Does Your Detention Pond Actually Function as Designed?

Or

Is your pond successful?

KC Urban Stormwater Conference

February 5th, 2019

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City of Leavenworth

Definition of Success

It has been said by many that determining how successful your pond is –

- **is a function of how many calls you get or don't get after it rains!**

- **is often defined as meeting the minimum criteria at the lowest cost for the client.**

How Should Success be defined?

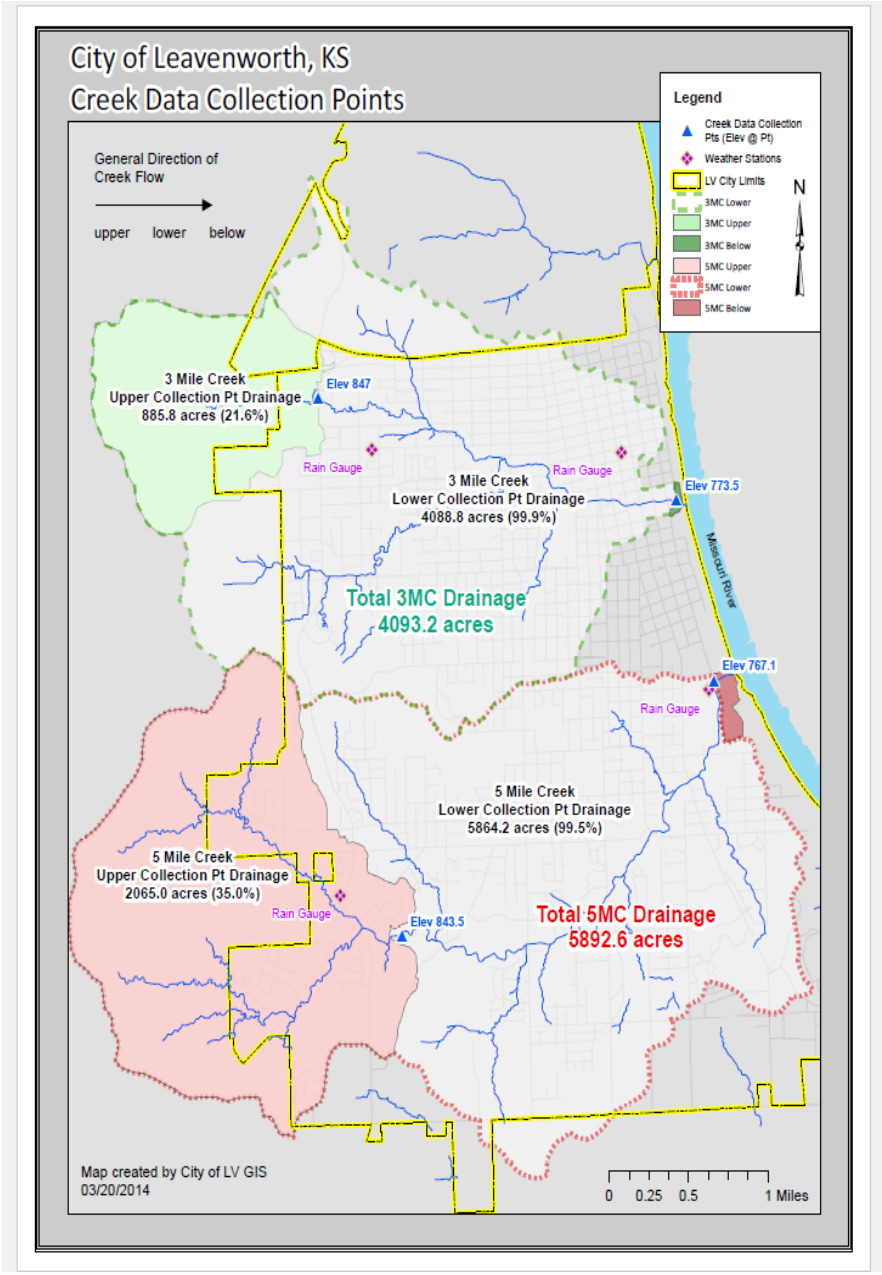
We suggest the following be considered besides "meeting the regulations":

- **Does the pond perform as envisioned by the <u>Owner</u>?**

- **Does the pond perform as designed by the <u>Engineer</u>?**

Who is Successful?

- I can tell you from our experience that very few agencies, entities, designers or firms can meet this definition of success on the normal sized development related detention ponds built in the KC Metro Area, and it is likely the same in most other areas of the Country.



City of Leavenworth

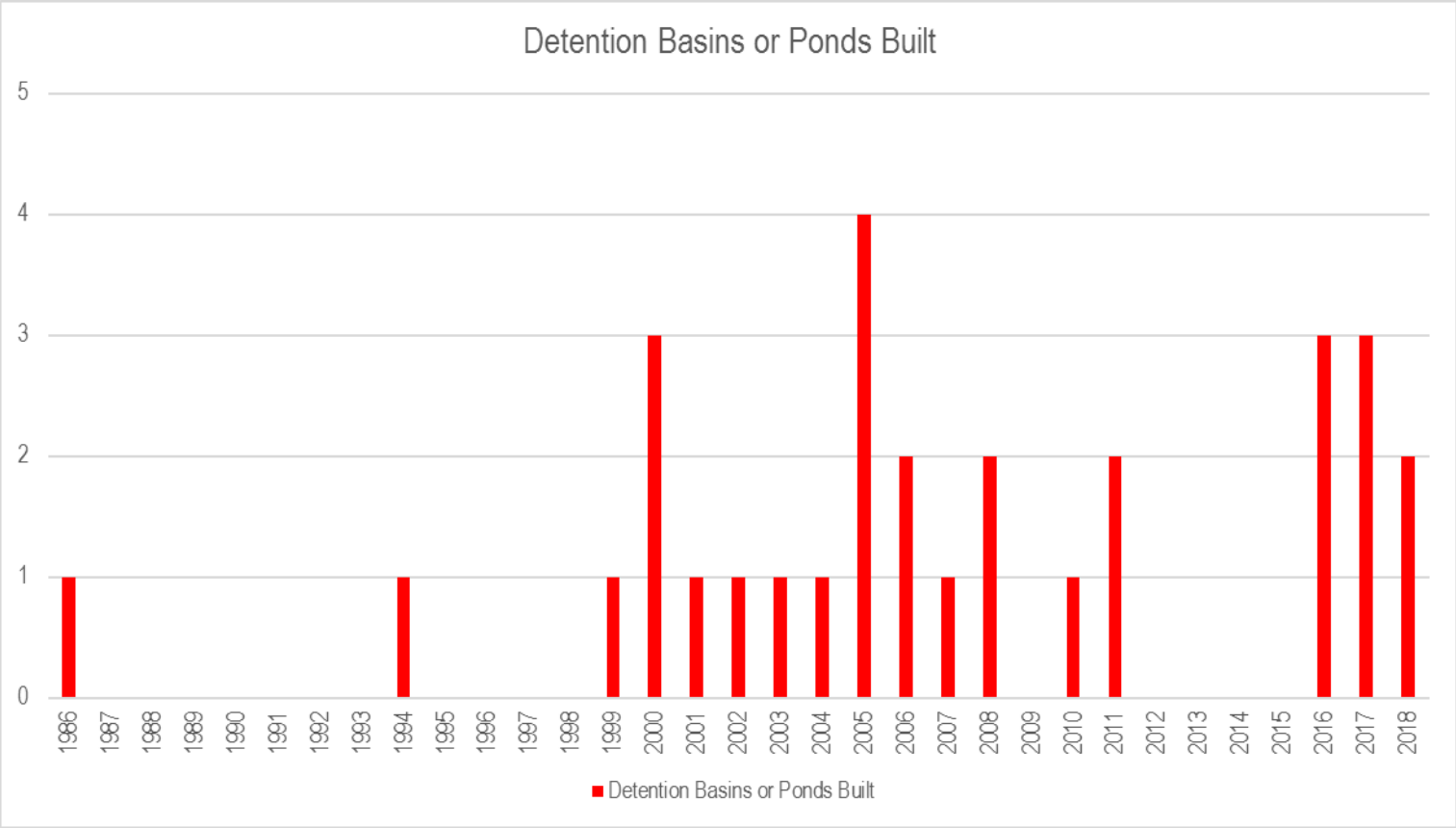
About 10,000 Acres of drainage area

- 4100 acres in 3-Mile Creek
- 5900 Acres in 5-Mile Creek

Map shows a lot of information

- City Limits
- Sub-basins of Interest
- Four Rain Gages
- Two Stream Monitors
- Four sampling locations

Here is our Story
29 Basins/Ponds/BMP's since 1986



The Leavenworth Experience

- **The City has either constructed or required to be constructed detention ponds of various types and sizes over the years.**

- **It is fair to say that we – without too many regulations relied heavily upon the skills of the firms designing the ponds.**

What – Us Worry?

Listen to the Environment!

- We had calls that there was never any water in the basins.
- We had calls that even with large new upstream basins – there continued to be bank erosion damaging landscaping and infrastructure.
- Bank erosion has contributed to several critical infrastructure failures.

What the heck is going on here!?

Inquiring Minds Wanted to Know! 2010 and 2012 were "Watershed" Years!

We had installed two rain gauges in 2010 and installed two more in 2012

Davis VantagePro 2 (about $600)

And - Depth Measurement Tools!

We also found “Autonomous Data Loggers” in 2012. They can live on the bottom of a pond or stream for months and record data – bought four of them (now seven)

Autonomous self-contained data loggers by Keller (about $400).

Fat, Dumb and Happy
2012 and 2013

We were really smart and learned a lot!

- Our first comparison of rainfall with detention basin performance verification revealed that in most cases – there was <u>little or no performance.</u>
- Learned that the streams in Leavenworth are "twitchy" – very sensitive (actually - *spectacularly sensitive*) to rainfall.
- Began to realize that managing a storm drainage a system was going to take a LOT of work

2013 EPA Visit, and 2014 KDHE MS4 Permits

- EPA "reminded" us that we were required to monitor the effectiveness of BMP's required as part of projects.
- KDHE required water quality sampling at least four times per year

These two events essentially forced the City to get into monitoring on a serious basis

Data - What We Do Now

So - From a Standing Start in 2010 and under very vague regulatory guidance since – we have evolved into the following into 2019:

- Rain Gauges - 4
- Stream Depth Monitors - 2
- Detention Basin/Stream Monitors – 3 to 5
- Sampling Program min. 4X/year (typically 6X)
  (Initial indications are that sampling not required in next Permit!)
- Extended Informal Data Sharing Network
  Leavenworth, Lansing, Basehor, Leavenworth County, misc. on-line users

Things I can talk About -
BUT –
*Let's talk about the one in **RED** today!*

- ❑ Regulations, regulators, reality and more
- ❑ Data Collection methods, practices and pitfalls
- ❑ Figuring out what the sampling data means
- ✓ **Evaluating Detention Basins and Ponds**
- ❑ Considering Water Quantity and Water Quality as the same problem rather than different ones
- ❑ What to do/not-do when the EPA comes to town.

Profound Engineering Principles

Water *Quality* and Water *Quantity* measurements rely on basically the same Data.

"Unless you know your costs – you know NOTHING. You learn your costs by MEASURING THINGS"

(with some liberties) Ed Aulerich, Professor of Forest Engineering, Oregon State University 1976

Monitoring Program delivers Immediate Results!

These devices have proven themselves many times over by "proving" to others that:

- ***there actually is water in the basins when it rains!***
- ***Rainfall was not "at least six inches" – but was more like three inches city-wide***
- ***"It rained all night" is more like it was raining when you went to bed and stopped an hour later***

We make Data Easily Available to the Public!

- Davis WeatherLink 2.0 is a fairly robust site readily available to the public - on-line and mobile app.
- Sign-up with one or more on-line sites to post/host your weather data.
  - Citizens Weather Observer Program (CWOP)
  - Weather Underground
- Make rain/wind summaries for PIO to post on social media sites

Some Thoughts on Data

- You can never have too much data – but can come close with these devices!
- Select an interval that works for you
  - Weather Data – 15 minutes (Testing a 5 min interval)
  - Depth Data – 5 Minutes
- Expect a learning curve with the software for both the device and the spreadsheet as these are HUGE tables.
- The World is full of Data/Weather Junkies, find them for help.
- You too can become a weather junkie pretty quickly.

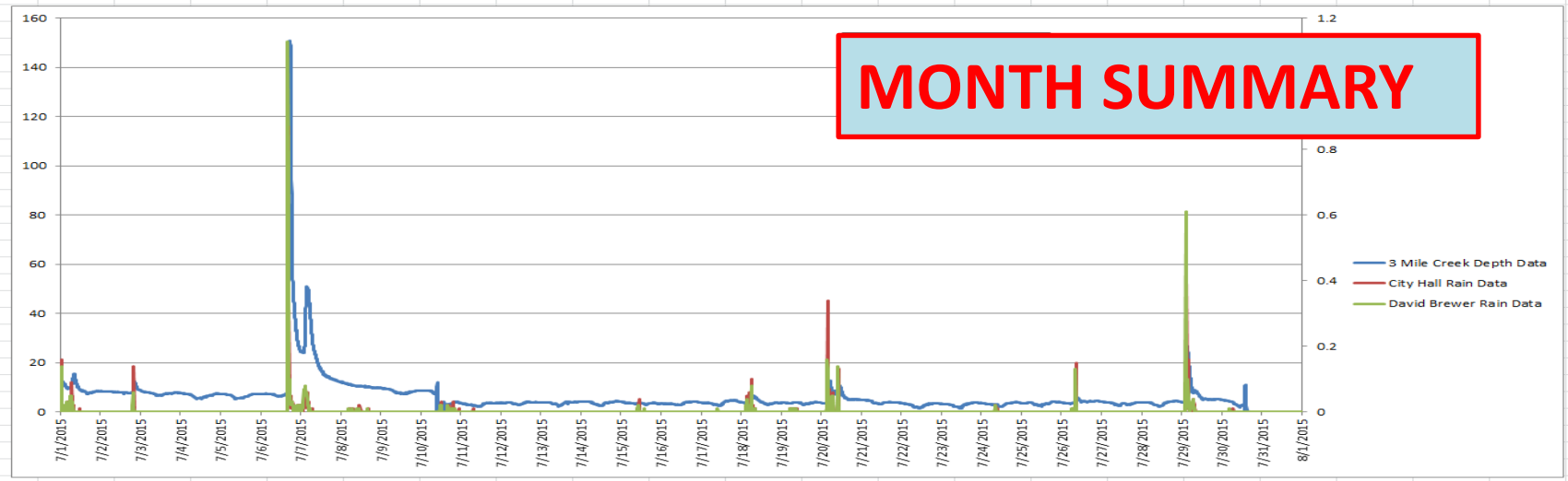
Useful Information?
We think so!

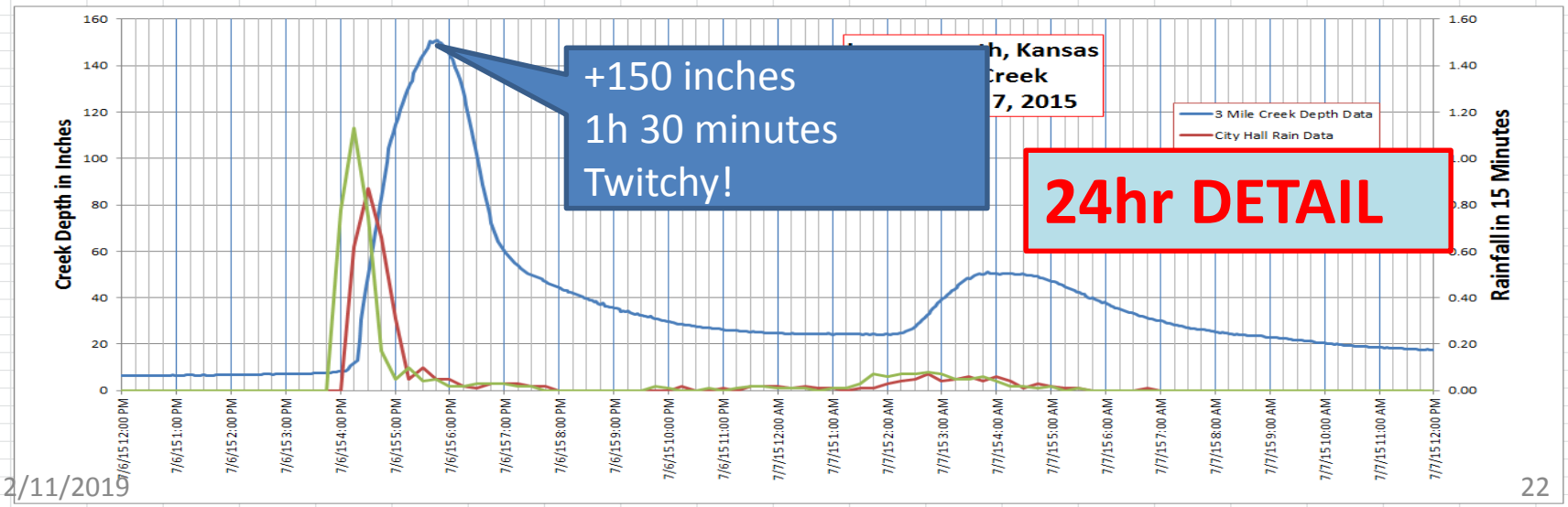
How we use it:

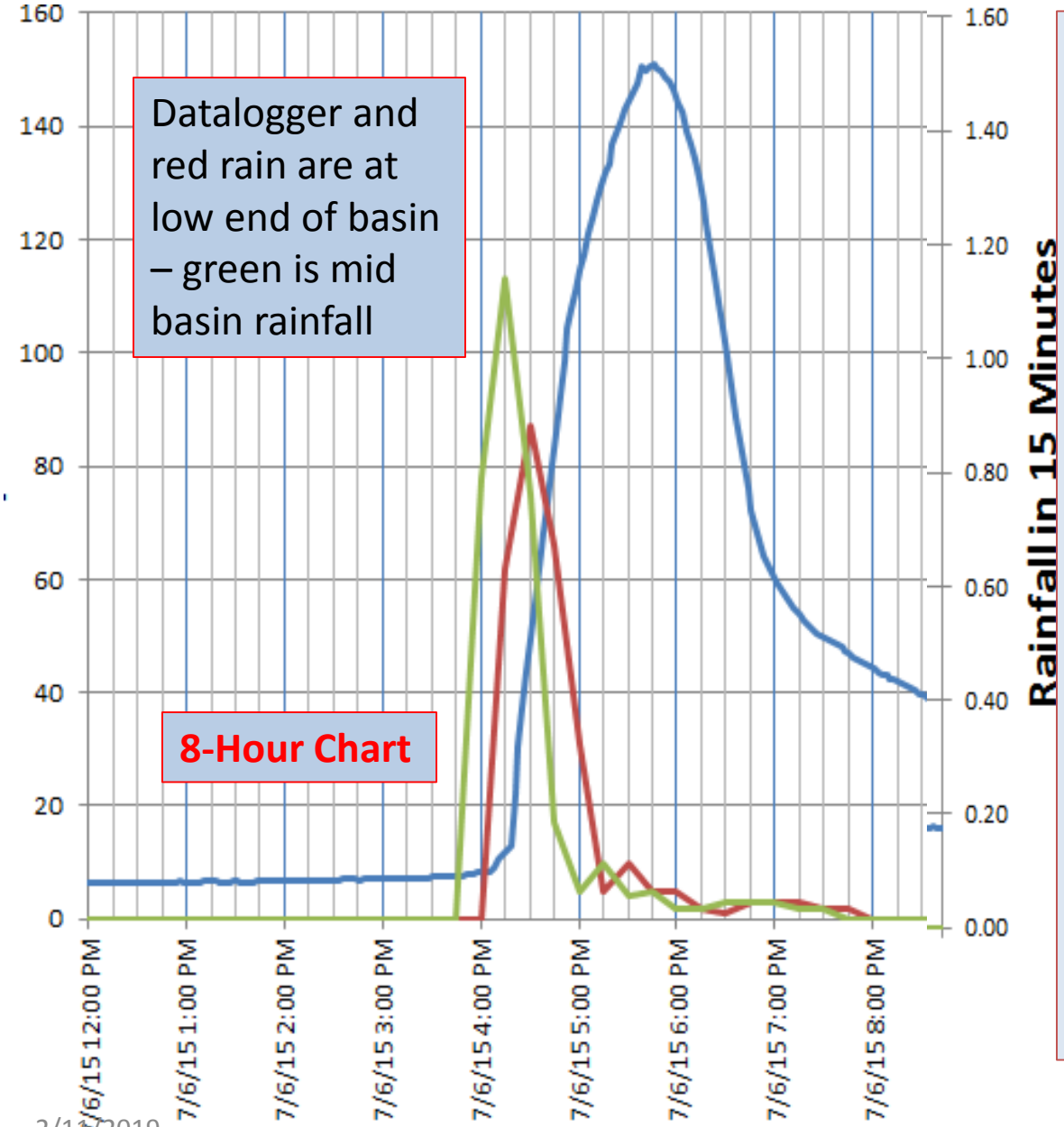
- **Steam Flow Monitoring**
- **Detention Basin Monitoring and evaluation**
- **Local Rainfall Data**
  - **For integrating into other monitoring**
  - **Design Considerations**
- **Influence Local Regulations**

Typical Stream Monitoring

Three-Mile Creek - Jul 7 2015





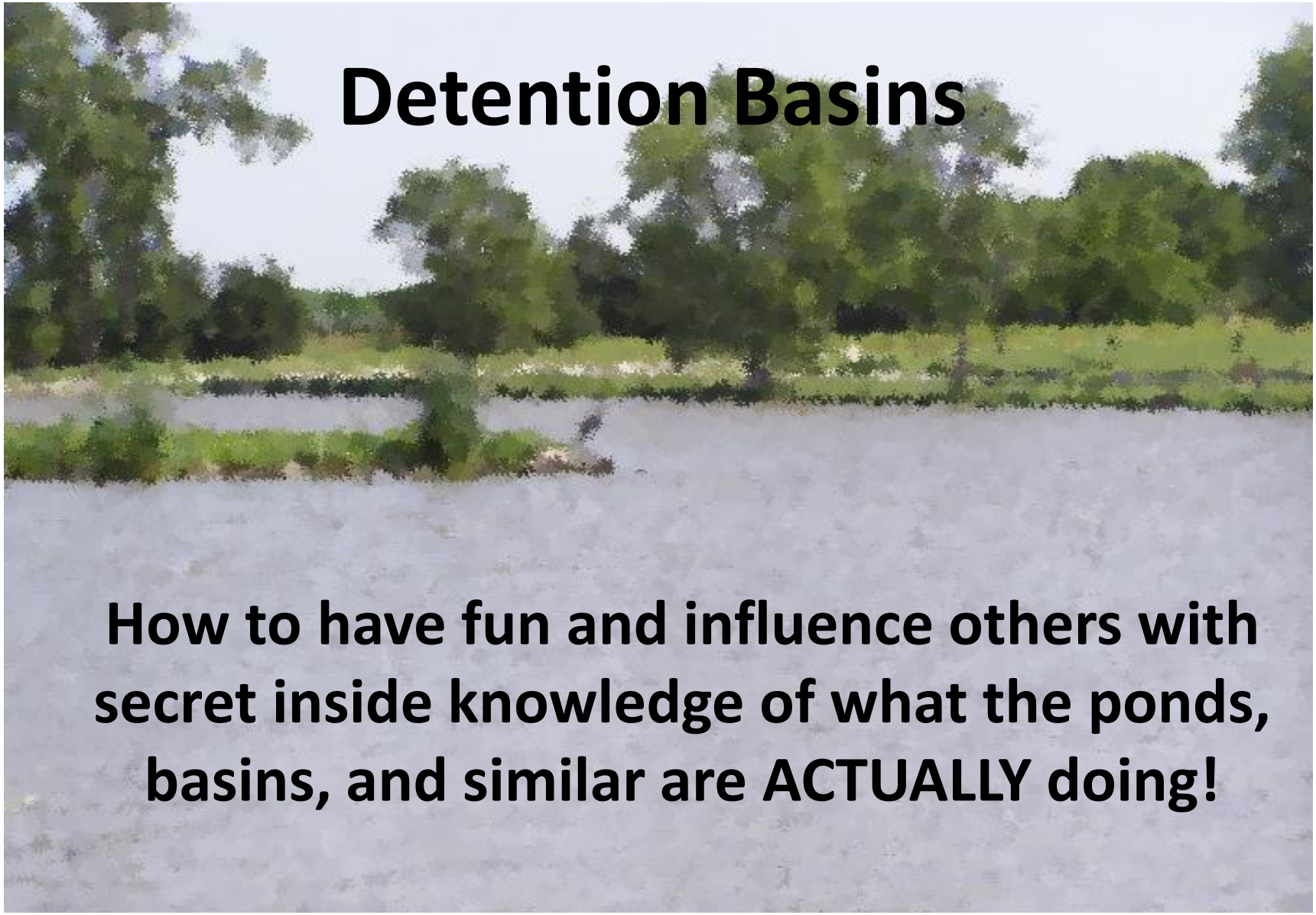


Three-Mile Creek July 6, 1015

- **Start of Rain to rising Stream – 15-30 minutes**
- **150 inch (Over 12 FEET!) rise occurs in 90 minutes**

Impact of this:

- ***Discussions with KDHE and MS4 regarding sampling requirements***
- ***Evaluating threats to adjoining properties***


Detention Basins
How to have fun and influence others with secret inside knowledge of what the ponds, basins, and similar are ACTUALLY doing!

Eagles Pond
a BIG project!

- Built by City in 2013 using CIP Funds
- An effort to reduce neighborhood Street Flooding and Sewer Back-ups
- Decades old problem
- A review of design documents from early 1960's showed it was built to standards with 5-year conveyances and lots of swales
- We would do it differently today!

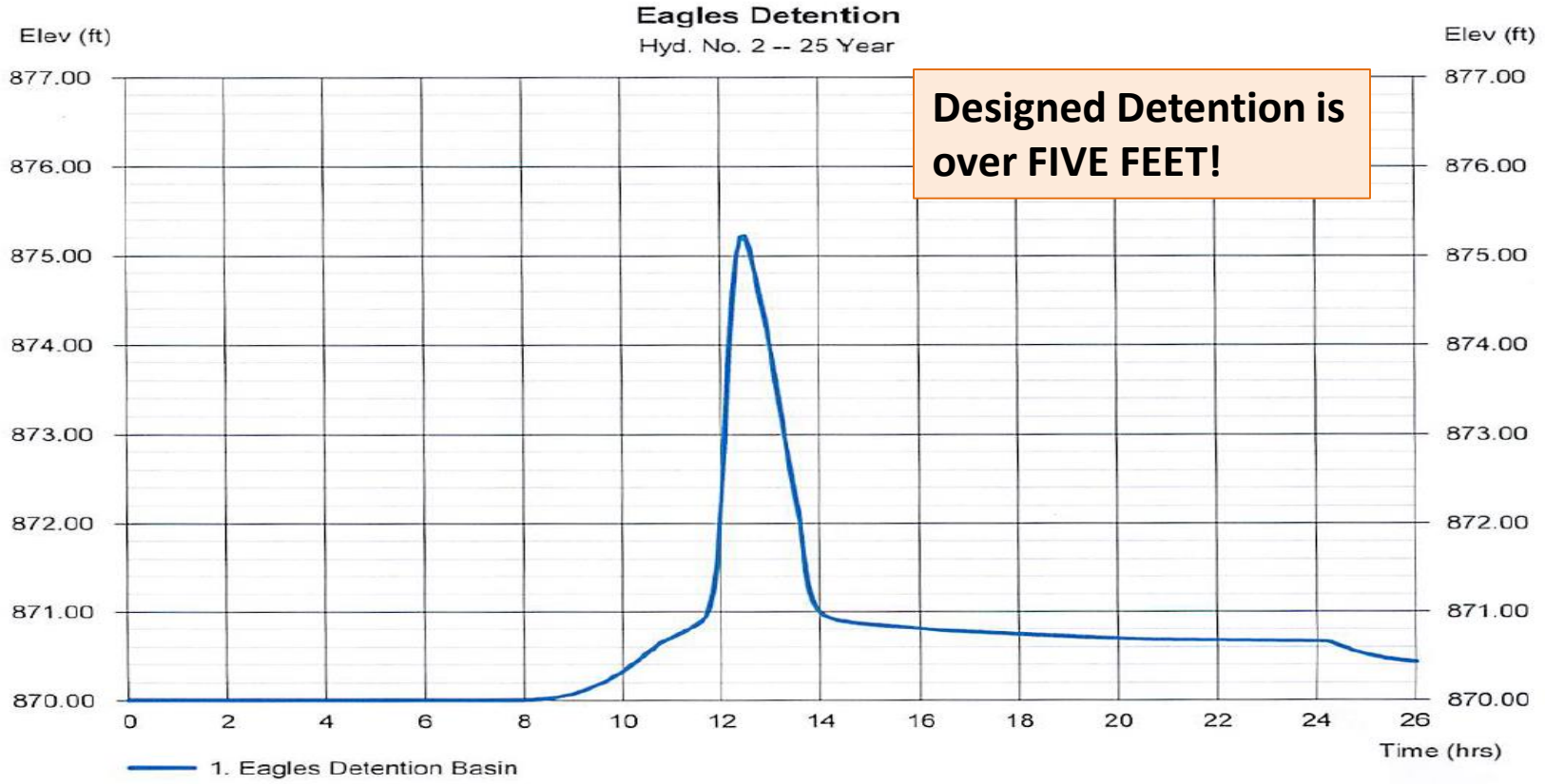
Eagles Detention Basin

- City Owned
- Built in 2013
- 79,000sf surface
- 9’ Deep
- 25-year overtop to street

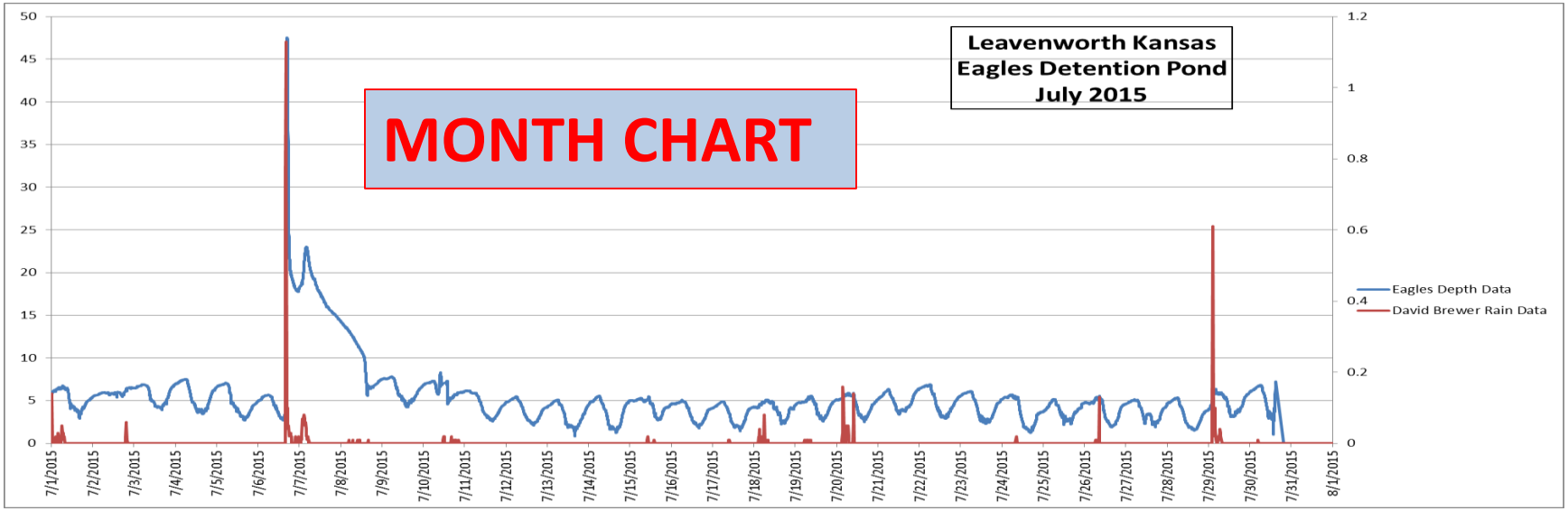
Eagles – **25 Year Detention** 2013 Design

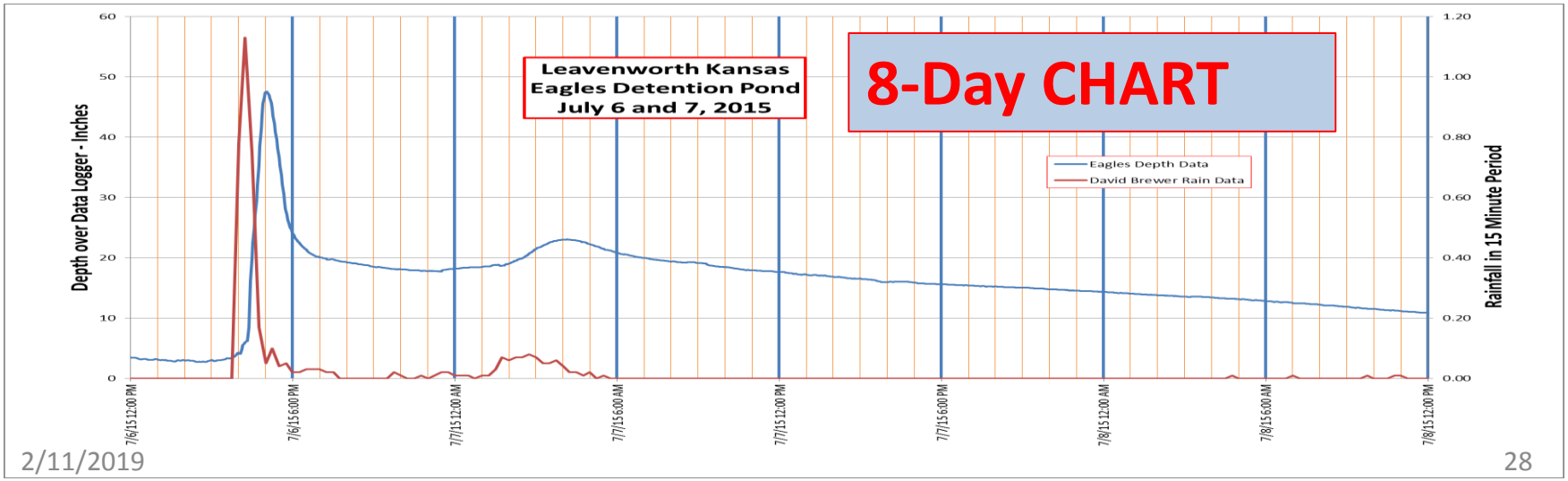
Problem Solved?

Maybe!



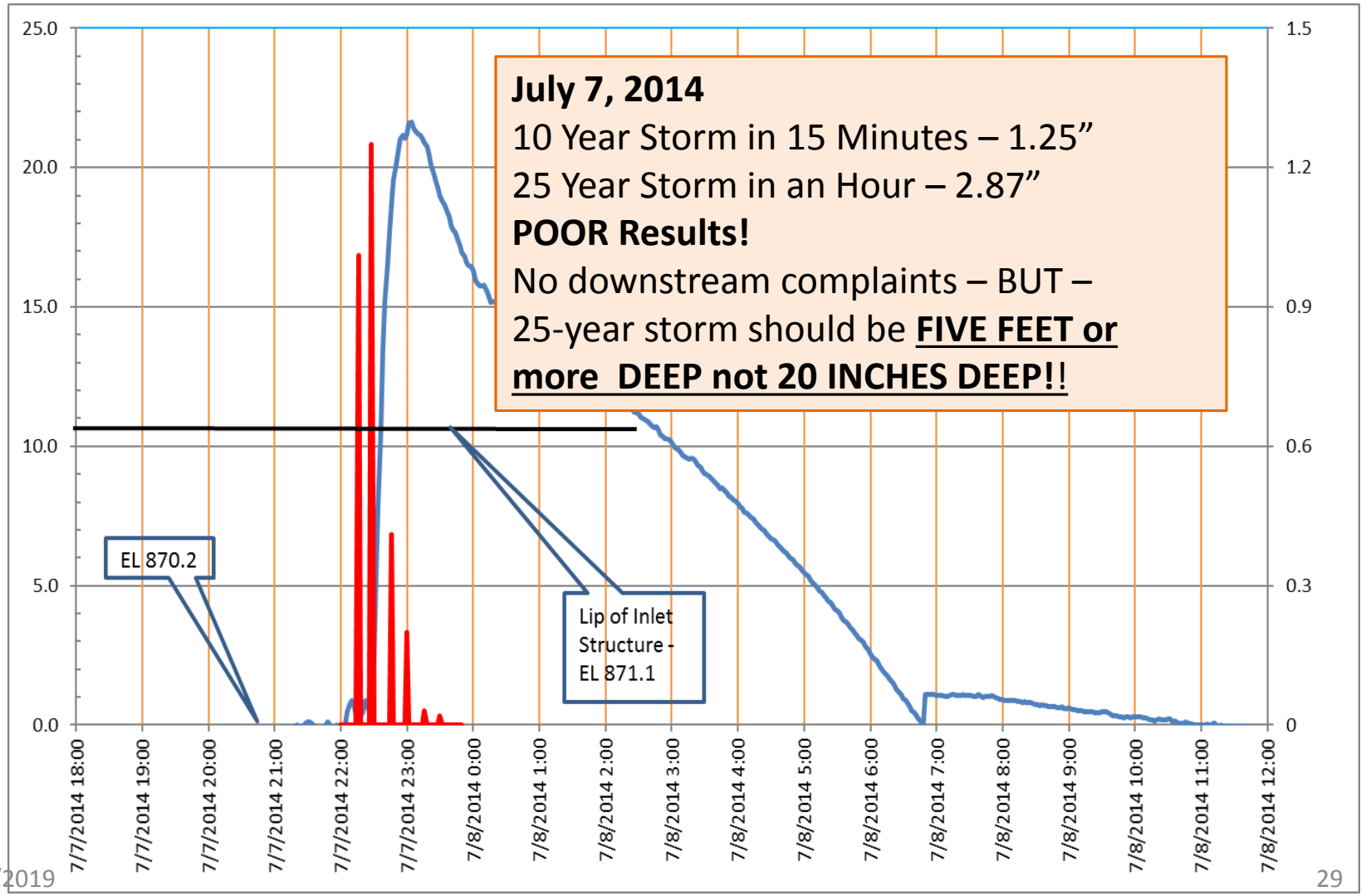
Eagles Detention Basin – July 2015





Eagles – **Actual 25 Year** Detention in 2014

MAYBE NOT!!



Modifying the Basin

This was a city project – so we have a lot of opportunity to make changes

I shared this information with the design engineer as we acquired it. He was interested – that helps!

Working with the engineer – we figured that the underdrains and related systems we had installed to have the bottom of the basin near dry (key to upstream neighborhood support) were way too effective, draining out the inflow quite efficiently! (Worth contemplating how much water can enter a 4” opening!) So we made a few changes:

Modifying the Basin

This was a city project – so we have a lot of opportunity to make changes

First - We capped all of the drains except one and monitored a while. That helped, but was not enough.

Second – We reduced the one remaining opening from 4” to 1.5”. That made a big difference.

Result – Basin now responds more as we “expect” it should.

Next – we may incrementally close the side entrances to the outlet structure.

BETTER RESULTS!

Eagles Detention Basin – 1 Year Storm

June 2015 – One Year Storm

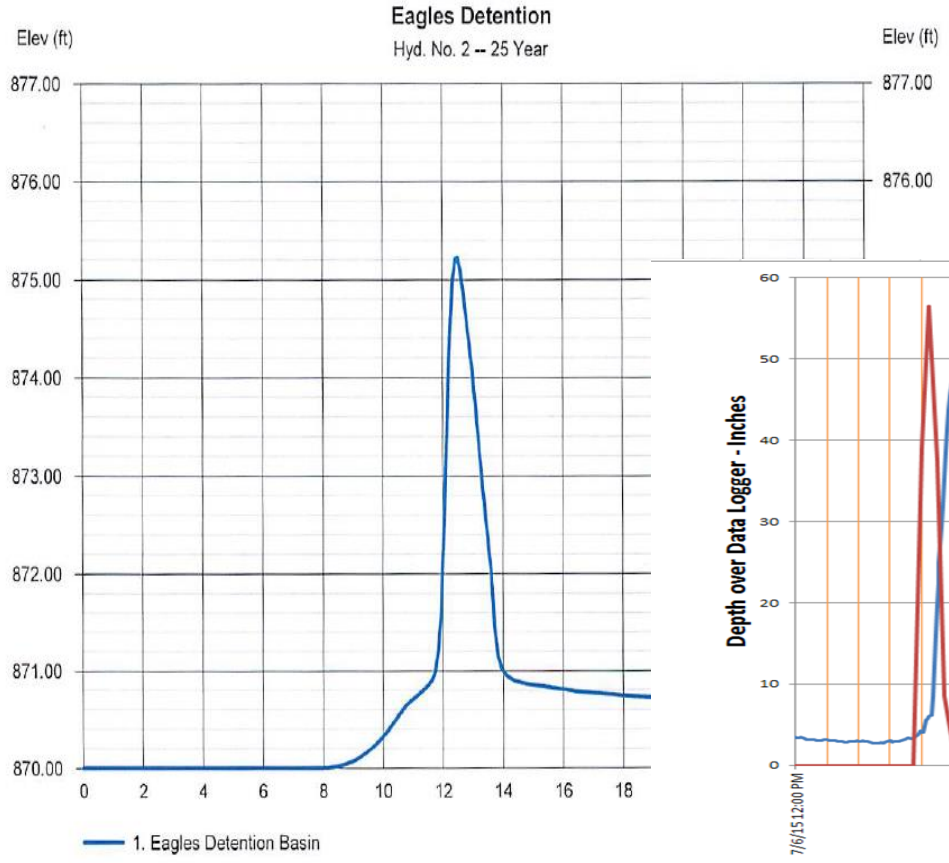
- After modifications we **saw better response** to actual rainfall

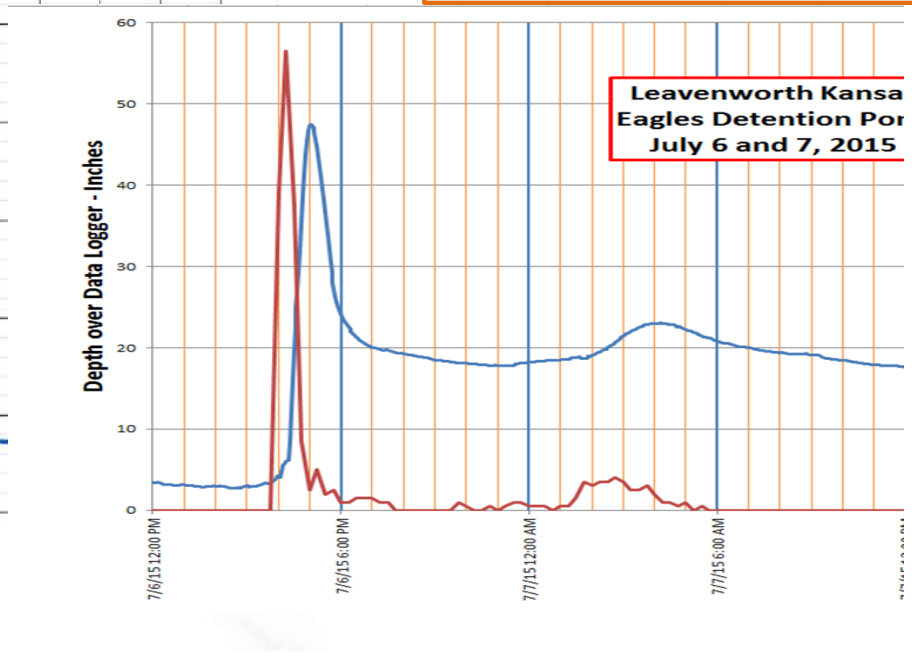
On July 6th 2015 the water was about a foot over the top of the inlet structure shown at left in a 10/25 year storm

Still 2 feet from overtopping the berm!

Still work to be done!

Eagles – July 6, 2015 10/25 Yr Storm



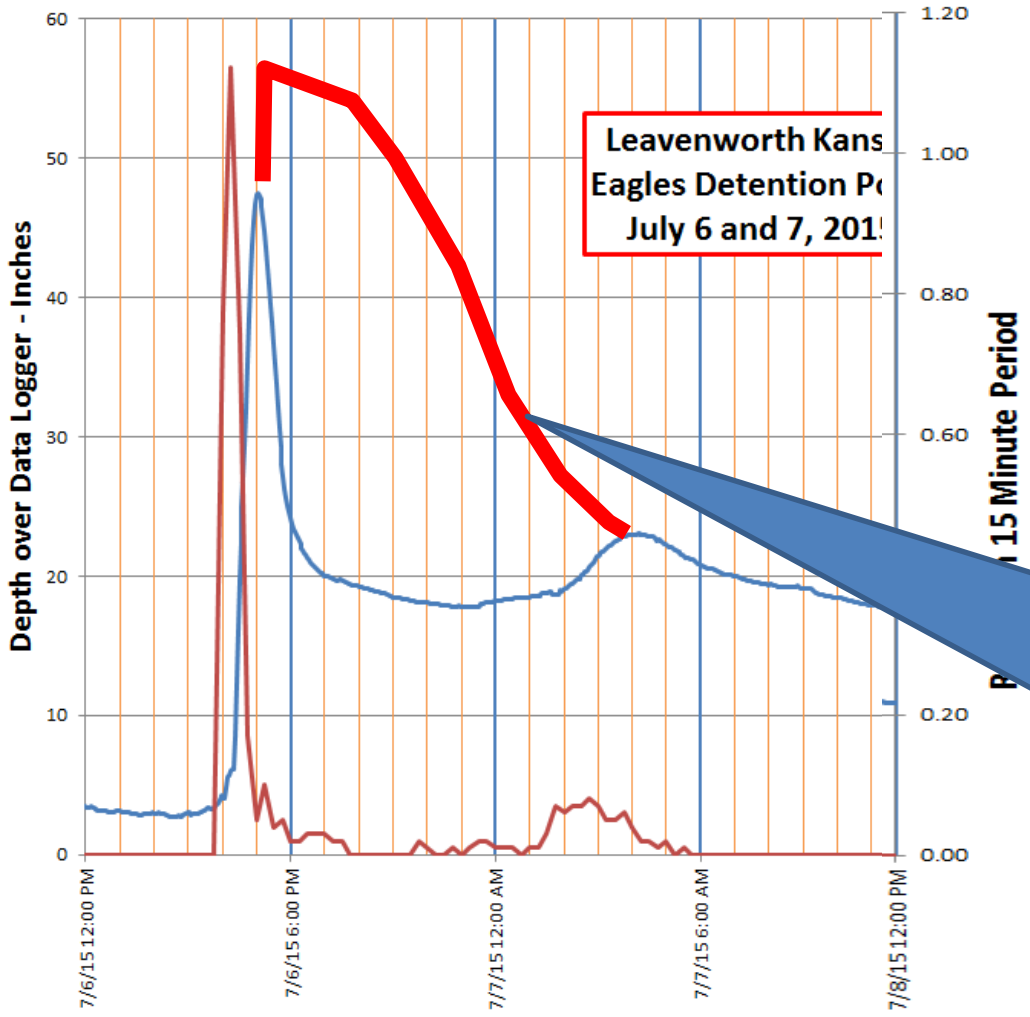


Shows much better response to an intense rainfall event – with the storage reacting very similar to the design.

Still room for changes!

This was a >10, <25 Year event

Detention Basin – Modification Goals based on 2015 data



The rainfall lasted about an hour – about 3" total in July 6 2015 Storm

The peak flows were "detained" about two hours.

This basically worked as intended as there was only minor damage downstream – but – really – it **<u>should work a LOT BETTER</u>**

City is discussing with the designer some modifications to change the curve to something like the red one.
Without data – this discussion would be IMPOSSIBLE!!

Eagles – Results (continued)

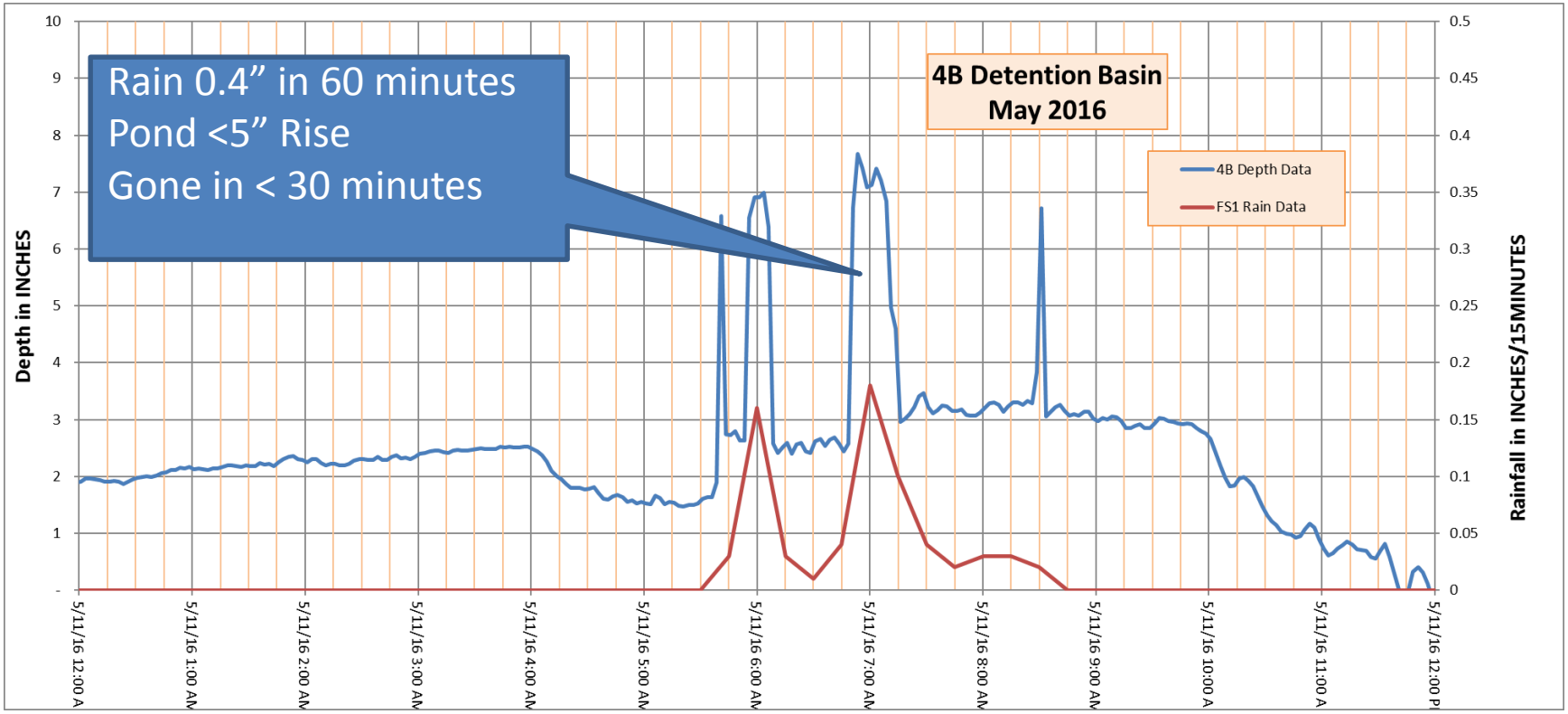
Cooperation is a very important tool!

We were able to work with this designer on subsequent projects, and they were designed to be easily modified or adjusted.

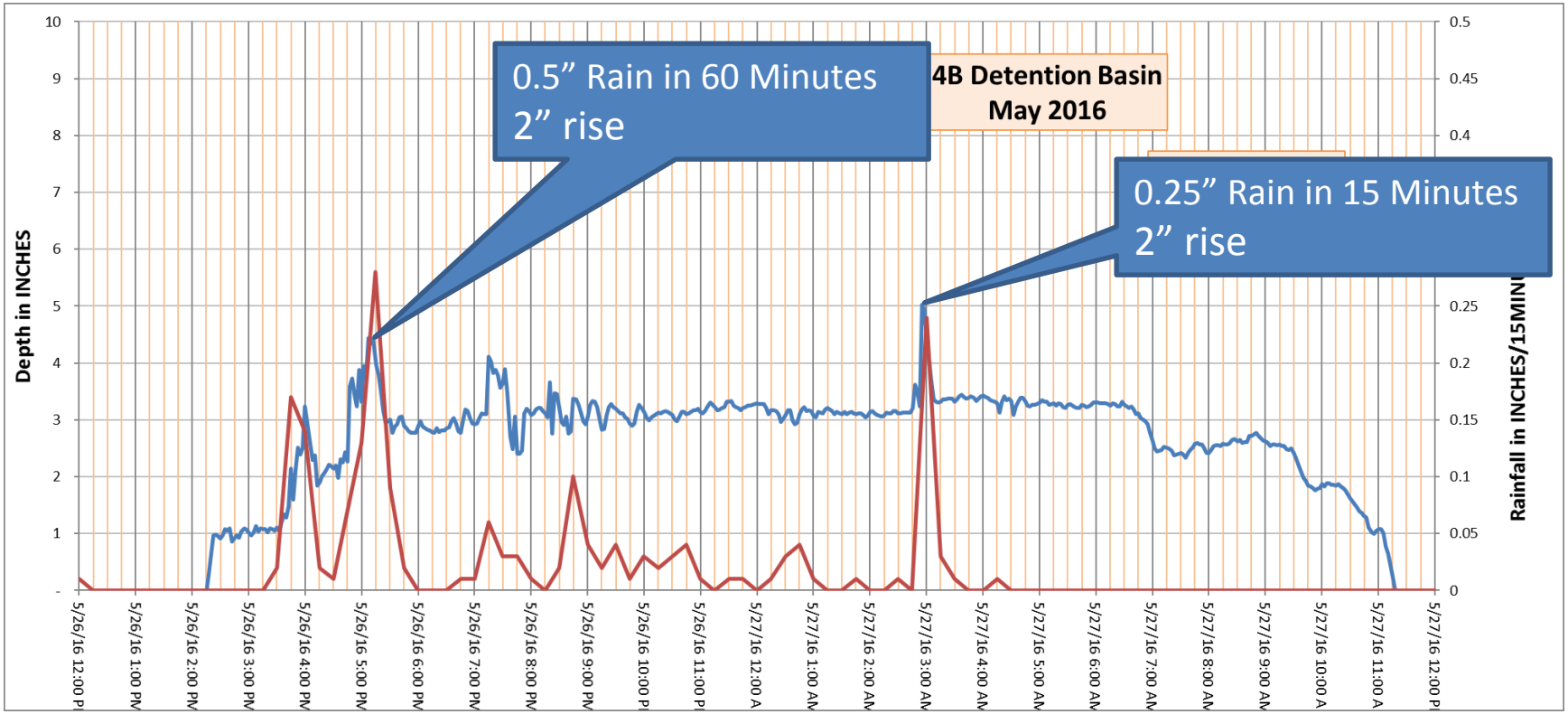
- Need for adjustments was focused on underdrain systems.
- Next project will be able to easily modify opening sizes

3B Detention Basin (2005)
13,000sf Surface, 3.5’ deep

3B Detention Basin, 11 May 2016
Built 2005, 13,000sf Surface, 32.5’ deep



3B Detention Basin, 27 May 2016
Built 2005, 13,000sf Surface, 3.5’ deep

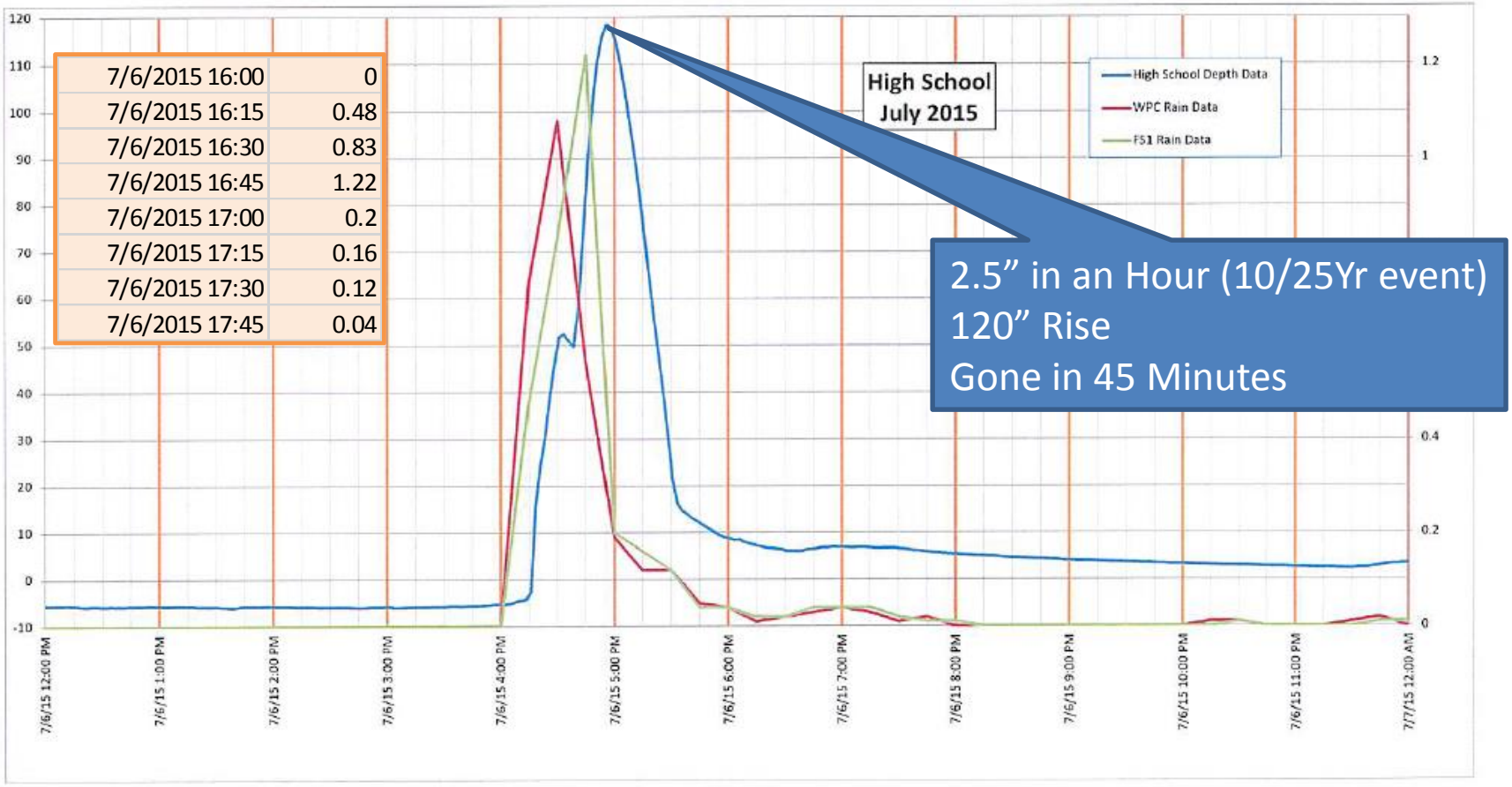


Leavenworth High School - 2011

13,000sf Surface, 13’ Deep

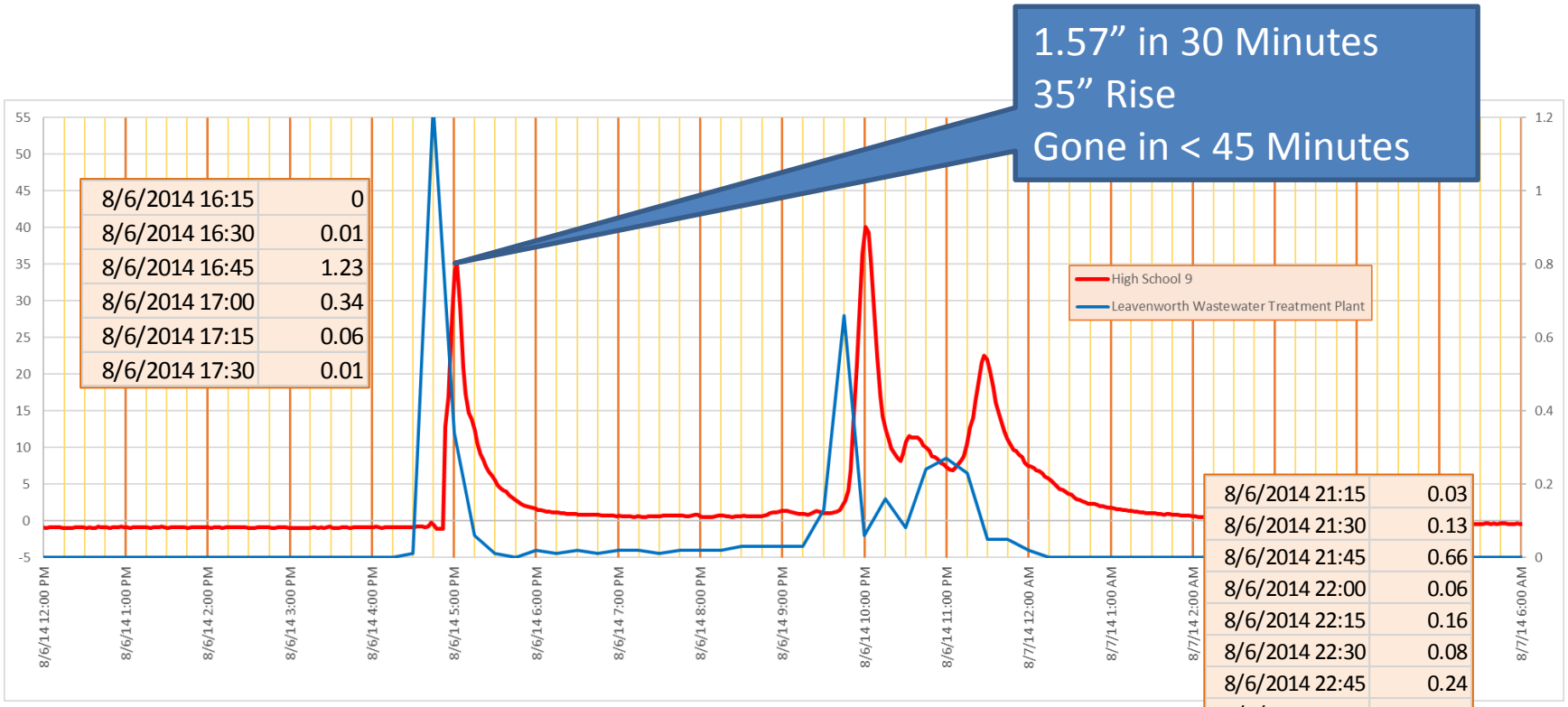
Leavenworth High School – Jul 6, 2015

Built 2011, 13,000sf Surface, 13’ Deep



High School – Aug 6, 2014

Built 2011, 13,000sf Surface, 13’ Deep

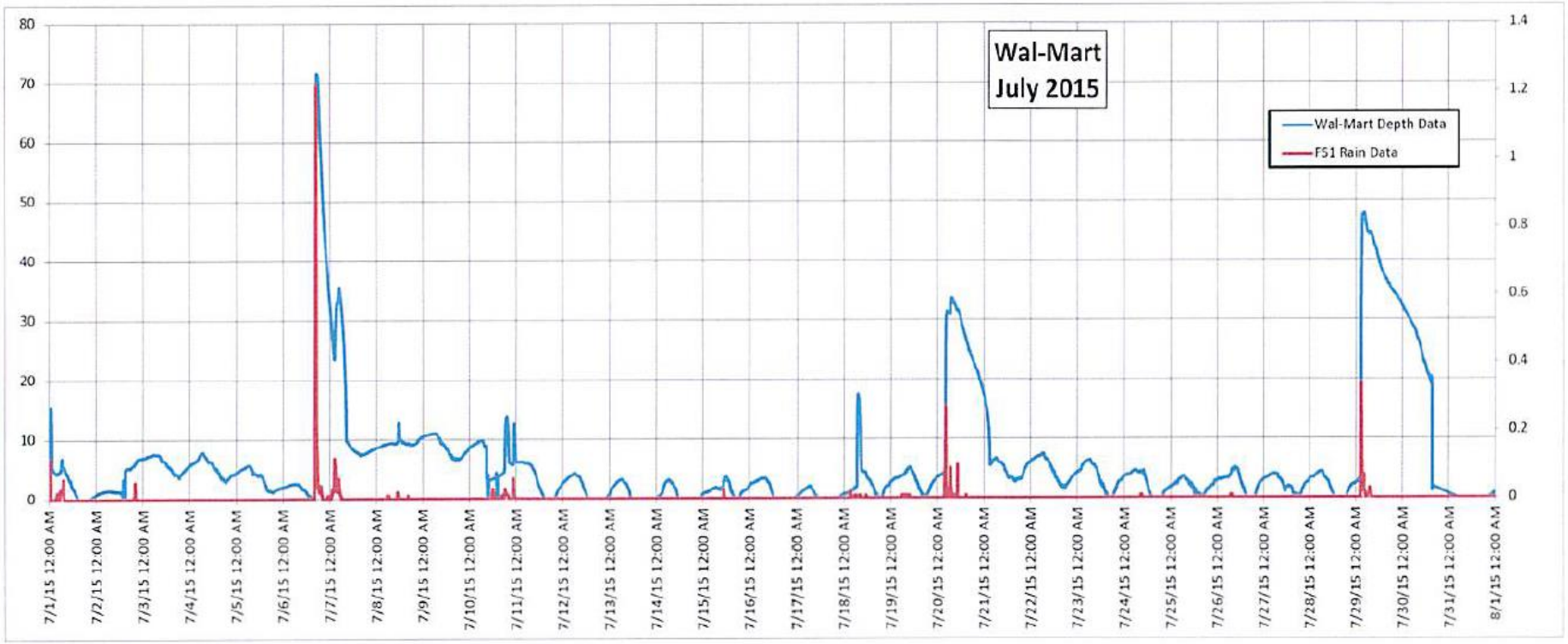


WalMart, 2008

45,000sf Surface, 12’ Deep

WalMart – July 2015

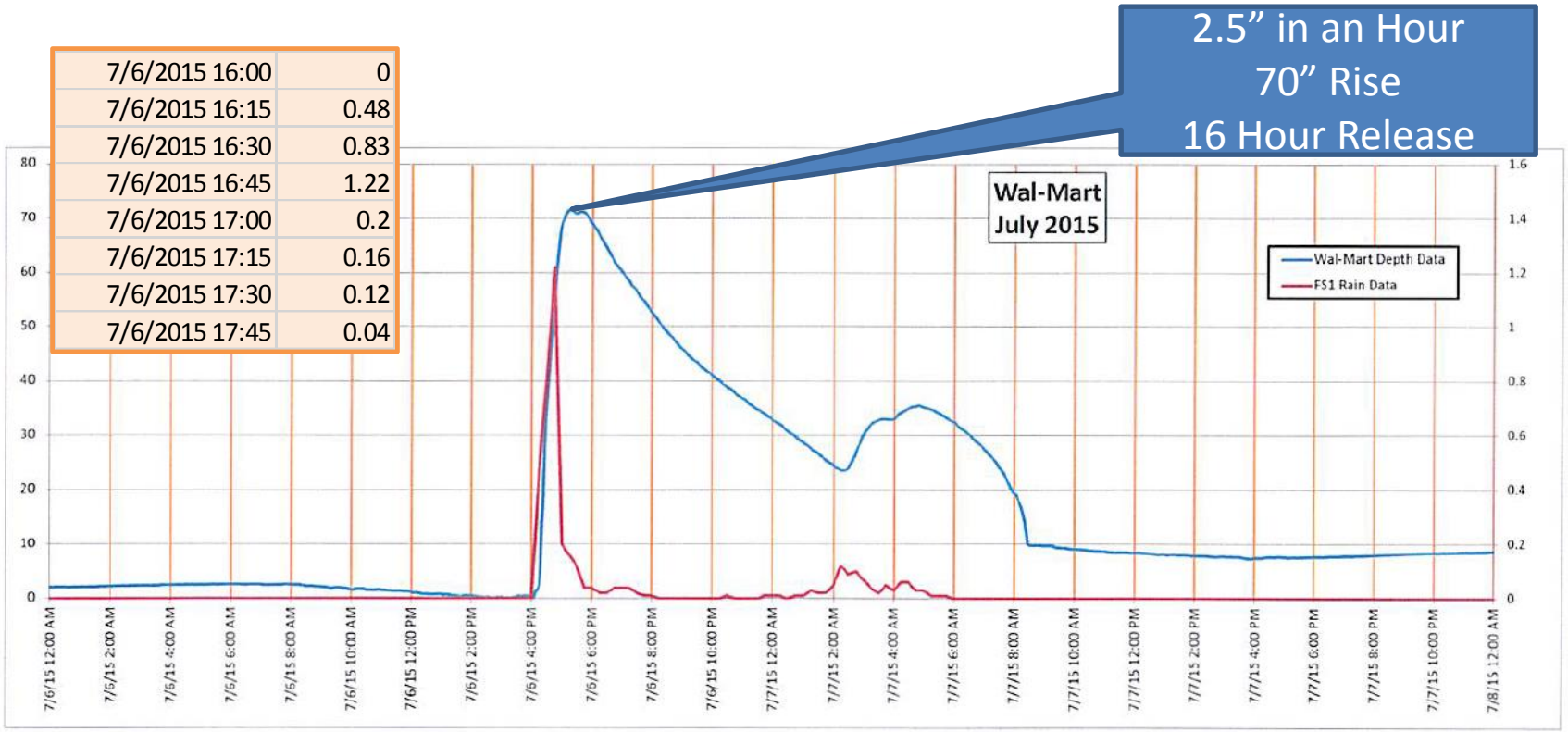
Built 2008, 45,000sf Surface, 12’ Deep



WalMart – Jul 6, 2015

Built 2008, 45,000sf Surface, 12’ Deep

7/6/2015 16:00	0
7/6/2015 16:15	0.48
7/6/2015 16:30	0.83
7/6/2015 16:45	1.22
7/6/2015 17:00	0.2
7/6/2015 17:15	0.16
7/6/2015 17:30	0.12
7/6/2015 17:45	0.04



Results

- Pond performance is not necessarily as expected or as designed, even if it “works”
- Pond performance can be modified
- Ponds can be designed to meet complex expectations

Let's talk **Rainfall**

You really cannot evaluate or design ponds, basins or streams without studying rainfall.

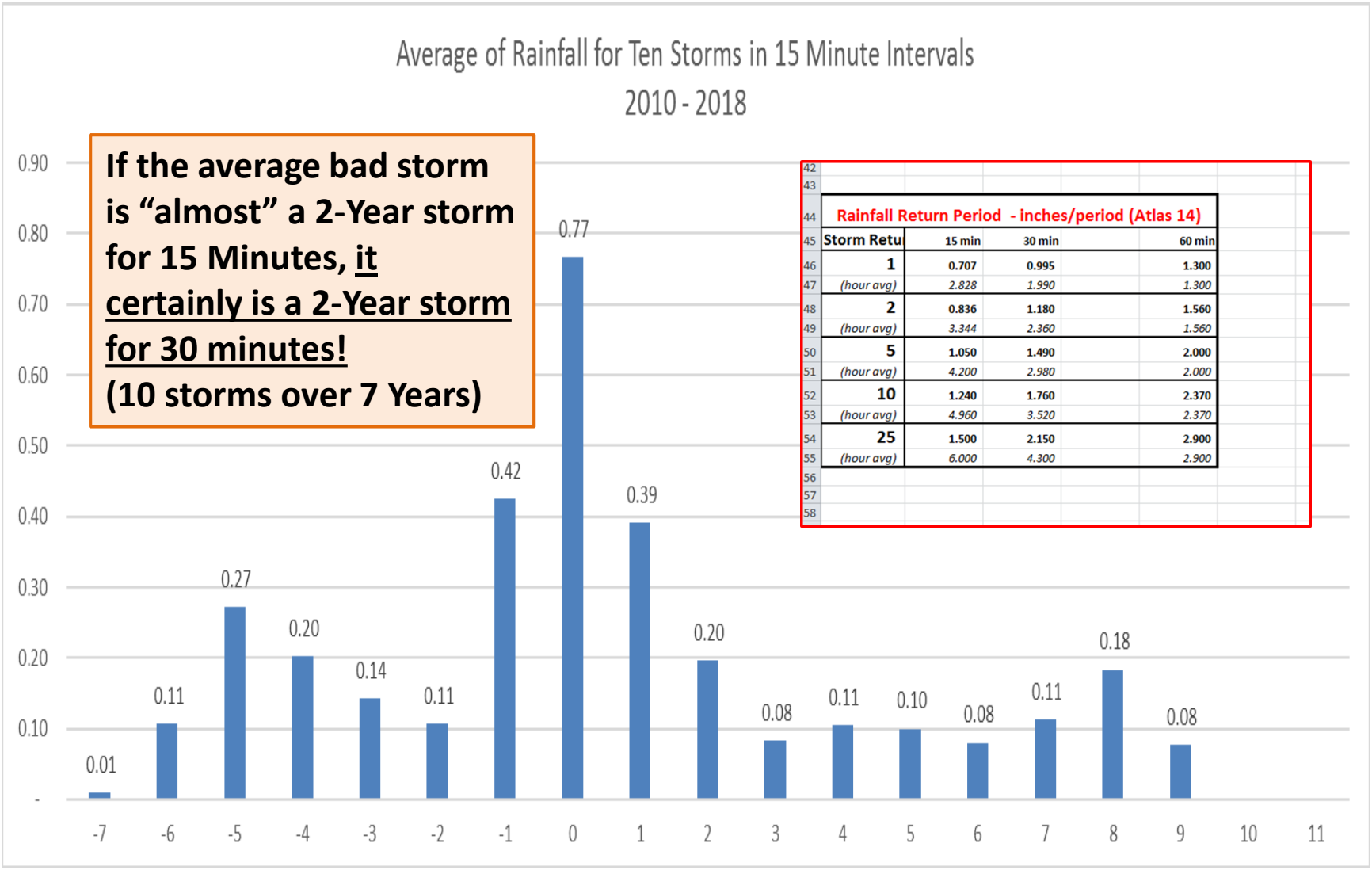
Intensity and timing are the critical elements of rainfall. Much design work is focused on short interval events – up to 15 and 30 minutes time of concentration – real world data is not necessarily as expected from tables

Actual "Time of Concentration" can be determined with basic measurements

Ten Big Storms 2010 – 2018
Data in 15 Minute Intervals
Centered on Peak Interval (green)

Leavenworth Kansas															
Some Rainfall Data															
				Time	1								9	10	11
Average					7/2/2016	8/6/2014	4/29/2012	7/6/2015	5/26/2016	4/26/2016	8/21/2017	8/20/2011	9/10/2015	7/7/2014	
15min	30min	60min													
									-						
									-	-					
0.01				-7					0.01	0.02	-				
0.11				-6					0.21	0.05	0.17	-			
0.27	0.38			-5			0.01		0.42	0.29	0.14	0.50			
0.20	0.47			-4			0.16		0.03	0.24	0.16	0.62	-		
0.14	0.34	0.72		-3			0.34		-	0.15	0.13	0.09			
0.11	0.25	0.72		-2	-		0.61	-	0.02	0.02	0.03	0.06	0.11		
0.42	0.53	0.87		-1	0.12		0.87	0.62	0.30	0.01	0.40	0.15	0.34	1.01	
0.77	**1.19**	1.44		**0**	**0.88**	**1.18**	**0.92**	**0.87**	**0.51**	**0.33**	**0.45**	**0.63**	**0.65**	**1.25**	
0.39	1.16	**1.69**		1	0.34	0.84	0.15	0.66	0.07	0.24	0.37	0.24	0.59	0.41	
0.20	0.59	**1.78**		2	0.46	0.16	0.03	0.31	0.03	0.30	0.03	0.03	0.42	0.2	
0.08	0.28	1.44		3	0.38	0.04		0.05	0.01	0.13	-	0.04	0.07	0.03	
0.11	0.19	0.78		4	0.42			0.10		0.04		0.01	0.04	0.02	
0.10	0.21	0.49		5	0.33					0.02			0.03	0.02	
0.08	0.18	0.37		6	0.25					0.02			0.03	0.02	
0.11	0.19	0.40		7	0.28								0.02	0.04	
0.18	0.30	0.48		8	0.51								0.03	0.01	
0.08	0.26	0.45		9	0.21								0.01	0.01	
	0.08	0.37		10											
	-	0.26		11											
		0.08													

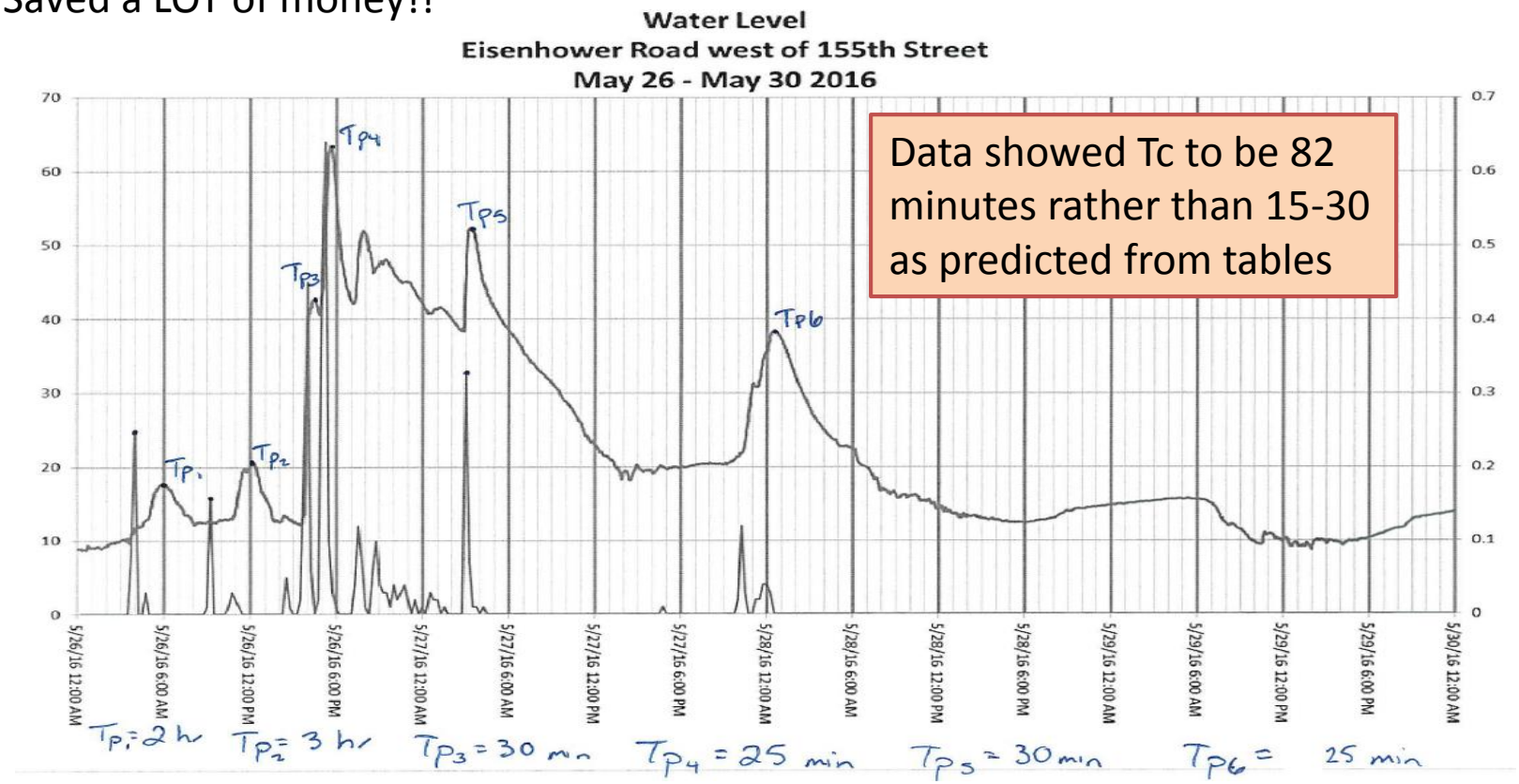
Note Storm Pattern!
7/7/14, 7/6/15, 7/2/16
We got to the point that first week of July was NOT seen as a holiday!



Rainfall Return Period - inches/period (Atlas 14)			
Storm Retu	15 min	30 min	60 min
1	0.707	0.995	1.300
(hour avg)	*2.828*	*1.990*	*1.300*
2	0.836	1.180	1.560
(hour avg)	*3.344*	*2.360*	*1.560*
5	1.050	1.490	2.000
(hour avg)	*4.200*	*2.980*	*2.000*
10	1.240	1.760	2.370
(hour avg)	*4.960*	*3.520*	*2.370*
25	1.500	2.150	2.900
(hour avg)	*6.000*	*4.300*	*2.900*

Real Data to the Rescue

We placed a data logger at a box culvert replacement, got lucky with a few big rains – and here is the Engineers work sheet on Tc. Eventually settled on Tc=82 minutes and HY8 Model which matched existing conditions very well. Saved a LOT of money!!



More Design Stories

- We liked what we were doing and planned ahead for 2017 and 2018 projects with good results.
- City has shared this data with designers of existing ponds and asked “Is it performing as expected”. In most cases there is no response at all. In others – they are very interested.

Things You Can Do

- This type of information gathered over time can lead to creation of stream specific tools such as stage/discharge graphs, hydrographs and other useful things to manage runoff for both quantity **and** quality. There is a wide variation between the calculated volume from stage/discharge graphs and observed conditions
- A smart person can use this information to verify model inputs/outputs with real world data (we are NOT doing this – but will gladly share)

New Initiatives in Leavenworth

- **Written Expectations –** Describe what we are trying to accomplish.
- **Prove Functionality** - We are considering adding a measurement component to permits on large basins.
- **Flexibility** – considering requiring multi-stage outlet structures WITH ability for some adjustments on larger (possibly all) ponds

New Initiatives +

- **Stage v. Discharge and Design Storm for Basins** - We are debating on requiring use of the July 6, 2015 storm (or some/all of the "big ones") as part of the design discussion.
  - Requiring engineers to show how the basin would perform using that rainfall data.
  - We like it because 7/6/15 was a (nearly) 25-year storm, has real rainfall data and now has an institutional memory as well (motivated staff)

“Pond”erments for Us as Engineers

Big Issue – put some thought into designs!

Owners and their representatives (and designers too) need to become familiar with the larger issues of stream health including patterns of erosion, degradation and water quality

Projects built solving one problem can likely be modified to solve several problems at minimal added cost.

“Pond”erments for Us as Engineers

It appears that what has been designed in the past probably met specs (or lack thereof) and meets the definition of success mentioned earlier –

“nobody called or got wet”

We can do better!

“Pond”erments for Us as Engineers

My Thoughts

- Retention and Detention facilities are often over-designed for their intended purpose, providing poor solutions to real problems.
- Efforts to keep the ponds “dry” may adversely impact the time of detention by underestimating efficiency of underground drains.
- “Facilities” (ponds) should be required to be evaluated over time as to meeting design criteria **AND** expectations.
- A Fertile Field exists for agencies and engineers seeking to improve existing facilities to meet todays (better understood) needs and modern regulations.

So - Does it Perform as Designed?

- These things “work”, but often perform poorly/inefficiently - I believe we have shown that an interested staff with an interested engineer can:
  - Monitor performance with low cost instrumentation.
  - make modest modifications to existing structures to achieve better performance.
  - Design better systems targeted toward problem solving rather than simply “following the book.”

Unanswered Questions

- At what point does stringing out the release period of detained water (both high and low flows) for much longer times adversely impact stream health and water quality?
- Could the Eagles Pond have been designed with a laser-focus on solving the problem rather than building a big pond, thereby saving a ton of money?
- Who should be responsible for the costs of retrofitting ponds and structures to meet todays criteria – agencies or owners? And When to modify?
- Rainfall seems headed for longer periods and higher intensity storms – designers and agencies need to look ahead with real data.

Questions?

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Links

- https://www.weatherlink.com/ - weather stations all over everywhere and a decent mobile app
- http://www.wxqa.com/ - Citizen Weather Observer Program
- https://www.wunderground.com/ Weather Underground
- https://www.davisinstruments.com/ - Weather Stations
- https://www.kelleramerica.com/ - Keller Autonomous Data Logger
- https://youtu.be/yIkkAOJMVvk - One of many EXCEL tip videos on YouTube related to working with really big spreadsheets
- If you want to be added to my periodic musings on this and other barely related subject material via a *"poor mans email blog"* – send me an email asking to be added.