Santa Fe Calvada Mine

Final Closure of a Heap Leach Facility

Case Study in Design and Construction of E-cells

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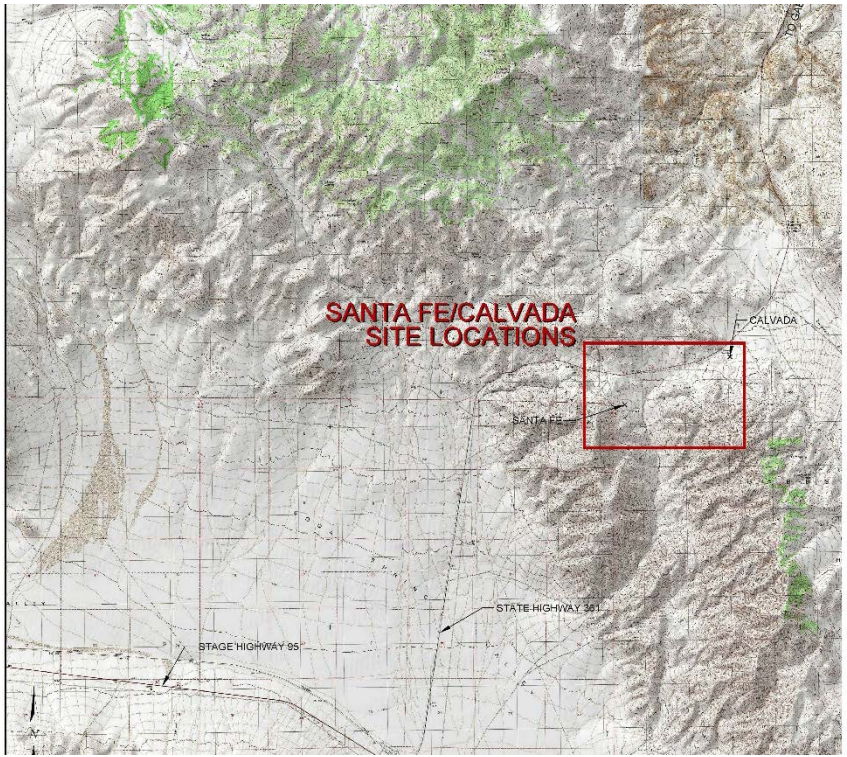
Site Location



Location with Surrounding Topography

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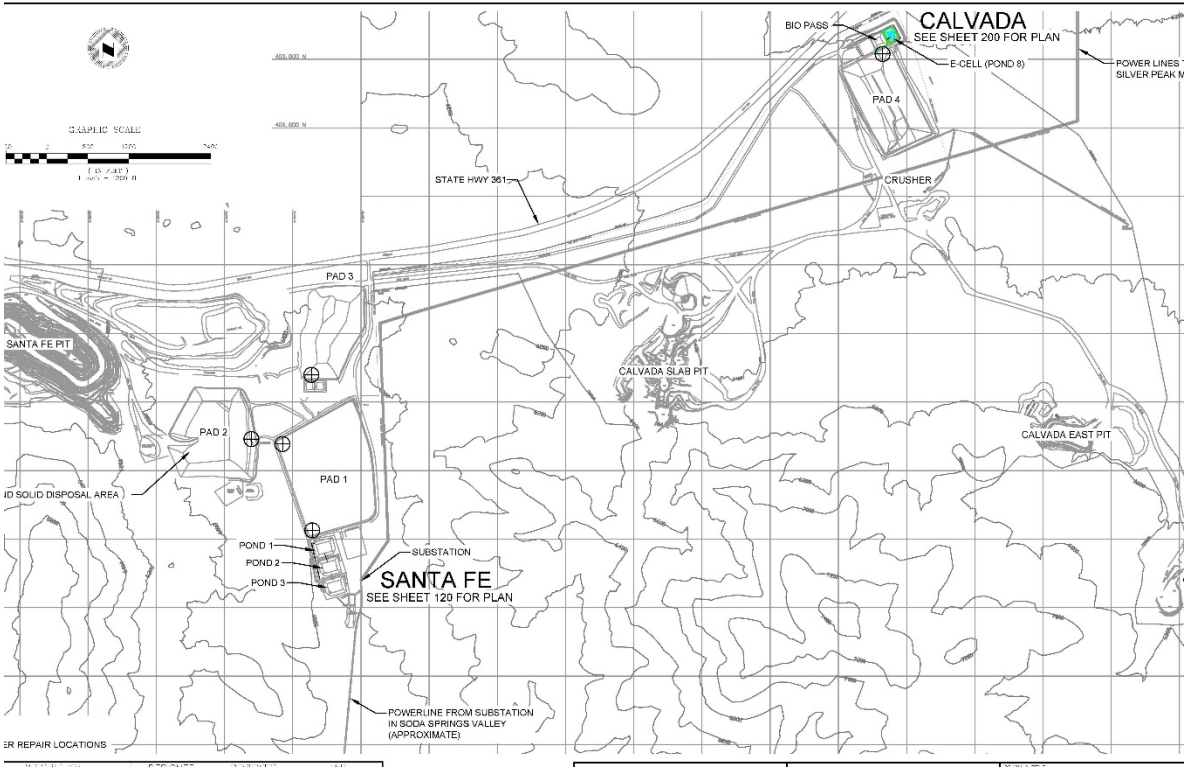

Overall Site Layout

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Google Earth View

History

- Mining started in 1998 and continued through 1993.
- Leaching and processing continued into 1995.
- Waste rock dumps reclaimed 1991 through 1994.
- Leach pads reclaimed 1997 through 1998.
- Leach pads re-graded to 3 to 1
- 8 inches of growth media applied
- Ore has enough clay to act as a store and release cover.

Santa Fe

- Pad 1 45 acres, 7.3 Mtons crushed ore stacked to a height of 100 feet.
- Pad 2 39 acres 3.8 Mtons crushed ore staked to a height of 80 feet.
- Pad 3 30 acres, 2.8 Mtons run of mine ore stacked to a height of 90 feet.
- Pad 1 and 2 shared ponds, Pad 3 had separate ponds, All 3 pads tied together at closure

Calvada

- Pad 4, 30 acres, 3.8 Mtons crushed ore stacked to a height of 110 feet
- Run of mine ore taken to Santa Fe Pad 2
- All Solution processed at Santa Fe Process Plant

Santa Fe Pad 1 and Pad 2 vegetation to compare with native vegetation in foreground

Santa Fe Pad 1 and Pad 3 reclaimed condition

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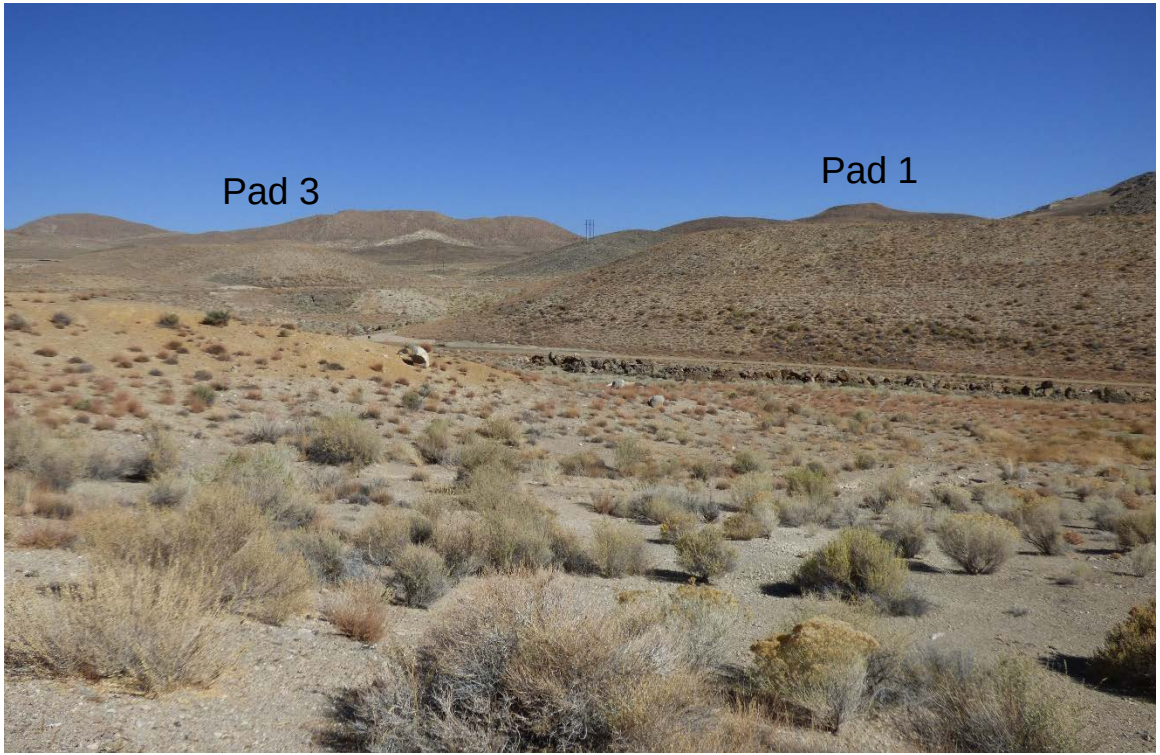

Santa Fe Pad 1 and Pad 3

Calvada Pad 4

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Santa Fe Pad 1 Southwest corner observation cut

Calvada pond level typically stayed at this level

Santa Fe at about max inventory

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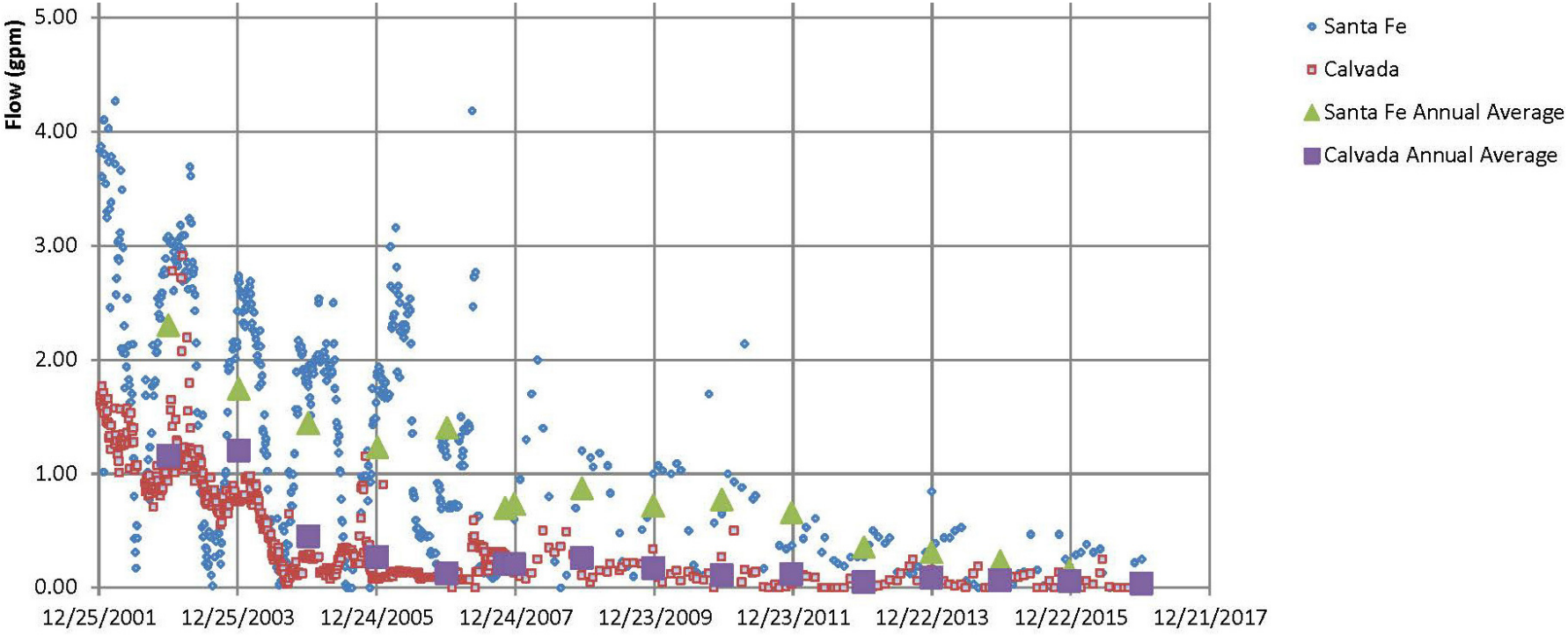
Santa Fe west pond slope with protective rip rap

Month	Precipitation (in.)[1]	Potential Evaporation (in.)[2]
January	0.61	0.00
February	0.56	0.00
March	0.58	2.47
April	0.71	4.93
May	0.93	7.20
June	0.52	8.70
July	0.55	10.15
August	0.52	9.38
September	0.41	6.70
October	0.56	4.05
November	0.43	1.43
December	0.53	0.00
Total	**6.91**	**55.01**

Climate

Drain Down Rates



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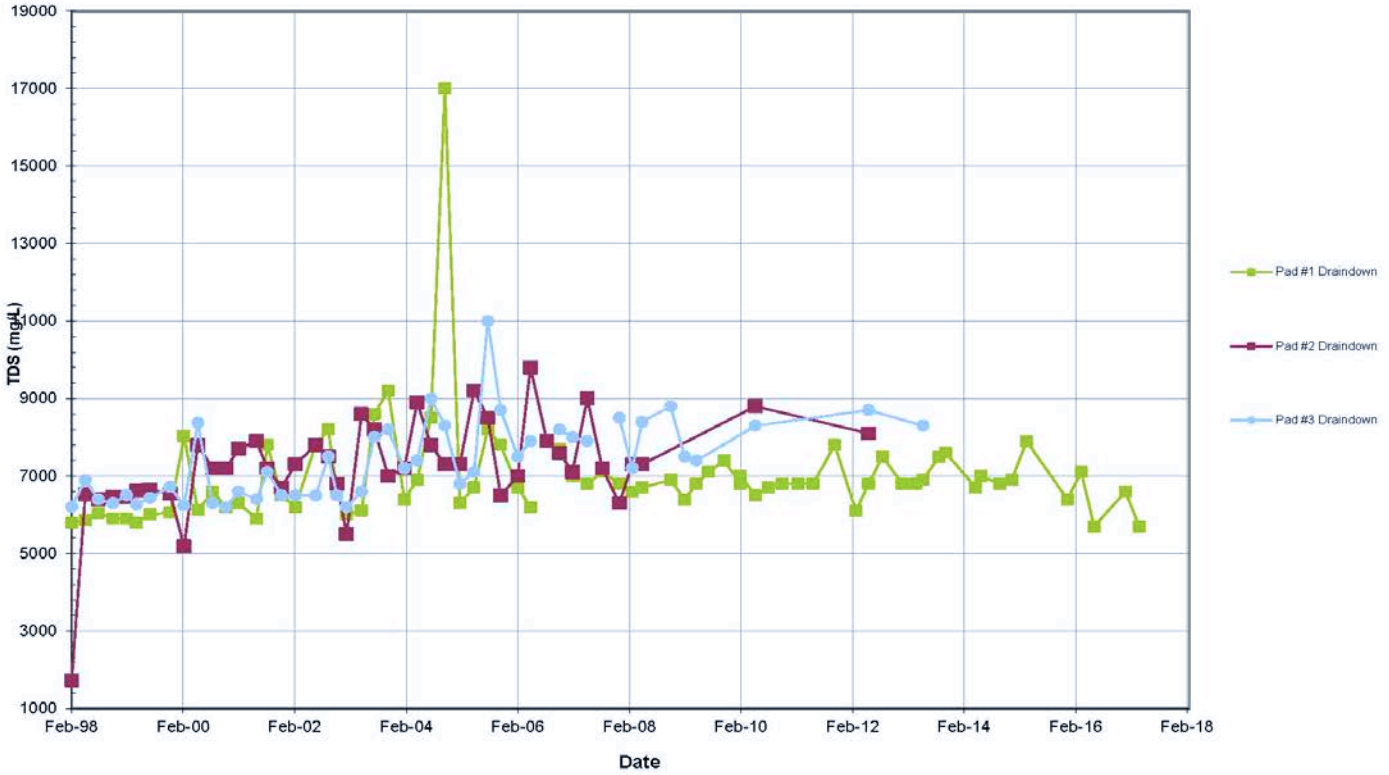

Santa Fe TDS

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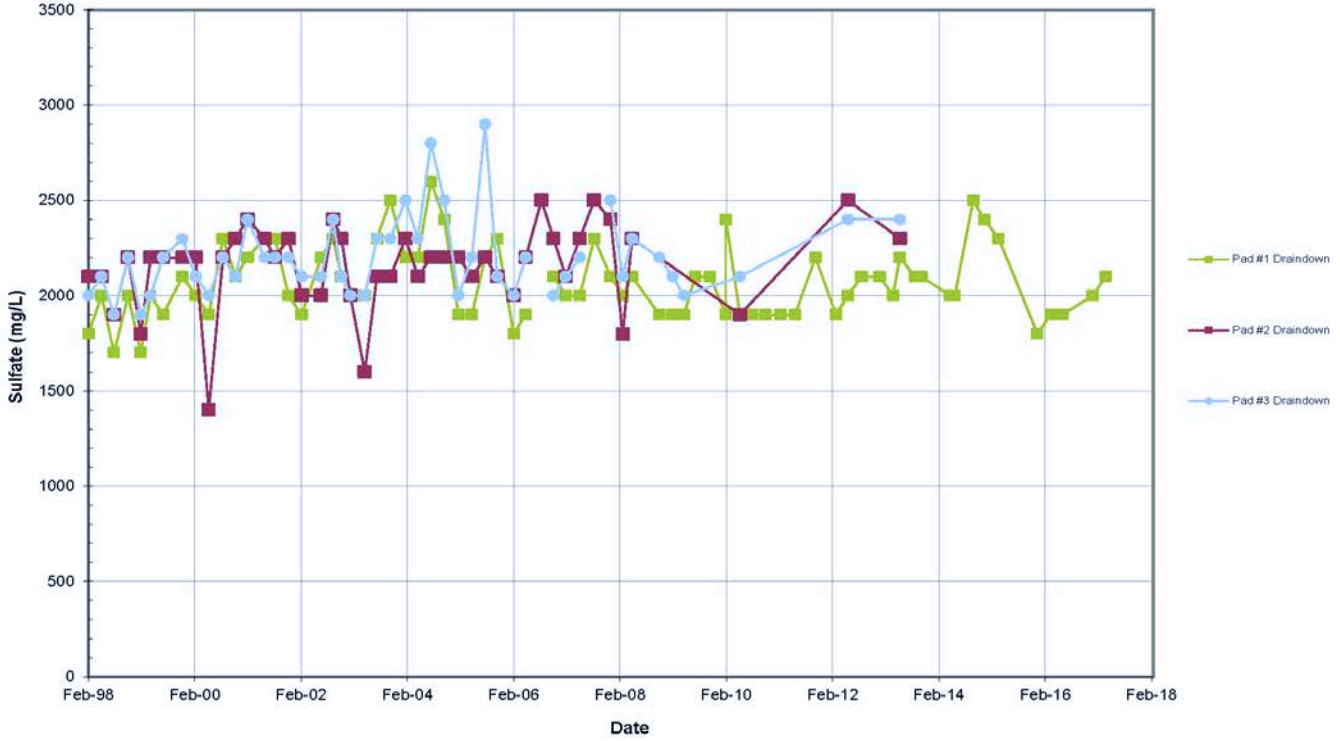

Santa Fe Sulfate

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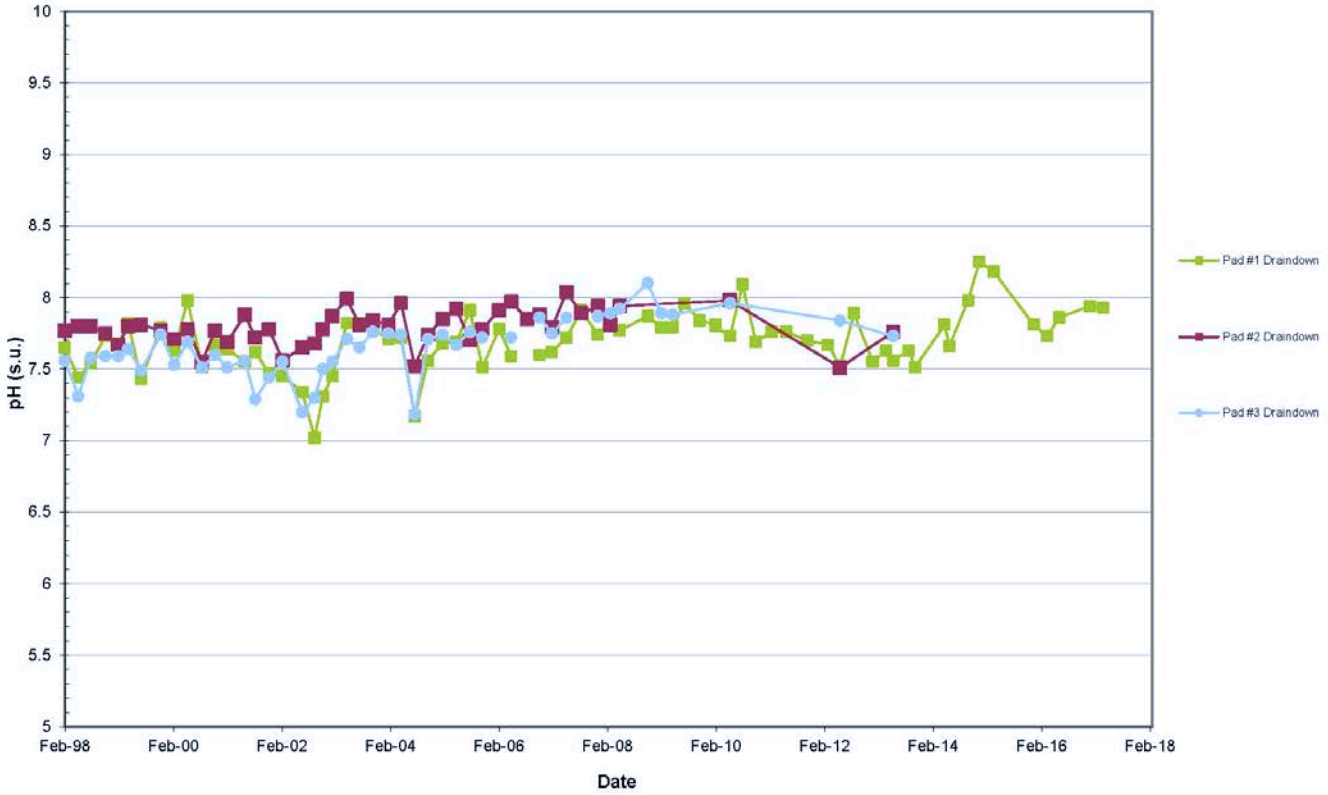
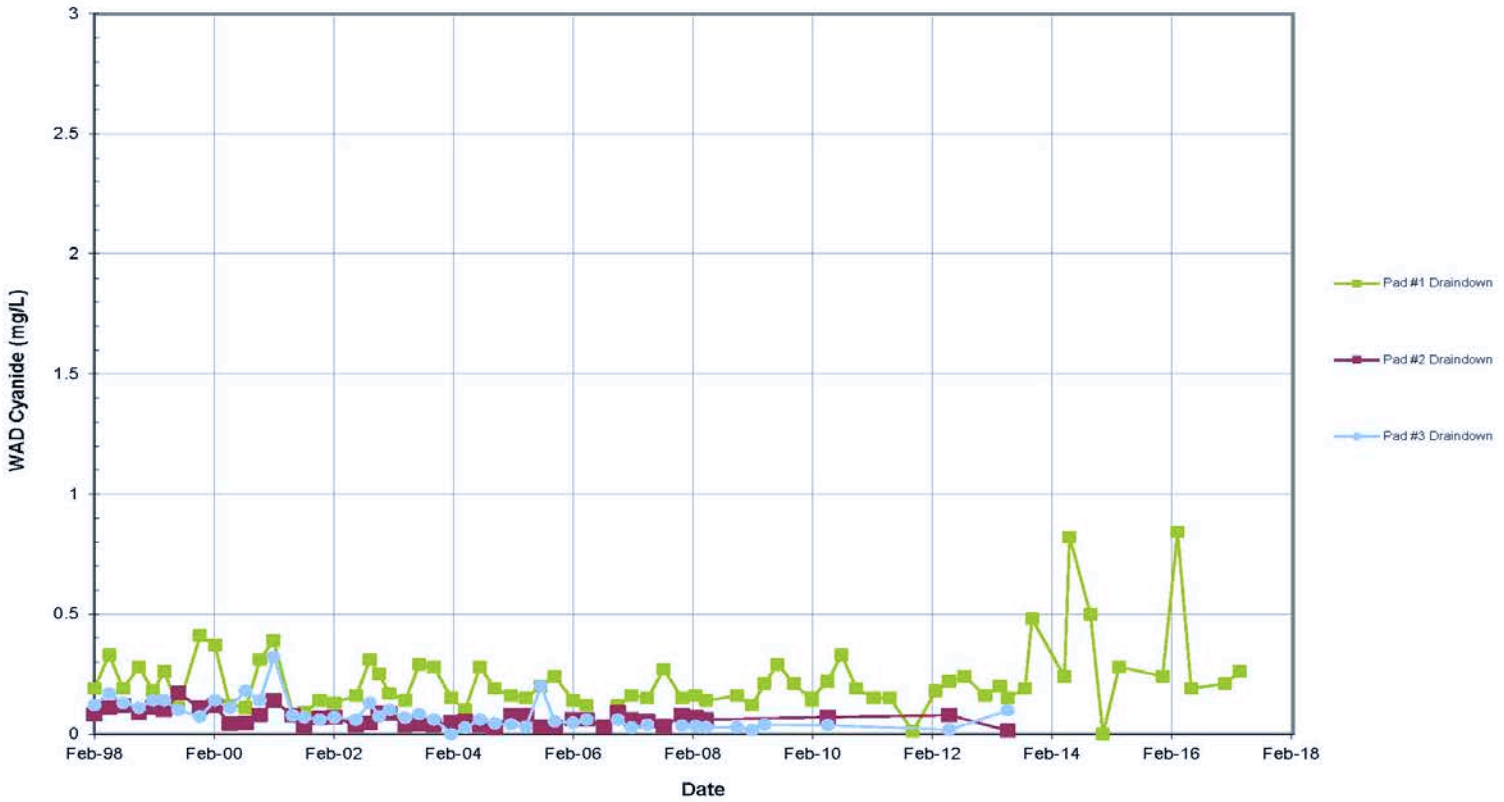

10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
pH (s.u.)
Feb-98
Feb-00
Feb-02
Feb-04
Feb-06
Feb-08
Feb-10
Feb-12
Feb-14
Feb-16
Feb-18
Date
Pad #1 Draindown
Pad #2 Draindown
Pad #3 Draindown

Santa Fe pH



Santa Fe Cyanide

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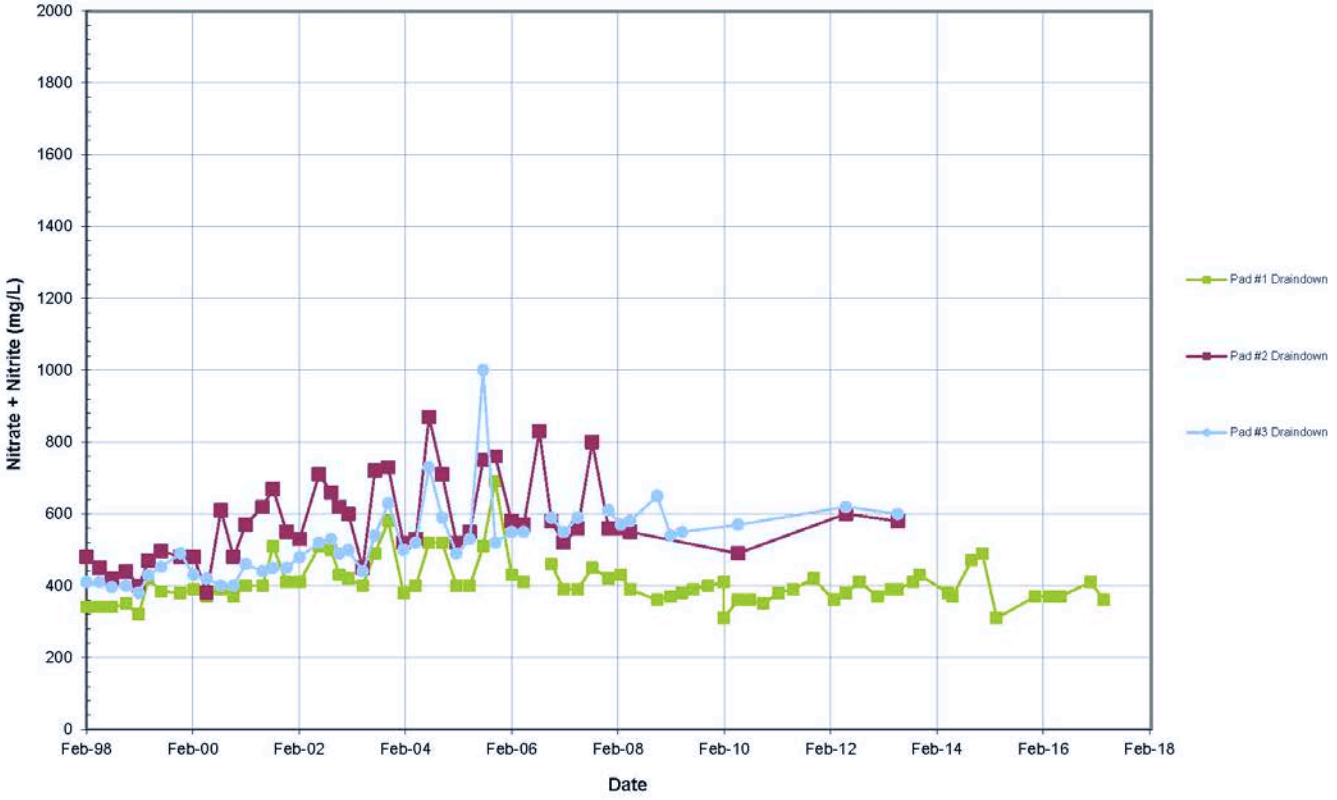
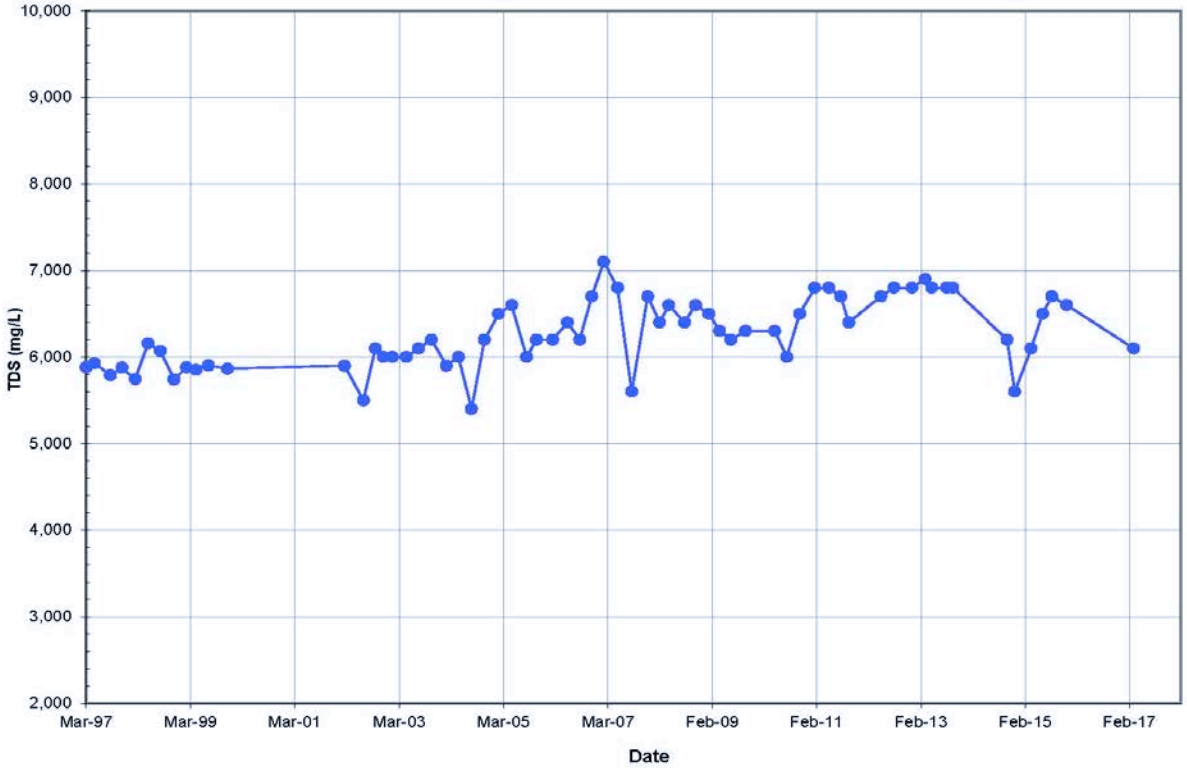
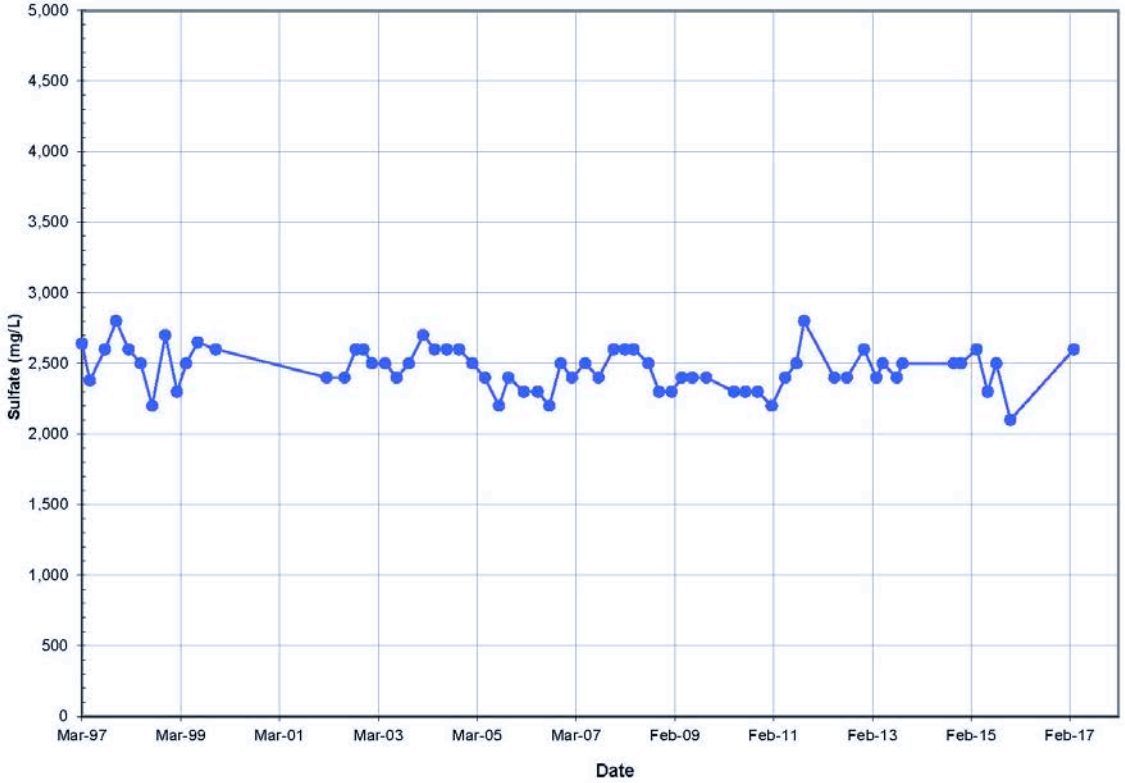


Santa Fe Nitrates



Calvada Fe TDS



Calvada Fe Sulfate

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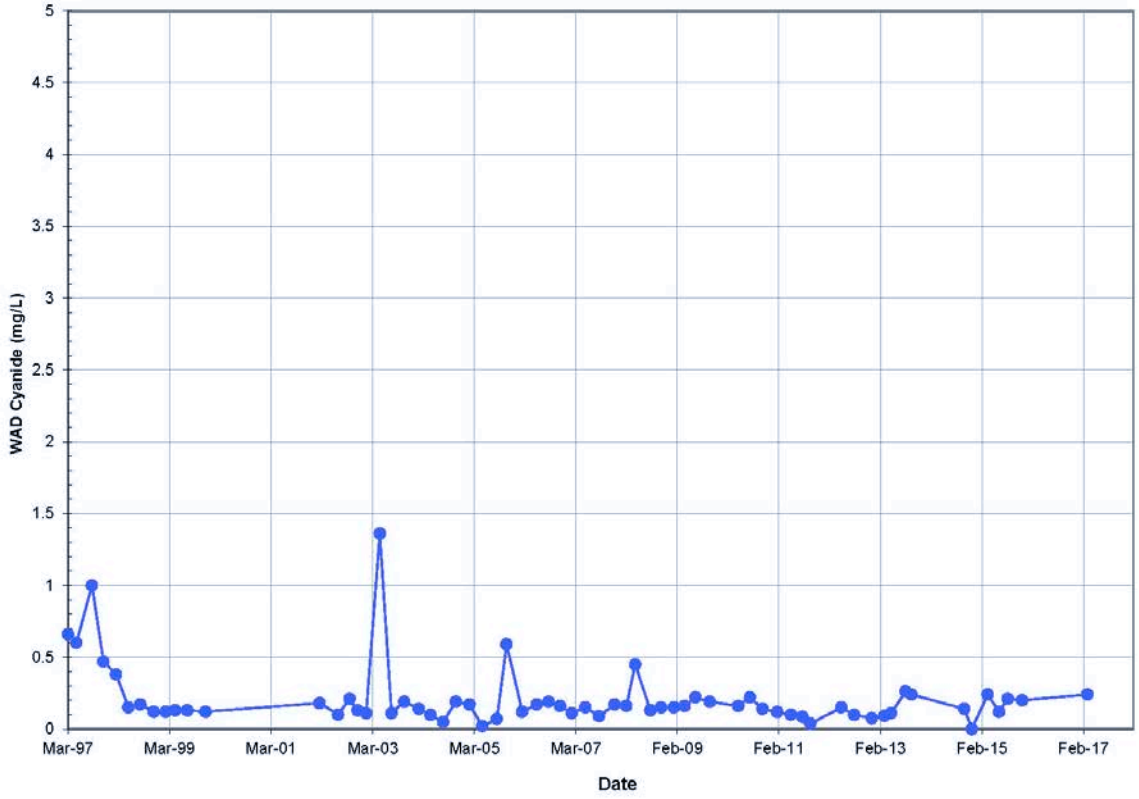
Calvada Fe pH



Calvada Cyanide

Calvada Fe Nitrates

Design Criteria

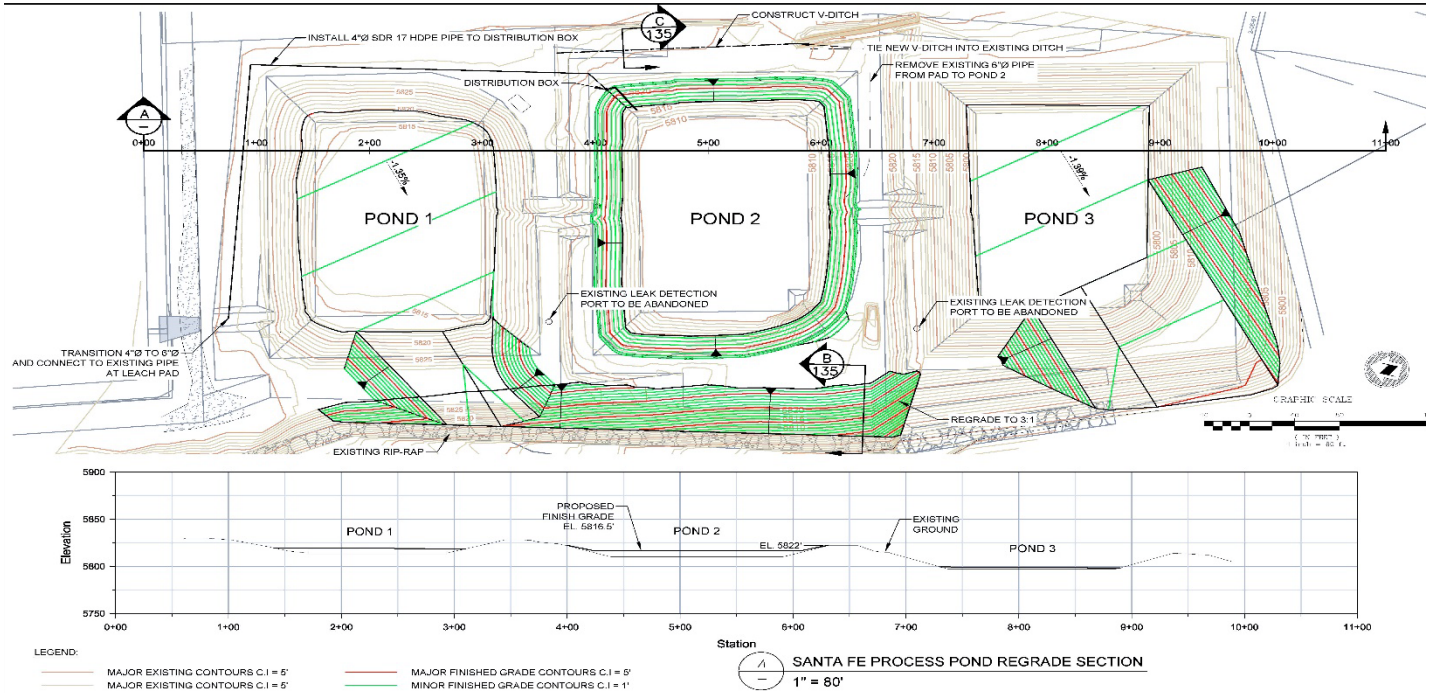
- Passive system with minimal maintenance
- Minimize expression of surface water
- Robust for longevity
- Contain the 500 year storm event
- Minimize disturbance of reclaimed facilities
- Minimize new disturbance

Systems Considered

- Infiltration Galleries - Eliminated due to poor water quality, cyanide kicks and possible quick transport to ground water. Zero discharge added to design criteria.
- ET Cells - Eliminated due to poor water quality limiting plant growth
- Open E-cells - Eliminated due to exposed liner having short life and always having a free water surface.
- Open E-cell with partial soil fill – Selected

Design

- Partially filled one pond at each side and double lined the resulting shallow basin with 80-mil primary over 60-mil secondary liner with geo-net in between.
- Leak detection sump and observation port.
- Liner covered with select backfill 2 feet of 4 inch minus material with a 6 inch layer of select rock fill.
- Placed distribution pipes 6 inches below the surface.
- Simple distribution box with no dosing siphon. Dosing siphons are mechanical and may fail over time especially with low flow rates and periods of no flow.
- Distribution box placed inside the liner area to provide secondary containment.
- Distribution box has single outlet to distribution header and overflow.
- Distribution box has loose fitting lid for additional overflow protection.
- Included inclined standpipes with insitu level troll to monitor solution elevation.
- Protected the Santa Fe E-cell with riprap.



Santa Fe Plan

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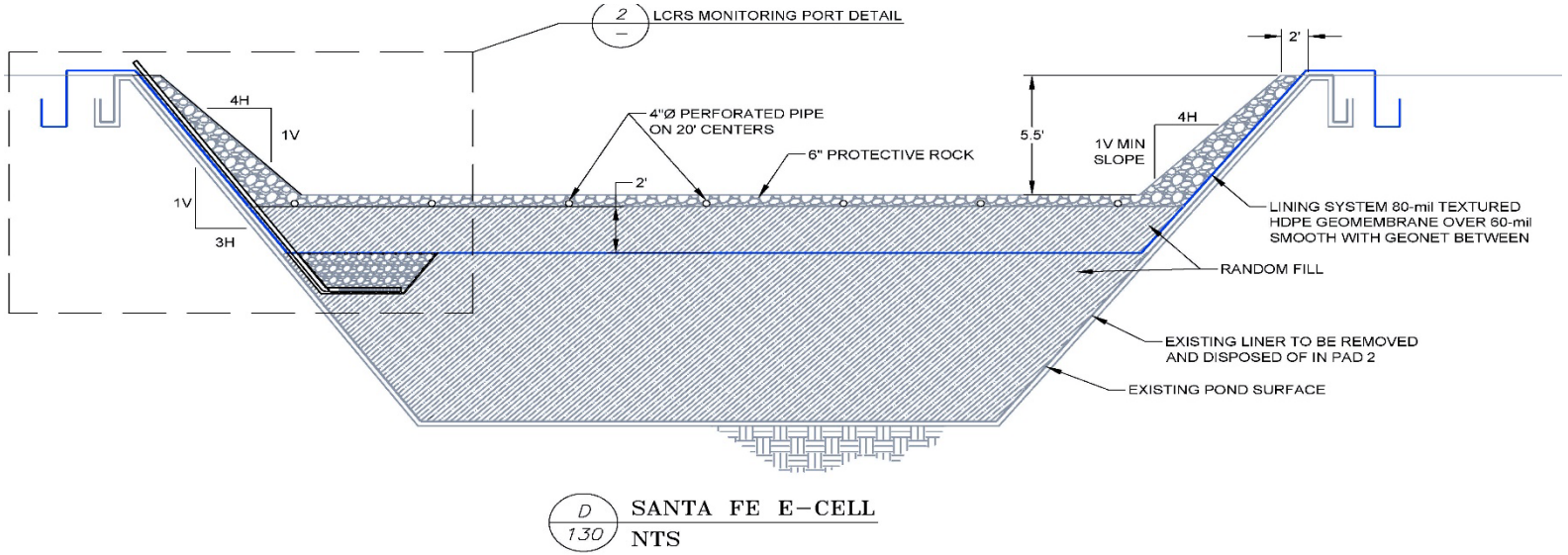
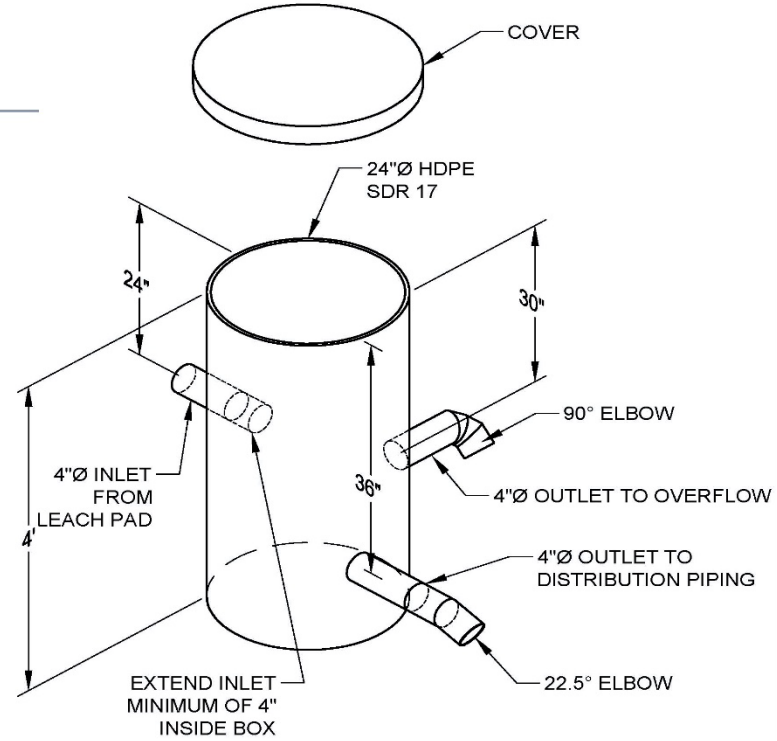


Santa Fe Cross Section



1/130 SANTA FE DISTRIBUTION BOX

NTS

Distribution Box

Month	Direct Precipitation into E-Cell (gallons)	Inflow from Leach Pad (gallons)	Total Inflow (gallons)	Evaporation (gallons)	Net Input (gallons)	Cumulative volume (gallons)
November	17,404	30,240	47,644	38,955	8,689	8,689
December	21,451	31,248	52,699	0	52,699	61,389
January	24,689	31,248	55,937	0	55,937	117,326
February	22,666	28,224	50,890	0	50,890	168,216
March	23,475	31,248	54,723	67,285	-12,562	155,654
April	28,737	30,240	58,977	134,298	-75,321	80,333
May	37,641	31,248	68,889	196,135	-127,245	0
June	21,047	30,240	51,287	236,996	-185,709	0
July	22,261	31,248	53,509	276,495	-222,986	0
August	21,047	31,248	52,295	255,520	-203,225	0
September	16,594	30,240	46,834	182,514	-135,680	0
October	22,666	31,248	53,914	110,326	-56,412	0
Total	279,677	367,920	647,597	1,498,523	-850,925	0

Santa Fe Monthly Water Balance

Month	Direct Precipitation into E-Cell (gallons)	Inflow from Leach Pad (gallons)	Total Inflow (gallons)	Evaporation (gallons)	Net Input (gallons)	Cumulative volume (gallons)
November	9,109	8,640	17,749	13,053	4,696	4,696
December	11,228	8,928	20,156	0	20,156	24,852
January	12,922	8,928	21,850	0	21,850	46,702
February	11,863	8,064	19,927	0	19,927	66,629
March	12,287	8,928	21,215	22,546	-1,331	65,298
April	15,041	8,640	23,681	45,002	-21,321	43,977
May	19,701	8,928	28,629	65,722	-37,093	6,884
June	11,016	8,640	19,656	79,414	-59,758	0
July	11,651	8,928	20,579	92,650	-72,071	0
August	11,016	8,928	19,944	85,622	-65,678	0
September	8,685	8,640	17,325	61,158	-43,833	0
October	11,863	8,928	20,791	36,969	-16,178	0
Total	146,381	105,120	251,501	502,136	-250,635	

Calvada Monthly Water Balance

Parameter	Value
1 E-Cell Contributing Surface Area (ft^2)	64,932
2 Direct Precipitation into Pond (gallons)	279,677
3 Inflow from Pad at 0.70 gpm (gallons)	367,920
4 Total Annual Inflow (gallons)	647,597
5 E-Cell bottom area (ft^2)	43,702
6 Evaporation from E-Cell bottom surface (gallons)	-1,498,523
7 Excess Evaporation in avg. year (gallons)	-850,925
8 Pad size (acres)	114
9 100-year/24-hour event (2.98-inches) from pads (gallons)	368,968
10 100-year/24-hour event into pond (gallons)	120,613
11 Total Inflow from 100-year/24-hour event (gallons)	489,591
12 Net balance of 100-year event, a full year of input and all evaporation (gallons)	-361,334
13 Total Open Water Capacity (gallons)	2,184,267
14 Maximum cumulative volume from the monthly water balance (gallons)	168,216
15 Maximum cumulative volume from the monthly water balance and 100-year event (gallons) (lines 11+14)	657,807
16 Approximate free board with volume from line 15 stored (ft)	3.5
17 Excess capacity to crest if the total in line 14 is stored (gallons) (line 13-line15)	1,526,460
19 Total Capacity allowing for 2 feet of free board	1,297,398
18 Excess capacity allowing for 2 feet of freeboard	639,591

Santa Fe Annual Water Balance

Parameter	Value
1 E-Cell Contributing Surface Area (ft^2)	33,985
2 Direct Precipitation into Pond (gallons)	146,381
3 Inflow from Pad at 0.20 gpm (gallons)	105,120
4 Total Annual Inflow (gallons)	251,501
5 E-Cell bottom area (ft^2)	14,644
6 Evaporation from E-cell bottom surface (gallons)	-502,136
7 Excess Evaporation in avg. year(gallons)	-250,635
8 Pad size (acres)	30
9 100-year/24-hour event (2.98-inches) from pad (gallons)	95,142
10 100-year/24-hour event into pond (gallons)	63,128
11 Total Inflow from 100-year/24-hour event (gallons)	158,270
12 Net balance of 100-year event, a full year of input and all evaporation (gallons)	-92,365
13 Total Open Water Capacity (gallons)	1,287,989
14 Maximum cumulative volume from the monthly water balance (gallons)	66,629
15 Total of input of annual and 100-year event (total of 9.74 inches for the year) (gallons) (lines 11+14)	224,899
16 Free board with volume from line 15 stored (ft)	5.5
17 Excess capacity if the total in line 14 is stored (gallons) (line 13-line15)	1,063,090
19 Total Capacity allowing for 2 feet of free board	845,008
18 Excess capacity allowing for 2 feet of freeboard (line 19-line15)	620,109

Calvada Annual Water Balance

Santa Fe pond backfill to form E-cell base

Santa Fe E-cell liner subgrade

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Santa Fe Secondary liner installed

Santa Fe LCRS sump under construction

Santa Fe lower 2 feet of fill in place

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Santa Fe Distribution box in place

Calvada Distribution box completed

Santa Fe Finished E-cell

Santa Fe E-cell completed with rip-rap upstream

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Calvada E-cell finished

Conclusions

- The E-cells appear to be working as intended with no free water surface observed in first year (October 2016 through present.).
- A passive system can work for normal conditions.
- A free water surface can be expected with large events.
- Fencing is required to keep wildlife and people out of cells.
- Remove anything that may be removed causing damage such as Carbon or transformers.

Santa Fe Pond 2 sampling damage

Santa Fe Pond 2 pond damage by samplers assumed to be looking for carbon

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Santa Fe transformers opened by copper thieves

QUESTIONS?