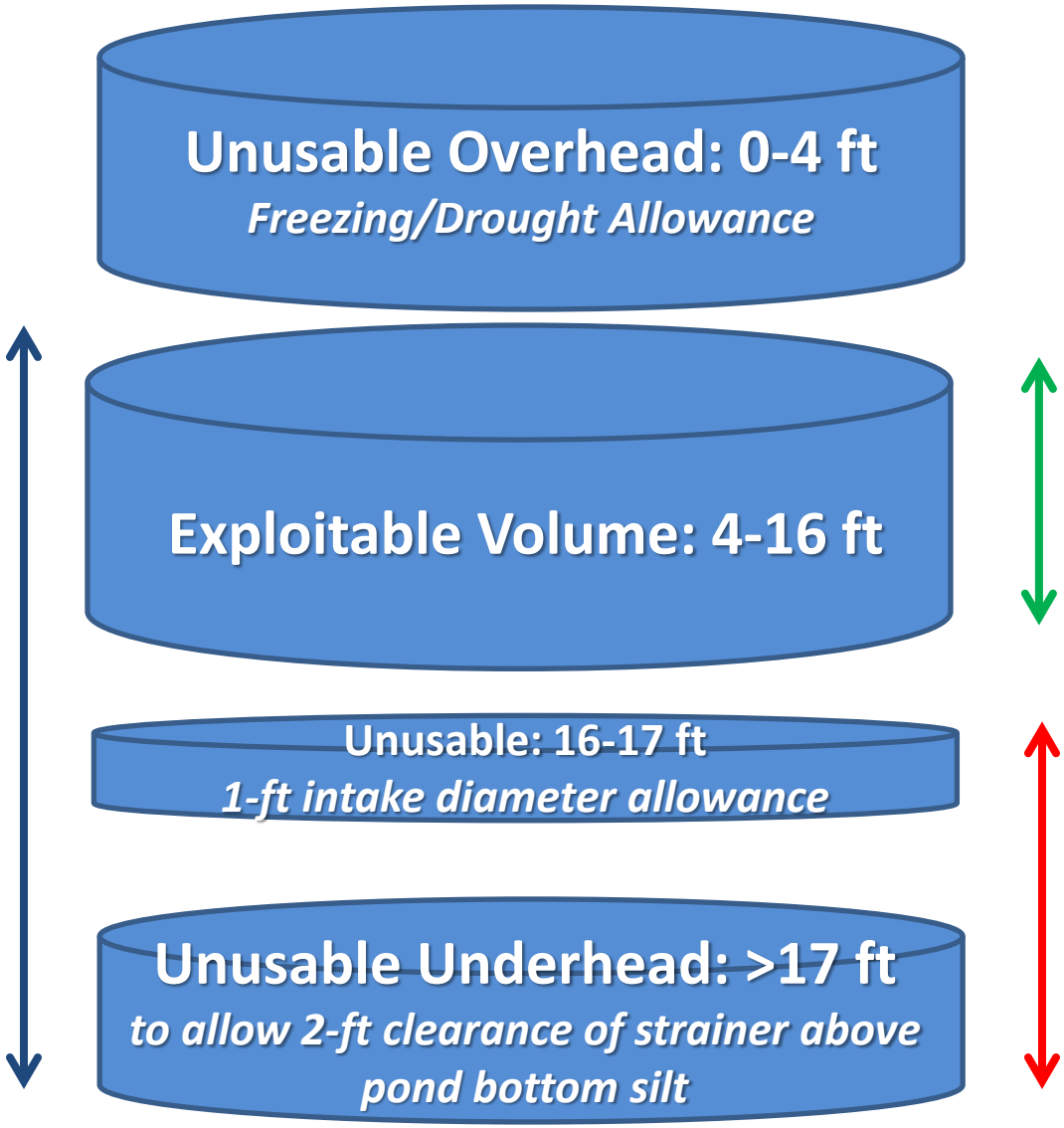
Assuming max. depth of 19 ft

Realistic Potentially Usable Volume

intake @ 10-ft depth

9,846,742 gal

(1,316,318 ft^3)



Volume below 4-ft

13,939,387 gal

(1,863,425 ft^3)

Max. Potentially Usable Volume:

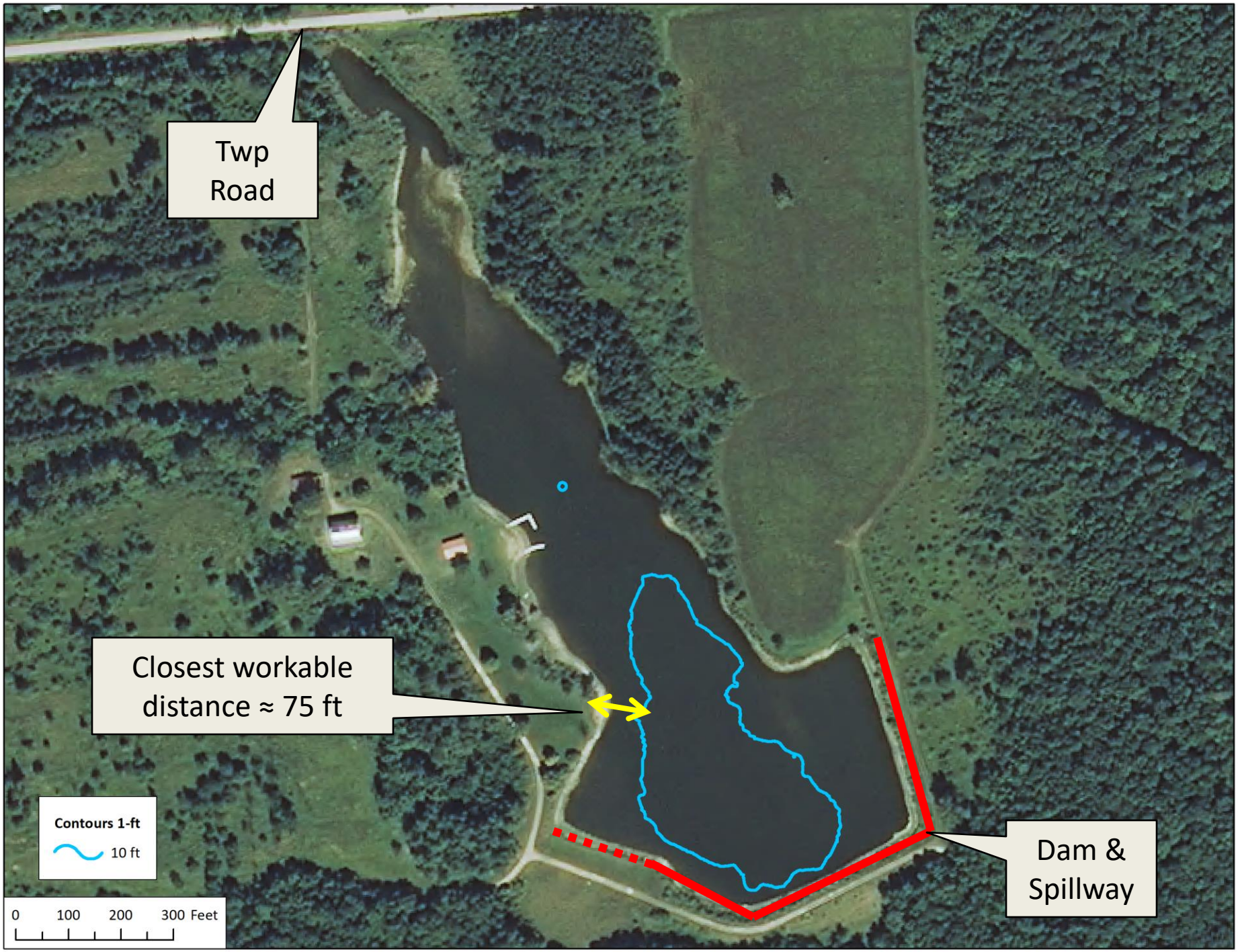
13,536,112 gal

(1,809,515 ft^3)

Volume below 16-ft:

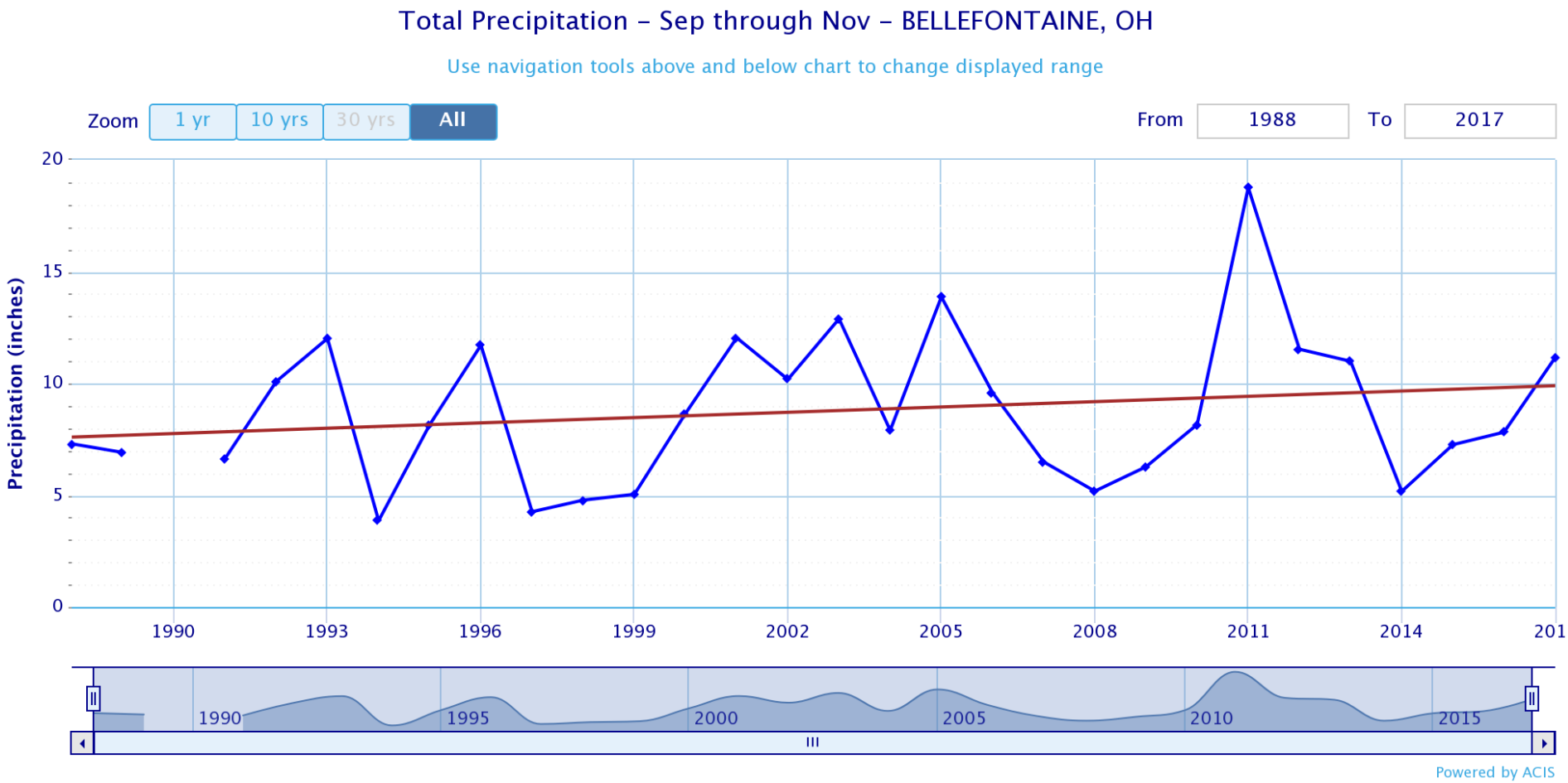
403,275 gal

(53,910 ft^3)


Twp
Road
Closest workable
distance ≈ 75 ft
Contours 1-ft
10 ft
0
100
200
300 Feet
Dam &
Spillway

How to Demonstrate Representative Conditions?

1. Take depth measurements during hydrologic low period (Autumn for Ohio)
2. Document your sampling period within longer climatic trend for area (20+ years of weather data)



NOAA Applied Climate Information System (ACIS)
http://drought.rcc-acis.org/#

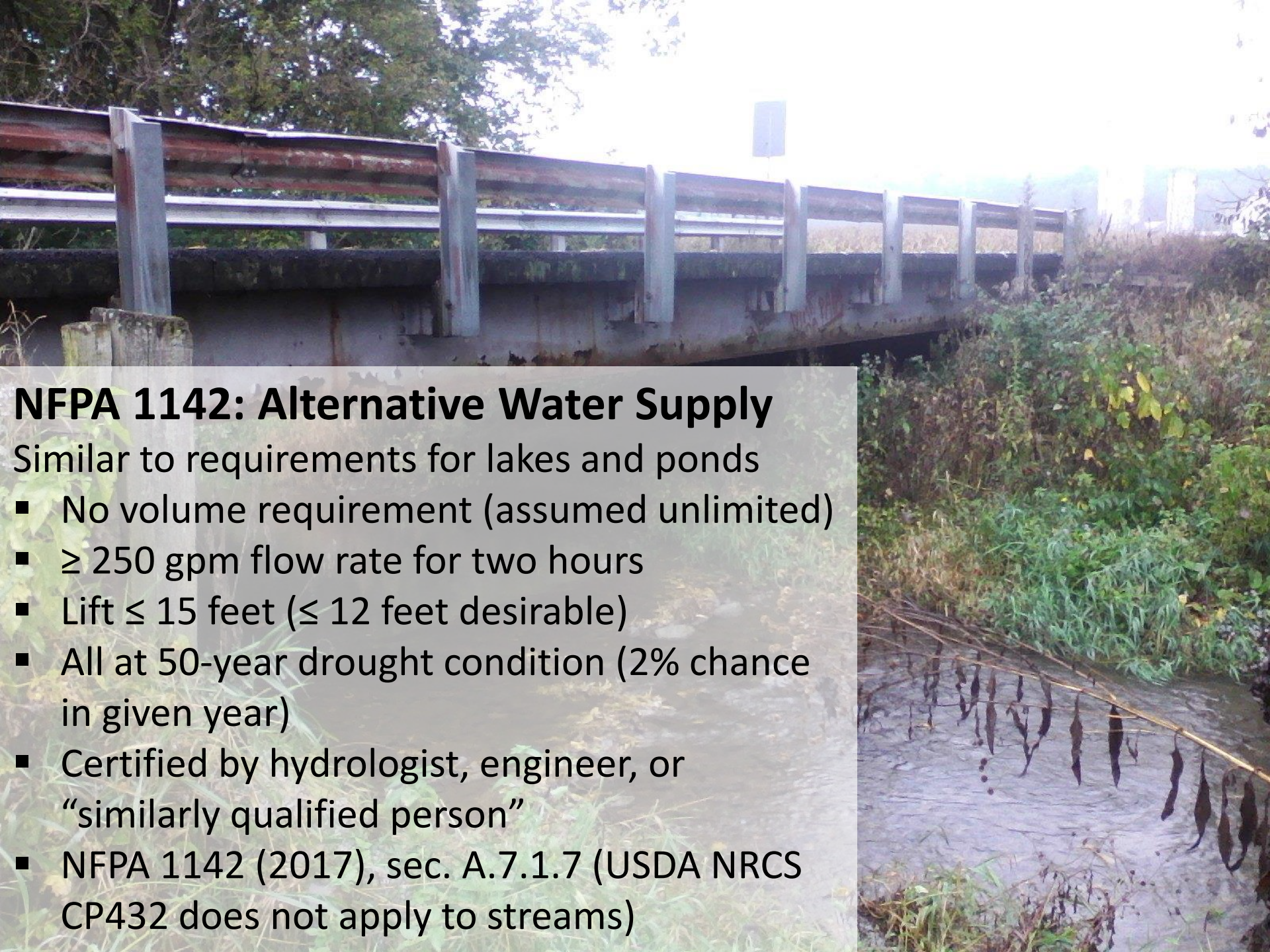
Data for BELLEFONTAINE, OH

Click column heading to sort ascending, click again to sort descending.

Date	Precipitation
2014-09-01	0.22
2014-09-02	0.19
2014-09-03	0.01
2014-09-04	0.00
2014-09-05	0.00
2014-09-06	0.03
2014-09-07	0.00
2014-09-08	0.00
2014-09-09	0.00
2014-09-10	0.00
2014-09-11	0.60
2014-09-12	0.00
2014-09-13	0.00
2014-09-14	0.00
2014-09-15	0.00
2014-09-16	0.10
2014-09-17	0.00
2014-09-18	0.00
2014-09-19	0.00
2014-09-20	0.00
2014-09-21	0.06
2014-09-22	0.00
2014-09-23	0.00
2014-09-24	0.00
2014-09-25	0.00
2014-09-26	0.00
2014-09-27	0.00
2014-09-28	0.00
2014-09-29	0.00
2014-09-30	0.00

Rural Water Supply

GIS Tools for Assessing Potential Water Supply Sources: Streams



NFPA 1142: Alternative Water Supply

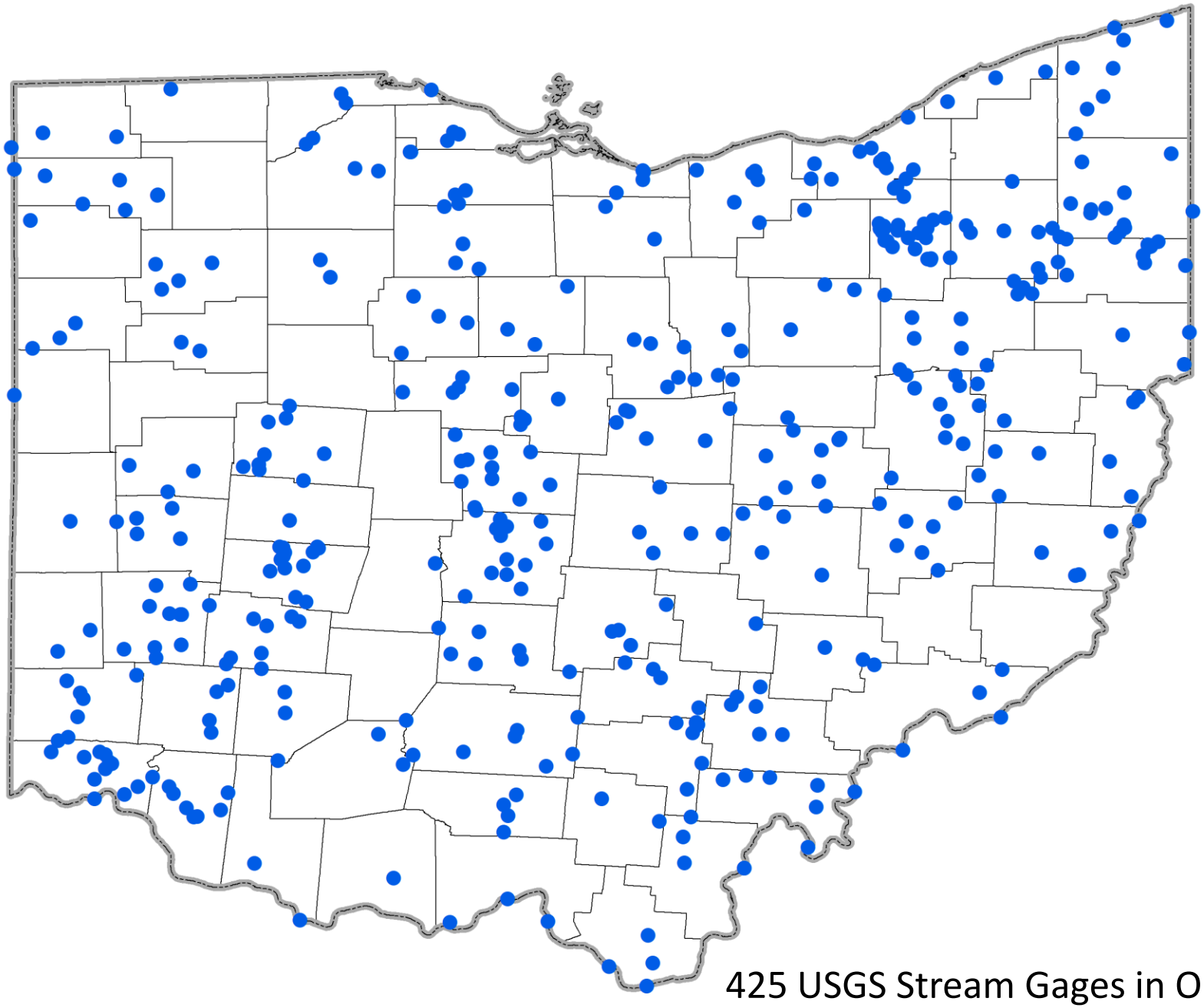
Similar to requirements for lakes and ponds

- No volume requirement (assumed unlimited)
- ≥ 250 gpm flow rate for two hours
- Lift ≤ 15 feet (≤ 12 feet desirable)
- All at 50-year drought condition (2% chance in given year)
- Certified by hydrologist, engineer, or "similarly qualified person"
- NFPA 1142 (2017), sec. A.7.1.7 (USDA NRCS CP432 does not apply to streams)

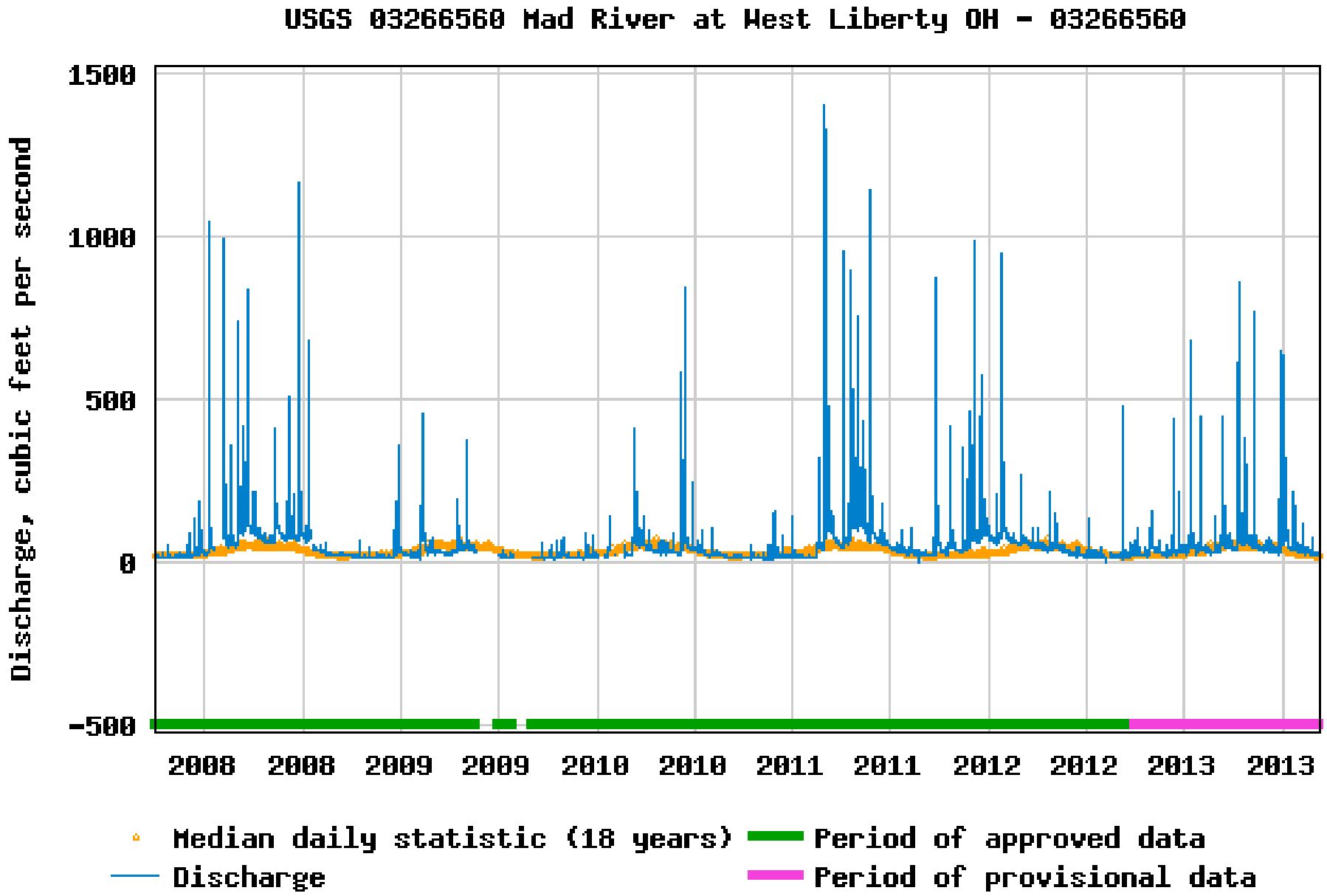
Stream Flow Data

USGS gage station data directly usable if:

- Proposed site in same reach as gage
- No major withdrawals between site and gage (municipal, irrigation, etc.)



425 USGS Stream Gages in Ohio


USGS 03266560 Mad River at West Liberty OH - 03266560
Discharge, cubic feet per second
1500
1000
500
0
-500
2008
2008
2009
2009
2010
2010
2011
2011
2012
2012
2013
2013
Median daily statistic (18 years)
Discharge
Period of approved data
Period of provisional data

What about ungaged streams?

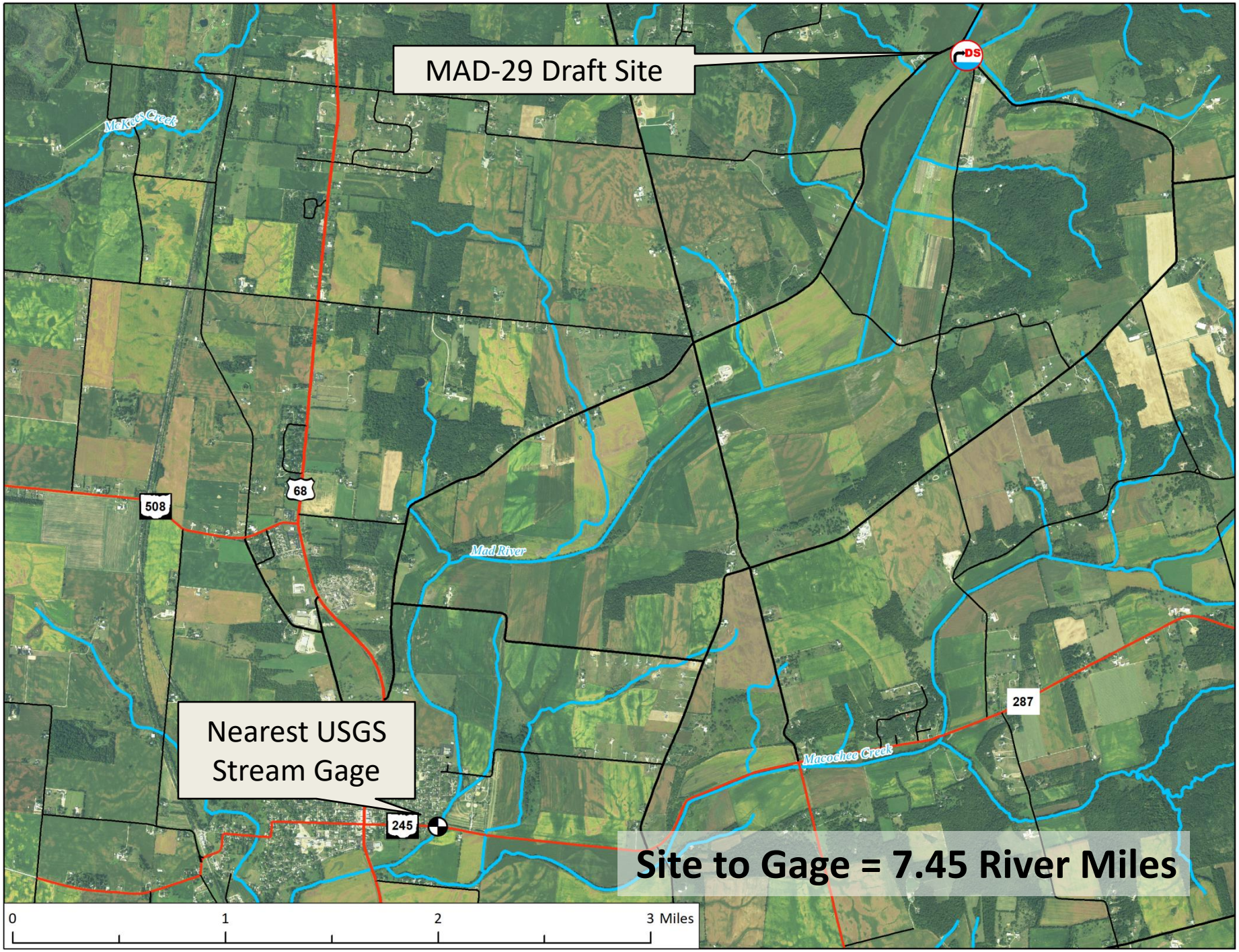
Two Options:

- Install stream gage and wait 50 years
- Use USGS StreamStats application

Example: MAD-29

Mad River @ CR-29, Logan County OH

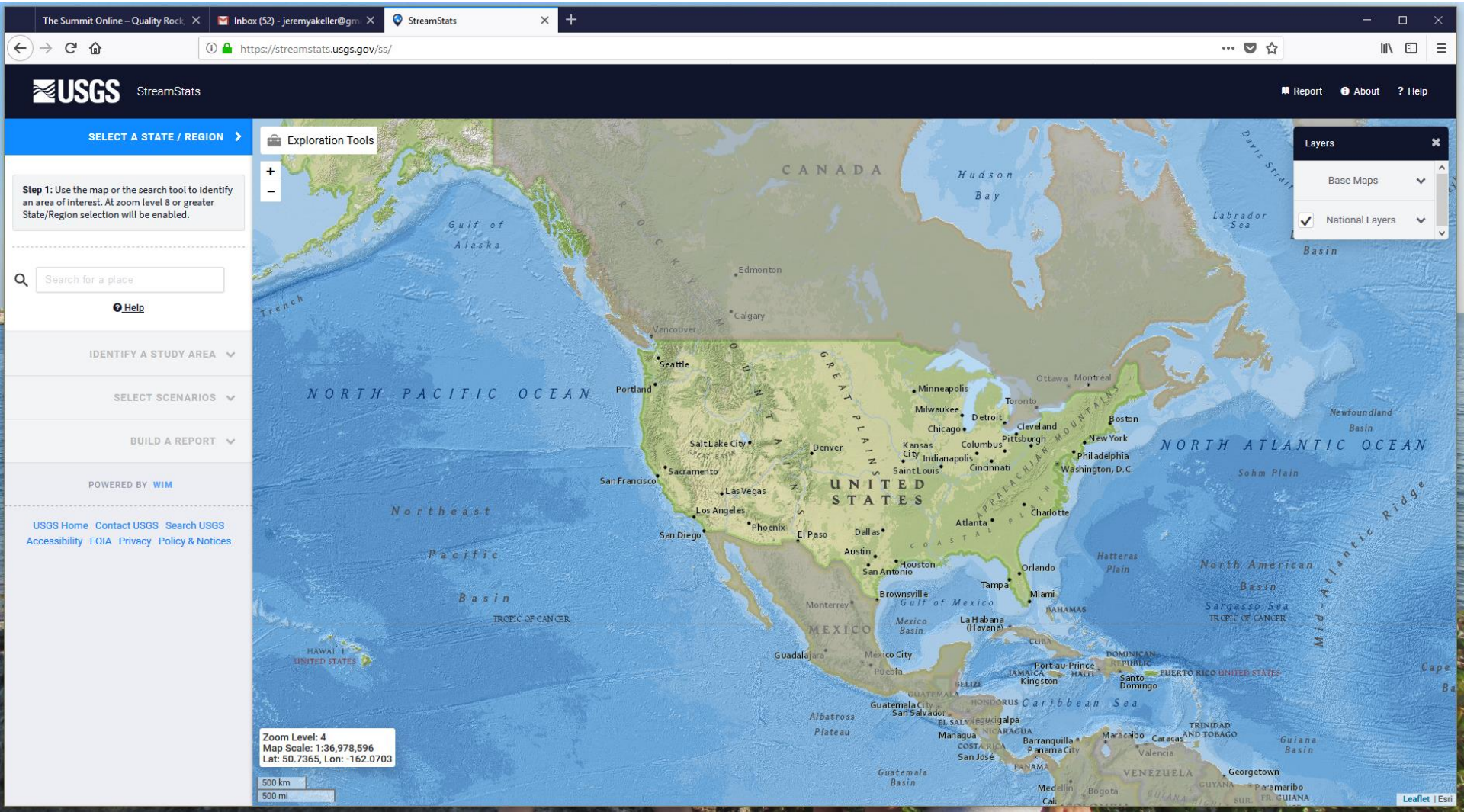
- County road bridge across upper Mad River

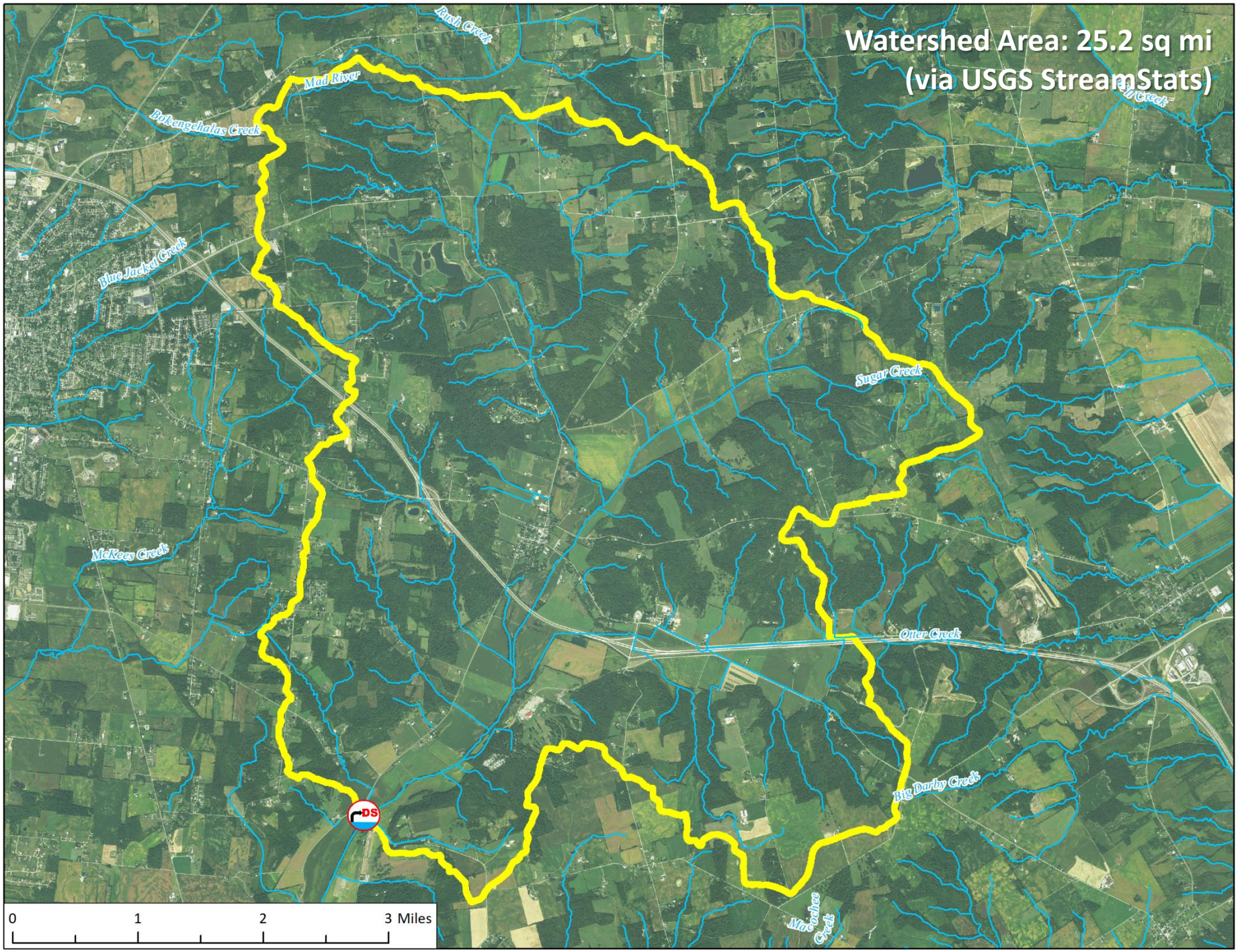

MAD-29 Draft Site
DS
McKees Creek
508
68
Mud River
287
Macochee Creek
Nearest USGS
Stream Gage
245
Site to Gage = 7.45 River Miles
0
1
2
3 Miles

Ungaged Site? No Problem (in Ohio)

USGS StreamStats web-based application

- Ohio has low-flow statistics available (most states do not)
- https://streamstats.usgs.gov/ss/




Watershed Area: 25.2 sq mi
(via USGS StreamStats)
Rush Creek
Mad River
Bokengehalas Creek
Blue Jacket Creek
McKees Creek
Sugar Creek
Otter Creek
Big Darby Creek
Macochee Creek
DS
0
1
2
3 Miles

Interpreting StreamStats Outputs for Water Supply

Is there likely to be flow at least 98% of the time?

- "Probability zero flow 7 day" should be very small (close to zero)

Probability Statistics Flow Report [P zero Flow 2012 5138]

PIl: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PC
Probability zero flow 1Day	0.00816	dim	91
Probability zero flow 7Day	0.00316	dim	94
Probability zero flow 30Day	0.000115	dim	97

Interpreting StreamStats Outputs for Water Supply

At least 250 gpm flow at least 98% of the time?

- "7 Day 10 Year Low Flow" should be > 1.12 (assuming 50% recovery)

Low-Flow Statistics Parameters [Low Flow Region A 2012 5138]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	25.2	square miles	1	1250
STREAM_VARG	Streamflow Variability Index from Grid	0.42	dimensionless	0.24	1.12

Low-Flow Statistics Flow Report [Low Flow Region A 2012 5138]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SE
1 Day 10 Year Low Flow	1.37	ft^3/s	53.1
7 Day 10 Year Low Flow	1.57	ft^3/s	40
30 Day 10 Year Low Flow	2.06	ft^3/s	35.7
90 Day 10 Year Low Flow	2.63	ft^3/s	29.8

Interpreting StreamStats Outputs for Water Supply

What are my planning flows?

- Input Monthly Flow Statistics into WSTAC worksheet
- Download .xlsx at: http://www.wstac.org/water-source-development/

Monthly Flow Statistics Flow Report [Low Flow LatLE 41.2 wri02 4068]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SE	SEp
January Mean Flow	38.2	ft^3/s	16.6	16.6
February Mean Flow	46.3	ft^3/s	11.9	11.9
March Mean Flow	54	ft^3/s	14	14
April Mean Flow	47.6	ft^3/s	11.2	11.2
May Mean Flow	30.3	ft^3/s	19.5	19.5
June Mean Flow	21.6	ft^3/s	27	27
July Mean Flow	14.2	ft^3/s	28.2	28.2
August Mean Flow	11.3	ft^3/s	36.8	36.8
September Mean Flow	8.1	ft^3/s	43.6	43.6
October Mean Flow	7.07	ft^3/s	50.8	50.8
November Mean Flow	13.6	ft^3/s	37.5	37.5
December Mean Flow	28.2	ft^3/s	21.8	21.8

WSTAC StreamStats Worksheet

Completed worksheet translates hydrologic data into useful format for fire department planning use

Ohio StreamStats Flow Worksheet

Ohio Fire Chiefs' Association
Water Supply Technical Advisory Committee

1. Fill Site Information

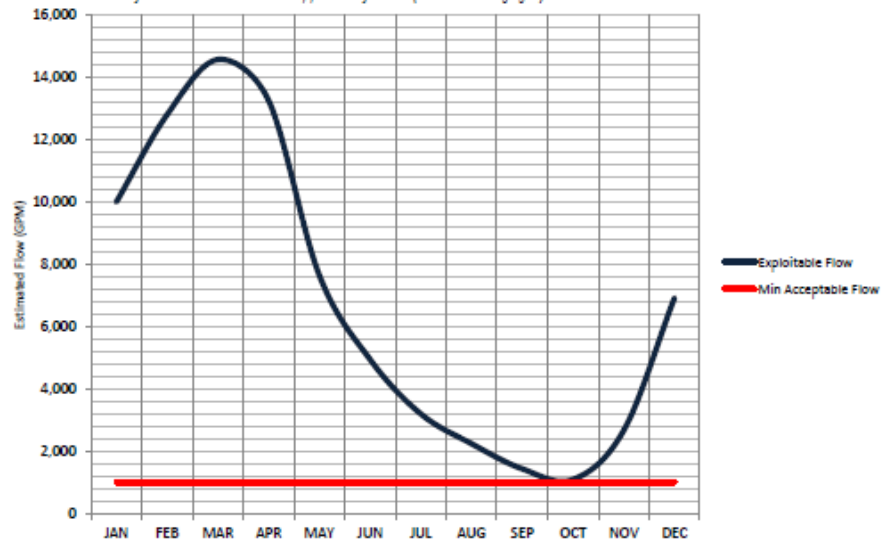
1a. Site Description / Designator	1c. Fill Site Bottom Substrate	→ *Exploitable Fraction*
MAD-29	1 - No Modifier	0.7
1b. Site Location	**1d. Minimum Acceptable Flow**	
Mad River @ CR29 Bridge (Monroe Twp)	1000	GPM

2. Flow Estimates

Month	StreamStats Data			Conversion to GPM			Exploitable Flow (GPM)
	StreamStats Statistic	*Flow (CFS)*	*Prediction Error (%)*	*Min Flow (GPM)*	*Average Flow (GPM)*	*Max Flow (GPM)*	
JAN	Q1	38.20	16.6	14,299	17,145	19,991	10,009
FEB	Q2	46.30	11.9	18,308	20,781	23,254	12,815
MAR	Q3	54.00	14.0	20,844	24,237	27,630	14,590
APR	Q4	47.60	11.2	18,972	21,364	23,757	13,279
MAY	Q5	30.30	19.5	10,948	13,600	16,252	7,663
JUN	Q6	21.60	27.0	7,077	9,695	12,312	4,954
JUL	Q7	14.20	28.2	4,576	6,373	8,171	3,203
AUG	Q8	11.30	36.8	3,205	5,072	6,938	2,244
SEP	Q9	8.10	43.6	2,050	3,636	5,221	1,435
OCT	Q10	7.07	50.8	1,561	3,173	4,785	1,093
NOV	Q11	13.60	37.5	3,815	6,104	8,393	2,670
DEC	Q12	28.20	21.8	9,898	12,657	15,416	6,928

3. Minimum Exploitable Flow Estimates (GPM)

Flow estimates derived from the USGS StreamStats application for Ohio (streamstats.usgs.gov)



Version 3 (Dec 2016) | http://www.ohiofirechiefs.org/aws/OFCA/pt/sp/water_TAC *locked worksheet password = wstac*

Planning Figures – CFS to GPM

Reference figures for quickly interpreting StreamStats outputs

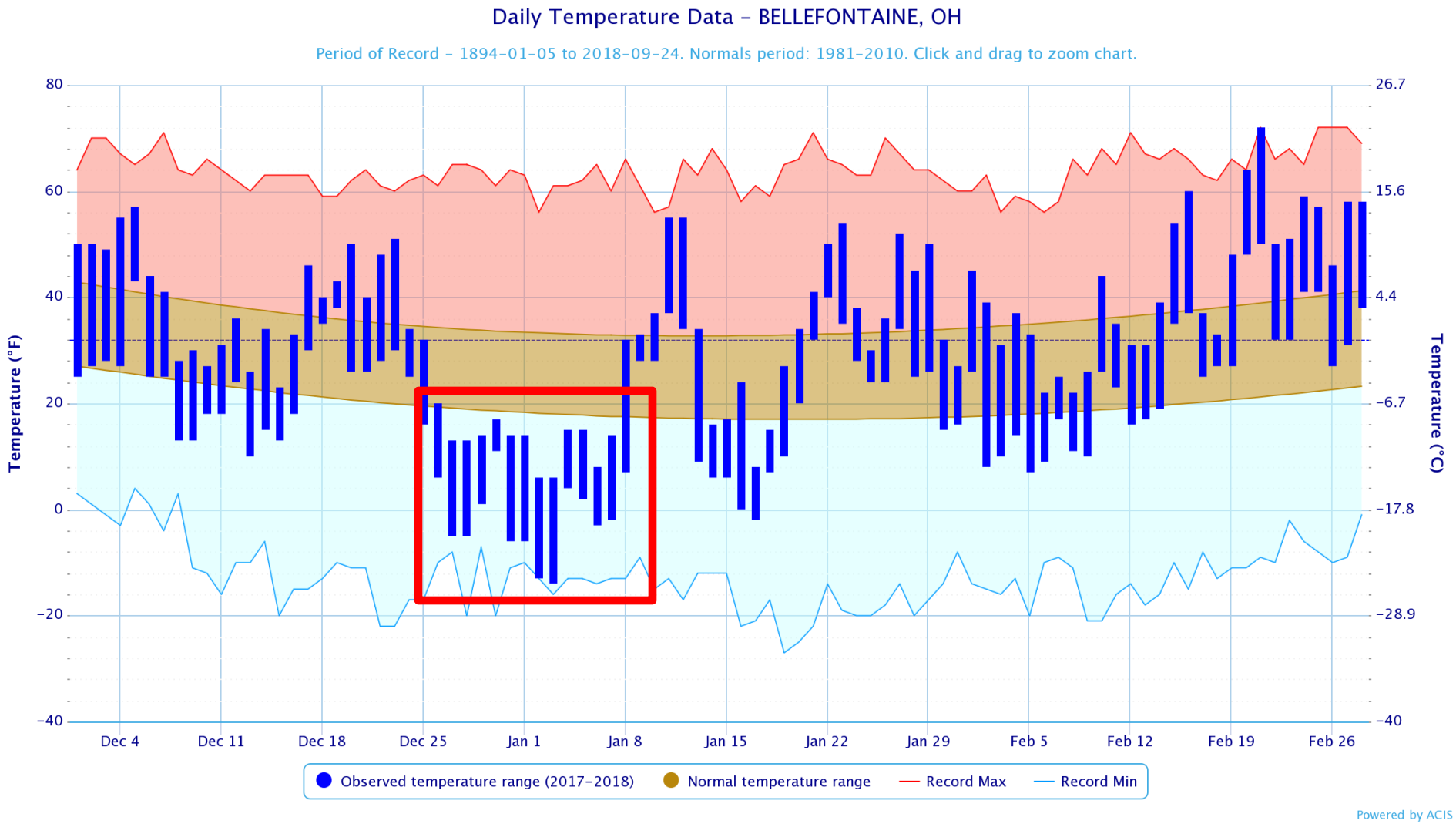
Desired GPM Flow	Min. CFS by Recovery Rate		
	100%	**70%**	**50%**
250	0.56	0.80	1.12
500	1.12	1.60	2.23
750	1.67	2.39	3.34
1000	2.23	3.19	4.46
1500	3.34	4.77	6.68
2000	4.46	6.37	8.92

What about Freezing?

No great tools for this, you just have to identify candidate sites and document ice-free conditions

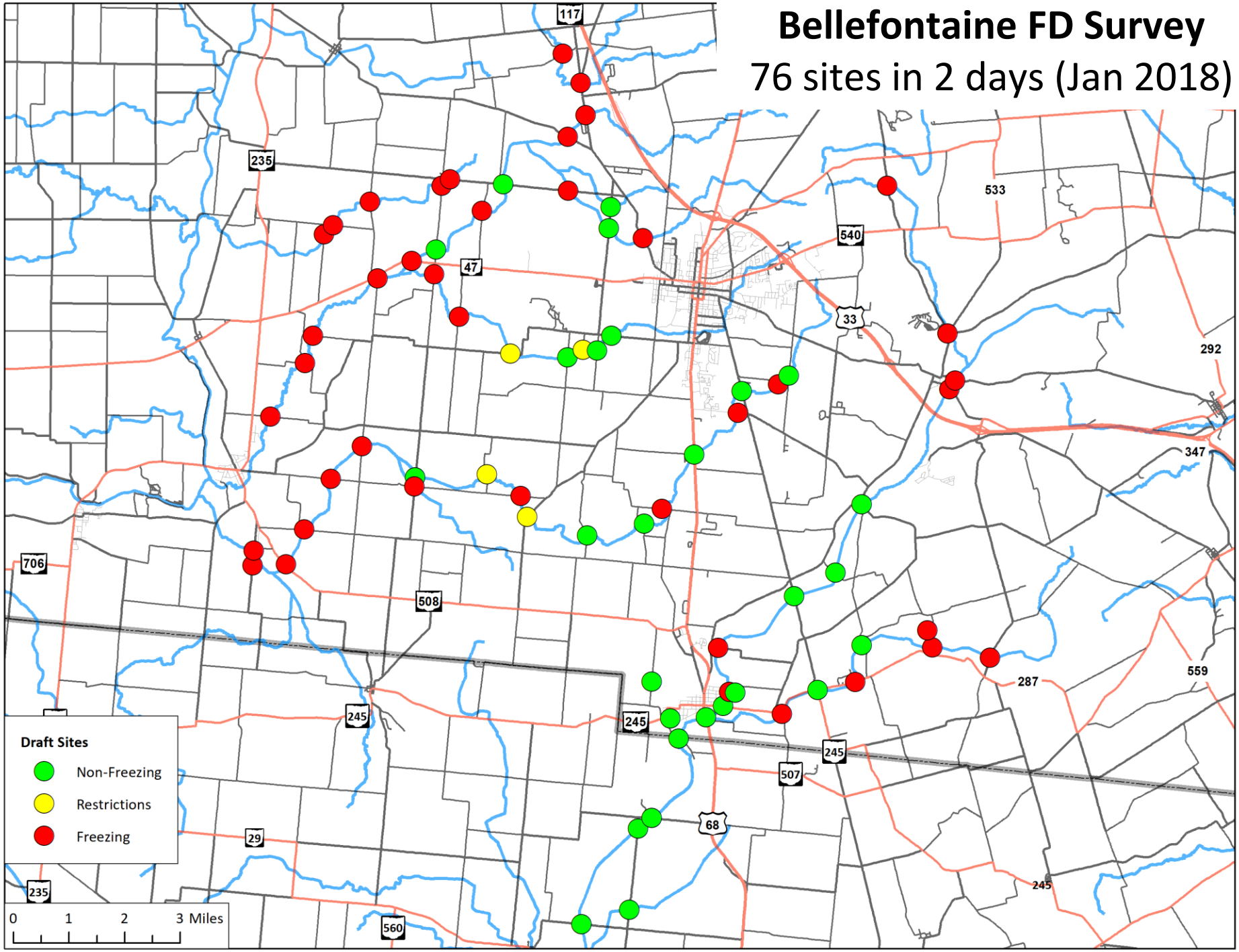
Use Drought-ACIS Data to Document Freezing Conditions

- Abnormally cold period: 12/26/2017 – 1/7/2018 (13 days)
- Freezing surveys of candidate sites conducted 1/6 and 1/7



Bellefontaine FD Survey

76 sites in 2 days (Jan 2018)



MAD-29 Dry Hydrant

Installed 5/3/2018

MAD-29 Dry Hydrant

Pivoting design allows stowing out of water when not in use

Selling the Project to Elected Officials

ArcGIS Network Analyst Service Areas used to develop cost/benefit analysis

Mad River Dry Hydrant Project

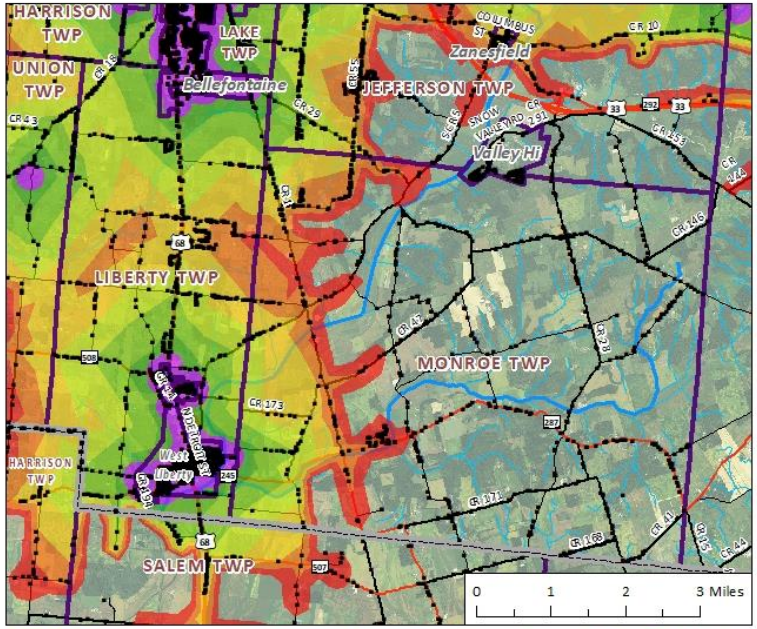
West Liberty Fire Department

A series of six clamp-on, bridge-mounted, swing-down dry hydrants along the Mad River in Logan County, supporting drafting operations by fire engines at rates of at least 1000 gallons per minute (gpm)

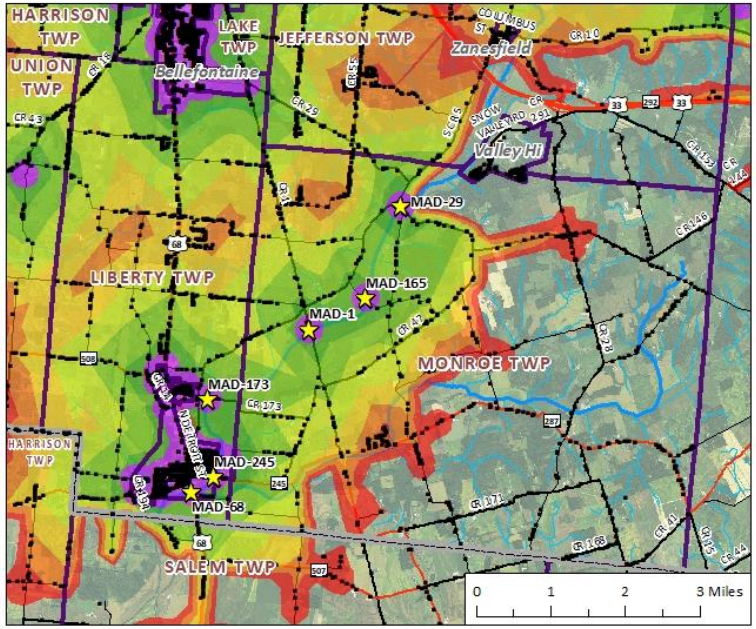
Distance from Hydrant: <0.5 mi, 0.5 - 1.0 mi, 1.0 - 1.5 mi, 1.5 - 2.0 mi, 2.0 - 2.5 mi, 2.5 - 3.0 mi

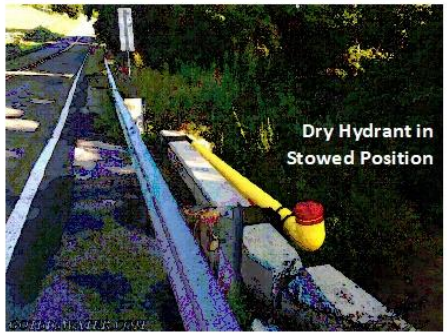
Mad River and Macochee Creek
Minor Streams
DRY HYDRANTS (MAD-___)
Hydranted Area (1000 ft)
Address Points

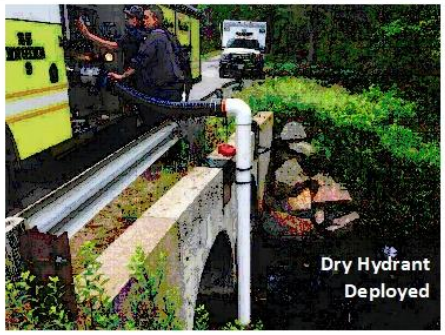
Current Situation



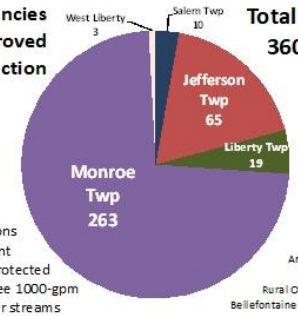
Proposed Project







Occupancies with Improved Fire Protection



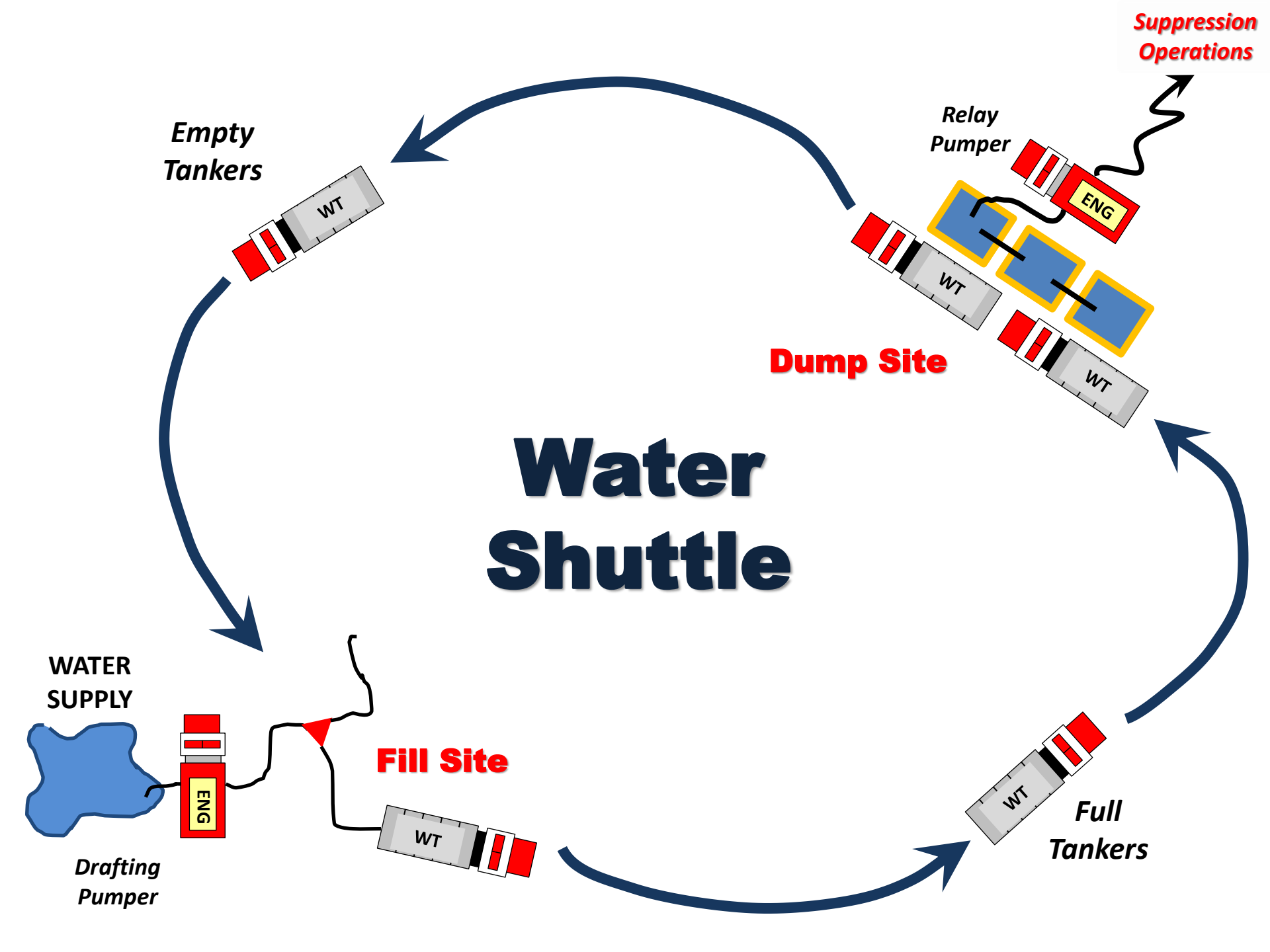
Project Benefits:

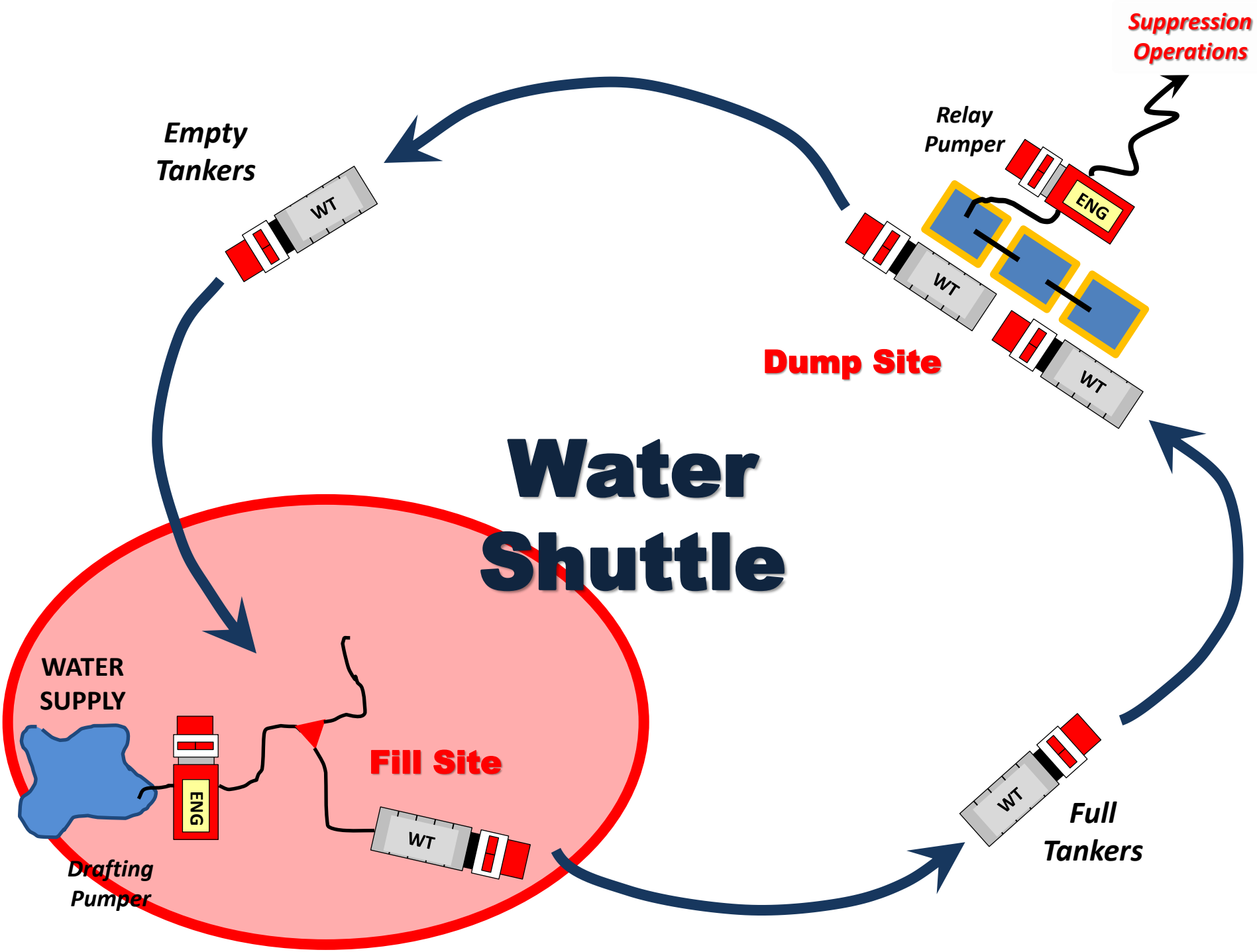
1. 12 occupancies newly move into "hydranted" status, and can qualify for reduced insurance rates (within 1000 feet of a recognized hydrant)
2. 348 total occupancies in five jurisdictions are at least 0.5 miles closer to a hydrant
3. West Liberty business district better protected from conflagration by presence of three 1000-gpm backup water sources to supply master streams

Analysis By:
J. Keller
Rural Ops. Coord.
Bellefontaine Fire Dept.
(2/2018)

Water Shuttle Operations

GIS Tools for Putting it all Together


Suppression Operations
Relay Pumper
ENG
WT
WT
WT
Dump Site
Empty Tankers
WT
Water Shuttle
WATER SUPPLY
ENG
Drafting Pumper
Fill Site
WT
WT
Full Tankers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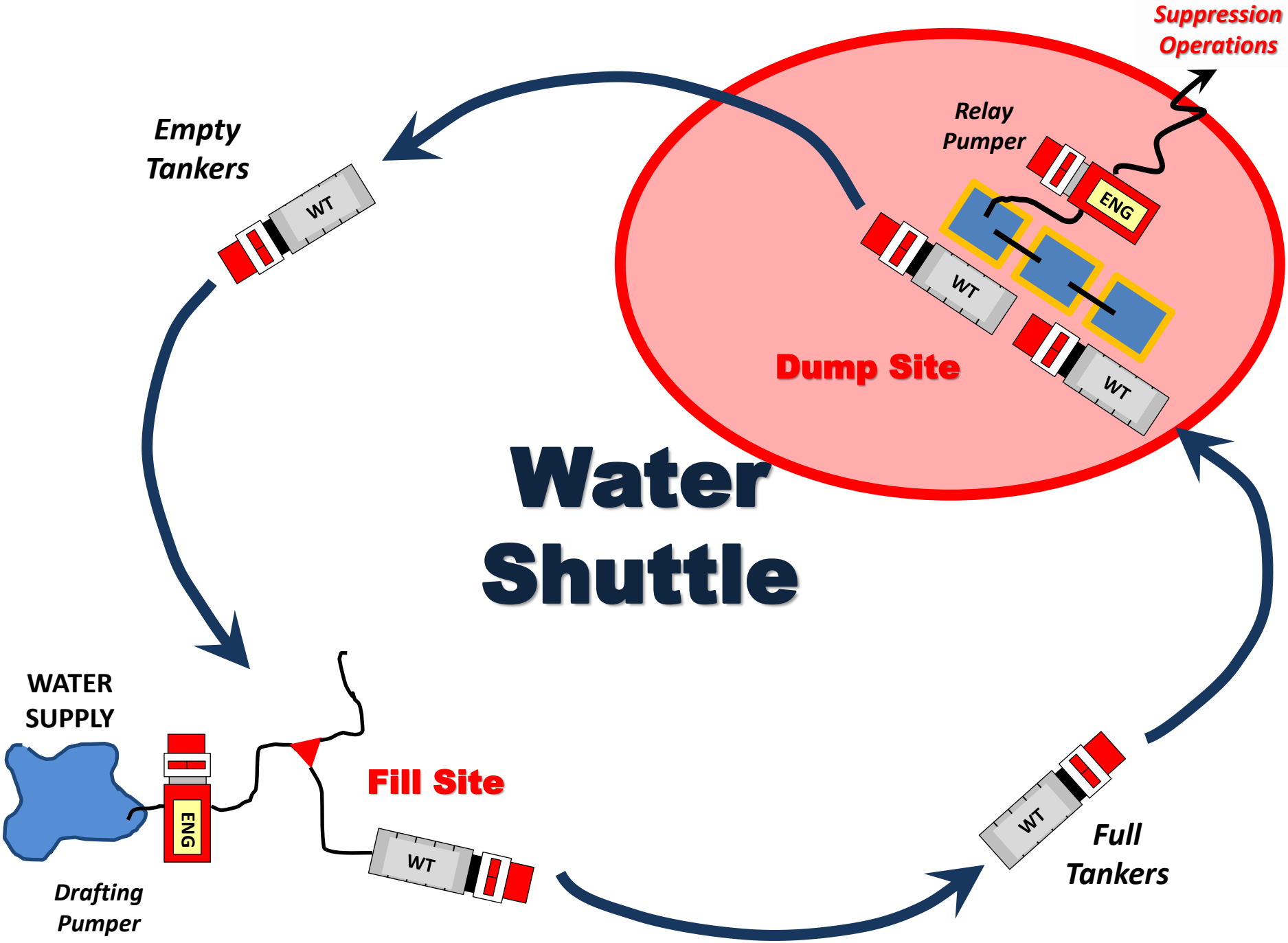
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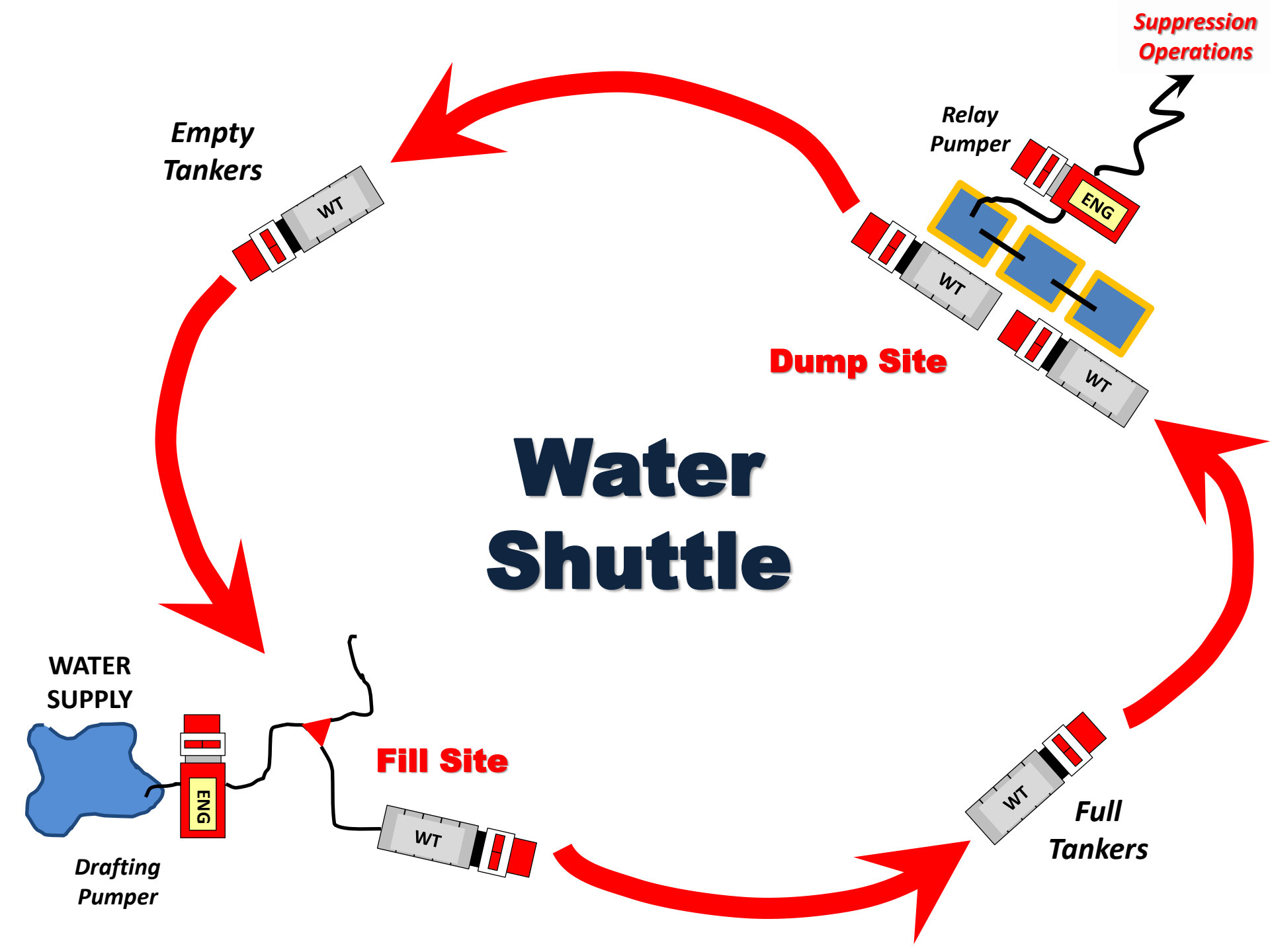
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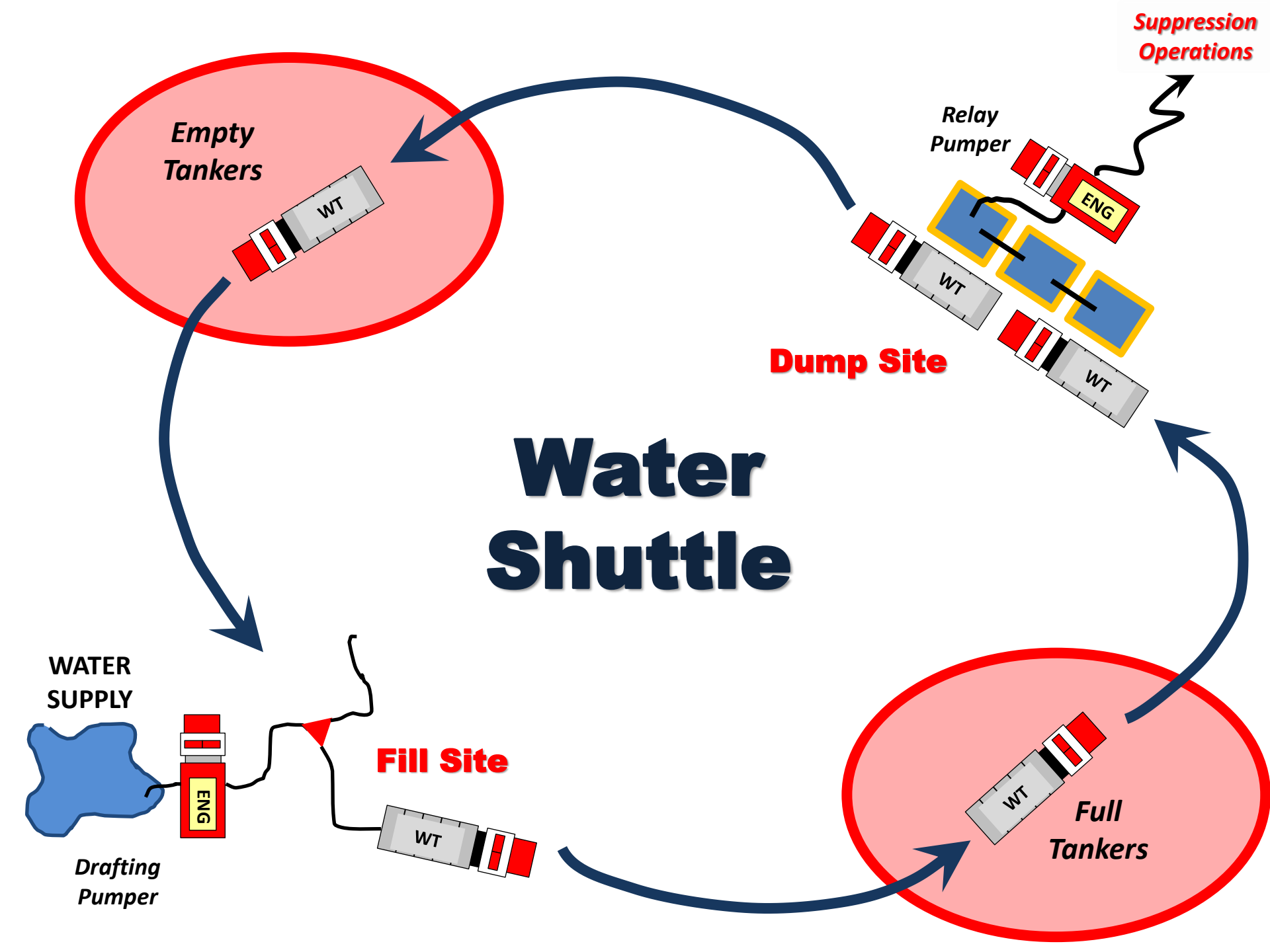
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Using GIS to Support Basic Water Shuttle Planning

- Gather basic geodata to support fire department needs

Layer	Data Type	Source	Specifics
Water Tenders (Tankers)	Point	Local	▪ Location ▪ Tank Capacity ▪ Fill Rate ▪ Dump Rate ▪ Design (conventional / vacuum)
Engines (Pumpers)	Point	Local	▪ Location ▪ Pump capacity
Fill Sites	Point	Local	▪ Location ▪ Flow rate
Dump Sites	Point	Local	▪ Location
Unit Dispatch Delays (tankers and engines)	Tabular	Dispatch office or NFIRS incident reports	▪ Time delay from dispatch (average, maximum, weekday v. weekend, etc.)
Roads (LBRS or better)	Line	OGRIP	▪ Quality roads layer suitable for use as network dataset ▪ Include sufficient neighboring areas to include mutual aid units
Crew Time Estimates	Tabular	Local	▪ Estimates of time needed for crews to establish dump site, establish fill site, and manage traffic at dump and fill sites

Quick & Dirty Data Workup to Plan a Shuttle Operation

- For a basic shuttle plan with one fill site and one dump site

Item	Description	How to Get It
Tankers x Dump Site	Road distance for each tanker to designated dump site	Network Analyst OD Matrix
Engines x Fill Site	Road distance for each potential fill site engine to designated water supply point	Network Analyst OD Matrix
Engines x Dump Site	Road distance for each potential fill site engine to designated dump site	Network Analyst OD Matrix
Shuttle Route Distance	Road distance of planned shuttle route	Create feature from roads layer and calculate length

Example: Tankers vs. Dump Site

- OD Matrix for 39 potential water tenders, ranked by distance
- Use Tanker as “destination” and Dump Site as “origin” for better results

ObjectID	Shape	Name	OriginID	DestinationID	DestinationRank	Total_length_mi
40	Polyline	2493 SR 287 - WLF_T-112	40	25	1	2.7
41	Polyline	2493 SR 287 - WLF_T-111	40	24	2	2.7
42	Polyline	2493 SR 287 - TVF_T-142	40	23	3	6.6
43	Polyline	2493 SR 287 - TVF_T-141	40	22	4	6.7
44	Polyline	2493 SR 287 - BFF_T-21	40	2	5	8.5
45	Polyline	2493 SR 287 - NEC_T-321	40	26	6	10.9
46	Polyline	2493 SR 287 - PTF_T-41	40	13	7	11.2
47	Polyline	2493 SR 287 - URB_T-1	40	33	8	11.9
48	Polyline	2493 SR 287 - DGF_T-31	40	6	9	13.1
49	Polyline	2493 SR 287 - HVF_T-52	40	8	10	14.9
50	Polyline	2493 SR 287 - HVF_T-51	40	7	11	15.0
51	Polyline	2493 SR 287 - ATF_T-601	40	3	12	15.5
52	Polyline	2493 SR 287 - BCF_T-121	40	4	13	15.9
53	Polyline	2493 SR 287 - BCF_T-122	40	5	14	15.9
54	Polyline	2493 SR 287 - QVF_T-72	40	15	15	15.9
55	Polyline	2493 SR 287 - RCF_T-91	40	21	16	15.9
56	Polyline	2493 SR 287 - QVF_T-71	40	14	17	15.9
57	Polyline	2493 SR 287 - RWD_T-161	40	20	18	16.1
58	Polyline	2493 SR 287 - LTF_T-291	40	27	19	16.9
59	Polyline	2493 SR 287 - RTF_T-12	40	17	20	19.0
60	Polyline	2493 SR 287 - RTF_T-11	40	16	21	19.1
61	Polyline	2493 SR 287 - IJF_T-101	40	9	22	19.6
62	Polyline	2493 SR 287 - RWF_T-82	40	18	23	21.5
63	Polyline	2493 SR 287 - RWF_T-83	40	19	24	21.5
64	Polyline	2493 SR 287 - LVF_T-61	40	11	25	21.6
65	Polyline	2493 SR 287 - JSP_T-4	40	32	26	21.6
66	Polyline	2493 SR 287 - MAR_T-271	40	39	27	21.8
67	Polyline	2493 SR 287 - MWF_T-151	40	12	28	22.8
68	Polyline	2493 SR 287 - RHD_T-1002	40	29	29	23.2
69	Polyline	2493 SR 287 - PTJ_T-965	40	38	30	24.5
70	Polyline	2493 SR 287 - MTV_T-02	40	28	31	25.6
71	Polyline	2493 SR 287 - JCF_T-561	40	10	32	25.7
72	Polyline	2493 SR 287 - KEN_T-75	40	34	33	29.6
73	Polyline	2493 SR 287 - WAY_T-944	40	31	34	31.0
74	Polyline	2493 SR 287 - ANN_T-164	40	36	35	31.3
75	Polyline	2493 SR 287 - STJ_T-6044	40	40	36	33.8
76	Polyline	2493 SR 287 - SVF_T-720	40	35	37	33.9
77	Polyline	2493 SR 287 - BOT_T-26x	40	37	38	34.8
78	Polyline	2493 SR 287 - UNI_T-844	40	30	39	36.7

Water Shuttle Planning Example

WS-215A Water Shuttle Tactical Resources Worksheet

Ohio Fire Chiefs' Association
Water Supply Technical Advisory Committee

1. Water Supply Requirements	2. Planning Speeds	3. Fill Site Factors		4. Dump Site Factors	5. Shuttle Route Factors	6. Supporting Resources		
Water Supply Zone / Incident Name	Response Speed (SR) mph	Assigned Fill Site	Engine Flow Rate (EQ) gpm	Assigned Dump Site	Assigned Route	Fill Site Unit	Dispatch Delay min	Response Distance miles
Minimum Water Volume (gal) gal	Shuttle Speed (SS) mph	Exploitable Volume (Vs) gal	Fill Site Set-Up Time min	Dump Site Set-Up Time min	Total Route Distance (mi) miles	Dump Site Unit	Dispatch Delay min	Response Distance miles
Water Delivery Rate (gpm) gpm		Maximum Flow Rate (FSQ) gpm	Crew Handling Time (HTF) min	Crew Handling Time (HTD) min	Route Travel Time (TR) min	Water Supply Officer	Fill Site Officer	Dump Site Officer

7. Water Tenders		8. Response Time Factors			9. Water Handling Factors				10. Fill Site Time			11. Dump Site Time		12. Flow Calculations			
No.	Unit Designator	Dispatch Delay (HD) minutes	Response Distance (HR) miles	Response Time (H) minutes	Nominal Tank Capacity (RV) gallons	Residual Water Factor (k) Conv = 0.9 Vac = 1.0	Fill Rate (RF) gpm	Dump Rate (RD) gpm	Restricted Fill Rate (FSR) gpm	Fill Time min	Total Fill Site Time (TF) min	Dump Time min	Total Dump Site Time (TD) min	Total Shuttle Time (T) min	Continuous Flow Contribution gpm	Cumulative Time min	Cumulative Flow gpm
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

13. Water Tender Arrival Sequence				
Water Tender	Dispatch Delay (HD) minutes	Response Distance (HR) miles	Response Time (H) minutes	Arrival Order (Rank)

13. Key Operational Benchmarks				14. Key Shuttle Flow Benchmarks	
Shuttle Element	Assigned Unit	On-Scene	Operational	Delivery Rate	Time
Fill Site				>250 gpm	min
Dump Site				>500 gpm	min
First Due Tender				>750 gpm	min
Full Planned Shuttle	# Units =			>1000 gpm	min

Maximum Shuttle Flow	gpm
Time to Achieve Max. Flow	min

Date Prepared	Prepared By

www.wstac.org/water-shuttle-resources/

Section 1. Required Water Supply

What Do We Need?

Water Supply Zone:
Maple Ridge subdivision (MR)

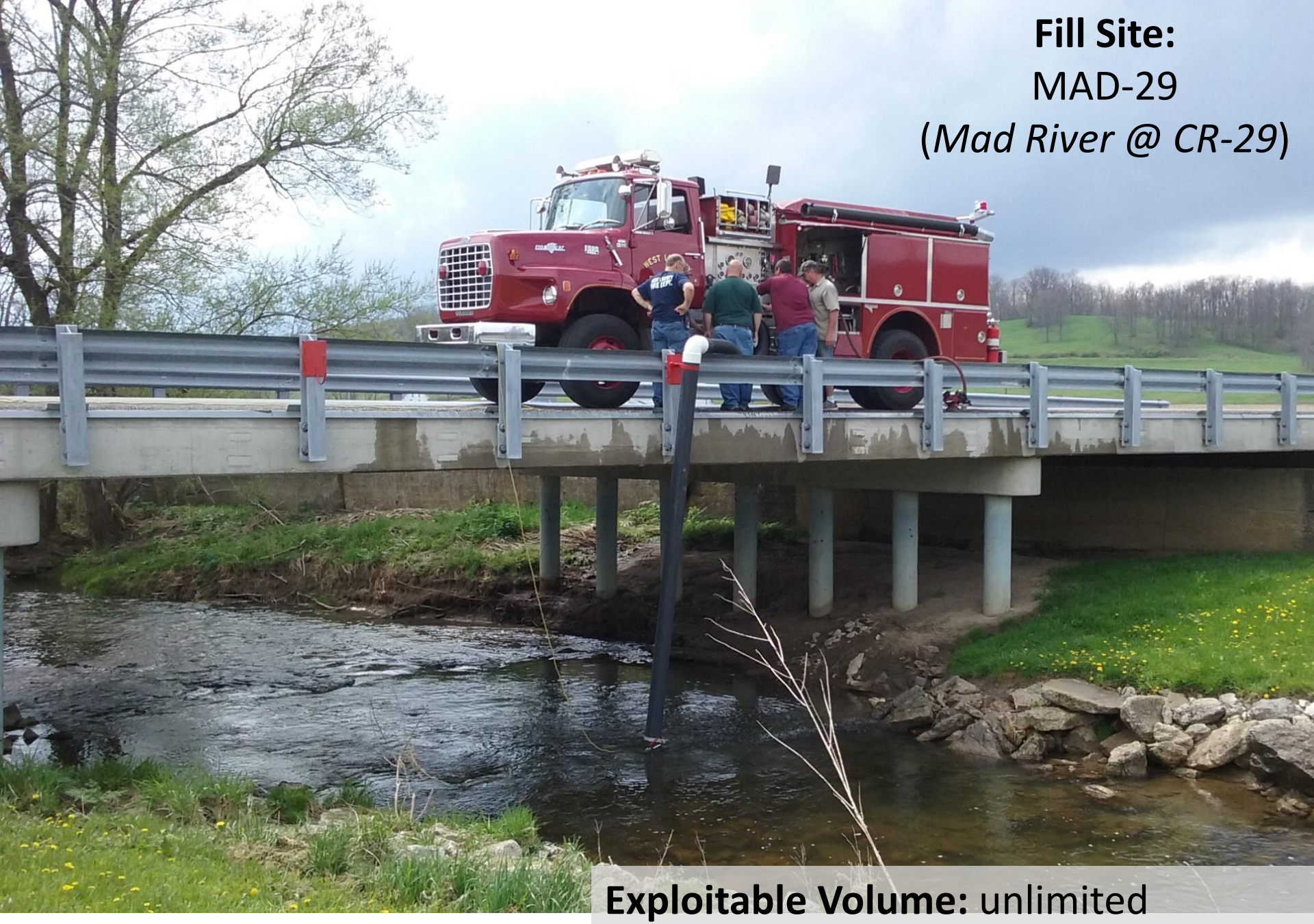
Min. Water Supply: 11,700 gallons
Water Delivery Rate: 750 gpm

1. Water Supply Requirements	
Water Supply Zone / Incident Name Maple Ridge Subdivision	
Minimum Water Volume (gal) 11,700	*gal*
Water Delivery Rate (gpm) 750	*gpm*

Planning Travel Speeds

- Choose reasonable average speeds for response and shuttle operations
- <u>Response</u> = station to incident location
- <u>Shuttle</u> = tankers making multiple circuits of shuttle route (NFPA 1142 = 35 mph)

2. Planning Speeds	
Response Speed (SR)	
45	*mph*
Shuttle Speed (SS)	
35	*mph*



Fill Site:
MAD-29
(*Mad River @ CR-29*)

Exploitable Volume: unlimited
Maximum Flow Rate (FSQ): 1000 gpm

3. Fill Site Factors	
Assigned Fill Site MAD-29	Engine Flow Rate (EQ) 1,250 *gpm*
Exploitable Volume (Vx) *unlimited* *gal*	Fill Site Set-Up Time 7.5 *min*
Maximum Flow Rate (FSQ) 1,000 *gpm*	Crew Handling Time (HTF) 1.0 *min*

3. Fill Site Factors

Assigned Fill Site MAD-29	Engine Flow Rate (EQ) 1,250 *gpm*
Exploitable Volume (Vx) *unlimited* *gal*	Fill Site Set-Up Time 7.5 *min*
Maximum Flow Rate (FSQ) 1,000 *gpm*	Crew Handling Time (HTF) 1.0 *min*

Dump Site:

MR-01

(*subdivision entrance @ SR-287*)

4. Dump Site Factors	
Assigned Dump Site MR-01	
Dump Site Set-Up Time 8.0	*min*
Crew Handling Time (HTD) 0.5	*min*

Shuttle Route:

HT-08

(*digitize and calculate distance*)

5. Shuttle Route Factors	
Assigned Route HT-08	
Total Route Distance (mi) 3.4	*miles*
Route Travel Time (TR) 5.8	*min*

TR = Distance * (60 / mph)

Supporting Resources:

Usually mutual aid units

(*distances from OD Matrix; delays from dispatch; set-up/handling times from departments*)

6. Supporting Resources		
Fill Site Unit E-232	Dipatch Delay 6.5 *min*	Response Distance 5.4 *miles*
Dump Site Unit E-45	Dispatch Delay 5.3 *min*	Response Distance 3.2 *miles*
Water Supply Officer	Fill Site Officer	Dump Site Officer

Water Tender Arrival Sequence:

Sequence important for calculations

(*Ranked based on estimated arrival time = travel time + dispatch delay)*

13. Water Tender Arrival Sequence

Water Tender	Dispatch Delay (HD) *minutes*	Response Distance (HR) *miles*	Response Time (H) *minutes*	Arrival Order (Rank)
T-44	5.9	3.2	10.2	1
T-122	5.2	4.8	11.6	2
T-31	6.8	10.5	20.8	5
T-81	5.1	5.5	12.4	3
T-121	5.4	11.2	20.3	4

Water Tenders:

Enter tanker data in ranked arrival order (*performance data from departments or estimated*)

7. Water Tenders		**8. Response Time Factors**		
No.	Unit Designator	Dispatch Delay (HD) *minutes*	Response Distance (HR) *miles*	Response Time (H) *minutes*
1	T-44	5.9	3.2	10.2
2	T-112	5.2	4.8	11.6
3	T-81	5.1	5.5	12.4
4	T-121	5.4	11.2	20.3
5	T-31	6.8	10.5	20.8

7. Water Tenders	
No.	Unit Designator
1	T-44
2	T-112
3	T-81
4	T-121
5	T-31

9. Water Handling Factors			
Nominal Tank Capacity (RV) *gallons*	Residual Water Factor (k) *Conv = 0.9* *Vac = 1.0*	Fill Rate (RF) *gpm*	Dump Rate (RD) *gpm*
2,200	0.9	785	965
1,800	0.9	810	950
1,500	0.9	520	725
1,800	0.9	725	890
2,200	0.9	990	1,200

7. Water Tenders	
No.	Unit Designator
1	T-44
2	T-112
3	T-81
4	T-121
5	T-31

10. Fill Site Time		
Restricted Fill Rate (FSR) *gpm*	Fill Time *min*	Total Fill Site Time (TF) *min*
785	2.5	3.5
810	2.0	3.0
520	2.6	3.6
725	2.2	3.2
990	2.0	3.0

FSR = Minimum of FSQ, EQ, RF

TF = [(RV * k) / FSR] + HTF

7. Water Tenders	
No.	Unit Designator
1	T-44
2	T-112
3	T-81
4	T-121
5	T-31

11. Dump Site Time	
Dump Time *min*	Total Dump Site Time (TD) *min*
2.1	2.6
1.7	2.2
1.9	2.4
1.8	2.3
1.7	2.2

$$TD = [(RV * k) / RD] + HTD$$

7. Water Tenders

No.	Unit Designator
1	T-44
2	T-112
3	T-81
4	T-121
5	T-31

12. Flow Calculations

Total Shuttle Time (T) *min*	Continuous Flow Contribution *gpm*	Cumulative Time *min*	Cumulative Flow *gpm*
11.9	166	10.2	166
11.0	147	11.6	313
11.8	115	12.4	428
11.4	142	20.3	570
11.0	180	20.8	750

13. Key Operational Benchmarks				14. Key Shuttle Flow Benchmarks	
Shuttle Element	**Assigned Unit**	**On-Scene**	**Operational**	**Delivery Rate**	**Time**
Fill Site	E-232	13.7	21.2	>250 gpm	11.6 *min*
Dump Site	E-45	9.6	17.6	>500 gpm	20.3 *min*
First Due Tender	T-44	10.2	10.2	>750 gpm	20.8 *min*
Full Planned Shuttle	*# Units =* 5	20.8	20.8	>1000 gpm	*min*

Boom!

Your quick & dirty water shuttle plan is complete!

Next Step:

- Improve travel time estimates using obstacles, slopes, segment speed limits, etc. (on your own)

For a Deeper Dive on ArcGIS Network Analyst for Fire & EMS Planning

Mike Price ArcUser Articles on Public Safety GIS (2005-2011)

Just the highlights, there are many other articles in the series from this timeframe – most use ArcGIS v9x, but changes in NA with v10x are minimal

"Got It Covered" (Fall 2006)
http://www.esri.com/news/arcuser/1006/files/covered.pdf

"Managing Volunteer Firefighter Response" (Spring 2007)
http://www.esri.com/news/arcuser/0507/files/odmatrix.pdf

"Priming the Pump" (Summer 2007)
http://www.esri.com/news/arcuser/0807/files/socd.pdf

"Priming the Pump – Stage II" (Fall 2007)
http://www.esri.com/news/arcuser/1207/files/priming2.pdf

Thank You!