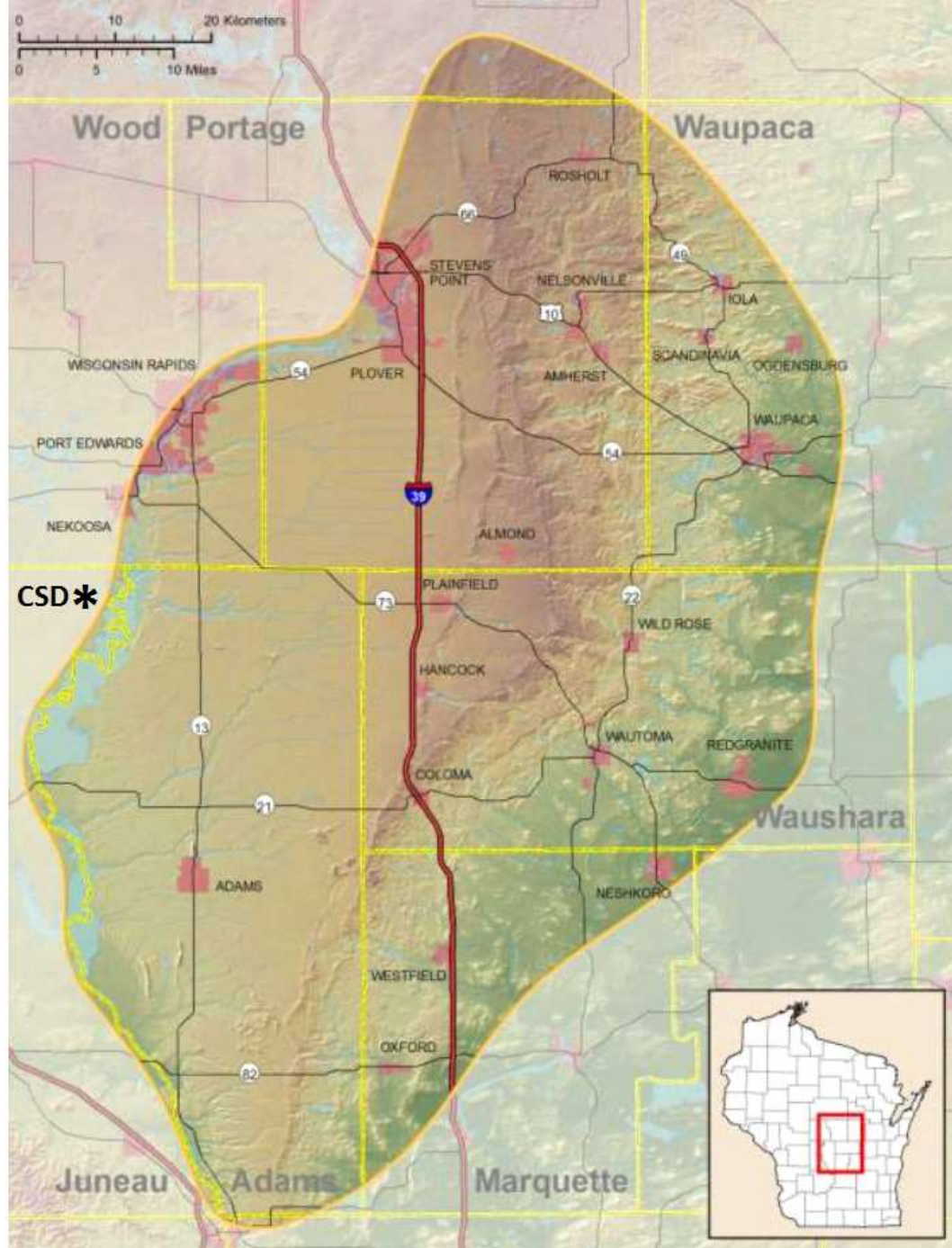


Groundwater Impacts Associated with Pine Forest Conversion to Irrigated Agriculture and Dairy Manure Waste Application in the Central Sands of Wisconsin

Kenneth Wade, Kenneth Wade
Consulting LLC



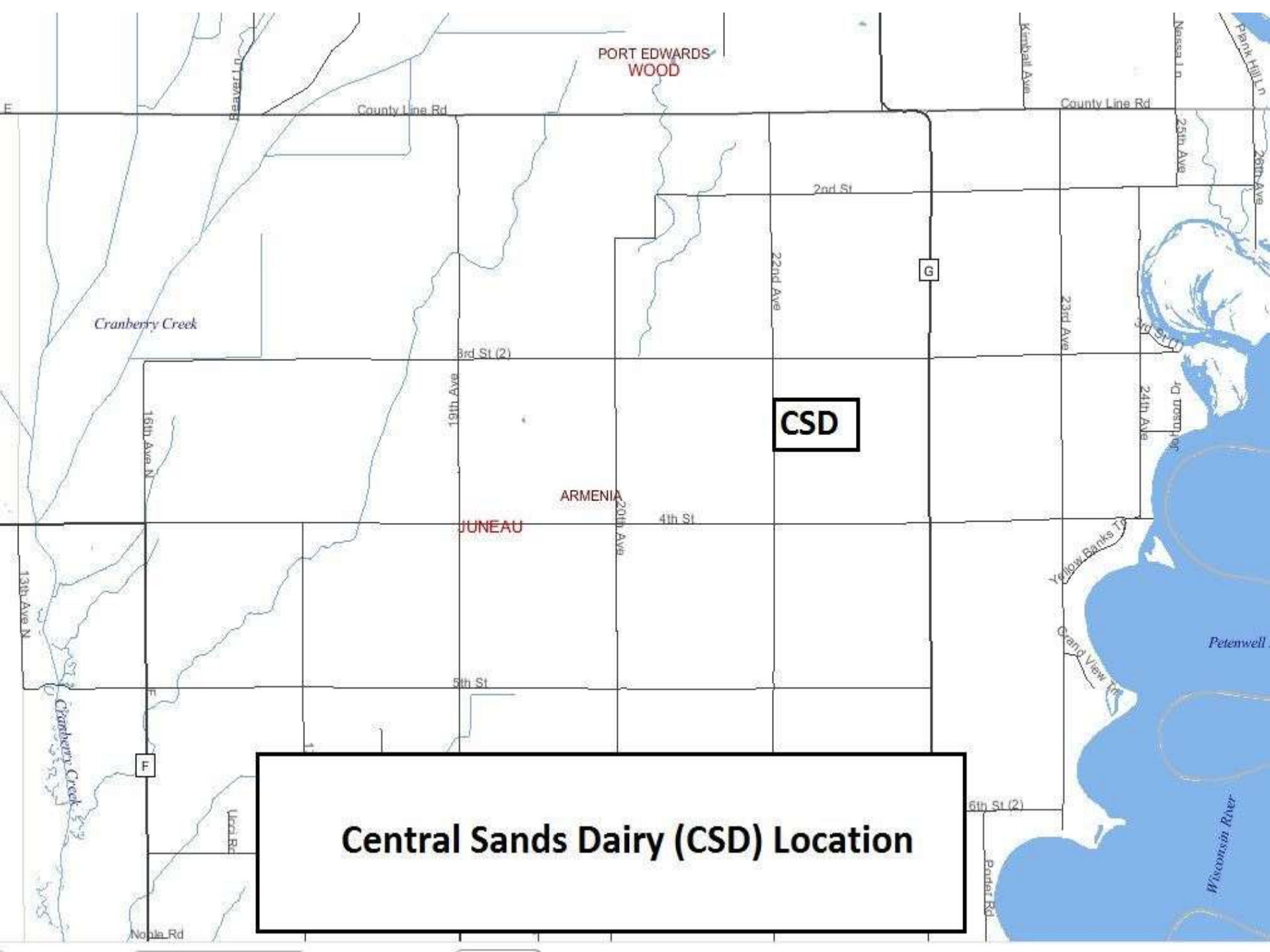
The Central Sands Dairy Site Location within The Central Sands Region of Wisconsin

* = Central Sands Dairy Site (CSD)

Fig. Modified from Kraft, 2010

Central Sands Dairy

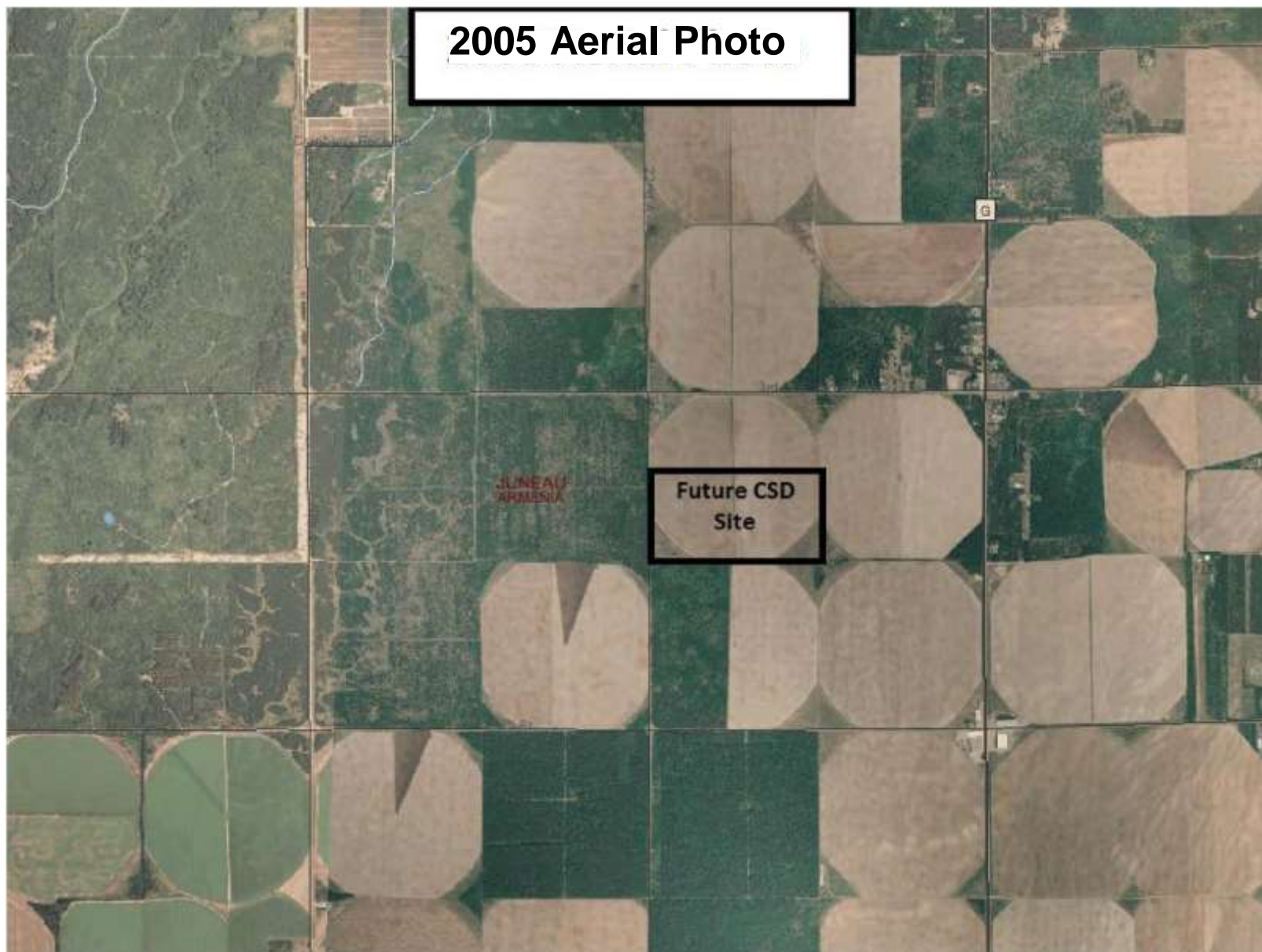
- **CAFO – Concentrated Animal Feeding Operation**
- **Permitted by WDNR**
 - **WPDES Requires Compliance with NR 140, Wis. Adm. Code & Groundwater Stds.**
 - **Nutrient Management Plan (NMP) with BMPs**
- **Town of Armenia Required Groundwater Monitoring**
- **Dairy Operation Started 2007**
- **Waste Manure Landspreading Started 2008**



CSD

Central Sands Dairy (CSD) Location

2005 Aerial Photo

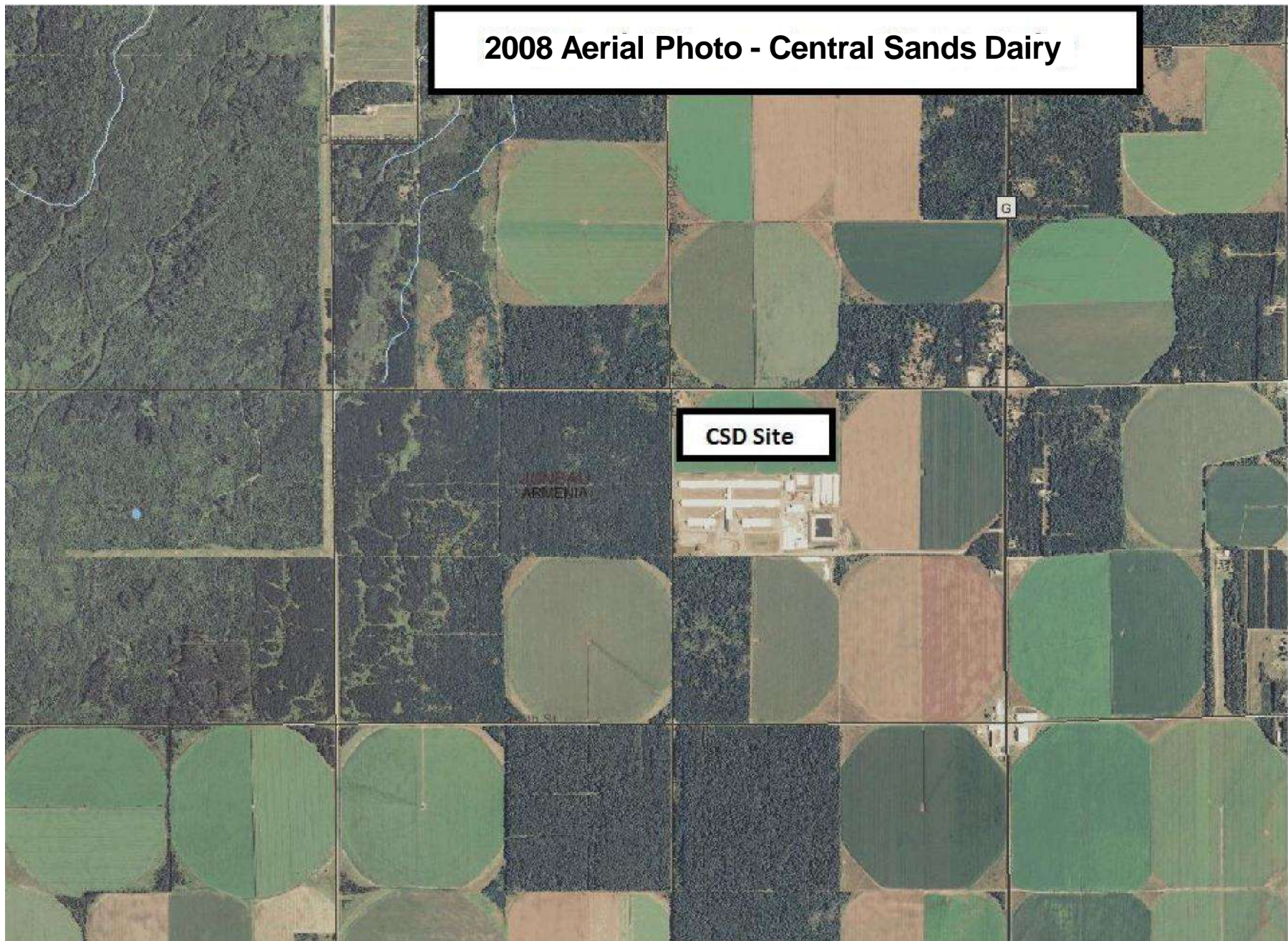


2008 Aerial Photo - Central Sands Dairy

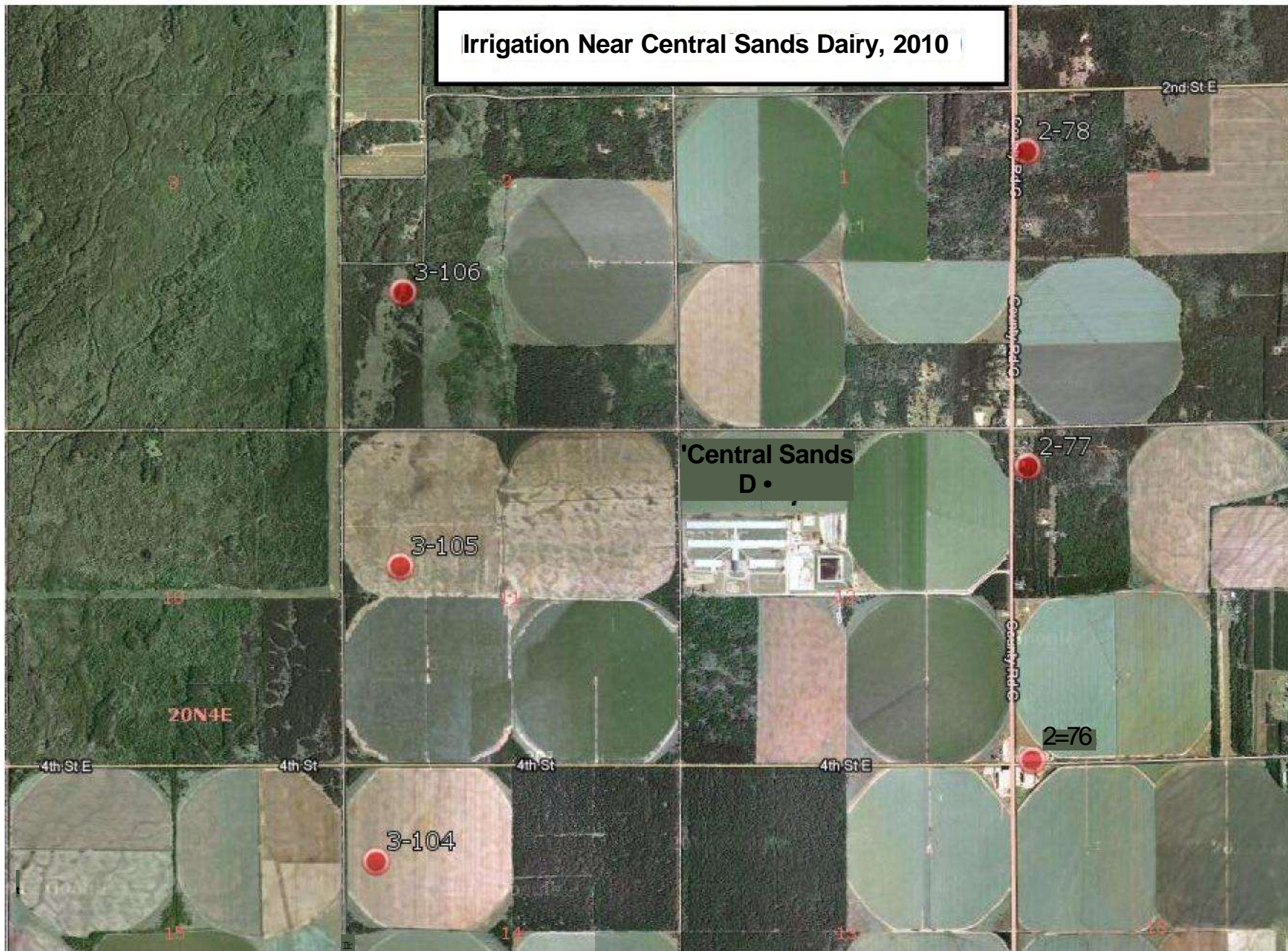
CSD Site

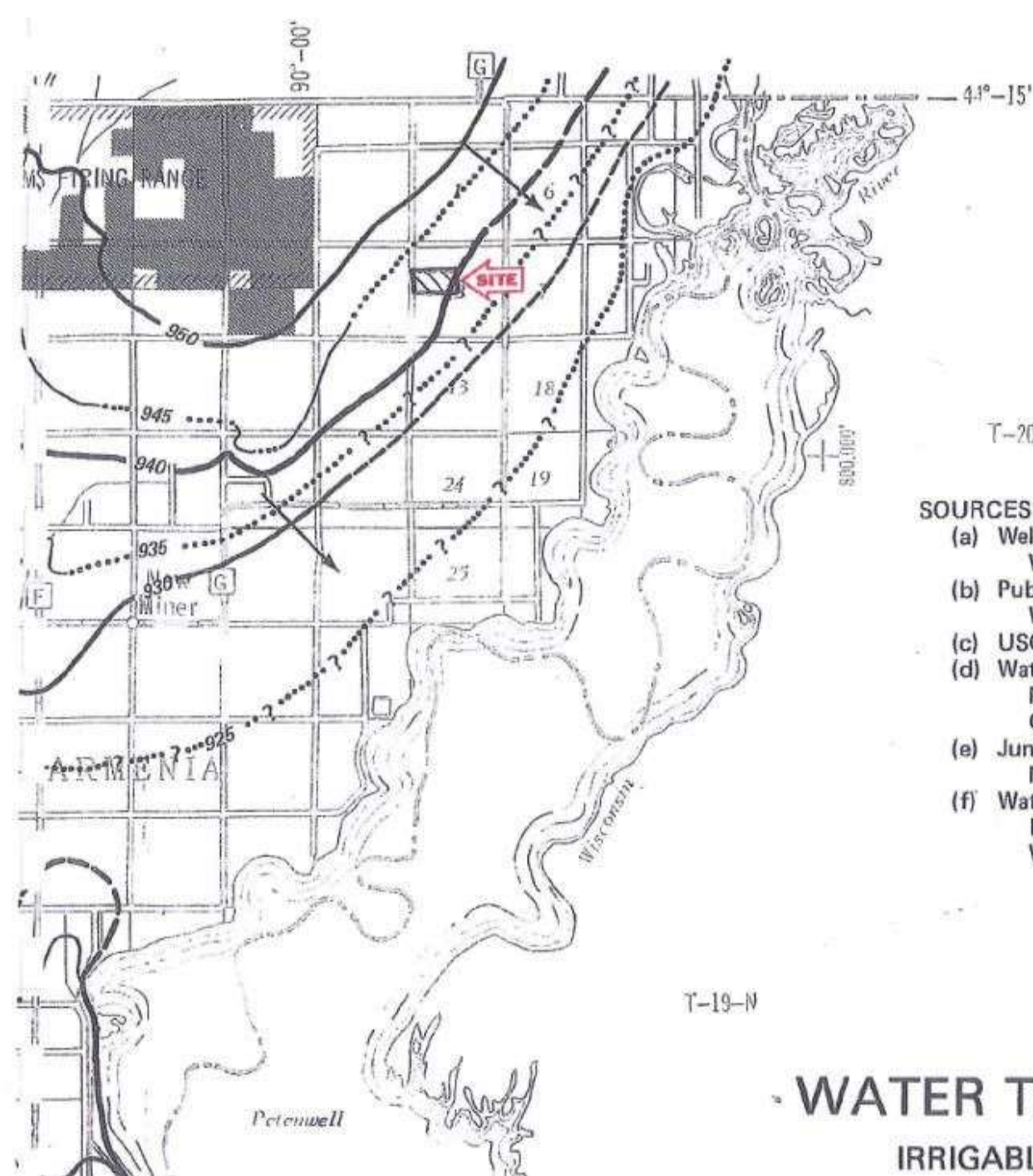
JOURNAL
ARMENIA

6



Irrigation Near Central Sands Dairy, 2010





ADAMS CO.

T-20-N

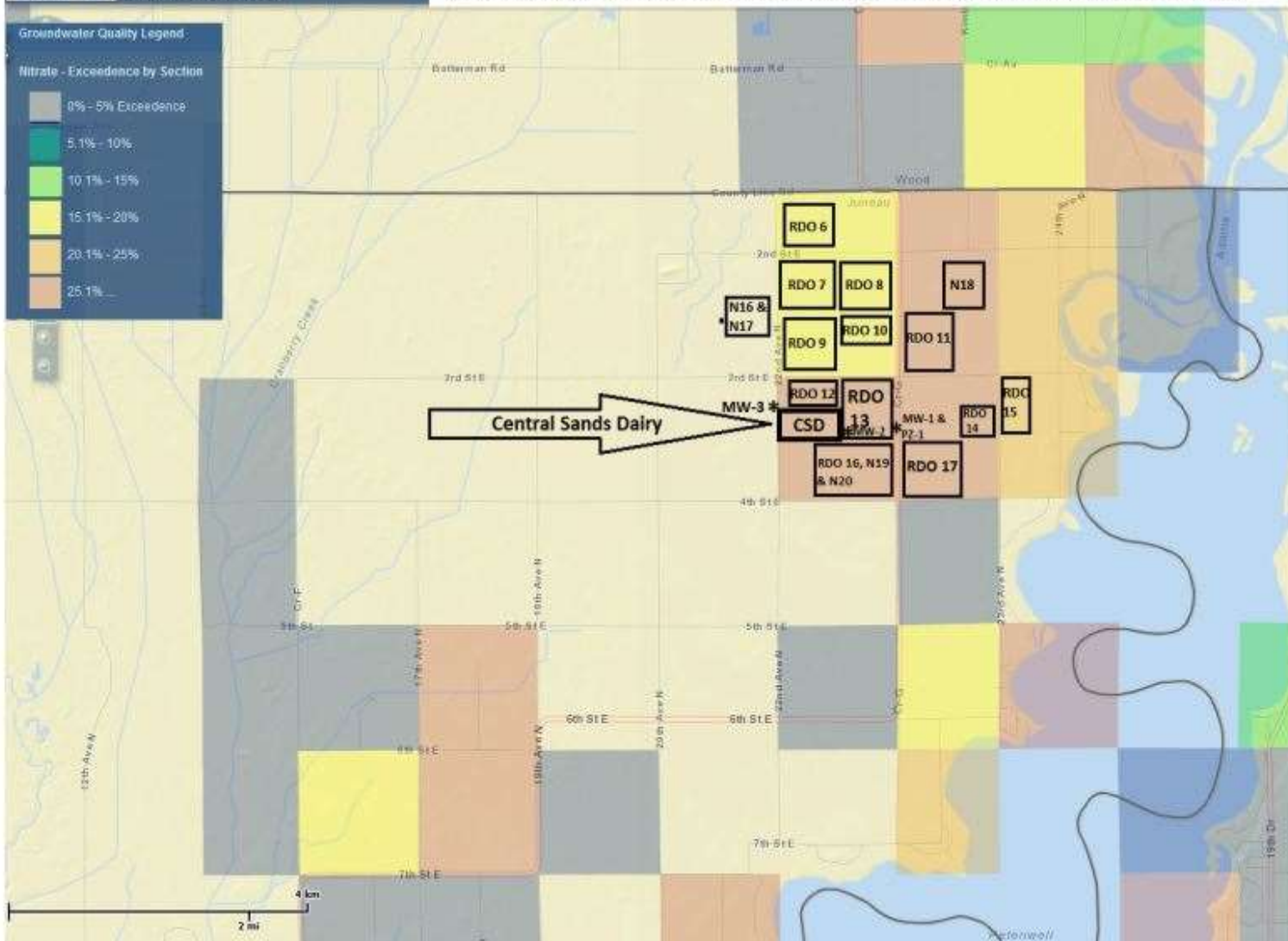
SOURCES:

- (a) Well Constructor's Reports (1936-1979) –
Wisconsin Department of Natural Resources
- (b) Published and unpublished Geologic Logs (1896-pres
Wisconsin Geological & Natural History Survey
- (c) USGS Topographic Maps
- (d) Water-level observation wells from the Ground-Water
Monitoring Network operated and maintained by
Geological and Natural History Survey and USGS.
- (e) Juneau County Land Atlas and Plat Book, 1980, Roc
Map Publishers, Inc.
- (f) Water Table Survey Notes (1935-1938) –
Emergency Conservation Work (ECW) –
Wisconsin Conservation Department

T-19-N

WATER TABLE ELEVATION

IRRIGABLE LANDS INVENTORY

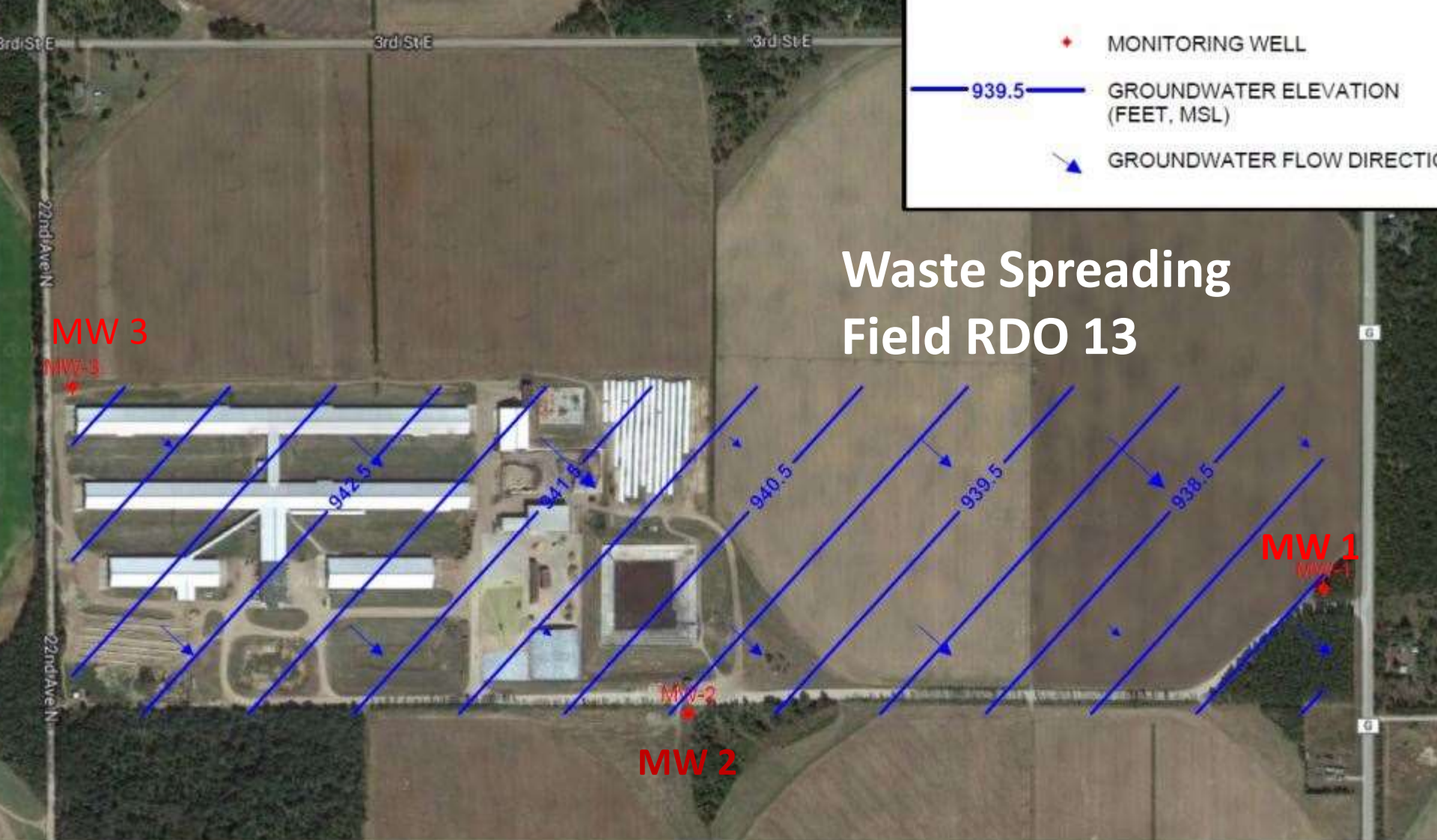


Legend

RDO 13

Central Sands Dairy - Manure Spreading Field Location

* MW-1
Central Sands Dairy Monitoring Well



January 2008 Water Table Map

SCALE IN FEET
300 600



RIN Environmental Services, LLC

Surface Water Studies
Groundwater Studies
Site Investigations

CENTRAL SANDS DAIRY
TOWN OF ARMENIA, WISCONSIN
WATER TABLE MAP 01/11/08

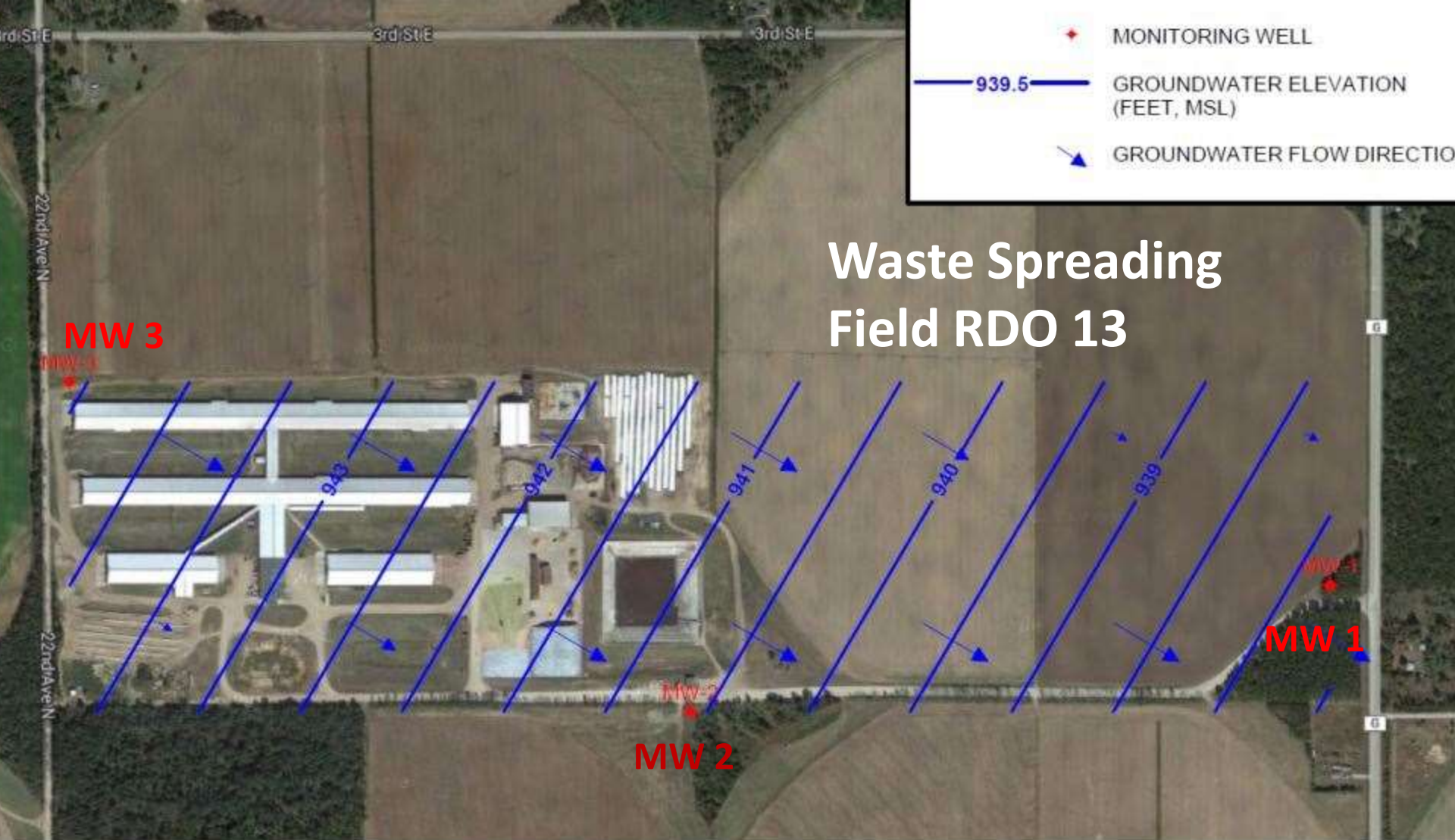
DRAWN BY

PROJ. No.

DATE

FIGURE
2

FILE



January 2009 Water Table Map

SCALE IN FEET
300 600



RIN Environmental Services, LLC

Surface Water Studies
Groundwater Studies
Site Investigations

CENTRAL SANDS DAIRY
TOWN OF ARMENIA, WISCONSIN
WATER TABLE MAP 01/30/09

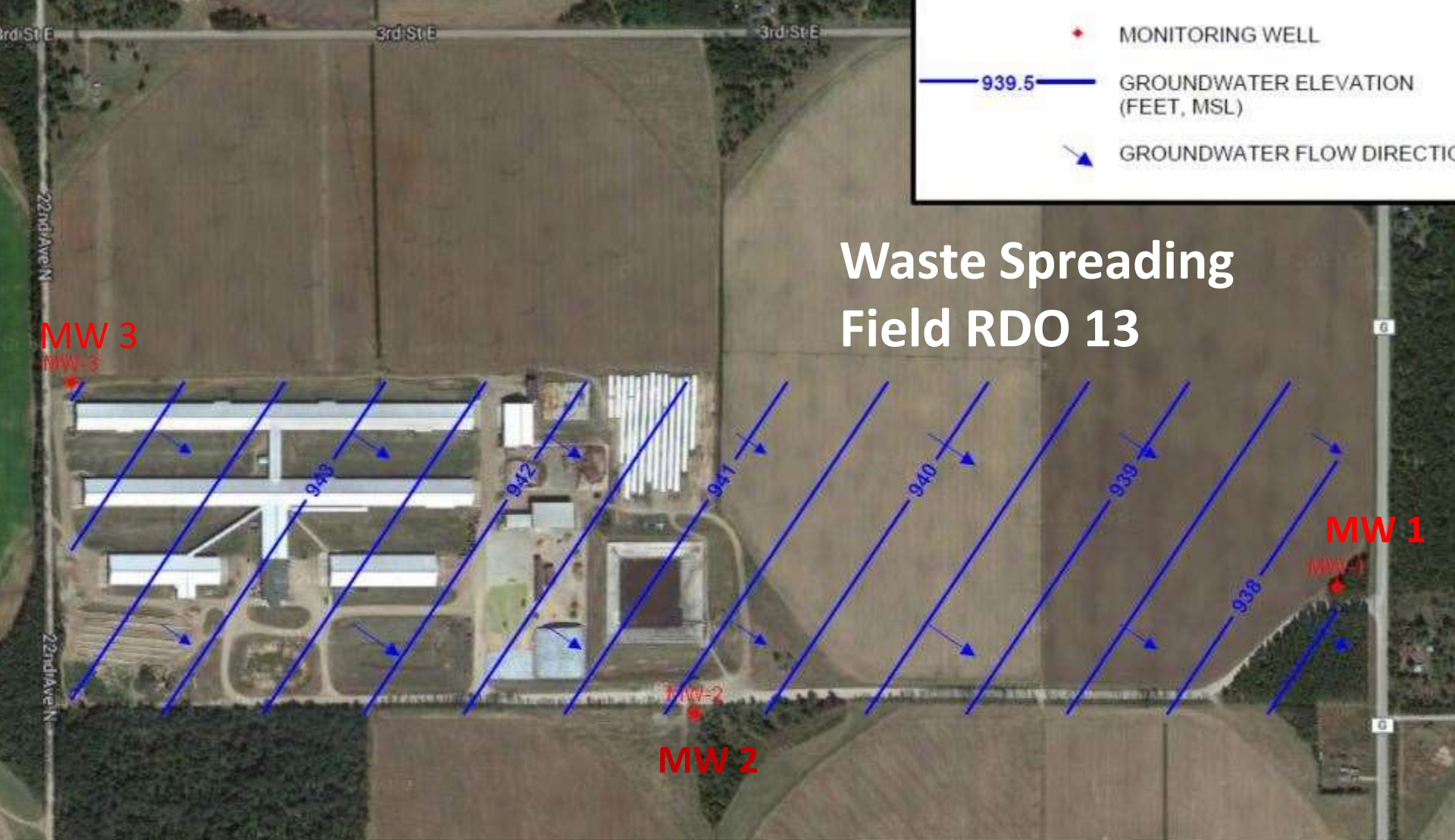
FIGURE
3

DRAWN BY

PROJ. No.

DATE

FILE



February 2010 Water Table Map

SCALE IN FEET
300 600



RJN Environmental Services, LLC

Surface Water Studies
Groundwater Studies
Site Investigations

CENTRAL SANDS DAIRY
TOWN OF ARMENIA, WISCONSIN
WATER TABLE MAP 02/17/10

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PROJ. No.

DATE

FIGURE
4

FILE



January 2012 Water Table Map

SCALE IN FEET
0 300 600



RIN Environmental Services, LLC

Surface Water Studies
Groundwater Studies
Site Investigations

CENTRAL SANDS DAIRY
TOWN OF ARMENIA, WISCONSIN
WATER TABLE MAP 01/10/12

DRAWN BY

PROJ. No.

DATE

FIGURE

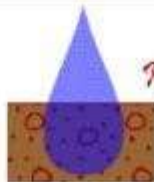
5

FILE



May 2014 Water Table Map

SCALE IN FEET
300 600



RJN Environmental Services, LLC
Surface Water Studies
Groundwater Studies
Site Investigations

CENTRAL SANDS DAIRY
TOWN OF ARMENIA, WISCONSIN
WATER TABLE MAP 05/14/14

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DATE

FILE

FIGURE
6

CSD Site Hydrogeology

- Over 150 ft of sand & gravel aquifer
- Extremely high infiltration
- Consistent East-Southeast Hydraulic Gradient (0.0015 ft/ft)
- Conductivity = 150 ft/d (Kraft & Mechenic, 1997)
- Porosity = 0.25 (Freeze & Cherry, 1979)
- Ave. Linear Velocity = 0.9 ft/day

MW 3 Sampling Results

Sample ID	Date	Nitrogen (mg/l)	
		Nitrate/Nitrite Nitrogen (mg/l)	Ammonia/Ammonium Nitrogen
MW-3	1/10/2008	1.8	-
	1/30/2009	1.3	-
	2/17/2010	16.2	-
	1/18/2011	17.8	-
	1/10/2002	28.4	-
	1/9/2013	39	0.01

MW 3 Sampling Results

- **Increase in NO₃ from 1.8 to 39 mg/l due to pine forest conversion to irrigated agriculture in 2009**
- **Timing of arrival of NO₃ to well is consistent with a travel distance of 200 feet and the site groundwater average linear velocity of 0.9 ft/day**

MW 1 & PZ 1 Sampling Results

Sample ID	Date	Nitrogen (mg/l)	
		Nitrate/Nitrite Nitrogen (mg/l)	Ammonia/Ammonium Nitrogen
MW-1	1/11/2008	31	2
	1/30/2009	16.3	-
	2/17/2010	26.8	-
	1/18/2011	24.1	0.04
	1/10/2012	40.8	-
	1/9/2013	29.8	0.03
PZ-1	1/11/2008	31	1.5
	1/30/2009	32.3	-
	2/17/2010	34.1	-
	1/18/2011	28.9	0.02
	1/10/2012	32.2	-
	1/9/2013	34.6	-

MW1 and PZ1 Sampling Results

- **Wells are down-gradient of manure waste spreading field RDO 13**
- **RDO 13 was former irrigated crop field converted to manure disposal in 2008**
- **The Jan. 2008 NO₃ values of 31 mg/l found in both MW1 and PZ1 reflect the irrigated cropping practices preceding that time**

MW1 and PZ1 Sampling Results, Cont.

- Sample years 2009 – 2013 reflect the impacts of waste manure application.**
- Five years (1825 days) allows for 1640 feet of groundwater travel at velocity of 0.9 ft/day**
- Since the up-gradient corner of Field RDO 13 is 2850 feet from MW1/PZ1 all NO₃ measured in the wells must originate from within spreading field RDO 13.**

MW1 and PZ1 Sampling Results, Cont.

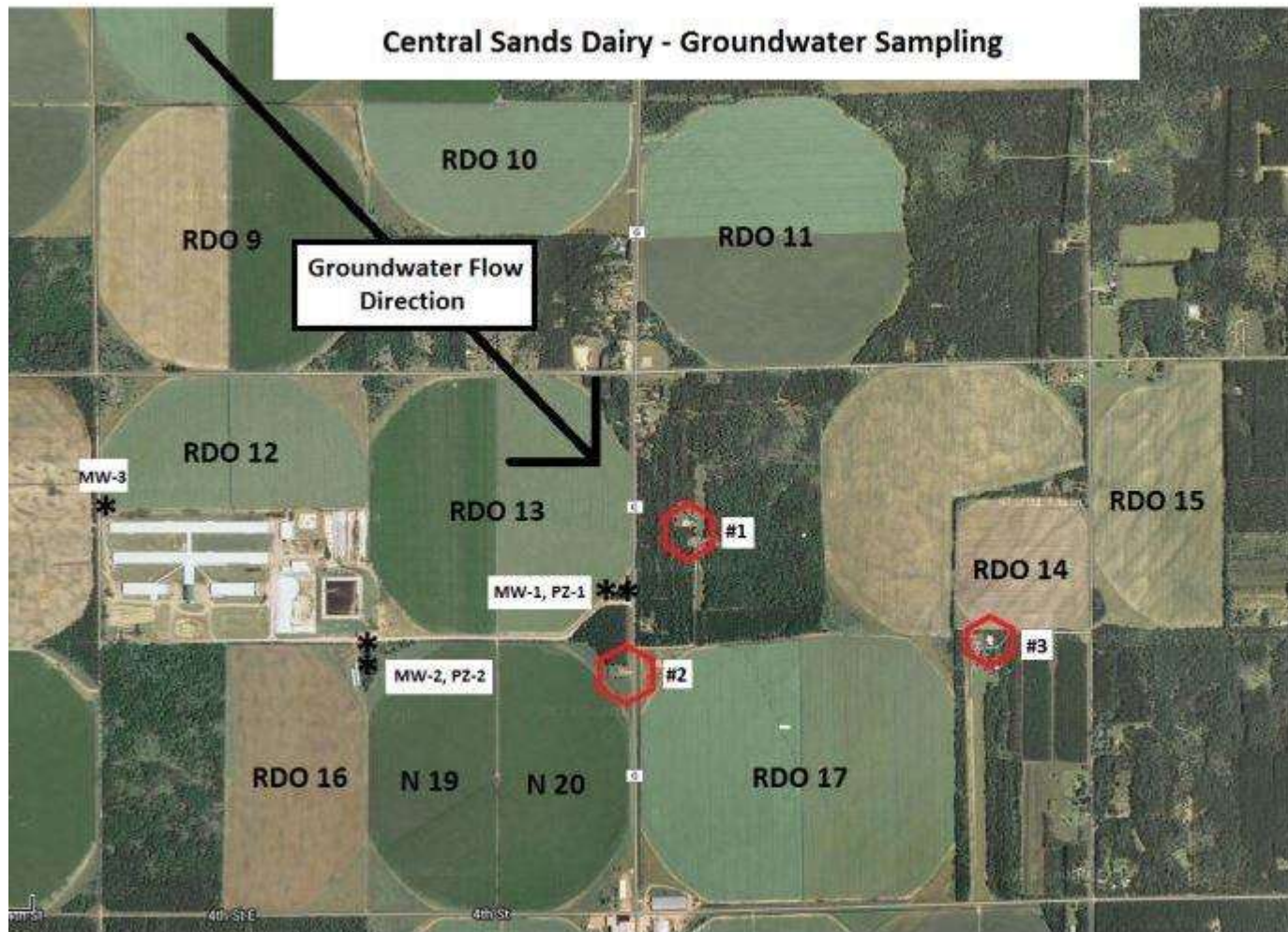
- **Depth of NO₃ penetration in aquifer**
 - **Natural recharge = 0.75 feet/yr.**
 - **Irrigated recharge up to 1.5 ft/yr.**
 - **Using estimated recharge of 1.0 foot/year and a porosity of 0.25 the annual recharge penetrated 4.0 ft/year.**
 - **5 years of waste spreading allows 20 feet of NO₃ penetration at MW1 & PZ1**
 - **PZ1 well screen located 20 to 25 ft below water table**

Depth of NO₃ penetration in aquifer, cont.

- **8.7 years required for groundwater to flow from NW to SW corner of field RDO 13**
- **Depth of aquifer penetration would be $8.7 \times 4 \text{ ft/year} = 34.8 \text{ feet}$**
- **This indicates contaminated water recharging at the NW corner of RDO13 is likely to pass well below the screen of PZ1**

Private Water Well Impacts from Manure Spreading

Central Sands Dairy - Groundwater Sampling



Legend



#1

Private Well Sample

- #1 - Owens, N15902 Co. Rd. G
Nitrate = 23.9 mg/l, 8/26/12
- #2 - Hoffman, N15883, Co. Rd. G
Nitrate = 35.9, 2012
- #3 - N15761 23rd Ave.
Nitrate = 30.7 mg/l, 2012

* = Central Sands Dairy Monitoring Well

- MW-1, Nitrate 40.8 (Jan. 2012)
29.8 (Jan. 2013)
- PZ-1, Nitrate 32.2 (Jan. 2012)
34.6 (Jan. 2013)
- MW-2, Nitrate 2.2 (Jan. 2012)
0.3 (Jan. 2013)
- PZ-2, Nitrate Not Detected (Jan 2012)
0.2 (Jan. 2013)
- MW-3, Nitrate 28.4 (Jan. 2012)
39 (Jan. 2013)

RDO 13 = Central Sands
Dairy Manure
Spreading Field

Private Well Impacts from RDO 13 Waste Spreading

- **“Hoffman” water supply well**
- **700 feet south of MW1/PZ1**
- **600 feet down-gradient of RDO 13**
- **Likely to be shallow driven well point**
- **35.9 mg/l NO₃ measured in 2012**
- **Using 0.9 ft/d velocity the water from RDO 13 would have left RDO 13 in 2010**
- **Conclusion: The NO₃ at the private well was a result of waste manure spreading.**

NO₃ Leaching from Manure Applications

- **Groundwater concentrations of NO₃ exceed 30 mg/l at the spreading field site**
- **One foot/yr. recharge of 30 mg/l NO₃-N water over one acre = 85 lb. NO₃-N/Acre/year**
- **Conclusion: Significant leaching of NO₃ is occurring in the waste application fields.**

Facility Compliance with NR140 Groundwater Stds.

- **NR 140 compliance boundary for waste application:**
 - 200 feet from point of waste application;
 - Property boundary or
 - Point of groundwater use
- **MW1 & PZ 1 are adjacent the property boundary at CTH “G”**
- **The Hoffman water supply well is a point of water use and is greater than 200 feet from a point of waste application**
- **Conclusion: Facility has resulted in exceedance of the Enforcement Std. of 10 mg/l – NO₃**

Use of Alternate Concentration Limits for NR 140 stds.

- **Alternate Concentration Limits (ACLs) allowed per NR 140.28(4)(a)**
- **Allows for calculation of higher enforcement limits for contaminants in recognition of elevated up-gradient or “background” groundwater concentrations when setting down-gradient facility compliance standards**
- **Is not appropriate for large waste application sites such as Central Sands Dairy where aquifer penetration of recharging contaminants over large field flow distances uncouples the up- and down-gradient well relationships**

Conclusions

- **Nutrient Management Plans and BMPs do not insure CAFO waste spreading compliance with NR 140 groundwater standards. The WPDES 590 standard specifically state that they are agronomic guides - not environmental standards.**
- **Groundwater monitoring is required to insure compliance.**
- **Current CAFO waste spreading rates need to be reduced drastically to insure NR 140 compliance**

Questions?