

ONE-PAGE PLACE ASSESSMENT: DENVER, COLORADO

LOCATED IN THE MIDDLE SOUTH PLATTE-CHERRY CREEK SUBWATERSHED WITHIN THE MISSOURI WATERSHED

CLIMATE		AVERAGE HIGH & LOW TEMPERATURES ¹ 1948-2013											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
° F HIGH	43.9	46.7	52.9	61.4	70.7	81.7	88.3	86.0	77.5	66.2	52.7	45.0	64.4
° F LOW	17	20.3	26.3	34.4	44.0	52.9	59.1	57.4	48.1	36.7	25.5	18.2	36.6
° C HIGH	6.6	8.2	11.6	16.3	21.5	27.6	31.3	30.0	25.3	19.0	11.5	7.2	18.0
° C LOW	-8.3	-6.5	-3.2	1.3	6.7	11.6	15.1	14.1	8.9	2.6	-3.6	-7.7	2.6

RECORD HIGH¹ 104° F 40.0° C June 26, 1994 RECORD LOW¹ -25° F -31.7° C February 1, 1951

SUN		MAR 21 JUN 21 SEP 21 DEC 21					
LATITUDE	39.7°	DEGREES N or S of DUE EAST THE SUN RISES ²		0°	32°N	0°	30°S
		DEGREES N or S of DUE WEST THE SUN SETS ²		0°	32°N	0°	30°S
ELEVATION	5,280 FT 1,610 m	SOLAR-NOON ALTITUDE ANGLE (ABOVE HORIZON) ^{a,2,3}		50°	74°	50°	27°
		SOLAR-NOON WINTER-SOLSTICE SHADOW RATIO ^b		1 : 1.97	...AND AZIMUTH ^c		0°
		9AM & 3PM WINTER-SOLSTICE SHADOW RATIO ^{b,2}		1 : 3.94	...AND AZIMUTH ^{c,2}		42°

WIND		PREVAILING WIND DIRECTION (FROM WHERE) ⁴ & AVERAGE SPEED ⁵												MAX SPEED ⁶ 70 113	
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	MPH	km/h
	S	S	S	N	S	S	S	S	S	S	S	S	S		
MPH	8.3	8.7	9.3	10.5	9.5	9.6	8.8	8.4	8.4	8.1	8.1	8.5	8.8		
km/h	13.4	14.0	15.0	16.9	15.3	15.4	14.2	13.5	13.5	13.0	13.0	13.7	14.2		

WATER		AVERAGE RAINFALL (GAIN) ¹ 1948-2013											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
INCHES	0.50	0.57	1.21	1.76	2.40	1.67	2.03	1.70	1.13	1.01	0.80	0.58	15.36
mm	12.7	14.5	30.7	44.7	61.0	42.4	51.6	43.2	28.7	25.7	20.3	14.7	390.1

AVERAGE PAN EVAPORATION (POTENTIAL LOSS) ^{d,7} 1900-2005	
INCHES	0.00 0.00 2.50 4.52 5.42 6.32 6.92 6.07 4.74 3.07 1.48 0.00 41.04
mm	0.0 0.0 63.5 114.8 137.7 160.5 175.8 154.2 120.4 78.0 37.6 0.0 1,042.4

WETTEST YEAR'S RAIN¹ 23.84 INCHES 605.5 mm 1997 DRIEST YEAR'S RAIN¹ 7.51 INCHES 190.8 mm 1954

LONGEST PERIOD WITH NO MEASURABLE PRECIPITATION⁸ 69 DAYS: November 26, 2002 – February 3, 2003 RAINFALL INCOME^e 176 GPCD
668 lpcd

AREA^{f,9} 153.0 SQ MILES 396 km² POPULATION^{f,9} 634,265 2012 est. UTILITY-WATER USE¹⁰ 171 GPCD
647 lpcd

HISTORICAL 54.0 FT 16.5 m 1965 DEPTH TO GROUNDWATER^{g,11} 101.87 FT 31.1 m 2013 CURRENT

CURRENT GROUNDWATER EXTRACTION > NATURAL GROUNDWATER RECHARGE^{h,12}

WATERGY	# of AVG CO HOMES THAT COULD BE POWERED W/KWH USED TO PUMP DENVER'S TREATED WATER ^{13,14}
	3,080

TOTEM SPECIES	PLANT:	MAMMAL:
	American Ground Nut (<i>Apios Americana Medicus</i>)	North American Beaver (<i>Castor canadensis</i>)
MEGAFUNA:	BIRD:	REPTILE:
	Northern Harrier Hawk (<i>Circus cyaneus</i>)	Common Garter Snake (<i>Thamnophis sirtalis</i>)
AMPHIBIAN:	FISH:	
	Northern Leopard Frog (<i>Lithobates pipiens</i>)	Greenback Cutthroat Trout (<i>Oncorhynchus clarki stomias</i>) ¹⁴

FOR MORE INFORMATION & HOW TO APPLY IT

1. For more CLIMATE information, see the introduction, chapters 1, 2, & 4, and appendix 5 of *Rainwater Harvesting for Drylands and Beyond (RWHDB), Volume 1, 2nd Edition*
2. For more SUN information, see chapters 2 & 4 and appendices 5 & 7
3. For more WIND information, see chapters 2 & 4 and appendices 5 & 9
4. For more WATER information, see the introduction, chapters 1–4, and appendices 1–5
5. For more WATERGY information, see chapters 2 & 4 and appendix 9
6. For more TOTEM SPECIES information: the ethics, principles, and strategies throughout *RWHDB* help us shift from a negative to a positive impact on these species and their habitats and ecosystems, on which our quality of life also depends.

DENVER PLACE-ASSESSMENT NOTES

- a. Altitude angle (a.k.a., elevation angle) refers to the number of degrees the sun is located above the horizon at a given time and date.
- b. The solar-noon winter-solstice shadow ratio is the object's height : length of object's shadow cast on December 21 at noon (the longest noontime shadow of the year). The ratio is $1 : x$, where $x = 1 \div \tan(90 - (\text{latitude} + 23.44))$.
- c. Azimuth is the angle formed between a reference direction (here, due south) to the point on the horizon directly below a given object. Solar noon is the time on any day when the sun's azimuth is 0° . The 9 am & 3 pm winter-solstice azimuth indicates the sun's deviation, in degrees, east/west of due south at those times ($-/+$ 3 hours from solar noon) on December 21.
- d. An evaporation pan holds water whose depth is measured daily as water evaporates. These data allow us to determine evaporation rates at a given location. Compare average rainfall (water gain) to potential water loss via evaporation by looking up pan-evaporation rates for your area. If pan-evaporation rates exceed rainfall rates, you are in a dryland environment, where evaporation-reducing strategies such as mulch, windbreaks, shading, and covered water storage are very important.
- e. Calculated in situ w/ average rainfall, area, & population
- f. City proper (City of Denver = Denver County)
- g. Well name: Smith, Albert. Location #SC00206603BBB. Latitude: 39.912650, Longitude: -104.770070. Well level for 1965 was taken Oct 11; 2013 reading was on April 8. Earliest April well level for this well was taken in 1989, at 66 feet. Groundwater levels within the Denver aquifer vary widely. This Denver well was chosen due to having the longest available period of record.
- h. The Denver Basin Aquifer system used by much of south metro Denver and other metro areas south of Denver is a deep system that gets very little natural recharge, and is basically being "mined." See USGS Professional Paper 1770 &/or Colorado Foundation for Water Education's Citizens' Guide to Denver Basin Groundwater for more background and information on this subject (per reference 12).
- i. In 2012, Denver Water used 26,277,763 kWh to pump treated water. This does not include energy used to treat or pump raw water (ref. 13). The average Colorado household used 711 kWh/month in 2011 (ref. 14), or 8,532 kWh/year. $26,277,763 \text{ kWh/year} \div 8,532 \text{ kWh/year/household} = 3,080$ households.

CREDITS: Brad Lancaster, Resource concept | Megan Hartman, Resource creation, research

DENVER PLACE-ASSESSMENT REFERENCES

1. Denver Stapleton station (#052220), wrcc.dri.edu, accessed 8/12/2013
2. Rainwater Harvesting for Drylands & Beyond, Vol 1, or esrl.noaa.gov/gmd/grad/solcalc, accessed 8/12/2013
3. RWHDB Vol 1, or Mar 21 = $90 - \text{latitude}$, Jun 21 = $90 - (\text{latitude} - 23.44)$, Sep 21 = $90 - \text{latitude}$, Dec 21 = $90 - (\text{latitude} + 23.44)$
4. www.wrcc.dri.edu/htmlfiles/westwinddir.html#COLORADO, Denver-Centennial AP, accessed 8/12/2013
5. www.wrcc.dri.edu/climatedata/climtables/westwind/#COLORADO, Denver-Centennial AP, accessed 8/12/2013
6. www.myforecast.com/bin/climate.m?city=12421, April & July, accessed 8/12/2013
7. www.wrcc.dri.edu/htmlfiles/westevap.final.html#COLORADO, most-comparable data for Fort Collins, accessed 8/12/2013
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9. www.census.gov, accessed 8/12/2013
10. 2012 Comprehensive Annual Financial Report (p. III-75), www.denverwater.org, accessed 8/13/2013
11. cdss.state.co.us/onlineTools/Pages/GroundWaterWaterLevels.aspx, accessed 8/13/2013
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13. 2012 Comprehensive Annual Financial Report (p. III-70), www.denverwater.org, accessed 8/13/2013
14. Table 5A. Residential average monthly bill by Census Division, and State 2011. www.eia.gov/electricity/sales_revenue_price/xls/table5_a.xls, accessed 8/13/2013
15. Jason Gerhardt, Real Earth Design, via email 2/4 & 2/5/2012