City of Farmers Branch Farmers Branch Creek Flow Study 2014

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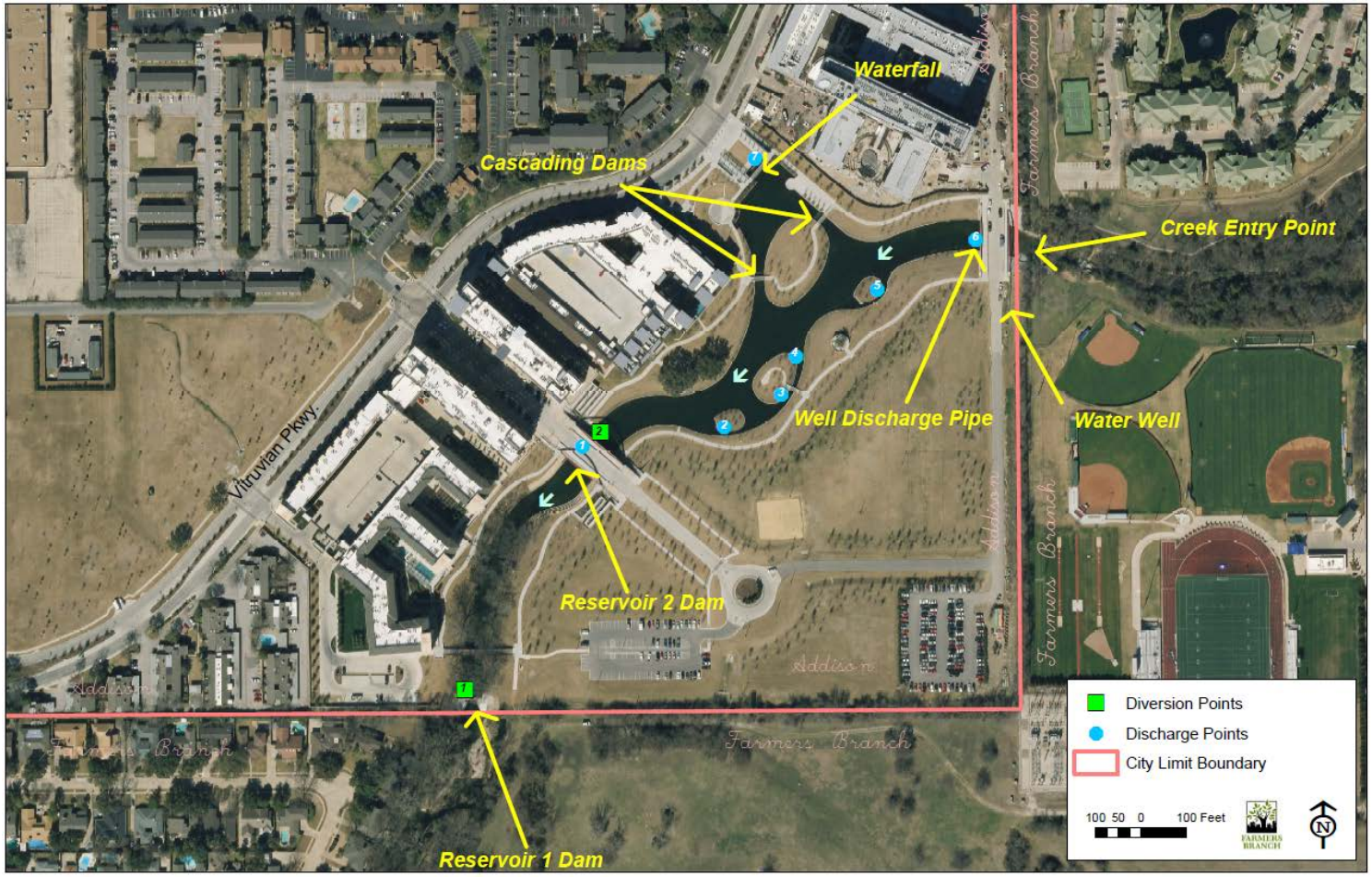
TRC

May 20, 2014

Vitruvian Park



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Results you can rely on

Falls

Falls-Higher Flow

West Cascading Dam-Zero Flow

Reservoir 2 Dam

Reservoir 1 Dam

Scope of Work

- Perform stream discharge measurements to estimate seepage losses
- Estimate all gross evaporation losses
- Develop water quantity budget to replace losses
- Sample groundwater and compare to water quality (WQ) standards
- Evaluate the well and aquifer for quality and quantity needed

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Results you can rely on

Stream Discharge Measurements

- 10 sets of measurements (upstream—Res. 2 inflow, & downstream—Res. 1 dam) over three days
- Groundwater pump and falls turned off
- February 6, 7, 10. Cold, low evaporation
- No losses, only gains, shallow groundwater discharge

Stream Discharge Measurements

Stream Discharge Measurements (flows in cfs)

Data Used*	No. of Sets of Measure-ments	Upstream Average	Downstream Average	Gain	% Gain
All data	10	0.673	0.730	0.057	9%
Excluding increasing flows	7	0.533	0.665	0.131	19%

* Flows increased upstream during the afternoons of February 7 and 10, and the reservoirs were not at steady state. The larger gains calculated excluding those data are considered more accurate.

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Results you can rely on

Gross Lake Evaporation

- 3.06 acres (ac), total of Res 1 + Res 2
- Average 14.6 acre-feet/year (4.7 Mgal/yr)

Evaporation Data Source	Average ac-ft/yr	Max Year ac-ft/yr	Min Year ac-ft/yr	Annual Average GW Pump Rate gpm	Max Month GW Pump Rate gpm	Month
TWDB Quad 511 (1954-2012)	14.6	19.4	12.2	9.0	21.5	Jul 1956
Grapevine-TWDB coefs. (1982-2013)	14.6	17.7	12.6	9.1	20.5	Jul 1998
Grapevine-USACE coefs. (1982-2013)	16.0	19.5	13.8	9.9	23.4	Aug 1999

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Enhanced Evaporation

- Kinetic energy -> heat energy (negligible)
- Enhanced: additional surface area from falls/dams
  - Similar to cooling tower
  - Proportional to heat transfer surface area
  - Additional area: “front,” “back,” droplets
  - Estimated at 2.5 times primary surface area
  - 1,317 sq. ft. X 2.5 = 3,292 sq. ft. = 0.08 ac
  - 3.06 + 0.08 = 3.14 ac effective area
  - Additional 0.38 ac-ft average annual loss

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Forced Evaporation

- Forced: addition of heat from concrete - solar gain. Falls and cascading dams only.
- Applicable model for power plants with once-through cooling
- Temperature measurements at falls and cascading dams taken on sunny days March 10-18
- 0.7 °F rise from nozzles to above base of falls, 0.3 °F at cascading dams
- Evaporative cooling ignored – conservative

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Results you can rely on

Forced Evaporation

- Modeled monthly
  - Average DFW meteorological data
  - Average surface water temp Grapevine Lake
  - 982 gpm (design flow for falls/cascading dams)
  - Average annual losses 0.13 ac-ft

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Results you can rely on

Forced Evaporation

Month	Main Waterfall	Cascading Dams	Total
January	583	1,000	1,584
February	592	1,015	1,607
March	989	1,696	2,686
April	1,269	2,176	3,445
May	1,463	2,508	3,972
June	1,930	3,309	5,239
July	2,216	3,798	6,014
August	2,026	3,474	5,500
September	1,553	2,662	4,215
October	1,244	2,132	3,375
November	846	1,451	2,297
December	625	1,071	1,696
TOTAL GAL	15,337	26,292	41,629
TOTAL AC-FT	0.05	0.08	**0.13**

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Results you can rely on

Evaporation Summary

Ac-Ft	gpm	Source
14.57	9.02	Average Annual Lake Evaporation
0.38	0.24	Average Annual Enhanced Evaporation
0.13	0.08	Average Annual Forced Evaporation
15.08	9.34	Total Average Annual Evaporation Losses

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Water Quantity Budget – Future Make-up

- Real-time evaporation pan data from Grapevine Lake (13 miles away) http://www.swf-wc.usace.army.mil/reports/GPVT2_b92.pdf
- Table with pan data yielding amount of make-up water required. Lake + enhanced + forced

	Make-up Groundwater Required, gallons											
Grapevine Lake Pan Evaporation inches	January	February	March	April	May	June	July	August	September	October	November	December
0.01	2,215	2,212	3,282	4,025	4,492	5,818	6,611	6,106	4,846	4,040	2,987	2,361
0.02	2,845	2,818	3,879	4,605	5,012	6,398	7,208	6,711	5,477	4,705	3,678	3,027

TRC Results you can rely on

Water Quantity Budget – Historical Make-up

Impoundment began late 2010-early 2011.
(3/24/2011. Impounded water, no outflow)

Water Quantity Budget – Historical Make-up

3/29/2011. Creek below Dam 1. No flow.

Water Quantity Budget – Historical Make-up

Inflow 4/13/2011. State water impounded.

Water Quantity Budget – Historical Make-up

- Impoundment began late 2010-early 2011
- Water Use Permit 5383A issued 5/20/2011
- Groundwater pumping began 8/6/2012
- 2/2011 through 12/2013 reconciliation:

  11.0 ac-ft initial filling

  + 47.6 evaporative losses

  = 58.6 required

  - 34.3 pumped

  = 24.3 ac-ft short (7.9 million gal.)

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Groundwater Quality

- Woodbine Aquifer. Three samples collected.

Parameter	Values in mg/L , Except as Noted			
Date-Time	2/6/14 16:40	2/7/14 14:50	2/10/14 16:00	WQ Stds.*
pH, units	7.93	8.00	8.07	6.5-9.0
Dissolved Oxygen	**3.5**	**4.2**	**4.2**	5.0
Tot. Diss. Solids	**2010**	**2110**	**2390**	500
Chloride	**578**	**573**	**567**	80
Sulfate	**444**	**436**	**428**	60

*Texas Surface Water Quality Standards, Segment No. 0822 (30 TAC Chapter 307)

- Water right says Trinity Aquifer (~600 TDS), not Woodbine

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Groundwater Quantity

- Modeling performed
- Required
  - 9.3 gpm average
  - 22.2 gpm peak month
- Well pumps at 32 gpm
- Aquifer is capable of producing more than peak required over long term

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Conclusions

- Gaining stream, no seepage losses. Springs from shallow groundwater, not Woodbine
- Grapevine pan data reasonable to use
- Average losses (lake surface + enhanced + forced evaporation) = 15.08 ac-ft/yr
- Make-up from losses determined from Grapevine real-time data and table
- State water impounded initially, contrary to permit

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Conclusions - 2

- Groundwater not pumped for 1-2 years after impoundment began. Downstream flow reduced or ceased.
- 23.4 ac-ft short in pumping through end of 2013
- Well in Woodbine, supposed to be Trinity. Lower WQ, does not meet standards.
- Well and aquifer capable of producing required volumes

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Recommendations

1. Grapevine Lake evaporation pan data should be used on a real-time basis to determine the amount of make-up groundwater required.
2. An effective surface area of 3.14 acres plus average monthly values of forced evaporation should be used to calculate total evaporative losses.
3. Total evaporation losses and groundwater pumped should be reconciled on at least a weekly basis to maintain streamflows downstream of the reservoirs.

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Results you can rely on

Recommendations - 2

4. Woodbine Aquifer well should be discontinued. New well should be installed in the Trinity Aquifer. Water testing should be performed prior to completing the well to assure acceptable quality.
5. Higher-capacity pump should be considered. Should the pump require servicing and be taken out of service for a period of time, additional water would need to be pumped to make up the losses accumulated during the down time.

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Results you can rely on

Recommendations - 3

6. Compliance with the terms of Water Use Permit No. 5383A would best be evaluated by a qualified water rights attorney.

Questions?

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