

Appendix 3-B

Updated October 2023

MDOT Rainfall Intensity-Duration-Frequency Development

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The National Oceanic and Atmospheric Administration (NOAA) Atlas 14 includes rainfall point precipitation statistics that were updated in 2013 for Michigan. The statistics are available online for recurrence intervals from one year to 1,000 years and durations from five minutes to 60 days. The data is unique to each selected location in the state. To obtain Atlas 14 rainfall point precipitation statistics, use the following steps:

- Step 1** Access Atlas 14 data through the NOAA website using this link:
[NOAA Atlas 14 Point Precipitation Frequency Estimates](#)
- Step 2** Choose Michigan.
- Step 3** Under "Data description," "Date type," select "Precipitation intensity" (see **Figure 1**).
- Step 4** Select location at the mid-point of the project (see **Figure 1**).
- Step 5** Scroll down the webpage, ensuring CSV format is set to "Precipitation frequency estimates" and click Submit (see **Figure 2**).
- Step 6** Open downloaded CSV file and paste project information and precipitation frequency estimates into the intensity duration frequency (IDF) spreadsheet. The paste region for the data is shown in **Figure 3**.
- Step 7** To generate rainfall intensities, use the following polynomial logarithmic equation. The IDF spreadsheet generates site-specific constants for the 5-, 10-, 25-, 50-, and 100-year recurrence intervals (see **Figure 4**) that can be pasted directly into OpenRoads Designer (ORD) Drainage & Utilities for inlet spacing and storm sewer calculations.

$$i = a + b(\ln D) + c(\ln D)^2 + d(\ln D)^3 \quad (3.B.1)$$

i = intensity (in/hr)

D = duration or time of concentration (T_c) (minutes)

a, b, c, d = constants

Hand Calculations

For other Rational Method calculations not using ORD, the T_c can be edited into the table for hand calculations in the IDF spreadsheet to obtain the intensities (see **Figure 5**) or use the polynomial logarithmic equation.

Figure 1. NOAA Atlas 14 – Data Type and Location

NOAA's National Weather Service
Hydrometeorological Design Studies Center
Precipitation Frequency Data Server (PFDS)

Home Site Map Organization

NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: MI

Data description
Data type: **Precipitation intensity** Units: **English** Time series type: **Partial duration**

Select location
1) Manually:
a) By location (decimal degrees, use [input] **Submit**
b) By station (list of MI stations): [Select station] [v]
c) By address [Search] [Q]

2) Use map:

Map [v] Terrain [x]

Select a location centered on the project area

a) Select location
Move crosshair or double click
b) Click on station icon
 Show stations on map

Location information:
Name: East Lansing, Michigan, USA*
Latitude: 42.7252°
Longitude: -84.5089°
Elevation: 843 ft **

* Source: ESRI Maps
** Source: USGS

Figure 2. NOAA Atlas 14 – Precipitation Frequency Estimates

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 8, Version 2

PF tabular

PF graphical

Supplementary information

Print page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches/hour) ¹										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	3.49 (2.99-4.14)	4.07 (3.48-4.82)	5.06 (4.32-6.02)	5.94 (5.04-7.10)	7.22 (5.93-8.98)	8.28 (6.80-10.4)	9.37 (7.20-12.0)	10.5 (7.73-13.9)	12.2 (8.54-16.4)	13.4 (9.17-18.4)
10-min	2.56 (2.19-3.03)	2.98 (2.55-3.53)	3.71 (3.16-4.42)	4.36 (3.68-5.20)	5.29 (4.34-6.57)	6.06 (4.84-7.61)	6.86 (5.27-8.81)	7.72 (5.66-10.2)	8.90 (6.26-12.0)	9.85 (6.71-13.4)
15-min	2.08 (1.78-2.46)	2.42 (2.07-2.87)	3.02 (2.57-3.59)	3.54 (3.00-4.23)	4.30 (3.53-5.34)	4.93 (3.93-6.18)	5.58 (4.28-7.16)	6.27 (4.60-8.26)	7.24 (5.09-9.78)	8.00 (5.45-10.9)
30-min	1.49 (1.28-1.77)	1.74 (1.49-2.08)	2.17 (1.85-2.58)	2.54 (2.15-3.04)	3.09 (2.53-3.83)	3.53 (2.82-4.44)	4.00 (3.07-5.14)	4.49 (3.30-5.92)	5.18 (3.64-7.00)	5.72 (3.90-7.81)
60-min	0.937 (0.803-1.11)	1.12 (0.954-1.32)	1.42 (1.21-1.69)	1.69 (1.43-2.02)	2.08 (1.70-2.58)	2.39 (1.91-3.00)	2.72 (2.09-3.50)	3.07 (2.25-4.05)	3.56 (2.60-4.80)	3.94 (2.68-5.38)
2-hr	0.564 (0.487-0.664)	0.680 (0.589-0.801)	0.879 (0.754-1.04)	1.05 (0.897-1.25)	1.30 (1.08-1.61)	1.51 (1.21-1.88)	1.72 (1.33-2.20)	1.95 (1.44-2.55)	2.26 (1.60-3.03)	2.51 (1.72-3.40)
3-hr	0.410 (0.355-0.481)	0.498 (0.431-0.585)	0.650 (0.560-0.764)	0.783 (0.670-0.925)	0.978 (0.811-1.20)	1.14 (0.917-1.41)	1.30 (1.01-1.66)	1.48 (1.10-1.93)	1.72 (1.23-2.30)	1.92 (1.32-2.59)
6-hr	0.246 (0.214-0.288)	0.293 (0.255-0.342)	0.377 (0.327-0.440)	0.453 (0.390-0.531)	0.565 (0.474-0.692)	0.659 (0.537-0.815)	0.758 (0.595-0.959)	0.865 (0.649-1.12)	1.02 (0.731-1.35)	1.14 (0.792-1.52)
12-hr	0.150 (0.132-0.173)	0.171 (0.150-0.198)	0.211 (0.184-0.244)	0.248 (0.215-0.288)	0.305 (0.259-0.373)	0.355 (0.292-0.437)	0.408 (0.324-0.515)	0.467 (0.354-0.604)	0.552 (0.401-0.731)	0.622 (0.437-0.828)
24-hr	0.089 (0.079-0.102)	0.100 (0.088-0.115)	0.121 (0.106-0.139)	0.140 (0.123-0.162)	0.171 (0.146-0.207)	0.197 (0.164-0.241)	0.226 (0.181-0.283)	0.258 (0.197-0.331)	0.304 (0.223-0.400)	0.342 (0.243-0.452)
2-day	0.050 (0.045-0.057)	0.057 (0.051-0.065)	0.070 (0.062-0.080)	0.082 (0.072-0.094)	0.100 (0.086-0.120)	0.115 (0.098-0.139)	0.131 (0.105-0.162)	0.148 (0.114-0.188)	0.173 (0.128-0.225)	0.193 (0.138-0.253)
3-day	0.037 (0.033-0.041)	0.042 (0.037-0.047)	0.051 (0.045-0.058)	0.059 (0.052-0.067)	0.071 (0.061-0.085)	0.082 (0.068-0.098)	0.093 (0.075-0.114)	0.105 (0.081-0.133)	0.122 (0.091-0.158)	0.136 (0.098-0.178)
4-day	0.029 (0.026-0.033)	0.033 (0.030-0.038)	0.040 (0.036-0.046)	0.046 (0.041-0.053)	0.056 (0.048-0.066)	0.064 (0.054-0.077)	0.072 (0.059-0.089)	0.082 (0.063-0.103)	0.095 (0.071-0.123)	0.106 (0.078-0.138)
7-day	0.020 (0.018-0.022)	0.022 (0.020-0.025)	0.026 (0.023-0.029)	0.030 (0.027-0.034)	0.036 (0.031-0.042)	0.040 (0.034-0.048)	0.046 (0.037-0.056)	0.051 (0.040-0.064)	0.059 (0.044-0.076)	0.066 (0.048-0.085)
10-day	0.015 (0.014-0.017)	0.017 (0.016-0.019)	0.020 (0.018-0.023)	0.023 (0.021-0.026)	0.027 (0.024-0.032)	0.031 (0.027-0.035)	0.035 (0.031-0.041)	0.039 (0.034-0.045)	0.045 (0.039-0.051)	0.049 (0.039-0.064)
20-day	0.010 (0.009-0.011)	0.011 (0.010-0.013)	0.013 (0.012-0.015)	0.015 (0.013-0.017)	0.017 (0.015-0.020)	0.019 (0.017-0.022)	0.021 (0.019-0.024)	0.023 (0.020-0.027)	0.025 (0.022-0.030)	0.029 (0.021-0.037)
30-day	0.008 (0.007-0.009)	0.009 (0.008-0.010)	0.011 (0.010-0.012)	0.012 (0.011-0.013)	0.014 (0.012-0.016)	0.016 (0.014-0.018)	0.018 (0.016-0.020)	0.020 (0.018-0.022)	0.022 (0.019-0.025)	0.022 (0.016-0.028)
45-day	0.007 (0.006-0.007)	0.007 (0.007-0.008)	0.009 (0.008-0.010)	0.010 (0.009-0.011)	0.011 (0.010-0.012)	0.012 (0.011-0.012)	0.013 (0.012-0.013)	0.014 (0.013-0.014)	0.015 (0.014-0.015)	0.016 (0.012-0.021)
60-day	0.006 (0.005-0.006)	0.006 (0.006-0.007)	0.007 (0.007-0.008)	0.008 (0.008-0.009)	0.008 (0.008-0.011)	0.009 (0.008-0.011)	0.009 (0.008-0.011)	0.010 (0.009-0.011)	0.010 (0.009-0.011)	0.013 (0.010-0.017)

Select "Precipitation Frequency Estimates" and Submit

¹ Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series. Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values. Please refer to NOAA Atlas 14 document for more information.

Estimates from the table in CSV format:

Figure 3. NOAA Rainfall Intensity Data

Project information from CSV file

Point precipitation frequency estimates (inches/hour)
 NOAA Atlas 14 Volume 8 Version 2
 Data type: Precipitation intensity
 Time series type: Partial duration
 Project area: Midwestern States
 Location name (ESRI Maps): East Lansing
 Station Name: -
 Latitude: 42.7252 Degree
 Longitude: -84.5089 Degree
 Elevation (USGS): 843 ft

Data Paste
Region

Precipitation Frequency Estimates

By duration for ARI (years):	Duration (Years)									
	1	2	5	10	25	50	100	200	500	1000
5-min:	3.490	4.070	5.060	5.940	7.220	8.280	9.370	10.500	12.200	13.400
10-min:	2.560	2.980	3.710	4.360	5.290	6.060	6.860	7.720	8.900	9.850
15-min:	2.080	2.420	3.020	3.540	4.300	4.930	5.580	6.270	7.240	8.000
30-min:	1.490	1.740	2.170	2.540	3.090	3.530	4.000	4.490	5.180	5.720
60-min:	0.937	1.120	1.420	1.690	2.080	2.390	2.720	3.070	3.560	3.940
2-hr:	0.564	0.680	0.879	1.050	1.300	1.510	1.720	1.950	2.260	2.510
3-hr:	0.411	0.499	0.650	0.784	0.978	1.140	1.300	1.480	1.720	1.920
6-hr:	0.246	0.294	0.378	0.453	0.566	0.659	0.759	0.866	1.020	1.140
12-hr:	0.150	0.172	0.211	0.248	0.306	0.355	0.409	0.468	0.553	0.622
24-hr:	0.090	0.101	0.121	0.141	0.171	0.198	0.227	0.259	0.305	0.343
2-day:	0.051	0.058	0.071	0.083	0.100	0.115	0.131	0.149	0.173	0.193
3-day:	0.037	0.042	0.051	0.059	0.072	0.082	0.093	0.105	0.122	0.136
4-day:	0.030	0.034	0.041	0.047	0.056	0.064	0.073	0.082	0.095	0.106
7-day:	0.020	0.022	0.027	0.030	0.036	0.041	0.046	0.052	0.060	0.066
10-day:	0.016	0.018	0.021	0.024	0.028	0.031	0.035	0.039	0.045	0.050
20-day:	0.011	0.012	0.014	0.015	0.018	0.020	0.022	0.024	0.027	0.030
30-day:	0.009	0.010	0.011	0.012	0.014	0.016	0.017	0.019	0.021	0.022
45-day:	0.007	0.008	0.009	0.010	0.011	0.012	0.013	0.014	0.016	0.017
60-day:	0.006	0.007	0.008	0.009	0.010	0.011	0.011	0.012	0.013	0.014

Data Paste
Region

Figure 4. IDF Data Formatted for ORD

$$i = a+b(\ln D)+c(\ln D)^2+d(\ln D)^3$$

Appendix 3-B Equation (3.B.1)

Return Period (years)	a	b	c	d
5	9.359	-3.255	0.384	-0.015
10	11.082	-3.921	0.482	-0.021
25	13.569	-4.878	0.622	-0.029
50	15.666	-5.701	0.745	-0.036
100	17.734	-6.461	0.847	-0.041

ORD Storm Event Constants

Figure 5. Rainfall Intensity Table for Hand Calculations

Time (Tc) (min)	Rainfall Intensity				
	5-year	10-year	25-year	50-year	100-year
10	3.71	4.35	5.29	6.05	6.85
15	3.06	3.58	4.35	4.98	5.64
20	2.64	3.10	3.77	4.31	4.89
25	2.35	2.76	3.36	3.84	4.36
30	2.13	2.50	3.05	3.49	3.96
35	1.95	2.30	2.80	3.21	3.64
40	1.81	2.13	2.60	2.98	3.38
45	1.69	1.99	2.43	2.79	3.17
50	1.58	1.87	2.29	2.63	2.98
55	1.49	1.77	2.17	2.49	2.83
60	1.42	1.68	2.06	2.36	2.69

Rainfall Intensities Developed for Hand Calculations

Edit Tc