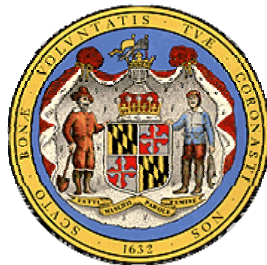


Department of Natural Resources
MARYLAND GEOLOGICAL SURVEY
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ADDENDUM TO OPEN-FILE REPORT NO. 2003-02-17

SCHEME 7: SELECTION OF WELL SITES TO MEET PROJECTED 2020
DEMAND



Prepared in cooperation with the
Charles County Department of Planning
and Growth Management
2003

Scheme 7: Selection of Well Sites to Meet Projected 2020 Demand

Well sites that produce the least amount of drawdown while supplying the projected 2020 demand in the Waldorf area were selected through optimization. Hypothetical wells were selected out of a set of candidate sites located in the southern and eastern parts of the Waldorf area (figs. 12 and 13). The candidate sites were located in those areas because available drawdown is greater in those areas compared to the western part of the Waldorf area. Fourteen of the sites are located within the Development District, eight of the sites are located within the area served by the Waldorf well system, and six of the sites are located east of the Development District. Optimization was conducted over an 18-year simulation period (2002 to 2020) using one-year stress periods. The hypothetical wells combined with the existing Lower Patapsco aquifer production wells and a proposed well at White Plains Business Park (Well 16), were required to pump 8.6 Mgal/d by 2020 during optimization. The rate of 8.6 Mgal/d was obtained by multiplying the projected 2020 Waldorf Election District 6 population of 107,996 by a per capita water use rate of 80 gal/d. Over the simulation period heads assigned to the general-head boundaries in model layers representing the Lower Patapsco and Patuxent aquifers declined at a rate of 0.5 ft/yr. This downward trend is a continuation of the regional head decline observed in the Lower Patapsco and Patuxent aquifers since about the mid-1980's. Pumpage from the Lower Patapsco aquifer outside the Waldorf well system was adjusted over the simulation period based on projected 2020 demand. The greatest increase in pumpage from the Lower Patapsco aquifer outside the Waldorf well system was simulated at La Plata where the 2020 withdrawal totaled 1.2 Mgal/d.

Two approaches were used to determine minimum total drawdown. The approaches consisted of either maintaining the existing number of wells or allowing existing wells to be discontinued. In the first approach (Scheme 7A), wells in the existing Waldorf well system plus proposed Well 16, were required to pump a minimum daily rate equal to 6 hours pumping at design rates. In the second approach (Schemes 7B and 7C), wells in the existing Waldorf well system plus Well 16, were allowed to shut off during optimization. This approach is dependant on the ability of the water-distribution system to supply the entire service area from a relatively small set of existing wells. Each hypothetical well selected by the optimization algorithm was required to pump 0.72 Mgal/d in both approaches.

In Scheme 7A, optimized pumping rates ranged from 0.014 Mgal/d at Eutaw Forest Well 2 to 1.0 Mgal/d at White Oak (tab. 11). Five of the hypothetical wells selected from 14 candidate sites are located in the Waldorf well system service area and three are located south of the service area but within the Development District (fig. 12). Drawdown in the existing Waldorf well system, proposed Well 16, and the hypothetical wells over the 18-year period ranged from 149 to 245 ft (tab. 11). Total drawdown equaled 4,183 ft. Simulated water levels ranged from -229 ft below sea level at Dutton's Addition to -310 ft below sea level at Hypothetical Well 7. Total simulated pumping head was 9,765 ft.

In Scheme 7B, optimized pumping rates ranged from 0.18 Mgal/d at Dutton's Addition to 1.0 Mgal/d at White Oak (tab. 12). Six of the hypothetical wells selected from 14 candidate sites are located in the Waldorf well system service area and two are located south of the service area but within the Development District (fig. 12). Drawdown in the existing Waldorf well system, proposed Well 16, and the hypothetical wells over the 18-year period ranged from 154 to 259 ft (tab. 12). Total drawdown equaled 2,648 ft. Simulated water levels ranged from -234 ft below sea level at Dutton's Addition to -316 ft below sea level at Westwood Drive. Total simulated pumping head was 5,817 ft. The relatively large reduction in total simulated pumping head between Schemes 7A and 7B illustrates the potential savings in pumping costs that can occur if

pumpage is distributed over fewer wells.

In both Schemes 7A and 7B, water levels exceeded the 80-percent management level in a relatively small area along the Potomac River at Bryans Road and Indian Head at the end of the 18-year simulation period. In order to constrain water levels above the 80-percent management level, the total withdrawal in Schemes 7A and 7B must be reduced to 3.2 and 4.1 Mgal/d, respectively. These amounts are less than the maximum optimized amount of 5.8 Mgal/d that can be withdrawn from the existing wells for two years without exceeding the 80-percent management level (Scheme 3). The lower pumping rates are caused by greater drawdowns in Schemes 7A and 7B than Scheme 3 resulting from a longer simulation period (18 years compared to 2 years) combined with greater regional head declines.

To increase withdrawals without exceeding the 80-percent management level, future wells must be located farther east of Waldorf. In the final optimization scheme (Scheme 7C), eight pumping-well sites were selected that did not result in water levels exceeding the 80-percent management level by 2020 and which produced the least amount of total drawdown. Six of the wells are located east of the Development District and two are within the Waldorf well system (fig. 13). The existing wells and proposed well 16 were allowed to shut off during optimization. Of the existing well sites only White Oak was pumped. The withdrawal rate at that site was 0.74 Mgal/d. The hypothetical wells each pumped 0.72 Mgal/d. The total withdrawal equaled 6.5 Mgal/d.

Table 11. Optimized withdrawal rates producing the minimum amount of total drawdown (Scheme 7A).

Well site	Well number (Owner's number)	Upper and lower pumping constraints, Mgal/d ¹	Optimized withdrawal rate in stress period 18, Mgal/d	Drawdown ² , ft	Simulated pumping level, feet related to sea level	Simulated pumping level, feet below land surface
Smallwood West (Well 11)	CH Be 58	0.18 / .72	0.18	-73.4-(-264.9) = 192	-265	475
Westwood Drive (Well 15)	CH Be 71	.23 / .94	.60	-56.5-(-276.6) = 220	-277	497
Billingsley Road (Well 12)	CH Be 64	.18 / .72	.18	-76.2-(-282.9) = 207	-283	493
White Oak (Well 10)	CH Bf 150	.25 / 1.0	1.0 ³	-51.2-(-263.4) = 212	-263	478
Cleveland Park (Well 14)	CH Be 67	.21 / .83	.21	-79.8-(-293.0) = 213	-293	508
St. Paul (Well 9)	CH Bf 147	.13 / .52	.13	-74.6-(-293.4) = 219	-293	486
Bensville	CH Bd 51 (Well 2)	.097 / .39	.097	-76.4-(-230.5) = 154	-230	415
	CH Bd 57 (Well 1)					
Dutton's Addition	CH Bd 49	.054 / .22	.054	-79.8-(-228.6) = 149	-229	412
Eutaw Forest	CH Bd 44 (Well 1)	.032 / .13	.032	-73.6-(-236.0) = 162	-236	416
	CH Bd 46 (Well 3)					
	CH Bd 40 (Well 2)					
Laurel Branch	CH Bd 48 (Well 4)	.049 / .19	.049	-69.0-(-241.0) = 172	-241	371
	CH Bd 39 (Well 1)					
	CH Bd 47 (Well 3)					
Proposed well at White Plains Business Park (Well 16)		.17 / .72	.17	-83.6-(-285.4) = 202	-285	485 ⁴
Hypothetical well 1		.72 / .72	.72 ³	-49.2-(-244.0) = 195	-244	444 ⁴
Hypothetical well 2		.72 / .72	.72 ³	-49.6-(-236.5) = 187	-236	436 ⁴
Hypothetical well 3		.72 / .72	.72 ³	-55.9-(-281.4) = 226	-281	481 ⁴
Hypothetical well 4		.72 / .72	.72 ³	-58.2-(-293.0) = 235	-293	493 ⁴
Hypothetical well 7		.72 / .72	.72 ³	-65.1-(-310.1) = 245	-310	510 ⁴
Hypothetical well 9		.72 / .72	.72 ³	-71.8-(-303.6) = 232	-304	503 ⁴
Hypothetical well 12		.72 / .72	.72 ³	-82.9-(-302.5) = 220	-302	502 ⁴
Hypothetical well 13		.72 / .72	.72 ³	-89.6-(-302.8) = 213	-303	503 ⁴
			Total = 8.6 Mgal/d	Total = 4,183 ft		Total = 9,765 ft

¹ Smaller number is equal to pumping 6 hours at the design rate and larger number is design rate.

² Drawdown is the difference between heads at the end of the simulation period (2020) with and without the managed wells.

³ Optimized rate equals design rate.

⁴ Assumes a land surface altitude of 200 ft.

Table 12. Optimized withdrawal rates producing the minimum amount of total drawdown (Scheme 7B).

Well site	Well number (Owner's number)	Upper and lower pumping constraints, Mgal/d ¹	Optimized withdrawal rate in stress period 18, Mgal/d	Drawdown ² , ft	Simulated pumping level, feet related to sea level	Simulated pumping level, feet below land surface
Smallwood West (Well 11)	CH Be 58	0 / .72	0.72 ³	-73.4-(-292.9) = 220	-293	503
Westwood Drive (Well 15)	CH Be 71	0 / .94	.94 ³	-56.5-(-315.6) = 259	-316	536
Billingsley Road (Well 12)	CH Be 64	0 / .72	0	--	--	--
White Oak (Well 10)	CH Bf 150	0 / 1.0	1.0 ³	-51.2-(-273.2) = 222	-273	488
Cleveland Park (Well 14)	CH Be 67	0 / .83	0	--	--	--
St. Paul (Well 9)	CH Bf 147	0 / .52	0	--	--	--
Bensville	CH Bd 51 (Well 2)	0 / .39	0	--	--	--
	CH Bd 57 (Well 1)					
Dutton's Addition	CH Bd 49	0 / .22	.18	-79.8-(-233.8) = 154	-234	417
Eutaw Forest	CH Bd 44 (Well 1)	0 / .13	0	--	--	--
	CH Bd 46 (Well 3)					
	CH Bd 40 (Well 2)					
Laurel Branch	CH Bd 48 (Well 4)	0 / .43	0	--	--	--
	CH Bd 39 (Well 1)					
	CH Bd 47 (Well 3)					
Proposed well at White Plains Business Park (Well 16)		0 / .72	0	--	--	--
Hypothetical well 1		.72 / .72	.72 ³	-49.2-(-251.1) = 202	-251	451 ⁴
Hypothetical well 2		.72 / .72	.72 ³	-49.6-(-242.1) = 192	-242	424 ⁴
Hypothetical well 3		.72 / .72	.72 ³	-55.9-(-289.3) = 233	-289	489 ⁴
Hypothetical well 4		.72 / .72	.72 ³	-58.2-(-305.8) = 247	-306	506 ⁴
Hypothetical well 5		.72 / .72	.72 ³	-62.6-(-313.6) = 251	-314	514 ⁴
Hypothetical well 7		.72 / .72	.72 ³	-65.3-(-309.7) = 244	-310	510 ⁴
Hypothetical well 9		.72 / .72	.72 ³	-72.0-(-294.8) = 223	-295	495 ⁴
Hypothetical well 12		.72 / .72	.72 ³	-82.2-(-283.6) = 201	-284	484 ⁴
			Total = 8.6 Mgal/d	Total = 2,648 ft		Total = 5,817 ft

¹ Upper pumping constraint is the design rate.

² Drawdown is the difference between heads at the end of the simulation period (2020) with and without the managed wells.

³ Optimized rate equals design rate.

⁴ Assumes a land surface altitude of 200 ft.

Table 13. Optimized withdrawal rates producing the minimum amount of total drawdown (Scheme 7C).

Well site	Well number (Owner's number)	Upper and lower pumping constraints, Mgal/d ¹	Optimized withdrawal rate in stress period 18, Mgal/d	Drawdown ² , ft	Simulated pumping level, feet related to sea level	Simulated pumping level, feet below land surface
Smallwood West (Well 11)	CH Be 58	0 / .72	--	--	--	--
Westwood Drive (Well 15)	CH Be 71	0 / .94	--	--	--	--
Billingsley Road (Well 12)	CH Be 64	0 / .72	--	--	--	--
White Oak (Well 10)	CH Bf 150	0 / 1.0	0.74	-44.7 - (-187.6) = 143	-188	403
Cleveland Park (Well 14)	CH Be 67	0 / .83	--	--	--	--
St. Paul (Well 9)	CH Bf 147	0 / .52	--	--	--	--
Bensville	CH Bd 51 (Well 2)	0 / .39	--	--	--	--
	CH Bd 57 (Well 1)					
Dutton's Addition	CH Bd 49	0 / .22	--	--	--	--
Eutaw Forest	CH Bd 44 (Well 1)	0 / .13	--	--	--	--
	CH Bd 46 (Well 3)					
	CH Bd 40 (Well 2)					
Laurel Branch	CH Bd 48 (Well 4)	0 / .43	--	--	--	--
	CH Bd 39 (Well 1)					
	CH Bd 47 (Well 3)					
Proposed well at White Plains Business Park (Well 16)		0 / .72	--	--	--	--
Hypothetical well 1		.72 / .72	.72 ³	-42.6 - (-187.2) = 145	-187	387 ⁴
Hypothetical well 2		.72 / .72	.72 ³	-42.7 - (-188.8) = 146	-189	389 ⁴
Hypothetical well 9		.72/.72	.72 ³	-71.8 - (-251.9) = 180	-252	452 ⁴
Hypothetical well 10		.72 / .72	.72 ³	-48.5 - (-219.0) = 170	-219	419 ⁴
Hypothetical well 11		.72 / .72	.72 ³	-51.6 - (-235.9) = 184	-236	436 ⁴
Hypothetical well 12		.72 / .72	.72 ³	-54.9 - (-244.2) = 189	-244	444 ⁴
Hypothetical well 13		.72 / .72	.72 ³	-63.5 - (-246.4) = 183	-246	446 ⁴
Hypothetical well 14		.72 / .72	.72 ³	-68.5 - (-240.1) = 172	-240	440 ⁴
			Total = 6.5 Mgal/d	Total = 1,512 ft		Total = 3,816 ft

¹ Upper pumping constraint is the design rate.

² Drawdown is the difference between heads at the end of the simulation period (2020) with and without the managed wells.

³ Optimized rate equals design rate.

⁴ Assumes a land surface altitude of 200 ft.

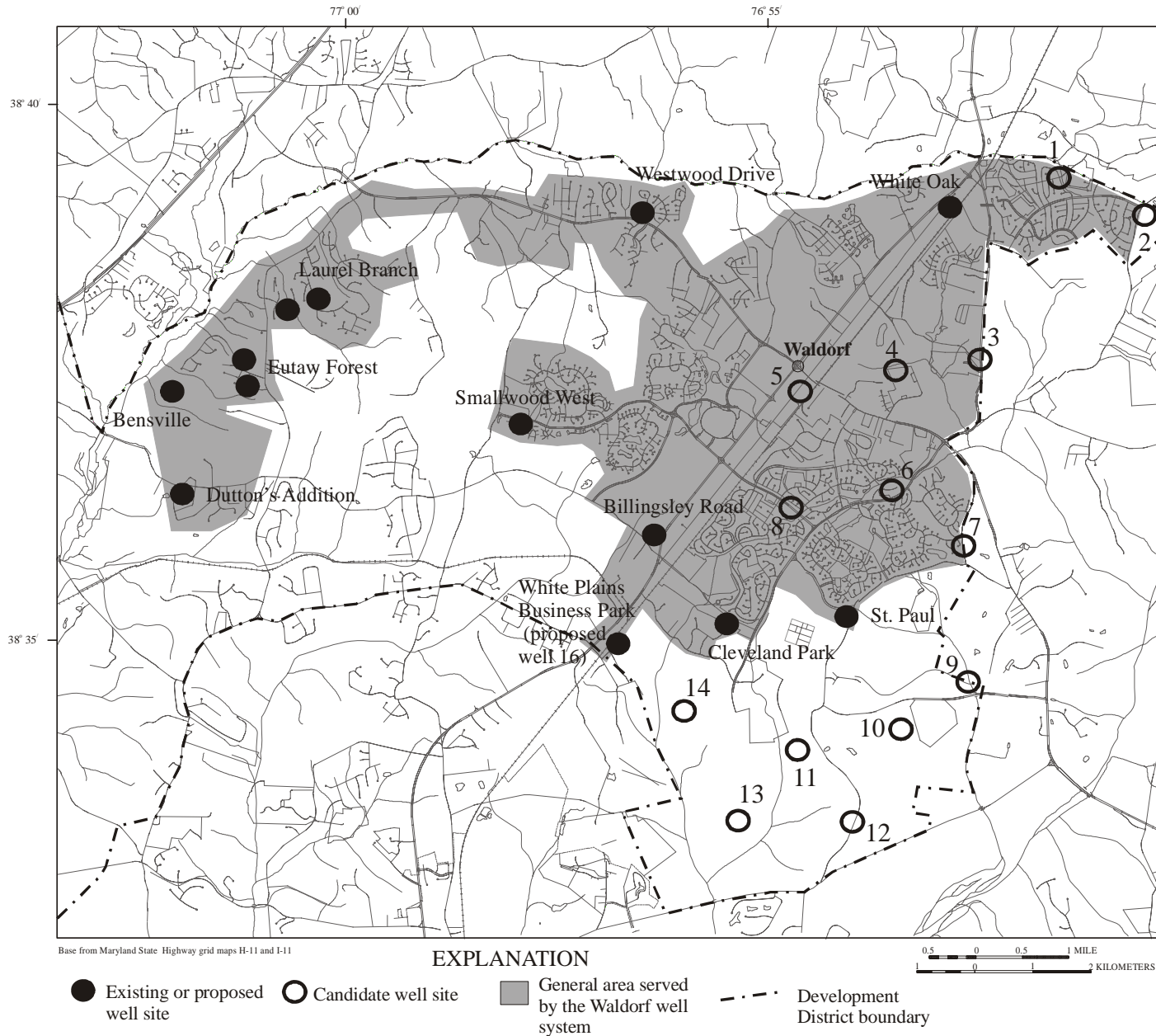
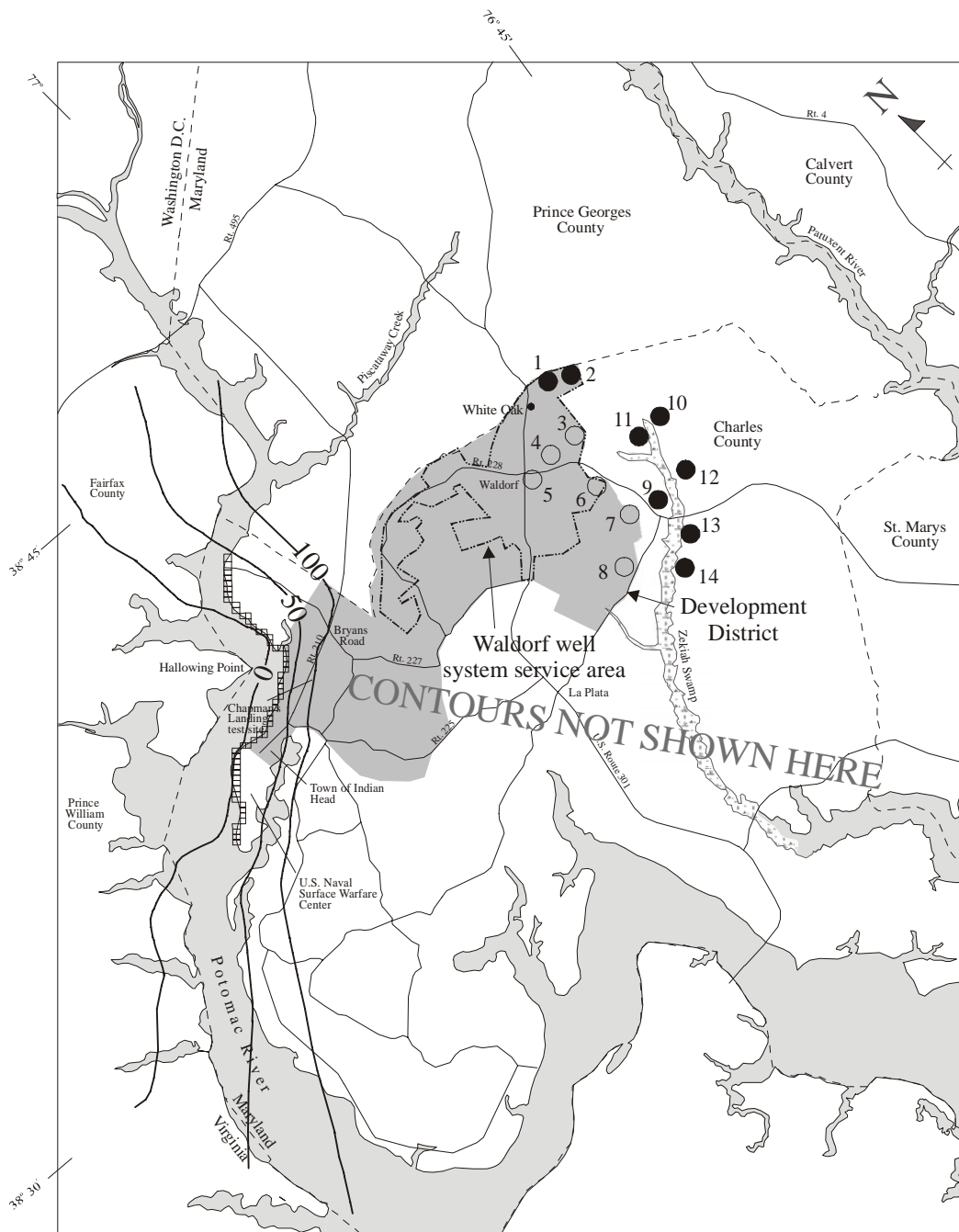


Figure 12. Well sites used in optimization Scheme 7.



Base from USGS 100K digital line graph quadrangles

EXPLANATION

- Line of equal available drawdown above the 80-percent management level, in feet.
- Existing well site.
- Candidate well site selected by optimization.
- Candidate well site.
- Model cell where head was constrained at the 80-percent management level.

0 5 10 MILES

0 5 10 KILOMETERS

Figure 13. Available drawdown in 2020 resulting from 6.5 million gallons per day withdrawn from the existing and hypothetical wells in the Lower Patapsco wells (Scheme 7C).