Water Model

New Mexico
Supercomputing Challenge,
Final Report,
April 3, 2019

Team 22
Las Cruces High School

By: Anabelle Fortin & Hannah Himelright
Teacher: Lauren Curry
Mentor: Maureen Psaila-Dombrowski

Table of Contents

Executive Summary

One touchy question that seems to be at the back of everyone's minds seems to be, how much water do we have left? Local laws for water conservation like the time restrictions on watering gardens and lawns change our schedules. "Remember to turn off the faucet when you are done", seems to be a common statement in the average house, but do we actually know how much we are actually helping? Here, especially in New Mexico, we are used to thinking about our limited water resources, but often times when we go about with our daily lives, without knowing the true extent of our water usage.

Our project strives to help inform people about how much water they are using and estimates future aquifer depletion rates. It is a computer program in which the user can find out the water usage for a state,multiple states or averages for the entire United States.

It is important for us to conduct this project because water usage concerns are becoming more evident and relevant in our everyday lives. Our project informs others to start thinking about being more careful with the way they use water everyday, so that our limited water supply doesn't run out as fast as our model products.

We created this model using python. We got our sources from responsible online databases which we used to calculate other estimates, like the water usage per person. We used the equation $A = Pe^{rt}$ (In which A is the final amount, p is the beginning amount, r is the depletion rate and t is time in years) to predict aquifer depletion rates, because we assumed aquifer depletion was changing in an exponential pattern.

Overall, informing others, is what we strive to do with our computer model. Water usage is an important factor that we have to adress, before it's too late.

Materials and Methods

Our data was gathered from online research. A method we used to test the accuracy of our data was to compare it to other sources. For example, using the data we gathered, we calculated the daily water usage for an average United States resident (we got 118 gal/day). We found that our results fell outside the range estimated by USGS (about 80-100 gal/day).

Results

In summary, our computer program relayed the water usage and population data we gathered from our research. It also calculated the individual water usage for each state. For our model, the program predicts the future population and aquifer depletion rates of each state. We estimated the individual water usage of the average individual in each state by dividing the public usage supply by the population of each state. Furthermore, we predicted the future population of each state using the Pert formula. For the rate, we plugged in the population growth rates over the past 66 years of each state.

Below a chart with all the data we gathered.

State	2019 Population	66 years Growth	% of US	ml of rainfall	Fresh Ground Water Per Day (Mgal)	Fresh Surface water per day (Mgal)	Public (Mgal/d)	Domestic (Mgal/d)	Irrigation (Mgal/d)	Live Stock (Mgal/d)	Indust (Mgal/d)	Mining (Mgal/d)	ThermoElec (Mgal/d)
Alabama	4888949	0.0070111	1.49%	1480	501	7750	762	37.7	223	26.2	494	30.2	6630
Alaska	738068	0.02655	0.22%	572	226	408	99.2	11.4	1.52	0.13	8.35	36.4	66.7
Arizona	7123898	0.0337	2.17%	345	2760	3220	1200	24	4530	39.9	6.12	68.3	83.5
Arkansas	3020327	0.006785	0.92%	1284	9590	4250	363	12.8	11600	34.1	157	3.07	1440
California	39776830	0.01985	12.13%	563	17100	85400	5150	127	19000	183	399	45.8	36.4
Colorado	5684203	0.021676	1.73%	405	1500	8800	844	35.4	9000	33.3	84.1	7.7	37.2

Connecticut	3588683	0.00875	1.09%	1279	128	489	240	30.8	11.3	1.15	181	4.25	126
Delaware	971180	0.01661	0.30%	1160	170	364	86.4	14.5	113	1.34	302	0.65	14.4
Florida	21312211	0.0304	6.50%	1385	3580	2110	2380	177	2450	26.1	245	130	434
Georgia	10545138	0.0304	3.21%	1287	1150	2130	1070	104	738	44.9	475	19.8	741
Hawaii	1426393	0.01591	0.43%	1618	338	334	267	8.1	385	1.61	0.24	0.92	1.48
Idaho	1753860	0.01592	0.53%	481	5350	12400	276	70.2	15300	50.8	57.6	23.1	1.79
Illinois	12768320	0.00583	3.89%	996	870	9600	1480	92.1	234	36.2	431	55	8140
Indiana	6699629	0.007914	2.04%	1060	699	6480	628	127	133	39.2	2290	126	3820
Iowa	3160553	0.00271	0.96%	864	630	2060	390	32	35	165	288	75.5	1680
Kansas	2918515	0.0064	0.89%	733	2840	1180	351	17.7	2680	104	38.1	5.99	817
Kentucky	4472265	0.00621	1.36%	1242	207	2630	553	22.1	39.6	40.8	225	40.6	1860
Louisiana	4682509	0.00843	1.43%	1528	1740	7000	709	39.3	1050	6.35	2140	6.24	4040
Maine	1341582	0.005704	0.41%	1072	84.8	424	85	31.6	18.9	2.05	182	6.33	5.3
Maryland	6079602	0.014288	1.85%	1131	295	935	750	114	64.1	8	49.4	16.8	220
Massachusetts	6895917	0.005653	2.10%	1211	380	540	648	35.1	139	1.03	27.9	9.6	50.1
Michigan	9991177	0.00672	3.05%	833	767	9290	1030	187	332	23.7	518	85.7	7800

Minnesota	5628162	0.009327	1.72%	693	776	2450	515	82.2	276	58.9	259	9.2	2010
Mississippi	2982785	0.004788	0.91%	1499	2260	427	400	48.1	1770	17.1	182	9.45	118
Missouri	6135888	0.006549	1.87%	1071	1740	6690	797	57.5	1370	63.7	85.2	29.6	5860
Montana	1062330	0.008599	0.32%	390	188	9610	153	23.7	9450	42.2	9.67	21.6	75.7
Nebraska	1932549	0.005512	0.59%	599	5810	3680	275	19	6090	110	44.3	9.6	2920
Nevada	3056824	0.0440983	0.93%	241	1360	1520	531	35.8	2070	4.94	5.71	195	8.73
New Hampshire	1350575	0.013902	0.41%	1103	80.4	162	95.5	29.7	5.2	0.84	12.6	6.13	74.8
New Jersey	9032872	0.00931948	2.75%	1196	569	1310	1180	90.7	93.9	0.88	94.1	58.3	361
New Mexico	2090708	0.016921	0.64%	370	1350	1460	292	24.6	2370	32	3.4	56.8	33.5
New York	19862512	0.0043371	6.06%	1062	890	4420	2420	187	53.5	25.8	312	40.2	2210
North Carolina	10390149	0.013871	3.17%	1279	520	8400	938	169	325	66.5	193	38.3	6180
North	755238	0.0030528	0.23%	452	187	1190	84.2	3.69	233	20.8	19.6	30.7	983

Dakota													
Ohio	11694664	0.00574998	3.57%	993	866	5660	1310	139	55	24.6	348	129	4480
Oklahoma	3940521	0.0085378	1.20%	927	960	848	611	30.3	931	70.6	52	37.4	71.7
Oregon	4199563	0.0149969	1.28%	695	1480	5100	567	73.9	5160	16.3	105	11.3	11.4
Pennsylvania	12823989	0.0029852	3.91%	1089	622	5410	1390	208	34.3	39.5	645	38.1	3580
Rhode Island	1061712	0.0043669	0.32%	1218	32.7	88.8	97.5	6.57	4.25	0.12	2.05	2.92	1.33
South Carolina	5088916	0.0043669	1.55%	1264	365	5810	633	118	126	9.87	286	10.1	4980
South Dakota	877790	0.004273868	0.27%	511	238	162	72	5.56	211	47.9	24.4	8.65	2.39
Tennessee	6782564	0.010657	2.07%	1376	430	5990	850	42.8	63.8	23.4	734	31.4	4620
Texas	28704330	0.0194638	8.75%	734	6170	12700	2890	137	5490	276	323	131	9640
Utah	3159345	0.022549	0.96%	310	1050	2820	627	10.4	3030	15.9	54.2	3.47	61

Vermont	623960	0.00761935	0.19%	1085	36.7	54.2	42.7	11	3.11	5.87	11	4.56	0.8
Virginia	8525660	0.014092	2.60%	1125	284	4030	697	125	51.7	27	370	24.9	2910
Washington	7530552	0.016963	2.30%	976	1530	2730	867	110	2520	29.7	412	17	52.2
West Virginia	1803077	-0.0013788	0.55%	1147	130	2190	185	31.3	4.15	5.08	424	53.3	1570
Wisconsin	5818049	0.0078831	1.77%	829	772	4980	479	76.4	460	74.5	382	29.3	4210
Wyoming	573720	0.010617	0.17%	328	652	7400	101	8.93	7790	16.2	8.04	44.5	51.8

Groundwater Depletion (Km**3/yr)

```
Alabama
0.356
Alaska
0.0001
Arizona
0.01
Arkansas
2
California
1.54
Colorado
1.237
Connecticut
0.0001
Delaware
0.042
Florida
0.356
Georgia
0.033
Hawaii
0.002
Idaho
0.237
Illinois
0.022
Indiana
0.022
Iowa
0.022
Kansas
2.406
Kentucky
0.0001
Louisiana
2.356
```

```
Maine
0.0001
Maryland
0.042
Massachusetts
0.0001
Michigan
0.022
Minnesota
0.022
Mississippi
3.045
Missouri
0.022
Montana
0.0001
Nebraska
2.7
Nevada
0.061
New Hampshire
0.0001
New Jersey
0.011
New Mexico
0.761
New York
0.011
North Carolina
0.053
North Dakota
0.0001
Ohio
0.0001
Oklahoma
0.262
```

```
Oregon
0.057
Pennsylvania
0.0001
Rhode Island
0.0001
South Carolina
0.062
South Dakota
0.062
Tennessee
2
Texas
3.349
Utah
0.12
Vermont
0.0001
Virginia
0.244
Washington
0.057
West Virginia
0.0001
Wisconsin
0.022
Wyoming
0.386
```

Here is a link to our program:
https://repl.it/@supercompHA/Water-Simulation-Supercomputing

Conclusion

In conclusion, our program emphasizes the importance of freshwater in the United States , and models the alarming aquifer depletion rates. We plan continue this project over the next two years. Next year we want to focus on the counties in New Mexico. We hope to gather more local data.

Personal Statement

Personal Statement

Anabelle Fortin is a sophomore currently attending Las Cruces High school. She plans to major in the computer science field, though she spends a lot of her free time working with the fine arts and computer graphics. She was interested in conducting this model experiment because she wanted to know more about how human activity affects the environment, and she wanted to practice her programming skills.

Hannah Himelright is a sophomore at Las Cruces High school. She wants to pursue a career in the STEM field, and is interested in mathematics and computer science. Hannah was excited to create this simulation because she was concerned about our accessibility to clean water in the future. She hopes to learn a lot about computer science and our water usage through this project!

Acknowledgements

Thank you to Maureen Psaila-Dombrowski an employee at the Los Alamos National Laboratory, for providing us with helpful statistics on water usage and ideas.
Thank you to Lauren Curry our computer science teacher and sponsor, for helping us to organize our project and keep us on track.
Thank you to David Himelright a computer scientist and mathematician at White Sands Missile range, for support and advice with the program.
Thank you to David Janecky, a scientist at the Los Alamos National Laboratory, for giving us inspiration.
Thank you to Phil Campbell, for giving us information on our community's local water conservation and usage.
Thank you to Stephen Pate and Ann Gomez for evaluating our projects and offering us constructive suggestions.

Works Cited

US States - Ranked by Population 2019. (n.d.). Retrieved March 30, 2019, from http://worldpopulationreview.com/states/

List of states and territories of the United States by population. (2019, March 30). Retrieved March 30, 2019, from https://en.wikipedia.org/wiki/List_of_states_and_territories_of_the_United_States_by_population

US States by Population Growth Rate 1950-2016. (2018, February 27). Retrieved from http://factsmaps.com/us-states-population-growth-rate-1950-2016/

Konikow, L. F. (2013, May 10). Groundwater Depletion in the United States (1900–2008). Retrieved from https://pubs.usgs.gov/sir/2013/5079/SIR2013-5079.pdf