



**MAYBE YOU HAVEN'T HEARD,
BUT THERE'S AN OIL BOOM
GOING ON...**



WATFORD CITY, ND

- In the Heart of the Well Field
- Experiencing Unprecedented Growth
- Municipal Services Stretched to Capacity

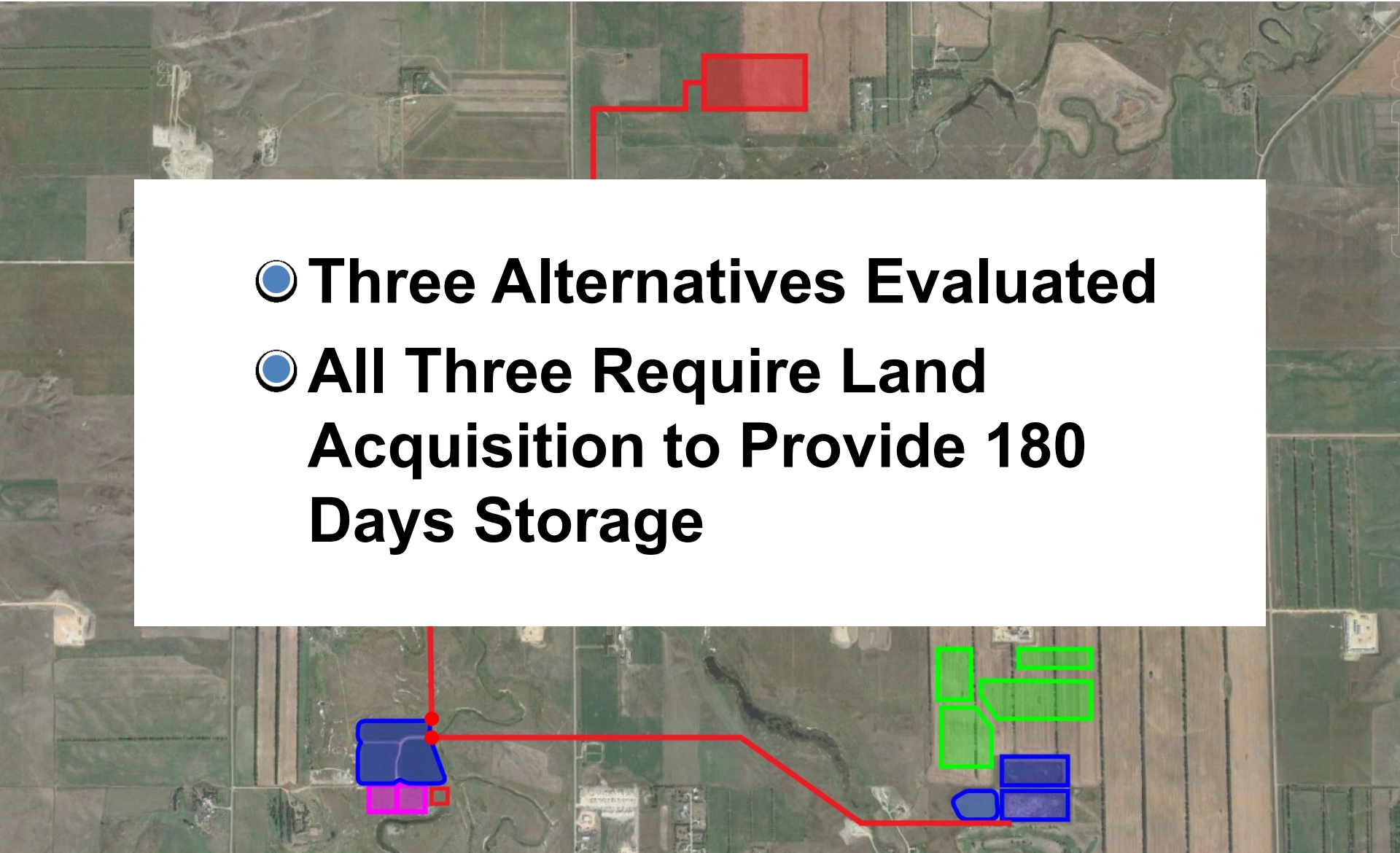


WATFORD CITY, ND

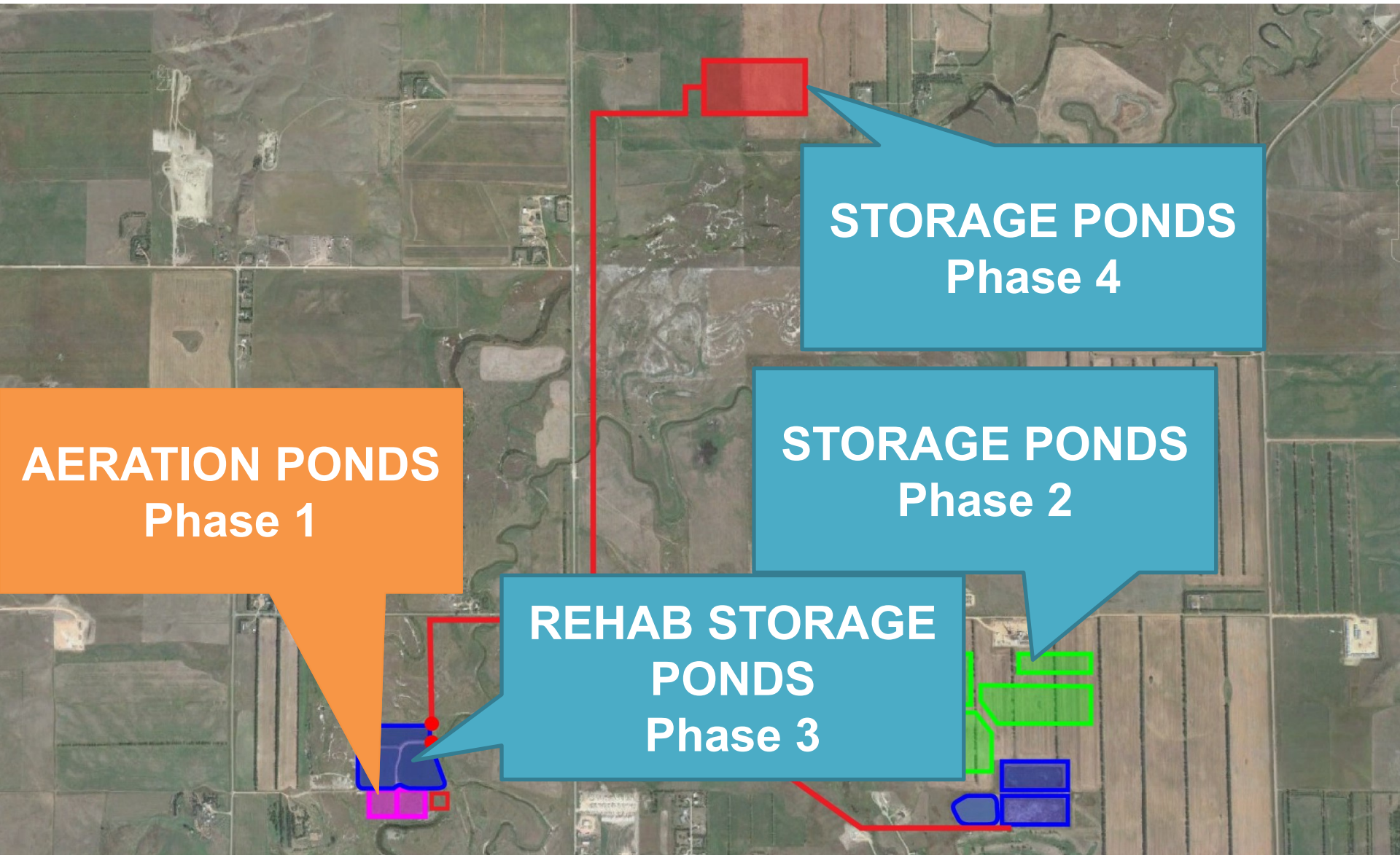
- **Aerated Pond Expansion Completed in 2013**
- **Need for Additional Storage Volume for Intermittent Discharge**
- **Land for Additional Storage Volume Not Available at Existing Site**

WATFORD CITY FACILITY PLAN AMENDMENT - JUNE 2013

- **Three Alternatives Evaluated**
- **All Three Require Land Acquisition to Provide 180 Days Storage**



ALTERNATIVE 3 PROPOSED IMPROVEMENTS FOR WASTEWATER TREATMENT FACILITY



**STORAGE PONDS
Phase 4**

**STORAGE PONDS
Phase 2**

**REHAB STORAGE
PONDS
Phase 3**

**AERATION PONDS
Phase 1**

WATFORD CITY FACILITY PLAN AMENDMENT - JUNE 2013

- **Additional aerated ponds and multiple pond storage sites as highest ranked alternative**
 - **Not particularly cost effective**
 - **Operational impacts of managing multiple sites**
 - **Land acquisition difficult**

NEED TO EXPLORE MORE ALTERNATIVES – QUICKLY!

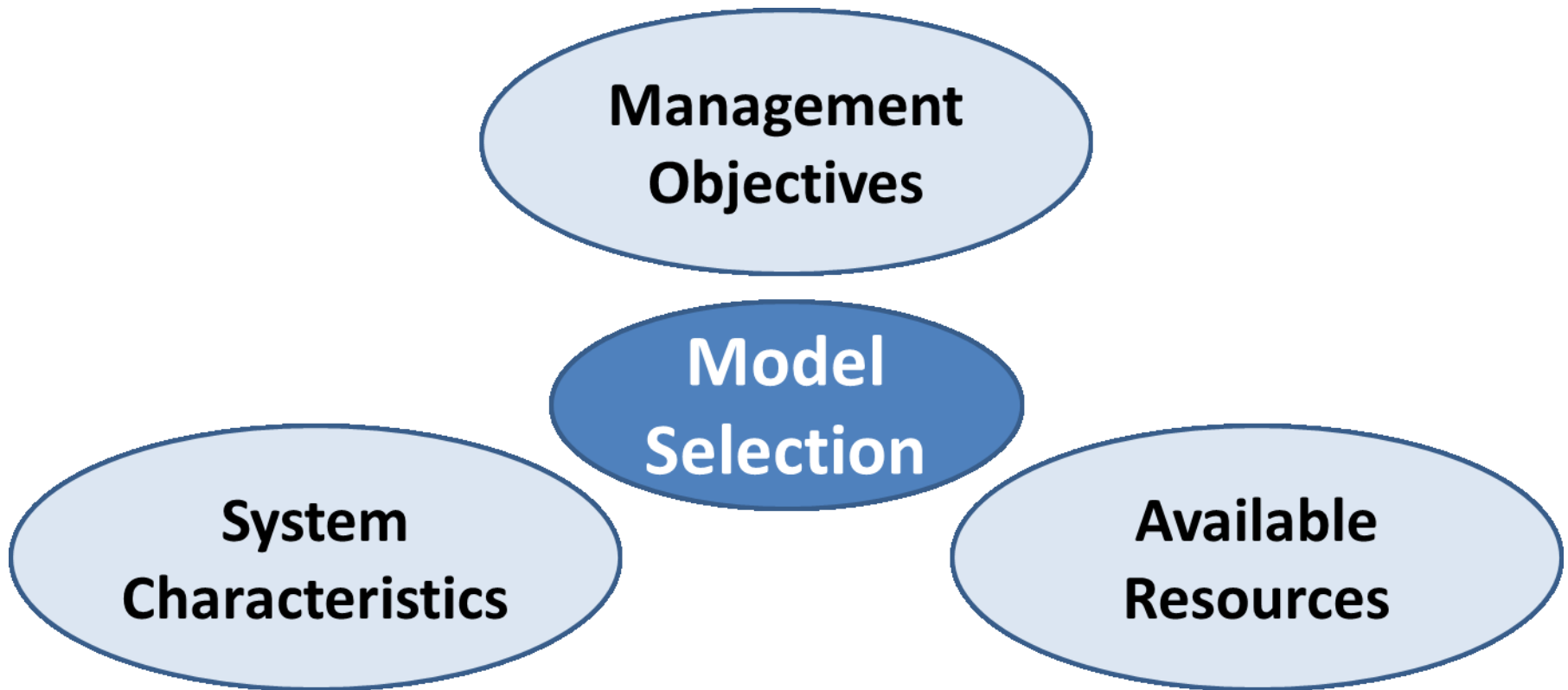
- **Fourth Alternative
Developed**
- **Continuous discharge
to an intermittent
stream (Cherry Creek)**



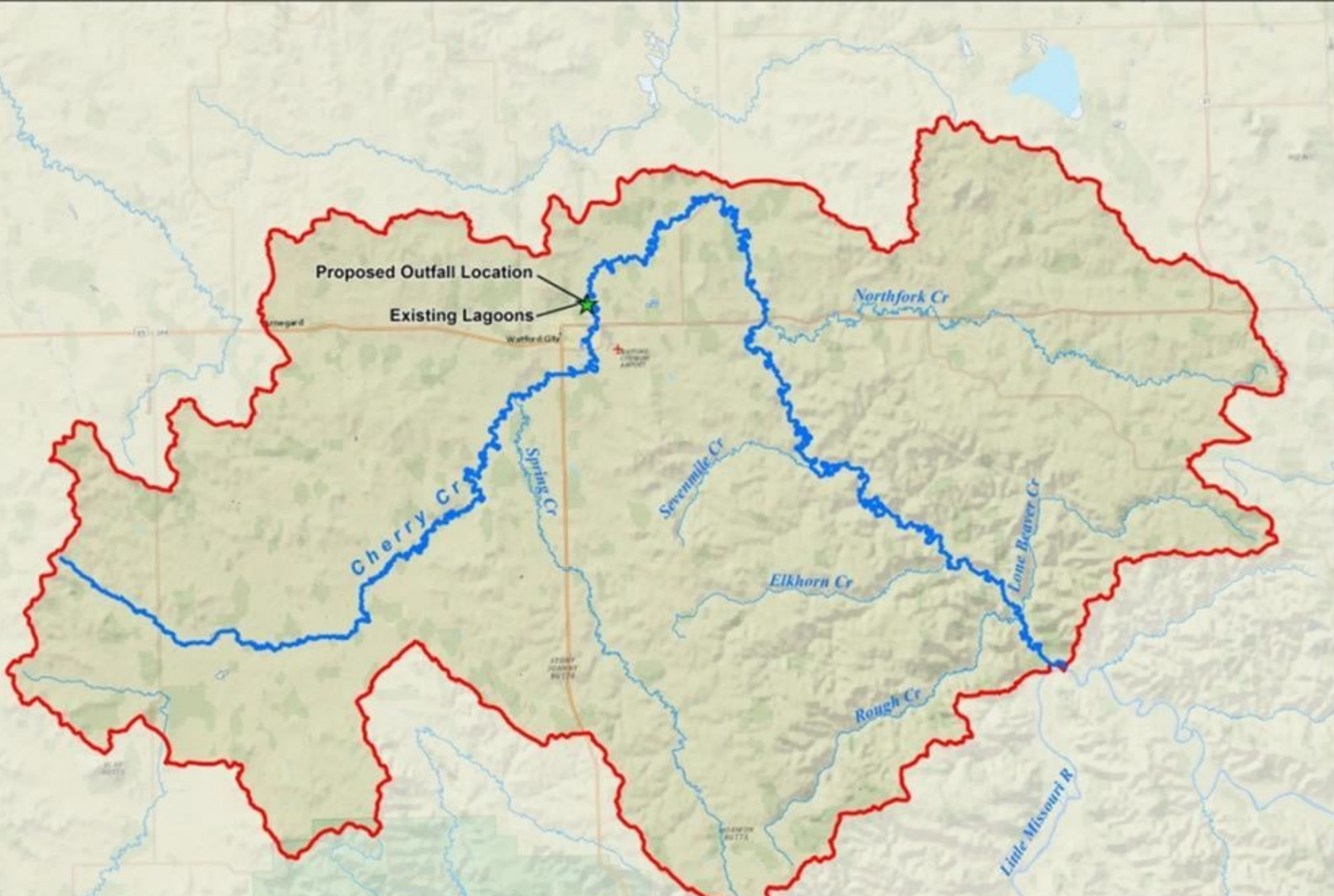
STREAM MODEL

- **AE2S partnered with LimnoTech (Hudson, WI) to develop stream model**
- **Wasteload allocation (WLA) study**
 - **How much “load” can Cherry Creek handle?**
 - **Dissolved oxygen criteria**
 - **Ammonia criteria**

MODEL SELECTION



What is the allowable level of BOD in the discharge that results in attainment of the dissolved oxygen criterion under critical conditions?



Proposed Outfall Location

Existing Lagoons

Northfork Cr

Cherry Cr

Spring Cr

Sevenmile Cr

Elkhorn Cr

Rough Cr

Lone Beaver Cr

Little Missouri R

Watford City, North Dakota
Cherry Creek Watershed Map





STREETER-PHELPS MODEL CHOSEN

$$DO_t = DO_{sat} - \left[(DO_{sat} - DO_{init}) \cdot e^{-K_a \cdot \Delta t} + K_d \cdot \left(\frac{BOD_5 \cdot BOD_u \cdot BOD_5}{K_a - K_d} \right) \cdot (e^{-K_d \cdot \Delta t} - e^{-K_a \cdot \Delta t}) \right]$$

where:

DO_t = dissolved oxygen concentration in stream after traveling for t (days) in mg/l

DO_{sat} = dissolved oxygen saturation concentration in mg/l

DO_{init} = initial dissolved oxygen concentration in mg/l

K_a = reaeration rate in day^{-1}

Δt = travel time downstream in days

K_d = deoxygenation rate in day^{-1}

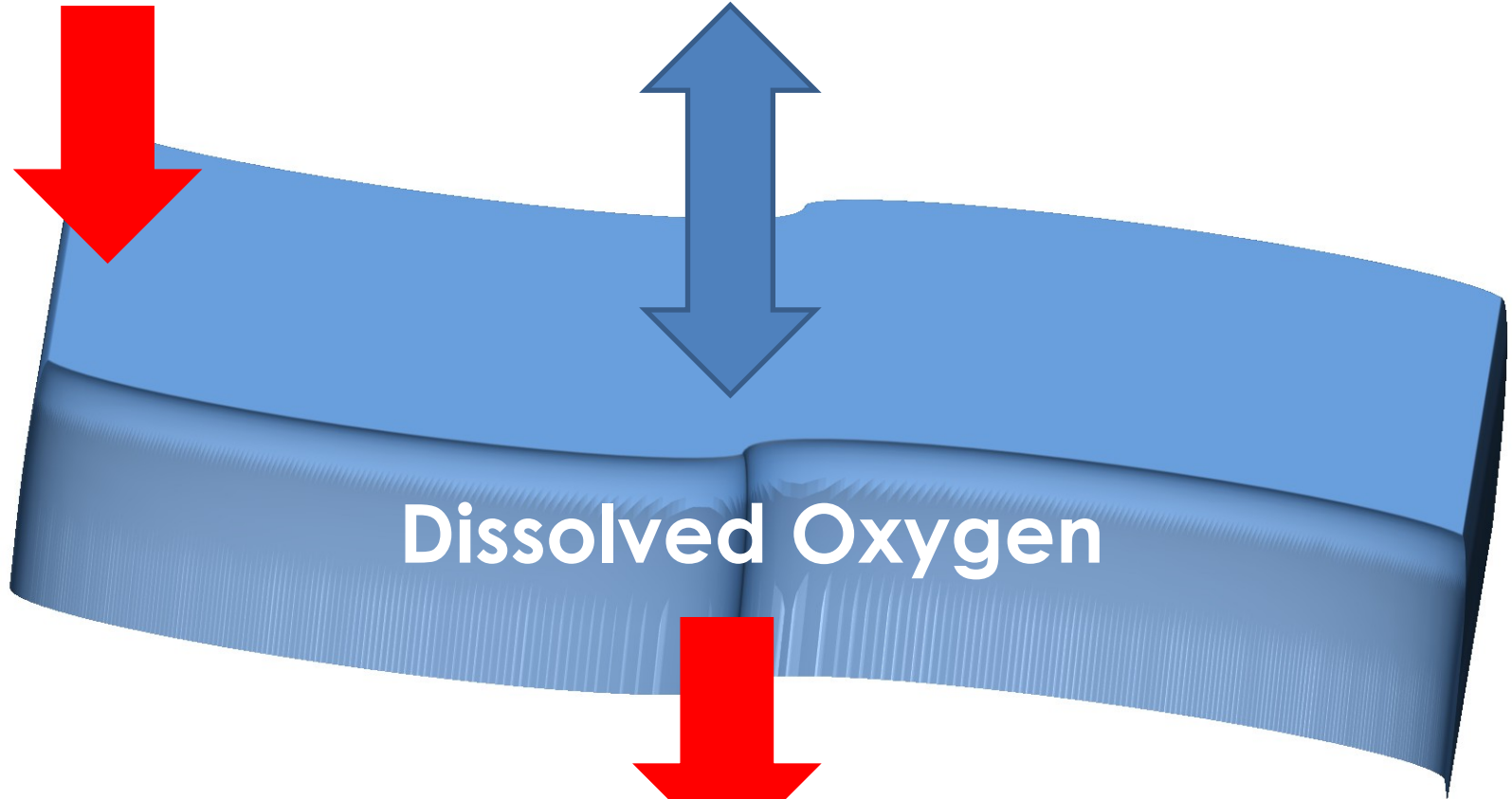
BOD_5 = initial 5 – day biochemical oxygen demand in mg/l

$BOD_u : BOD_5$ = ultimate to 5 – day ratio of biochemical oxygen demand

STREETER-PHELPS SCHEMATIC

BOD Load

Reaeration: K_a

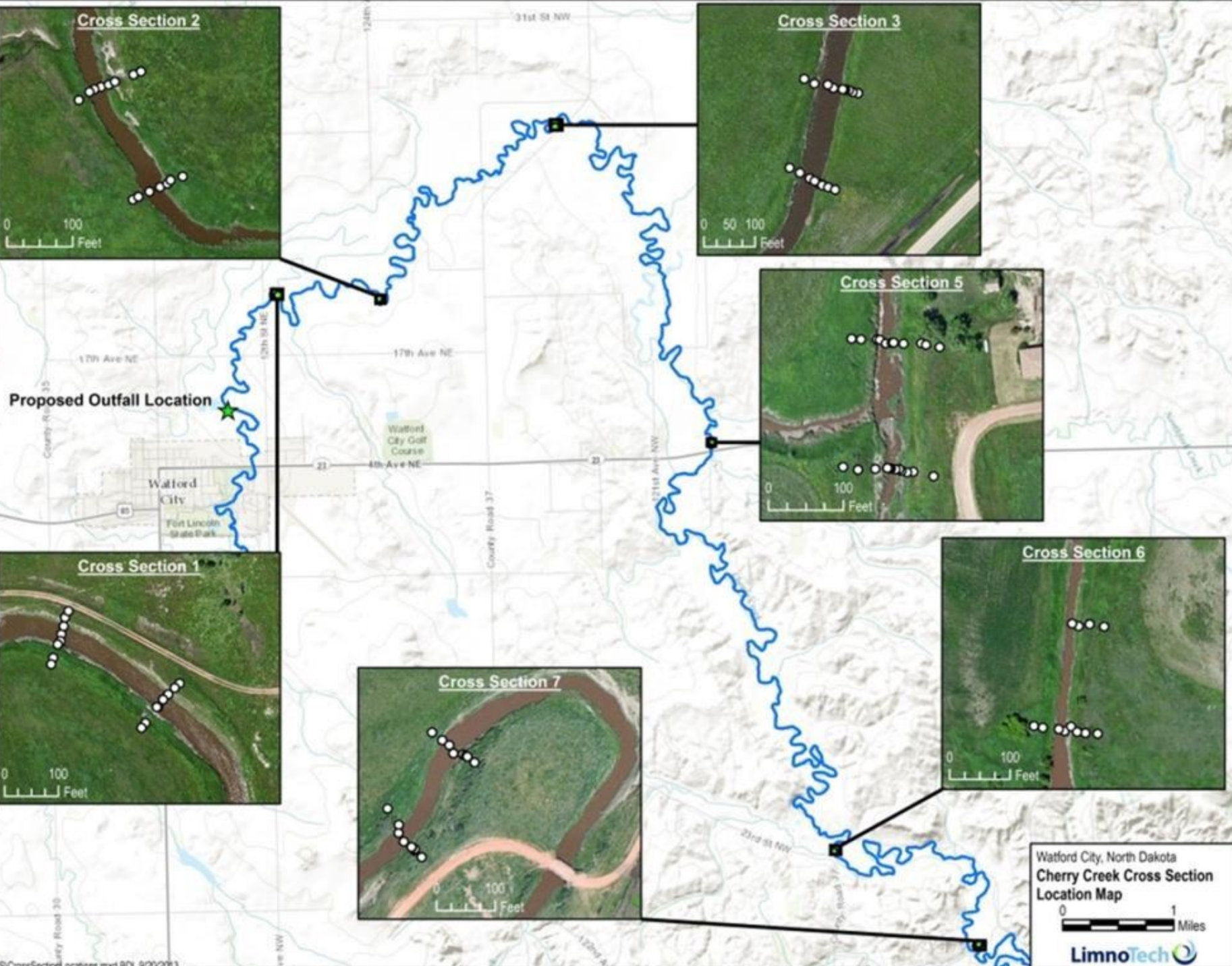
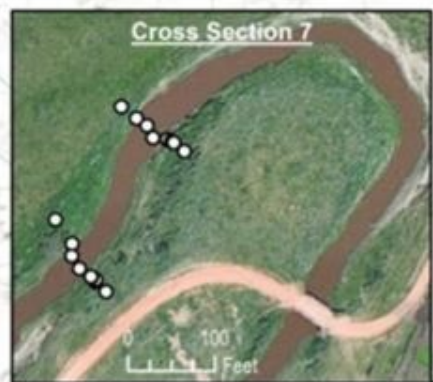


Dissolved Oxygen

Deoxygenation: K_d

COMPILE REQUIRED INFORMATION/DATA

- Critical stream low-flow and temperature
 - Intermittent stream, background low flow = 0
 - Plant discharge: 0.8 MGD, increasing to 1.6 MGD
- Hydraulics using Manning's Equation
 - Need cross-section, slope, and channel roughness
- K_d and $BOD_u : BOD_5$
 - Use literature rates appropriate for level of treatment
- K_a
 - Select appropriate reaeration formula for stream



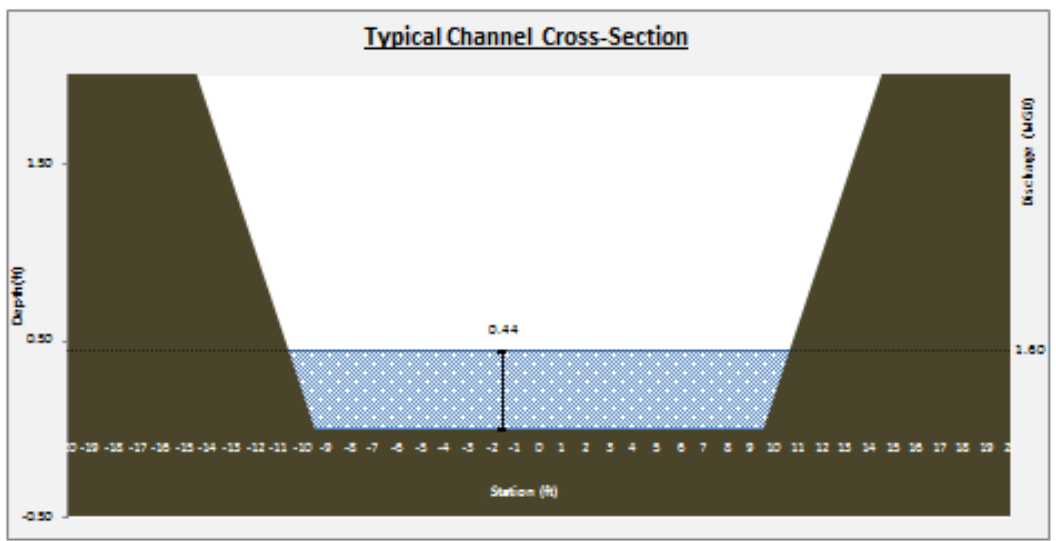
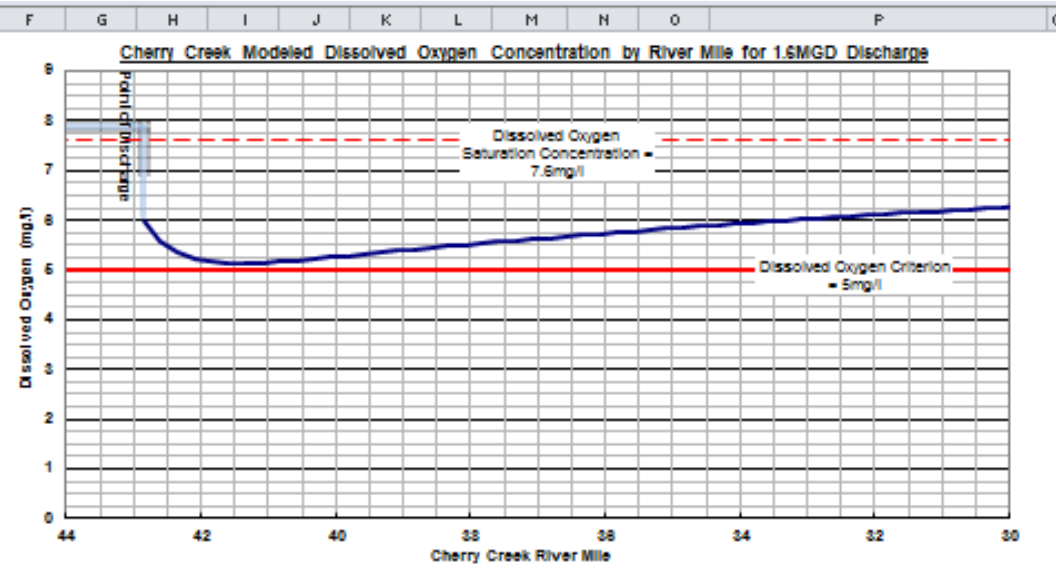
Watford City, North Dakota
Cherry Creek Cross Section Location Map

0 1 Miles



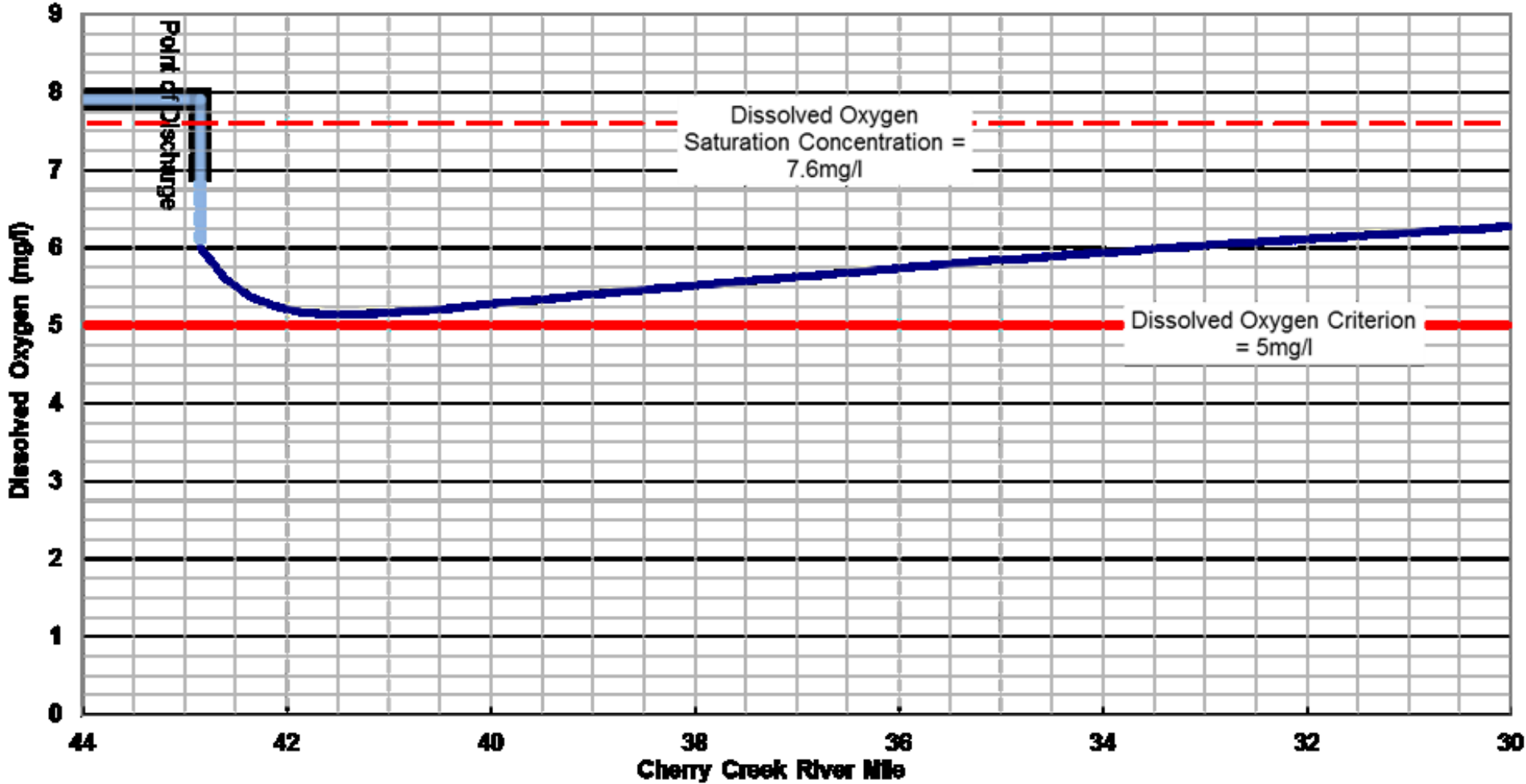
APPLY MODEL IN SPREADSHEET

INPUTS			
Preferred Discharge Characteristics			
Flow Rate (mgd)		1.600	
BOD5 (mg/l)		40	
D.O. (mg/l)		6	
Temp (Celsius)		25.6	
Receiving Water Characteristics			
Upstream Discharge (cfs)		0	
Elevation (ft NGVD)		2040	
Kinetic Rates			
BODult:BOD5		2.3	
Deoxygenation or BOD decay (day ⁻¹)		0.2	
Reaeration adjustment factor for ice cover		1	
Stream characteristics			
Slope (ft/ft)		1.48	
Width (ft)		19	
Manning Roughness		0.05	
OUTPUTS			
Stream characteristics			
AR ² /S		4.96	
Depth (ft)		0.44	
Velocity (ft/s)		0.28	
Cross-Sectional Area (ft ²)		8.91	
Streeter-Phelps Model			
Reaeration			
Reaeration Rate (Day ⁻¹)		7.90	
Predictive Equation		Nequlescu-Rajanrki & Krenkel-Orlab (average) (data class 1)	
Preferred Predictive Equations (Skalicky and Fircher 1985, by data class)			
	Applic. Slope	Applic. Flow (cfs)	Suggested Value
Nequlescu-Rajanrki & Krenkel-Orlab (average) (data class 1)	<3	-	7.90
Parkhurst-Pomeroy (data class 2)	3-10	0-30	48.39
Thackerton-Krenkel (data class 3)	3-10	>30	4.53
Trivaqlau-Neal (data class 4)	>10	-	0.74
Flow Rate (cfs)		2.48	
DO Saturation (mg/l)		7.6	
Initial DO Deficit (mg/L)		1.6	
Reaeration (day ⁻¹) (Nequlescu-Rajanrki & Krenkel-Orlab (average) (data class 1)) (Temp & Ice Adjusted)		9.02	
BOD Decay (day ⁻¹) (Temperature Adjusted)		0.26	
Initial BODult (mg/L)		92	
TRAVEL TIME TO CRITICAL DO CONC. (days)		0.31	
DISTANCE TO CRITICAL DO CONC. (miles)		1.39	
CRITICAL DO DEFICIT (mg/L)		2.4	
CRITICAL DO CONCENTRATION (mg/L)		5.1	



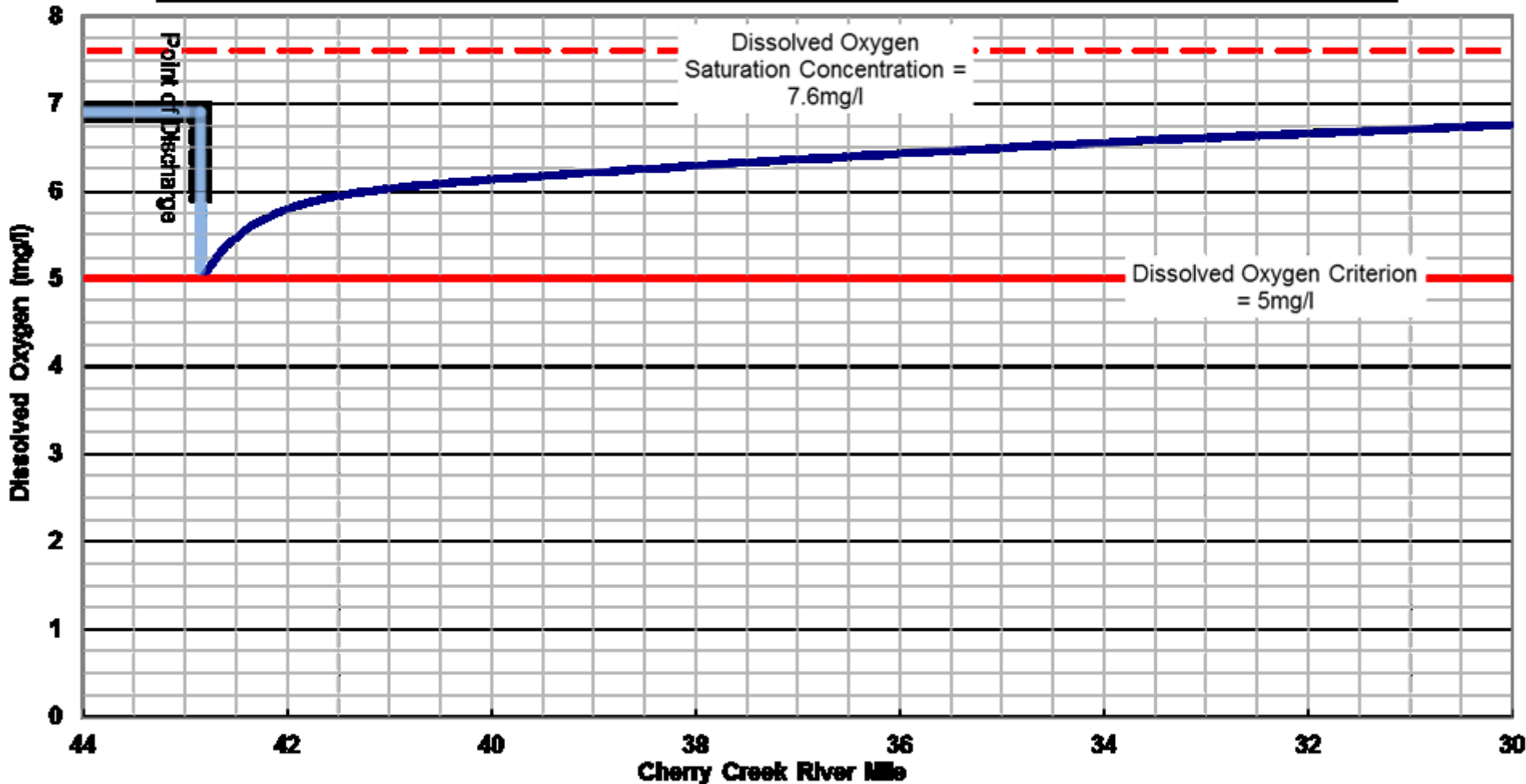
ESTABLISH WASTELOAD ALLOCATION

Cherry Creek Modeled Dissolved Oxygen Concentration by River Mile for 1.6MGD Discharge



ESTABLISH WASTELOAD ALLOCATION

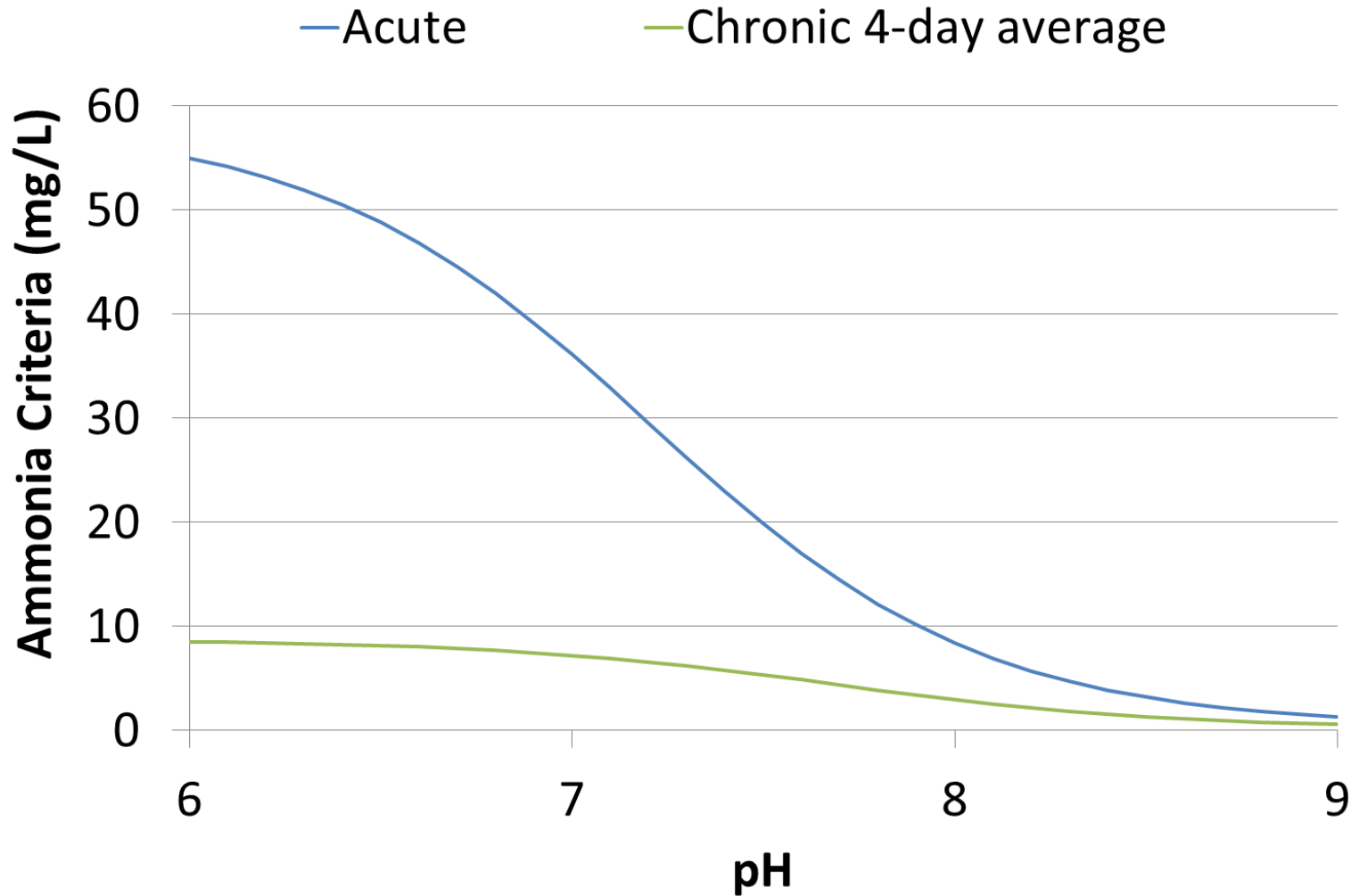
Cherry Creek Modeled Dissolved Oxygen Concentration by River Mile for 1.6MGD Discharge



EVALUATE MODEL UNCERTAINTY

- Conduct model sensitivity analyses
 - Adjust model inputs within reasonably expected range of uncertainty
 - Identify any concerns
- If concerns are identified, either:
 - Build in a margin-of-safety; or
 - Collect data to reduce uncertainty

ASSESS AMONIA TOXICITY



WATFORD CITY FACILITY PLAN ADDENDUM - SEPTEMBER 2013

- **Used Wasteload Allocation study results for unit processes**
 - **Continuous Discharge with estimated limits**
- **Evaluated phasing, costs, operations, and more**

WATFORD CITY FACILITY PLAN ADDENDUM - SEPTEMBER 2013

Evaluation determined mechanical facility with continuous discharge had the lowest life-cycle cost and the most “bang for your buck” of all alternatives.



WATFORD CITY FACILITY PLAN ADDENDUM - SEPTEMBER 2013

- **Water Resource Recovery Facility**
 - **Mechanical Treatment**
 - **Continuous Discharge to Cherry Creek**
 - **No additional storage requirements**
 - **No additional land requirements**
 - **Reuse portions of existing facility**



NDDH NDPDES PERMIT

- **General Permit Limits (Current)**

- **BOD = 25 mg/L, TSS = 30 mg/L, pH = 6 – 9**

- **Individual Permit Limits**

- **Will be based on receiving water**

- **Will include limits on Ammonia, Dissolved Oxygen, and E Coli**

- **Possible Phosphorus limits in the future**

- **Potential limits for continuous discharge**

- **BOD = 25 mg/L, TSS = 30 mg/L, pH = 6 – 9, NH₃-N = 4.4 mg/L (Summer); 8.8 mg/L (winter), e. coli = 126 org/100 ml, DO = 5.0 mg/L**

PROPOSED MECHANICAL FACILITY



60% SUBMITTAL
 WATER RESOURCE RECOVERY FACILITY
 WATERFORD CITY
 WATERFORD CITY, NORTH DAKOTA
 ENLARGED GRADING PLAN

DRAWING TITLE	PRELIMINARY
PREPARED BY	---
CHECKED / APPROVED	---
DATE	---
PROJECT NUMBER	PO3578-2013-29
SHEET	1 of 1
FACILITY	SW
DRAWING	C2

A group of people, mostly in light blue shirts, are holding up white rectangular signs with large, bold black question marks. The signs are held in front of their faces, partially obscuring them. The background is a bright, slightly blurred indoor setting.

**Thank You,
QUESTIONS?**