Measure Alkalinity for Better Process Control of Wastewater Treatment Plants

Cheap, Easy, and Effective Methods for Attaining Ammonia Compliance

March 23, 2022

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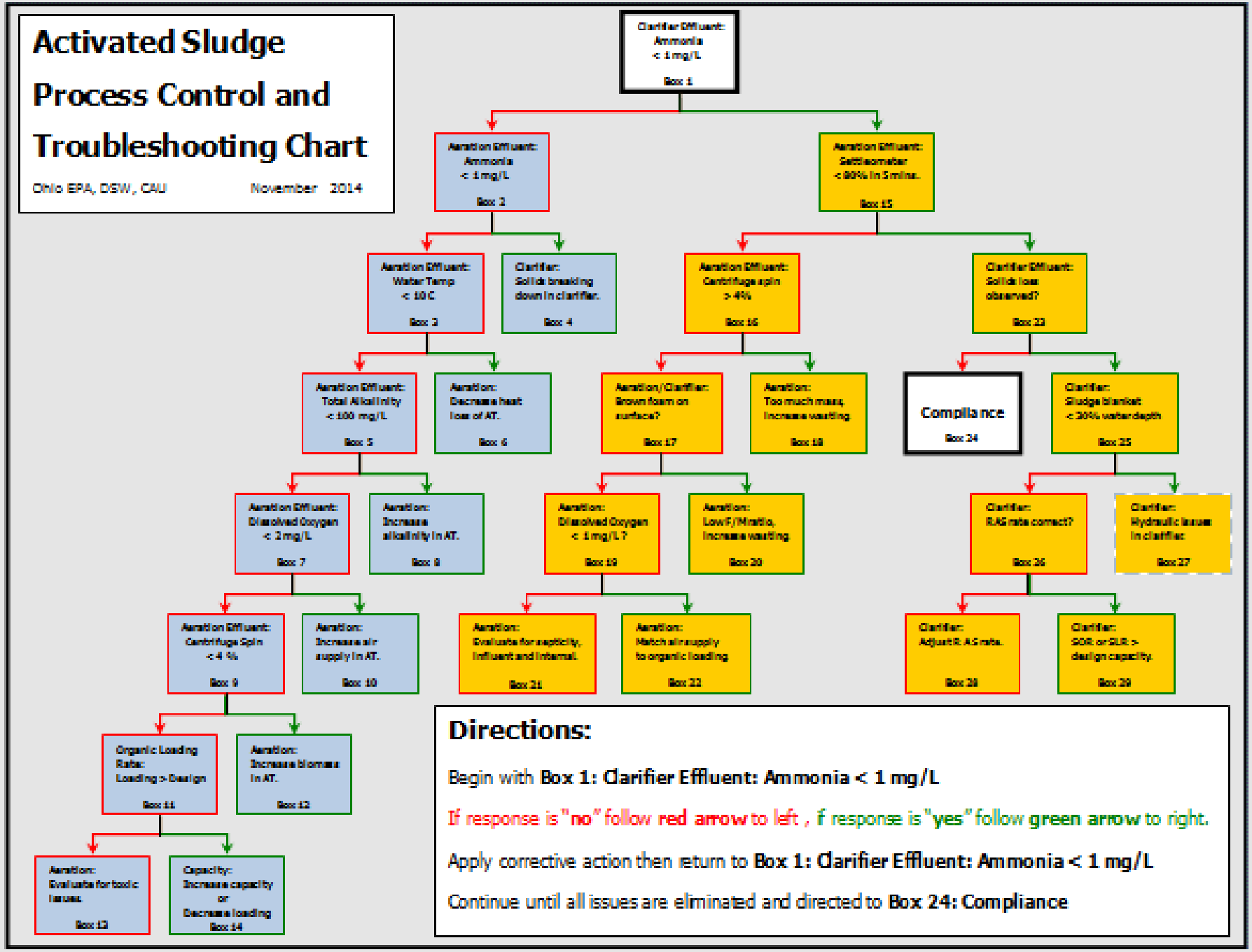
Ohio EPA – Compliance Assistance Unit

Activated Sludge Process Control and Troubleshooting Chart

Ohio EPA, DSW, CAU November 2014



Directions:

Begin with **Box 1: Clarifier Effluent: Ammonia < 1 mg/L**

If response is "**no**" follow **red arrow** to left , if response is "**yes**" follow **green arrow** to right.

Apply corrective action then return to **Box 1: Clarifier Effluent: Ammonia < 1 mg/L**

Continue until all issues are eliminated and directed to **Box 24: Compliance**

Activated Sludge Process Control and Troubleshooting Chart

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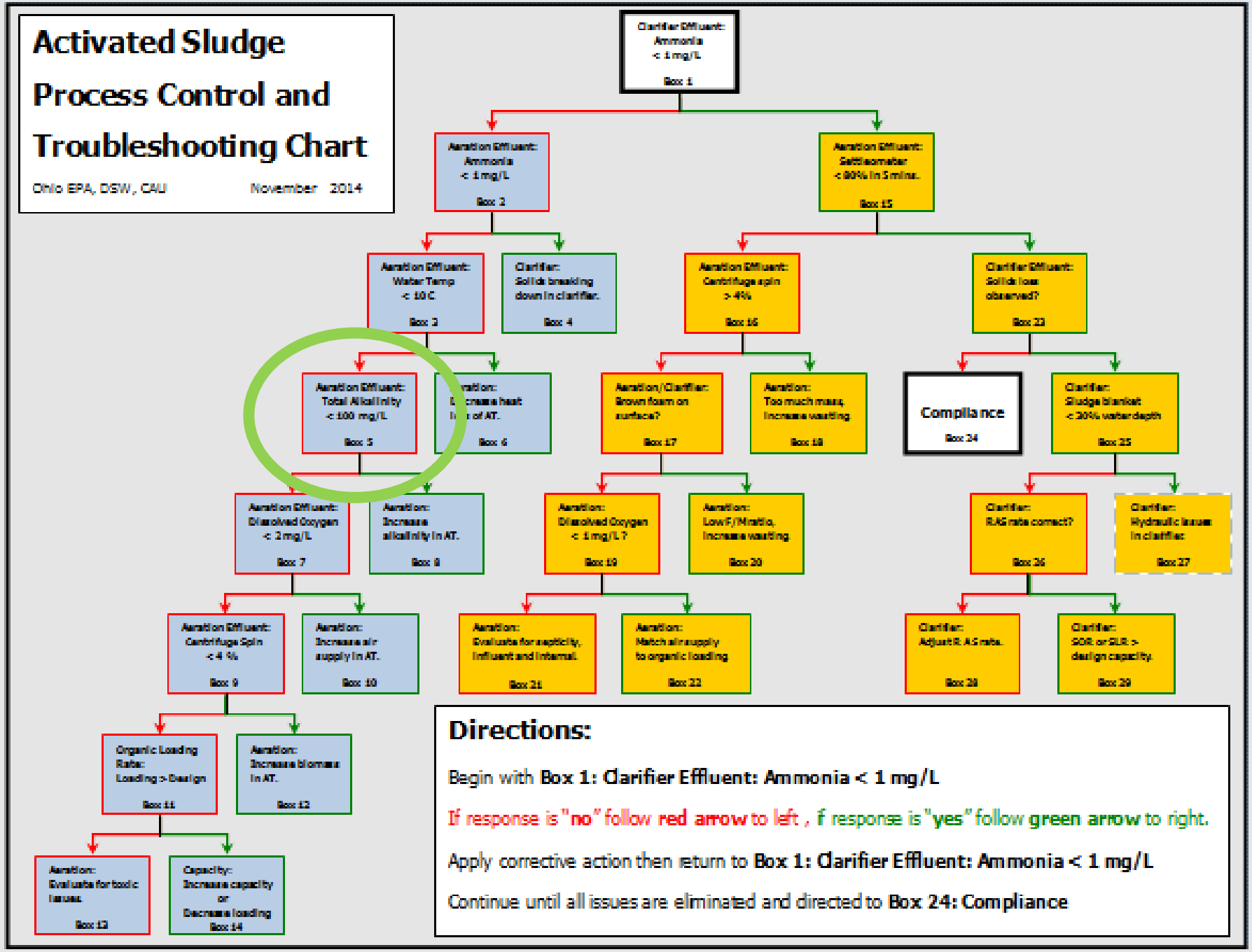

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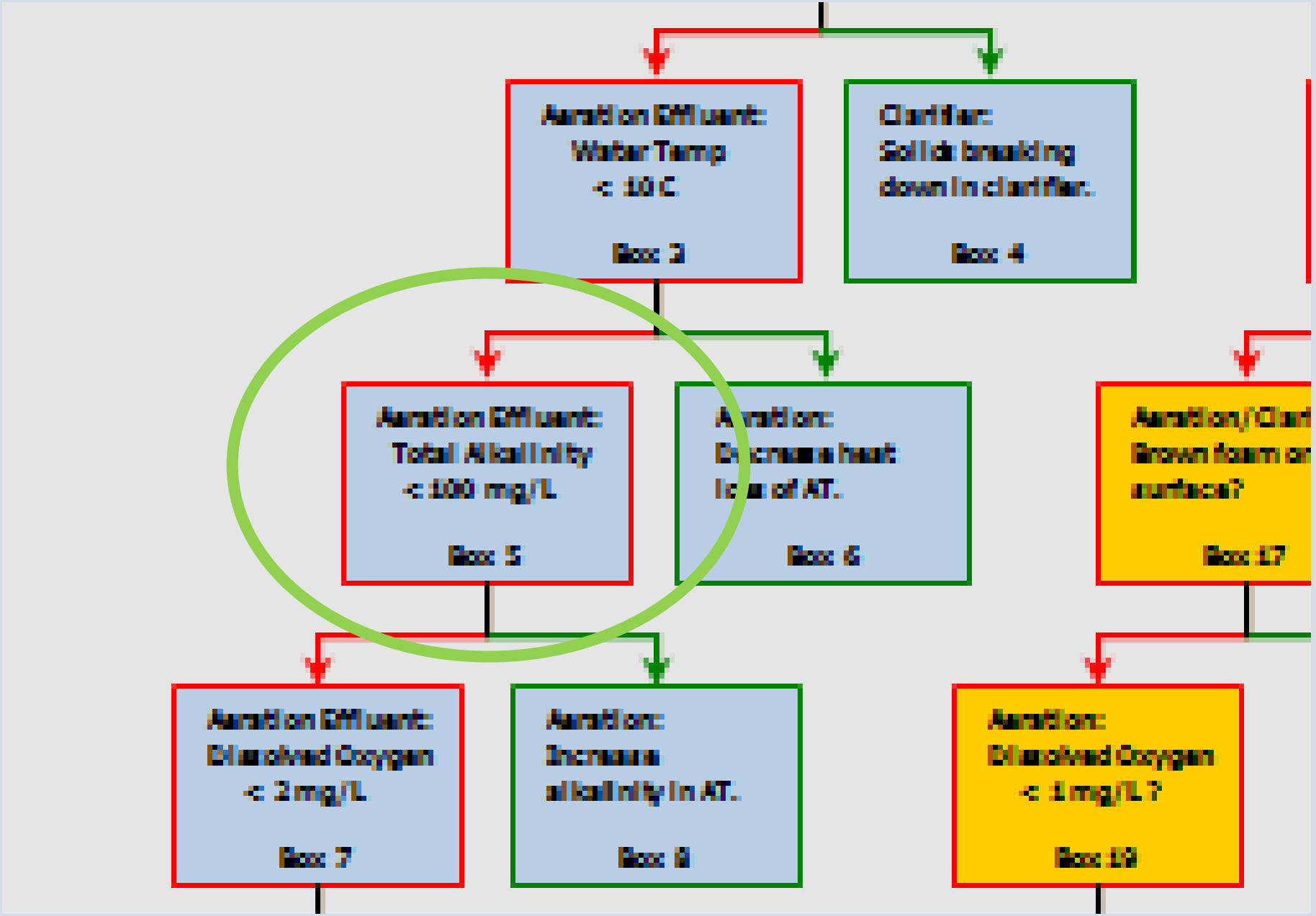

Box 3
Box 4
Box 5
Box 6
Box 7
Box 8
Box 9

Nitrification

Why Nitrify?

Free Ammonia (un-ionized Ammonia) is toxic to aquatic organisms

Ionized Ammonia (ammonium) is an oxygen demanding substance

Nitrogen in any form is a nutrient (fertilizer)…

…and algae is a plant

Nitrification

Inhibitions to Nitrification in WWTPs:

- Not enough dissolved oxygen (inefficient blowers; clogged diffusers)
- Not enough temperature (winter)
- Not enough biomass (nitrifiers)
- Not enough time (capacity; high flows)
- Not enough **alkalinity**

Nitrification

Nitrifying bacteria are:

Chemo-litho-auto-trophs

Energy Source:
Chemo : Chemical Reaction
Photo : Photon Reaction

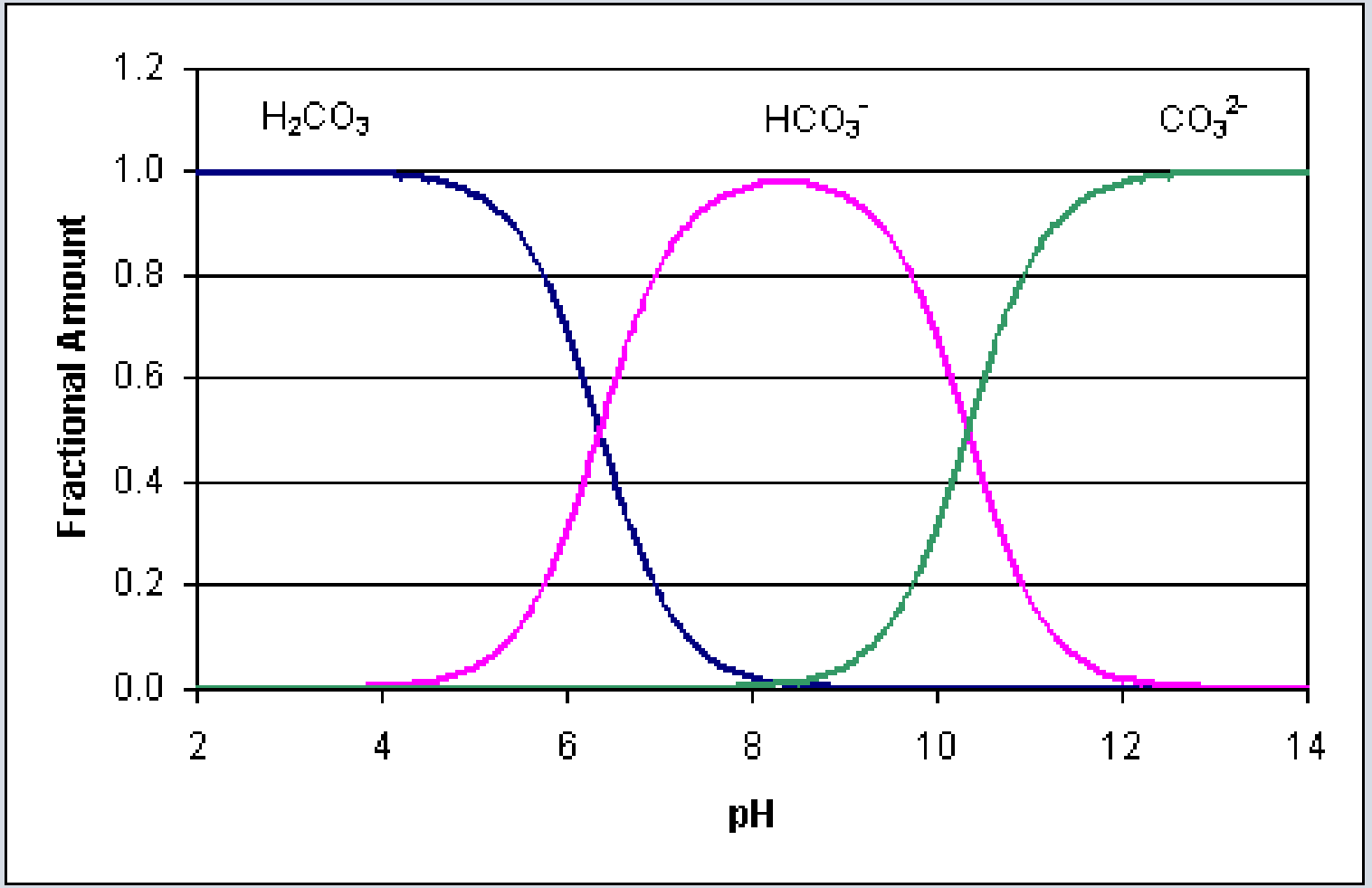
Carbon Source:
Auto: Inorganic Carbon
Hetero: Organic Carbon

Electron Donor:
Litho : Inorganic Chemicals
Organo : Organic Chemicals

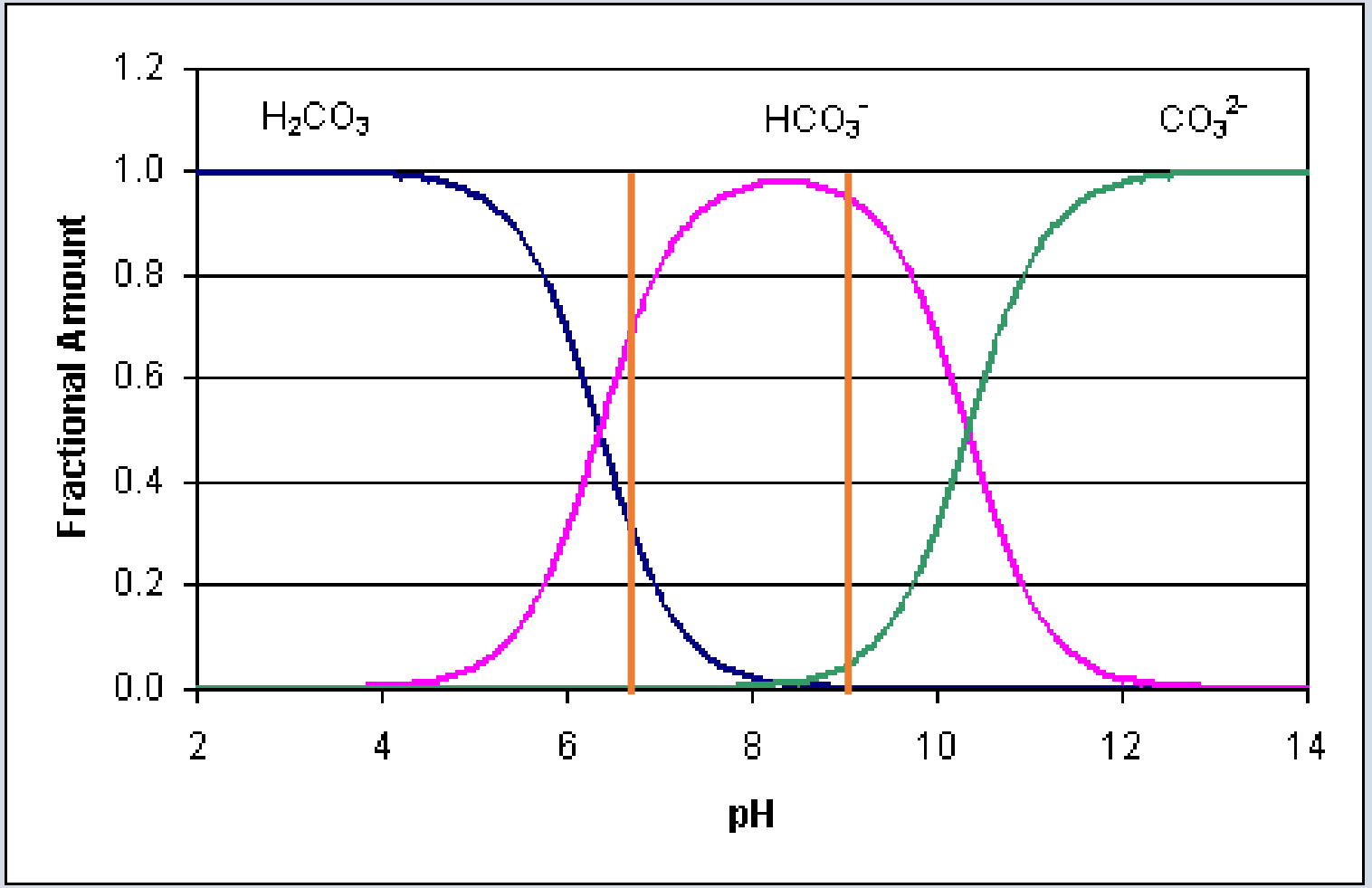
Troph: Eater

“Rock Eaters”

Nitrification



Nitrification



Nitrification

When the alkalinity is gone,

nitrification ceases…

until the alkalinity is replenished with influent,

and then nitrification proceeds,

until the alkalinity is gone again.

Nitrification

Typical Human Nitrogen Contribution in Domestic Wastewater:

16 grams/capita/d[1]

Per capita N	Per capita Q	Mg/L NH3-N	Alkalinity for Nitrification (Bicarbonate Alkalinity)	Excess Alkalinity (Buffer)	Total Goal Alkalinity
16 gm	200 gpd	5.3 mg/L	38 mg/L	80 mg/L	118 mg/L
16 gm	100 gpd	10.6 mg/L	76 mg/L	80 mg/L	156 mg/L
16 gm	50 gpd	21.2 mg/L	152 mg/L	80 mg/L	232 mg/L
16 gm	25 gpd	42.4 mg/L	304 mg/L	80 mg/L	384 mg/L

[1] Sedlak, *Phosphorus and Nitrogen Removal from Municipal Wastewater*, Lewis Publishers, 2nd Ed.,1991

Village of O***
WWTP

Village of O

Parameter	Dilution	Meter	Concentration	Alkalinity Required
AT NH_3-N	(1:9)	0.94	9.4 mg/L	67 mg/L
AT NO_3-N	(1:0)	19.7	19.7mg/L	-
AT Alkalinity (LR)	12 drops (@5 mg / L / drop)	-	60 mg/L	67 (req) – 60 (available) + 80 (buffer) = 87 mg/L (additional)

The WWTP nitrifies until the alkalinity drops out.
When the Equalization Basin pumps influent into the aeration tank, nitrification continues,
Until the alkalinity is gone again.

The County Water System is notorious for low alkalinity in the drinking water

Highland Local School District

Highland Local School District

Highland Local School District

- Trash Trap
- Flow Equalization
- Aeration: 2 trains – 25,000 gallon each
- Clarifier: 2 trains – one per train
- UFFM: 2
- Dosing Tank
- Sand Filters: 4
- UV Disinfection and Post Aeration

Highland Local School District

In 2004:

New High School Constructed On Site

Existing High School Converted to Middle School (modernized)

Existing Middle School Converted to Elementary (modernized)

Highland Local School District

Average Design Flow

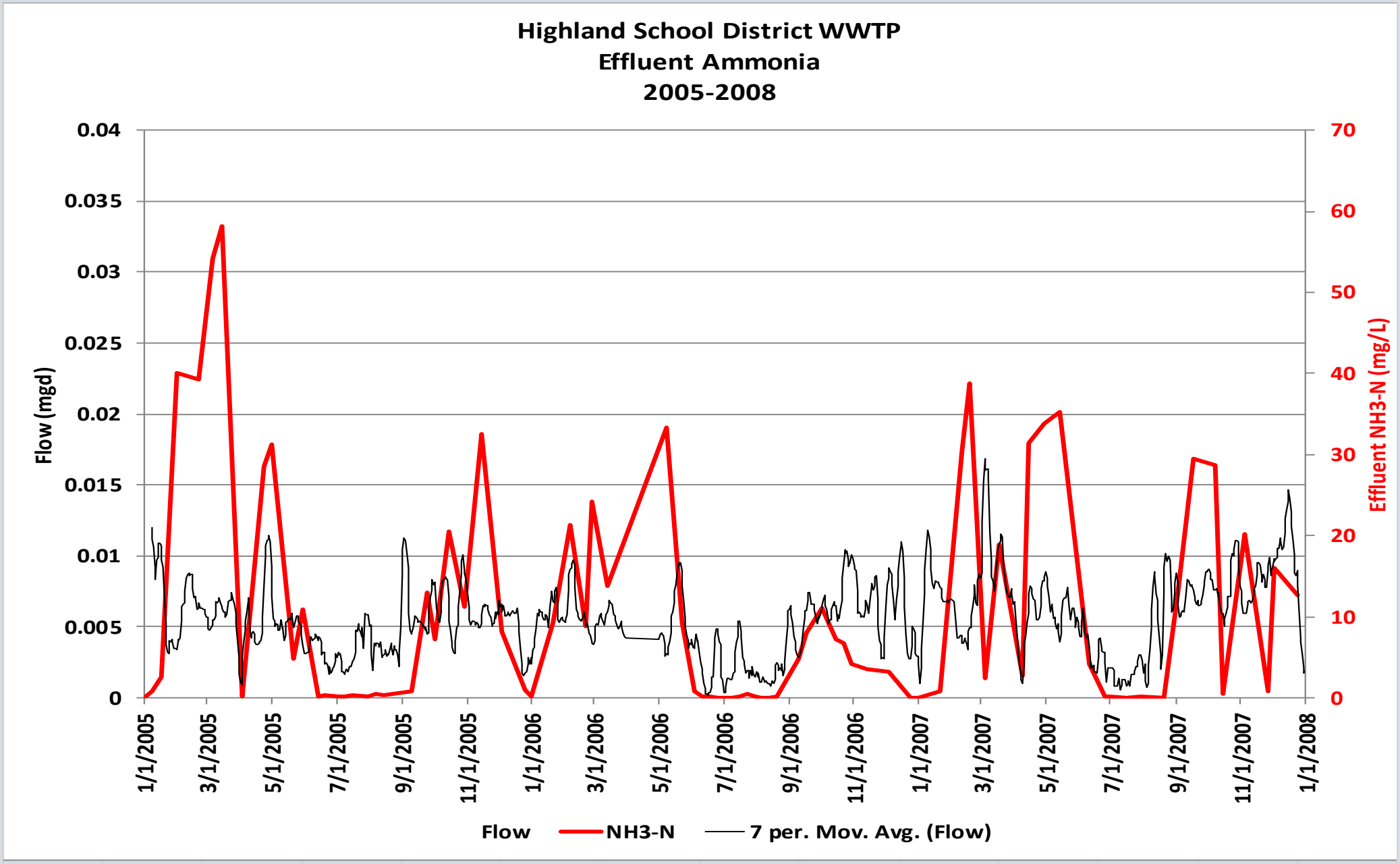
- **50,000 gpd**

Violations:

- Ammonia

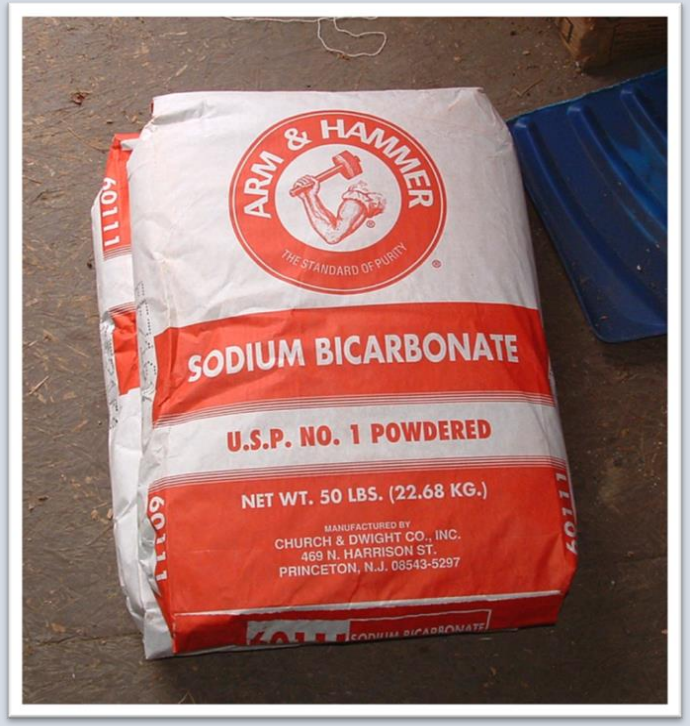
Symptoms from Operator:

- Aeration Pinched Back or the pH Drops Out


Highland School District WWTP
Effluent Ammonia
2005-2008
Flow (mgd)
Effluent NH3-N (mg/L)
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
70
60
50
40
30
20
10
0
1/1/2005
3/1/2005
5/1/2005
7/1/2005
9/1/2005
11/1/2005
1/1/2006
3/1/2006
5/1/2006
7/1/2006
9/1/2006
11/1/2006
1/1/2007
3/1/2007
5/1/2007
7/1/2007
9/1/2007
11/1/2007
1/1/2008
Flow
NH3-N
7 per. Mov. Avg. (Flow)

Highland Local School District

- WWTP Alkalinity Limited
- Drinking water was low in alkalinity (~80 mg/L)
- Considered Feeding $NaHCO_3$

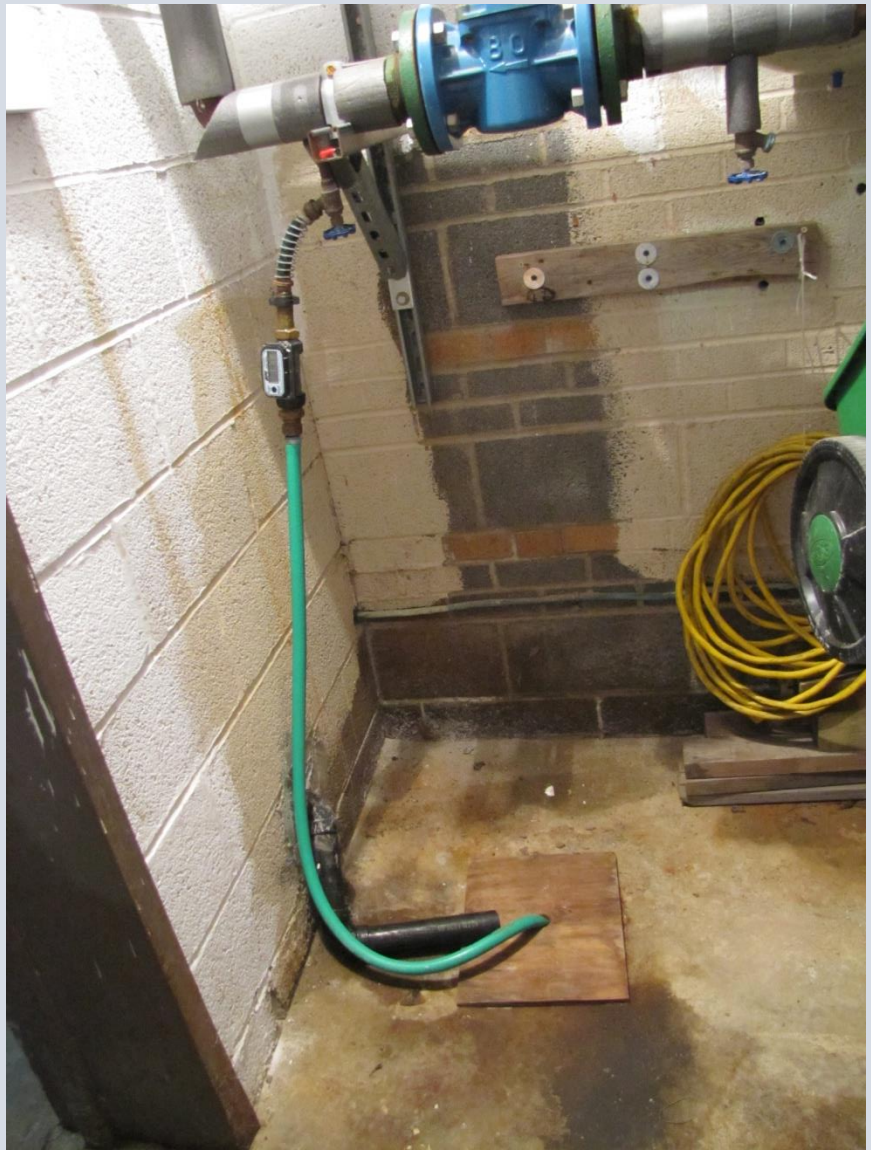


Highland Local School District

The School District Uses Well Water to Irrigate Athletic Fields

Well Alkalinity:
> 400 mg/L

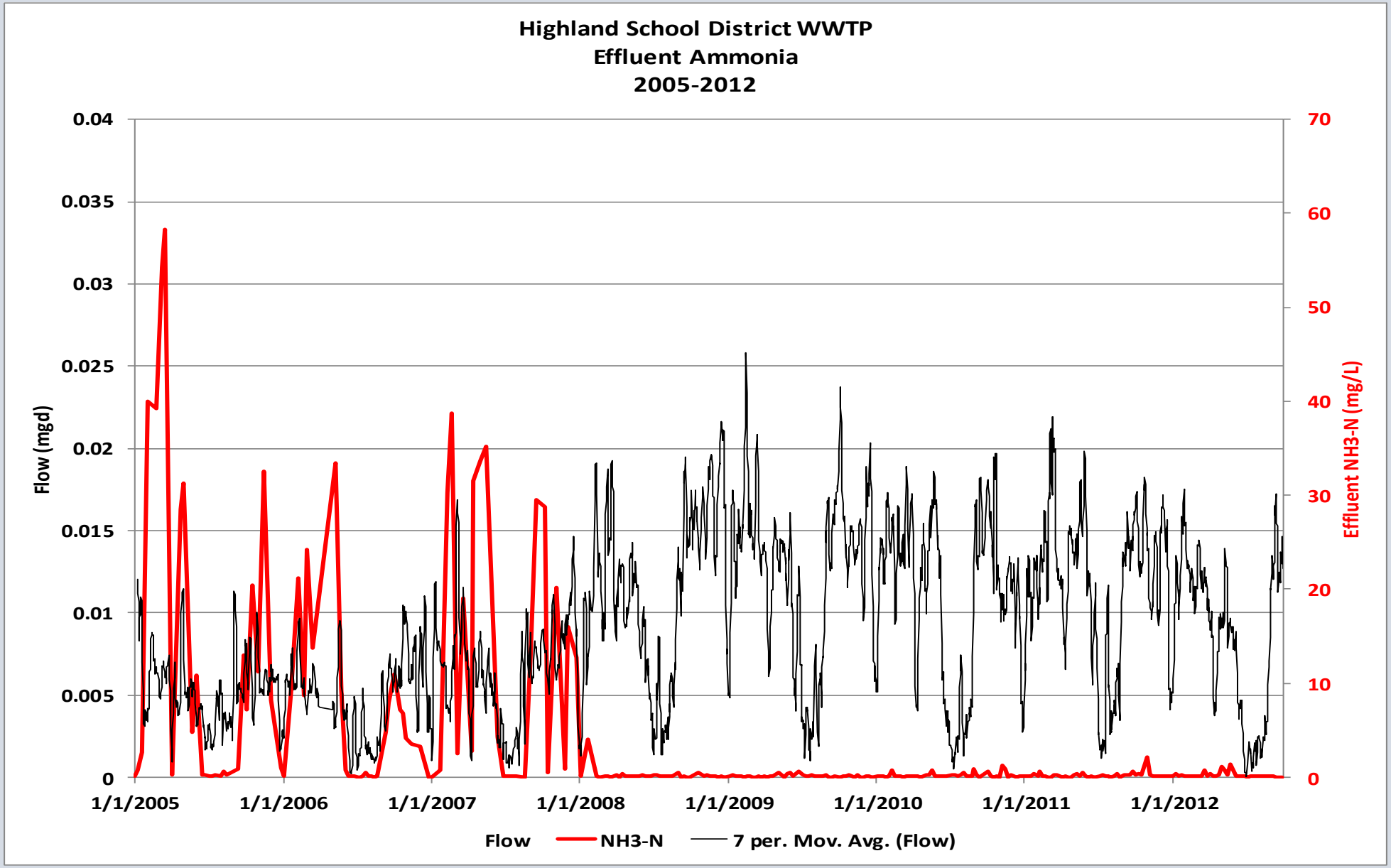
Started Dripping In Well Water



Highland Local School District

- Started with ~ 2000 gpd (about 1.5 gpm)

Date	Day	Alkalinity	pH	NH3N	Temp	Notes
2/4	Monday	300	7.2	27	7	Started Well Feed 2000 gpd
2/5	Tuesday	340	7.2	44	9	Things worse! More Air?
2/6	Wednesday	300	-	8	-	Full Aeration
2/7	Thursday	100	6.9	3	6.5	Increased Well Feed to 7000 gpd
2/8	Friday	40	6.5	0.1	7.5	Hit the Limit!
2/11	Monday	120	7.1	0.4	5.5	Adjust Feed Rate


Highland School District WWTP
Effluent Ammonia
2005-2012
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Flow (mgd)
70
60
50
40
30
20
10
0
Effluent NH3-N (mg/L)
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
Flow
NH3-N
7 per. Mov. Avg. (Flow)

Highland Local School District

From February 2008 up to Today

- Checks ammonia, Alkalinity
- Operates only One Treatment Train
- Runs Aeration On/Off to promote denitrification (~ 15 hours/day)
- Feeds approximately <5000 gpd Well Water
- Influent Flow: 12,000 – 15, 000 gpd
- In Compliance.

Hardin Northern School District

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Hardin Northern School District

10,000 gpd Package Plant

School Expanded and Remodeled in 2010

Water Conservation Plumbing

Hardin Northern School District

10,000 gpd Package Plant

School Expanded and Remodeled in 2010

Water Conservation Plumbing

<1000 gallons per day influent flow

Hardin Northern School District

Compliance Issues:

High Ammonia
High cBOD5
High Total Suspended Solids

No conversion
No separation

Hardin Northern School District

Compliance Issues:

High Ammonia

High $cBOD_5$

High Total Suspended Solids

High Operator Anxiety

Hardin Northern School District

Initial Observations

Settleometer

5 minutes	**500 (very turbid)**
30 minutes	**100 (still very turbid)**

Hardin Northern School District

Initial Observations

Settleometer

5 minutes 500 (very turbid)

30 minutes 100 (still very turbid)

Centrifuge Spins

Aeration Tank 1: 3.5

Aeration Tank 2: 2.5

Clarifier Core 1: 4.2

Clarifier Core 2: 4.2

RAS 1 : 3.5

RAS 2 : 3.2

Hardin Northern School District

Initial Observations

Ammonia Profile

Influent (EQ)	**> 150 mg/L**
Aeration Tank 1	**5.0 mg/L**
Aeration Tank 2	**4.6 mg/L**
Sand Filter Dosing Tank	**5.2 mg/L**

Hardin Northern School District

Initial Observations

Aeration Tank Temperature: ~ 5 – 6 C

Hardin Northern School District

Initial Observations

Aeration Tank Temperature: ~ 5 – 6 C

Aeration Cycle: 1.5 hours ON / 1.5 hours OFF

Hardin Northern School District

Initial Observations

Aeration Tank Temperature: ~ 5 – 6 C

Aeration Cycle: 1.5 hours ON / 1.5 hours OFF

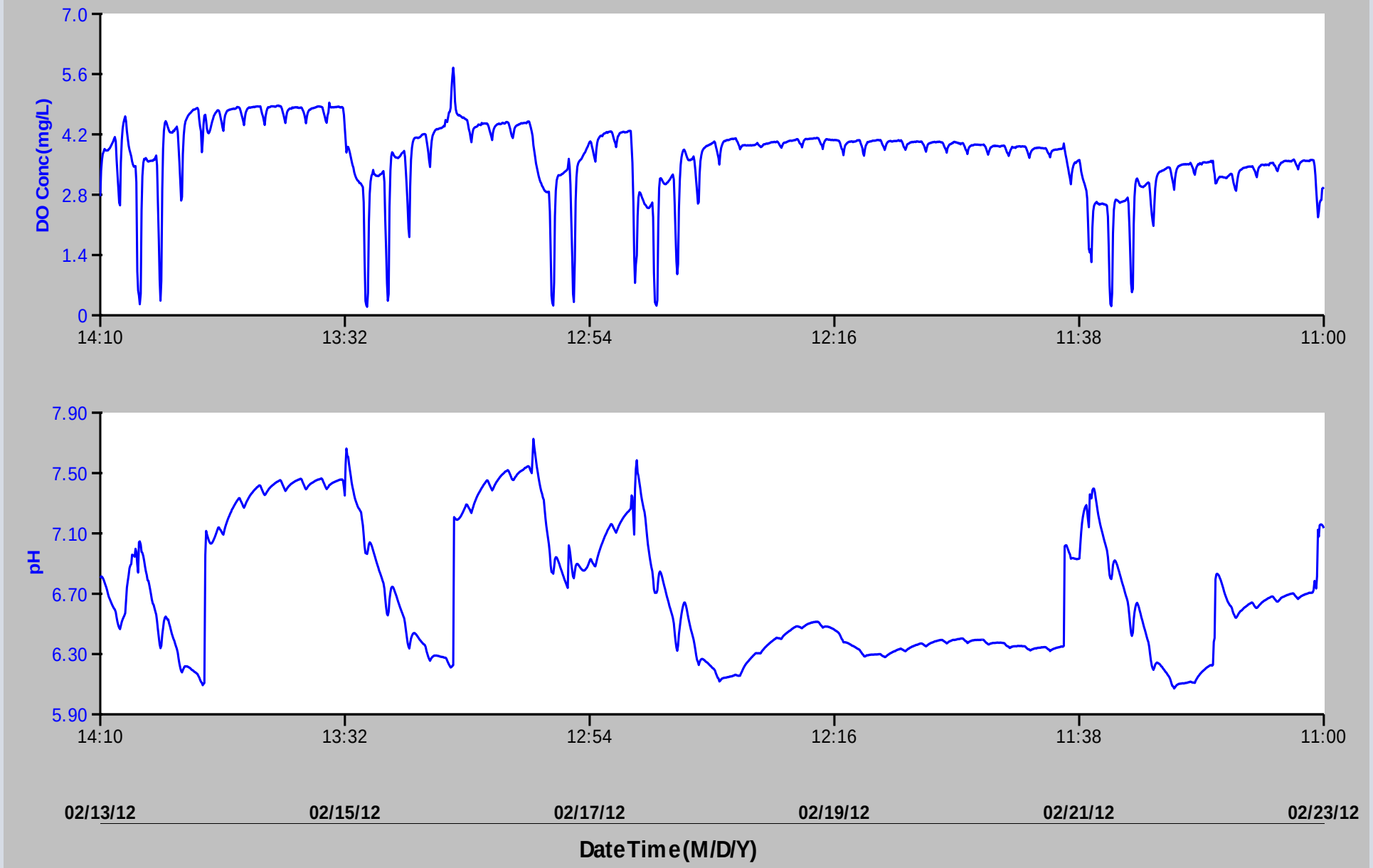
Aeration Tank Alkalinity: 40 – 50 mg/L

Dataloggers: Onset “HOBO” Pressure Transducer

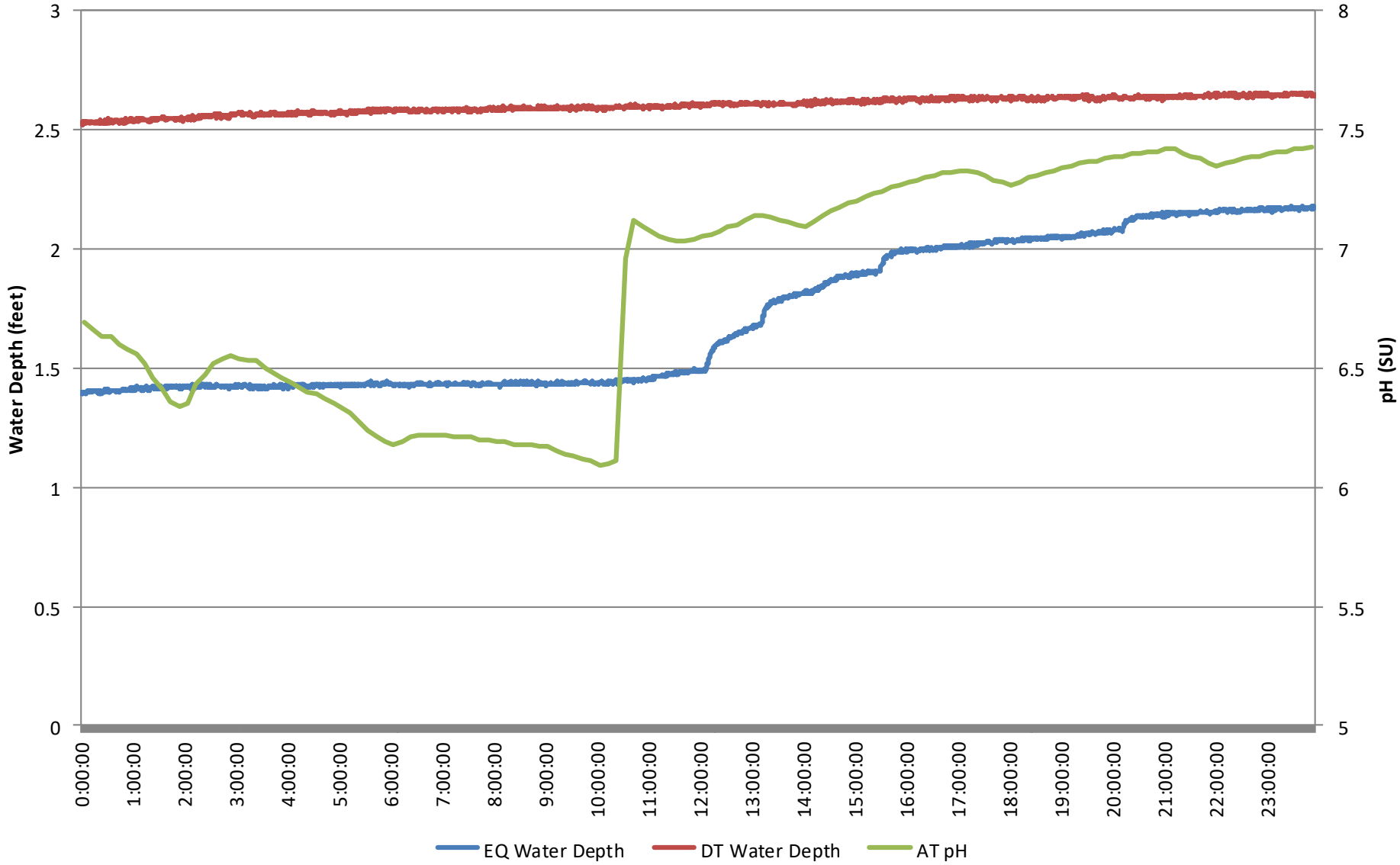
Datasondes: YSI 600 XLM

Hardin Northern School District

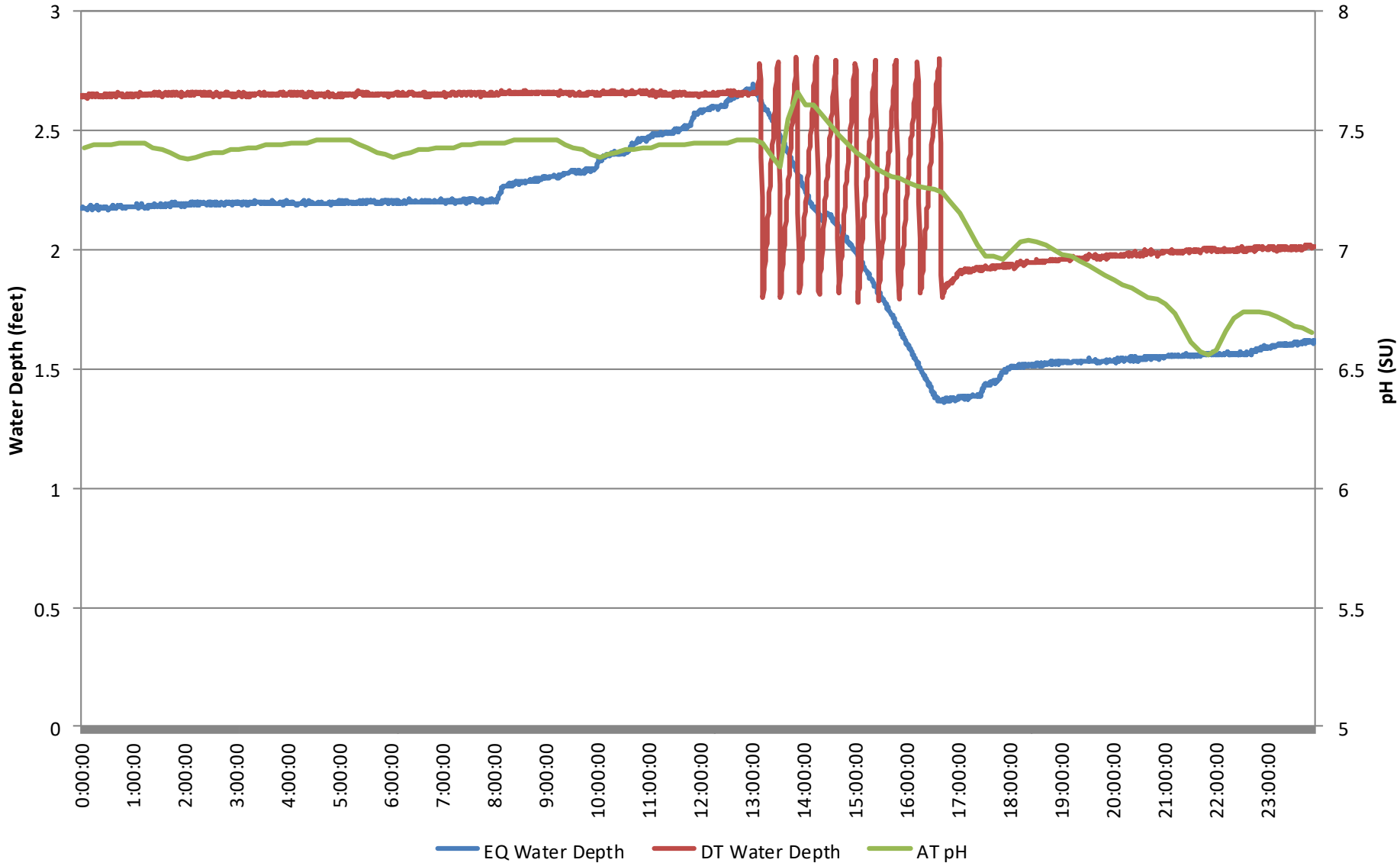
Aeration Tank 1



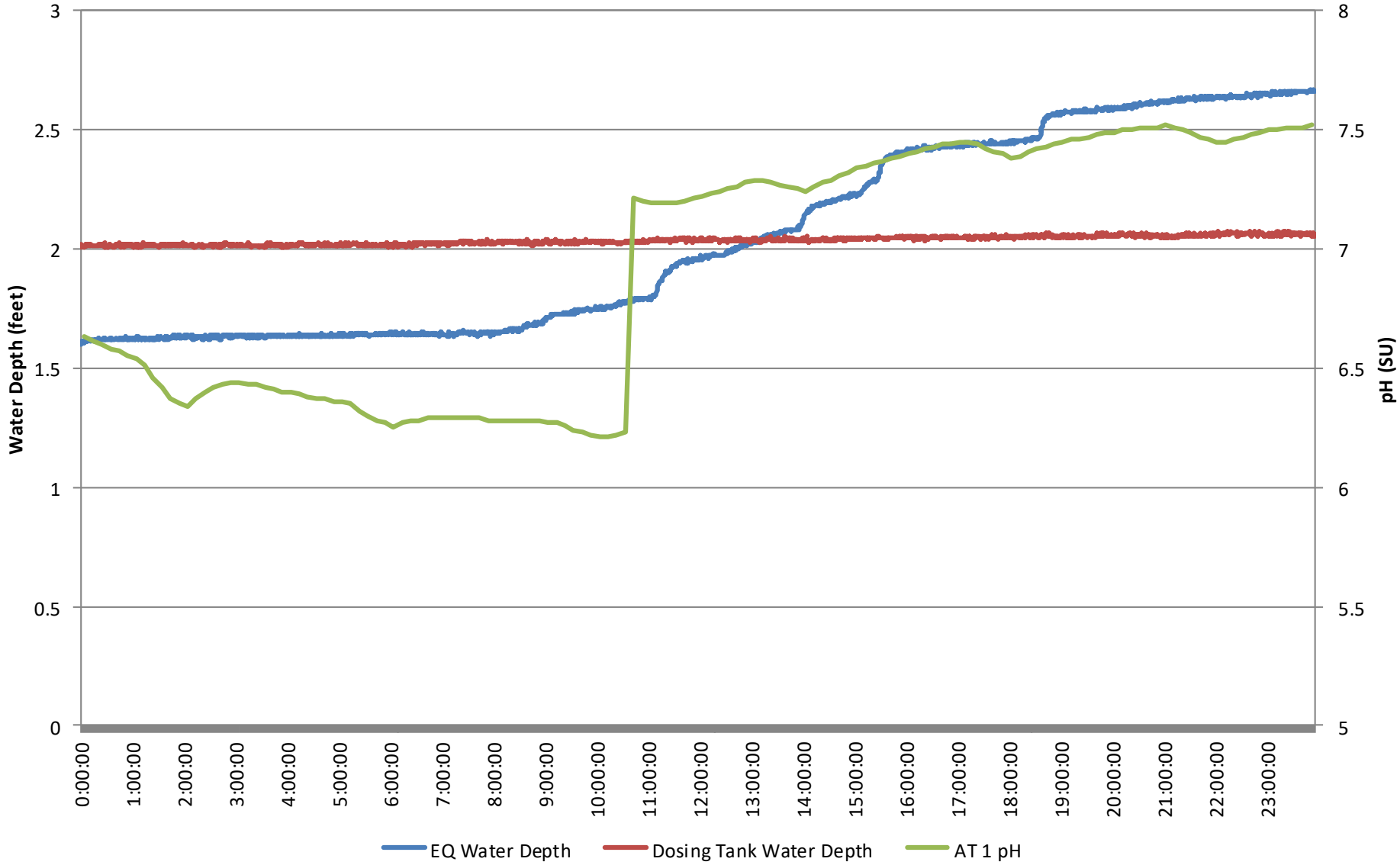
Hardin Northern School District
Flow and pH Study
Tuesday, February 14, 2012



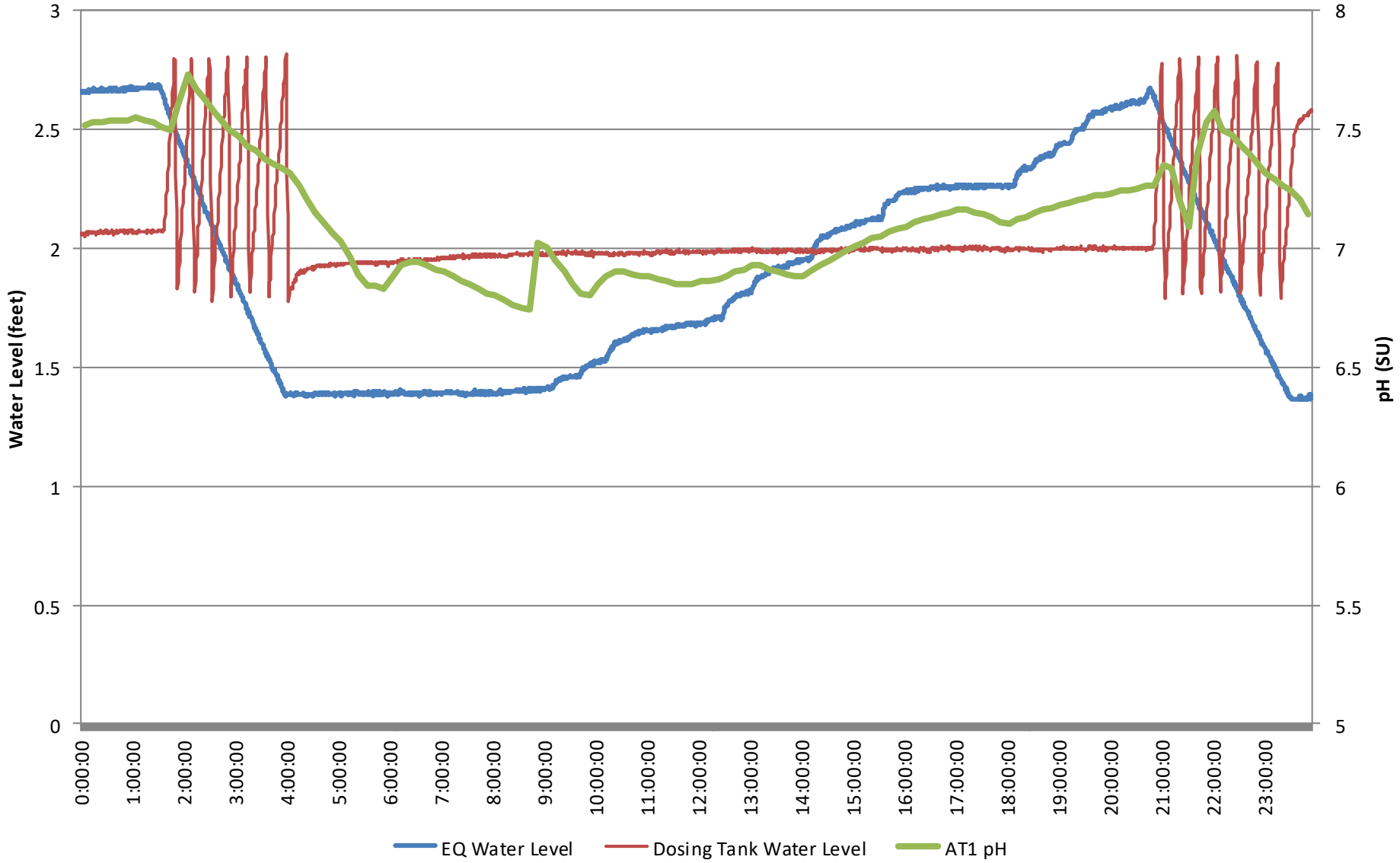
Hardin Northern School District
Flow and pH Study
Wednesday, February 15, 2012



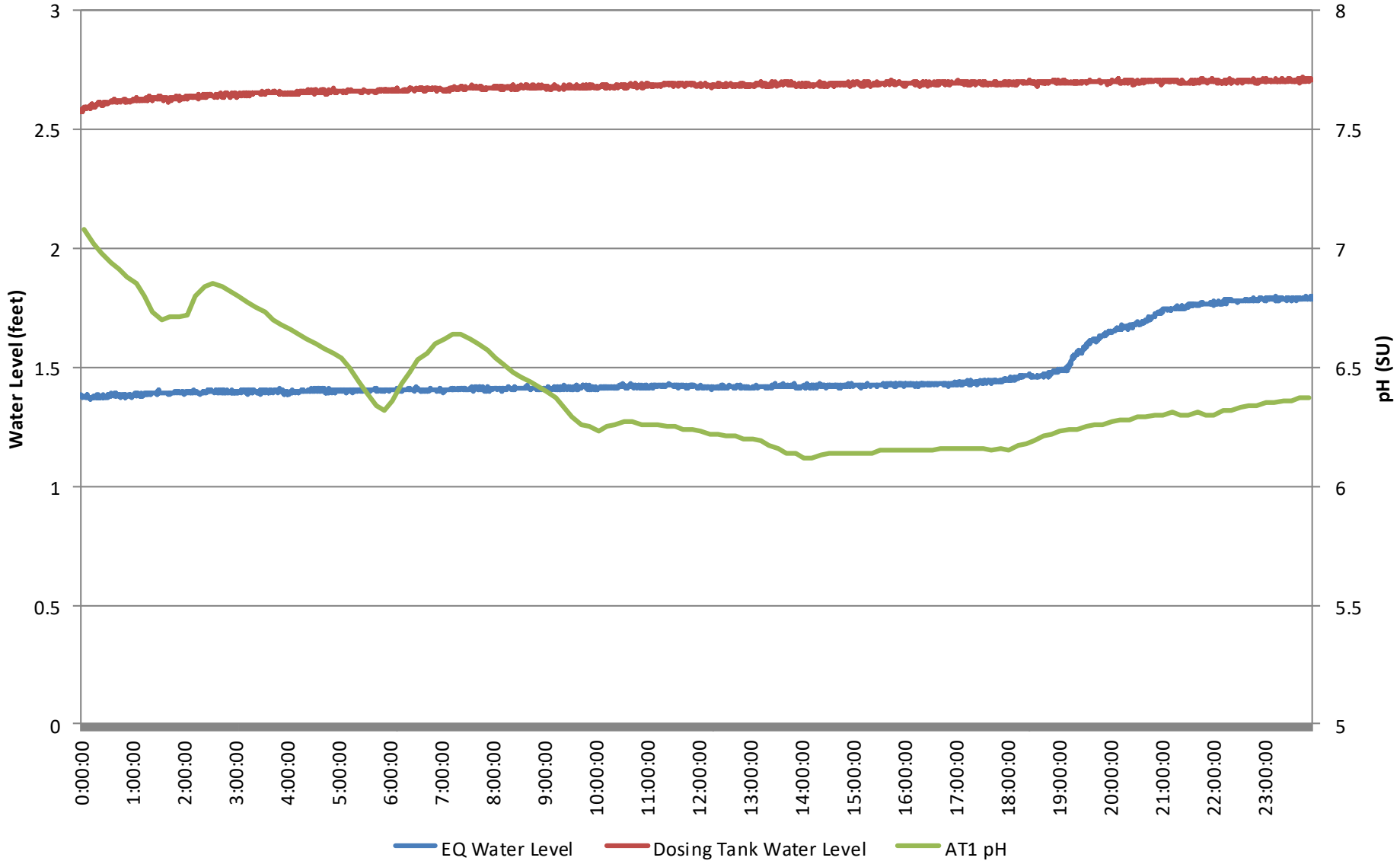
Hardin Northern School District
Flow and pH Study
Thursday, February 16, 2012



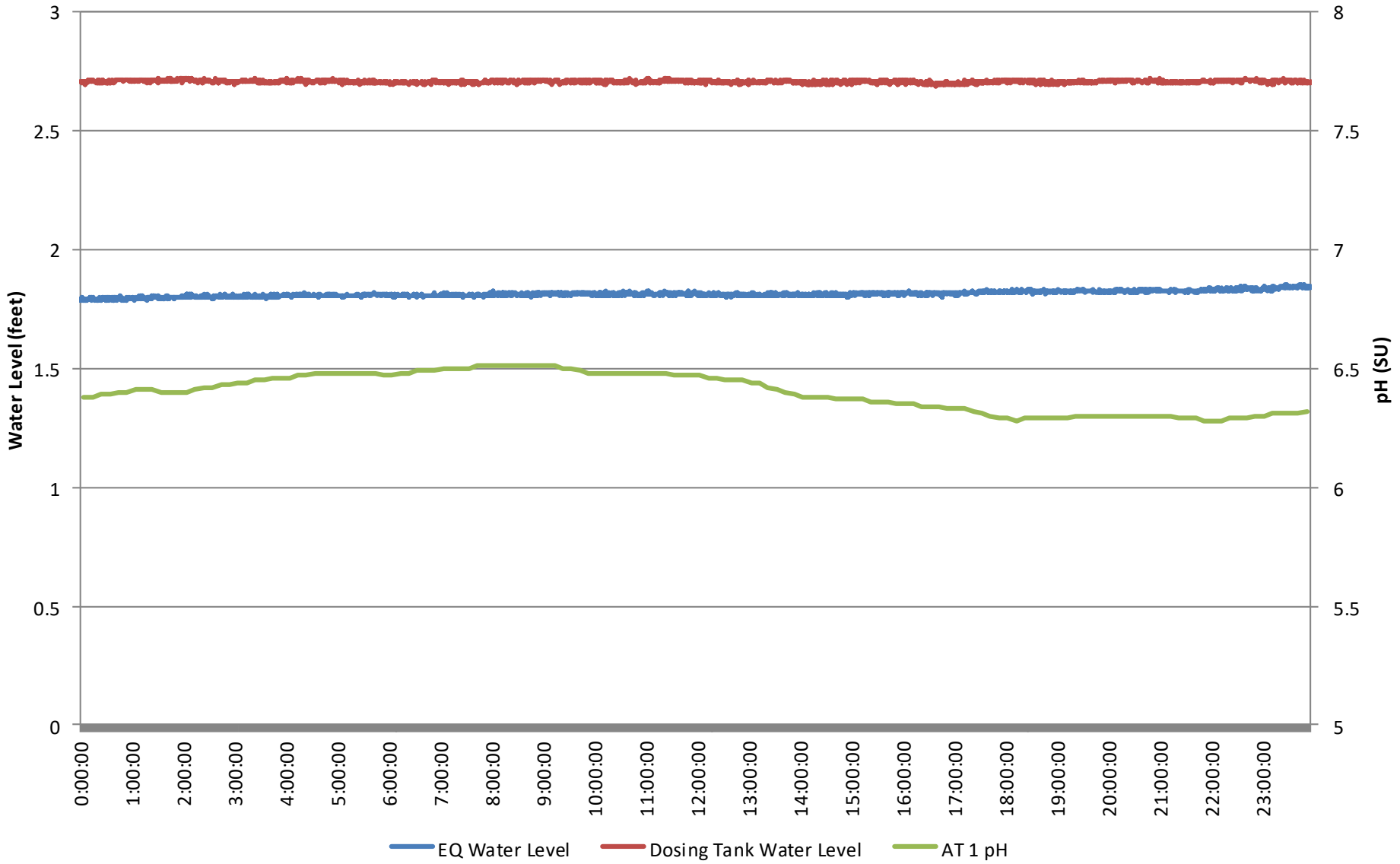
Hardin Northern School District
Flow and pH Study
Friday, February 16, 2012



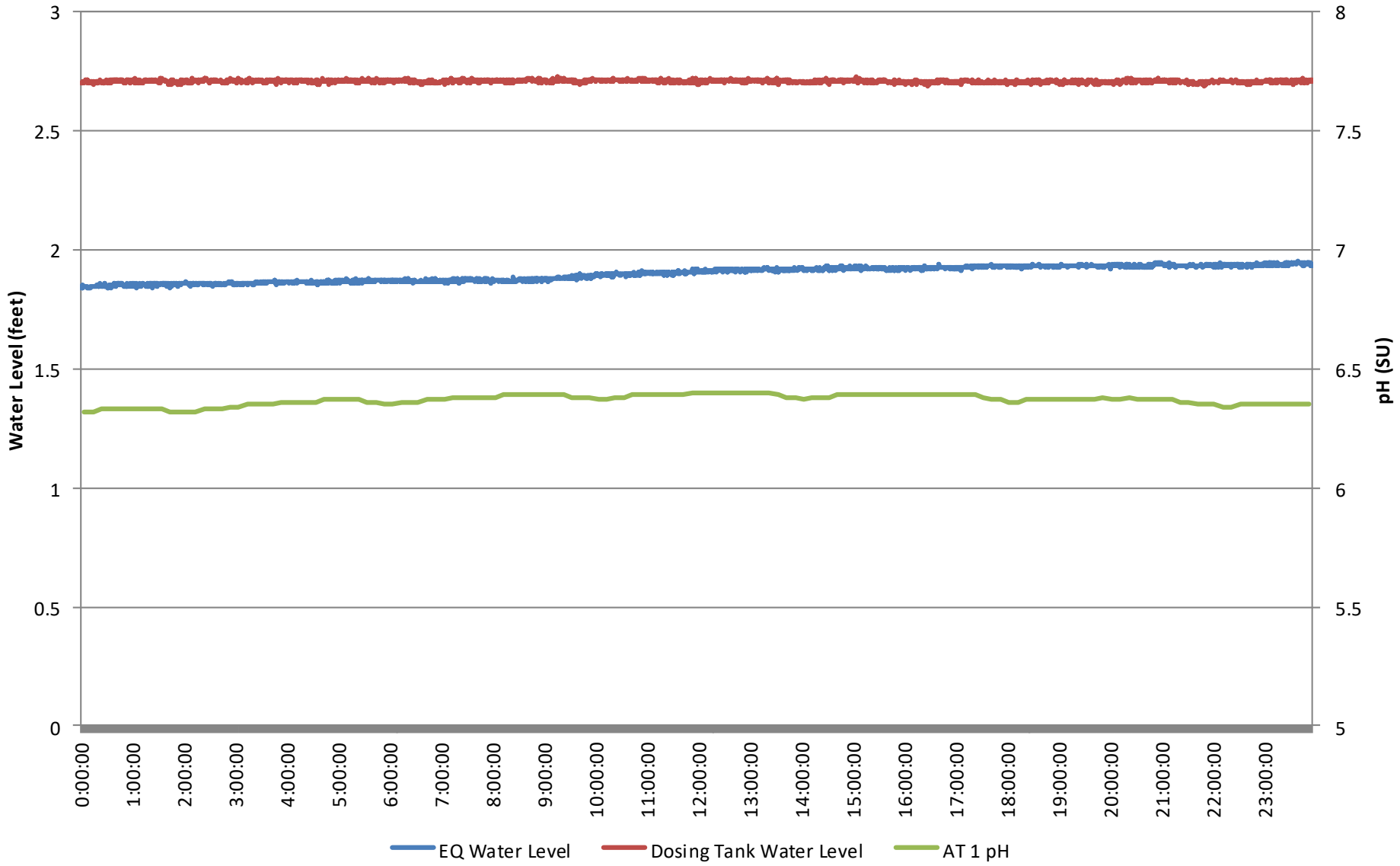
Hardin Northern School District
Flow and pH Study
Saturday, February 18, 2012

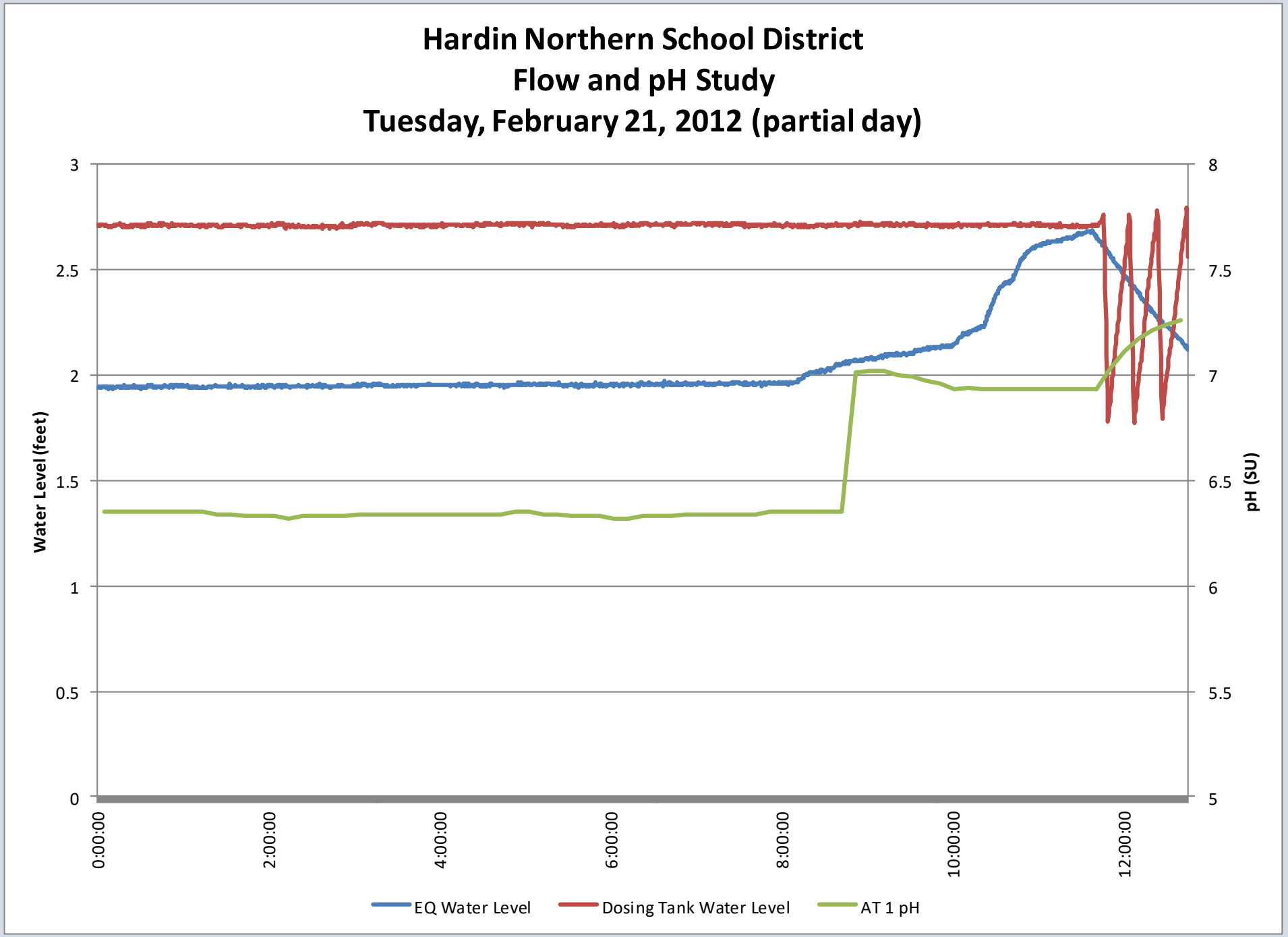


Hardin Northern School District
Flow and pH Study
Sunday, February 19, 2012



Hardin Northern School District
Flow and pH Study
Monday, February 20, 2012 (No School)




Hardin Northern School District
Flow and pH Study
Tuesday, February 21, 2012 (partial day)
Water Level (feet)
pH (SU)
3
2.5
2
1.5
1
0.5
0
8
7.5
7
6.5
6
5.5
5
0:00:00
2:00:00
4:00:00
6:00:00
8:00:00
10:00:00
12:00:00
EQ Water Level
Dosing Tank Water Level
AT 1 pH

Hardin Northern School District

Compliance Plan

- **Decrease EQ basin effective depth**
  - More cycles over more of the day
- **“Timed” the blower cycles to be OFF when EQ pumps energize with 15 minute bump.**
  - Load the tank with carbon and mix it “anoxicly”
- **Carefully watch pH/Conductivity**
  - Check pH/Conductivity prior to EQ pump cycle
  - Add sodium bicarbonate to maintain > 7 pH

Hardin Northern School District

On-going Compliance Plan

Monitor Clarifier Effluent Ammonia

Monitor Spins

Monitor Settleometer

Make adjustments according to the data:

- **Adjust air (blower cycles)**
- **Adjust wasting**
- **Adjust alkalinity**

Alkalinity Problems?

Low alkalinity in drinking water (first example)

Low flow plumbing, high ammonia influent (new schools, old WWTPs)

High influent ammonia?

- Village with 0.500 MGD Oxidation Ditch
- Huge landfill pumps leachate to the Village 24/7
- Leachate contains 600-1000 mg/L NH3-N
- Combined influent is 100-250 mg/L NH3-N (25% leachate avg.)
- Drips in alkalinity feed 24/7 and oxidizes ammonia to < 1 mg/L
- No blanket in Clarifier: nitrate in effluent ~ 100 mg/L on average

Conclusion

- Nitrification depends on 5 conditions:
  - Enough dissolved oxygen
  - Enough water temperature
  - Enough bacteria
  - Enough detention time
  - **Enough Alkalinity**
  - **Enough Process Control to know if there is enough**
  - **Measure… don't guess.**

Questions?

Jon van Dommelen

Ohio EPA

Compliance Assistance Unit

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