Rebuttal Report: Part 3, Prediction of Impacts Caused by Southern Nevada Water Authority Pumping Groundwater From Distributed Pumping Options for Spring Valley

Presented to the Office of the Nevada State Engineer

On behalf of Great Basin Water Network and the Confederated Tribes of the Goshute Reservation

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Introduction

The *Clark, Lincoln, and White Pine Counties Groundwater Development Project Draft Environmental Impact Statement* (DEIS) was released near the deadline for evidence reports for the State Engineer Hearings on water rights applications #54003 through 54021. The DEIS revealed substantial variations being considered by the Southern Nevada Water Authority in terms of where and how they actually intend to develop the water rights under the above-referenced applications, which had not been revealed in the applications. This rebuttal report presents new analyses of groundwater pumping regimes to reflect the changed circumstances presented in the DEIS and SNWA's surprising failure to acknowledge those alternative plans of development in its July 1, 2011, submission. It shows that distributing the points of diversion (PODs) around the valley more efficiently captures the discharge, meaning it more quickly dries up the springs and wetlands.

Pumping the full amount from the original application locations would cause immense, obviously unsustainable drawdowns (Myers 2011a, b, and c; BLM, 2011). Wells in the original application locations poorly capture the discharge, which causes severe drawdown (Myers, 2011c). The authors of the DEIS, with the participation of SNWA, recognized this, and therefore came up with a distributed pumping option, which moves some of the pumping north where more discharge may be captured.

The DEIS distributed pumping option for Spring Valley involved PODs that vary from the original PODs. The DEIS proposed action, in fact, calls for distributed pumping, as shown in Figure 1. This rebuttal report addresses the impacts to water resources in Spring Valley and surrounding valleys due to the Southern Nevada Water Authority (SNWA) pumping from locations other than those proposed in the water rights applications under protest in these hearings.

BLM (2011) is not clear on how SNWA selected the locations or the amount of pumping for the distributed pumping scenario. The locations would be selected to "help minimize the pumping effects" (BLM, 2011, p. 2-33) based on "geology, hydrology, well interference studies, environmental issues, existing senior water rights, and proximity to main and lateral pipelines" (BLM, 2011, p. 2-35). Pumping rates would range from 800 to 1000 gpm at a 1000 to 2000 ft depth (BLM, 2011, p. 2-36). SNWA does not present this pumping option in its evidence submittal, and therefore there is no more information available.

The DEIS proposed action implicitly assumes that SNWA will apply for and the Nevada State Engineer (NSE) will grant change applications for the water rights being considered in this hearing. It seems clear that the actual water rights being applied for in this hearing represent a moving target. The effects estimated by SNWA for the water rights hearing (Watrus and Drici, 2011) do not resemble that which will eventually occur in the valley and do not provide the NSE with an accurate impact estimate. Distributed pumping would have substantially different impacts on the water resources in Spring Valley than would pumping from the original applications (alternative B in the DEIS).

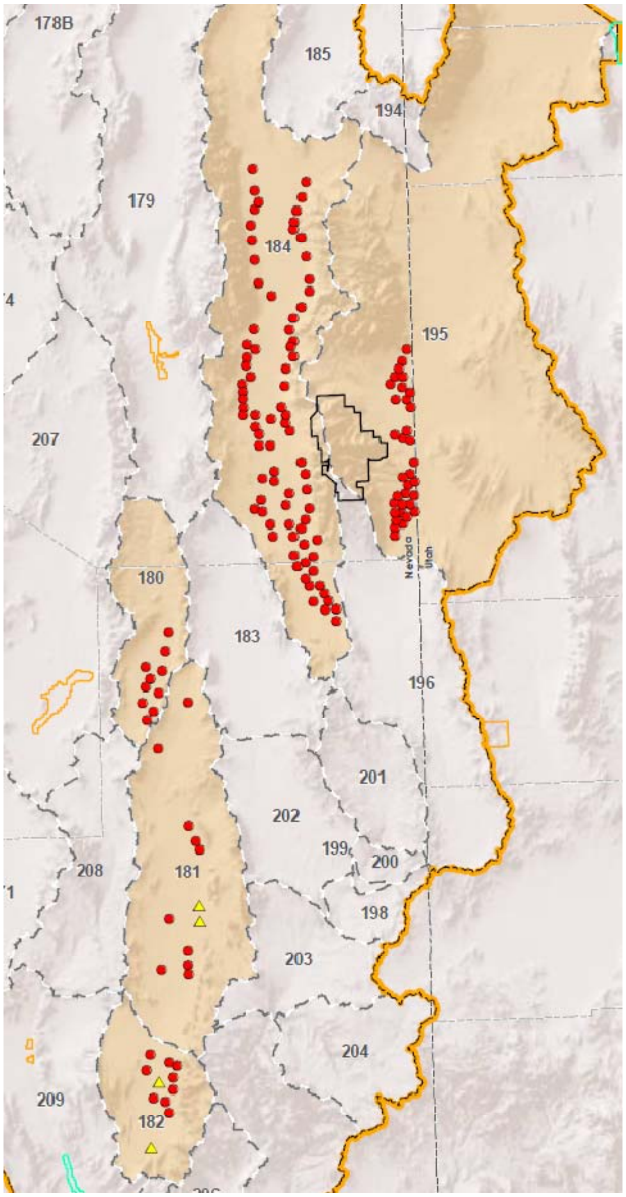


Figure 1: Snapshot from DEIS Figure 3.3.2-2 (BLM, 2011) showing the well locations for the proposed action.

This report presents predictions for two distributed pumping scenarios. The first is the pumping scenario proposed in the DEIS. The second is a more systematic grid-based scenario. This was chosen because SNWA provided no explanation for the POD locations and it seems equally likely that any grid could be the ultimate layout. I pumped both scenarios for 10,200 years to assess whether they approach equilibrium at the full application amount (c 91,200 af/y) and at 30,000 af/y. These additional pumping scenarios have been developed to:

- Provide the NSE with a tool to consider the estimated impacts from a range of points of diversion and total pumping rates.

- To show the range of impacts that would occur due to anticipated change applications. These include differences in the amount of discharge captured, drawdown distribution around the valley, and to interbasin flow to and from Steptoe and Snake Valleys.

This report also compares the distributed pumping options with each other and with the results of pumping the original applications. For specifics on that simulation, refer to Myers (2011c).

Simulating Distributed Pumping

Both scenarios were run for 10,200 years broken into three stress periods – 75, 125, and 10,000 years as described in Myers (2011c). The wells pumped from model layers 4 and 5 with the amount per layer determined based on layer transmissivity using the GWVistas routine as described in Myers (2011c). There were a few exceptions where the distributed POD intersected low-conductivity rock in layer 5; in these situations pumping occurred from layers 2 through 4. The actual pumping rates for the DEIS alternative were as specified in the DEIS (SNWA, 2010). The pumping rates used for the Grid alternative were the total amount for the valley divided proportionally among the wells.

Pumping rates are not ramped as done by Watrus and Drici (2011) because the proposed ramping rates are just as speculative as the distributed pumping options. Once granted, SNWA could pump at the full application rate. The impacts of pumping at lower rates can be assessed using Myers (2011c) and the 30,000 af/y alternative presented below.

DEIS Distributed Pumping Option

The DEIS distributed pumping option moves the PODs from the original application locations to locations shown on Figure 1 and Figure 2 and changing pumping rates as shown in Table 1. Eighty wells would be pumped in the DEIS distributed pumping option. In 2009, the BLM had considered a distributed option based on SNWA pumping 60,000 af/y from Spring Valley. This option is an increase of 28 wells from that original alternative considered by the BLM.

Table 2 and Figure 2 show the monitoring stations added to be consistent with Watrus and Drici (2011); these monitoring sites were added to the simulations completed for the original applications (Myers, 2011c) and are reported herein for comparison.

Distributed pumping spreads the impacts of pumping around Spring Valley more efficiently than does pumping from the original applications. Drawdown near the wells is less than for the original Apps because the pumping rate, per well, is less than a quarter as much. After 75 years the 20-foot drawdown has spread around most of Spring Valley with more drawdown only near the wells (Figure 3). Five-foot drawdown has spread into Tippet and Hamlin Valleys with the total extent (one-foot drawdown) reaching Snake Valley. Twenty-foot drawdown has reached the boundary with Steptoe which causes the inflow from that valley to increase.

Drawdown after 200 years approaches 50 feet around most of Spring Valley, and the 20-foot drawdown reaches into Tippet and Hamlin Valleys; five-foot drawdown touches Snake Valley and affects spring flow in the Big Springs area (as described below) (Figure 4). Numerous closed 200-foot contours occur around some of the pumping areas. The Snake Range massif, with its impermeable bedrock, prevents drawdown from extending into the central part of Snake Valley near Baker (Figure 4).

The DEIS distributed option initially draws all of the water from storage; only after about two years is there a discernible decrease in the amount drawn from storage and decrease in total discharge (Figure 5). After 75 and 200 years, respectively, pumpage continues to draw about two-thirds and one-half from storage. The difference is captured discharge which has decreased proportionately (Figure 5). Only the amount drawn from Steptoe Valley has been ignored and will be discussed below.

Storage flux drops to almost 8000 af/y after 1600 years, but is still 1000 af/y after 10,200 years (Figure 5), indicating the system has not come fully into equilibrium. Much of the continuing drawdown expansion is into Snake Valley, which is manifested by a decrease in flow to Snake Valley. The pumpage rate exceeds the recharge within Spring Valley (as it also does with the SNWA model), so equilibrium would require substantial flow to be drawn from or prevented from flowing to adjacent basins.

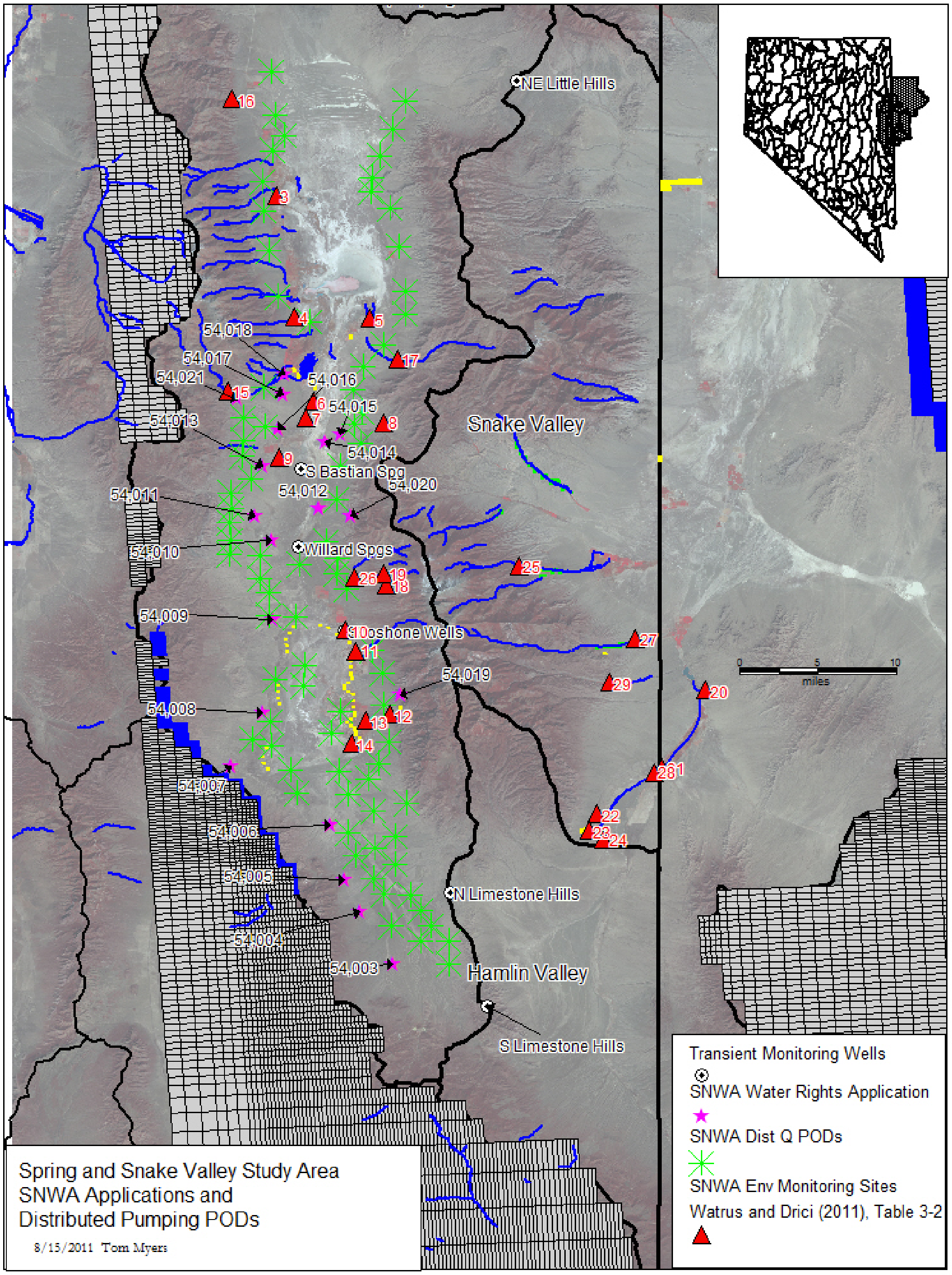


Figure 2: Site map showing application points of diversion, DEIS distributed PODs, monitoring sites from Myers (2011c), and SNWA environmental monitoring sites (Watrus and Drici, 2011). See Table 2 for a description of numbered sites.

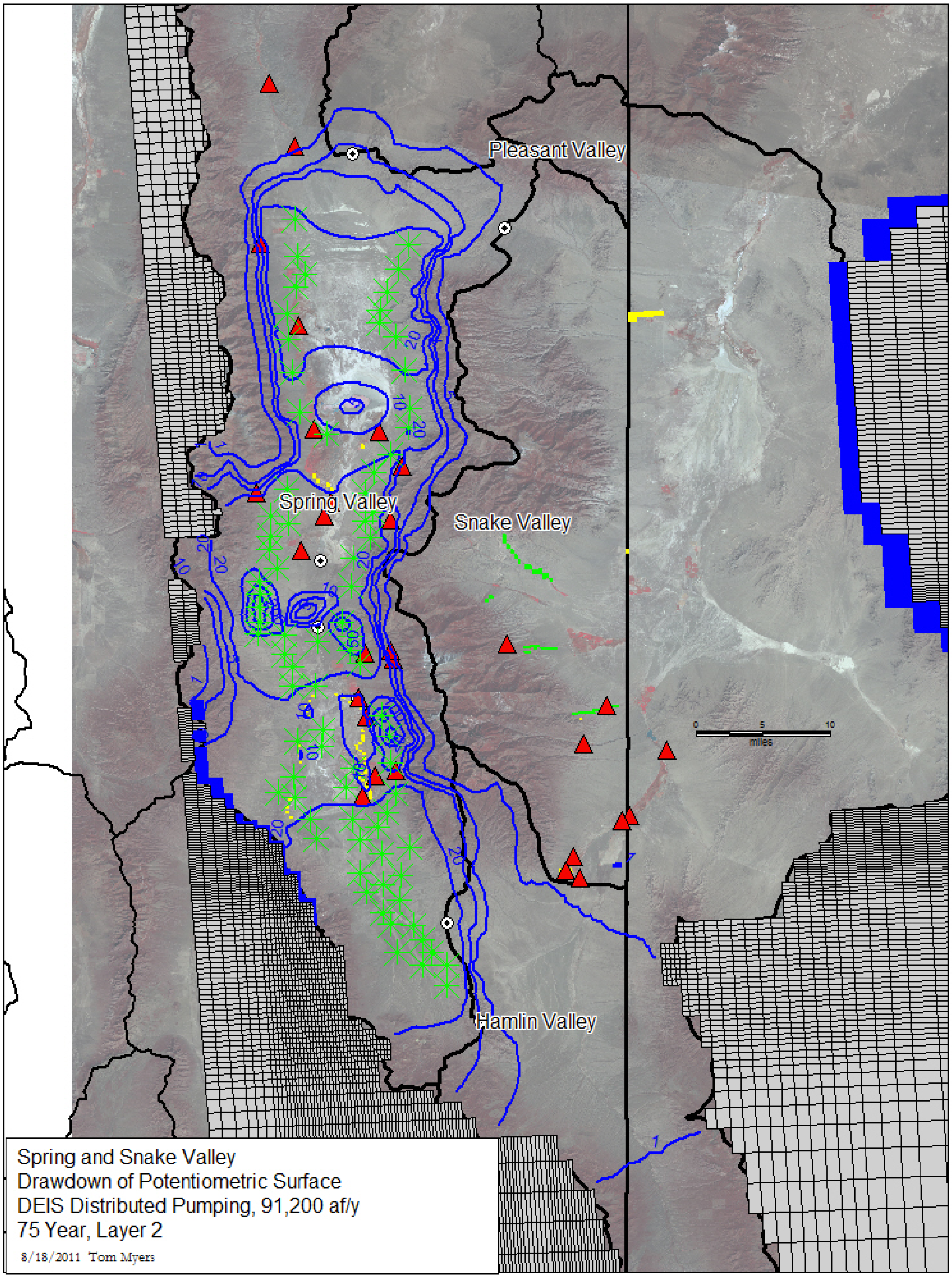
Table 1: Distributed Pumping Points of Diversion for DEIS Proposed Action. Type PA refers to POD from 2009 version, PA FullApp refers to PODs added for the full application amount with distributed pumping option. Flow rate Qfull is distributed pumping rate. Source SNWA (2010) and spreadsheet appendix.

Type	POD_Name	UTM_North	UTM_East	Qfull_afy	Q__ft3_d_	ROW	Column
PA_FullApp	SPR80	4385940	714058	1181.4	140992.4	31	30
PA_FullApp	SPR79	4382420	727773	1000.0	119342.5	34	64
PA	SPR59	4380244	714615.1	1181.4	140992.4	35	31
PA_FullApp	SPR78	4378656	726647	1000.0	119342.5	38	60
PA	SPR58	4377453	715545.1	1181.4	140992.4	39	32
PA	SPR57	4375465	714486.8	1181.4	140992.4	41	29
PA_FullApp	SPR66	4375133	725409	1000.0	119342.5	43	56
PA	SPR62	4372308	724681.9	1181.4	140992.4	46	54
PA_FullApp	SPR52	4371515	713545	1181.4	140992.4	46	26
PA	SPR61	4370407	724594.9	1181.4	140992.4	48	53
PA	SPR60	4368284	726599.4	1181.4	140992.4	51	58
PA_FullApp	SPR73	4367577	713850	1181.4	140992.4	51	26
PA_FullApp	SPR81	4363279	727765	1181.4	140992.4	58	60
PA_FullApp	SPR77	4362437	714466	1181.4	140992.4	57	27
PA_FullApp	SPR67	4357446	728537	1181.4	140992.4	65	60
PA_FullApp	SPR71	4356332	715530	1181.4	140992.4	65	28
PA_FullApp	SPR68	4354364	728589	1181.4	140992.4	69	60
PA_FullApp	SPR72	4353191	718873	1181.4	140992.4	69	36
PA_FullApp	SPR69	4350289	726552	1181.4	140992.4	74	54
PA	SPR65	4347467	724573.8	1181.4	140992.4	77	48
PA_FullApp	SPR70	4344550	714393	1181.4	140992.4	79	23
PA_FullApp	SPR20	4344323	723574	1181.4	140992.4	81	45
PA_FullApp	SPR21	4341413	724566	1181.4	140992.4	84	47
PA_FullApp	SPR06	4340421	712499	1181.4	140992.4	84	17
PA	SPR23	4339917	723812.7	1181.4	140992.4	86	45
PA	SPR08	4339317	714670.3	1181.4	140992.4	86	22
PA_FullApp	SPR75	4337391	724514	1181.4	140992.4	89	46
PA_FullApp	SPR74	4337338	712551	1181.4	140992.4	88	17
PA	SPR32	4335300	712413.1	1181.4	140992.4	91	16
PA_FullApp	SPR76	4334361	722581	1181.4	140992.4	93	41
PA	SPR12	4332421	713518.3	1181.4	140992.4	94	18
PA	SPR11	4330507	711376.9	1181.4	140992.4	96	12
PA	SPR19	4330017	722339.7	1181.4	140992.4	98	39
PA_FullApp	SPR27	4328405	711558	1181.4	140992.4	99	12
PA	SPR35	4326604	711427.1	1181.4	140992.4	103	12
PA	SPR31	4324378	721415.4	1000.0	119342.5	110	36
PA	SPR10	4324235	711629.4	1181.4	140992.4	108	12
PA_FullApp	SPR26	4322397	711506	1000.0	119342.5	113	11
PA	SPR09	4322359	714673.2	1000.0	119342.5	113	19
PA	SPR38	4322326	722661.2	1000.0	119342.5	115	38
PA	SPR33	4321355	718683.6	1000.0	119342.5	117	28
PA_FullApp	SPR36	4320255	722529	900.0	107408.2	120	38
PA	SPR07	4319396	714699.7	1000.0	119342.5	121	18
PA	SPR34	4318267	723718.3	900.0	107408.2	125	40
PA	SPR18	4317454	715652.2	1000.0	119342.5	126	20

PA	SPR04	4314557	715723	1000.0	119342.5	133	20
PA	SPR63	4314514	718543.7	900.0	107408.2	134	27
PA FullApp	SPR55	4310329	726552	1000.0	119342.5	146	46
PA	SPR56	4308053	719656.2	1181.4	140992.4	150	28
PA	SPR17	4307304	727634.2	1000.0	119342.5	153	48
PA	SPR05	4306165	716612.3	1000.0	119342.5	154	20
PA	SPR28	4305413	719563.4	1181.4	140992.4	156	27
PA	SPR16	4303165	727913.8	1000.0	119342.5	164	47
PA	SPR40	4302225	723435.6	1000.0	119342.5	165	36
PA	SPR54	4300586	716300.6	1000.0	119342.5	168	18
PA	SPR53	4299228	722593.2	1000.0	119342.5	172	33
PA	SPR29	4298350	728565.9	1000.0	119342.5	176	48
PA	SPR37	4298224	714530.9	1000.0	119342.5	173	13
PA	SPR64	4297461	716553.4	1181.4	140992.4	175	18
PA	SPR25	4295476	727626.5	1181.4	140992.4	183	45
PA	SPR51	4294339	723589.2	1181.4	140992.4	185	35
PA	SPR50	4294294	718518.9	1181.4	140992.4	184	22
PA	SPR13	4293313	726563.1	1181.4	140992.4	188	42
PA	SPR03	4291264	719332.6	1181.4	140992.4	191	24
PA	SPR48	4291260	724500.7	1181.4	140992.4	192	37
PA	SPR47	4290301	730586.1	1181.4	140992.4	196	51
PA	SPR01	4289208	727275.6	1181.4	140992.4	198	43
PA	SPR02	4286267	724660.6	1181.4	140992.4	205	36
PA	SPR39	4285982	729591.5	1181.4	140992.4	207	48
PA FullApp	SPR44	4284417	727544	1181.4	140992.4	210	43
PA	SPR46	4283350	725575.8	1181.4	140992.4	212	38
PA	SPR30	4282270	729607.3	1181.4	140992.4	215	47
PA	SPR45	4280284	727554.3	1181.4	140992.4	218	42
PA FullApp	SPR42	4278410	728537	1181.4	140992.4	221	44
PA	SPR24	4278281	731353.1	1181.4	140992.4	221	51
PA	SPR15	4276295	732479.5	1181.4	140992.4	224	53
PA FullApp	SPR41	4274387	733552	1181.4	140992.4	226	55
PA	SPR49	4274261	729527.8	1181.4	140992.4	226	45
PA	SPR14	4272346	735531.1	1181.4	140992.4	229	60
PA	SPR43	4272290	732570.5	1181.4	140992.4	229	53
PA	SPR22	4269367	735569.7	1181.4	140992.4	233	59
Total				91221.78	10886632.1		

Table 2: Location of SNWA Environmental Monitoring Sites (Watrus and Drici, 2011, Table 3-2).

No	**Site ID**	Name	Type	UTM North	UTM East	Elev
	1847401	Stonehouse Spring	Spring	4406507	710511	6256
	1845501	Willow Spring	Spring	4397069	713756	5987
	1847101	Keegan Spring	Spring	4369664	715050	5617
	1847601	West Spring Valley	Spring	4353812	717309	5603
	1845702	South Millick Spr	Spring	4353754	725031	5593
		Swamp Cedar North	Area	4342717	719507	5621
	1847701	Unnamed 5 Spring	Spring	4340641	718911	5645
	1847301	Rock Spring	Spring	4340204	726798	6364
	1847001	Four Wheel Drive Spring	Spring	4335256	716255	5754
	3.85613E+14	Shoshone Pond Well	Flowing	4312898	723711	5781
		Swamp Cedar South	Area	4310128	724802	5813
	1846201	Swallow Springs	Spring	4301920	728597	6080
	1847201	Minerva Spring	Spring	4301025	726101	5825
	1846401	Blind Spring	Spring	4298025	724717	5773
	1841610	Cleve Creek	Stream	4343870	710765	5964
	1840704	Kalamazoo Creek	Stream	4382169	710123	6233
	1842004	Negro Creek	Stream	4348593	727948	6032
	1842702	Pine/Ridge Creek	Stream	4318879	727728	7345
	1843102	Shingle Creek	Stream	4320388	727332	7309
	1953001	Clay Spring	Spring	4306147	760875	5446
		Stateline Springs	Spring	4295881	756735	5423
		Unnamed 1 Spring	Spring	4289483	750194	5572
	1951901	Big Spring	Spring	4287293	749422	5578
	195N10E7034D	North Little Springs	Spring	4286207	751006	5562
	1951902	Big Springs Creek	Stream	4295165	755908	5450



Spring and Snake Valley
Drawdown of Potentiometric Surface
DEIS Distributed Pumping, 91,200 af/y
75 Year, Layer 2
8/18/2011 Tom Myers

Figure 3: Map of drawdown contours after 75 years for DEIS distributed pumping option at full application rates. See Figure 2 for description of wells and monitoring sites.

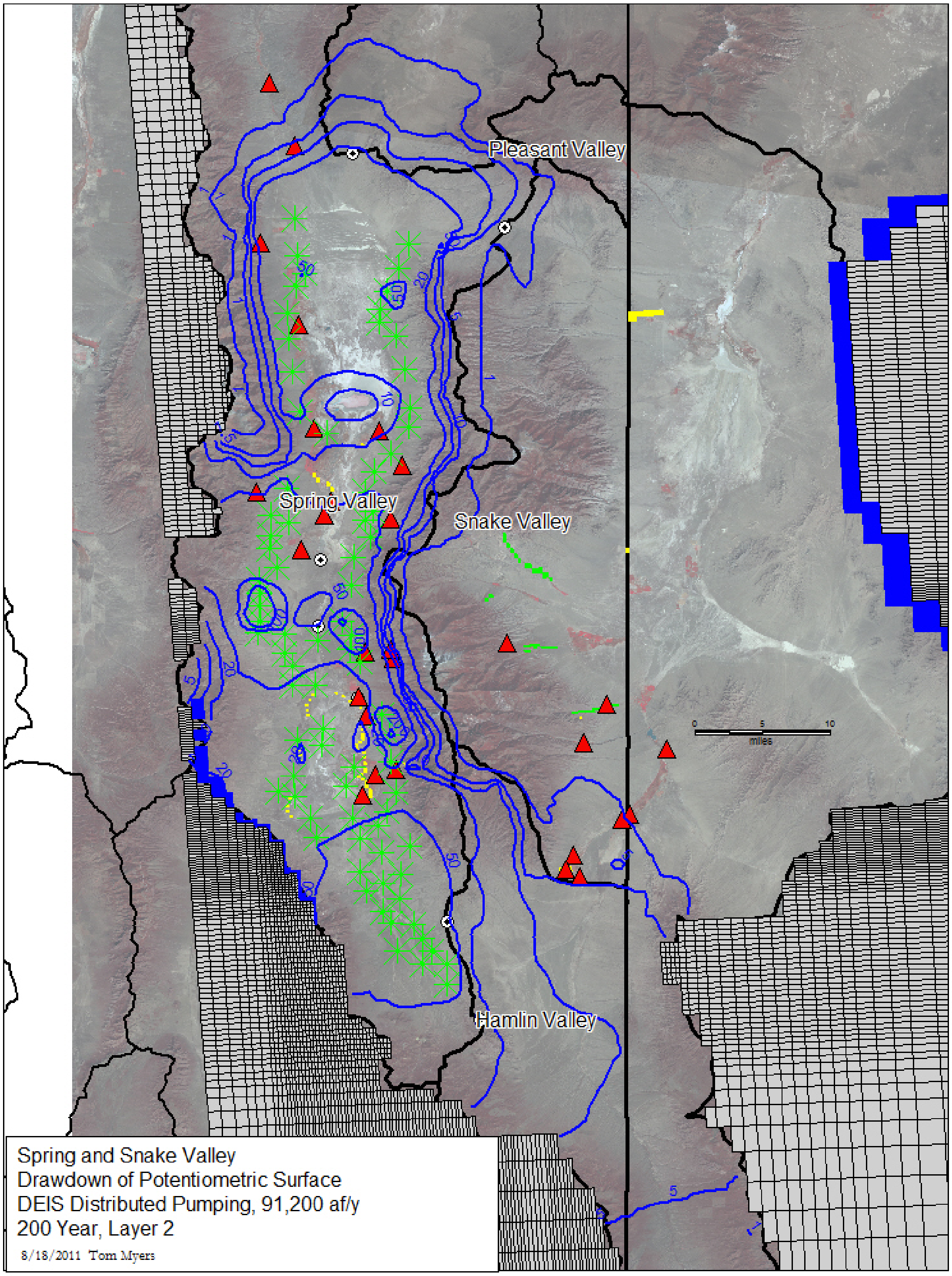


Figure 4: Map of drawdown contours after 200 years for DEIS distributed pumping option at full application rates. See Figure 2 for description of wells and monitoring sites.

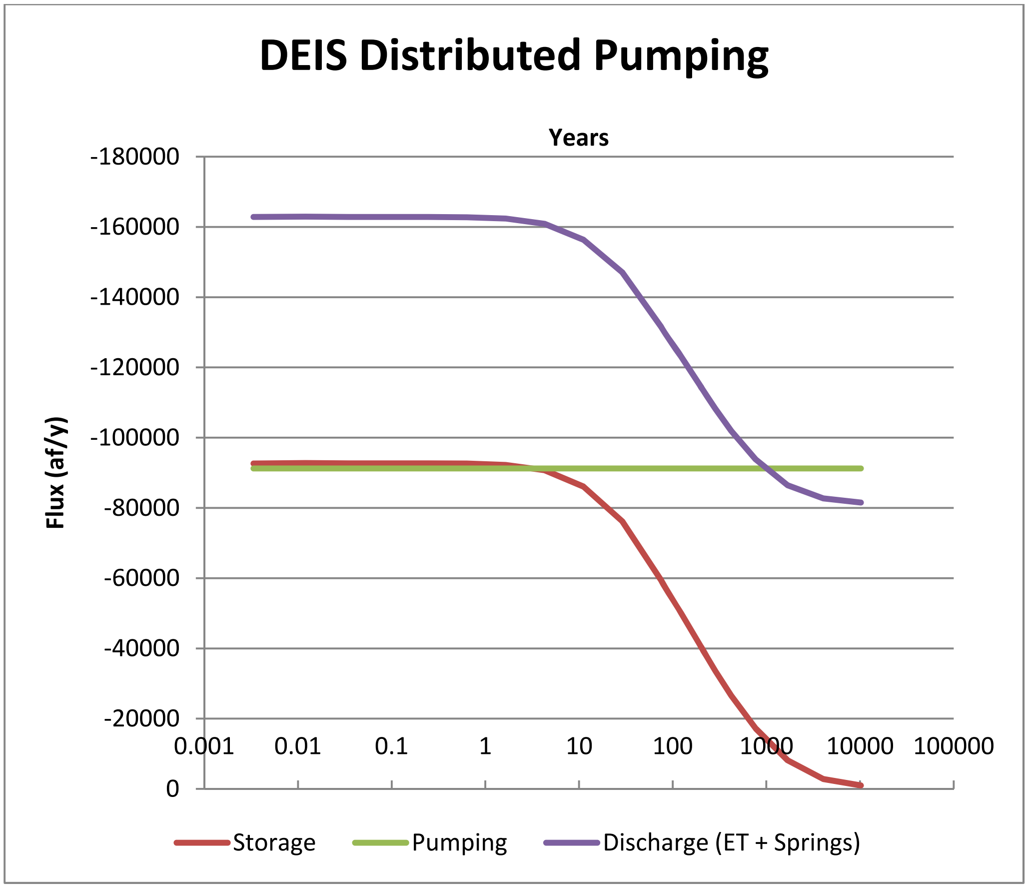


Figure 5: Hydrograph of flux for pumping the full DEIS option. Simulated discharge is the sum of springs and ET for the entire model domain. Recharge is 186,154 af/y.

Systematic Distributed Pumping Option

SNW's pumping distribution may eventually vary from that considered in the DEIS, although choosing one now would be guesswork. Therefore, I created a systematic pumping option simulating the PODs on a grid (Figure 6), referred to as the Grid option herein, with pumping distributed evenly. The grid has 60 wells loosely spaced on a grid north and south through the valley; this is 28 wells less than the DEIS option. The grid has 15 rows with 4 wells per row (Figure 6).

Drawdown contours are very similar to the DEIS option in the northern portion of Spring Valley but in the south, the contours extend less far across Hamlin Valley (Figure 6 and Figure 7). The drawdown is less extensive in the south because the pumping was further from the basin boundaries. Drawdown in the south Spring Valley playa area is also less than in the north where more of the pumping occurs. Drawdown is slightly more expansive into Pleasant Valley and is deeper near the Snake Range massif due to the inability to draw much from a nearby aquifer.

Fluxes are similar to Figure 5 and will be discussed below in comparison with other alternatives.

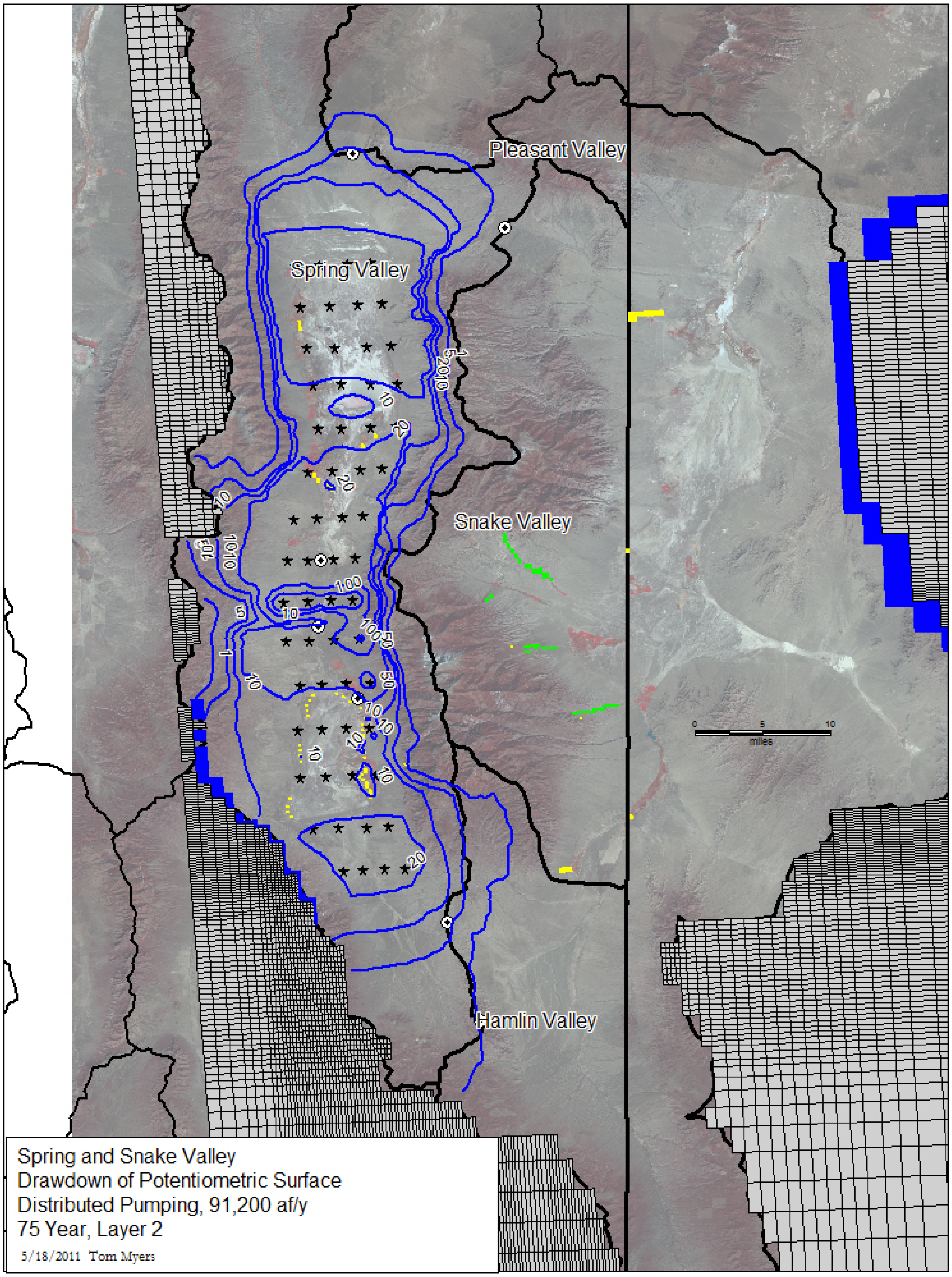


Figure 6: Map of drawdown contours after 75 years for distributed pumping of full application amount. The black stars are the distributed well locations on a grid.

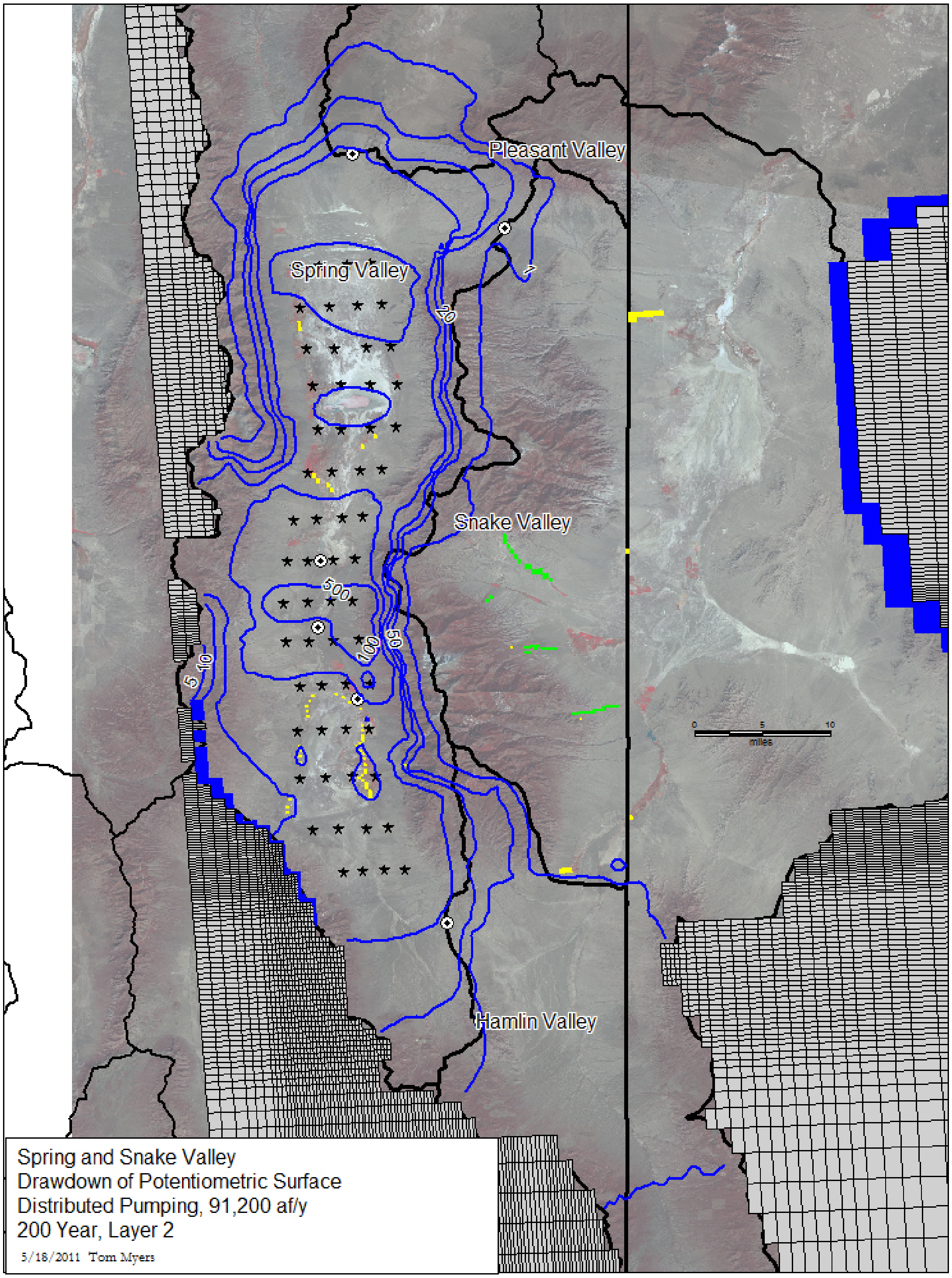


Figure 7: Map of drawdown contours for distributed pumping full application amount after 200 years. Black stars are well points.

Comparison among Pumping Scenarios

The most telling difference among the pumping scenarios is the change in total discharge and in storage fluxes (Figure 8). The Apps alternative draws more groundwater from storage for longer than does either distributed pumping option. After 100 years, the range is almost 15,000 af/y with the Apps option removing about 60,000 af/y from storage and the Grid option removing the least amount (Figure 8). Both total discharge and ET decrease more quickly for distributed options (Figure 8). Distributed pumping dries the valley more quickly – affecting both springs and wetlands – by capturing the discharge more efficiently.

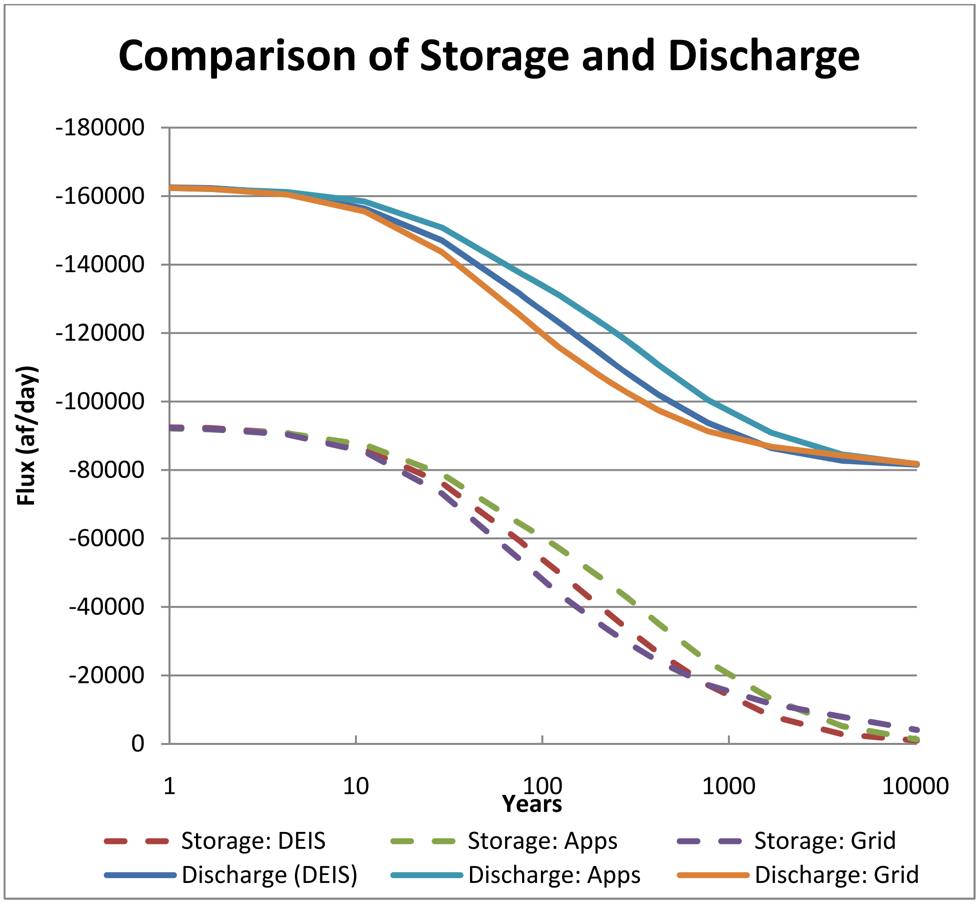


Figure 8: Comparison flux from storage and to discharge (ET and springs combined) for the three alternatives: Apps, Distributed DEIS, and Grid.

Cumulative groundwater removed from storage also demonstrates the differences. The Apps option removes more than 90,000,000 af from storage in 10,200 years, or more than twice that removed with the Grid option and 50 percent more than with the DEIS option (Figure 9). The Apps option removes 5,700,000 af within 75 years. The primary reason the Apps option removes so much more from storage is that pumping at high rates from each POD causes very large drawdown, many hundreds or even a thousand feet (Myers, 2011c). Distributed pumping does not draw the water table down that deeply, even though it causes shallow drawdown to spread further. The additional drawdown caused by the Apps option is water not captured from discharge, so the alternative appears to have less effect on the surface water sources than the distributed pumping options. Because the drawdown is unrealistic in practice, the results of this alternative may be incorrect.

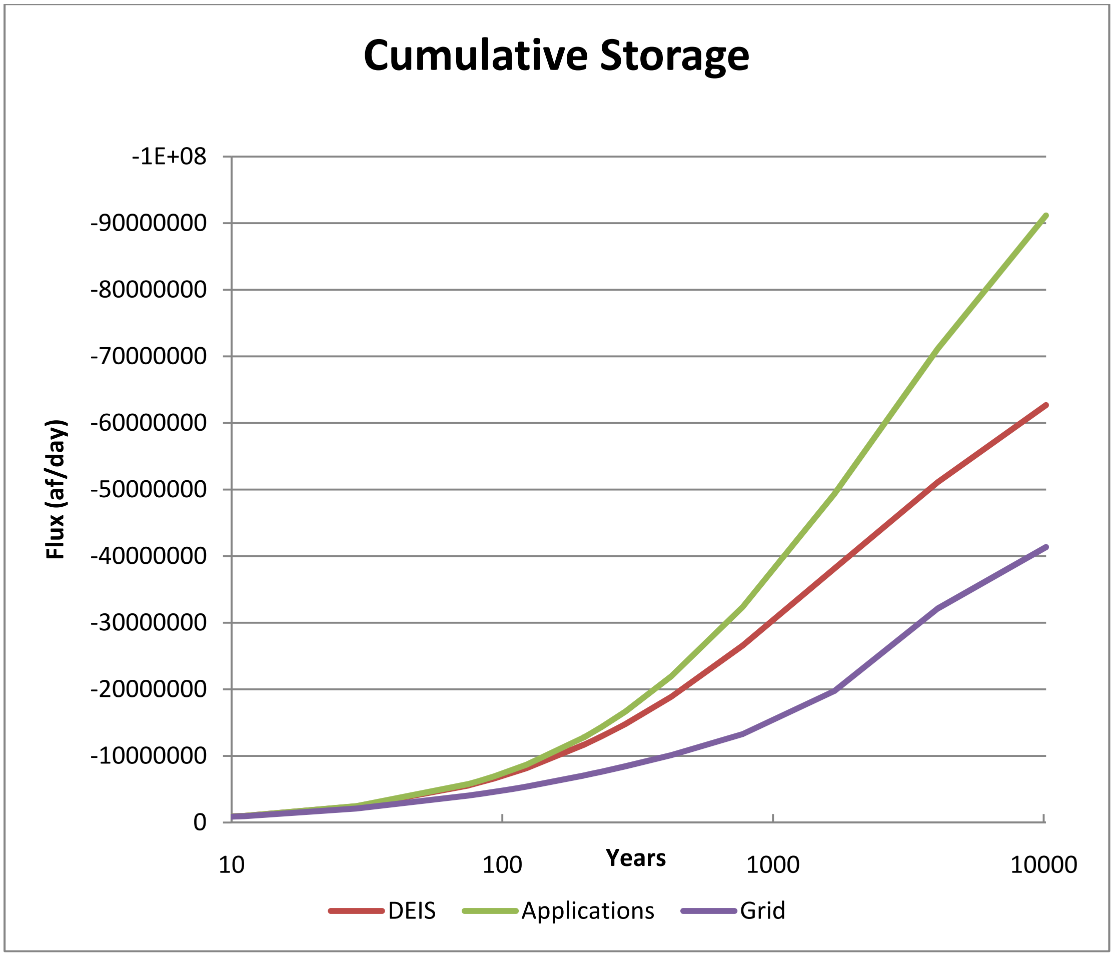


Figure 9: Cumulative amount of groundwater removed from storage for the three alternatives.

Spring Flow

Pumping affects springs by capturing their discharge by drawing the water table down around them. Drawdown affects springs throughout the study area differently, primarily based on the distance of the spring from the pumping and potential presence of a fault between the two. This section presents hydrographs for a number of springs around the domain for all three pumping alternatives.

All three pumping scenarios dry up Millick Springs in much less than 100 years. The Apps alternative allows flow to maintain longer while the Grid alternative reduces the flow more quickly (Figure 10). The faster decreases for distributed pumping reflects the fact the pumping intercepts flow closer to the springs. The S Spring Valley Playa springs discharge decreases much faster for the distributed options than for the Apps option, with discharge after 100 years being less than 15 percent of the natural discharge (Figure 11). The S Spring Valley Playa springs all eventually dry no matter which alternative is chosen, with the DEIS distributed pumping alternative causing it quickest, within a few hundred years (Figure 11). The Apps option dries Cleve Creek springs in less than 100 years (Figure 12), significantly faster than the distributed options because several applications are near that area (Myers, 2011a). At any given time period up to full drying, the distributed options' flow rate is much higher. The Apps alternative also dries Swallow Springs much quicker, with decreases beginning in 20 years. A fault combined with a short distance from high carbonate rock recharge helps to protect this spring. Distributed pumping affects this spring less because the wells are west of the fault.

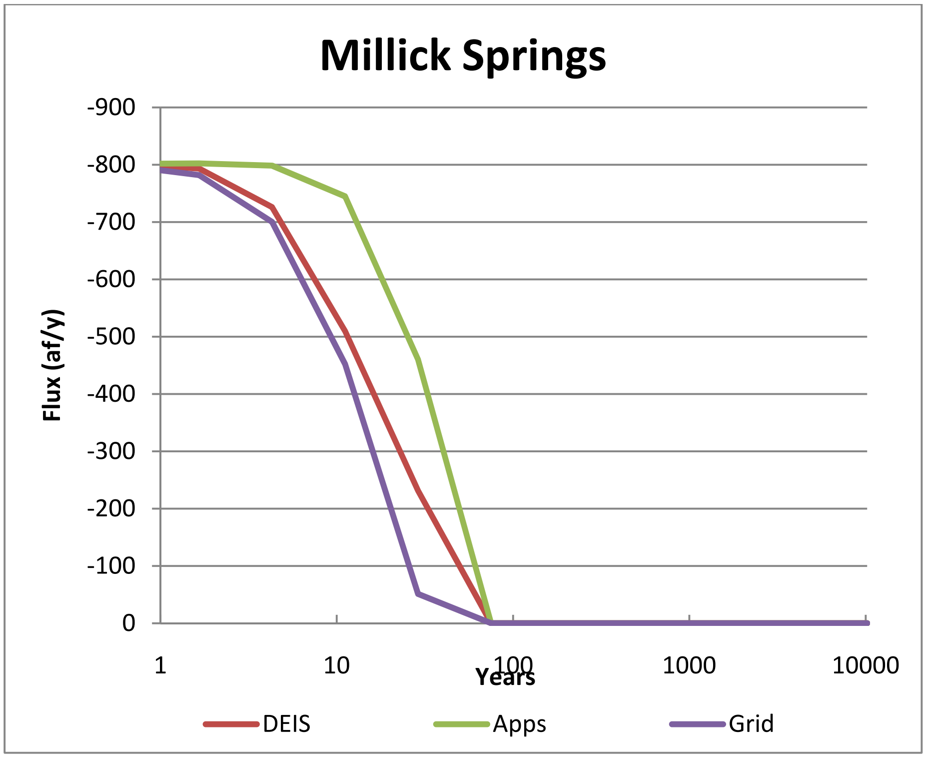


Figure 10: Discharge hydrographs at Millick Springs for pumping full Apps, and DEIS and Grid distributed pumping options.

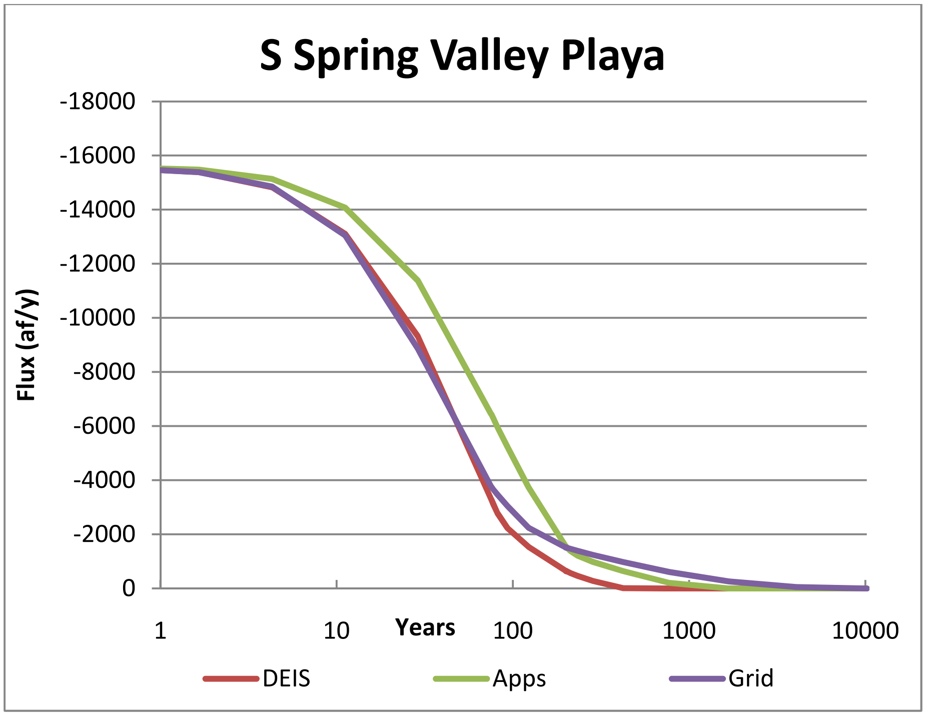


Figure 11: Discharge hydrographs S Spring Valley Playa Springs for pumping full Apps, and DEIS and Grid distributed pumping options.

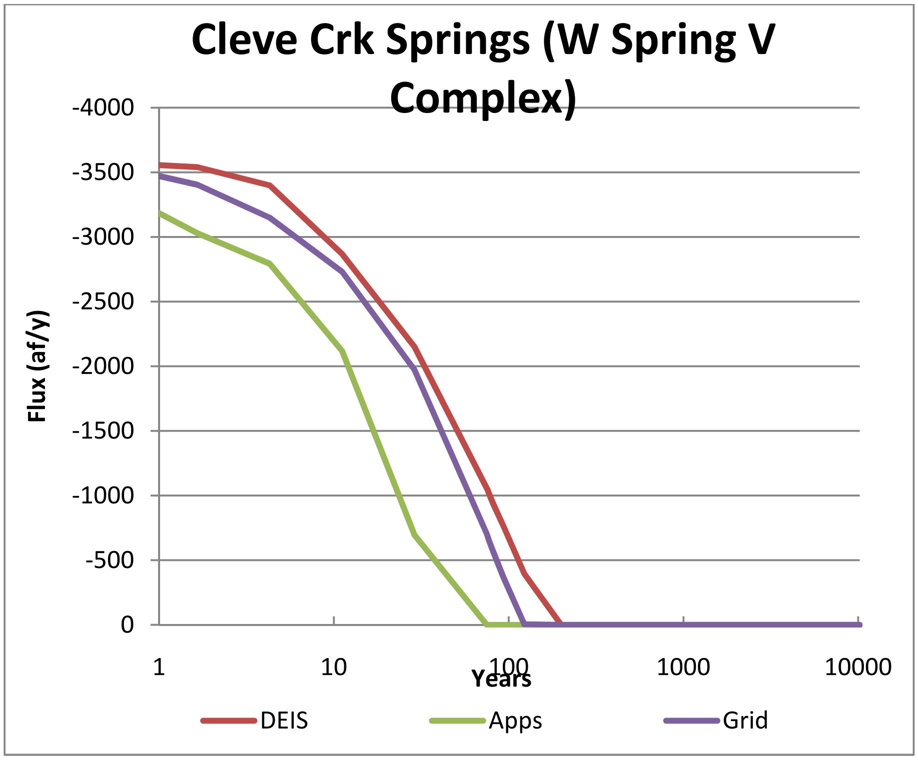


Figure 12: Discharge hydrographs for Cleve Creek springs for pumping full Apps, and DEIS and Grid distributed pumping options.

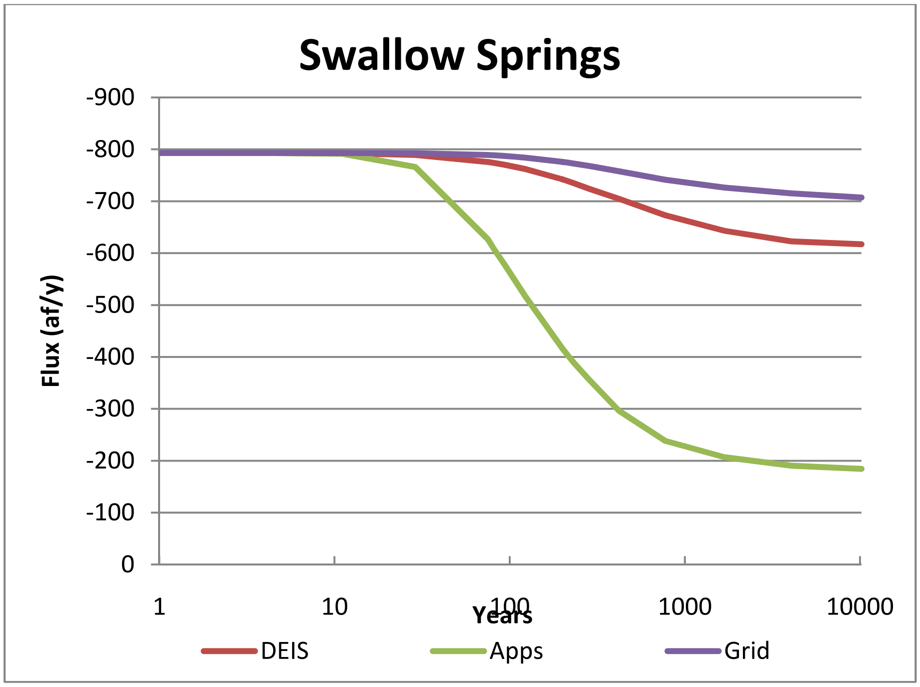


Figure 13: Discharge hydrographs for Swallow Springs for pumping full Apps, and DEIS and Grid distributed pumping options.

Pumping from Spring Valley affects discharges from Snake Valley because the discharge depends on interbasin flow. It barely affects Big Springs for 50 years, but after 100 years its discharge decreases quickly (Figure 14). For the Apps and DEIS option, the discharge eventually goes to zero (at around 1000 years), but for the Grid the flow just decreases to about 40 percent of its natural value; it appears to still be decreasing after 10,200 years (Figure 14). Spring Creek spring loses about 10 percent of its flow in the long term (Figure 15). Stateline Springs begin to decrease after 100 years and decreases to less than 15 percent for the Apps and DEIS option. The similarity between Apps and DEIS scenarios reflects the total amount of pumping that occurs in the south end of Spring Valley. Specific locations do not matter as much further from the wells. The Grid alternative pumps more from further north in Spring Valley.

Pumping begins to affect Gandy Warm Springs after about 400 years, with both distributed options having a similar effect until about 2000 years (Figure 17). Pumping the Apps affects the spring only after 2000 years because the PODs are further south in the valley. The Grid option causes the springs to eventually go dry. The effect reflects the lost interbasin flow from Spring Valley.

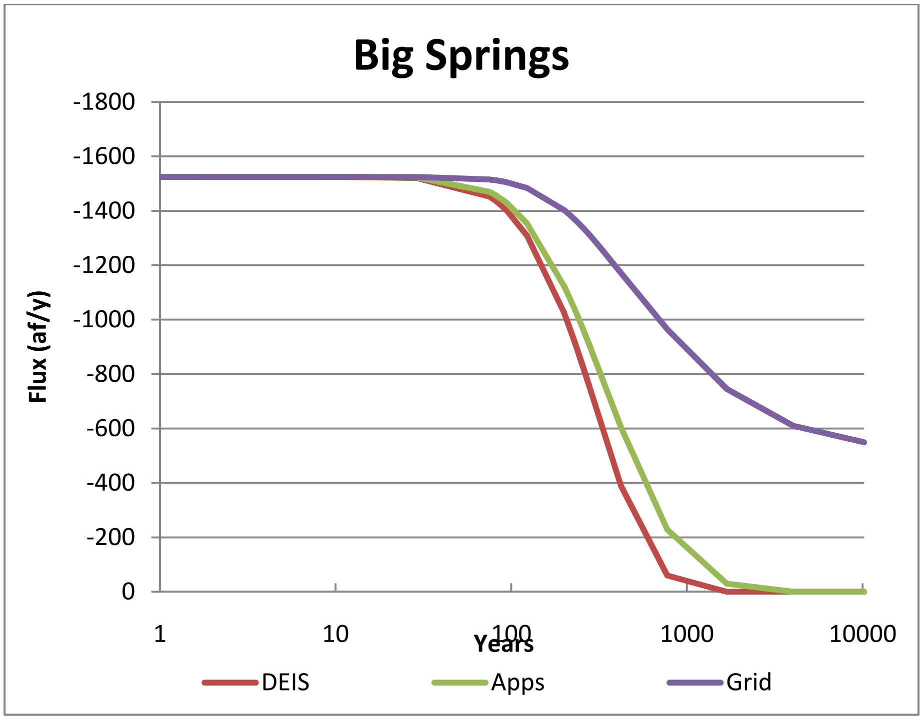


Figure 14: Discharge hydrographs for Big Springs for pumping full Apps, and DEIS and Grid distributed pumping options.

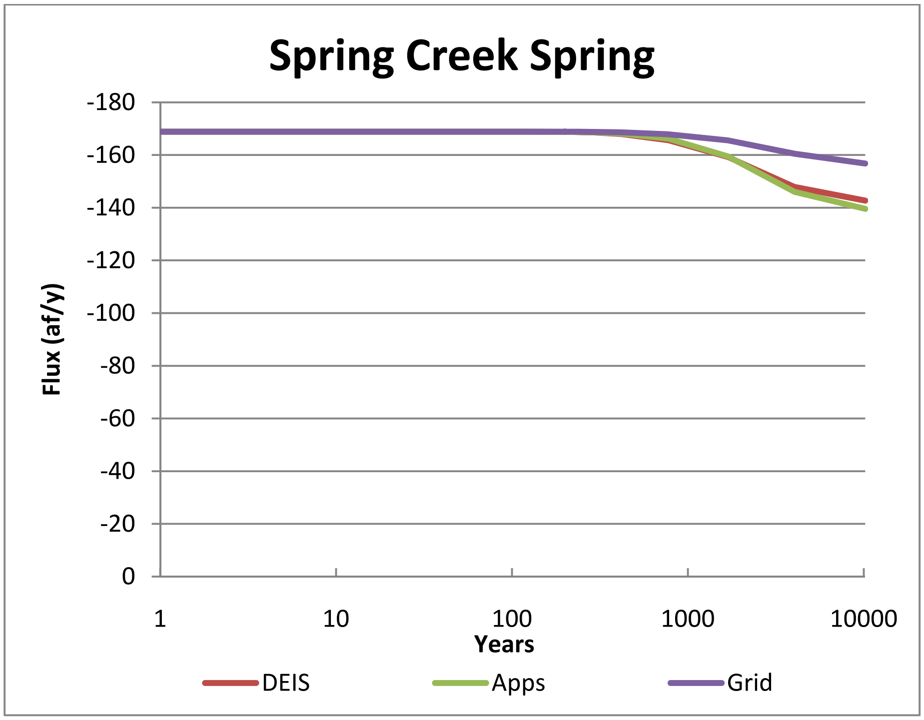


Figure 15: Discharge hydrographs for Spring Creek spring for pumping full Apps, and DEIS and Grid distributed pumping option.

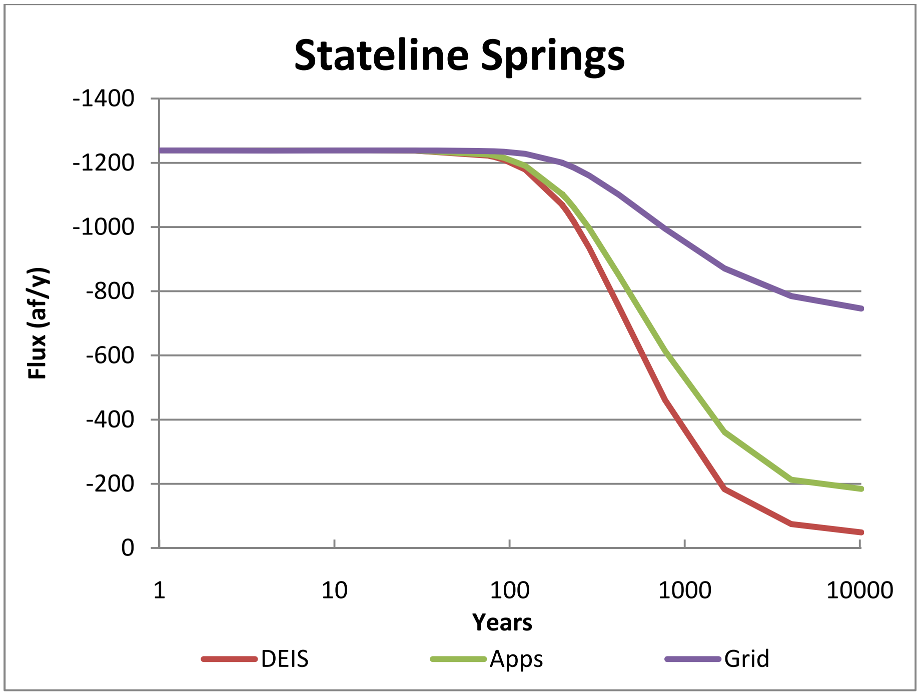


Figure 16: Discharge hydrographs for Stateline Springs for pumping full Apps, and DEIS and Grid distributed pumping options.

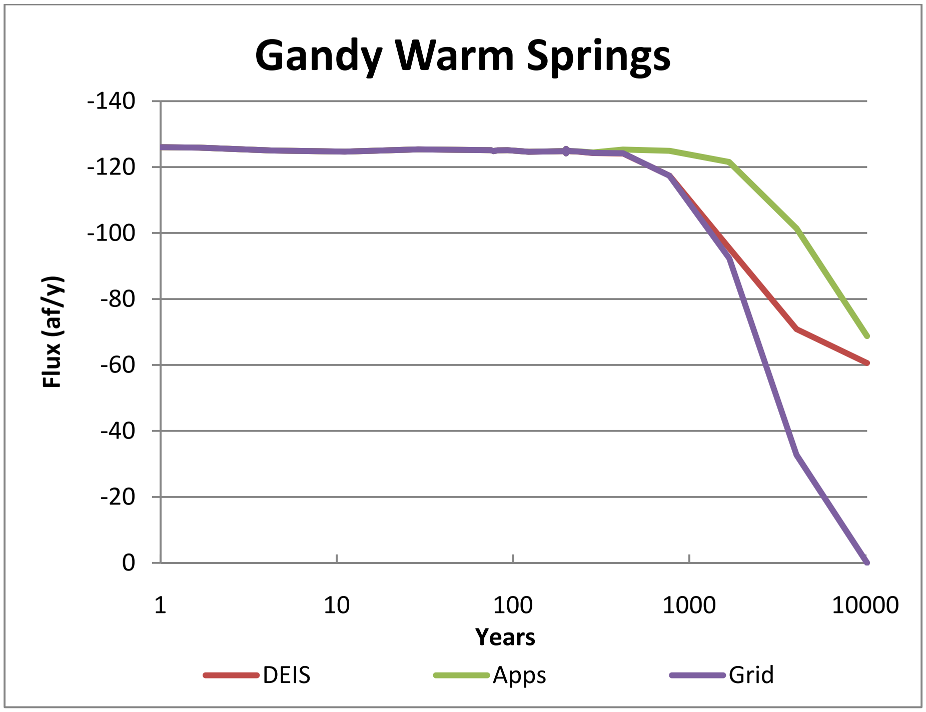


Figure 17: Discharge hydrographs for Gandy Warm Springs for pumping full Apps, and DEIS and Grid distributed pumping options.

Interbasin Flow

Pumping groundwater from Spring Valley draws additional groundwater from Steptoe Valley (Myers, 2011a and b; SNWA, 2010). Steady state flows into Spring Valley (Myers, 2011b) are just higher than 15,000 af/y (Figure 18). Pumping the full amount from the application PODs increased the inflow by almost 1000 af/y within 10 years and more than 3000 af/y within 100 years (Figure 18). Neither distributed pumping option increased the inflow within 10 years, but the DEIS option eventually increased the inflow as much as the applications PODs. The Grid option drew more water from other sources such that it increased inflow by about 4000 af/y less than the 10,000 af/y increase caused by the Apps and DEIS options. Both the Apps and DEIS options increased inflow from about 15,000 to 25,000 af/y, with up to 3000 af/y increase within 100 years. Pumping the Apps and DEIS options at the full application amount will eventually cause an almost 10,000 af/y added draft on the Steptoe Valley water budget; pumping the Grid options at full application amount will eventually cause an approximately 7,000 af/y added draft on the Steptoe Valley budget.

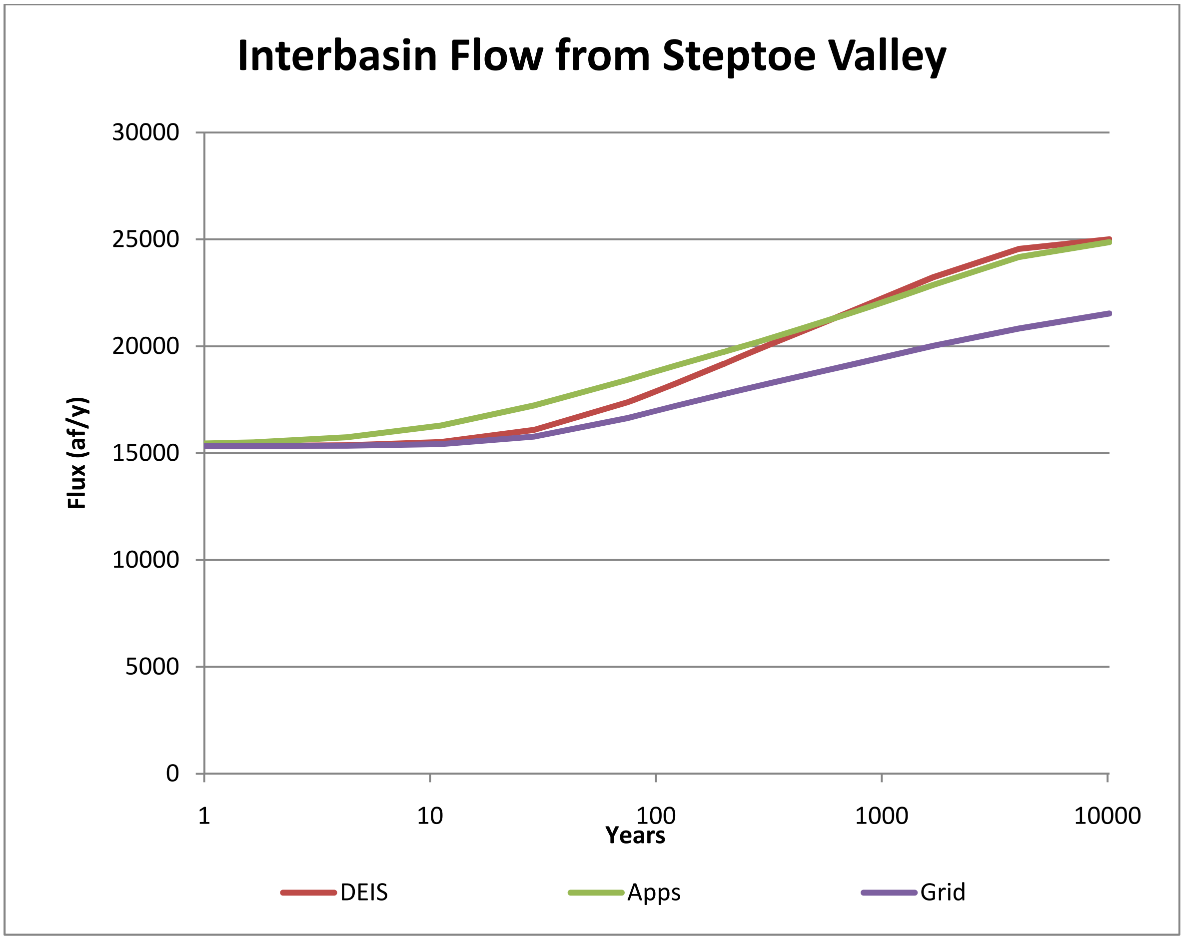


Figure 18: Hydrograph of flow from Steptoe/Lake Valley to Spring Valley.

Water Level Hydrographs

SNWA presented analyses for various environmental monitoring points around their study area (Watrus and Drici, 2011), as did Myers (2011c). This section provides and compares hydrographs for all of SNWA's environmental monitoring points in Spring Valley, some of them in Snake Valley, and Myers' monitoring wells in and around Spring Valley (Figure 2). The figures include hydrographs at each point for each scenario, including the Apps (Myers, 2011c) for layers 1 through 4. The water levels are presented on a logarithmic scale for clarity. Each hydrograph commences at the same point, at time 0. The hydrographs are presented in Appendix A.

Distributed pumping generally causes more drawdown at Shoshone Wells, South Center Spring Playa, Stonehouse Spring, Willow Spring, Kalamazoo Creek, and Keegan Spring. Some of these are in northern Spring Valley where the distributed option moves the wells, although S Central Spring Valley Playa is in the south where distributed pumping has wells scattered around the playa.

The Apps option caused more drawdown at South Bastian Spring, Willard Springs, West Spring Valley Complex, Cleve Creek, Swamp Cedar North, Unnamed Five Spring , Rock Spring, 4WD Spring , and Swallow Springs. These are mostly points in the middle of Spring Valley near the monitoring points. They reflect the drying of springs within this area.

The DEIS option and the Apps cause similar drawdown in southern Spring Valley into Snake Valley. For example, DEIS options affect the North and South Limestone Hills site, Big Springs, Big Springs Creek, Unnamed No. 1 spring, and Stateline Spring more than the other options, although the Apps option is a close second. The biggest effects occur after 100 years due to the distance from the pumping wells.

Drawdown at Big Springs reaches 1 foot after 100 and 12 feet after 1000 years, respectively, for the DEIS and Apps options. This drawdown causes the springs to effectively go dry, which demonstrates why considering a 50-foot drawdown at the environmental sites (Watrus and Drici, 2011) is insufficient as discussed by Myers (2011d).

Pumping Less Water from Distributed Locations

Simulation of distributed pumping with a lesser amount of pumping allows a comparison among options, including the Apps option (Myers, 2011c). For this rebuttal report, only the 30,000 af/y option has been considered. The scenarios are as described above, except the diversion rate from each well has been reduced to one-third the full application amount. The simulation herein differs from the DEIS option for reduced pumping (60,000 af/y) in that I used the full 80 wells rather than removing about 25 wells. This would lessen the predicted drawdown at the wells, as compared to the DEIS alternative E, due to less pumping at each POD.

Drawdown maps for pumping 30,000 af/y from the DEIS option resemble the maps for pumping the full application amount (Figure 19 and Figure 20), the main difference being the magnitude of drawdown. This means that drawdown affects most of Spring Valley even for pumping just a third as much water. After 75 years, the one-foot drawdown has reached Tippet Valley and is a few miles into Hamlin Valley; this is less than for pumping the full amount, for which the one-foot drawdown was reaching into Snake Valley (Figure 3). Drawdown reaches Snake Valley after 200 years (Figure 20). Most of the initial pumpage draws water from storage (Figure 21), just as it does for higher pumping rates, but continues to do so much longer for the lower pumping rate because it is slower to capture the discharge (Figure 5). The removal from storage drops close to zero after about 2000 years, reflecting the time required for the system to approach equilibrium.

The drawdown contours for the systematic Grid option, pumping 30,000 af/y, are a little less extensive than those for the DEIS grid, with the one-foot drawdown remaining mostly within Spring Valley after 75 years (Figure 22) and not reaching as far across Hamlin Valley after 200 years (Figure 23). It is less extensive because the drawdown within the valley is a little deeper, especially in the north, as demonstrated by the larger extent of 20-foot drawdown (Figure 23). More pumping occurs near the middle of the valley under this option which increases the drawdown directly under the playa. This Grid pumping option captures discharge more quickly, thereby limiting the amount of groundwater it removes from storage but drying wetlands and springs sooner.

This is apparent for almost 2000 years over which the storage flux for the Grid option is less than the other two options (Figure 24). Although the lines appear close on the graph (Figure 24), the Grid option differs by about 5000 af/y from the other options. This difference amounted to less than half as much total groundwater removed from storage (Figure 25).

The close similarities between the Apps and DEIS options are misleading. The effects on individual features, such as springs are vastly different. The valley-wide cumulative values shown on Figure 24 are only coincidentally similar. The proximity of the PODs to different springs/wetlands still controls the amount of water removed from each feature.

The proximity to the feature may be seen by the effect on interbasin flow from Steptoe Valley (Figure 26). Pumping the original Apps locations draws the most water from Steptoe Valley because of the proximity of the PODs to the boundary. The Grid option pulls the least amount because it pumps more from the center of the valley, and takes more from in-valley discharge than from nearby basins.

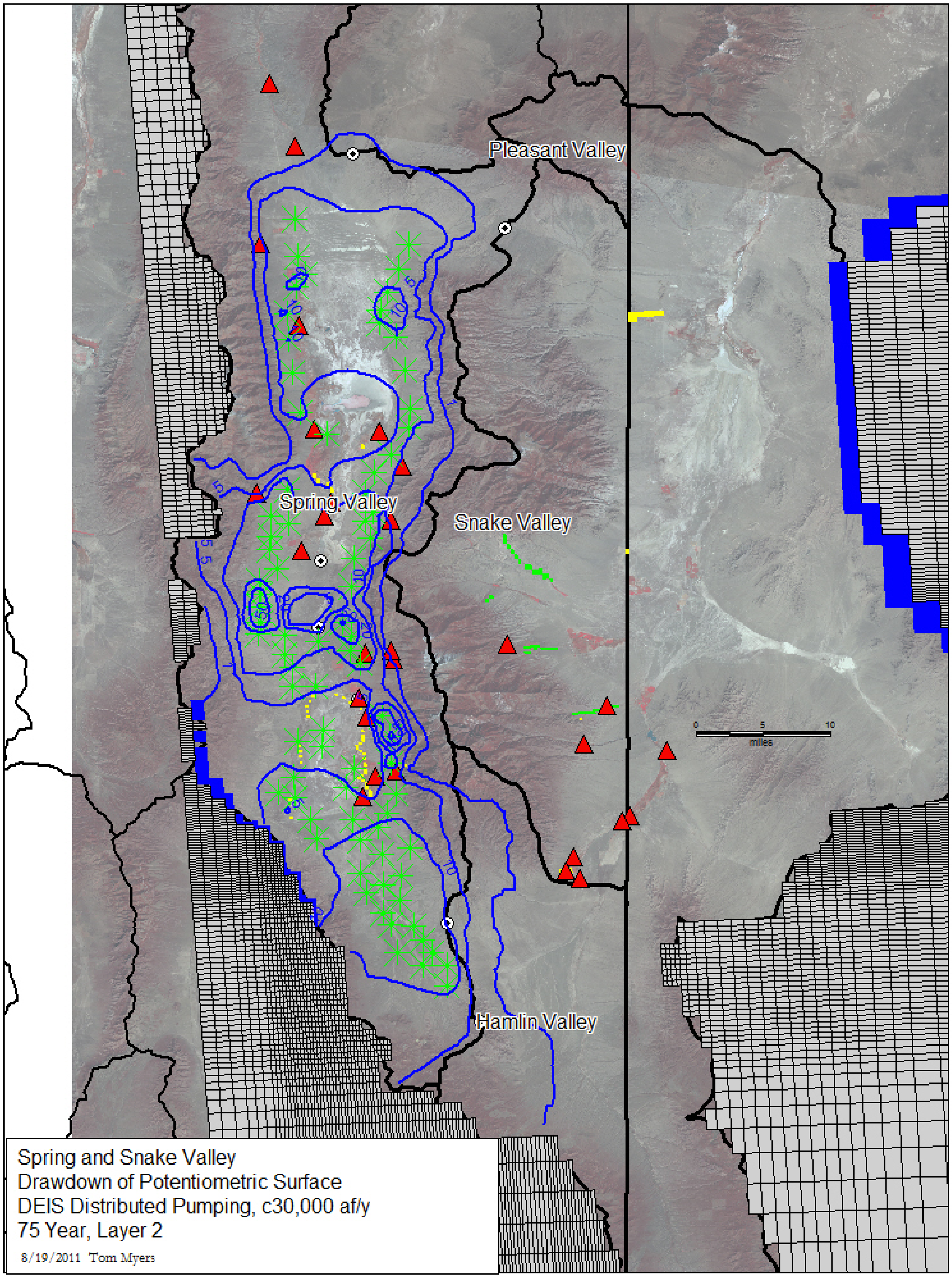


Figure 19: Map of drawdown contours after 75 years for DEIS distributed pumping option at 30,000 af/y. See Figure 2 for description of wells and monitoring sites.

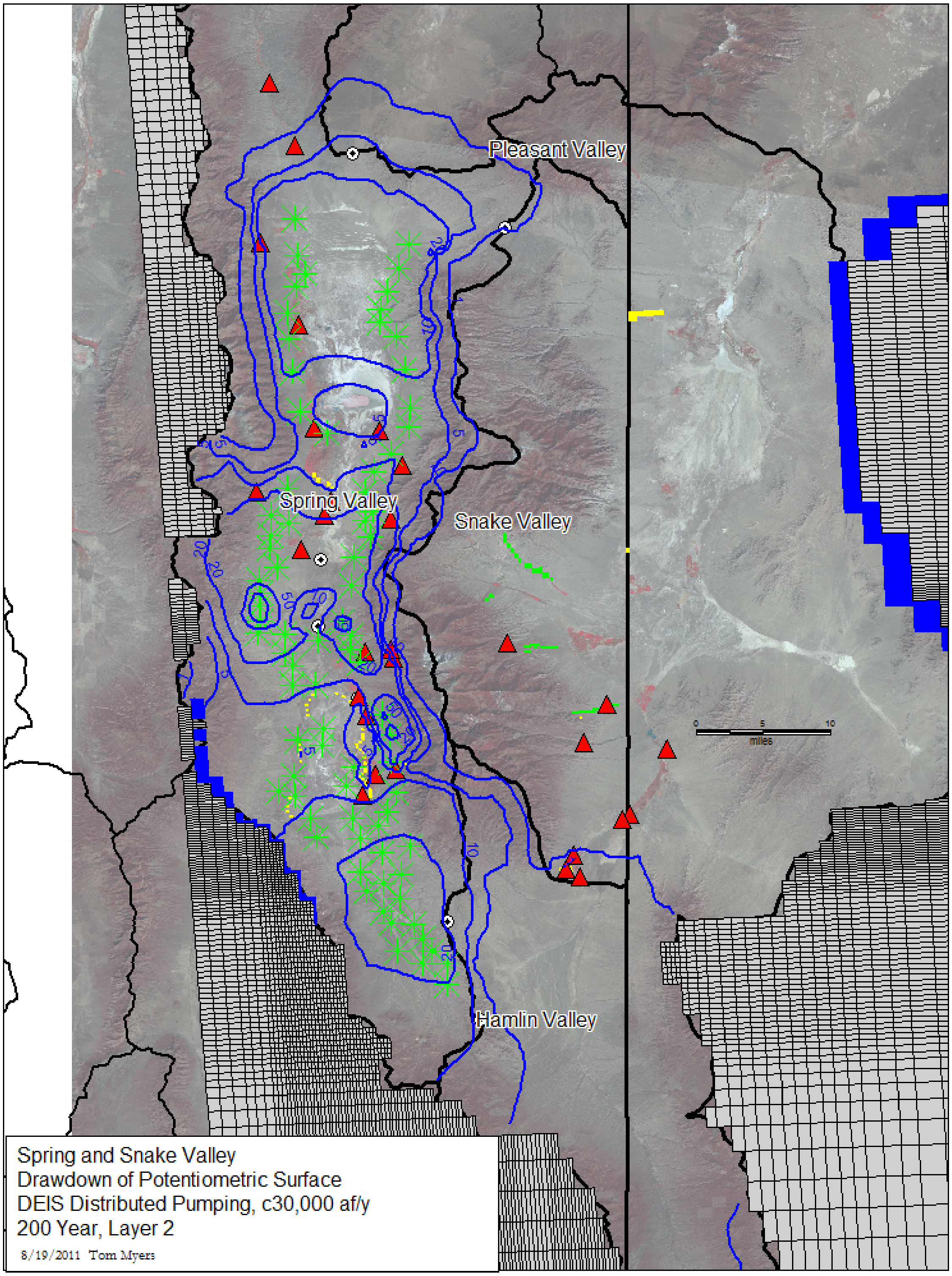


Figure 20: Map of drawdown contours after 200 years for DEIS distributed pumping option at 30,000 af/y. See Figure 2 for description of wells and monitoring sites.

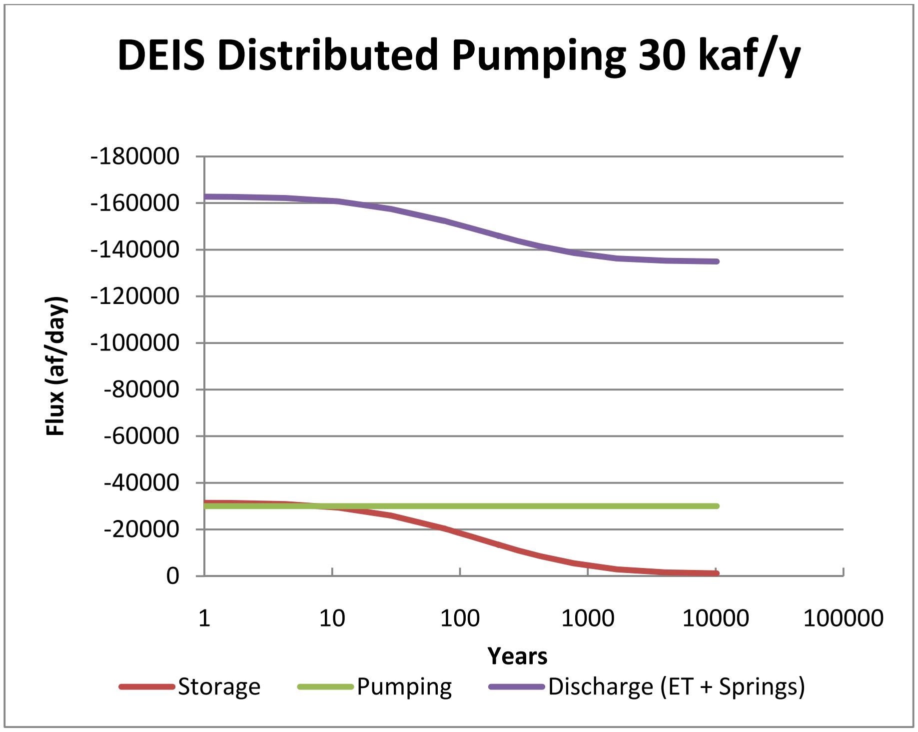


Figure 21: Flux hydrograph of storage and discharge for the DEIS distributed pumping option, with the valleywide rate equaling 30,000 af/y.

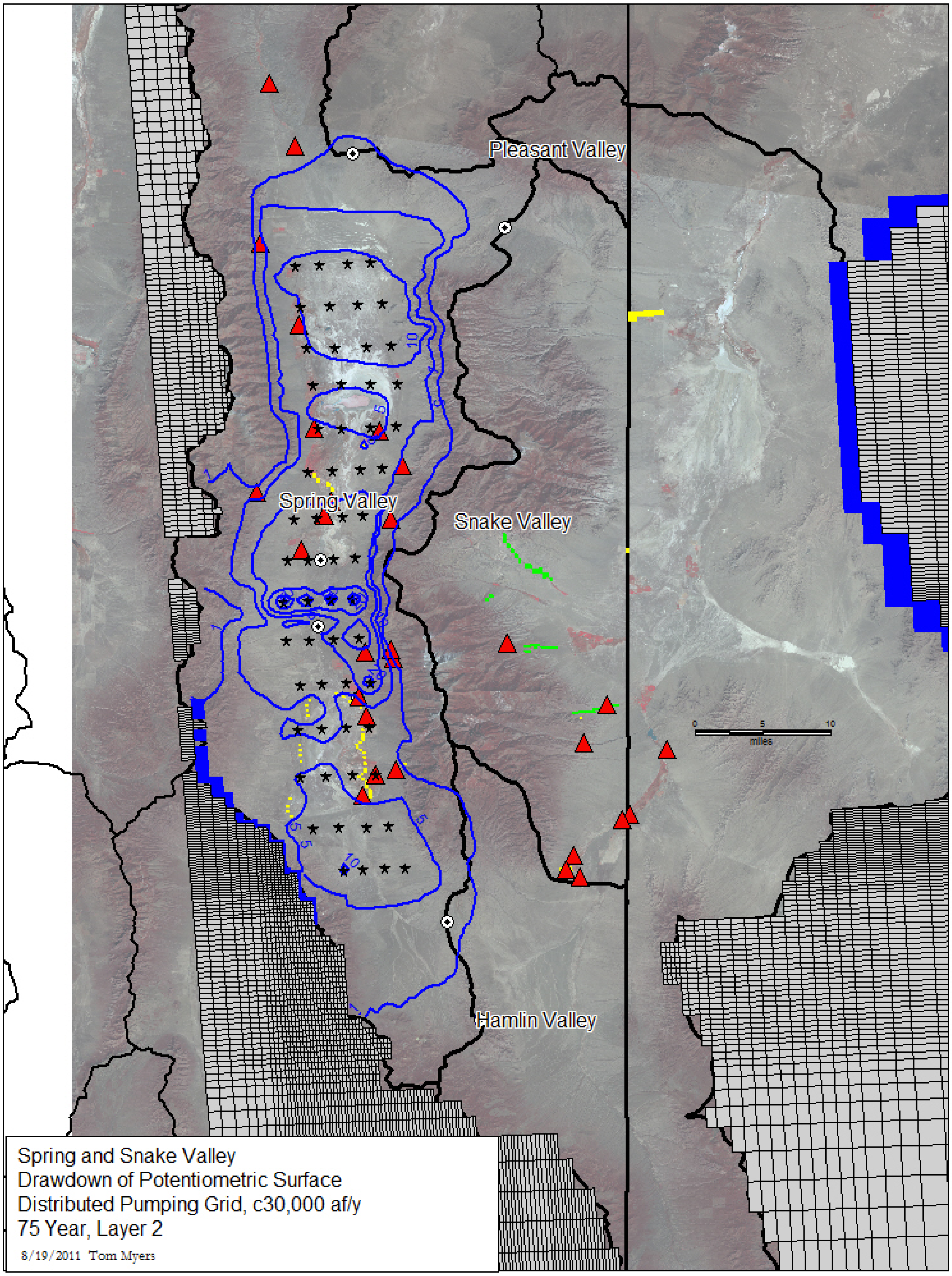


Figure 22: Map of drawdown contours after 75 years for distributed grid pumping option at 30,000 af/y. See Figure 2 for description of wells and monitoring sites; the black stars are PODs.

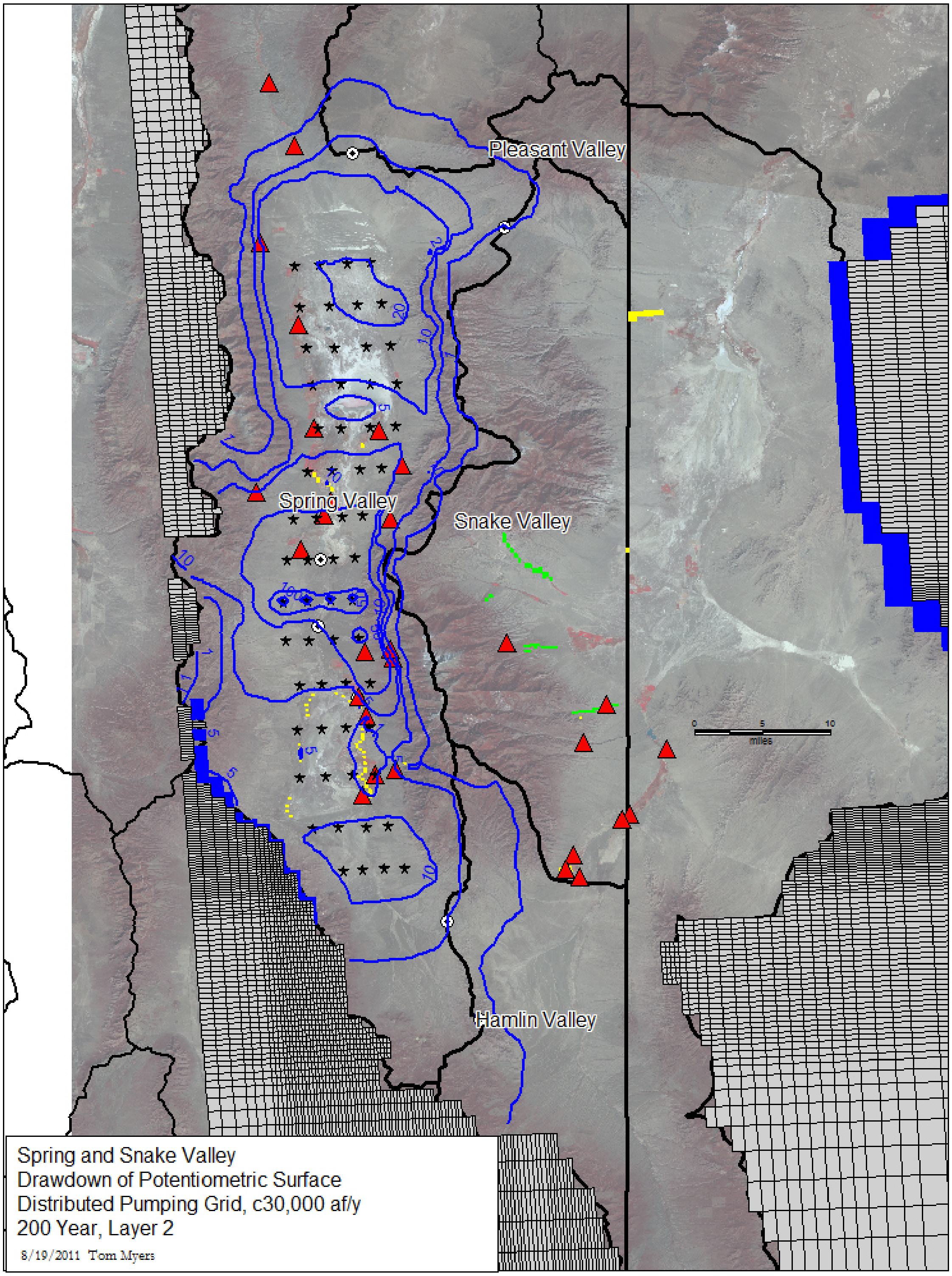


Figure 23: Map of drawdown contours after 200 years for distributed grid pumping option at 30,000 af/y. See Figure 2 for description of wells and monitoring sites; the black stars are PODs.

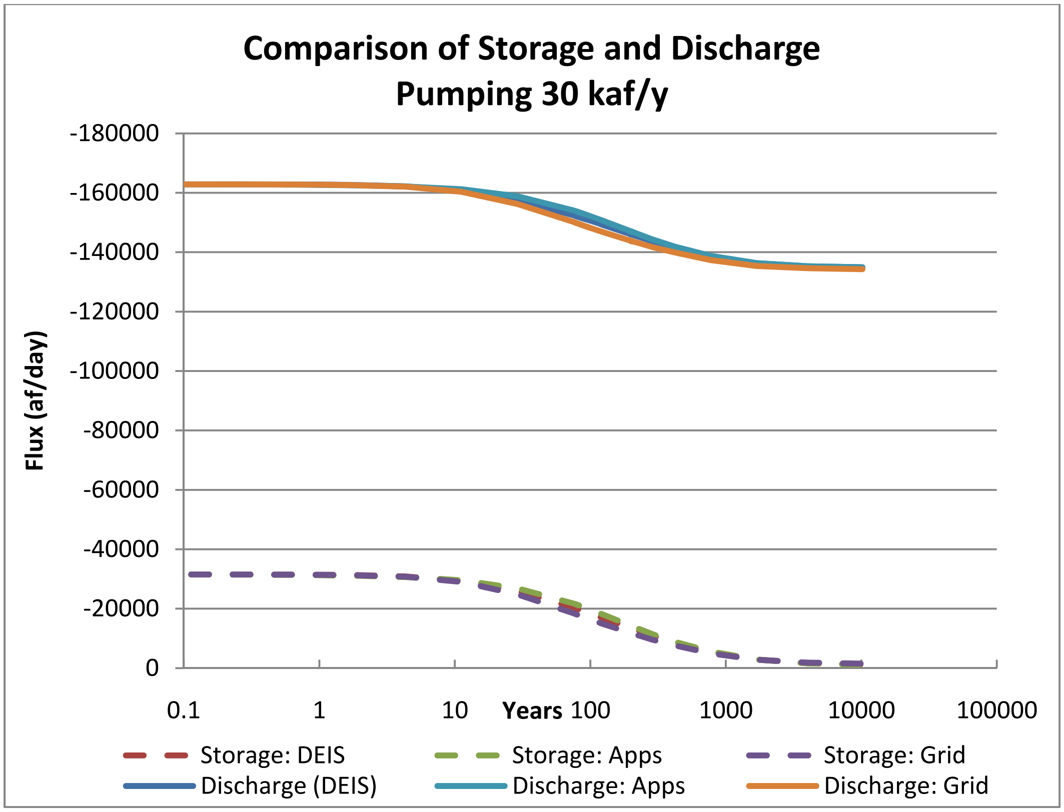


Figure 24: Storage and discharge flux for pumping all three scenarios at 30,000 af/y.

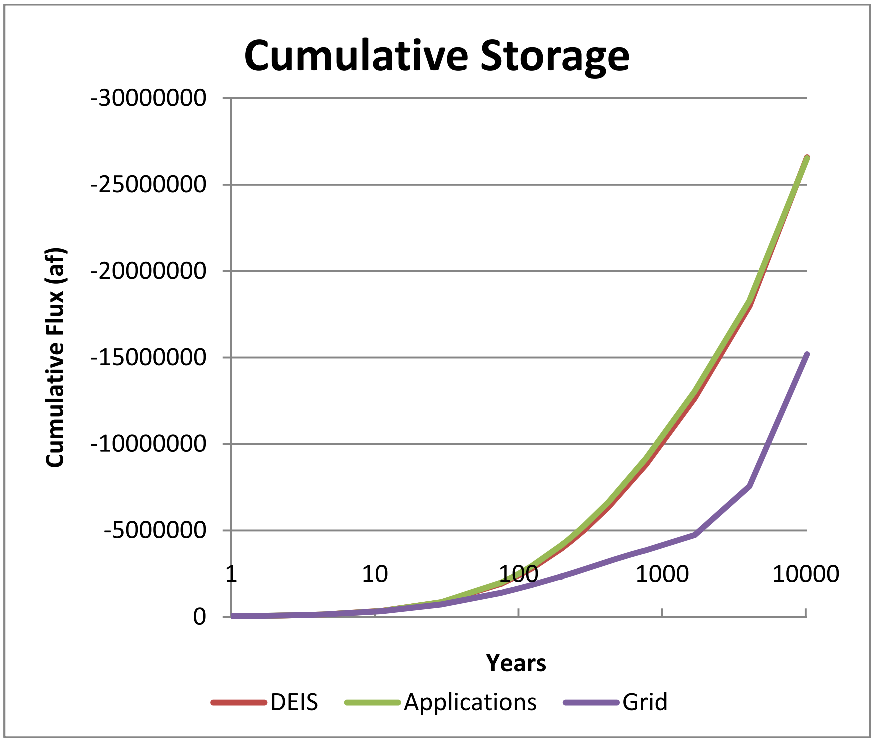


Figure 25: Cumulative groundwater removed from storage for the three scenarios pumping 30,000 af/y.

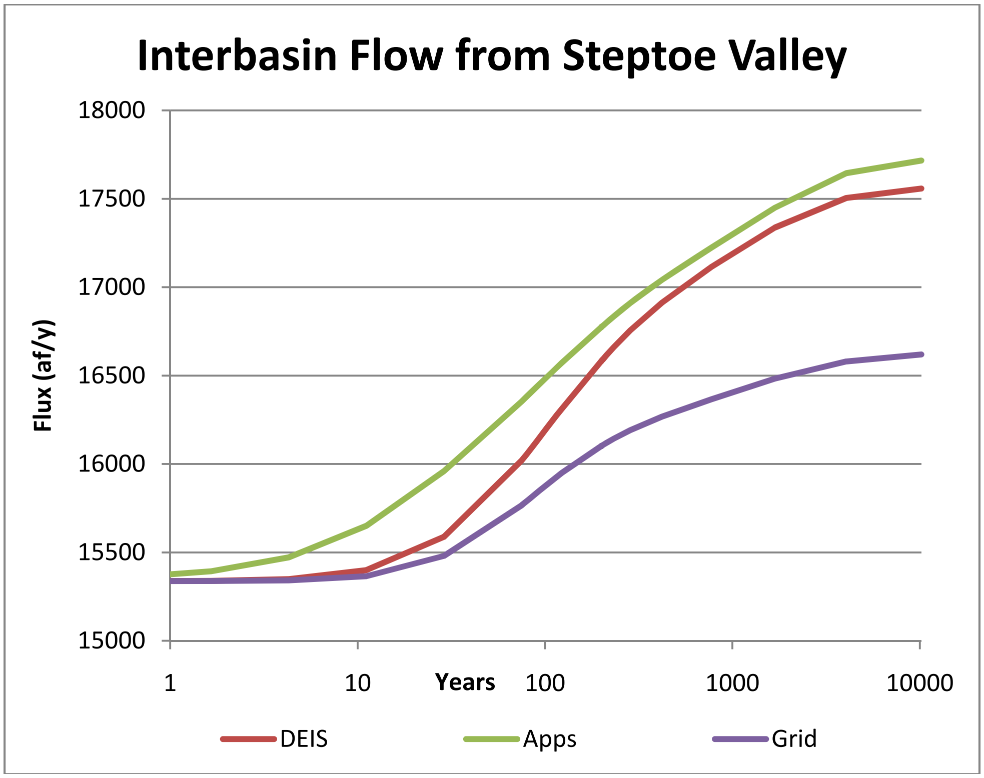


Figure 26: Flux hydrograph for interbasin flow from Steptoe Valley for the three scenarios pumping at 30,000 af/y.

Discussion

Pumping the full application amount from the original application locations causes massive and unsustainable drawdown (Myers, 2011c; BLM, 2011). It dries wetlands and springs and causes drawdown within Spring Valley to be as much as hundreds of feet and eventually spreads substantial drawdown into surrounding basins. Pumping from two different distributed options decreases the amount of water removed from storage, and hence the total drawdown at the pumping wells, by more quickly capturing discharge, thereby drying springs and wetlands more quickly. The distributed pumping drawdown is spread around Spring Valley more than for the Apps scenario.

Reducing the amount of groundwater pumped from any of the three POD distributions does not decrease the extent of drawdown, meaning the same features are affected as for pumping the full amount, although the magnitude of impact is lessened. The full extent of impacts is similar among pumping rates because the drawdown reaches the boundaries of the valley. The model hydrogeology has an impervious boundary along much of the Schell Creek Range and simulates the Snake Range with a very low conductivity – both factors effectively limit the drawdown extent. The exceptions are the model boundary with Steptoe/Lake Valley and higher conductivity between Spring and Hamlin and Spring and Tippet and Pleasant Valleys. In each of these boundaries the pumping causes drawdown, thereby limiting interbasin flow to the downgradient valleys, or drawing interbasin flow from Steptoe Valley.

The distance of the pumping from the boundaries affects and controls the time for the system to reach equilibrium. Pumping the full application amount from any POD distribution would require some flow be drawn from adjoining basins because the pumping rate exceeds the in-basin recharge. The low-conductivity boundaries cause the drawdown within Spring Valley to continue deepening, which creates a sufficient gradient to draw groundwater from adjoining basins. The system approaches equilibrium only after 2000 years of pumping just 30,000 af/y because the natural discharge points are spread out through the basin and because up to 50 feet of drawdown is required due to the extinction depth of the ET boundaries (Myers, 2011b).

Pumping from the original applications causes less drawdown to be predicted at various environmental monitoring points than does pumping from distributed PODs. Considering just the application PODs likely underestimates the drawdown that would ultimately occur due to pumping these water rights because the drawdown associated with removing the application amounts from the original PODs is unrealistically high. The drawdown cone itself intersects the monitoring sites at the peripheries, which leads to the low but unrealistic drawdown estimates. The Apps scenario causes more drawdown only at monitoring points near the center of Spring Valley, such as Cleve Creek, West Spring Valley spring complex, South Bastian spring, Willard Springs, and Swamp Cedar North. For some central sites, the Apps scenario causes drawdown similar to the Grid scenario because the amount of groundwater removed near the monitoring site is similar. Monitoring points which have more drawdown for both distributed pumping scenarios include Willow, Stonehouse, and Keegan springs and Kalamazoo Creek – the sites in northern Spring Valley most affected by the distributed pumping. This is because the distributed pumping option spreads the diversions around the valley, as would likely occur due to change applications.

The monitoring wells indicate how fast the system approaches equilibrium – the hydrograph becomes horizontal as it approaches equilibrium. The hydrographs in Appendix A to this report are on logarithmic scales to improve the detail. Pumping the full application amount, the DEIS layout approaches equilibrium at more sites within 10,200 years than do the other regimes. These sites include S Millick Spring, Negro Creek, Cleve Creek, Swamp Cedar North, and Pine/Ridge Creek. The DEIS layout removes more water closer to the monitoring site, which speeds the drawdown at the site. All scenarios approached equilibrium at Swamp Cedar South, Minerva Spring, and Blind Spring. In the south end and in Snake Valley, all scenarios approached equilibrium after 4000 years. Based on domain discharge and storage fluxes (Figure 8), all three scenarios approach equilibrium after 4000 years, with the DEIS scenario being slightly faster (as seen by the change in storage approaching 0 sooner); however, even after 10,000 years, up to 4000 af/y continues to be removed from storage, as the drawdown cones continue to slowly expand. Small changes in the flux to the Great Salt Lake and to the Goshute Valley north of Tippet Valley (not shown) begin to manifest after approximately 4000 years.

Considering the locations of the original applications, it is difficult not to conclude that the applications were located to draw water from Steptoe Valley. They are located near the carbonate boundaries between the valleys (Welch et al, 2007) where interbasin flow would have been expected even in 1989.

Conclusion

The three pumping scenarios considered herein and in Myers (2011c) demonstrate that no water should be exported from Spring Valley. The system does not come to equilibrium for thousands of years, even when pumping at only a third of the application amount. Distributing the wells around the valley differently from the applications changes the proportion of water removed from storage and captured from wetlands and springs, but all scenarios cause unreasonable, environmentally unsound, detrimental impacts to the Valley. The NSE should deny the applications due to potential damages to environmental resources and water rights within Spring Valley and in adjacent valleys.

References

(BLM) U.S. Bureau of Land Management, 2011. Clark, Lincoln, and White Pine Counties Groundwater Development Project Draft Environmental Impact Statement. Reno, NV.

Myers, T., 2011a. Hydrogeology of Spring Valley and Surrounding Areas, Part A: Conceptual Flow Model. Presented to the Nevada State Engineer on behalf of Great Basin Water Network and the Federated Tribes of the Goshute Indians.

Myers, T., 2011b. Hydrogeology of Spring Valley and Surrounding Areas, Part B: Groundwater Model of Snake Valley and Surrounding Area. Presented to the Nevada State Engineer on behalf of Great Basin Water Network and the Federated Tribes of the Goshute Indians.

Myers, T., 2011c. Hydrogeology of Spring Valley and Surrounding Areas, PART C: IMPACTS OF PUMPING UNDERGROUND WATER RIGHT APPLICATIONS #54003 THROUGH 54021. Presented to the Nevada State Engineer on behalf of Great Basin Water Network and the Federated Tribes of the Goshute Indians.

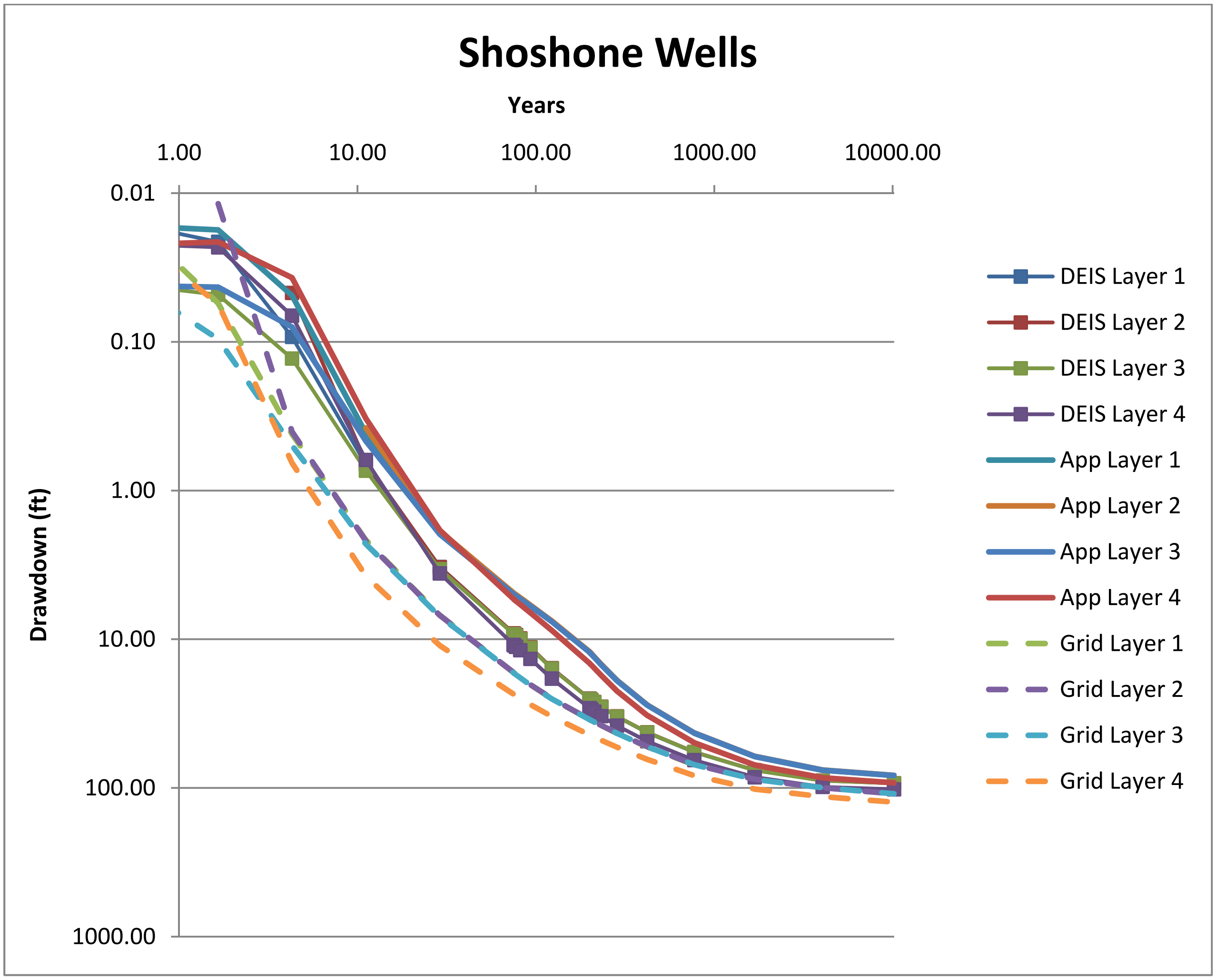
Myers, T., 2011d. Rebuttal Report: Part 1, Review of Evidence Reports Submitted by Southern Nevada Water Authority in Support of Water Rights Applications for Spring, Cave, Dry Lake, and Delamar Valleys. Presented to the Nevada State Engineer on behalf of Great Basin Water Network and the Federated Tribes of the Goshute Indians.

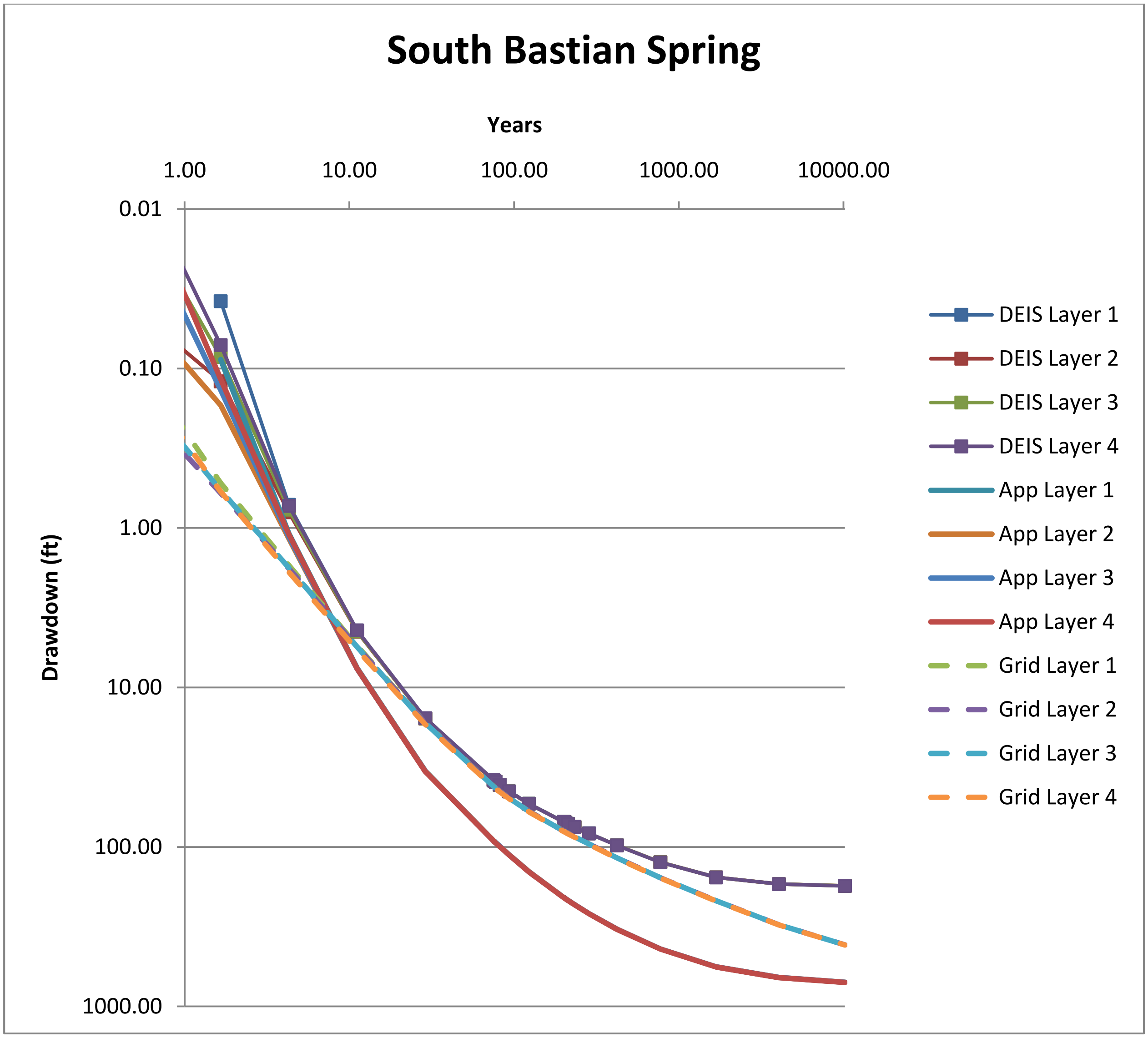
(SNWA) Southern Nevada Water Authority, 2010. Simulation of Groundwater Development Scenarios Using the Transient Numerical Model of Groundwater Flow for the Central Carbonate-Rock Province: Clark, Lincoln, and White Pine Counties Groundwater Development Project. Prepared in Cooperation with the Bureau of Land Management.

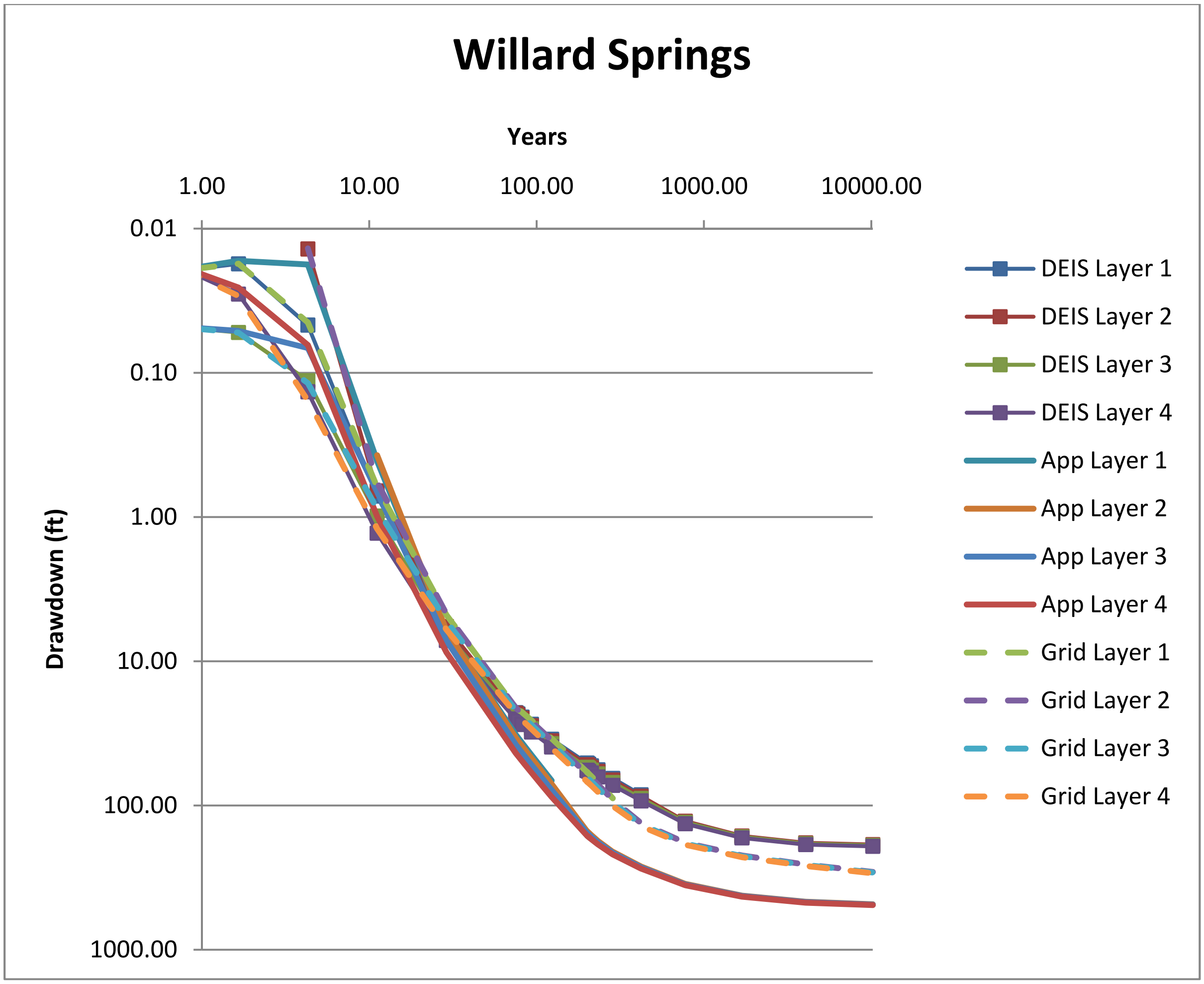
Watrus, J.M., and Drici, W., 2011, Conflicts analysis related to Southern Nevada Water Authority groundwater applications in Spring, Cave, Dry Lake, and Delamar valleys, Nevada and vicinity: Presentation to the Office of the Nevada State Engineer: Southern Nevada Water Authority, Las Vegas, Nevada.

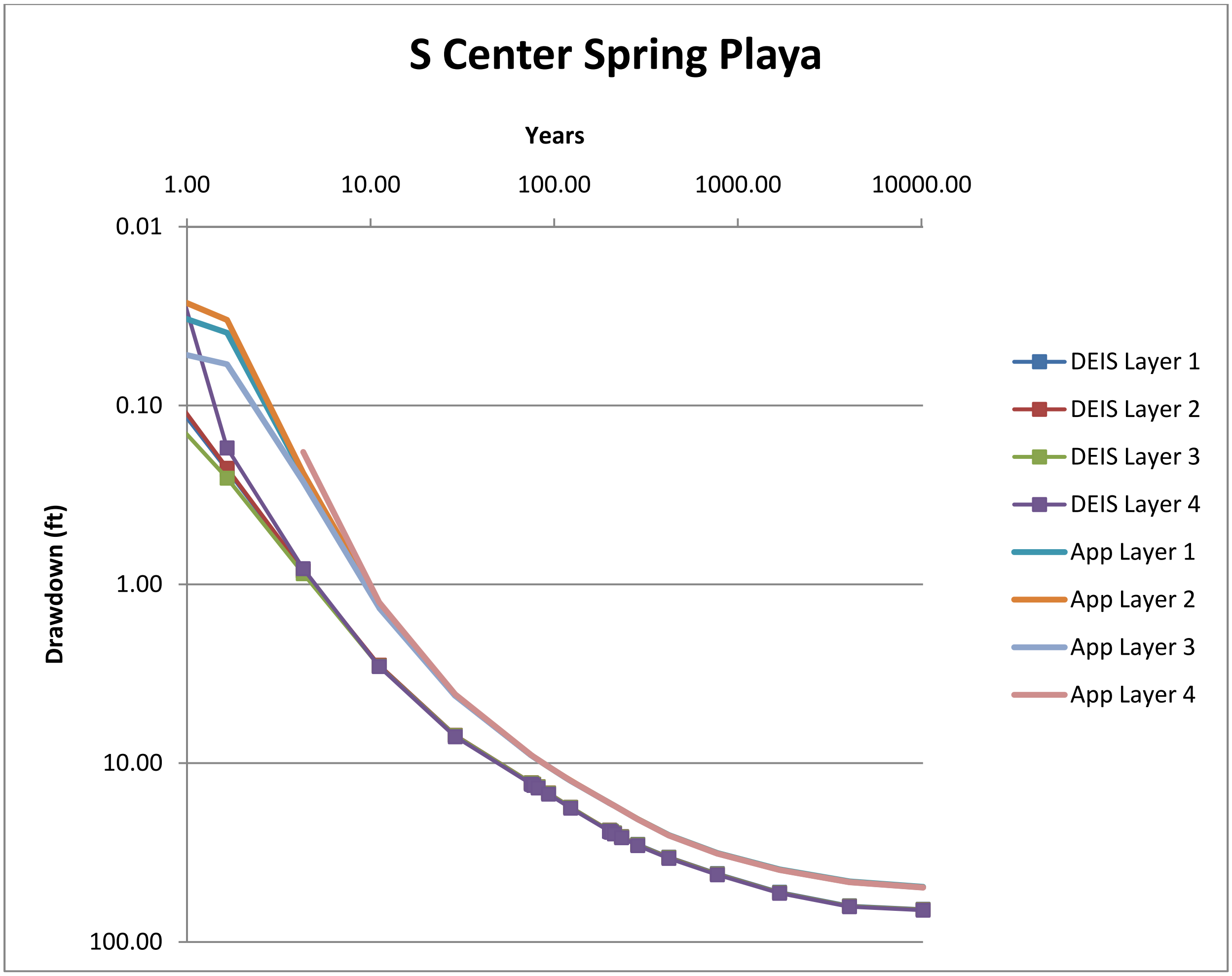
Welch, A.H., Bright, D.J., and Knochenmus, L.A., eds., 2008. Water resources of the Basin and Range carbonate-rock aquifer system, White Pine County, Nevada, and adjacent areas in Nevada and Utah: U.S. Geological Survey Scientific Investigations Report 2007–5261, 96 p.

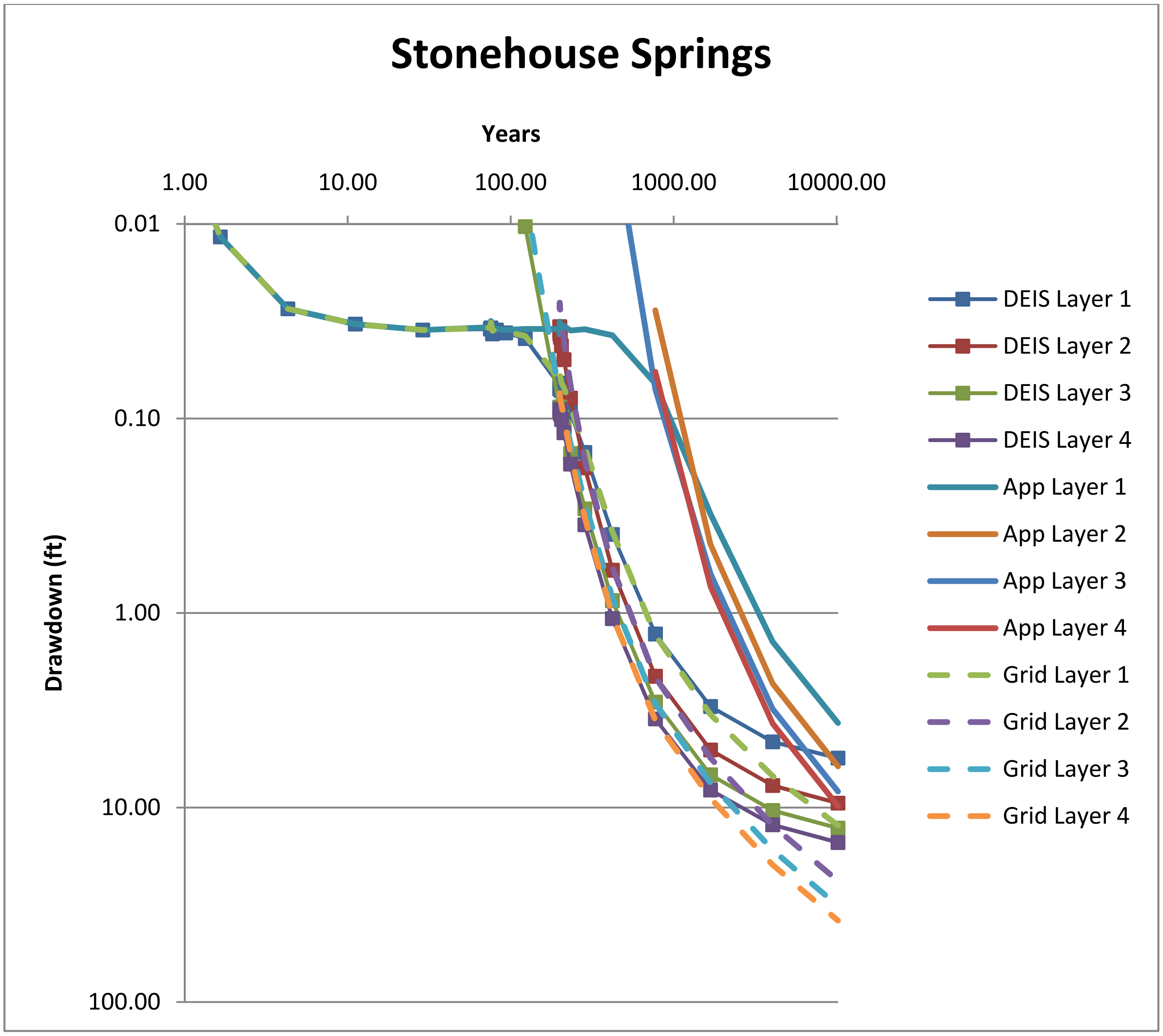
Appendix A: Water Level Hydrographs for Pumping Scenarios at Monitoring Sites around the Model Domain




South Bastian Spring
Years
1.00
10.00
100.00
1000.00
10000.00
0.01
0.10
1.00
10.00
100.00
1000.00
Drawdown (ft)
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 1
App Layer 2
App Layer 3
App Layer 4
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4


Willard Springs
Years
1.00
10.00
100.00
1000.00
10000.00
0.01
0.10
1.00
10.00
100.00
1000.00
Drawdown (ft)
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 1
App Layer 2
App Layer 3
App Layer 4
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4


S Center Spring Playa
Years
1.00
10.00
100.00
1000.00
10000.00
Drawdown (ft)
0.01
0.10
1.00
10.00
100.00
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 1
App Layer 2
App Layer 3
App Layer 4

Stonehouse Springs
Years
1.00
10.00
100.00
1000.00
10000.00
0.01
0.10
1.00
10.00
100.00
Drawdown (ft)
DEIS Layer 1
DEIS Layer 2
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DEIS Layer 4
App Layer 1
App Layer 2
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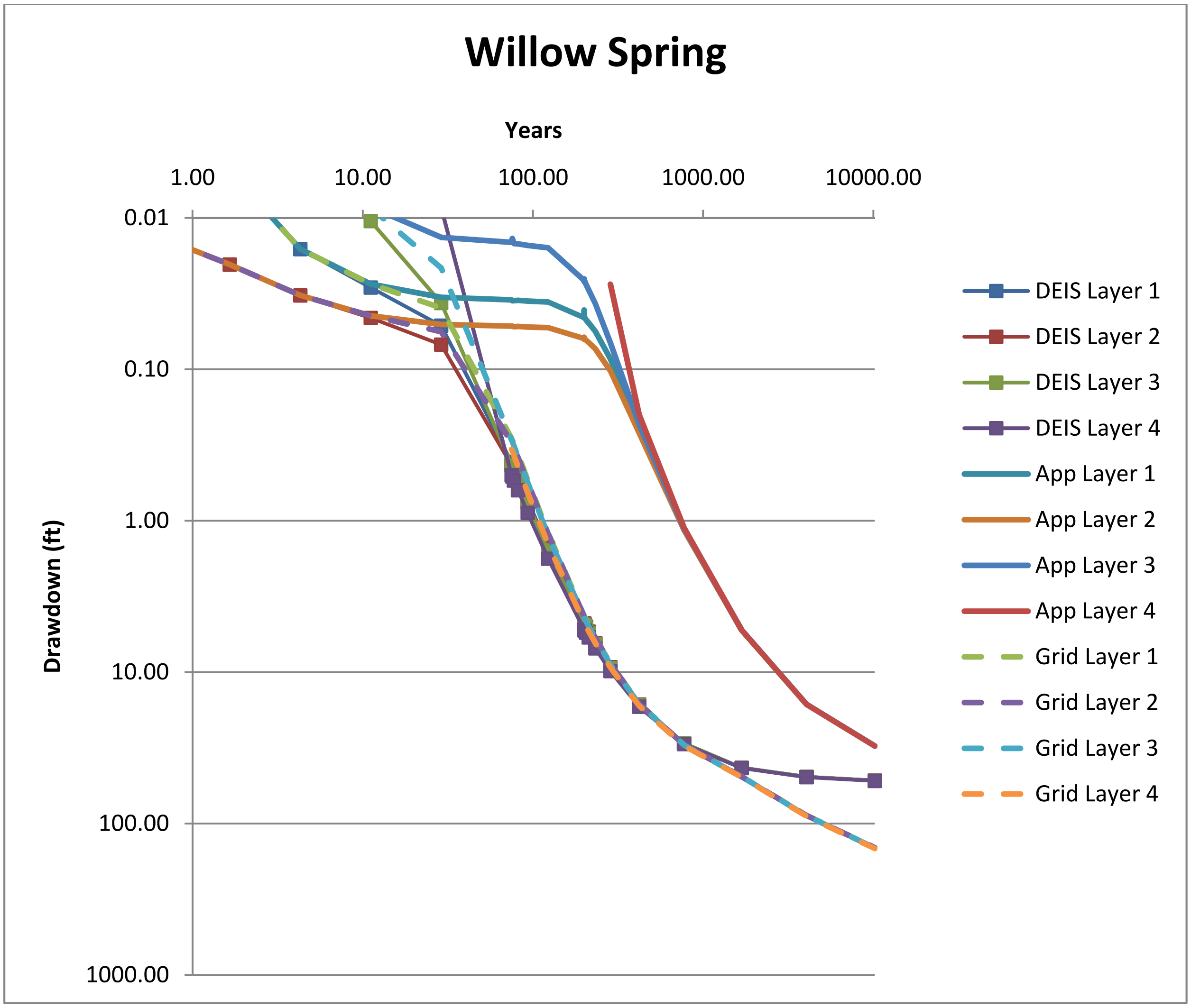
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4


Willow Spring
Years
1.00
10.00
100.00
1000.00
10000.00
Drawdown (ft)
0.01
0.10
1.00
10.00
100.00
1000.00
DEIS Layer 1
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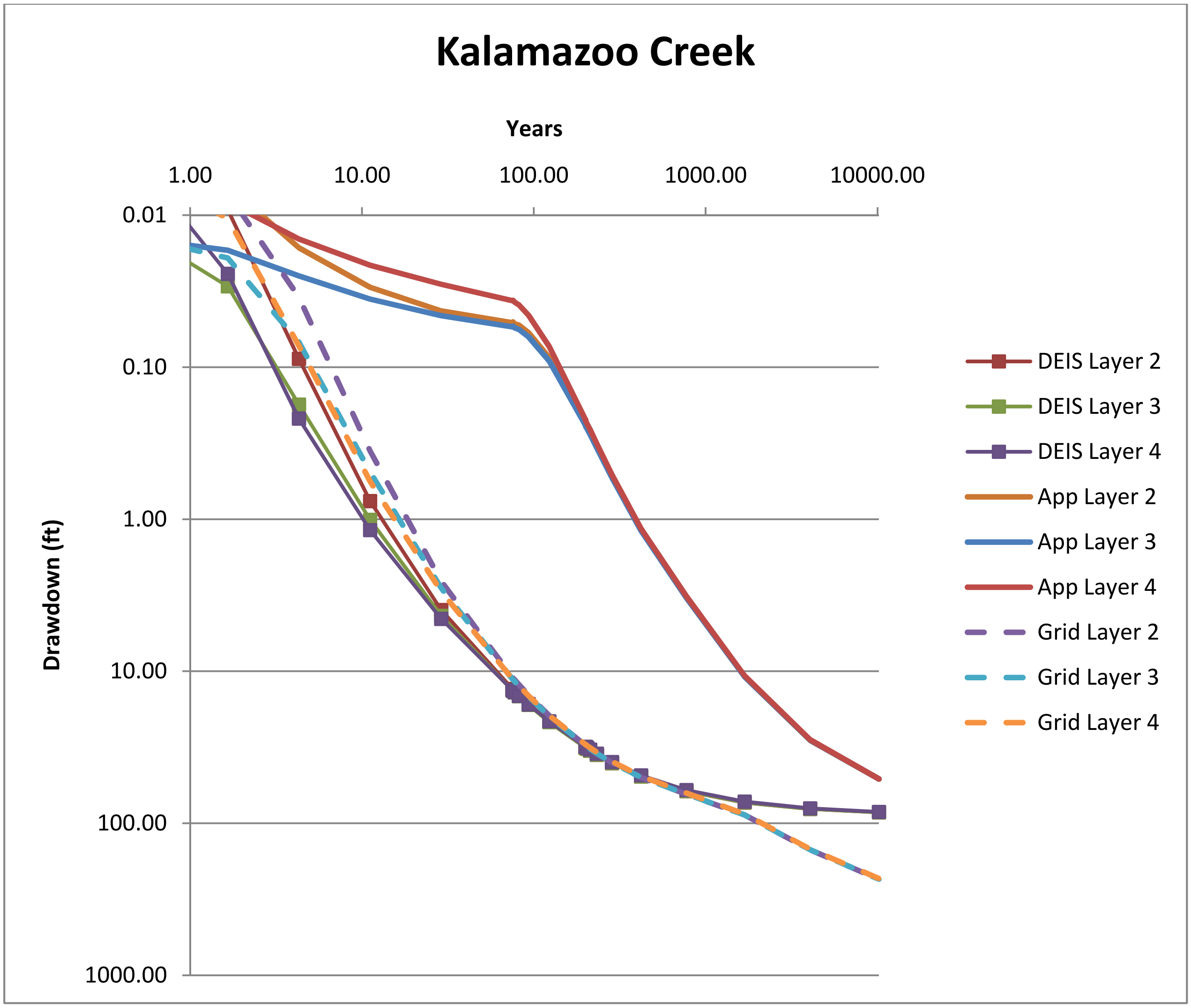
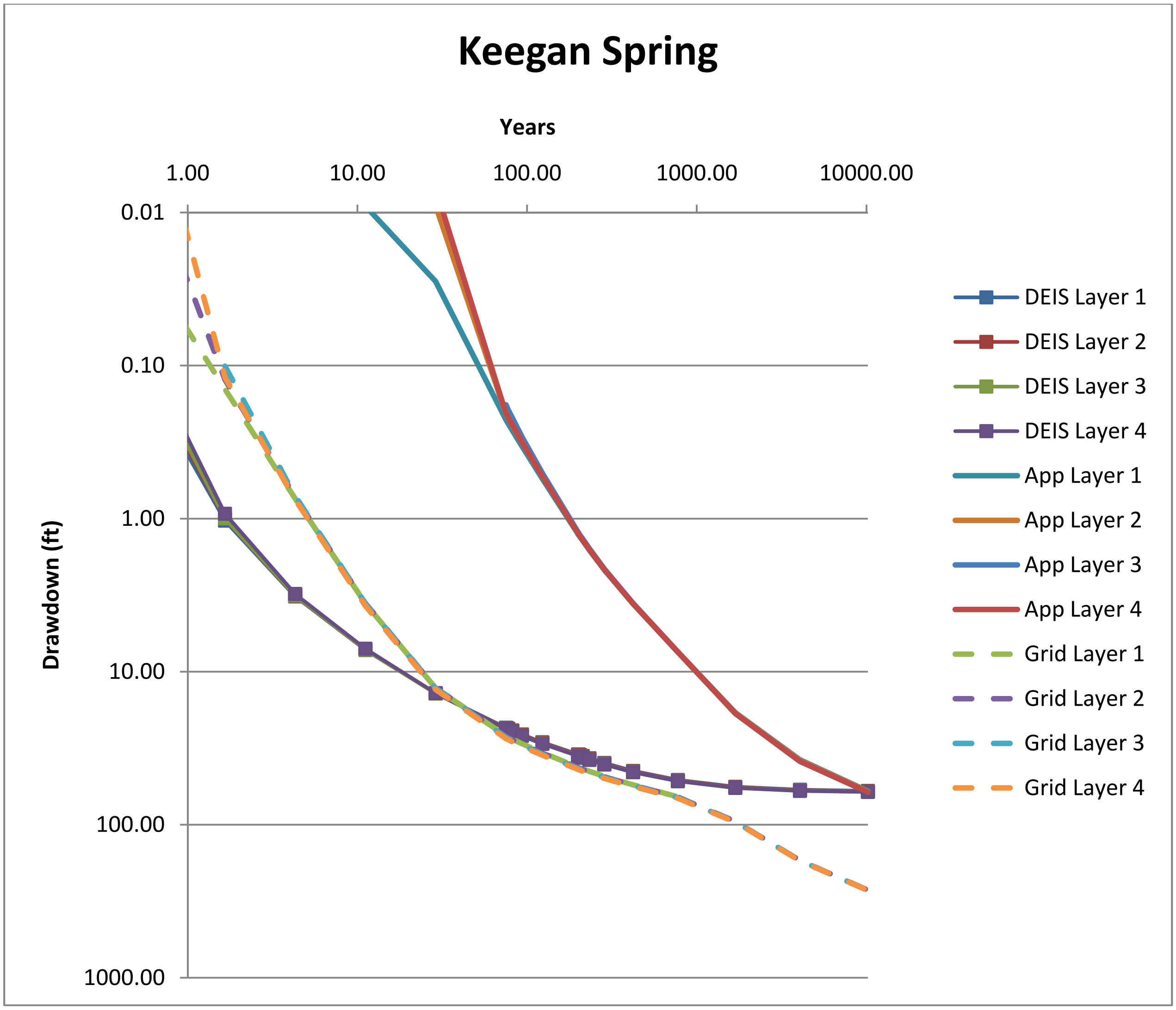
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4


Kalamazoo Creek
Years
1.00
10.00
100.00
1000.00
10000.00
0.01
0.10
1.00
10.00
100.00
1000.00
Drawdown (ft)
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 2
App Layer 3
App Layer 4
Grid Layer 2
Grid Layer 3
Grid Layer 4


Keegan Spring
Years
1.00
10.00
100.00
1000.00
10000.00
0.01
0.10
1.00
10.00
100.00
1000.00
Drawdown (ft)
DEIS Layer 1
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DEIS Layer 4
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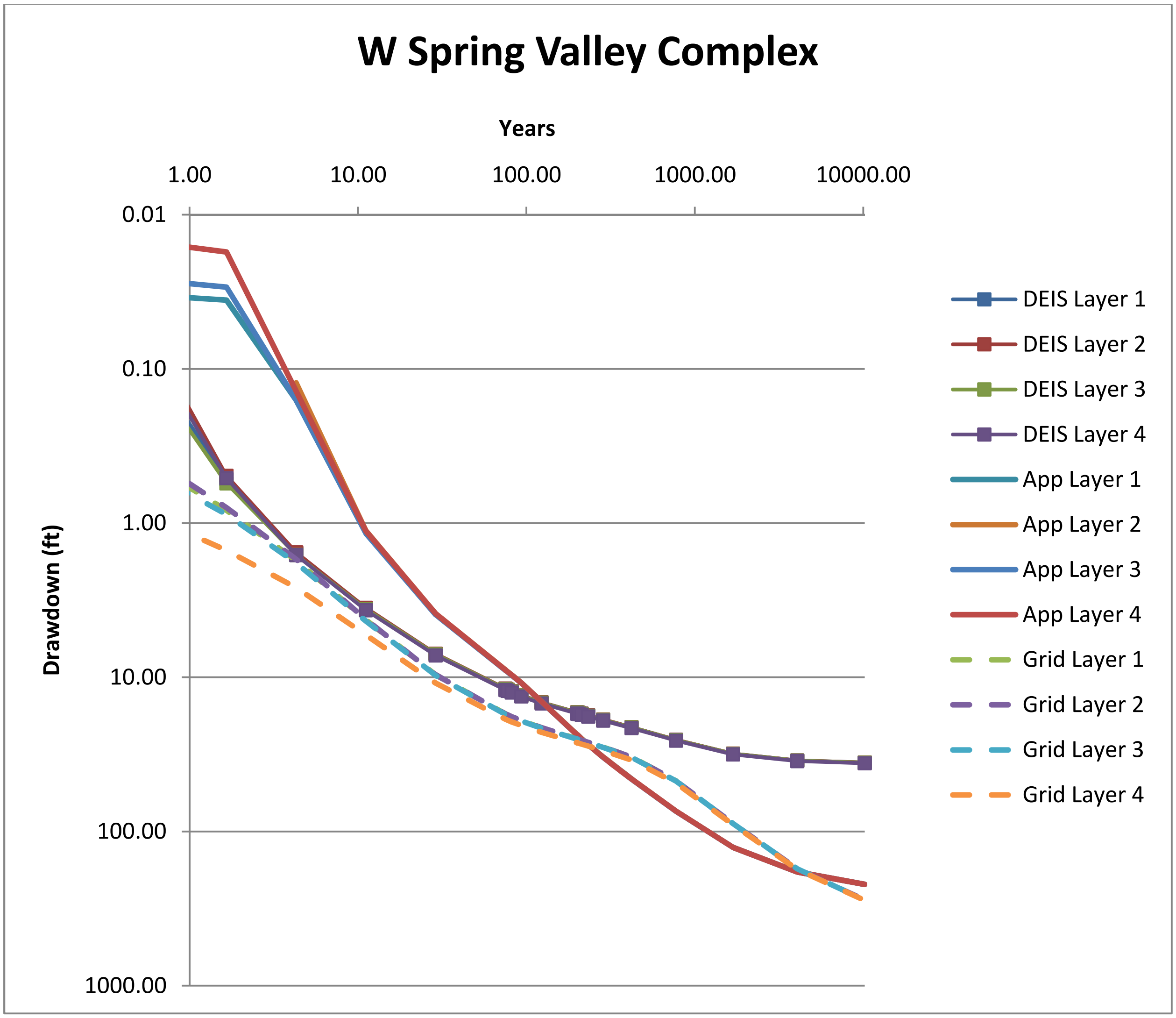
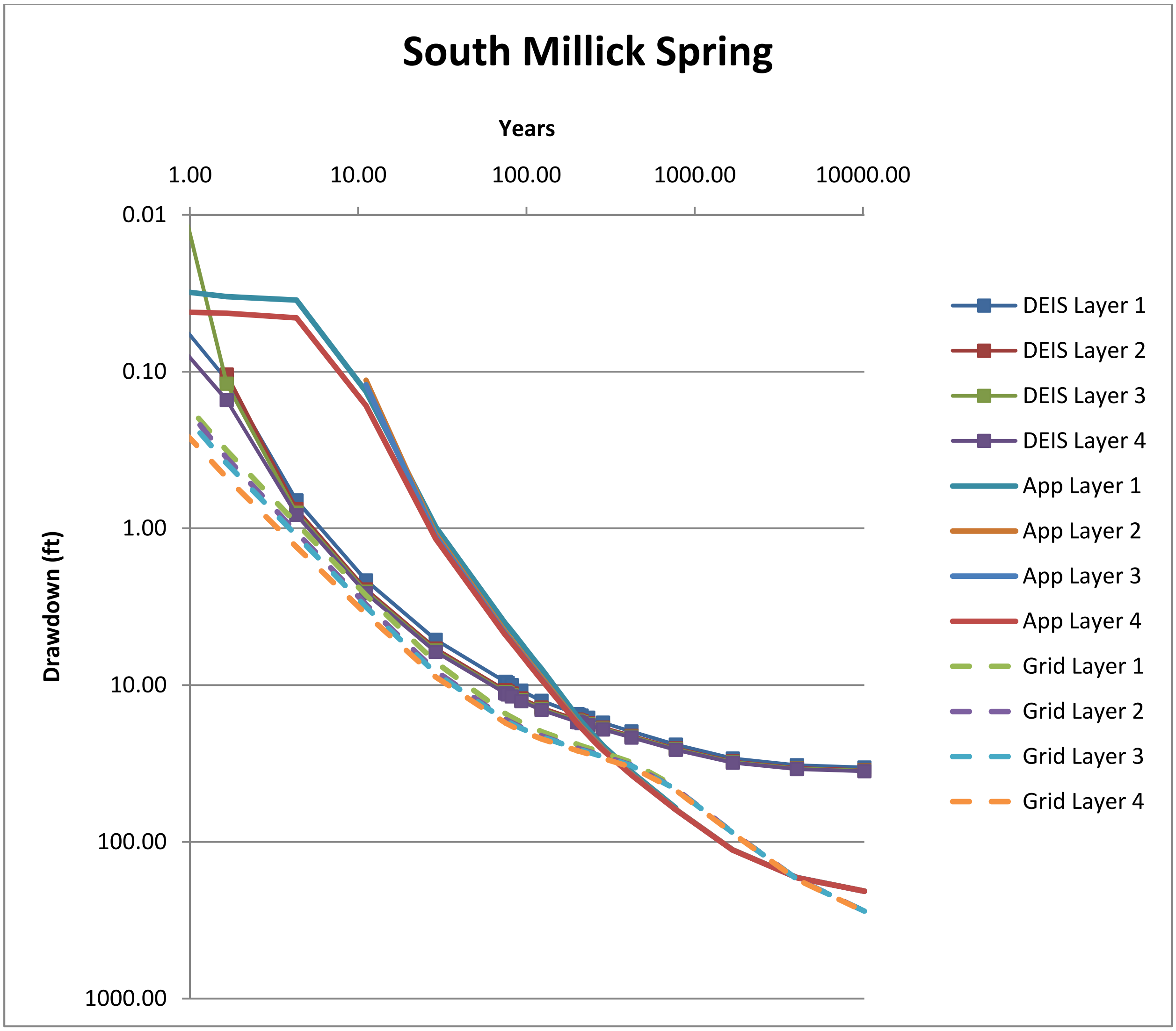
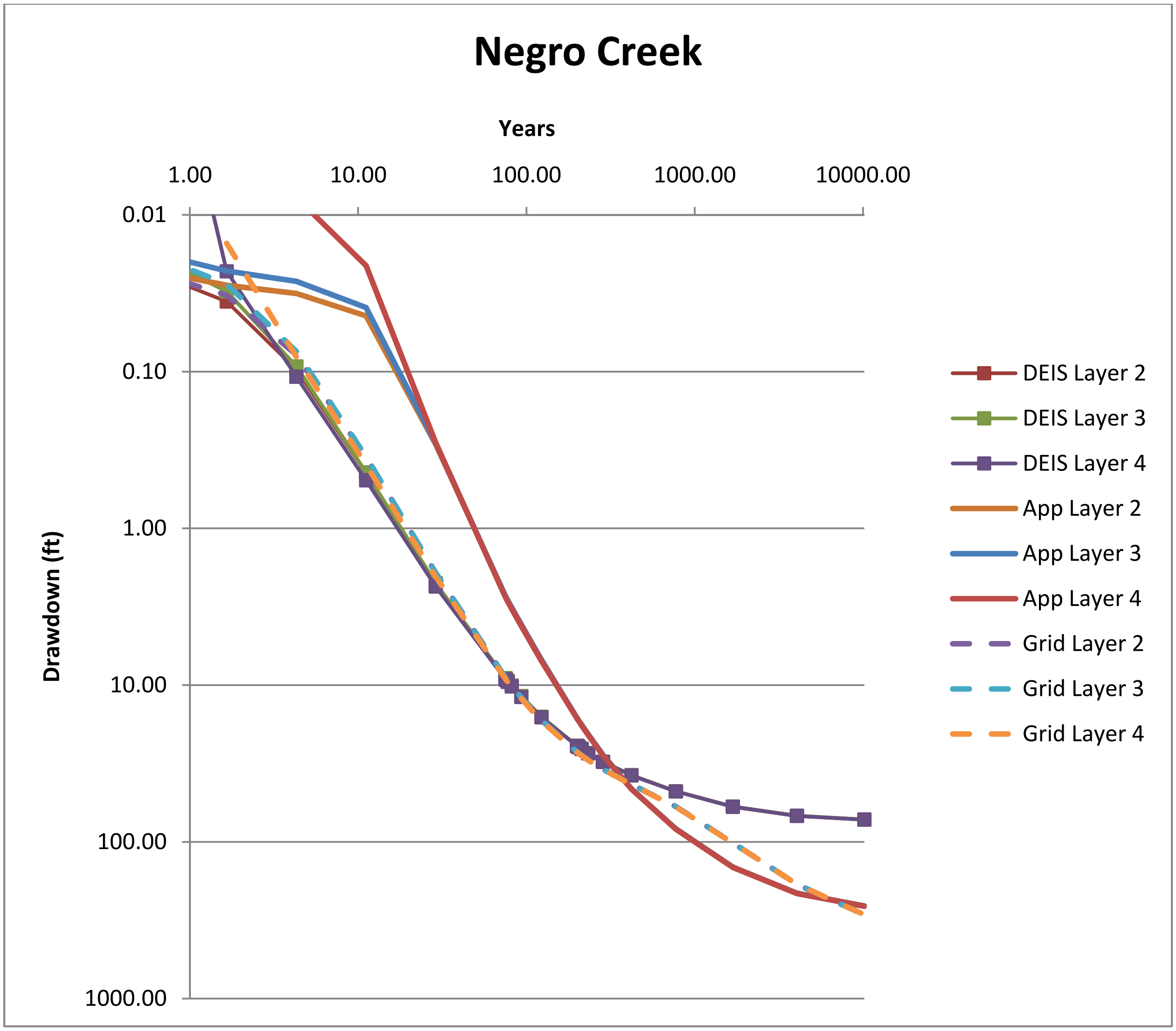
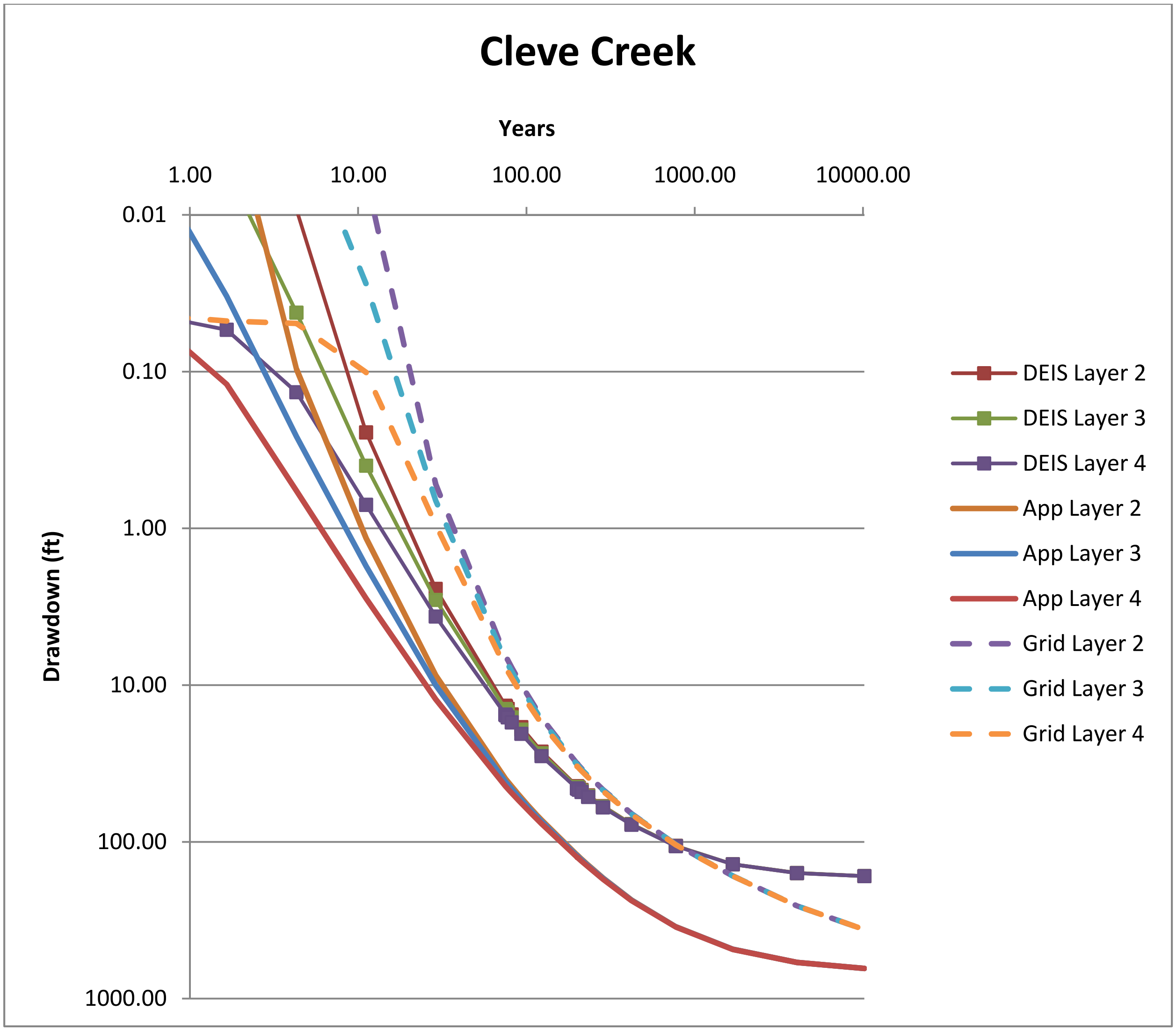
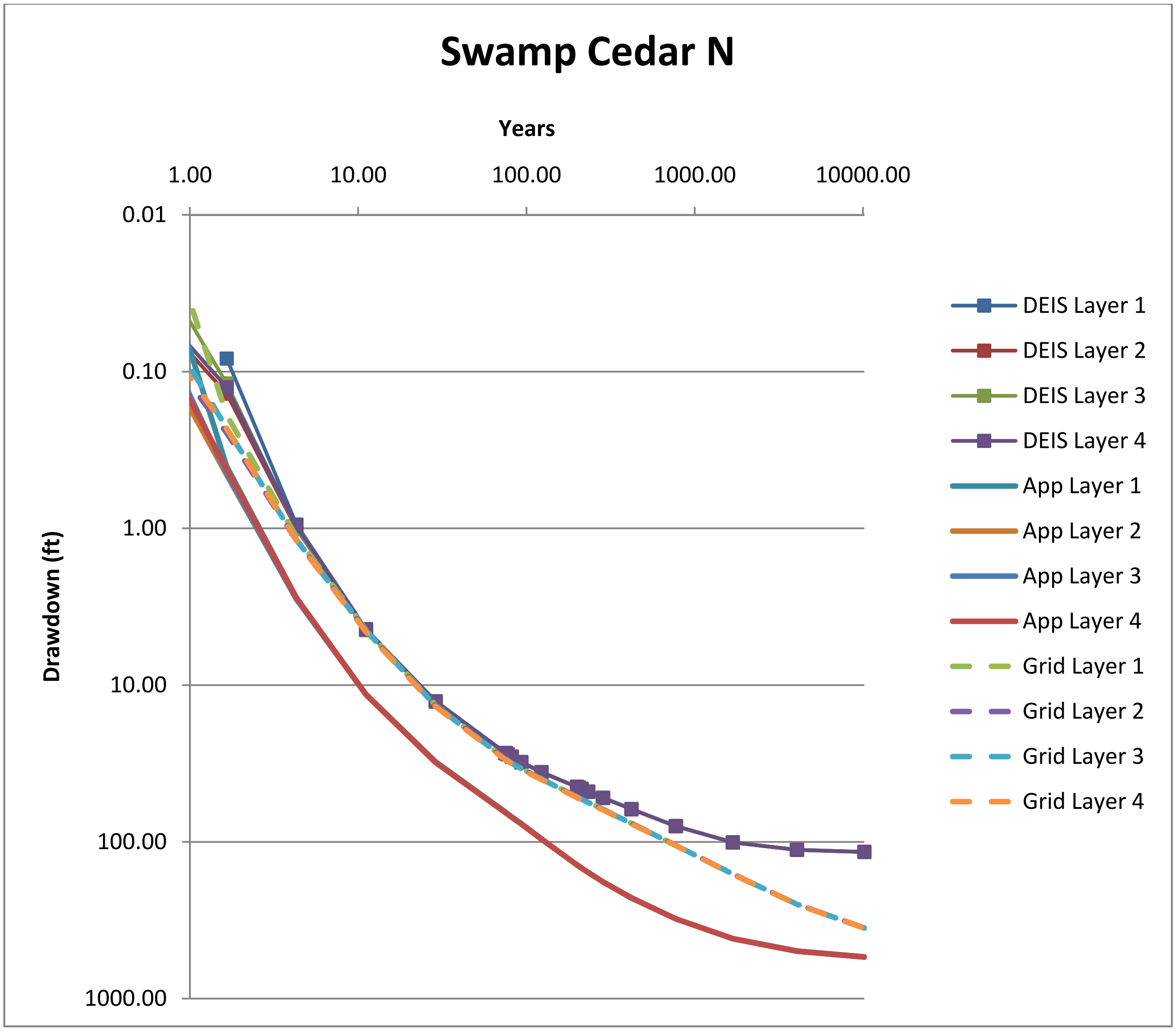
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4

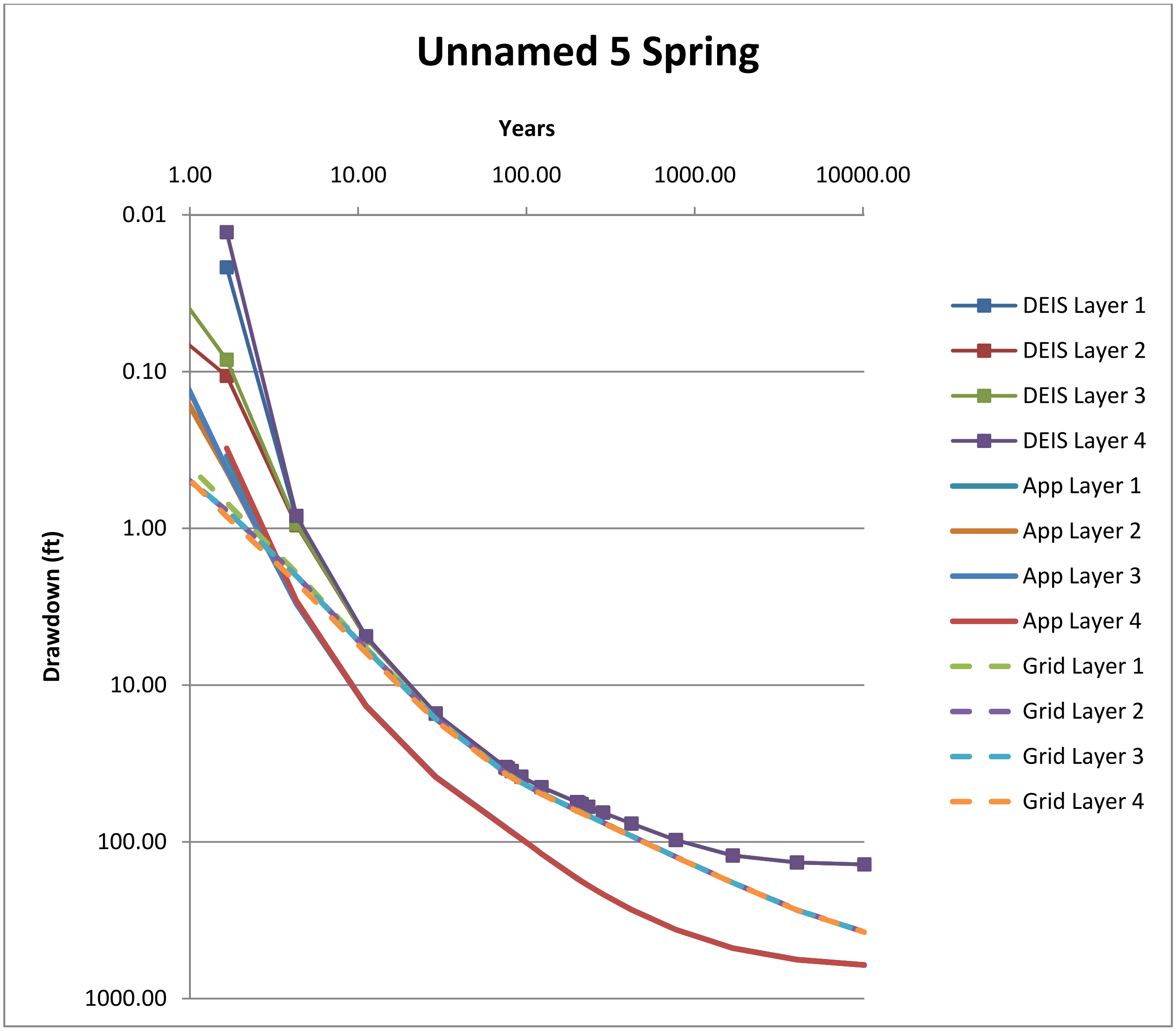

W Spring Valley Complex
Years
1.00
10.00
100.00
1000.00
10000.00
Drawdown (ft)
0.01
0.10
1.00
10.00
100.00
1000.00
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 1
App Layer 2
App Layer 3
App Layer 4
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4

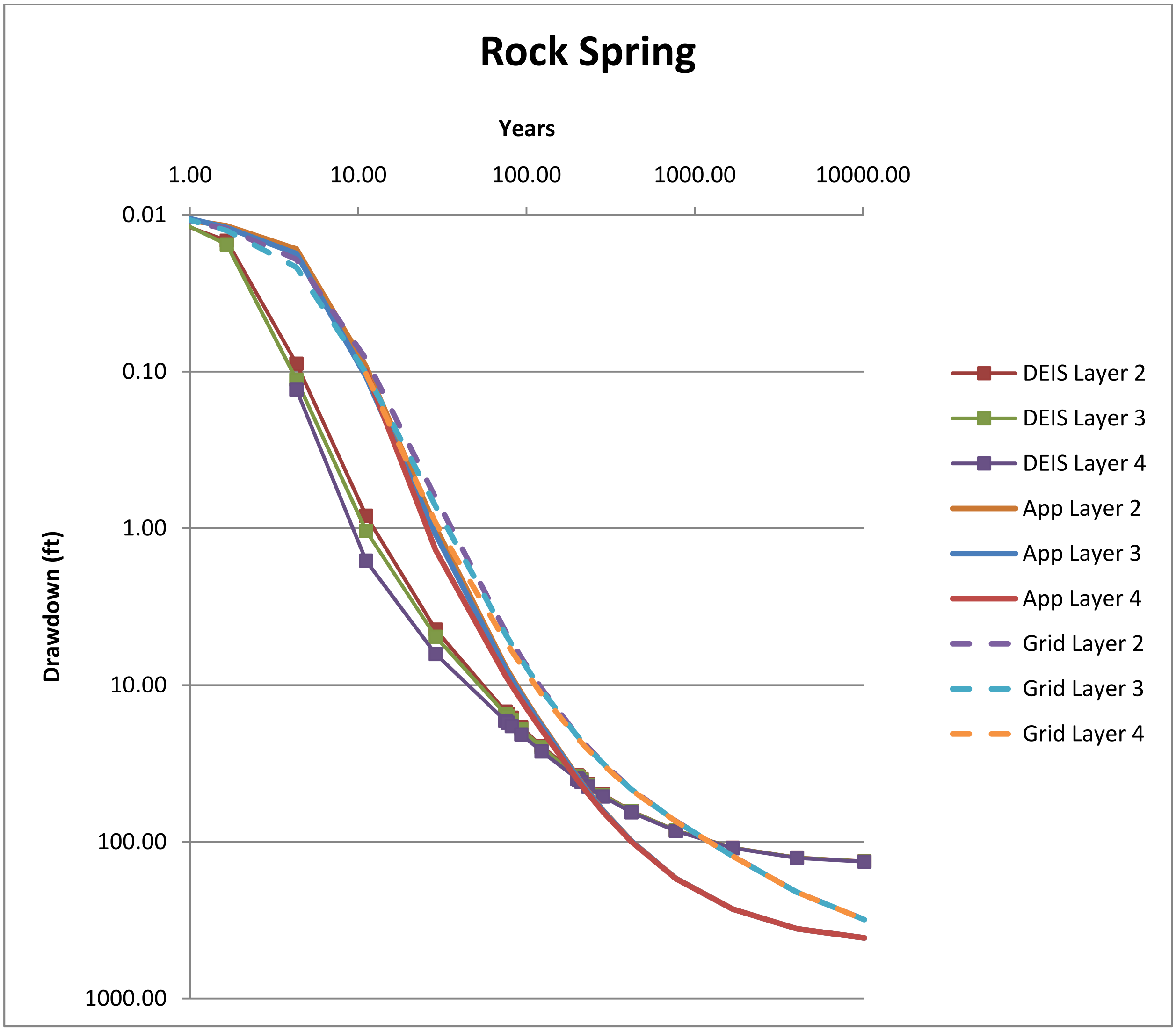

South Millick Spring
Years
1.00
10.00
100.00
1000.00
10000.00
0.01
0.10
1.00
10.00
100.00
1000.00
Drawdown (ft)
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 1
App Layer 2
App Layer 3
App Layer 4
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4

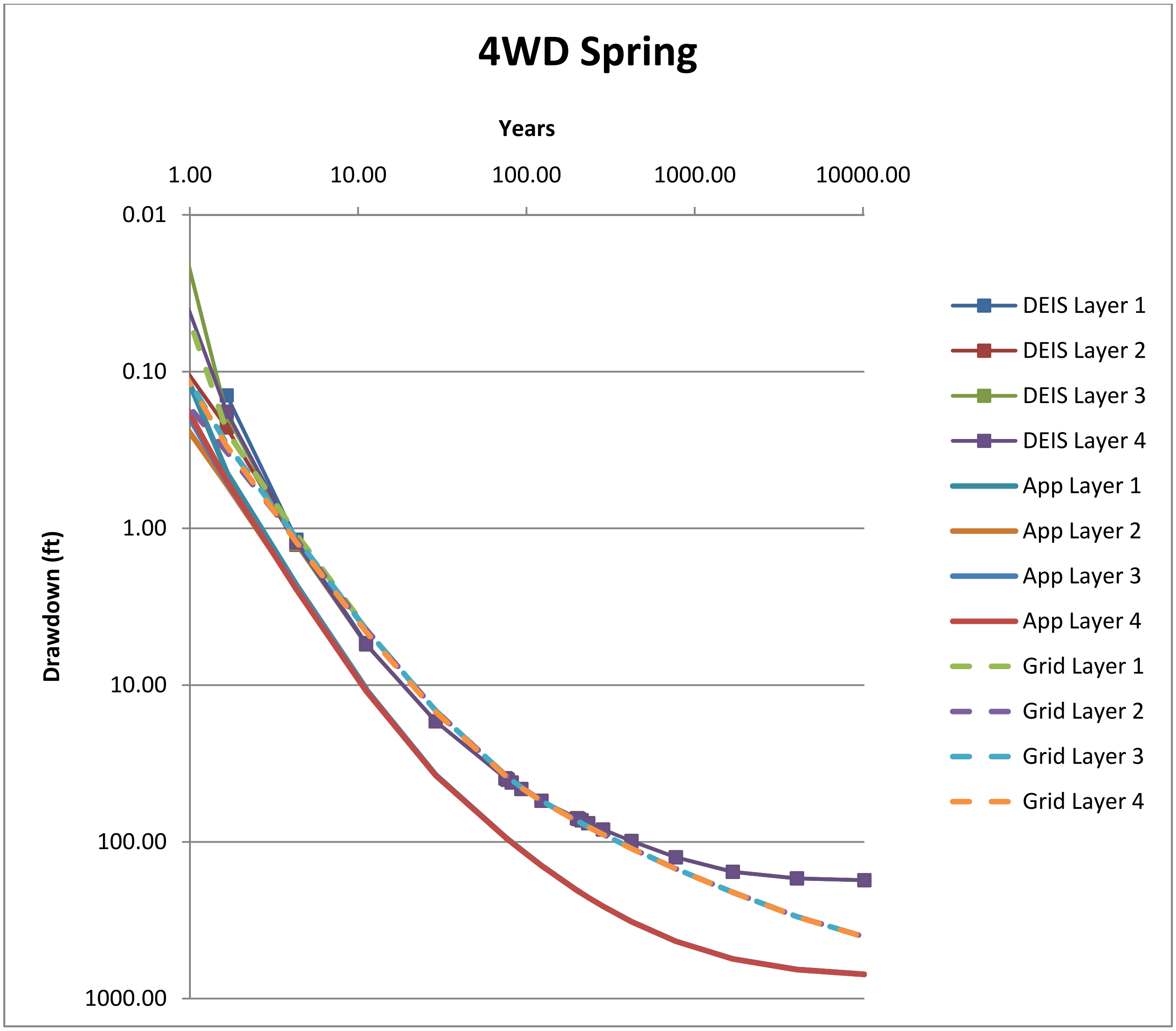

Negro Creek
Years
1.00
10.00
100.00
1000.00
10000.00
0.01
0.10
1.00
10.00
100.00
1000.00
Drawdown (ft)
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 2
App Layer 3
App Layer 4
Grid Layer 2
Grid Layer 3
Grid Layer 4

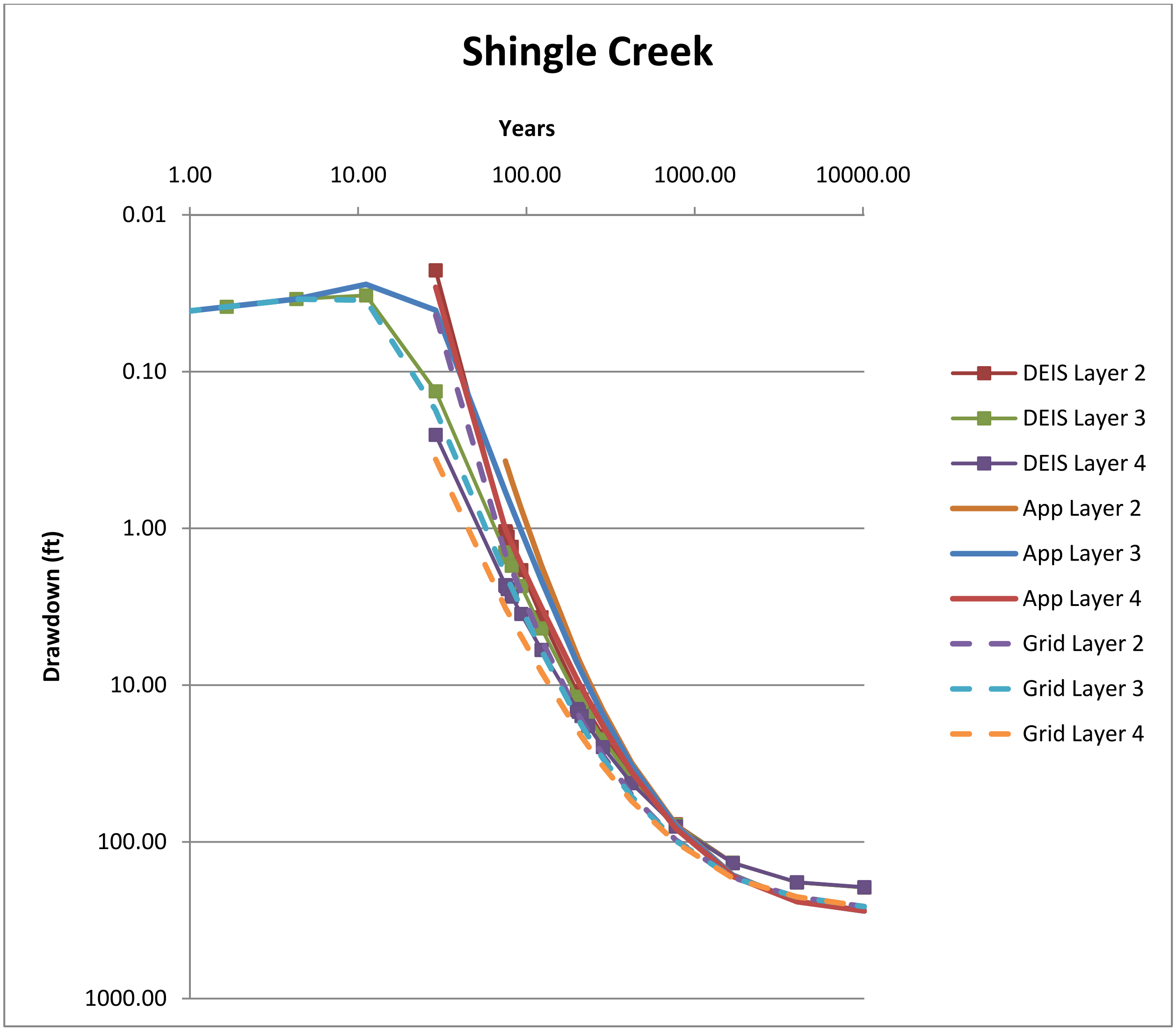

Cleve Creek
Years
1.00
10.00
100.00
1000.00
10000.00
Drawdown (ft)
0.01
0.10
1.00
10.00
100.00
1000.00
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 2
App Layer 3
App Layer 4
Grid Layer 2
Grid Layer 3
Grid Layer 4

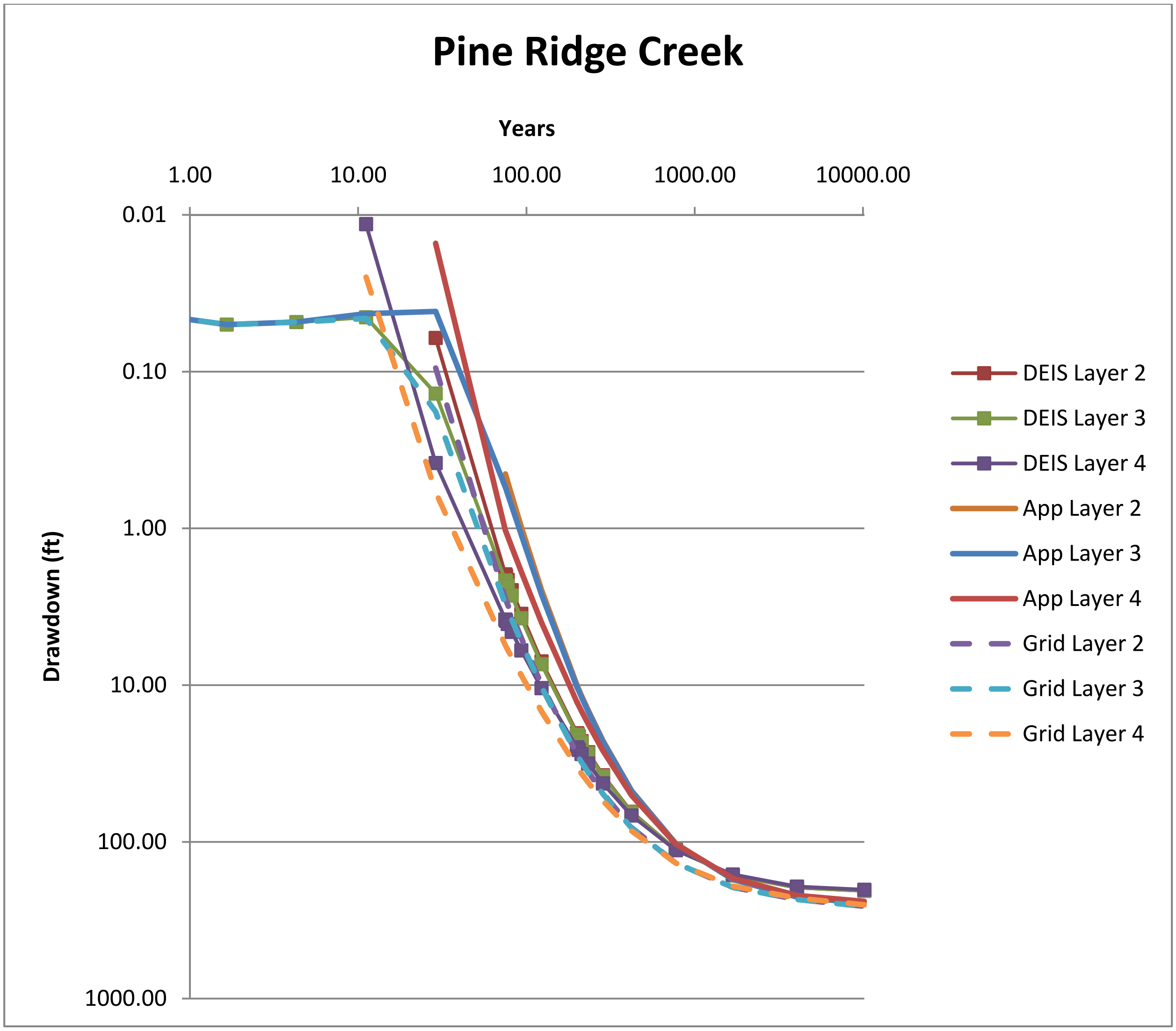

Swamp Cedar N
Years
1.00
10.00
100.00
1000.00
10000.00
Drawdown (ft)
0.01
0.10
1.00
10.00
100.00
1000.00
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 1
App Layer 2
App Layer 3
App Layer 4
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4

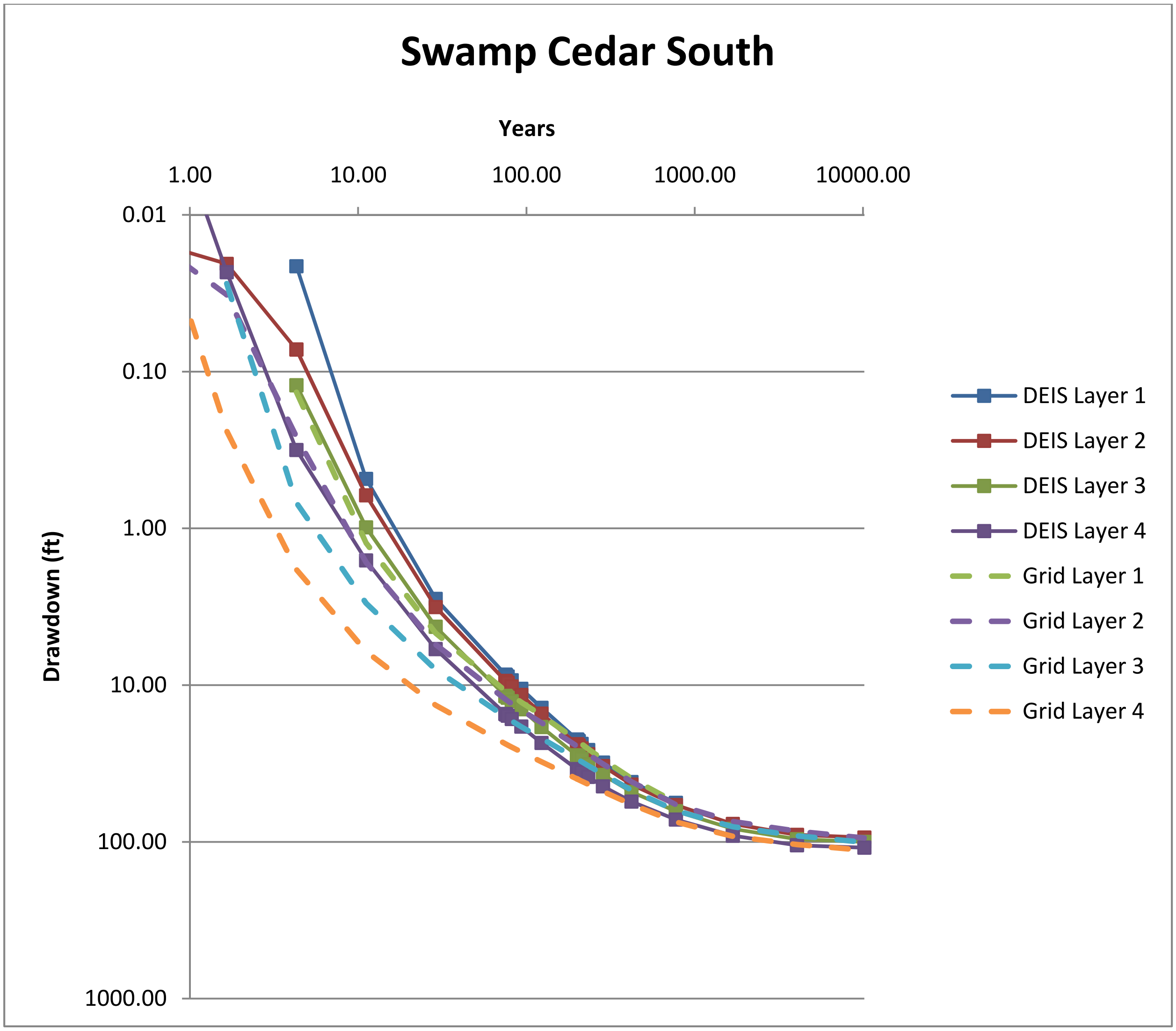

Unnamed 5 Spring
Years
1.00
10.00
100.00
1000.00
10000.00
Drawdown (ft)
0.01
0.10
1.00
10.00
100.00
1000.00
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 1
App Layer 2
App Layer 3
App Layer 4
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4


Rock Spring
Years
1.00
10.00
100.00
1000.00
10000.00
Drawdown (ft)
0.01
0.10
1.00
10.00
100.00
1000.00
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 2
App Layer 3
App Layer 4
Grid Layer 2
Grid Layer 3
Grid Layer 4

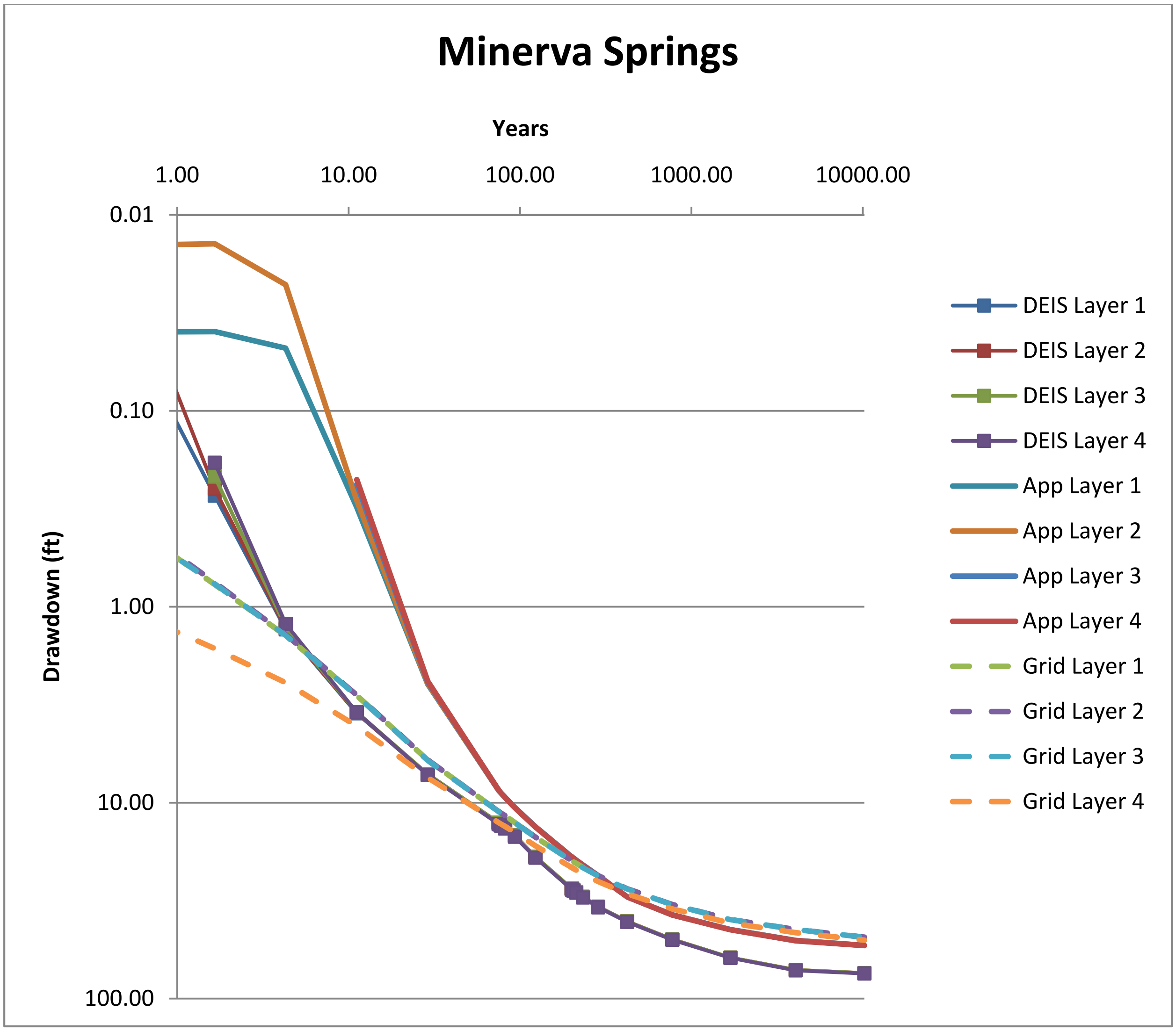

4WD Spring
Years
1.00
10.00
100.00
1000.00
10000.00
Drawdown (ft)
0.01
0.10
1.00
10.00
100.00
1000.00
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 1
App Layer 2
App Layer 3
App Layer 4
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4

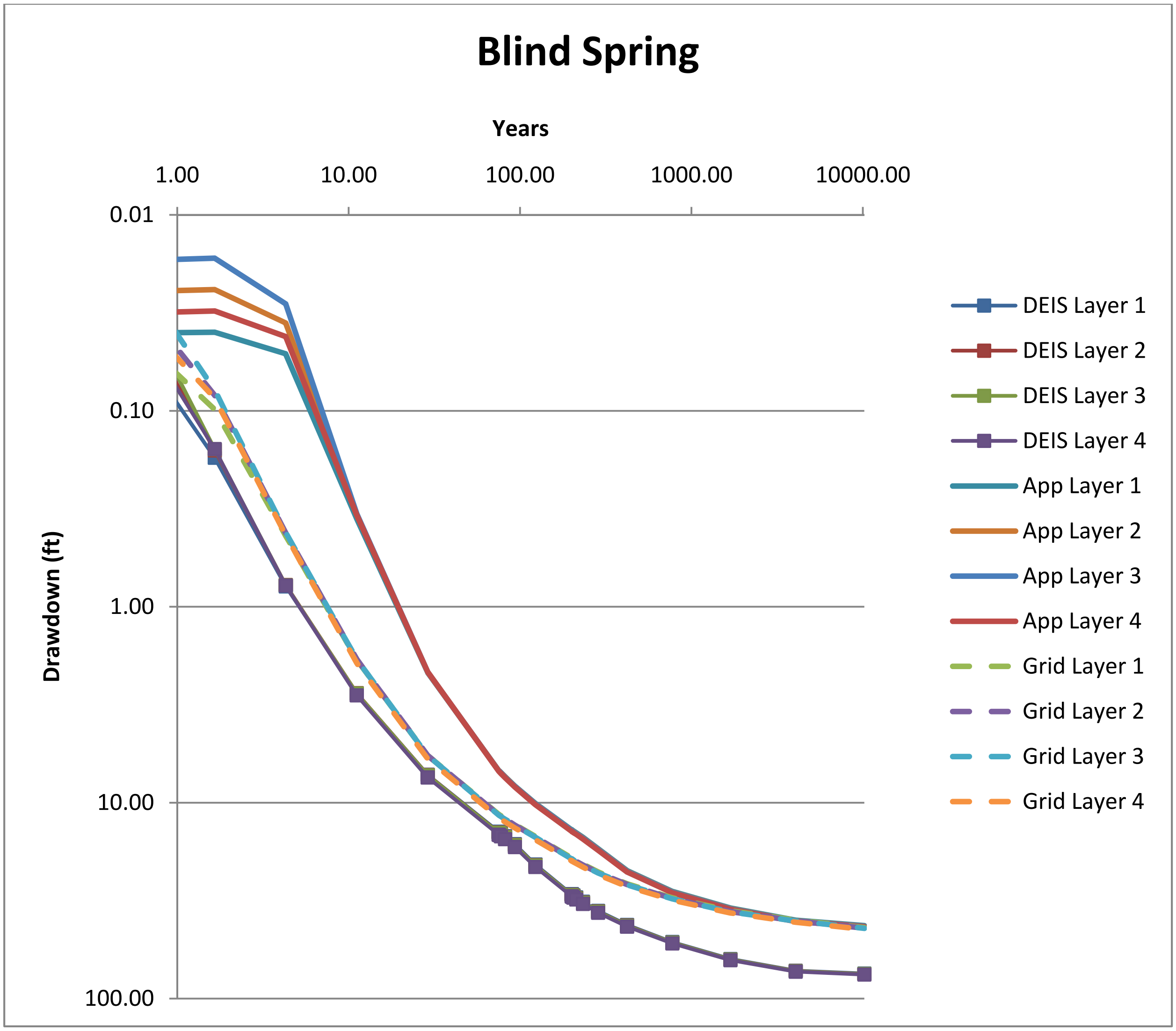

Shingle Creek
Years
1.00
10.00
100.00
1000.00
10000.00
0.01
0.10
1.00
10.00
100.00
1000.00
Drawdown (ft)
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 2
App Layer 3
App Layer 4
Grid Layer 2
Grid Layer 3
Grid Layer 4

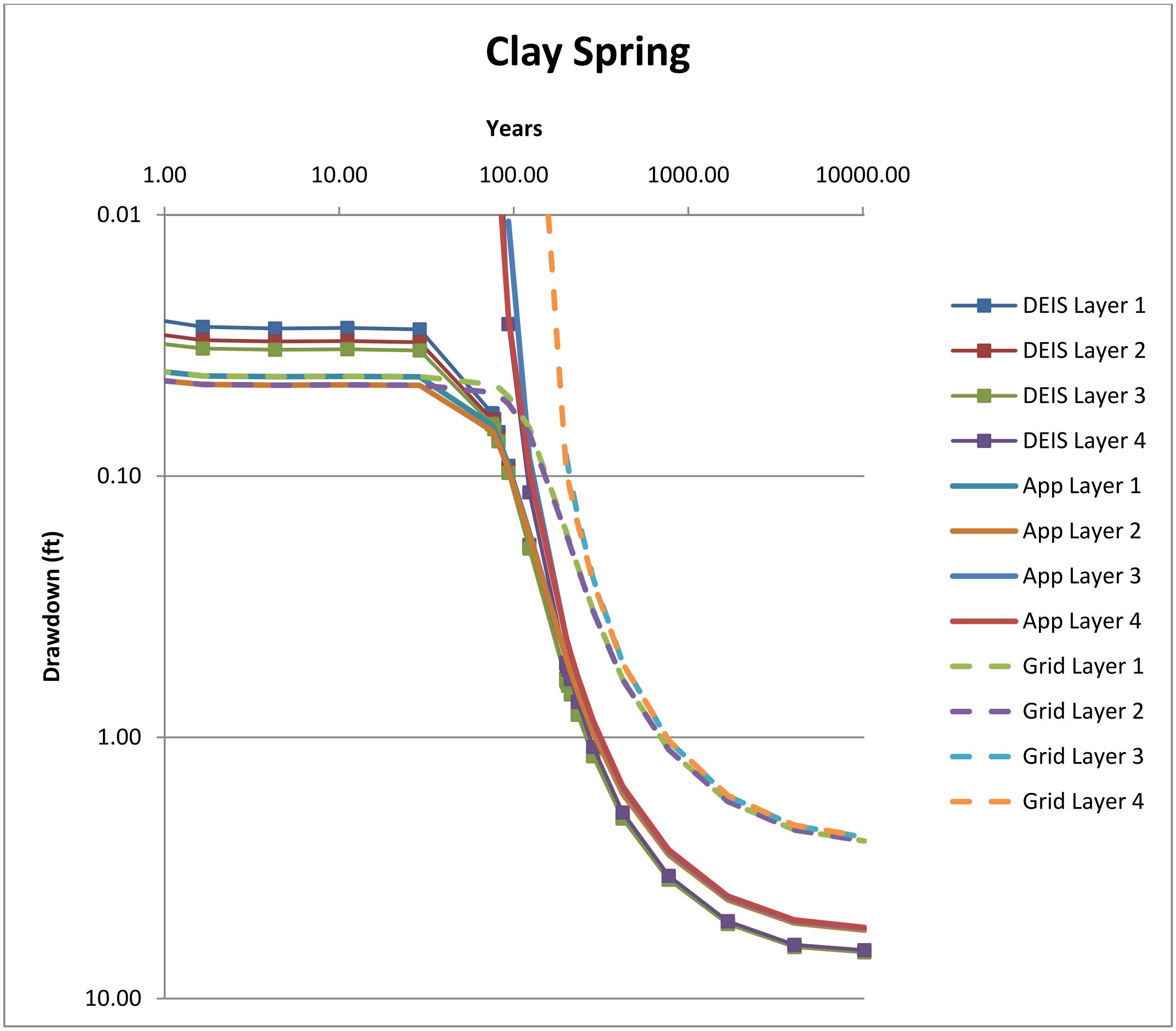

Pine Ridge Creek
Years
1.00
10.00
100.00
1000.00
10000.00
0.01
0.10
1.00
10.00
100.00
1000.00
Drawdown (ft)
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 2
App Layer 3
App Layer 4
Grid Layer 2
Grid Layer 3
Grid Layer 4

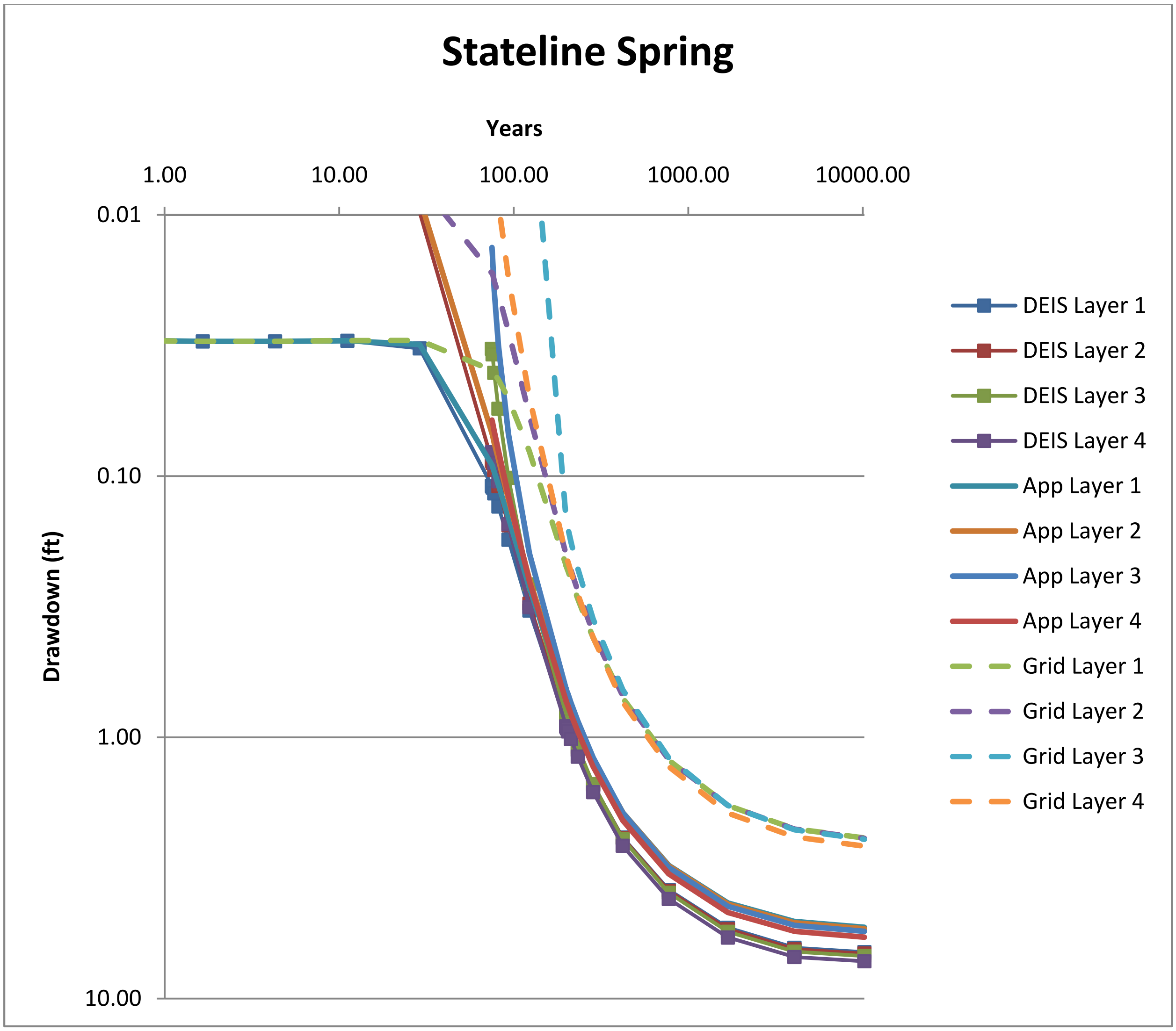

Swamp Cedar South
Years
1.00
10.00
100.00
1000.00
10000.00
Drawdown (ft)
0.01
0.10
1.00
10.00
100.00
1000.00
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4

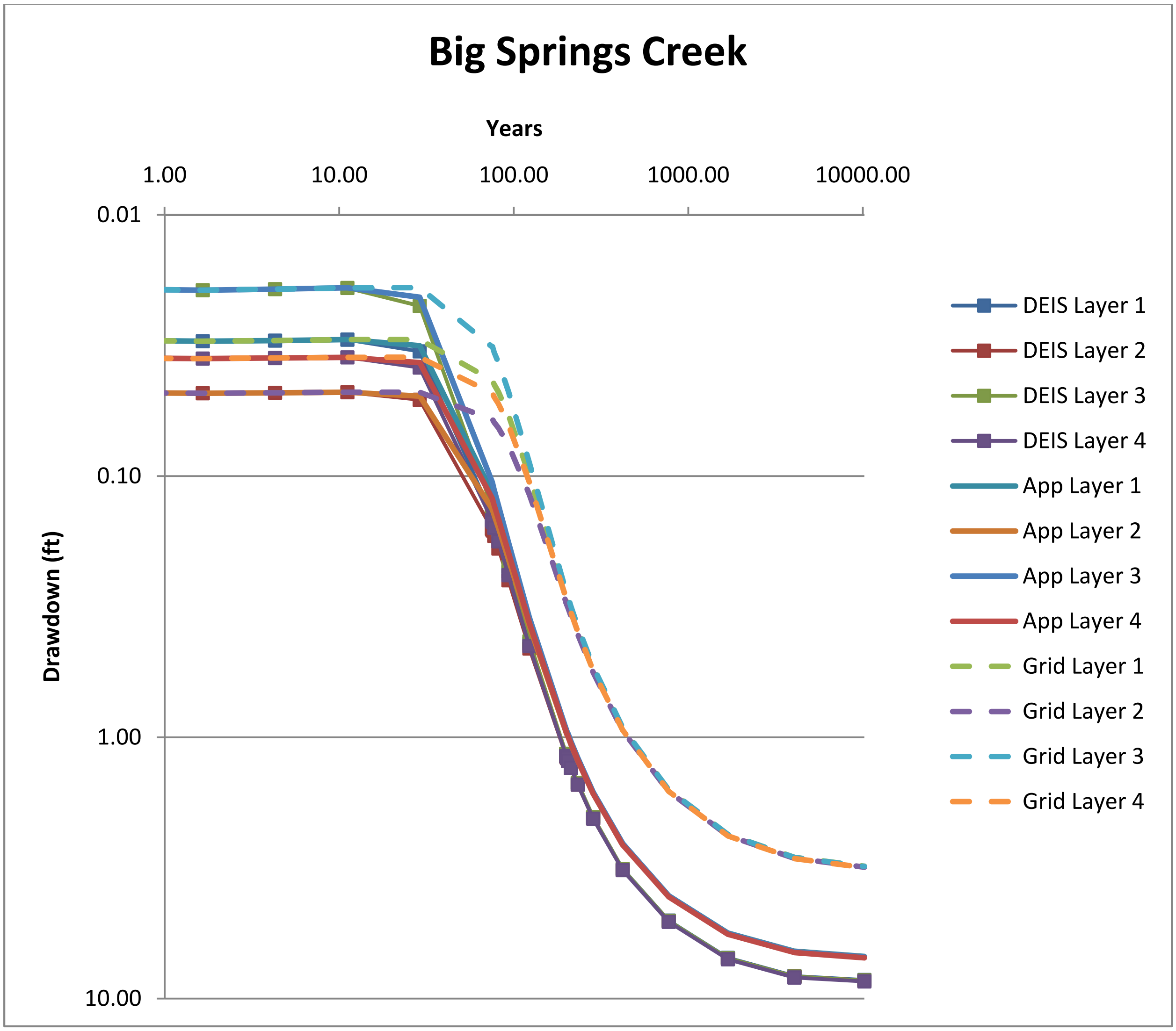

Swallow Springs
Years
1.00
10.00
100.00
1000.00
10000.00
Drawdown (ft)
0.01
0.10
1.00
10.00
100.00
1000.00
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 2
App Layer 3
App Layer 4
Grid Layer 2
Grid Layer 3
Grid Layer 4

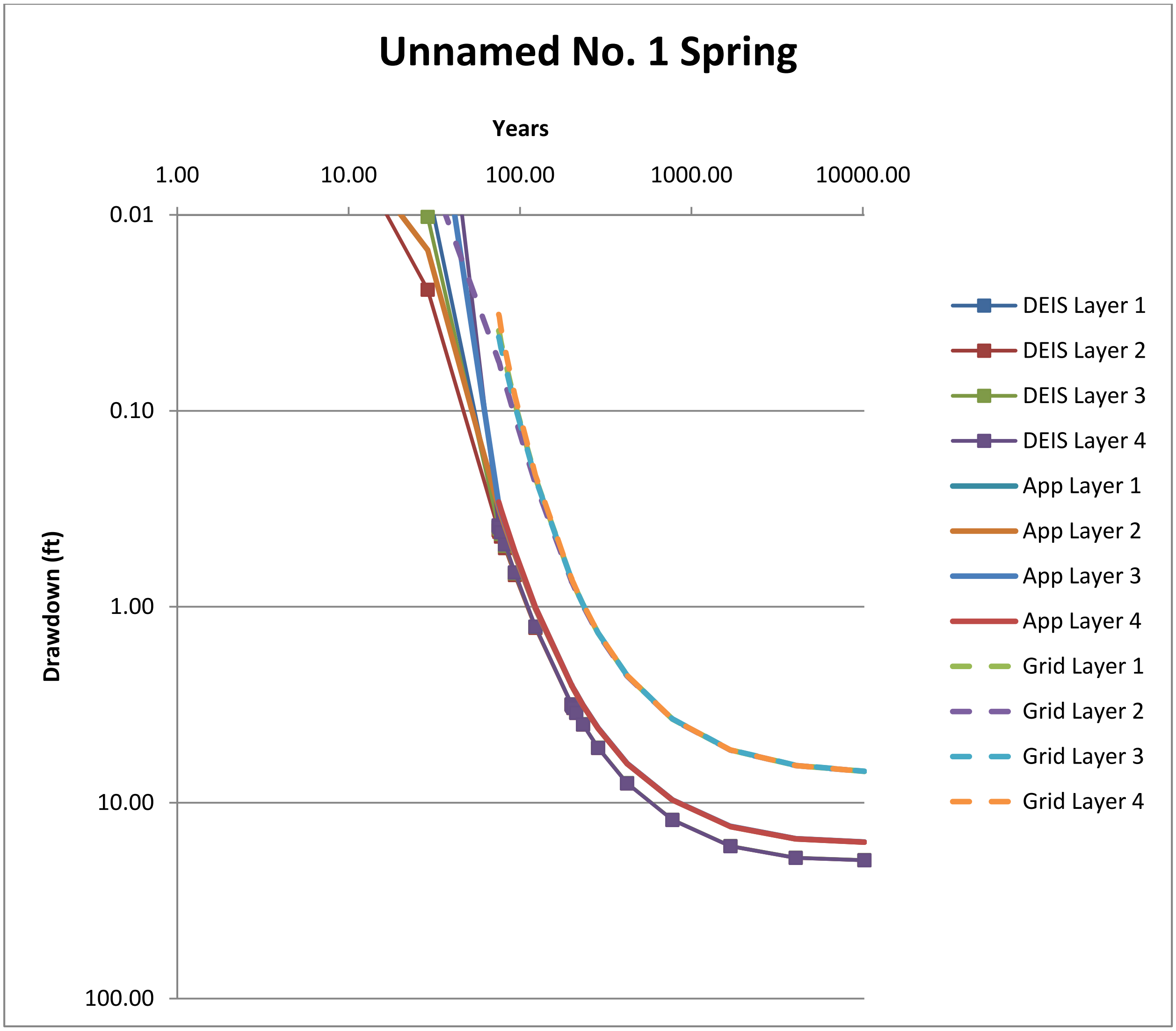

Minerva Springs
Years
1.00
10.00
100.00
1000.00
10000.00
0.01
0.10
1.00
10.00
100.00
Drawdown (ft)
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 1
App Layer 2
App Layer 3
App Layer 4
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4

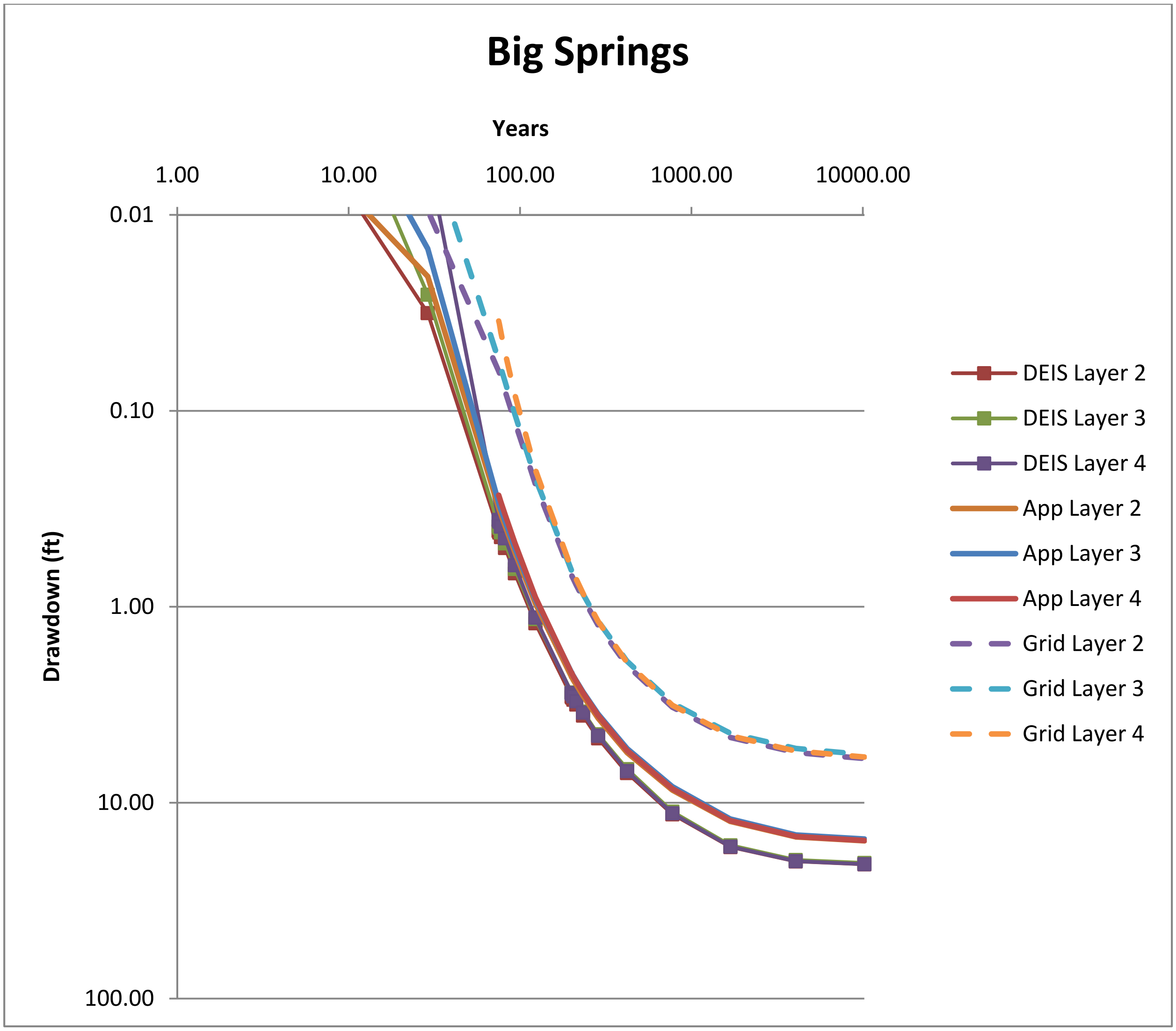

Blind Spring
Years
1.00
10.00
100.00
1000.00
10000.00
0.01
0.10
1.00
10.00
100.00
Drawdown (ft)
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 1
App Layer 2
App Layer 3
App Layer 4
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4

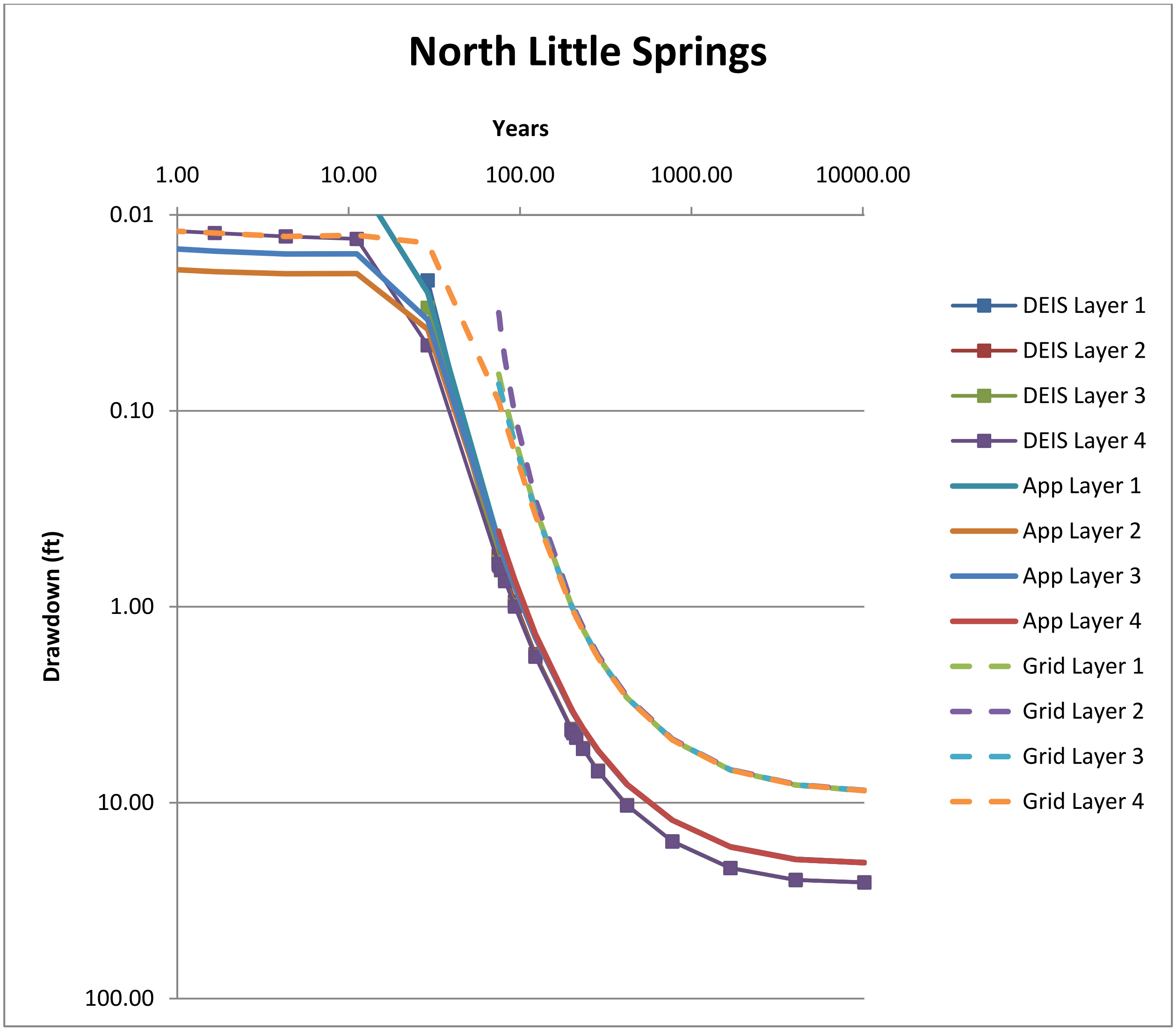

Clay Spring
Years
1.00
10.00
100.00
1000.00
10000.00
0.01
0.10
1.00
10.00
Drawdown (ft)
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 1
App Layer 2
App Layer 3
App Layer 4
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4

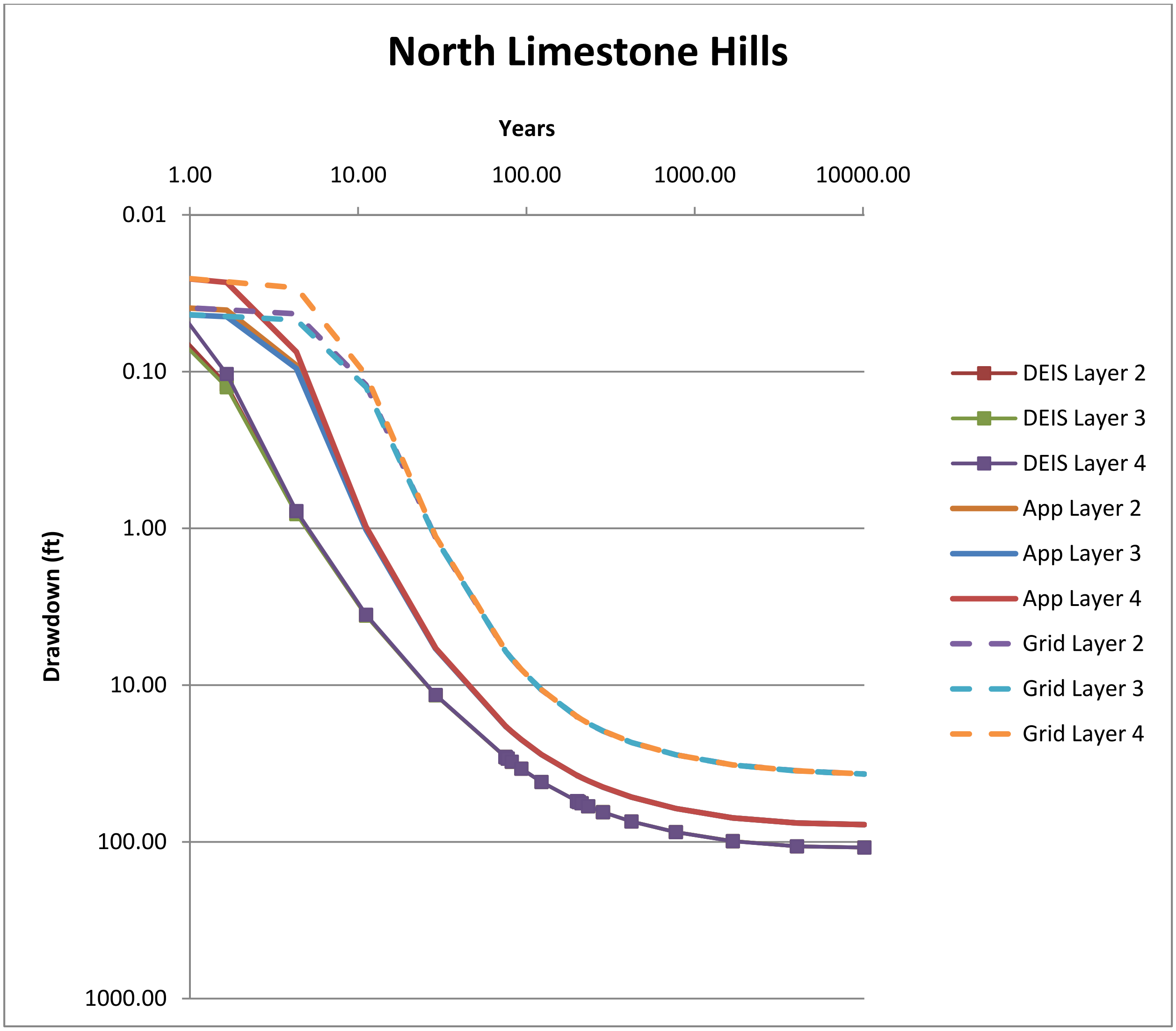

Stateline Spring
Years
1.00
10.00
100.00
1000.00
10000.00
0.01
0.10
1.00
10.00
Drawdown (ft)
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 1
App Layer 2
App Layer 3
App Layer 4
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4

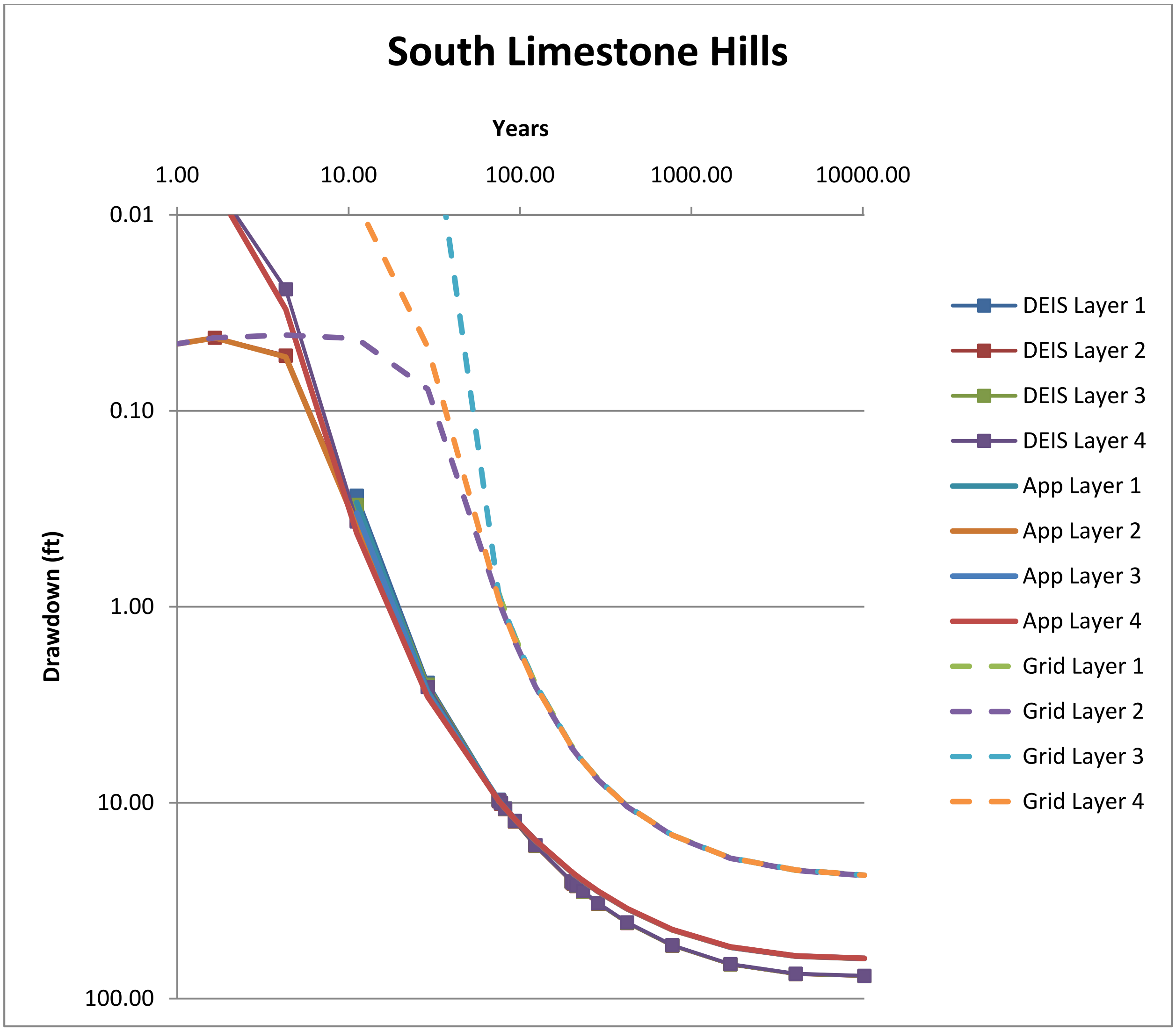

Big Springs Creek
Years
1.00
10.00
100.00
1000.00
10000.00
0.01
0.10
1.00
10.00
Drawdown (ft)
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 1
App Layer 2
App Layer 3
App Layer 4
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4


Unnamed No. 1 Spring
Years
1.00
10.00
100.00
1000.00
10000.00
Drawdown (ft)
0.01
0.10
1.00
10.00
100.00
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 1
App Layer 2
App Layer 3
App Layer 4
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4


Big Springs
Years
1.00
10.00
100.00
1000.00
10000.00
0.01
0.10
1.00
10.00
100.00
Drawdown (ft)
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 2
App Layer 3
App Layer 4
Grid Layer 2
Grid Layer 3
Grid Layer 4


North Little Springs
Years
1.00
10.00
100.00
1000.00
10000.00
0.01
0.10
1.00
10.00
100.00
Drawdown (ft)
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 1
App Layer 2
App Layer 3
App Layer 4
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4


North Limestone Hills
Years
1.00
10.00
100.00
1000.00
10000.00
Drawdown (ft)
0.01
0.10
1.00
10.00
100.00
1000.00
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 2
App Layer 3
App Layer 4
Grid Layer 2
Grid Layer 3
Grid Layer 4


South Limestone Hills
Years
1.00
10.00
100.00
1000.00
10000.00
Drawdown (ft)
0.01
0.10
1.00
10.00
100.00
DEIS Layer 1
DEIS Layer 2
DEIS Layer 3
DEIS Layer 4
App Layer 1
App Layer 2
App Layer 3
App Layer 4
Grid Layer 1
Grid Layer 2
Grid Layer 3
Grid Layer 4