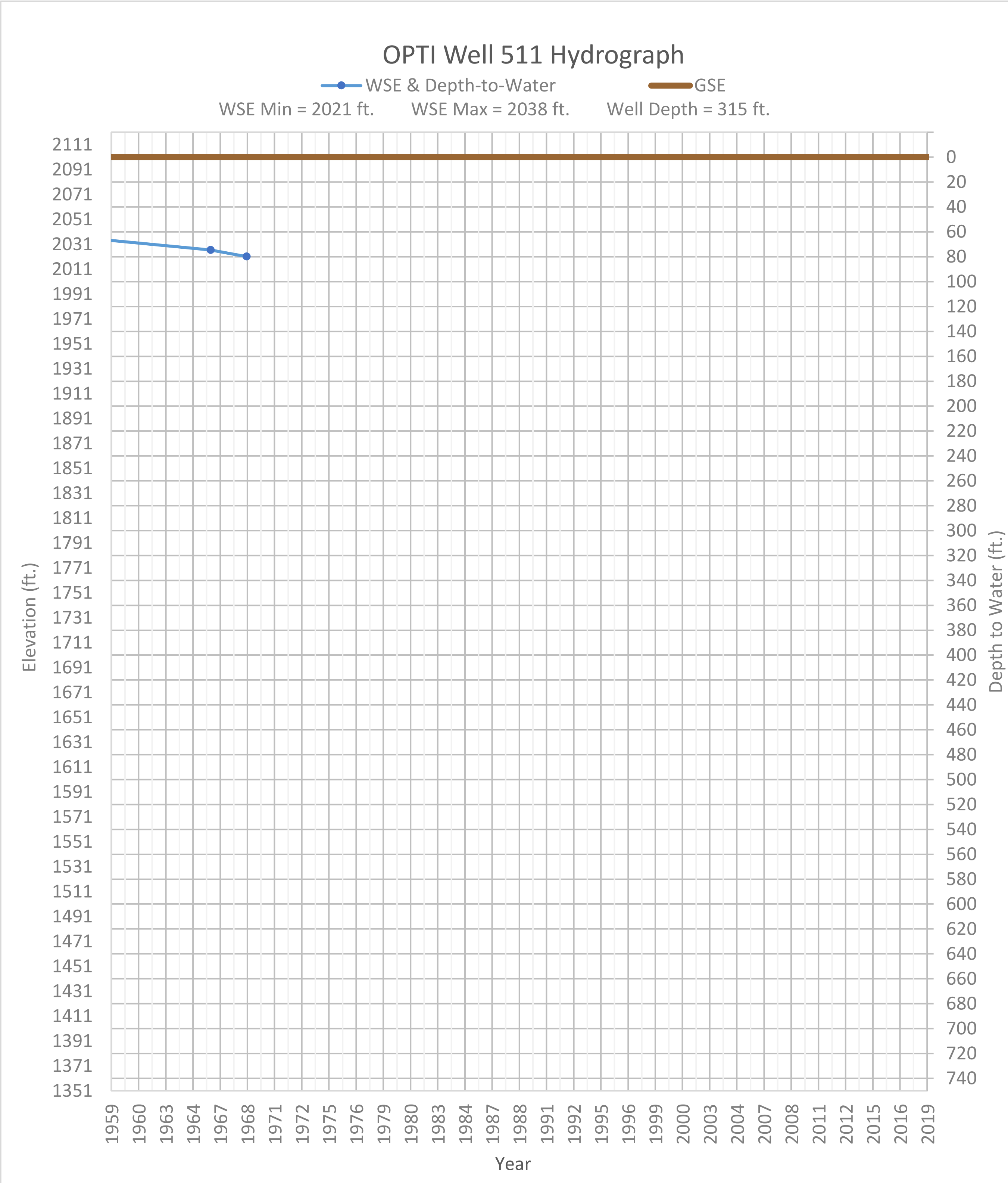
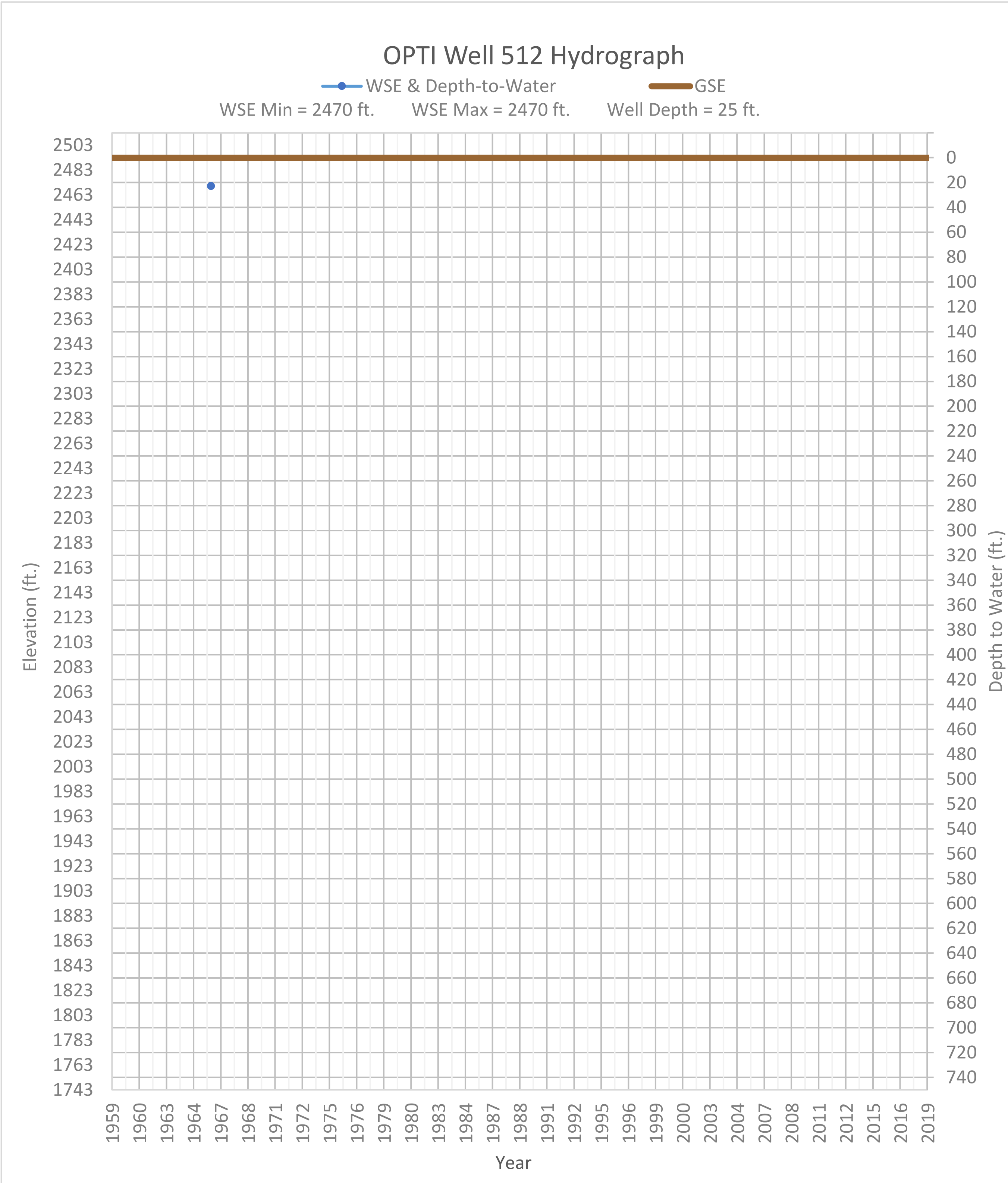
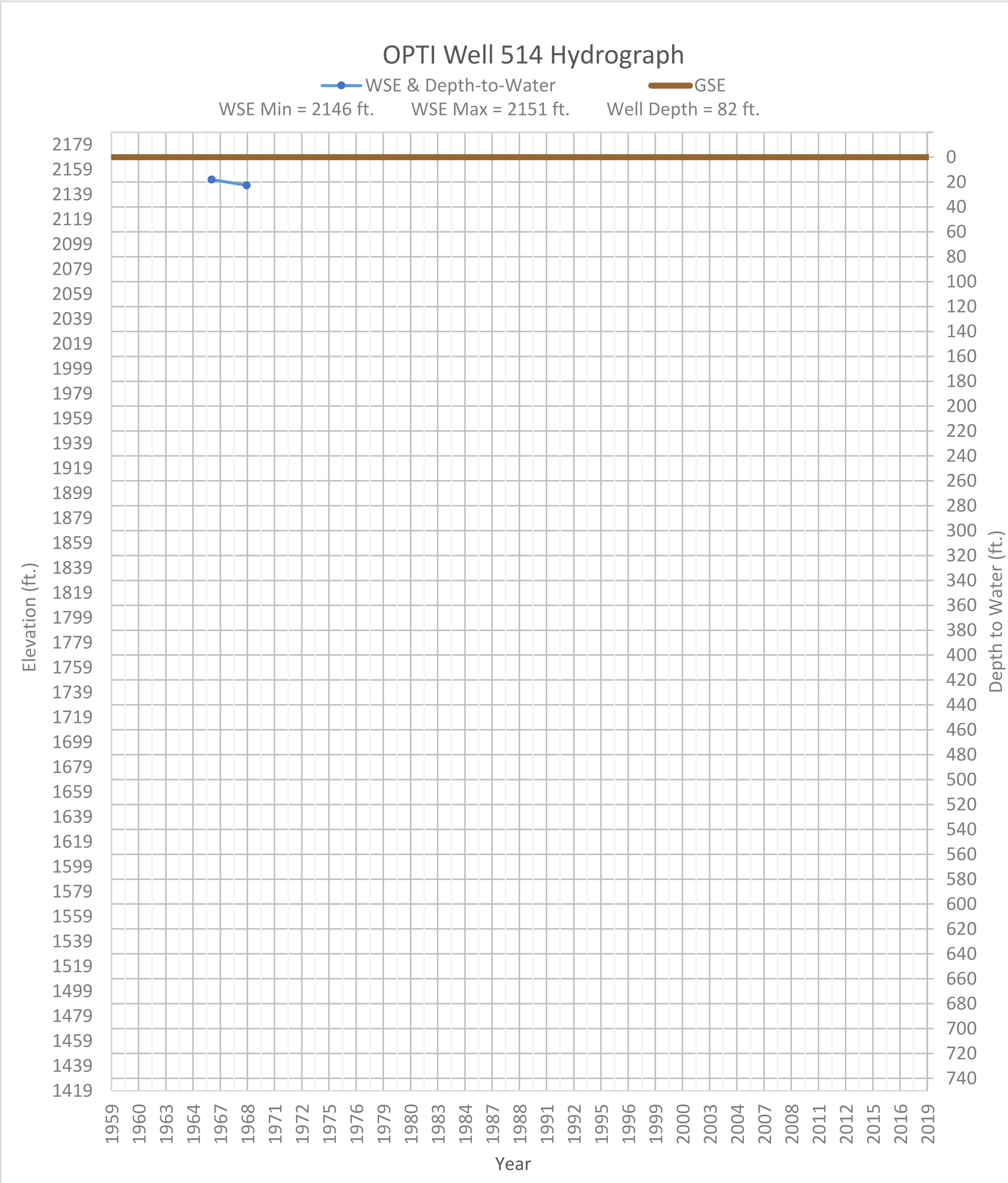

OPTI Well 511 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2021 ft.
WSE Max = 2038 ft.
Well Depth = 315 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 512 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2470 ft.
WSE Max = 2470 ft.
Well Depth = 25 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 514 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2146 ft.
WSE Max = 2151 ft.
Well Depth = 82 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2179
2159
2139
2119
2099
2079
2059
2039
2019
1999
1979
1959
1939
1919
1899
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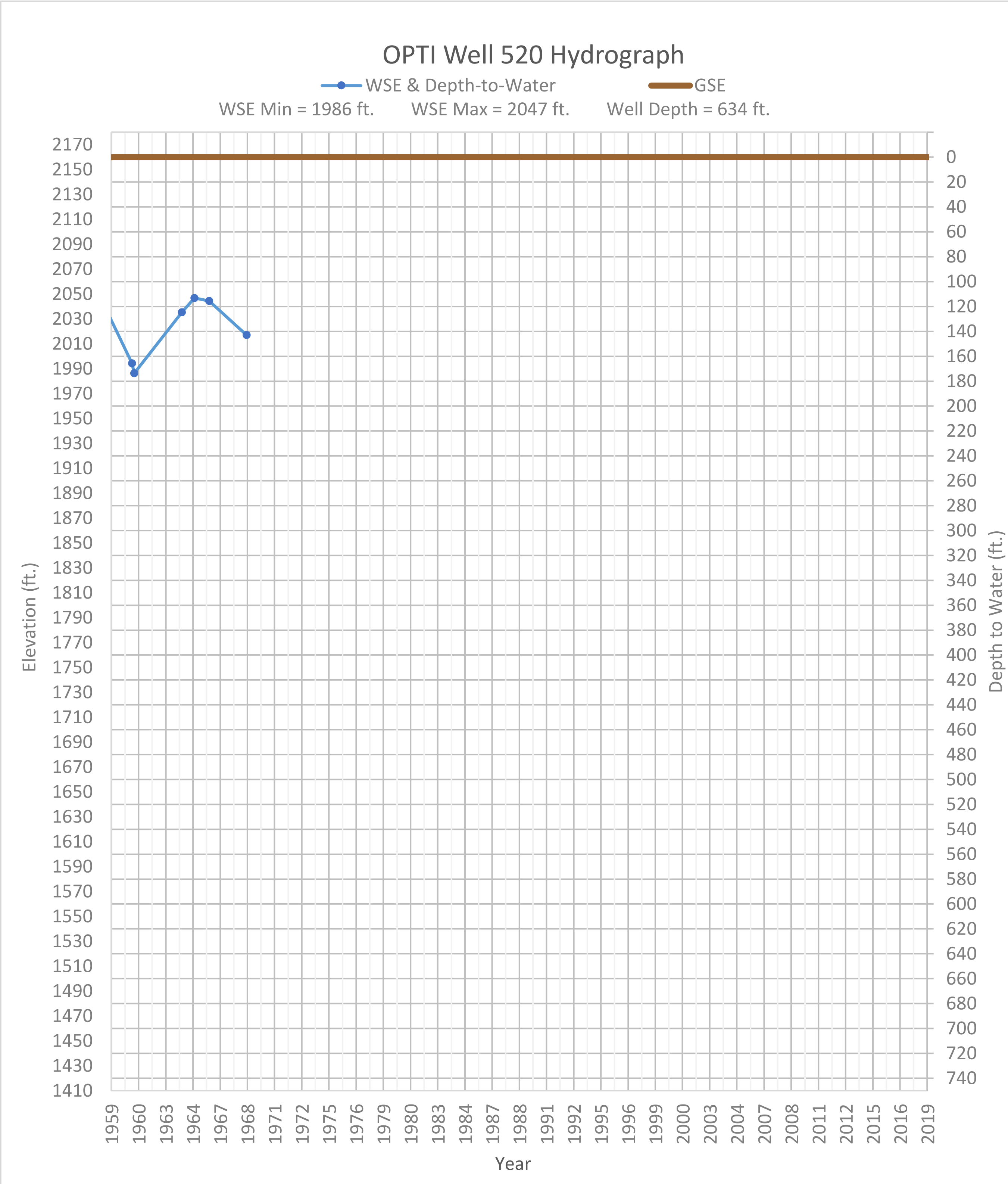
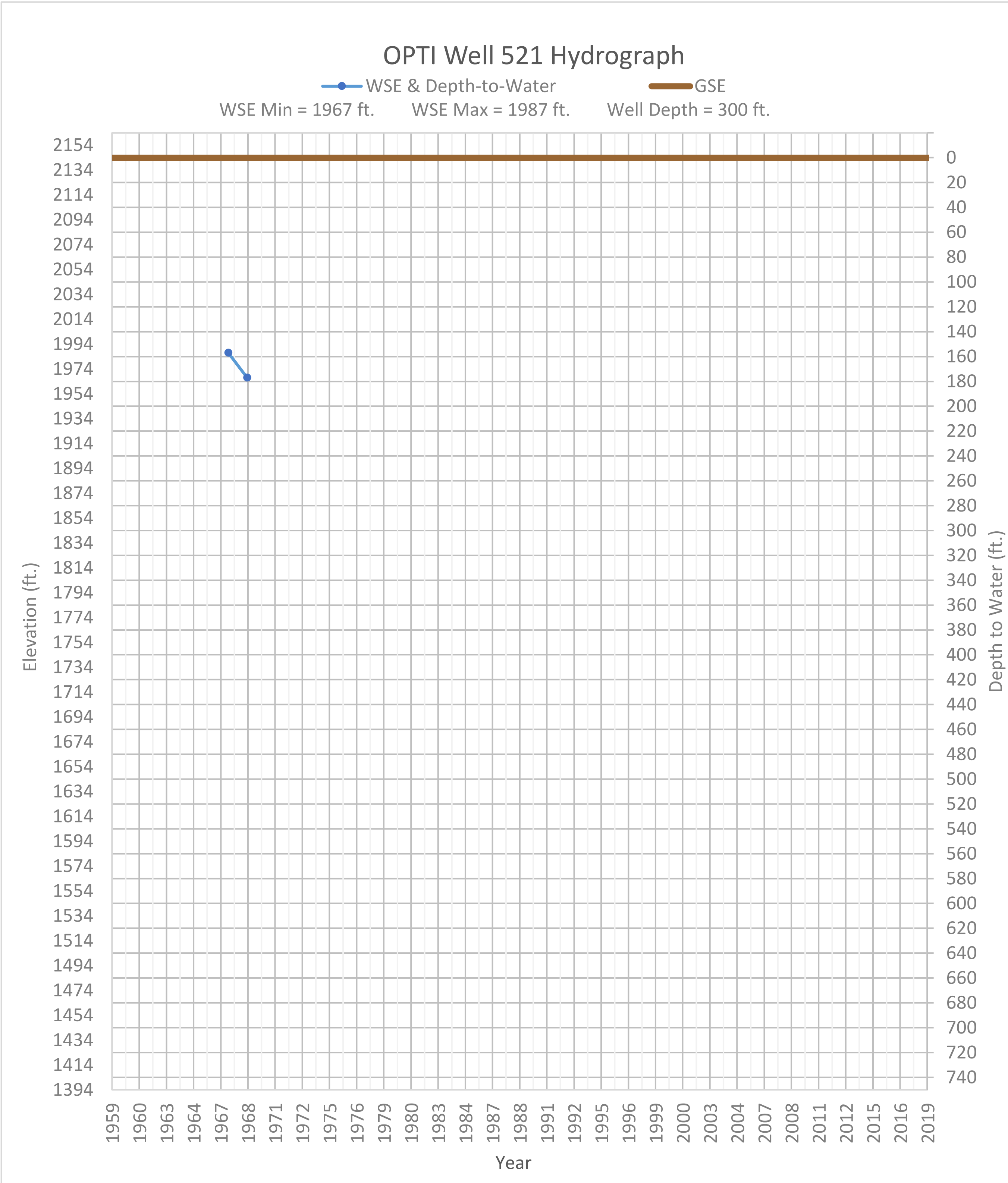
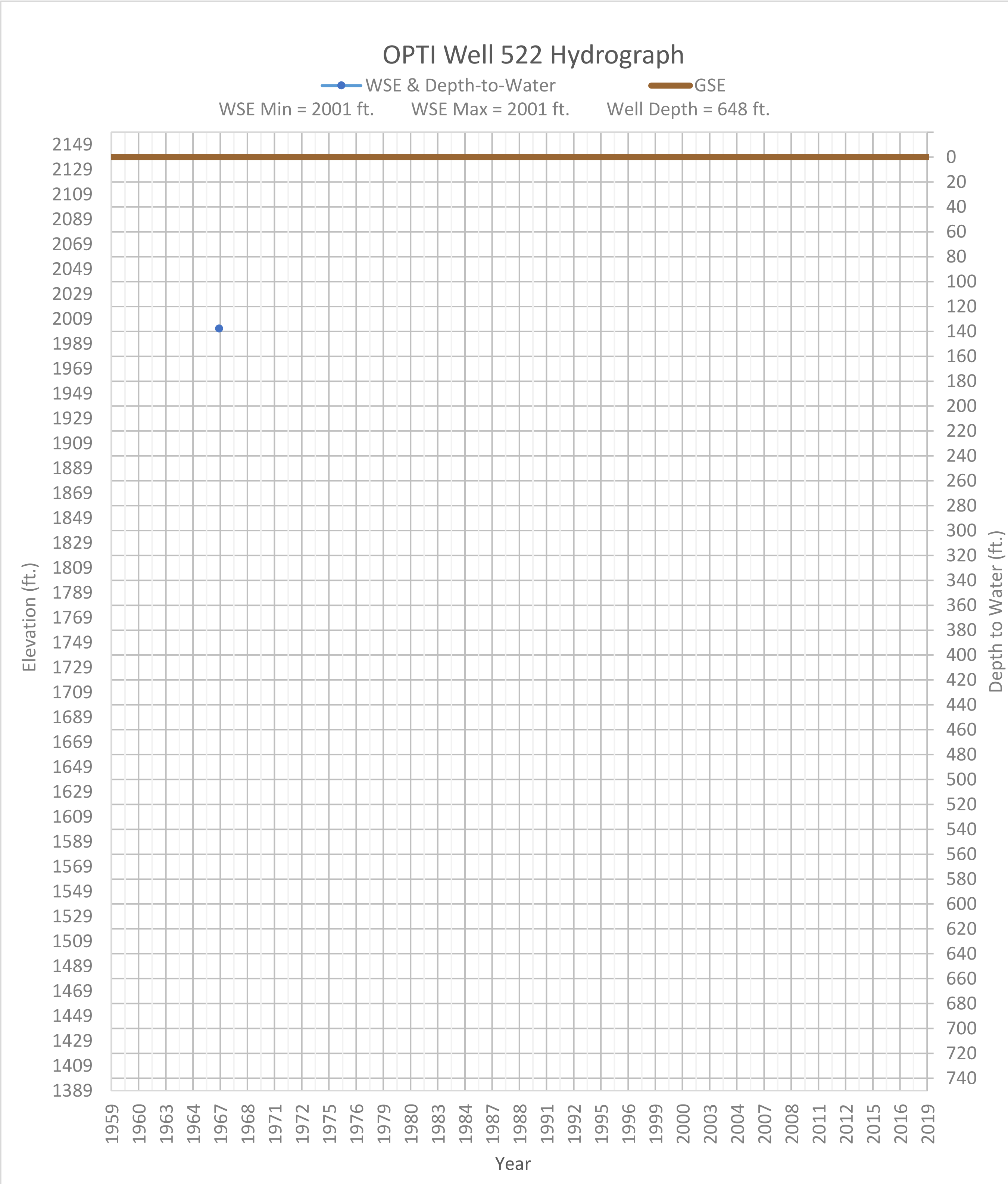
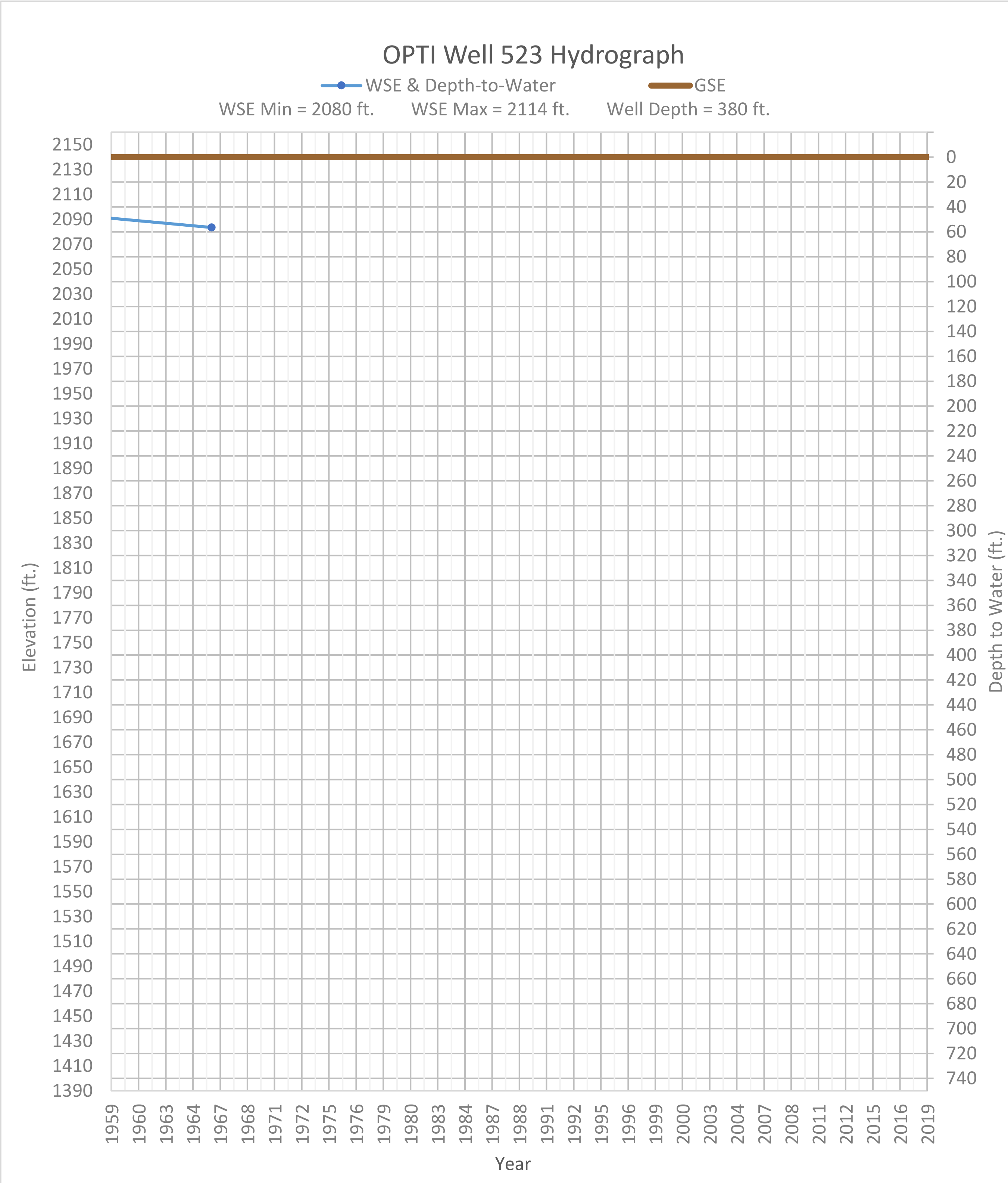
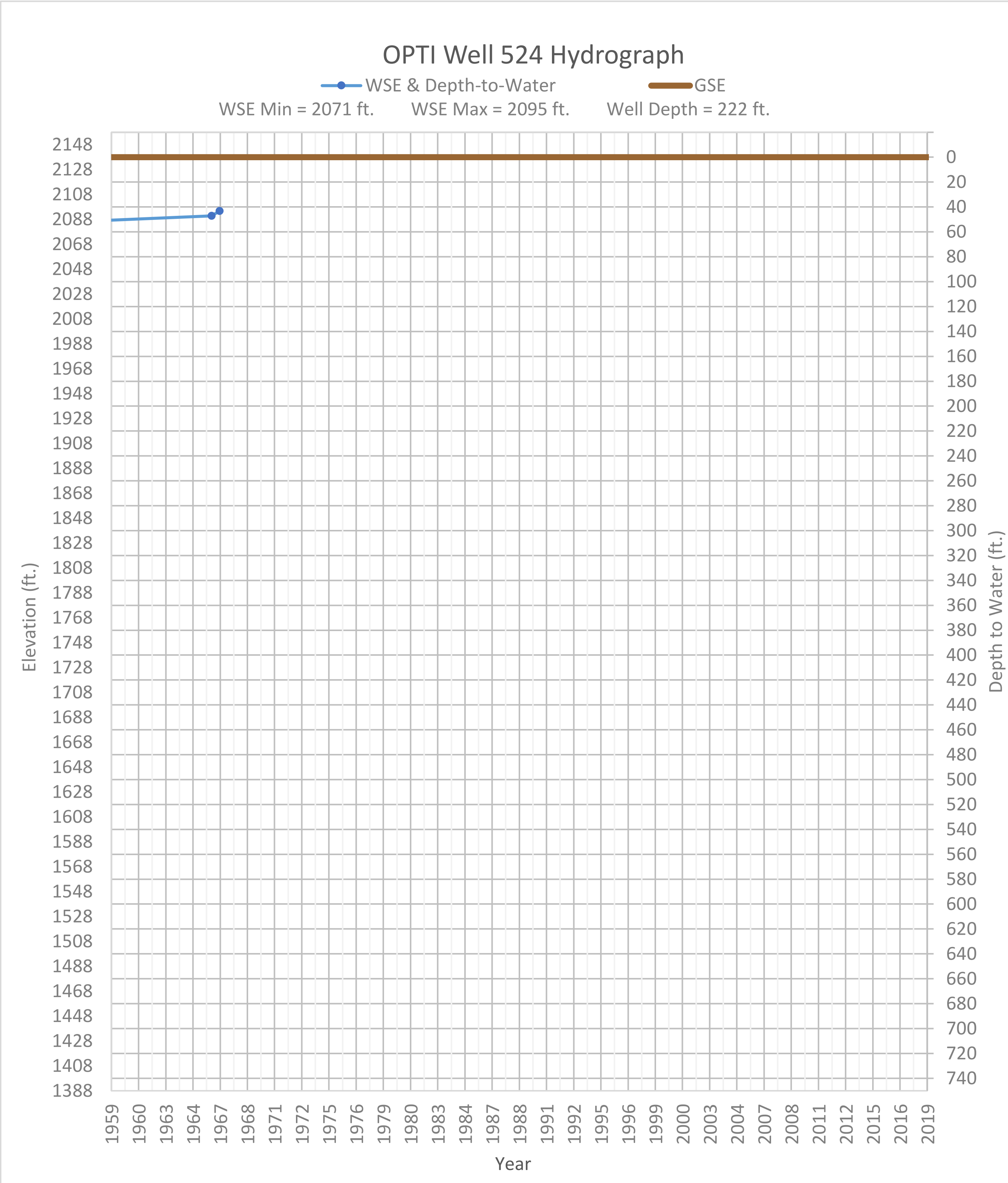

OPTI Well 520 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1986 ft.
WSE Max = 2047 ft.
Well Depth = 634 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 521 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1967 ft.
WSE Max = 1987 ft.
Well Depth = 300 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

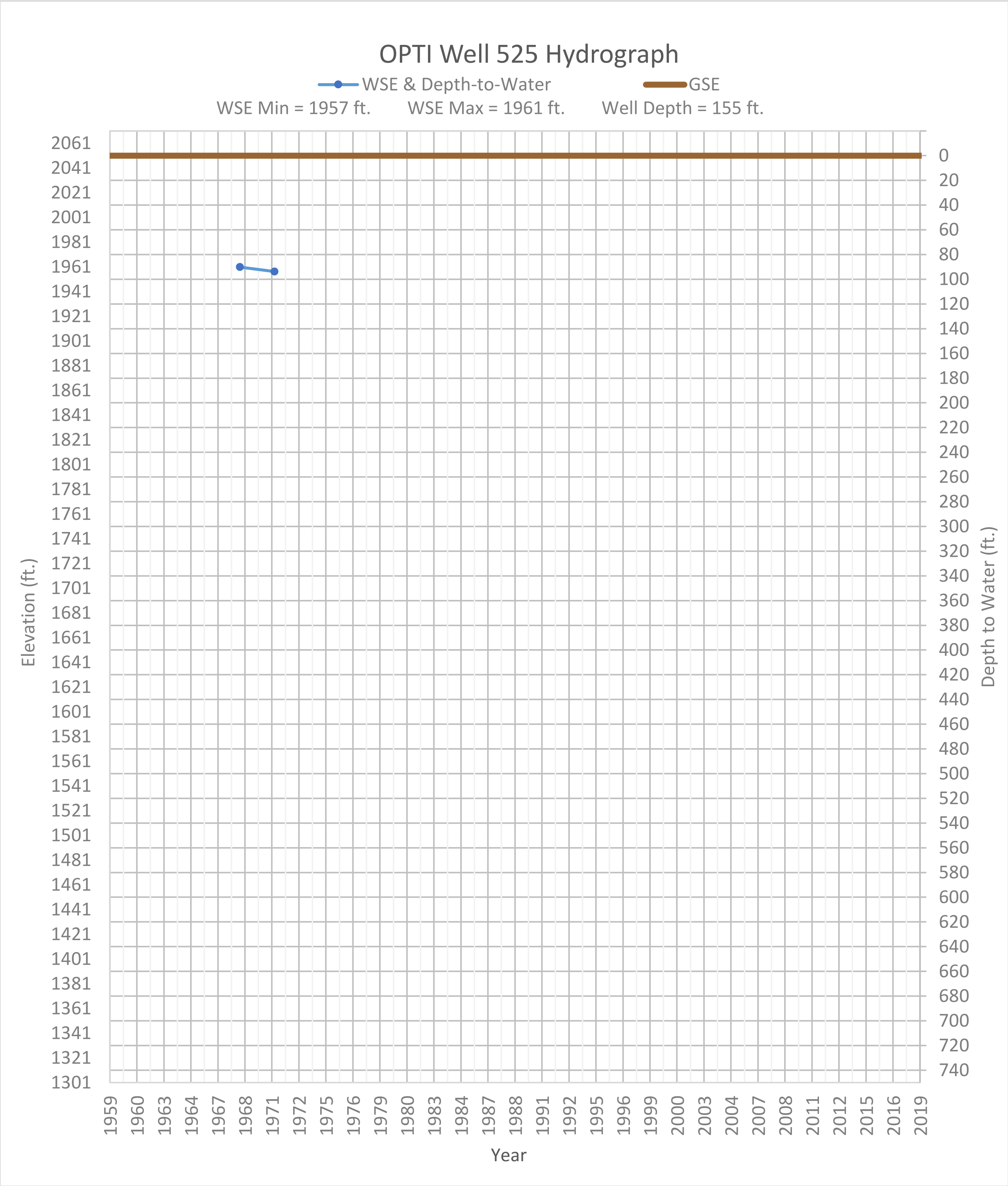

OPTI Well 522 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2001 ft.
WSE Max = 2001 ft.
Well Depth = 648 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 523 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2080 ft.
WSE Max = 2114 ft.
Well Depth = 380 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 524 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2071 ft.
WSE Max = 2095 ft.
Well Depth = 222 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 525 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1957 ft.
WSE Max = 1961 ft.
Well Depth = 155 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2061
2041
2021
2001
1981
1961
1941
1921
1901
1881
1861
1841
1821
1801
1781
1761
1741
1721
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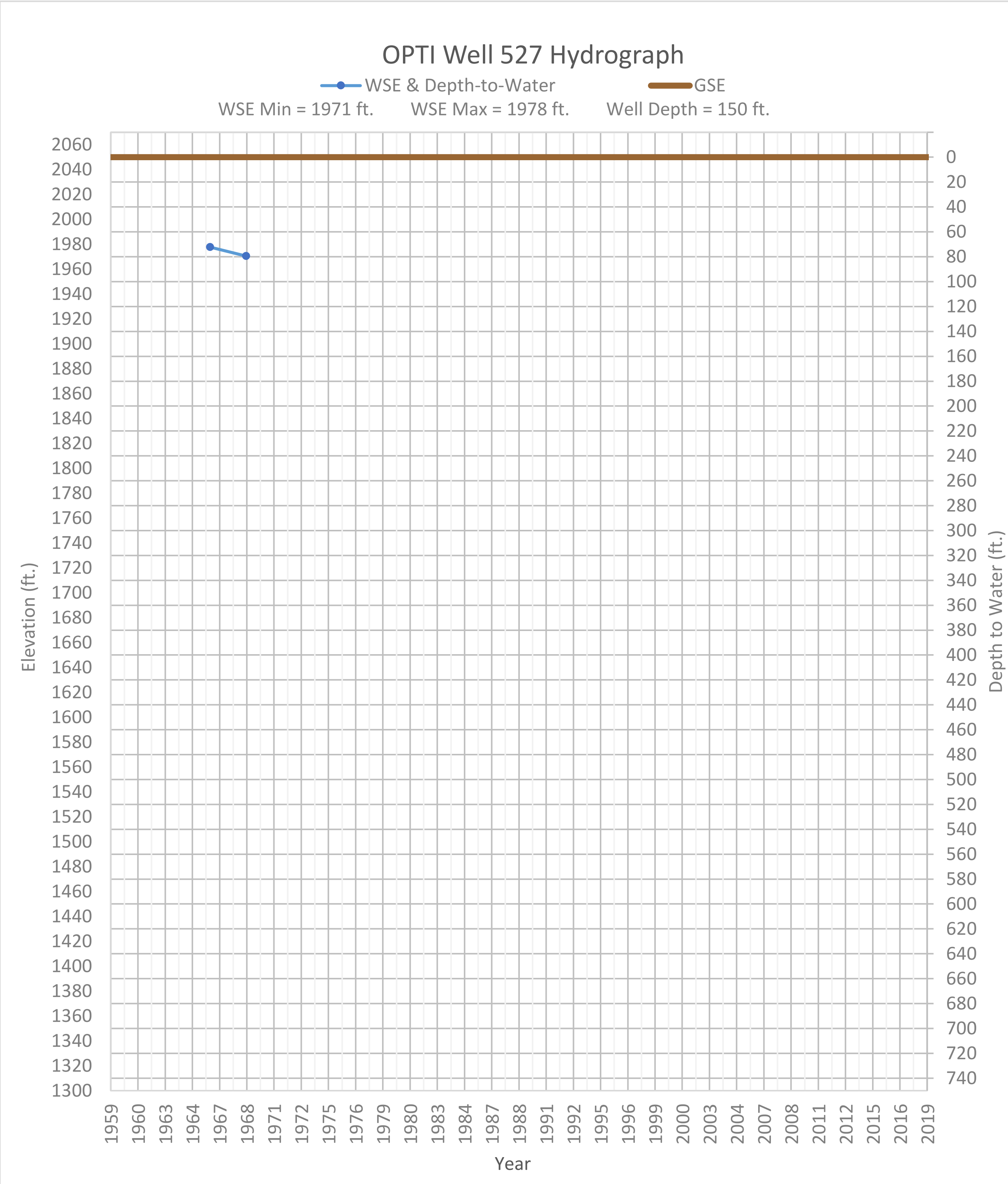
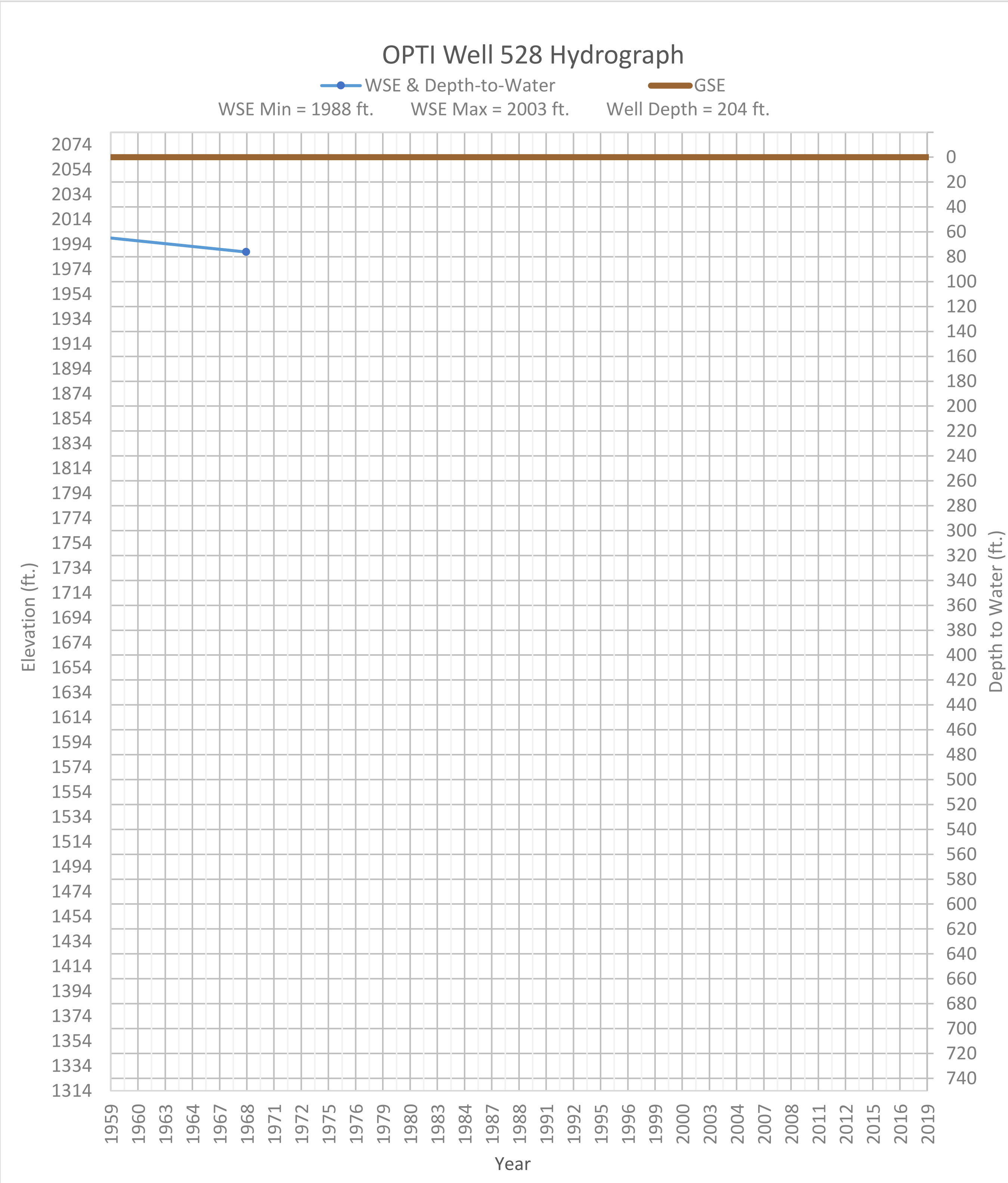
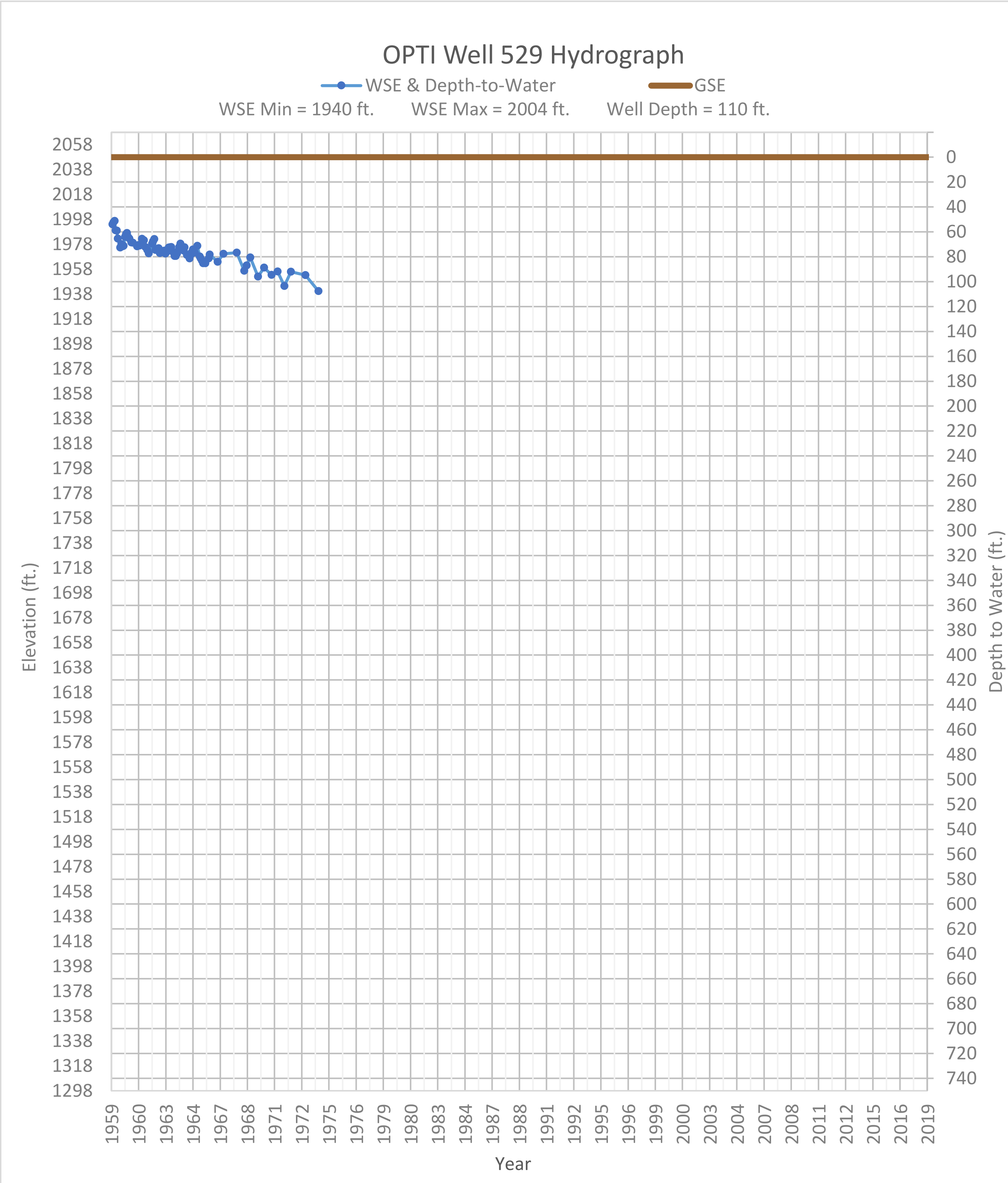
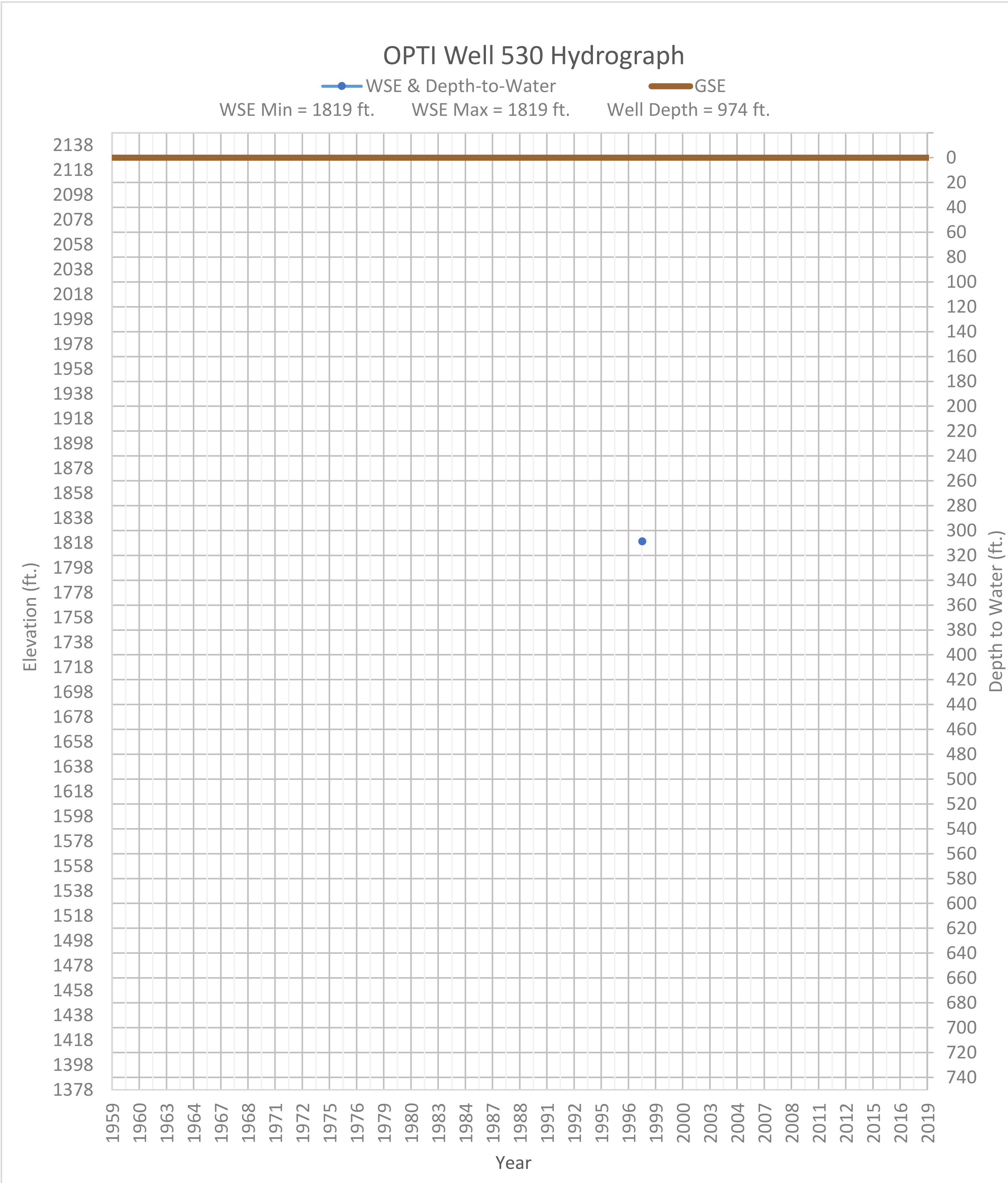


OPTI Well 527 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1971 ft.
WSE Max = 1978 ft.
Well Depth = 150 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

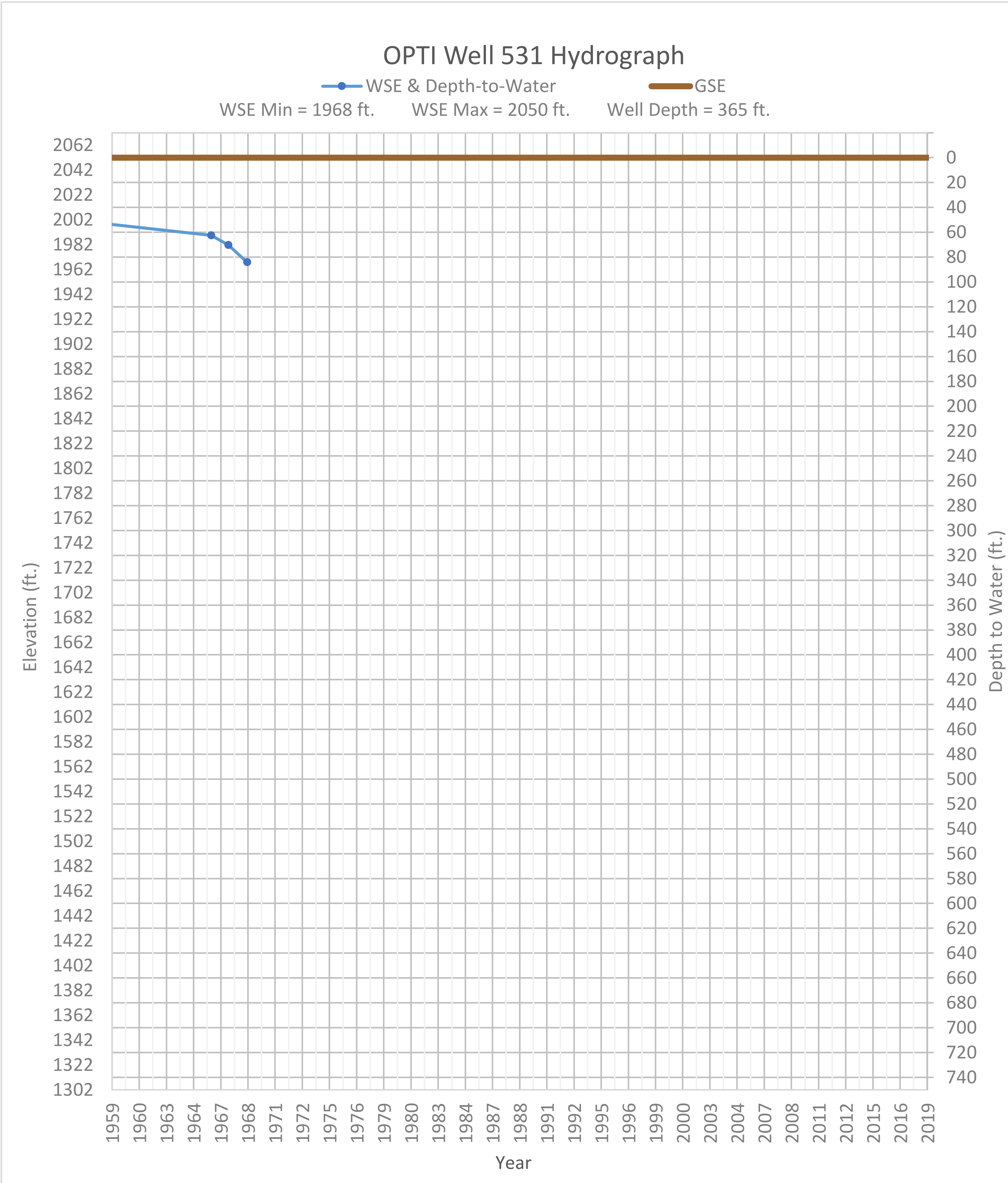


OPTI Well 528 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1988 ft.
WSE Max = 2003 ft.
Well Depth = 204 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

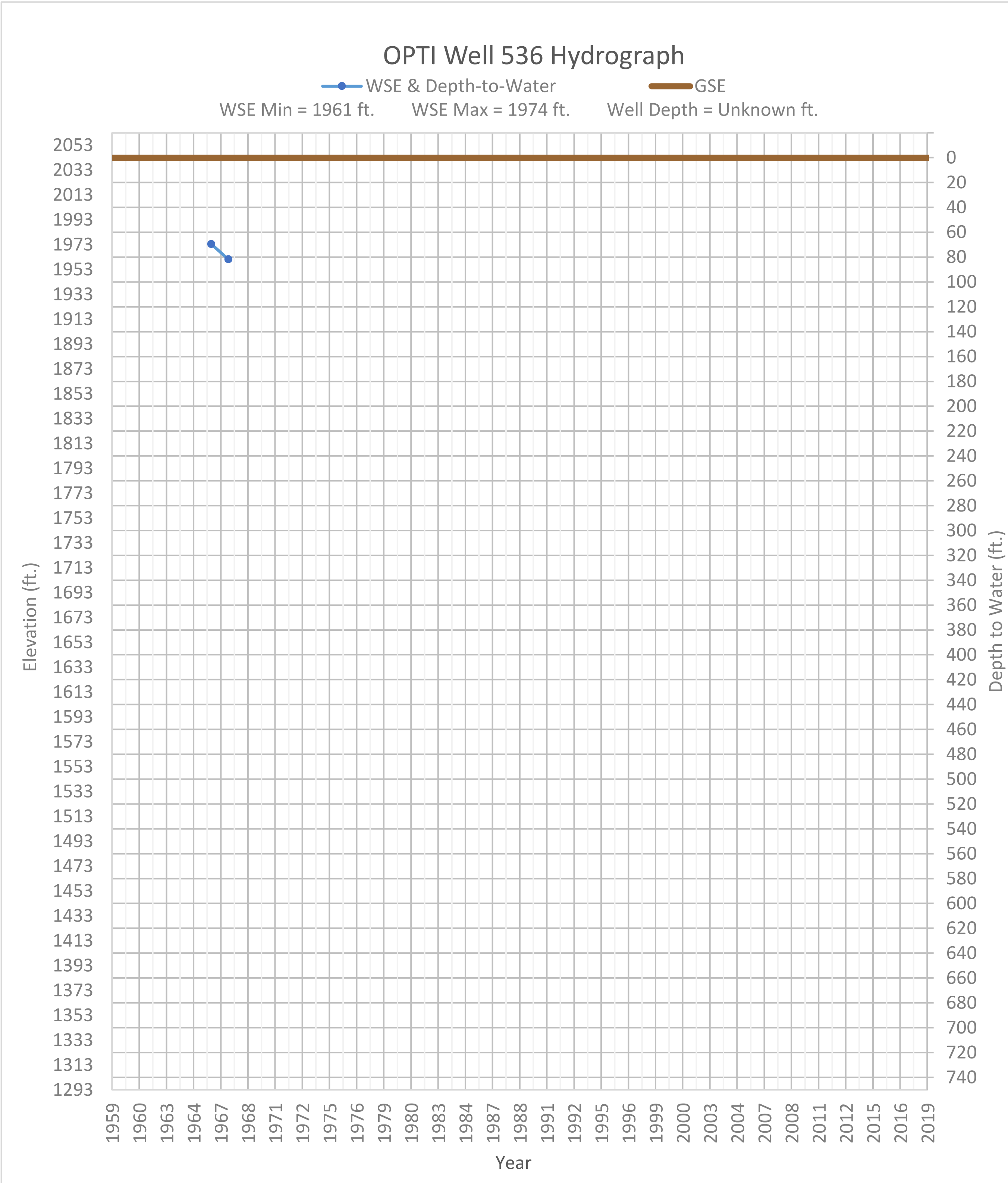

OPTI Well 529 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1940 ft.
WSE Max = 2004 ft.
Well Depth = 110 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



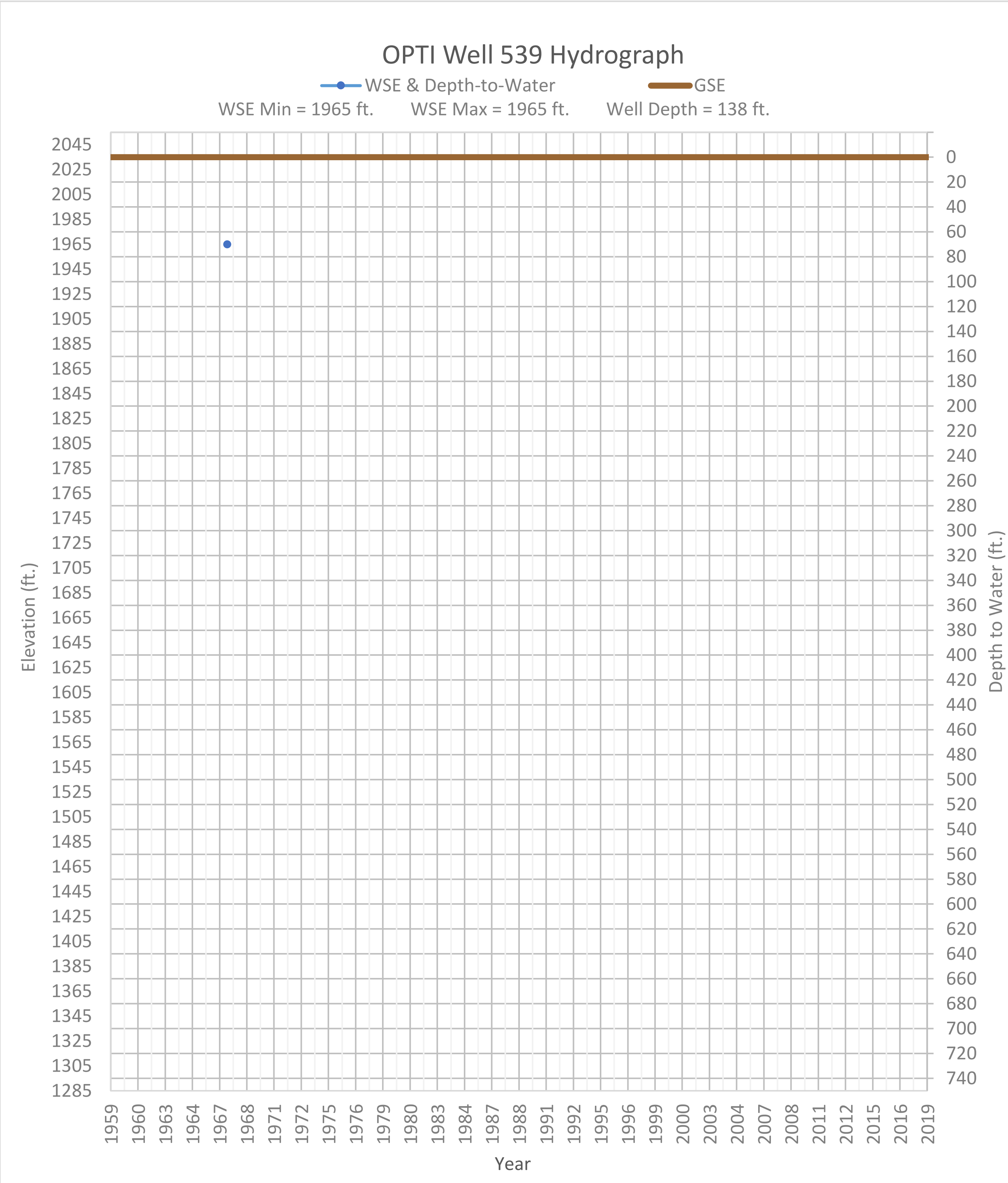
OPTI Well 530 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1819 ft.
WSE Max = 1819 ft.
Well Depth = 974 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

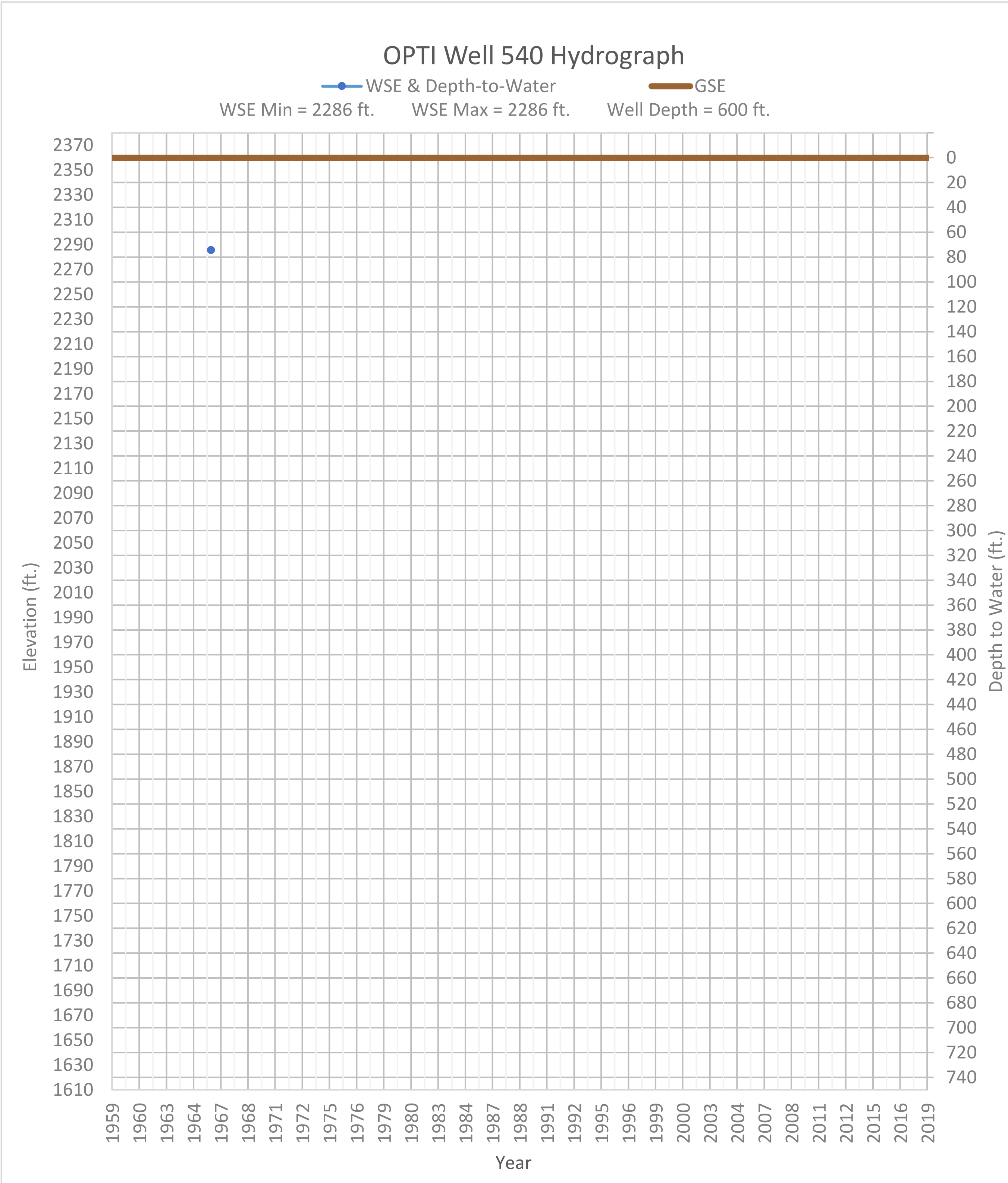


OPTI Well 531 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1968 ft.
WSE Max = 2050 ft.
Well Depth = 365 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 536 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1961 ft.
WSE Max = 1974 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 539 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1965 ft.
WSE Max = 1965 ft.
Well Depth = 138 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 540 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2286 ft.
WSE Max = 2286 ft.
Well Depth = 600 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2370
2350
2330
2310
2290
2270
2250
2230
2210
2190
2170
2150
2130
2110
2090
2070
2050
2030
2010
1990
1970
1950
1930
1910
1890
1870
1850
1830
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1690
1670
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1610
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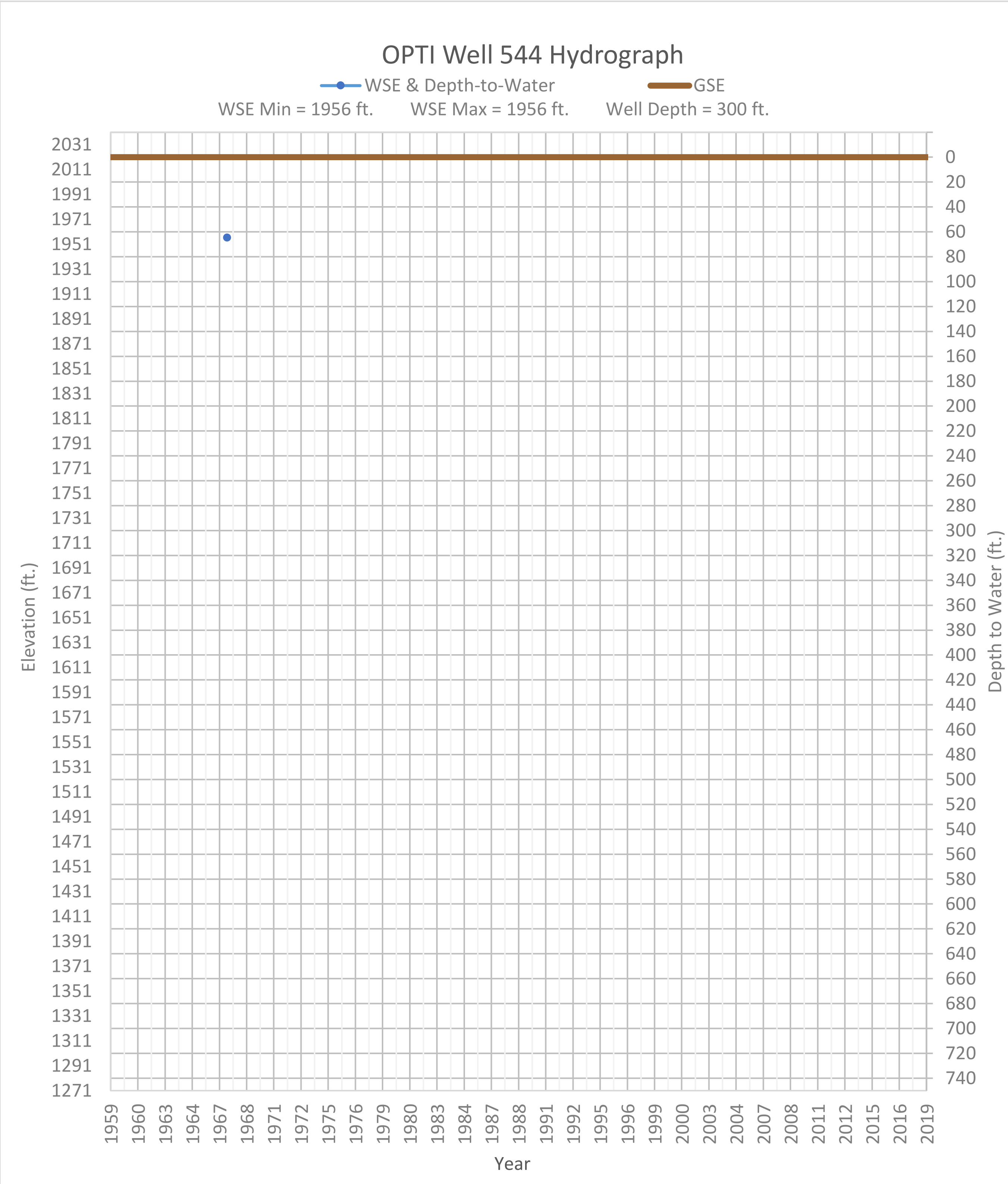
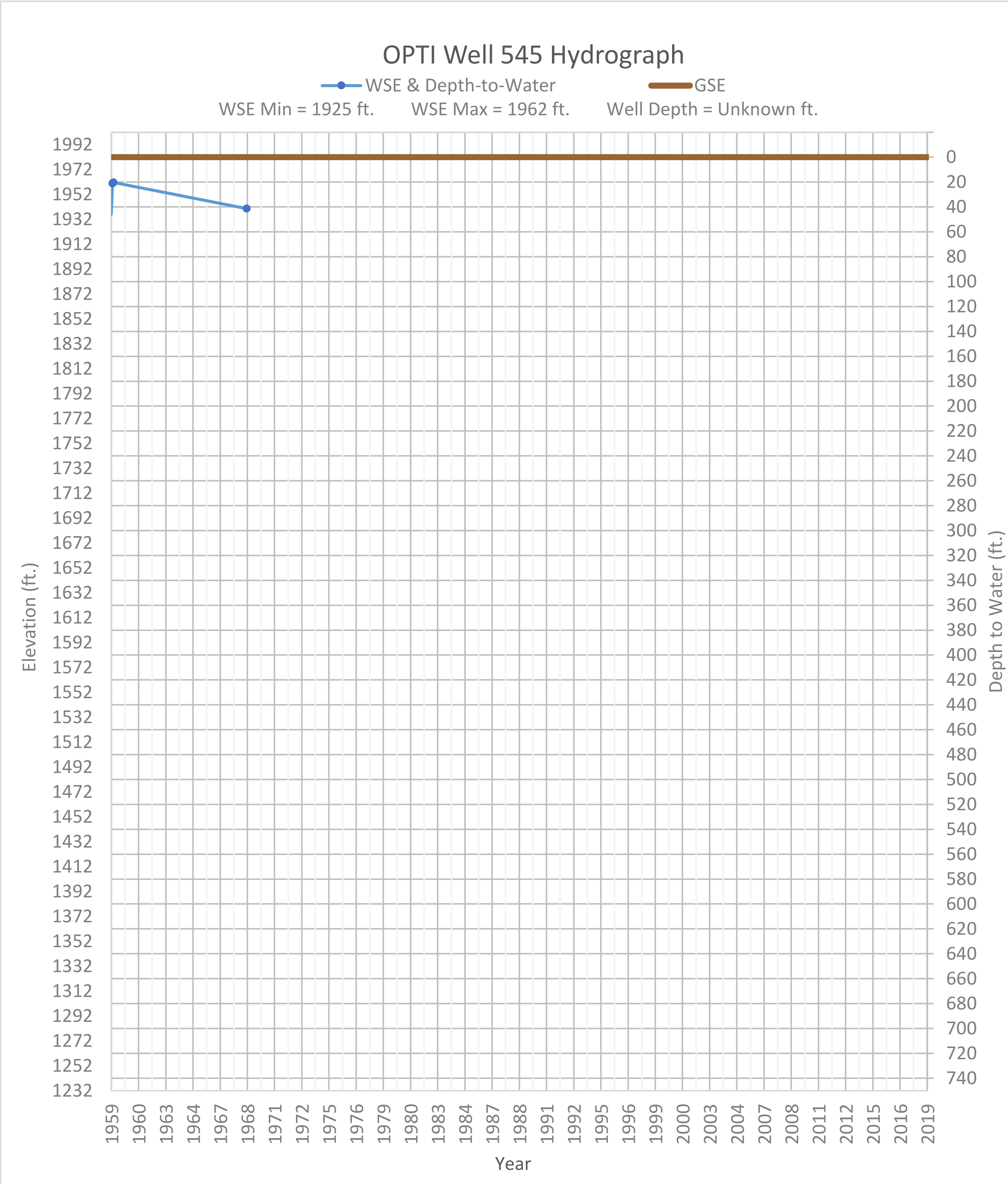


OPTI Well 544 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1956 ft.
WSE Max = 1956 ft.
Well Depth = 300 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 545 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1925 ft.
WSE Max = 1962 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1992
1972
1952
1932
1912
1892
1872
1852
1832
1812
1792
1772
1752
1732
1712
1692
1672
1652
1632
1612
1592
1572
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1532
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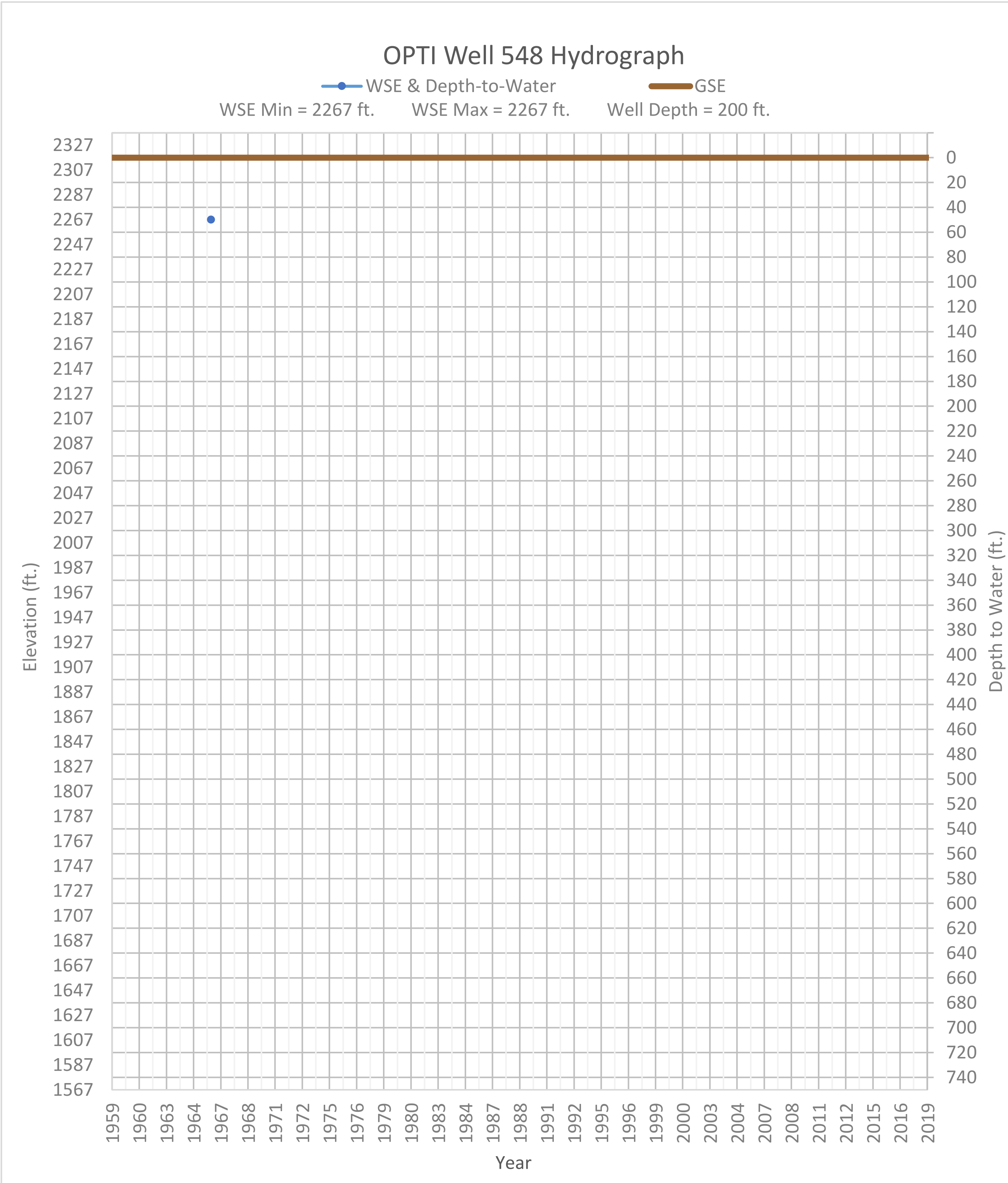
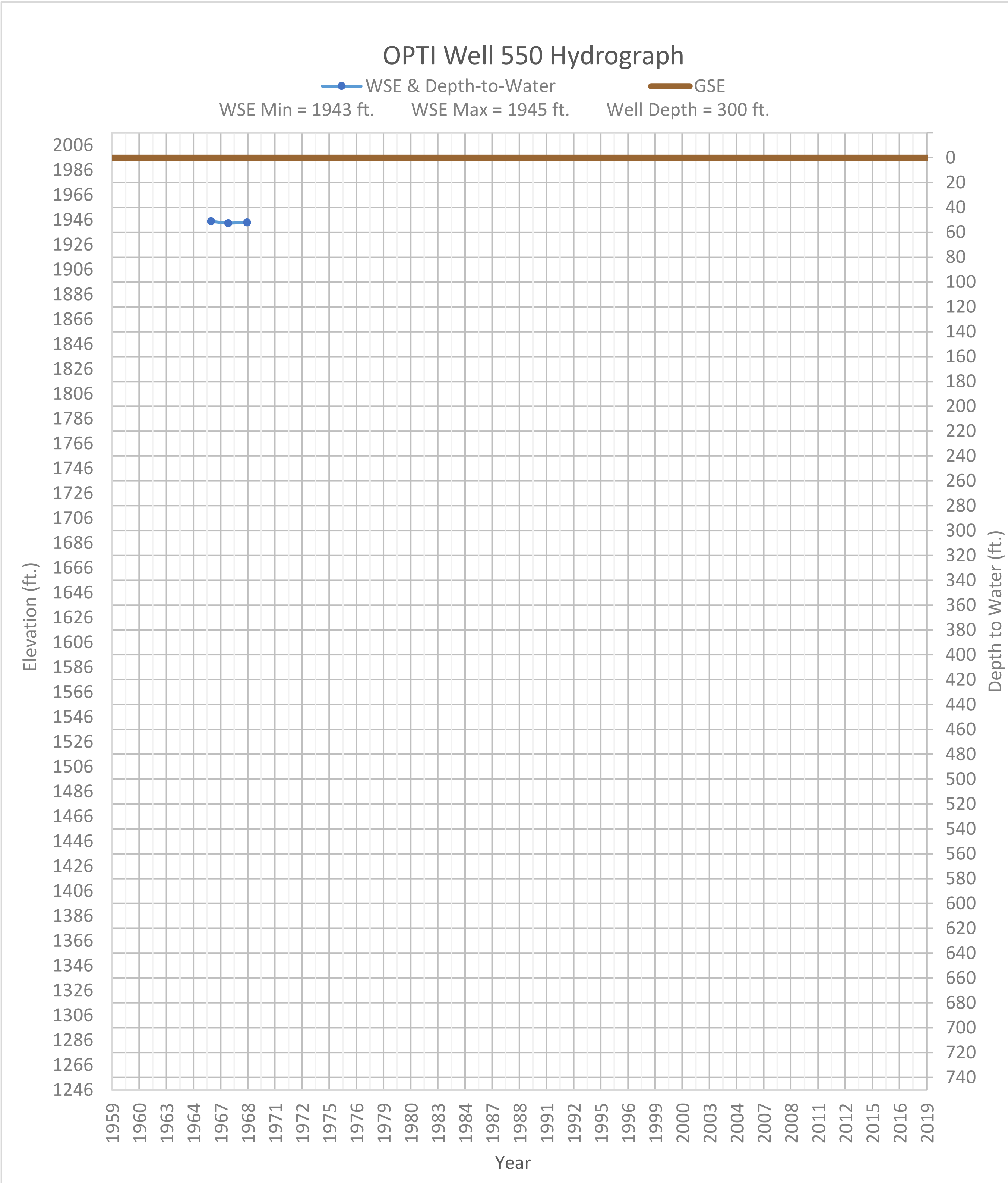
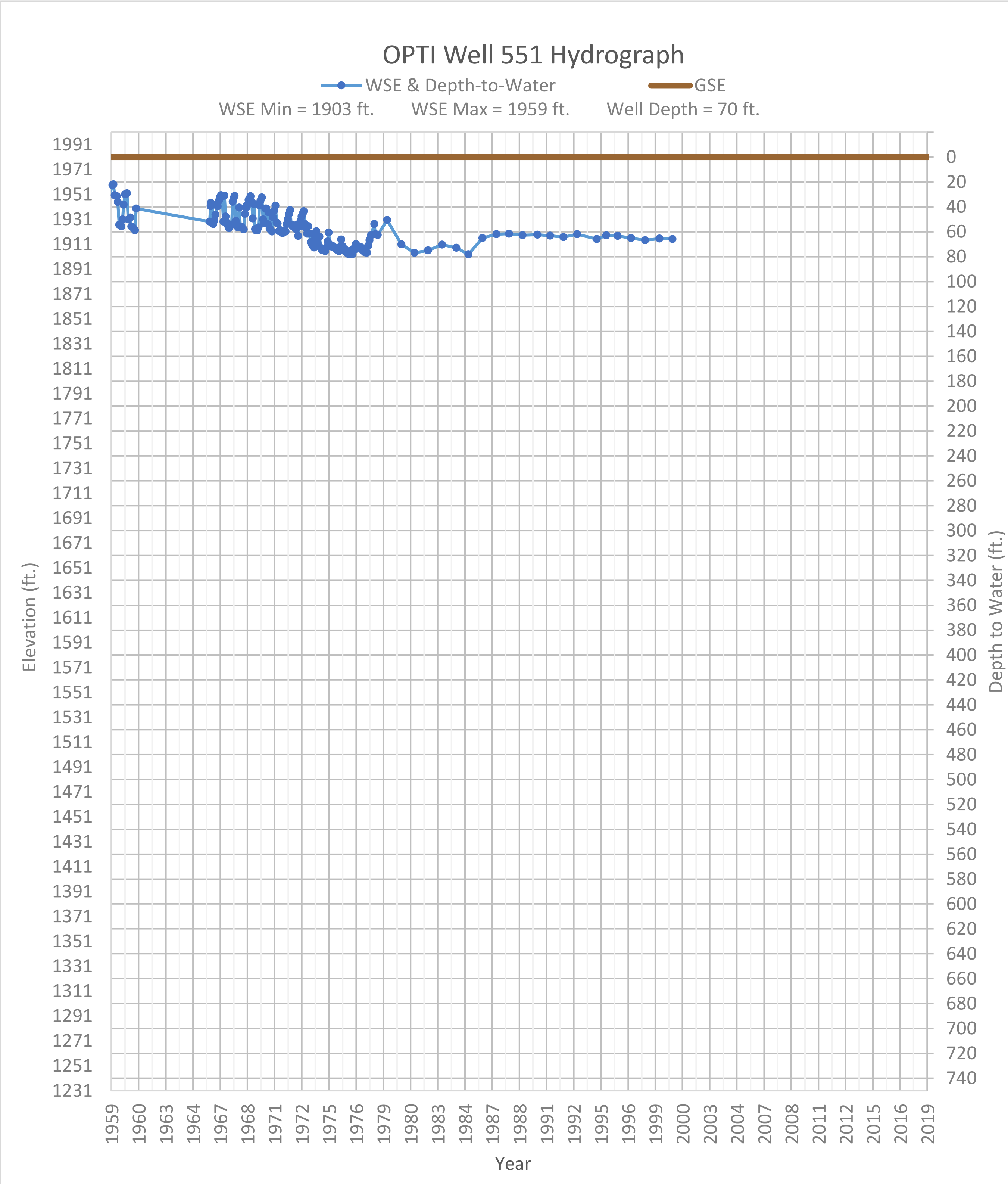
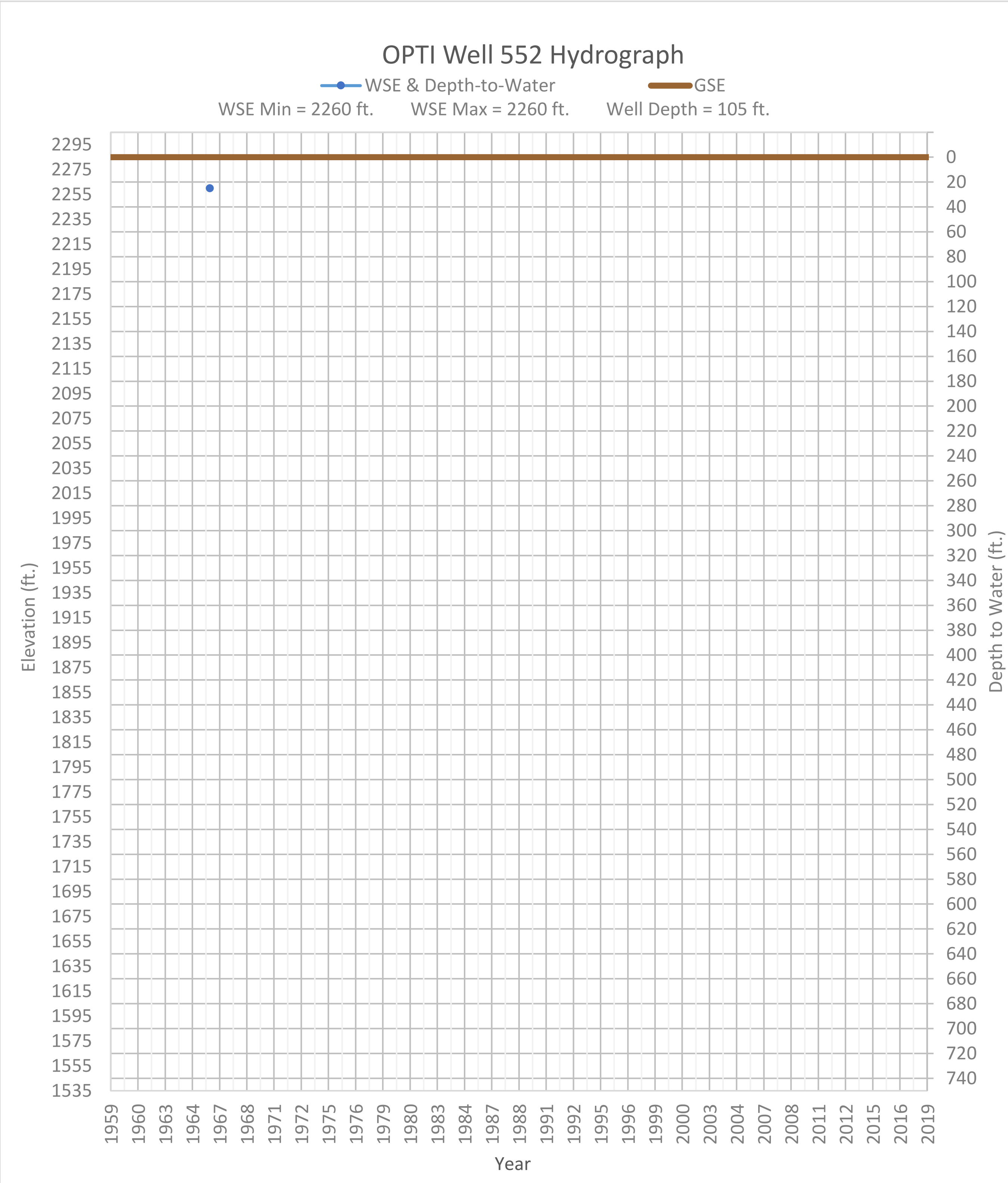


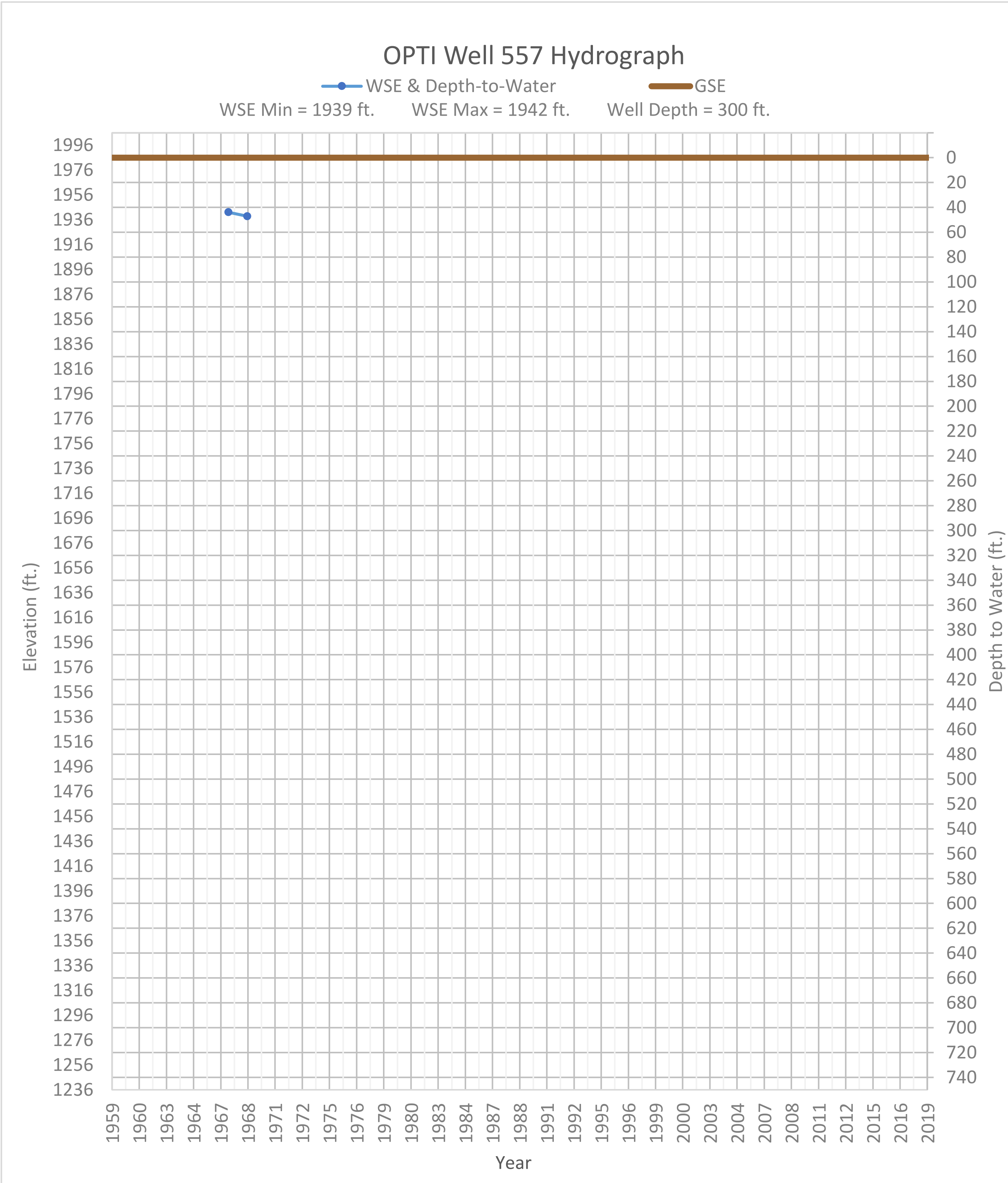
OPTI Well 548 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2267 ft.
WSE Max = 2267 ft.
Well Depth = 200 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 550 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1943 ft.
WSE Max = 1945 ft.
Well Depth = 300 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

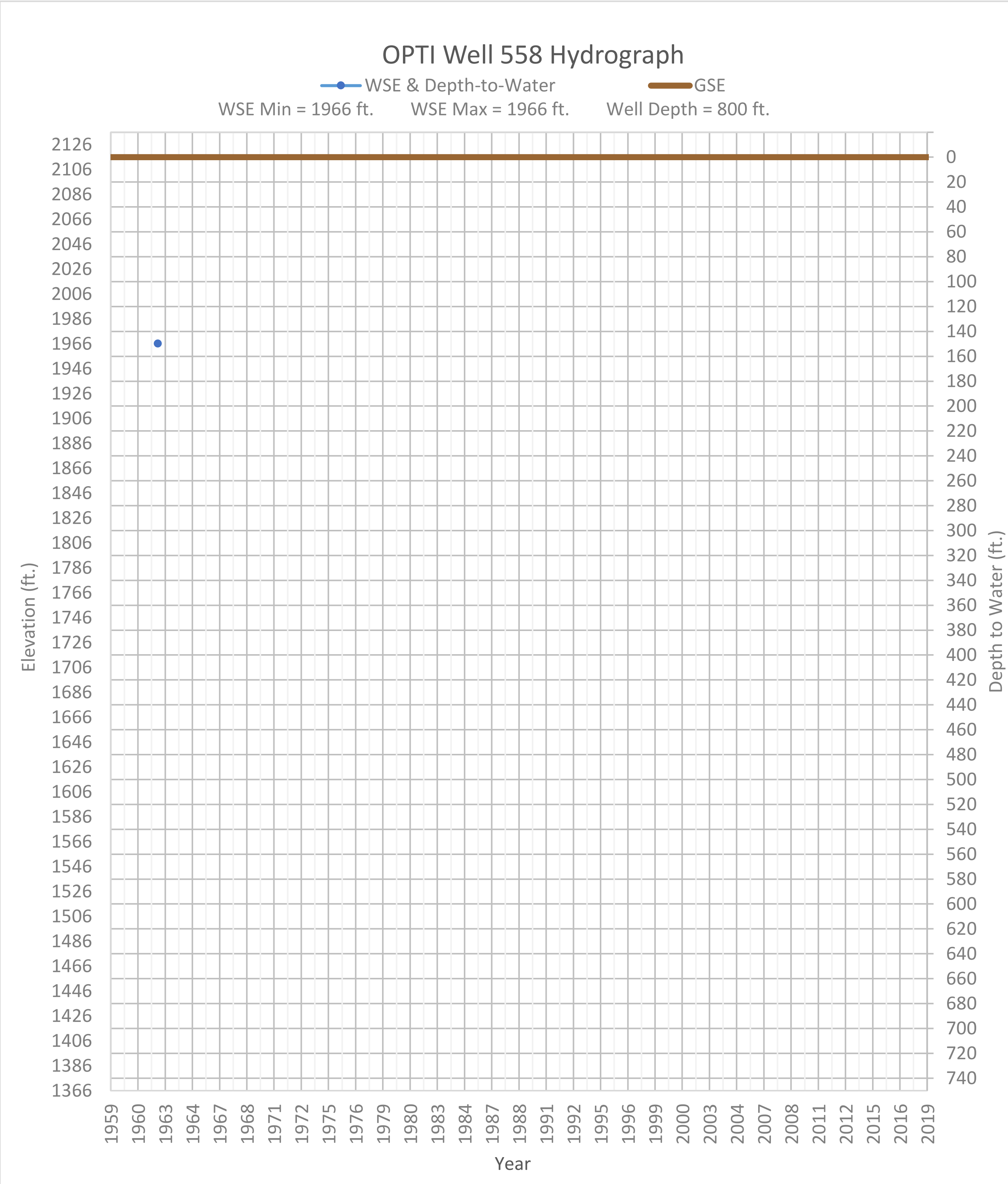

OPTI Well 551 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1903 ft.
WSE Max = 1959 ft.
Well Depth = 70 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 552 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2260 ft.
WSE Max = 2260 ft.
Well Depth = 105 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

OPTI Well 554 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1879 ft.
WSE Max = 1947 ft.
Well Depth = 378 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 557 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1939 ft.
WSE Max = 1942 ft.
Well Depth = 300 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 558 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1966 ft.
WSE Max = 1966 ft.
Well Depth = 800 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2126
2106
2086
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
1786
1766
1746
1726
1706
1686
1666
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1446
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1406
1386
1366
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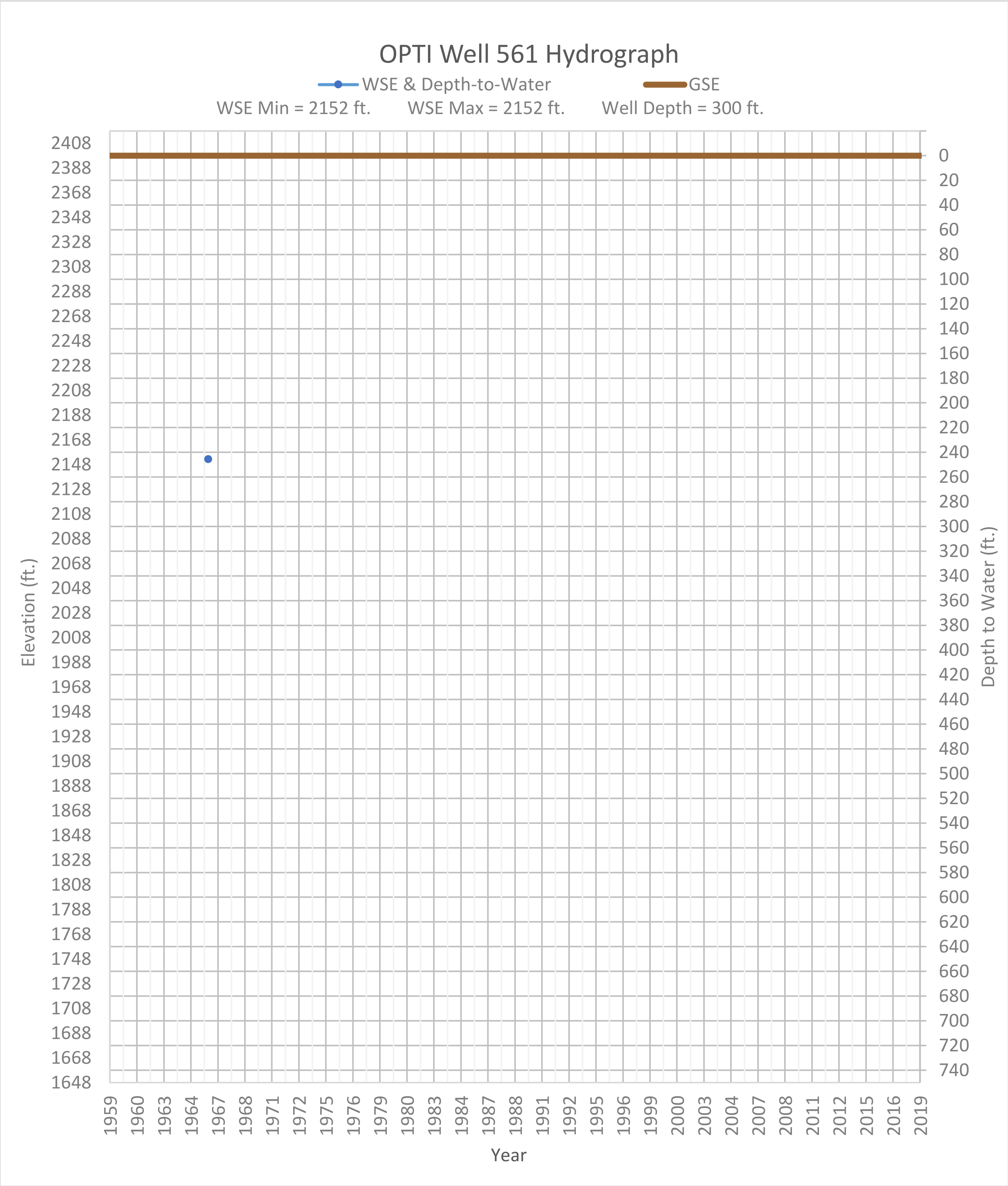
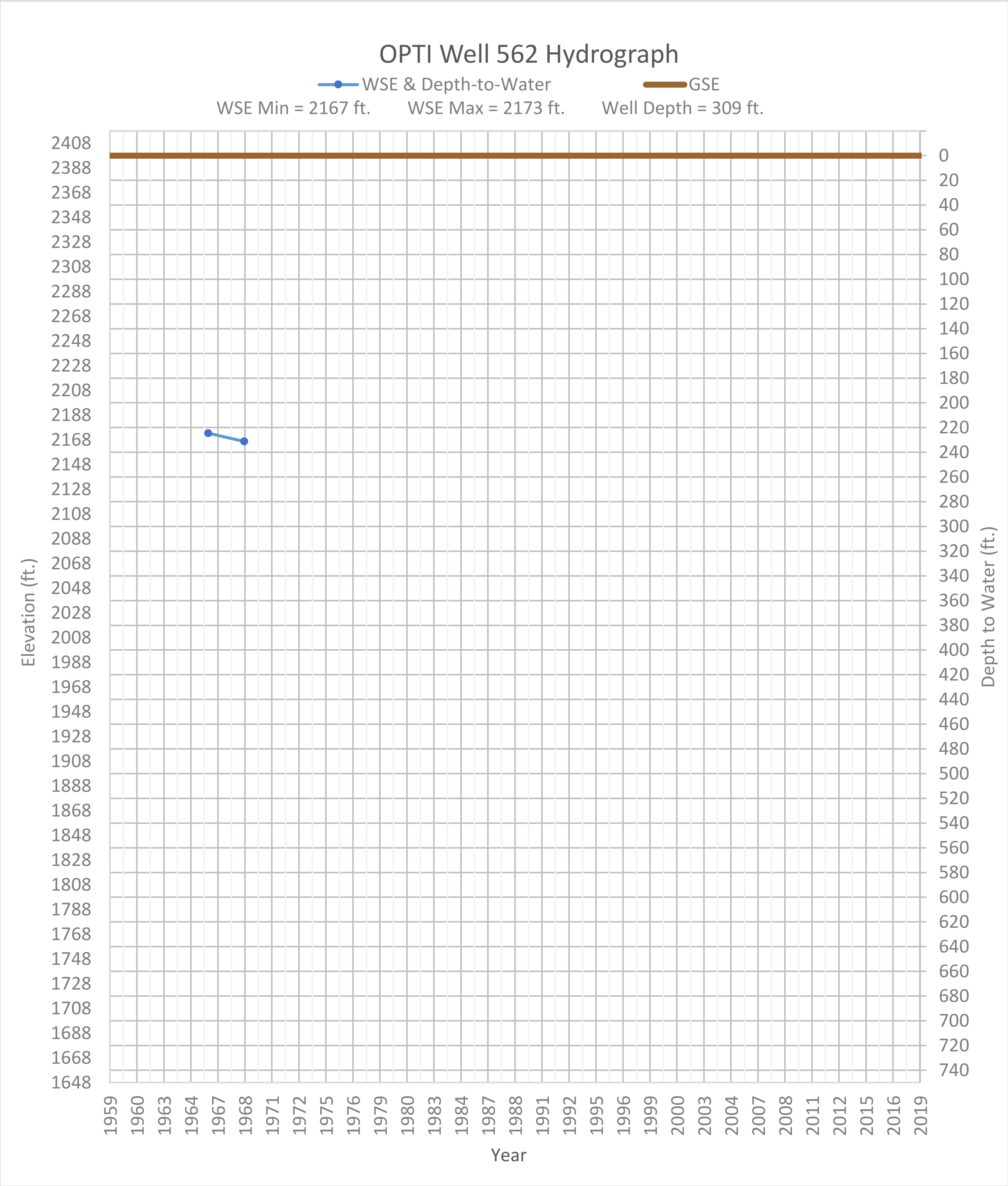
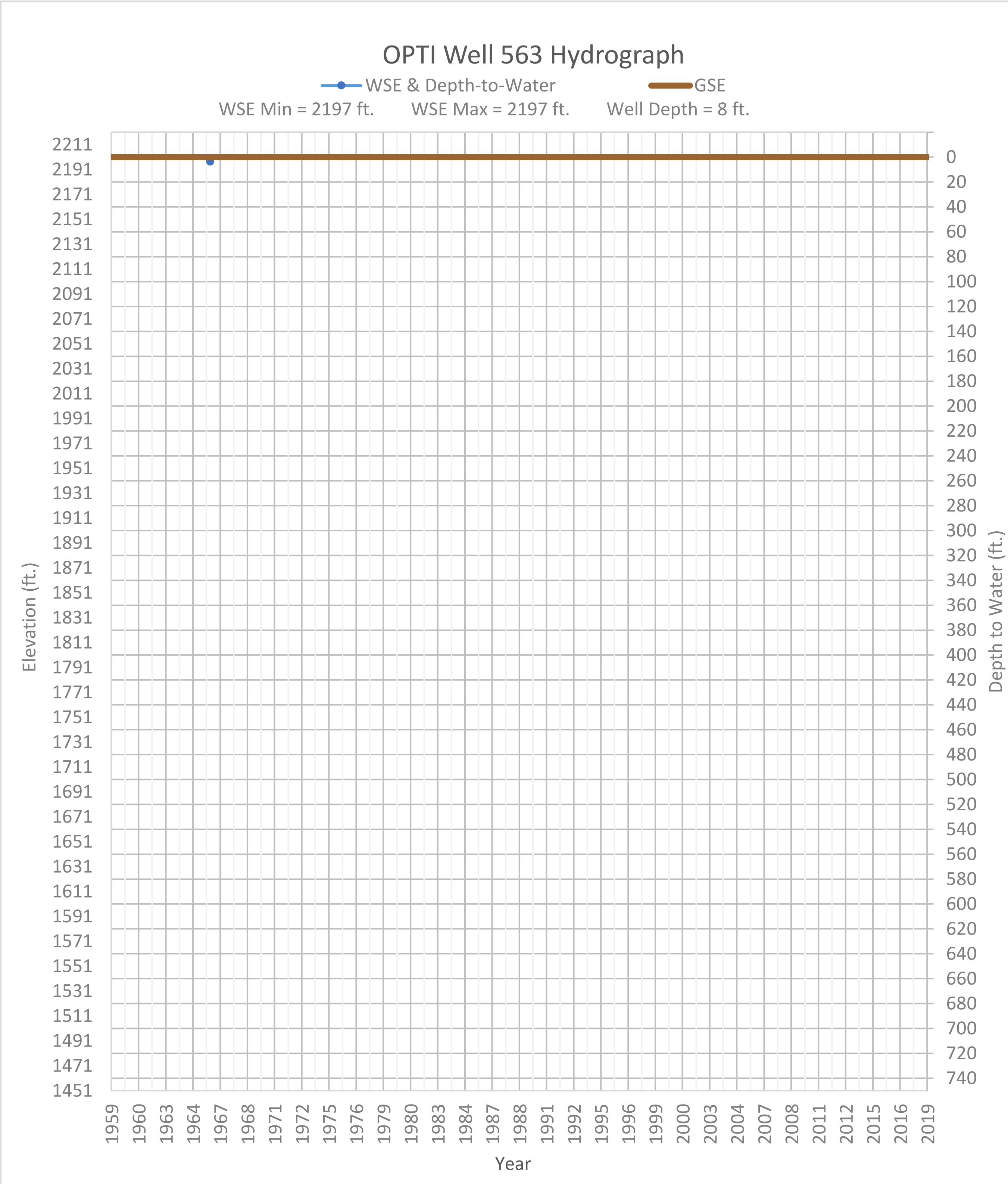


OPTI Well 561 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2152 ft.
WSE Max = 2152 ft.
Well Depth = 300 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 562 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2167 ft.
WSE Max = 2173 ft.
Well Depth = 309 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 563 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2197 ft.
WSE Max = 2197 ft.
Well Depth = 8 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2211
2191
2171
2151
2131
2111
2091
2071
2051
2031
2011
1991
1971
1951
1931
1911
1891
1871
1851
1831
1811
1791
1771
1751
1731
1711
1691
1671
1651
1631
1611
1591
1571
1551
1531
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1491
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1451
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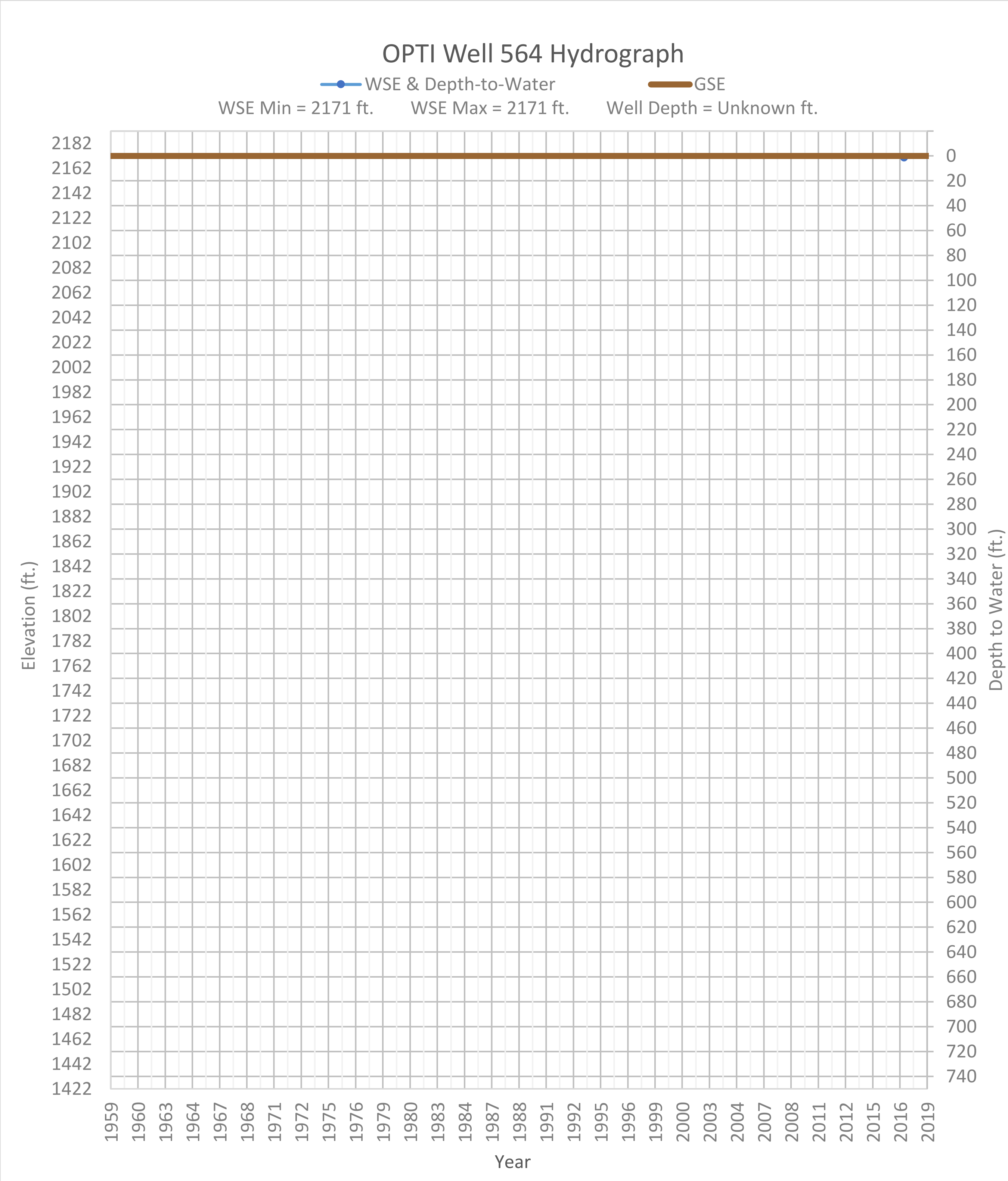
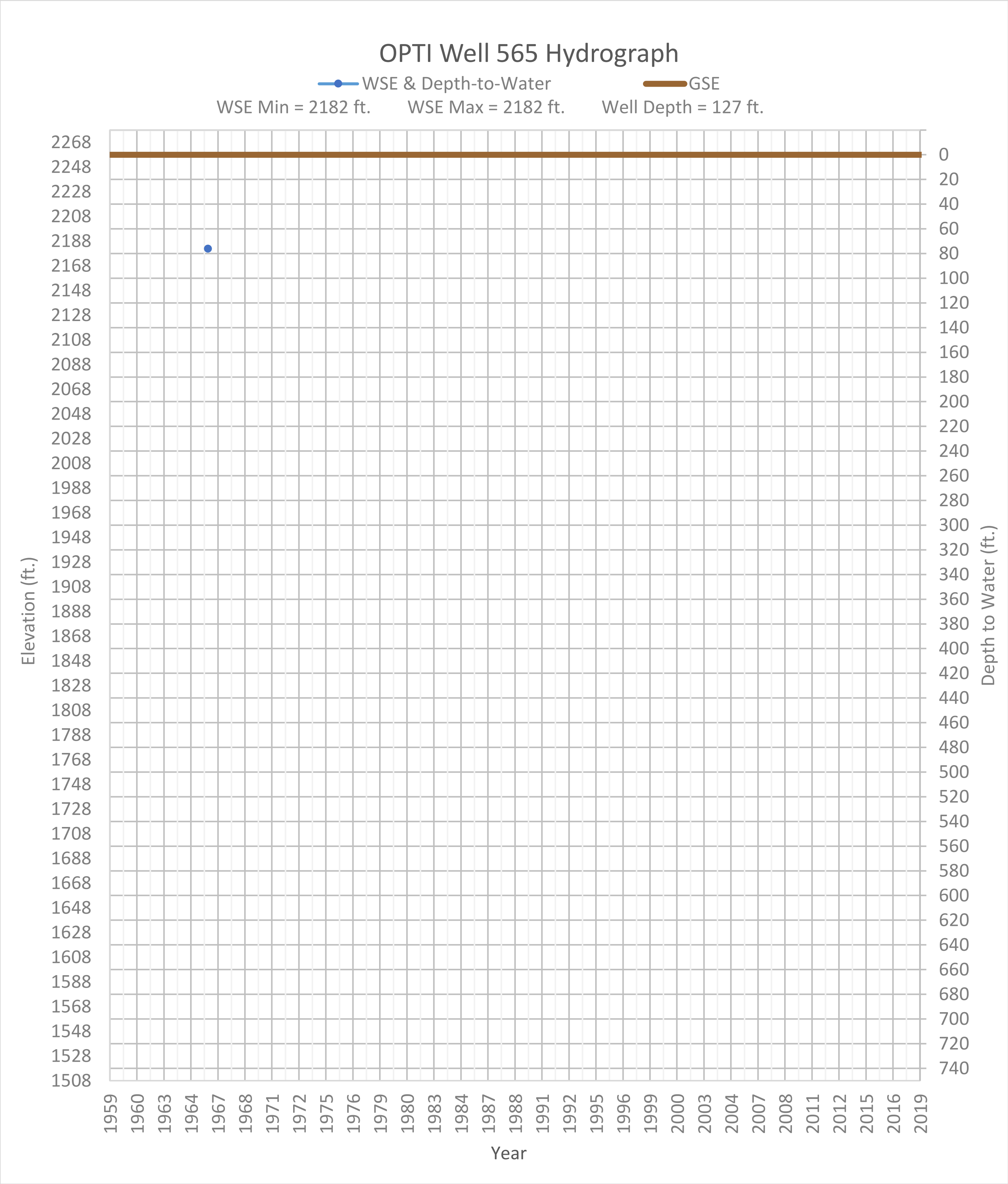

OPTI Well 564 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2171 ft.
WSE Max = 2171 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 565 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2182 ft.
WSE Max = 2182 ft.
Well Depth = 127 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2268
2248
2228
2208
2188
2168
2148
2128
2108
2088
2068
2048
2028
2008
1988
1968
1948
1928
1908
1888
1868
1848
1828
1808
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1768
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1608
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1568
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1508
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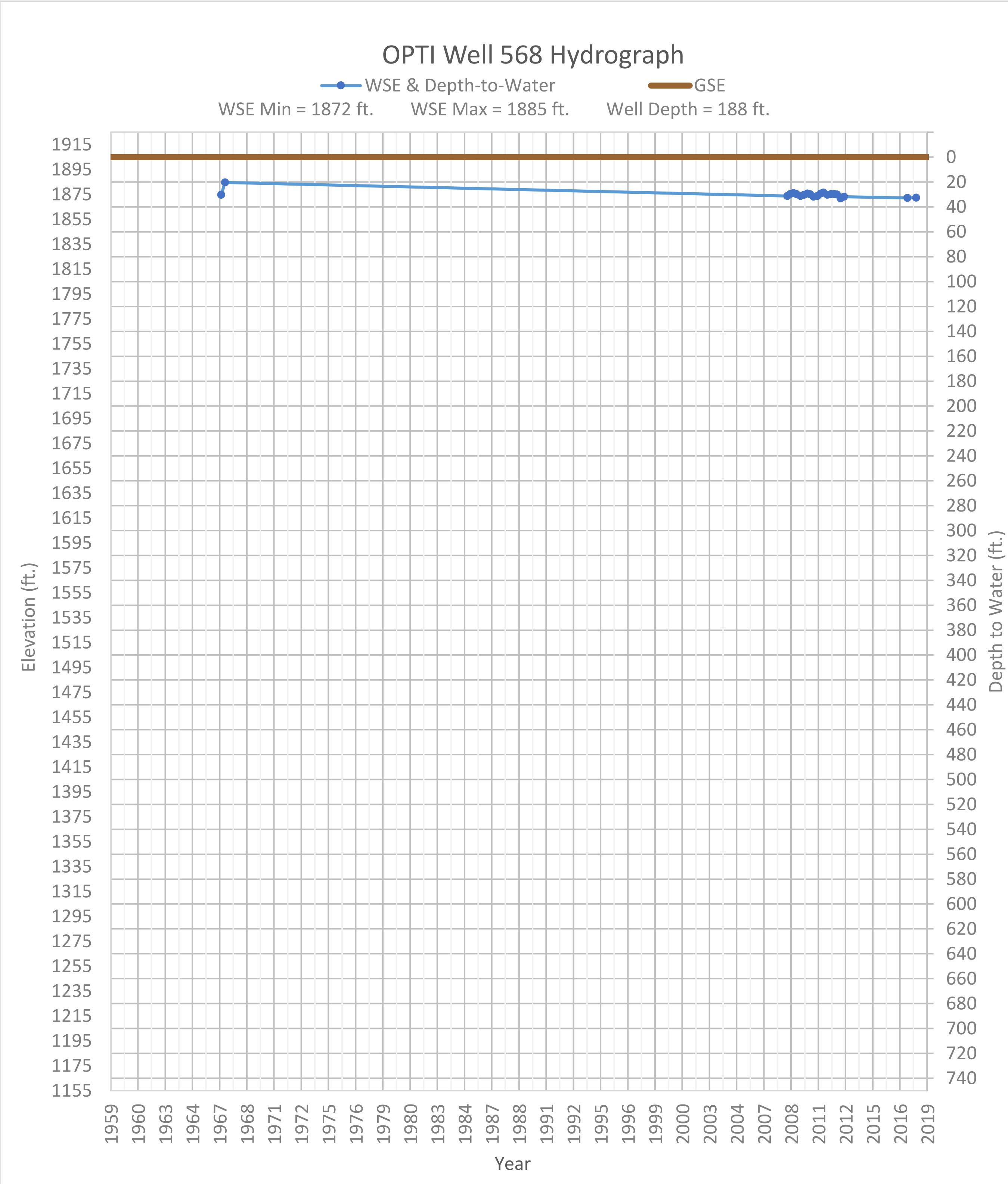
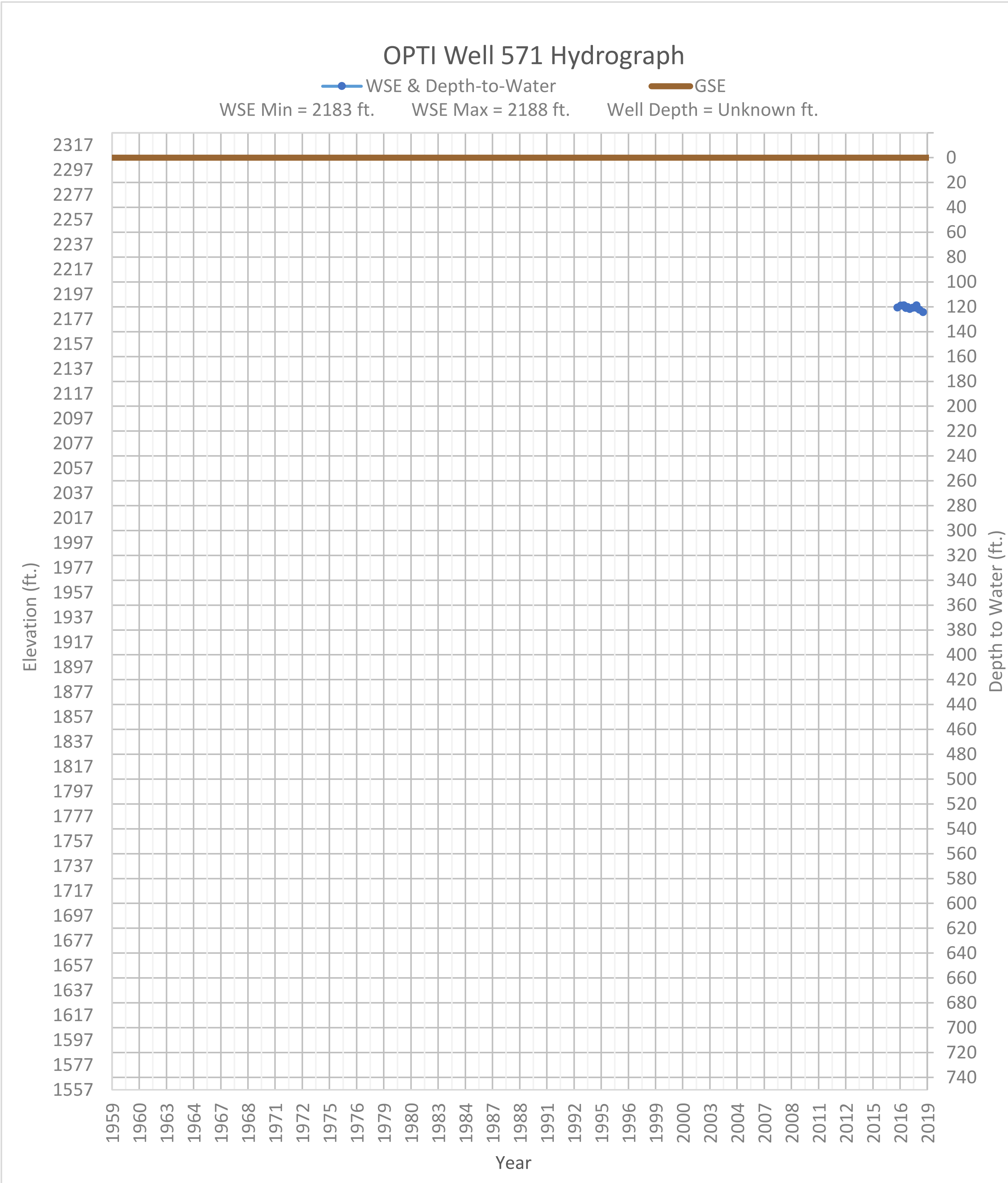

OPTI Well 568 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1872 ft.
WSE Max = 1885 ft.
Well Depth = 188 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 571 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2183 ft.
WSE Max = 2188 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2317
2297
2277
2257
2237
2217
2197
2177
2157
2137
2117
2097
2077
2057
2037
2017
1997
1977
1957
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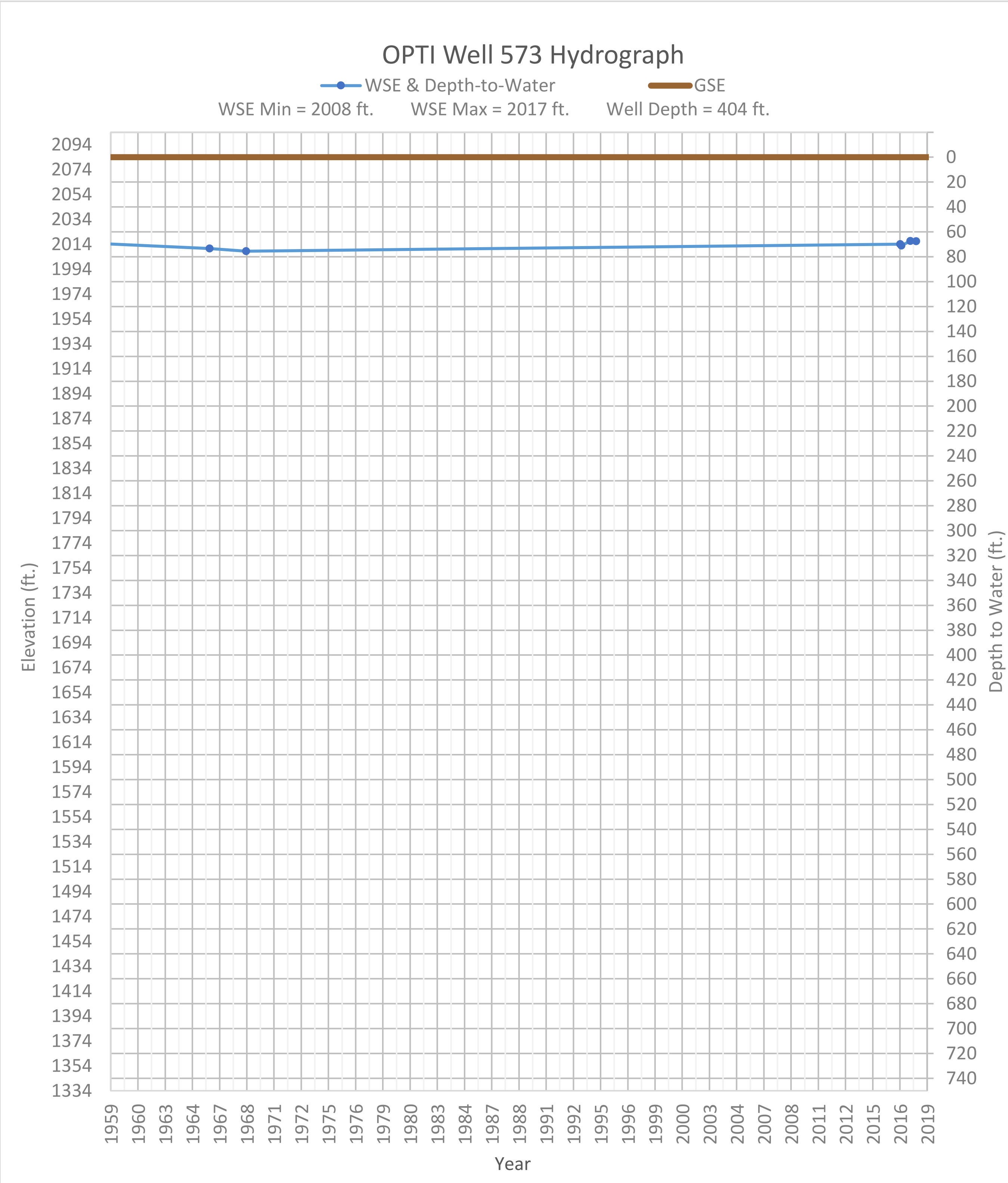
OPTI Well 573 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2008 ft.
WSE Max = 2017 ft.
Well Depth = 404 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2094
2074
2054
2034
2014
1994
1974
1954
1934
1914
1894
1874
1854
1834
1814
1794
1774
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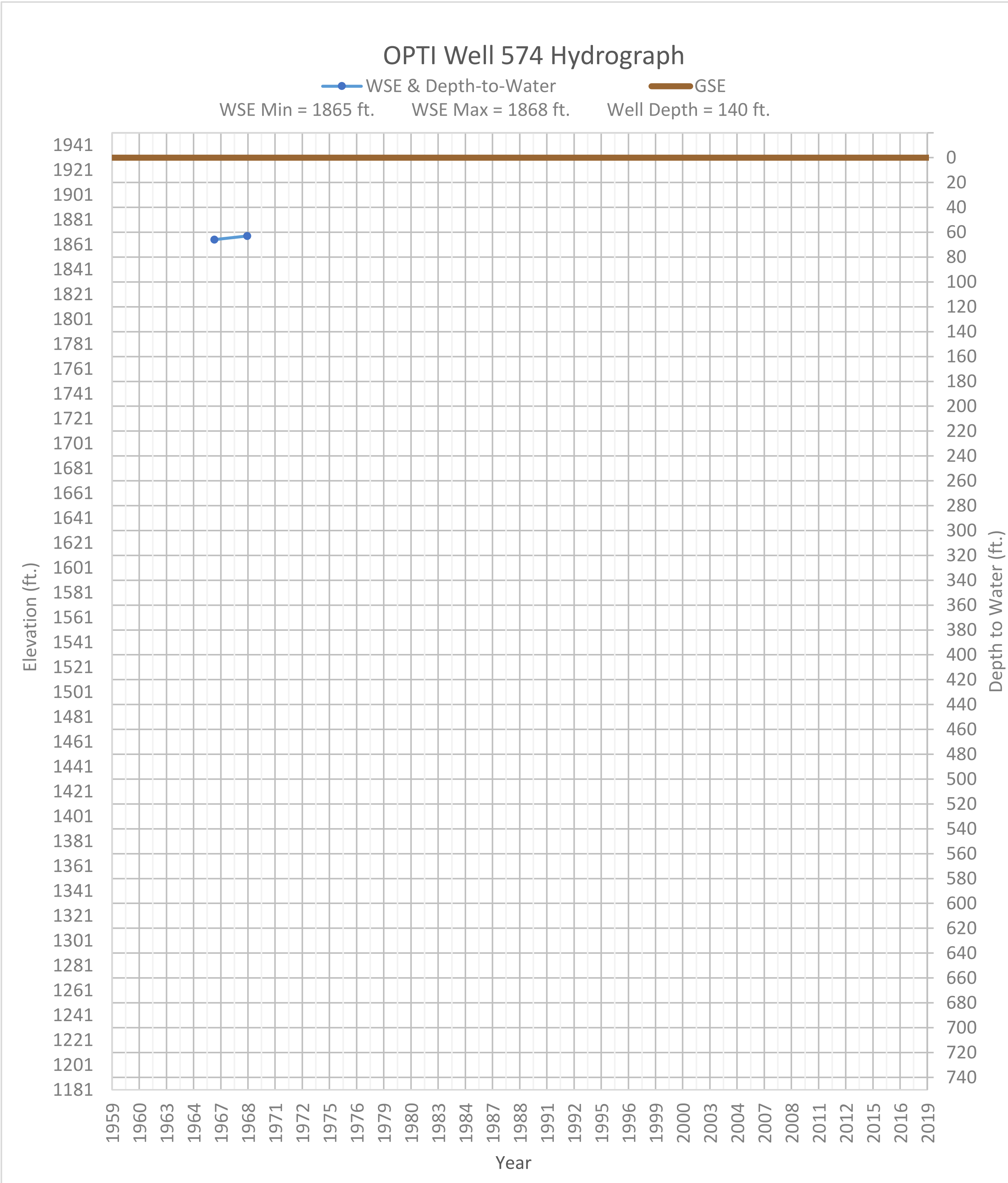

OPTI Well 574 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1865 ft.
WSE Max = 1868 ft.
Well Depth = 140 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1941
1921
1901
1881
1861
1841
1821
1801
1781
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1701
1681
1661
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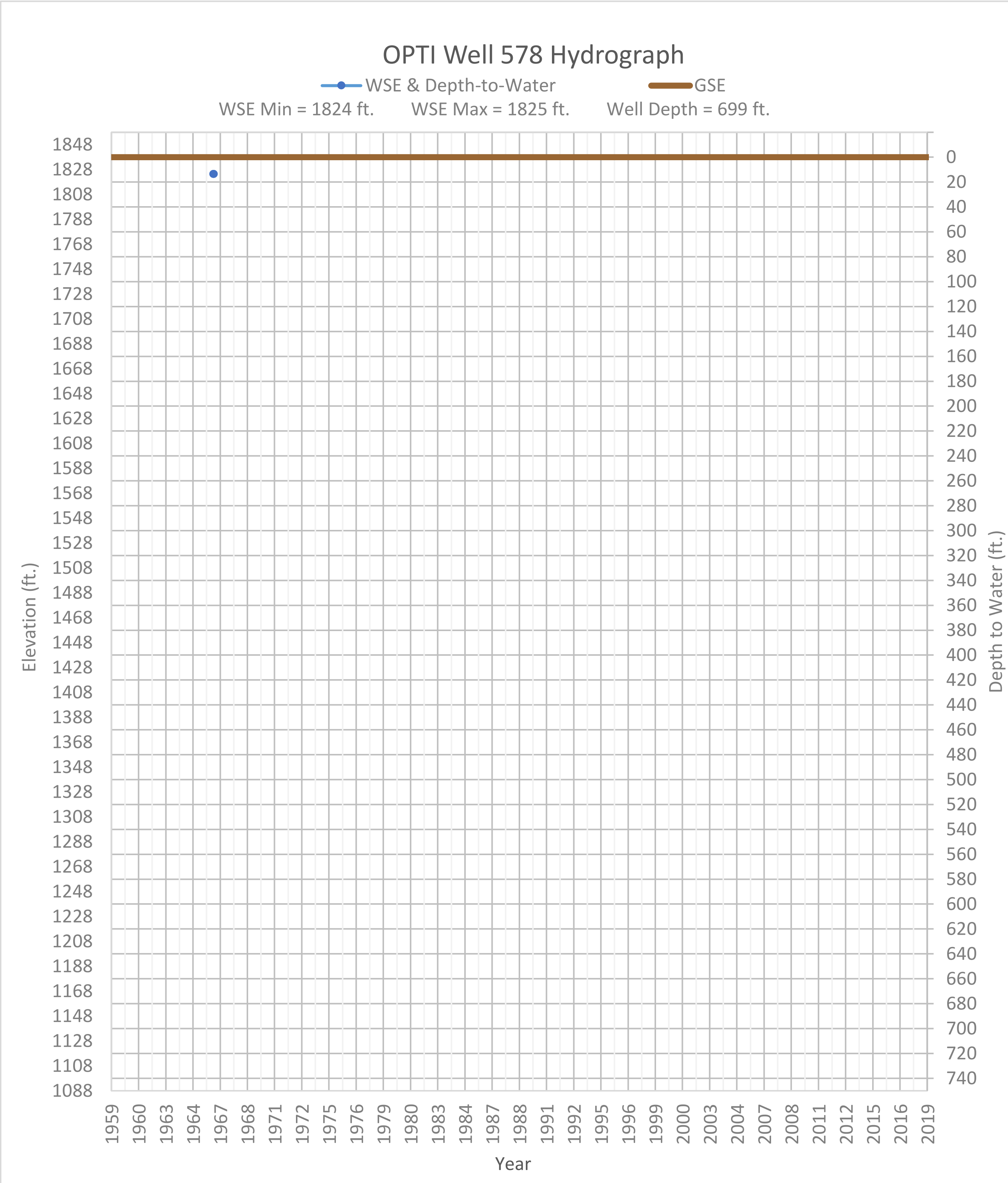
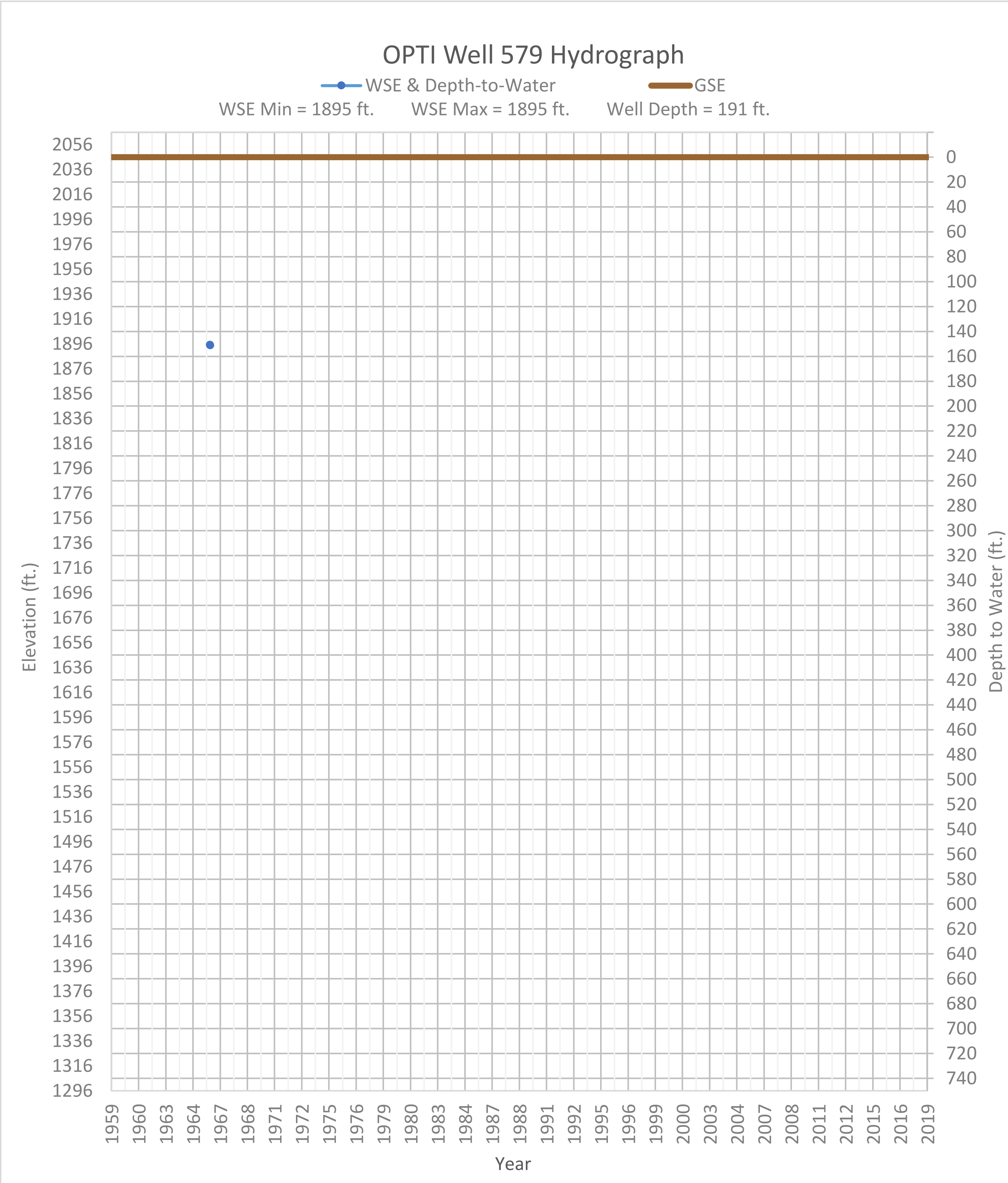
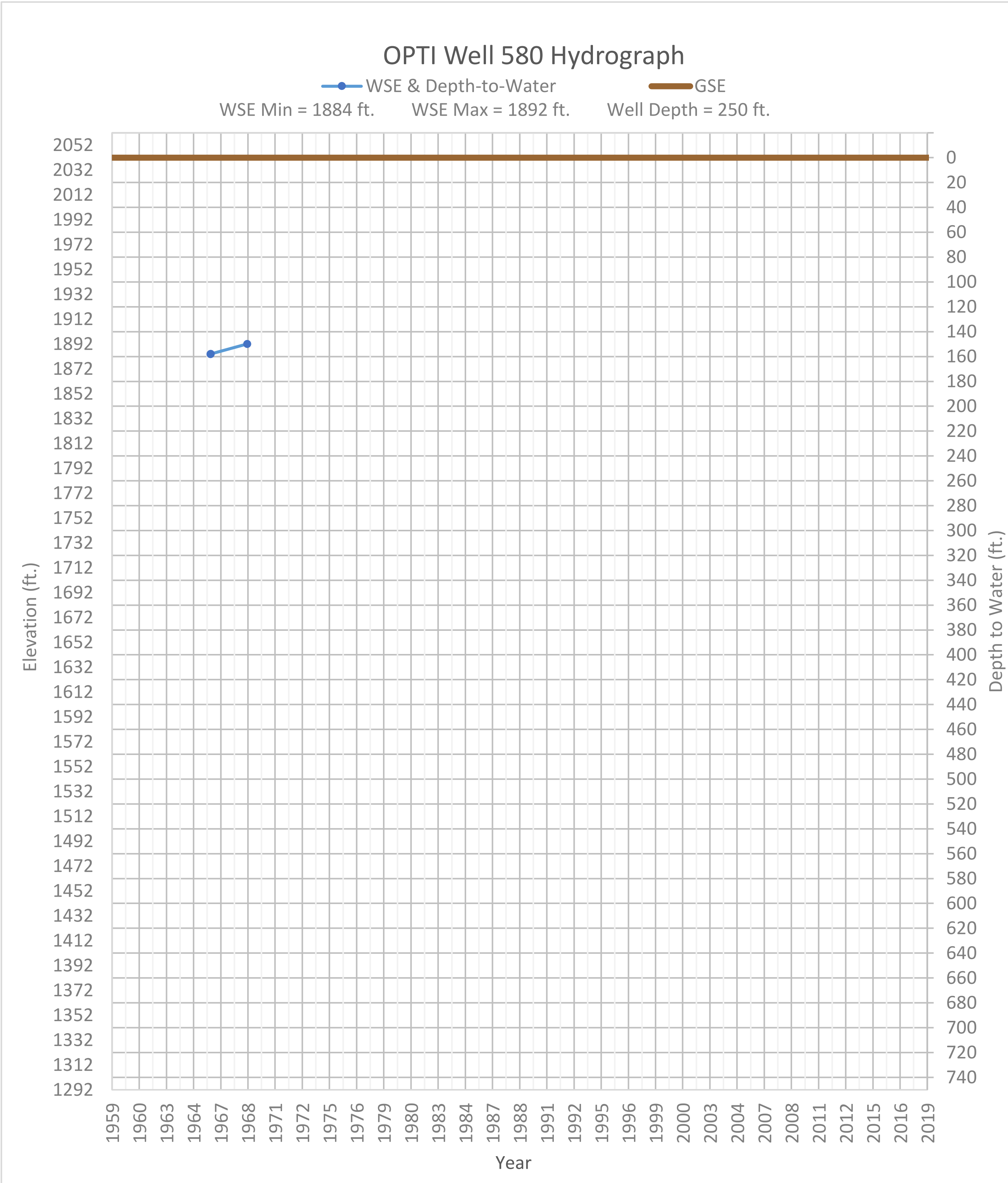
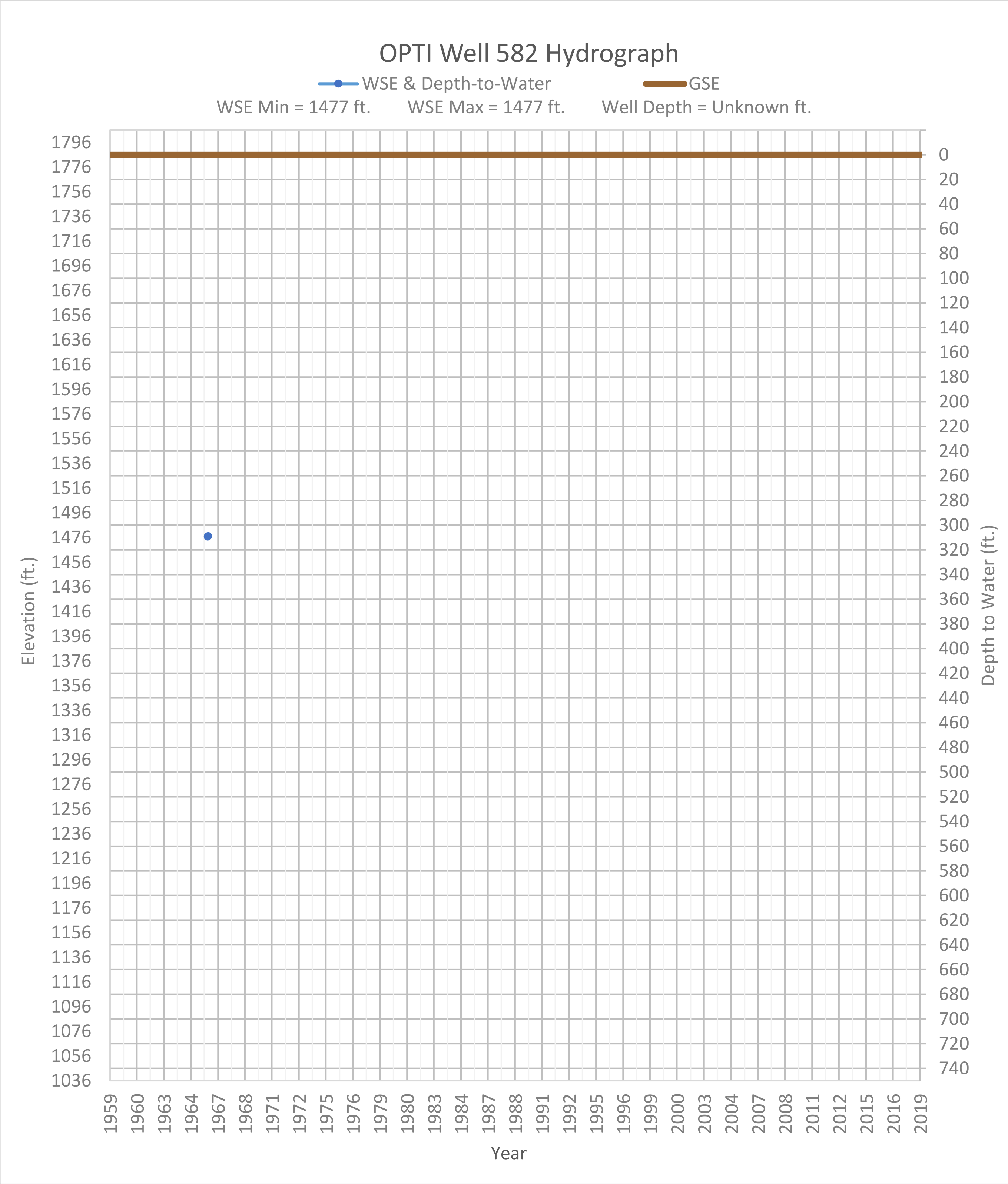

OPTI Well 578 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1824 ft.
WSE Max = 1825 ft.
Well Depth = 699 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



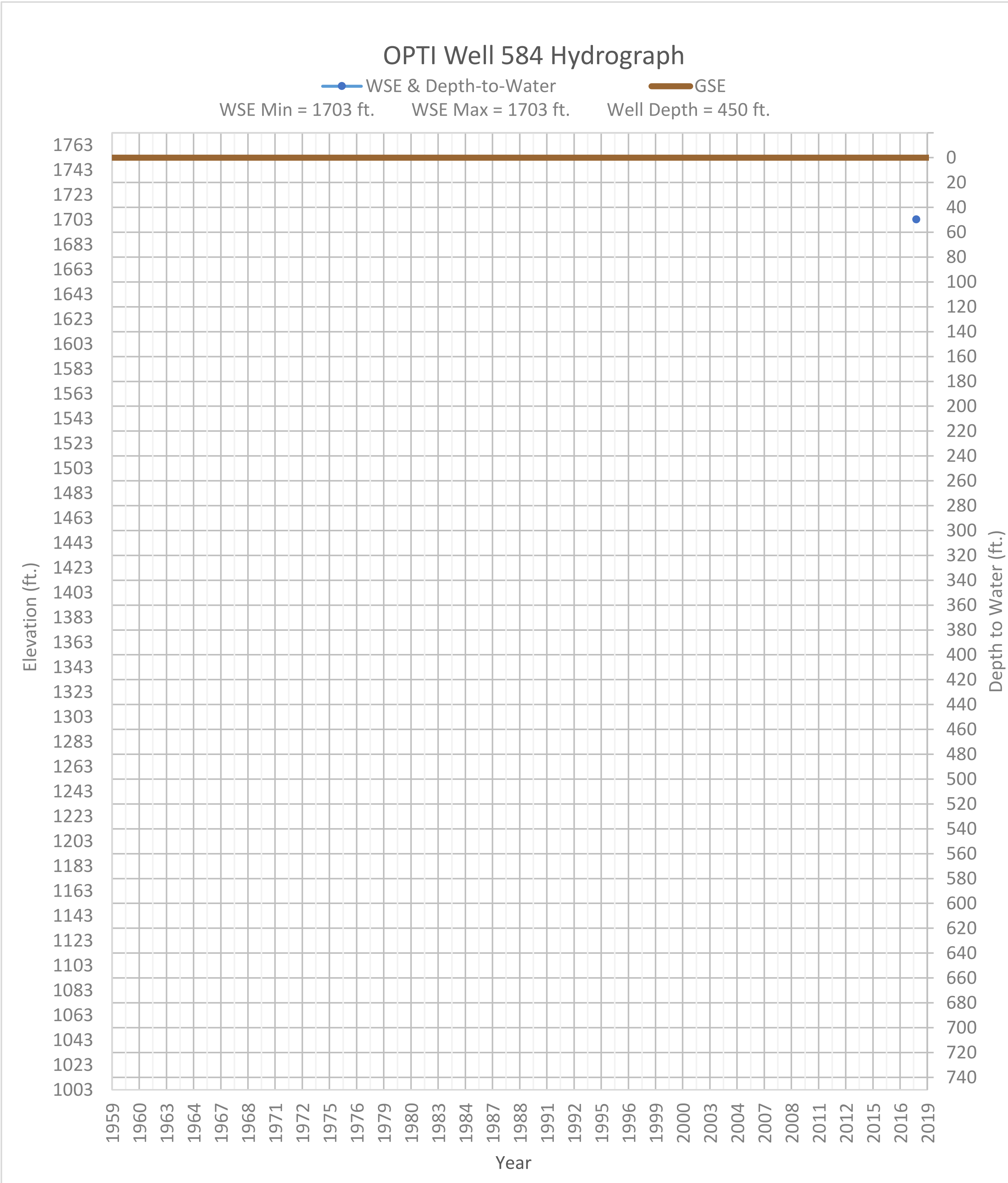
OPTI Well 579 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1895 ft.
WSE Max = 1895 ft.
Well Depth = 191 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

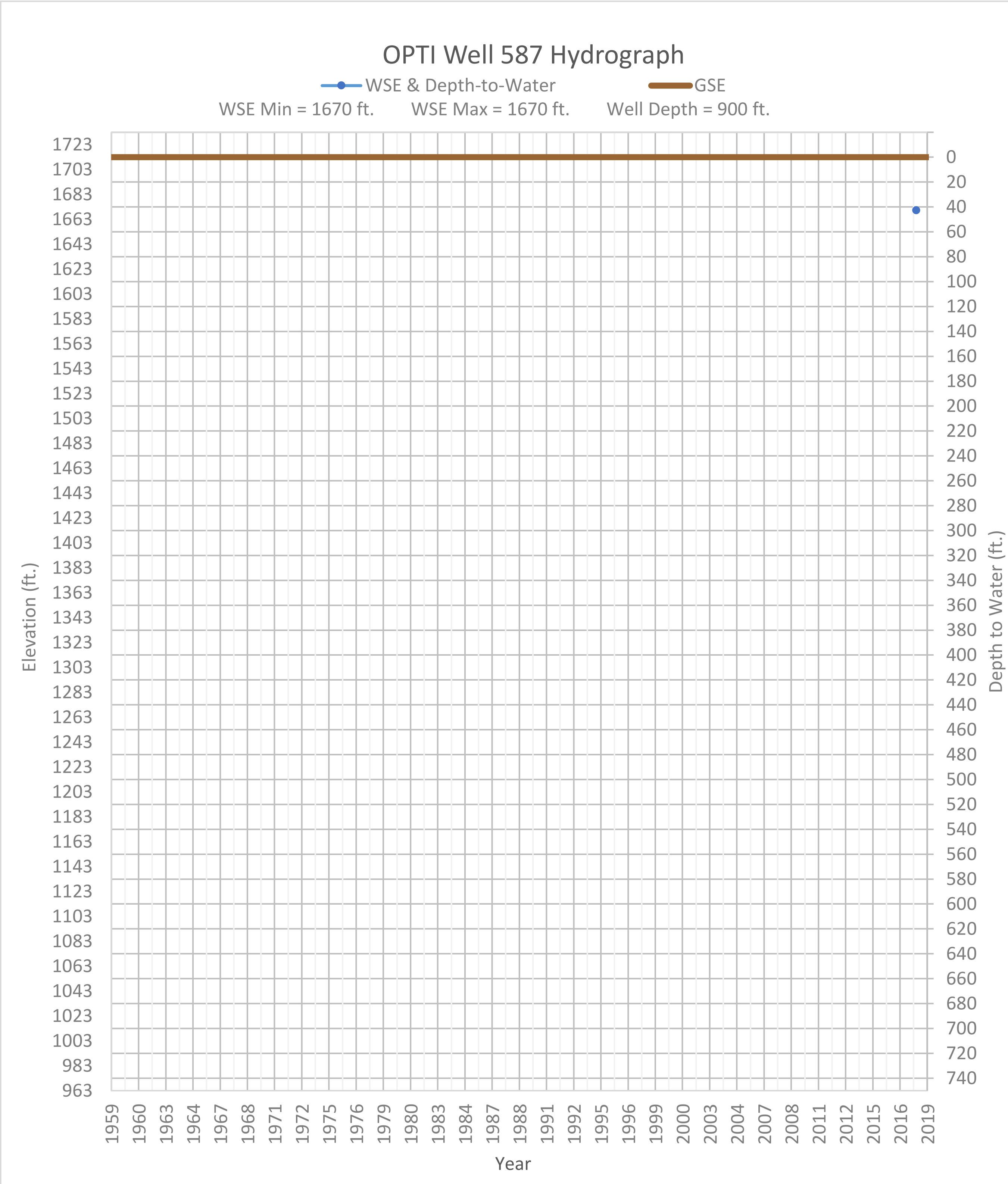


OPTI Well 580 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1884 ft.
WSE Max = 1892 ft.
Well Depth = 250 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 582 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1477 ft.
WSE Max = 1477 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 584 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1703 ft.
WSE Max = 1703 ft.
Well Depth = 450 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 587 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1670 ft.
WSE Max = 1670 ft.
Well Depth = 900 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1723
1703
1683
1663
1643
1623
1603
1583
1563
1543
1523
1503
1483
1463
1443
1423
1403
1383
1363
1343
1323
1303
1283
1263
1243
1223
1203
1183
1163
1143
1123
1103
1083
1063
1043
1023
1003
983
963
0
20
40
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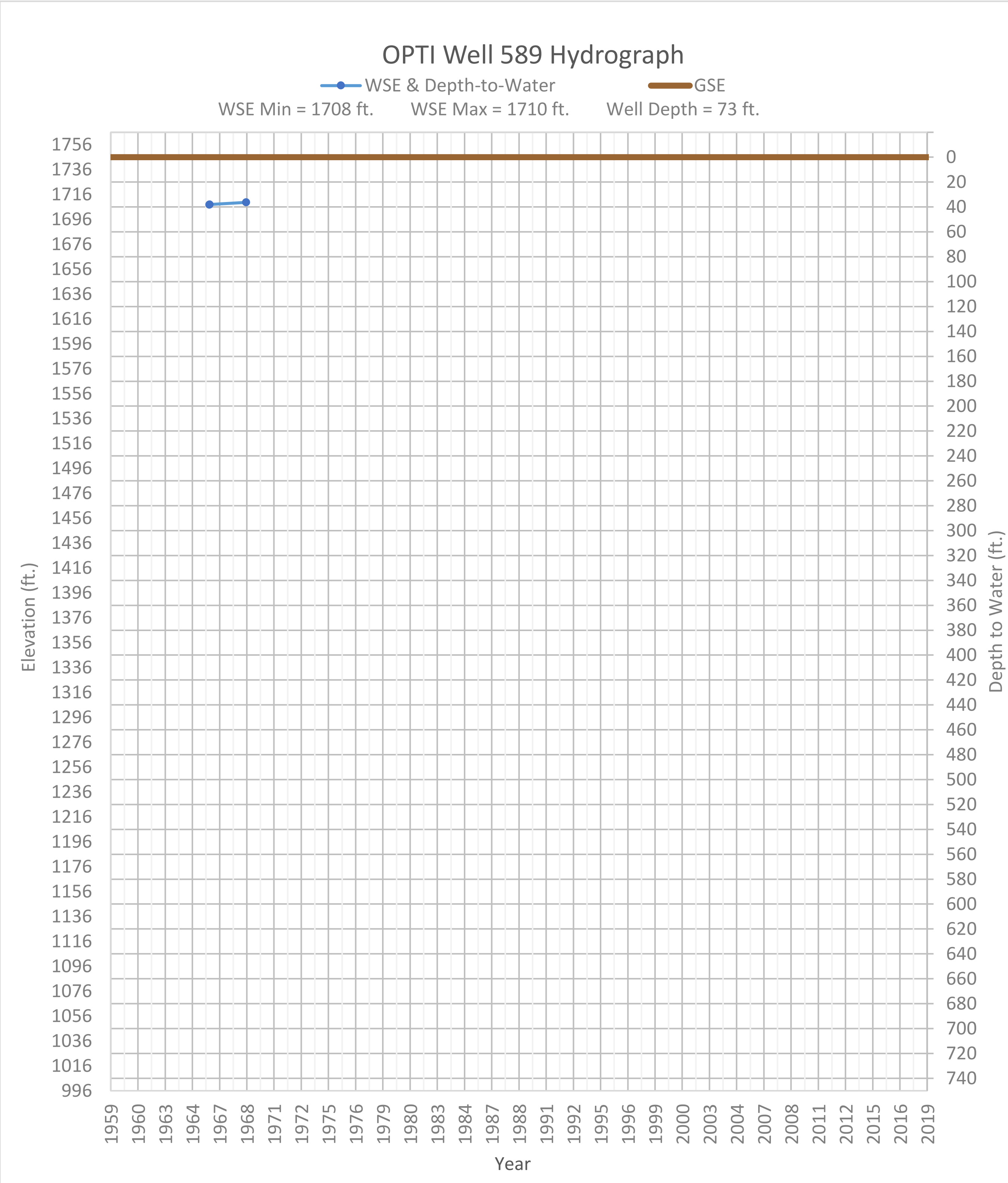
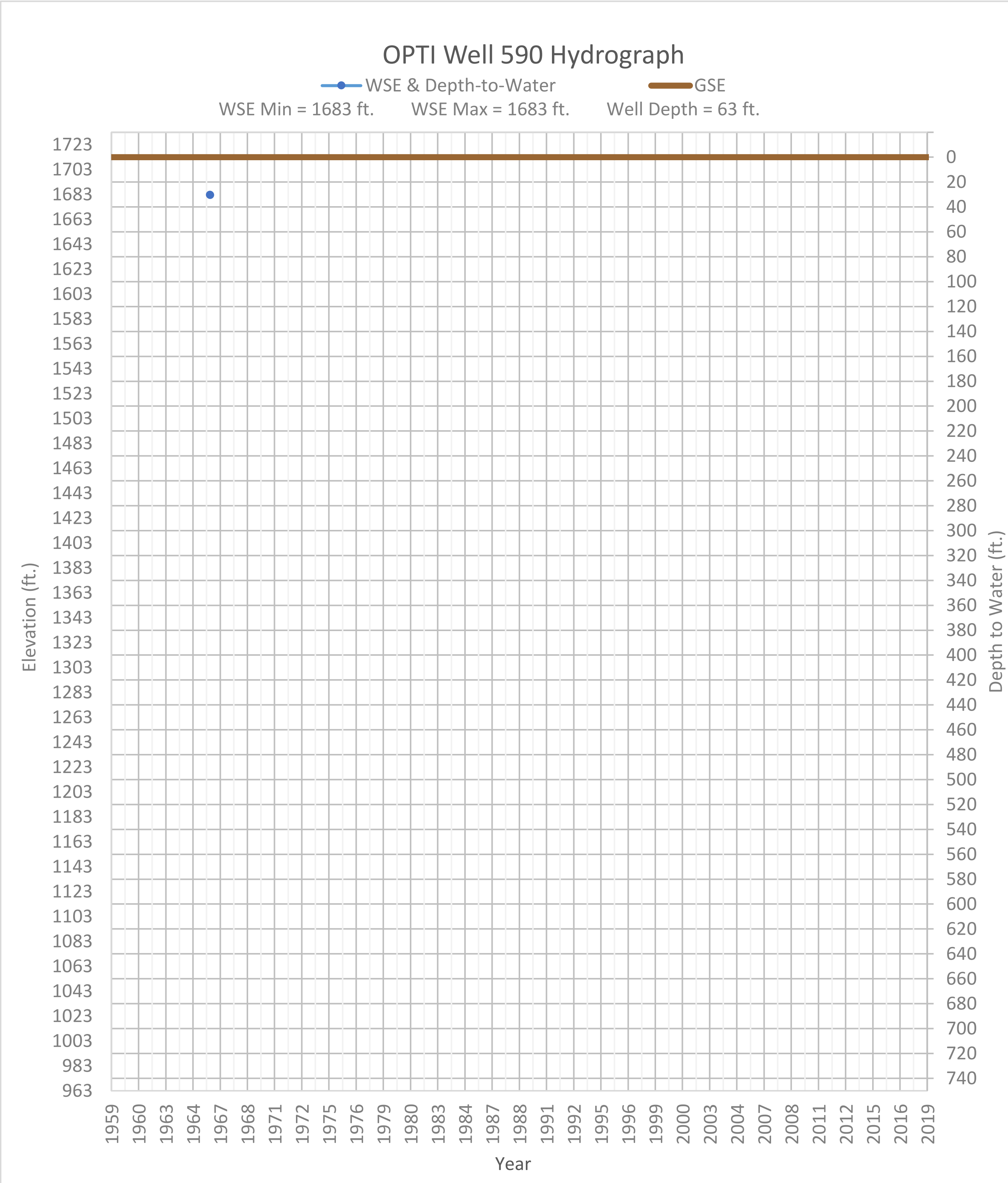
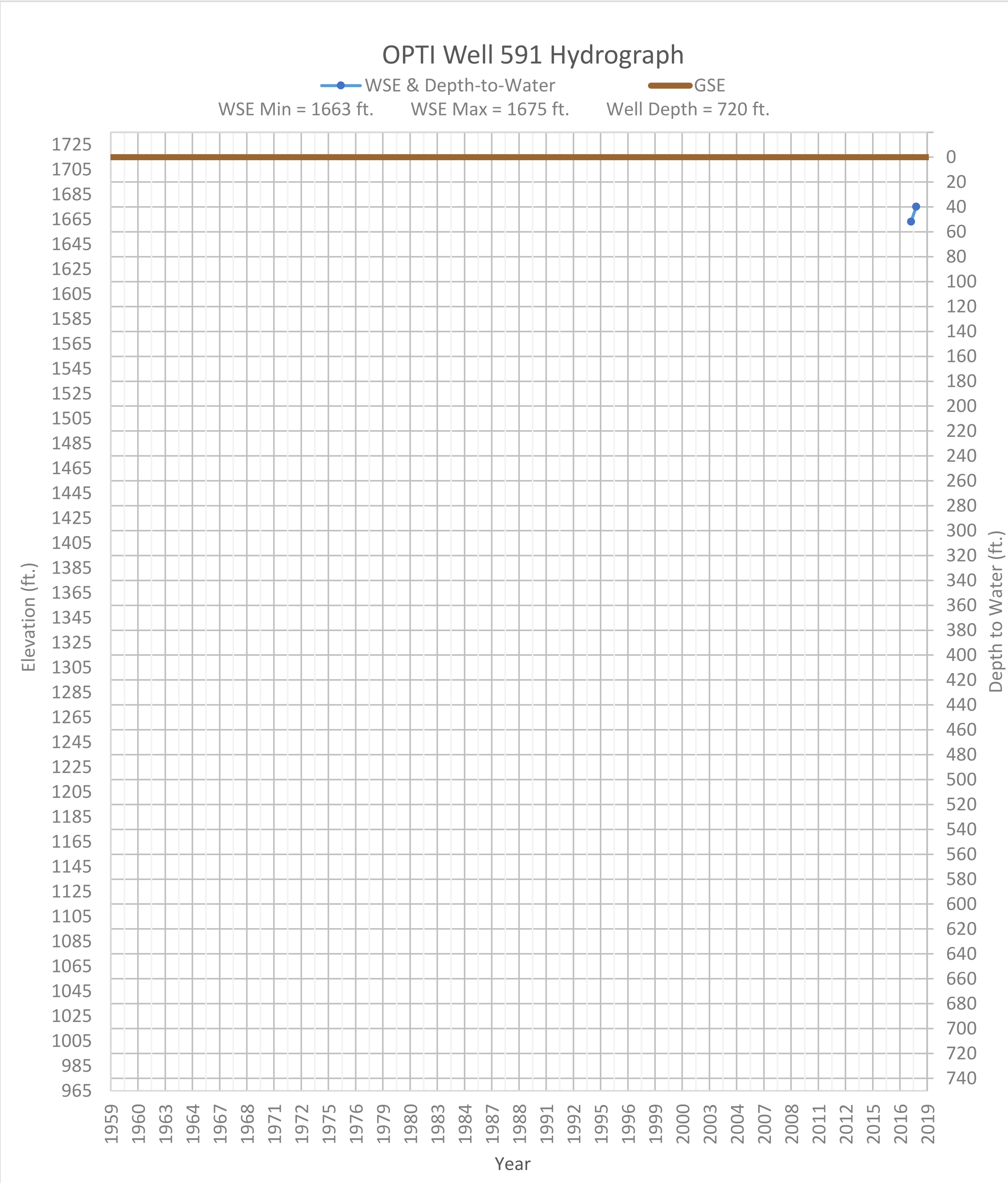
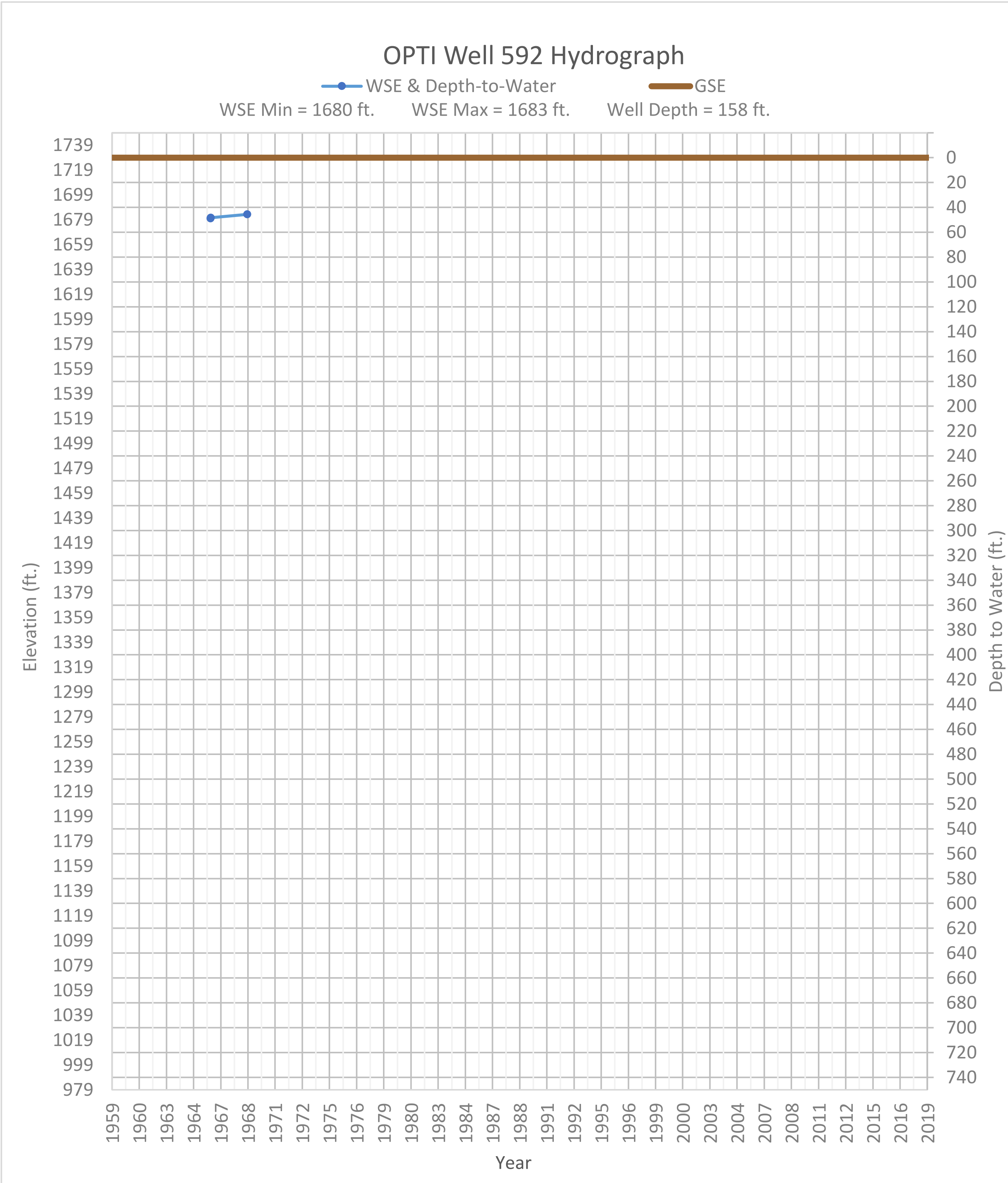
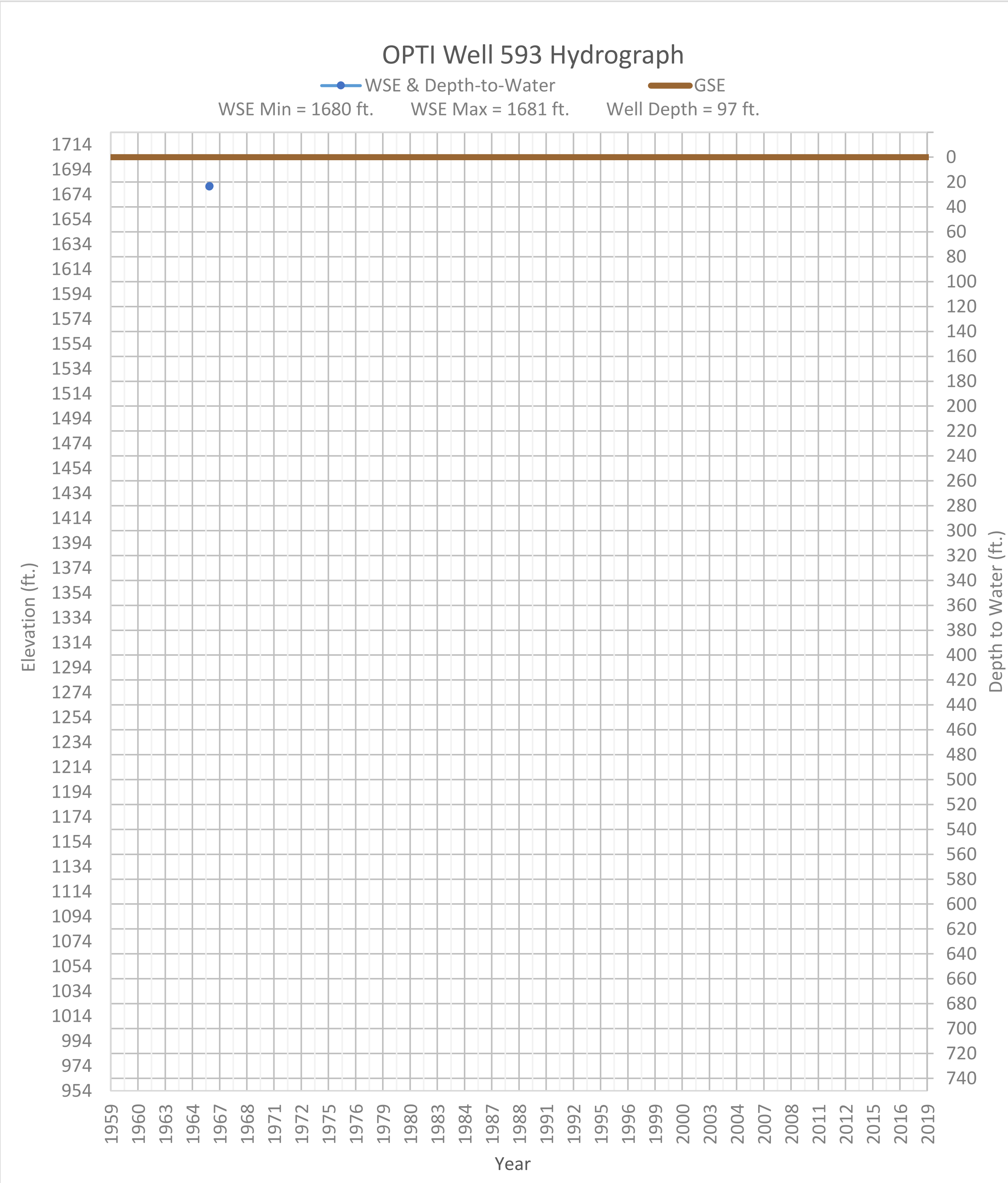


OPTI Well 589 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1708 ft.
WSE Max = 1710 ft.
Well Depth = 73 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

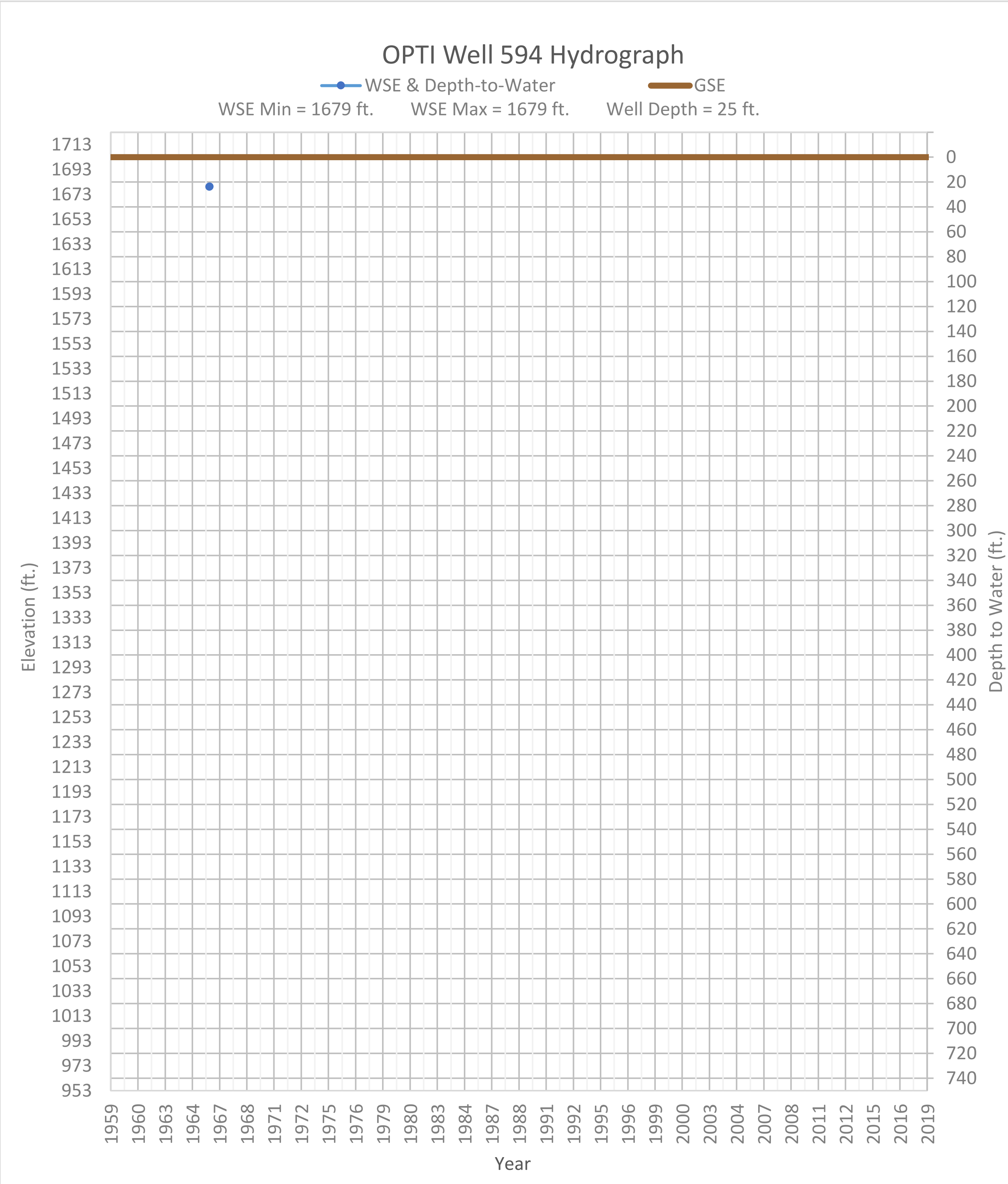

OPTI Well 590 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1683 ft.
WSE Max = 1683 ft.
Well Depth = 63 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 591 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1663 ft.
WSE Max = 1675 ft.
Well Depth = 720 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 592 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1680 ft.
WSE Max = 1683 ft.
Well Depth = 158 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 593 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1680 ft.
WSE Max = 1681 ft.
Well Depth = 97 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 594 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1679 ft.
WSE Max = 1679 ft.
Well Depth = 25 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1713
1693
1673
1653
1633
1613
1593
1573
1553
1533
1513
1493
1473
1453
1433
1413
1393
1373
1353
1333
1313
1293
1273
1253
1233
1213
1193
1173
1153
1133
1113
1093
1073
1053
1033
1013
993
973
953
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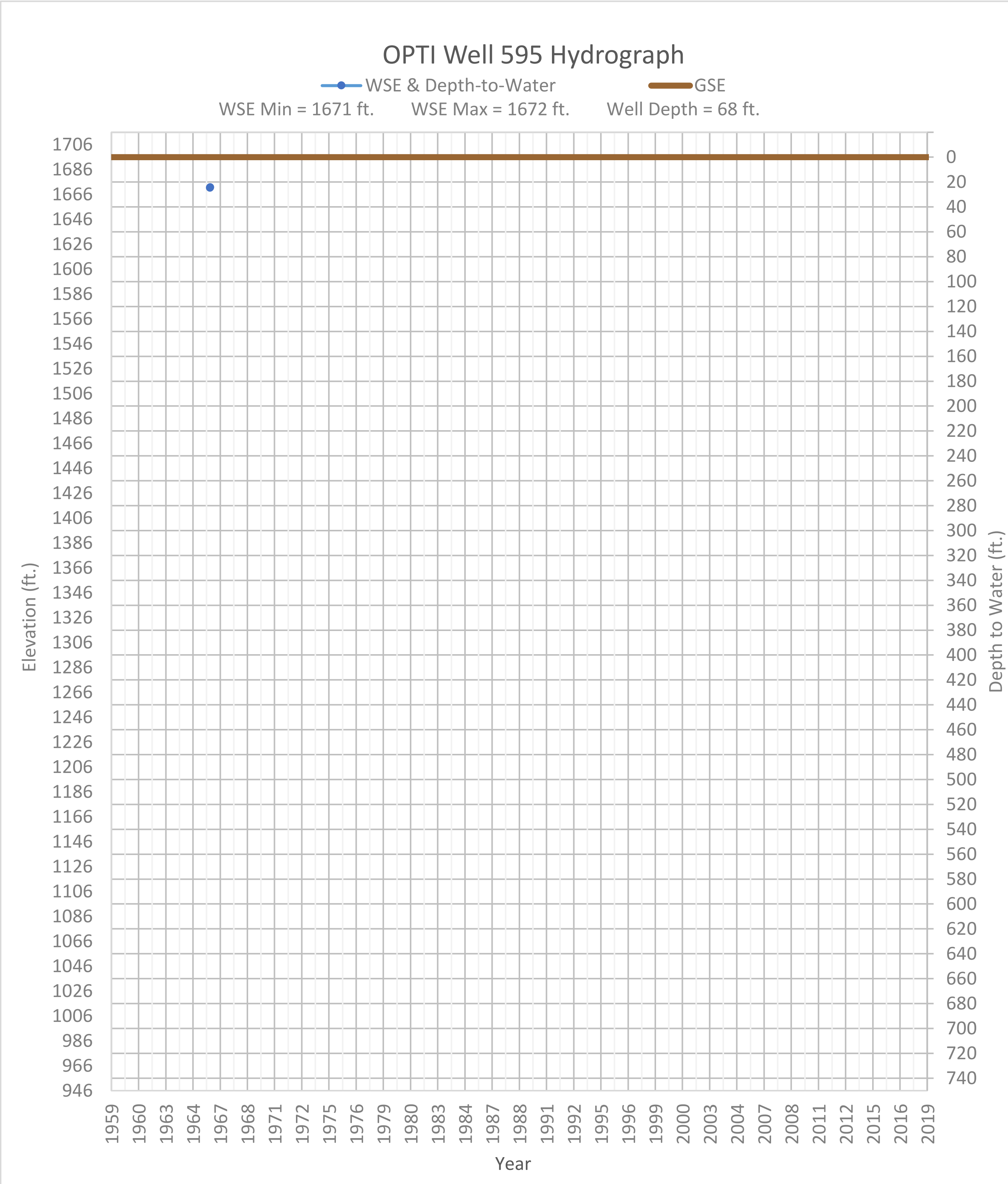

OPTI Well 595 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1671 ft.
WSE Max = 1672 ft.
Well Depth = 68 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1706
1686
1666
1646
1626
1606
1586
1566
1546
1526
1506
1486
1466
1446
1426
1406
1386
1366
1346
1326
1306
1286
1266
1246
1226
1206
1186
1166
1146
1126
1106
1086
1066
1046
1026
1006
986
966
946
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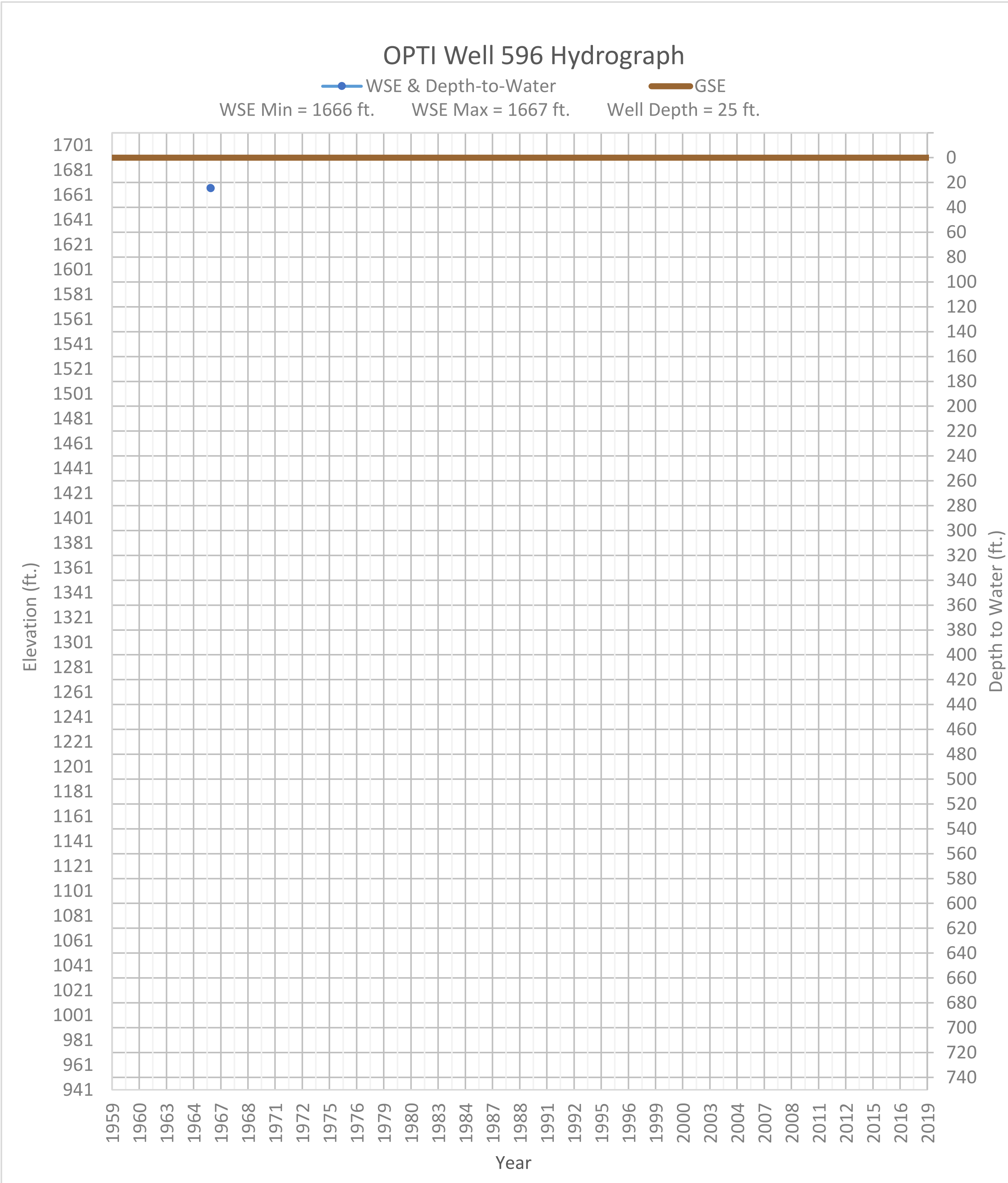
OPTI Well 596 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1666 ft.
WSE Max = 1667 ft.
Well Depth = 25 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1701
1681
1661
1641
1621
1601
1581
1561
1541
1521
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1481
1461
1441
1421
1401
1381
1361
1341
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1301
1281
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1081
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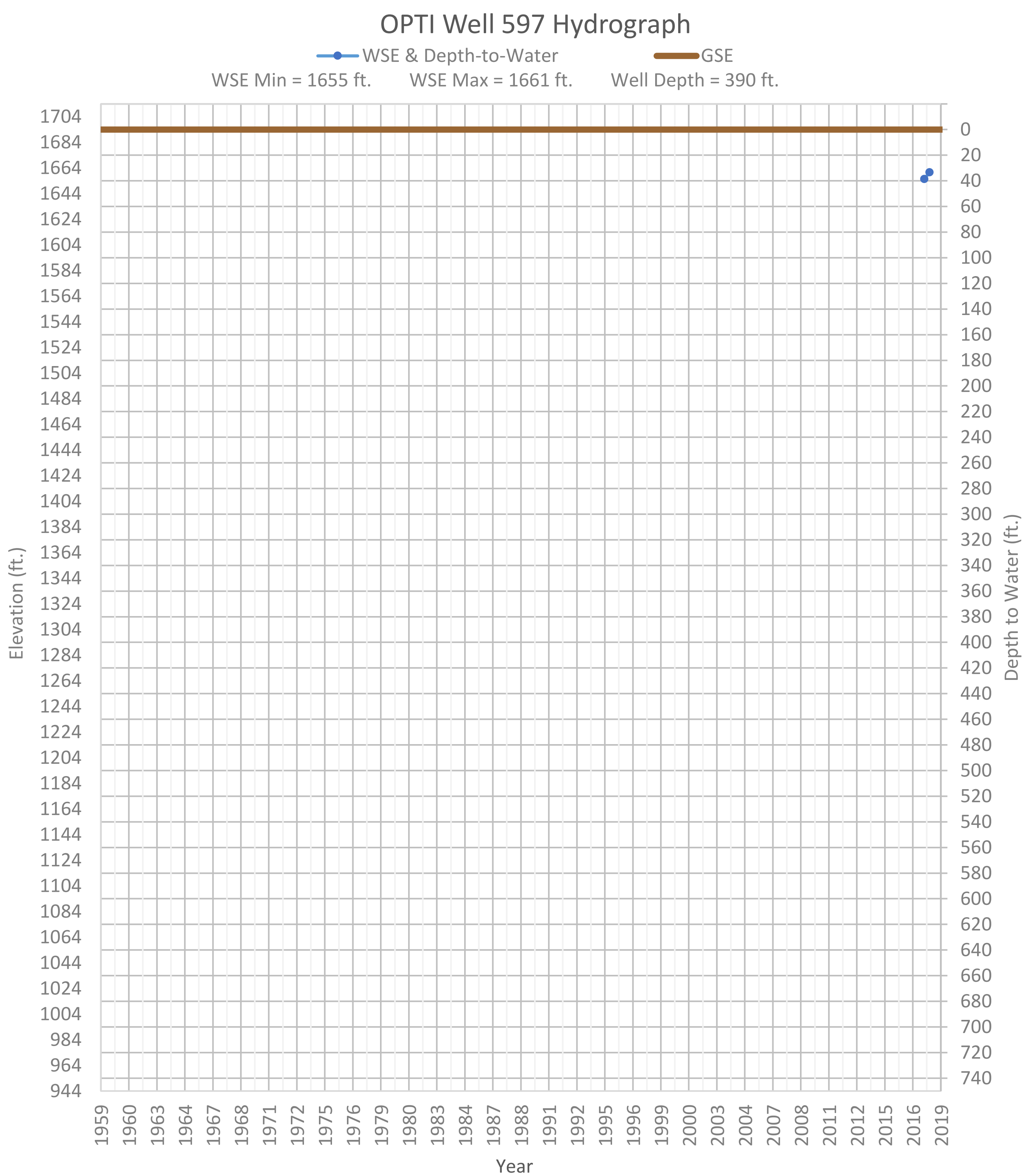
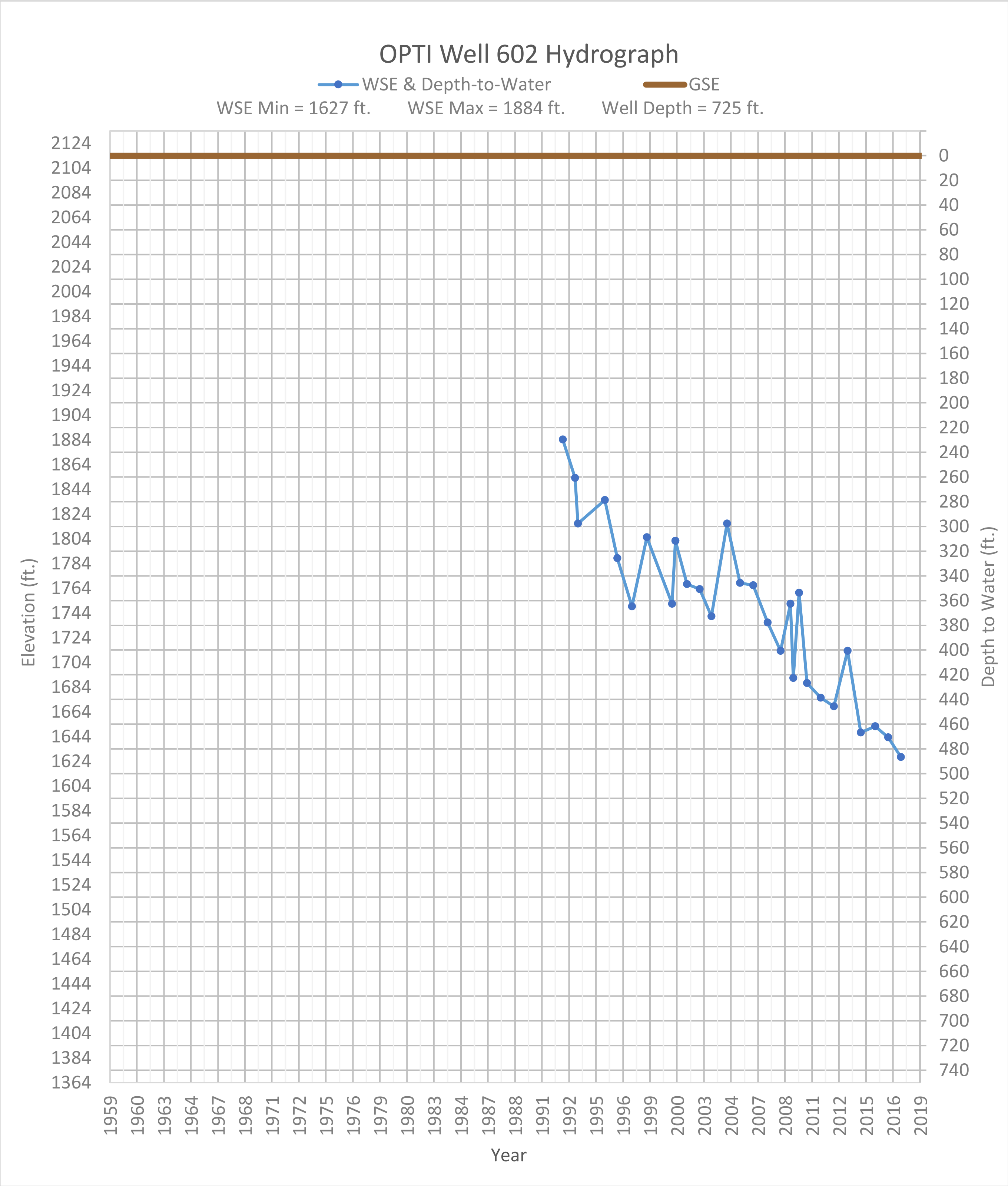
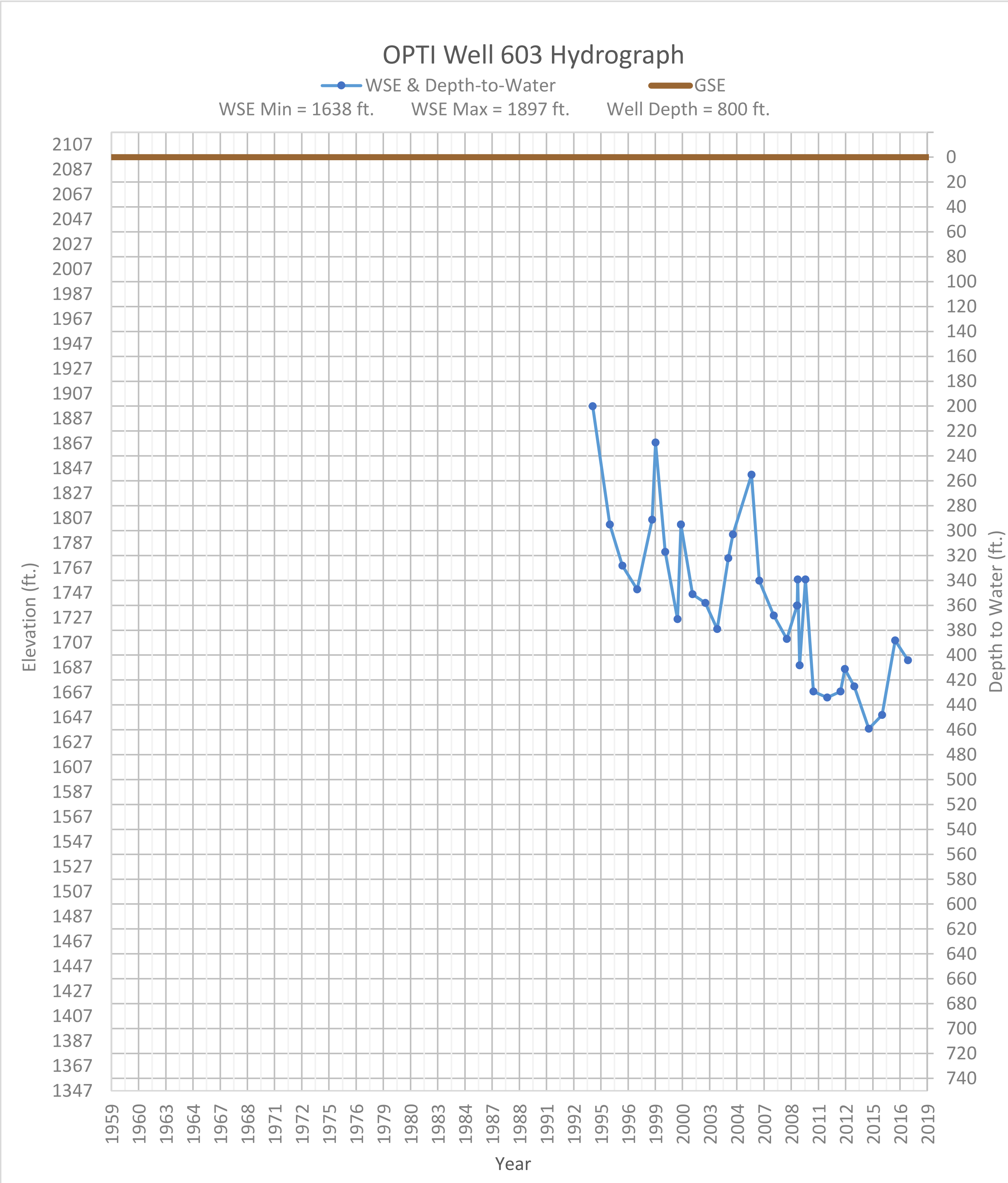

OPTI Well 597 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1655 ft.
WSE Max = 1661 ft.
Well Depth = 390 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

OPTI Well 601 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1640 ft.
WSE Max = 2056 ft.
Well Depth = 723 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 602 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1627 ft.
WSE Max = 1884 ft.
Well Depth = 725 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 603 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1638 ft.
WSE Max = 1897 ft.
Well Depth = 800 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

OPTI Well 604 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1607 ft.
WSE Max = 1844 ft.
Well Depth = 924 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2135
2115
2095
2075
2055
2035
2015
1995
1975
1955
1935
1915
1895
1875
1855
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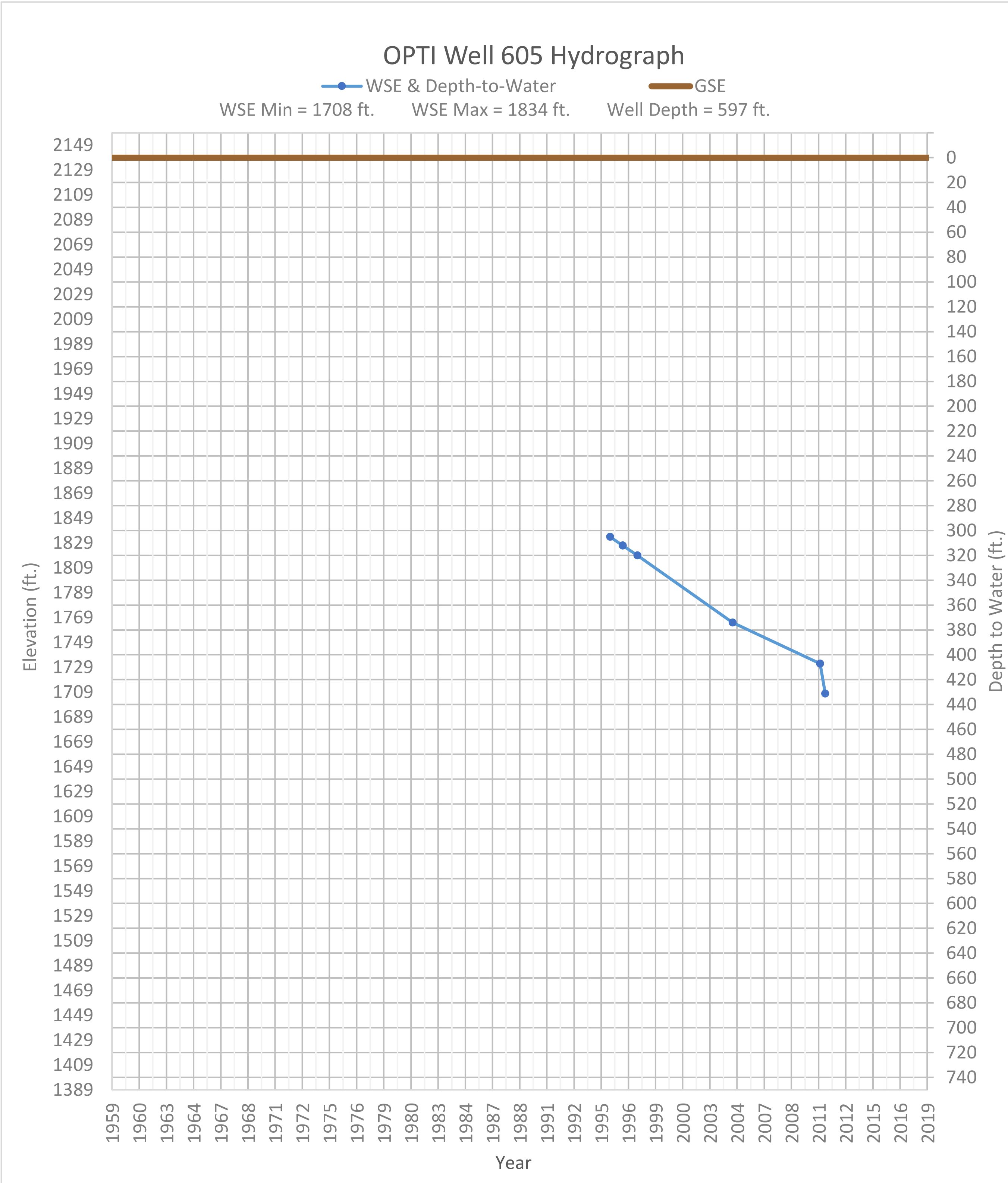

OPTI Well 605 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1708 ft.
WSE Max = 1834 ft.
Well Depth = 597 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2149
2129
2109
2089
2069
2049
2029
2009
1989
1969
1949
1929
1909
1889
1869
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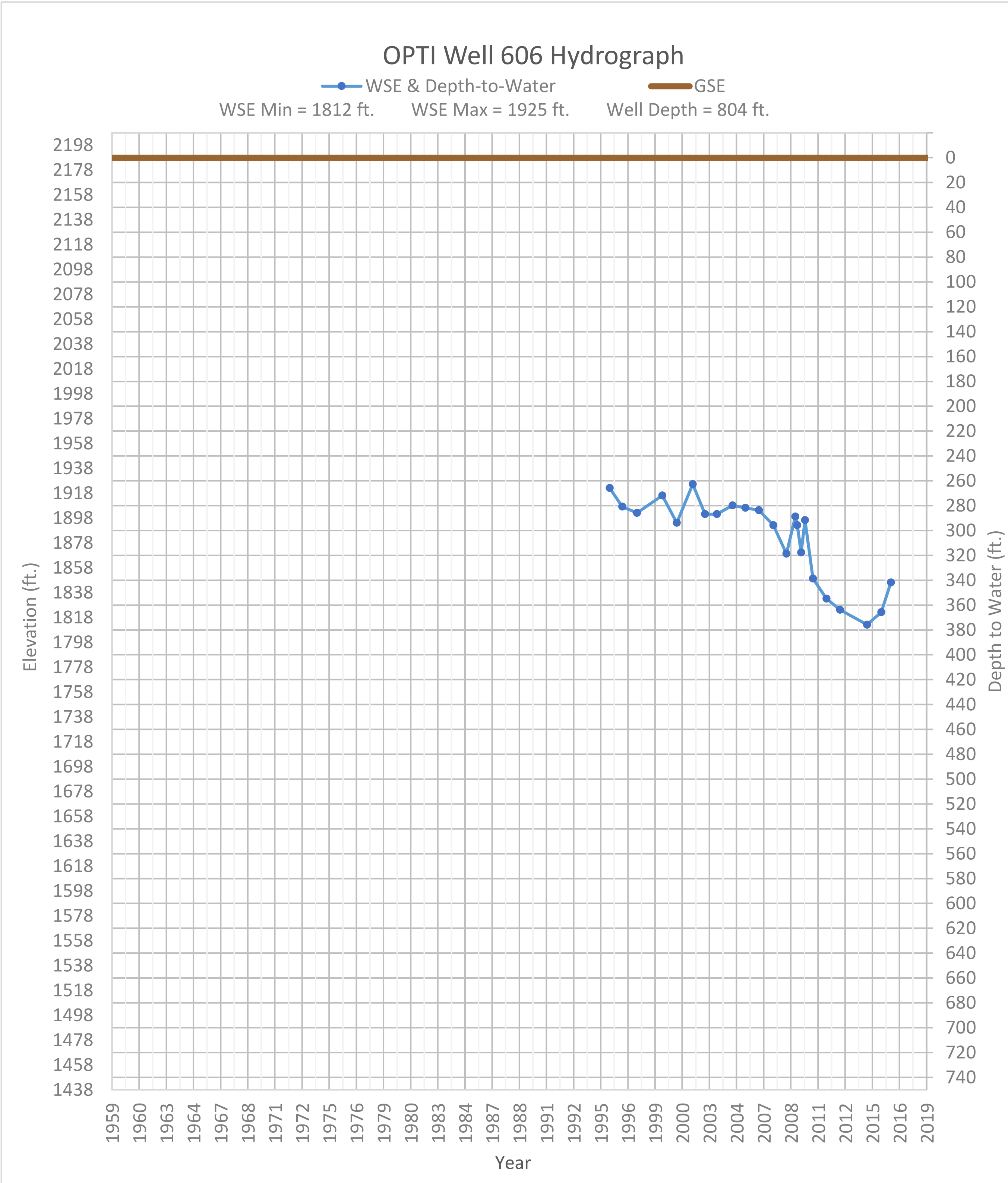
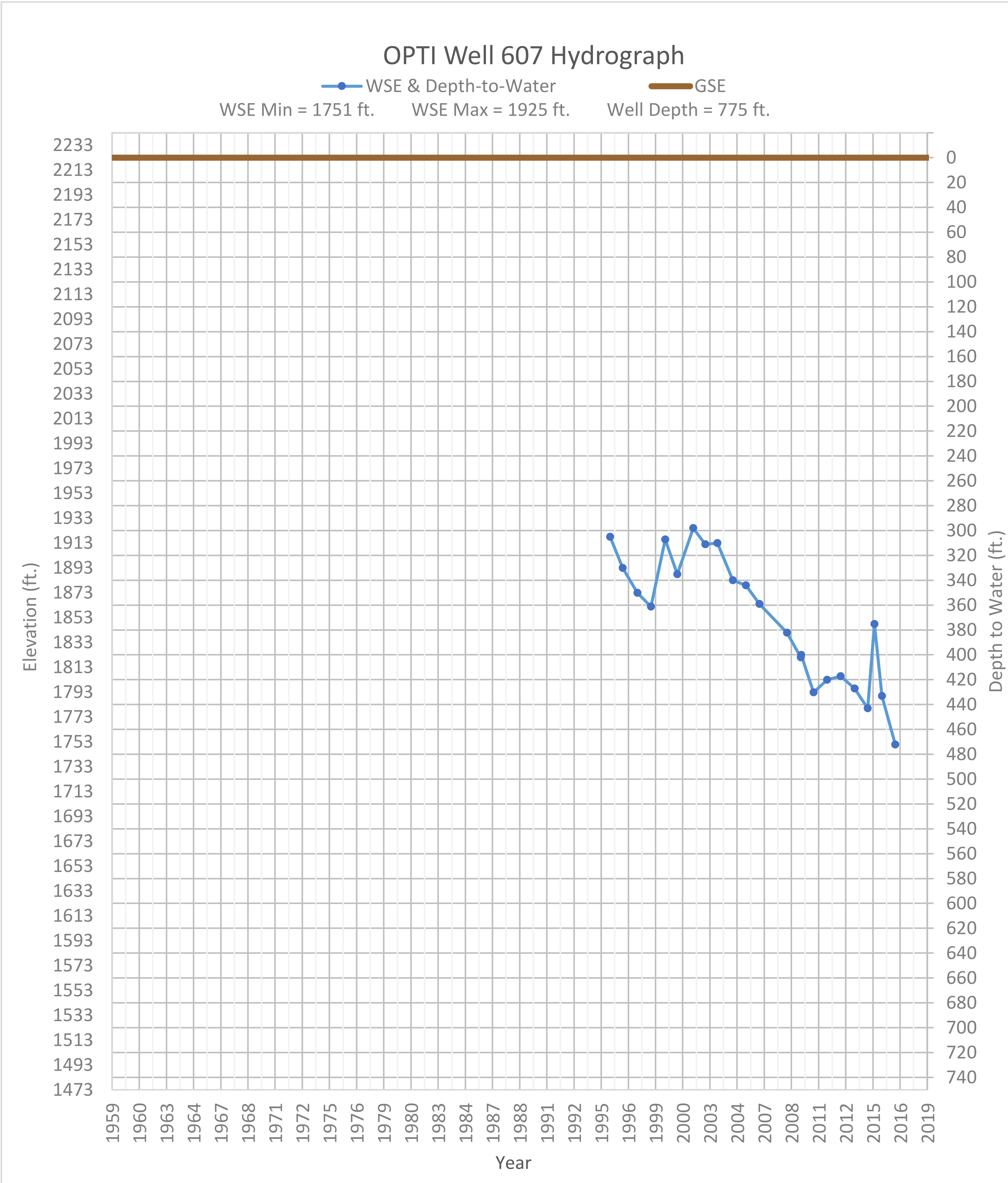
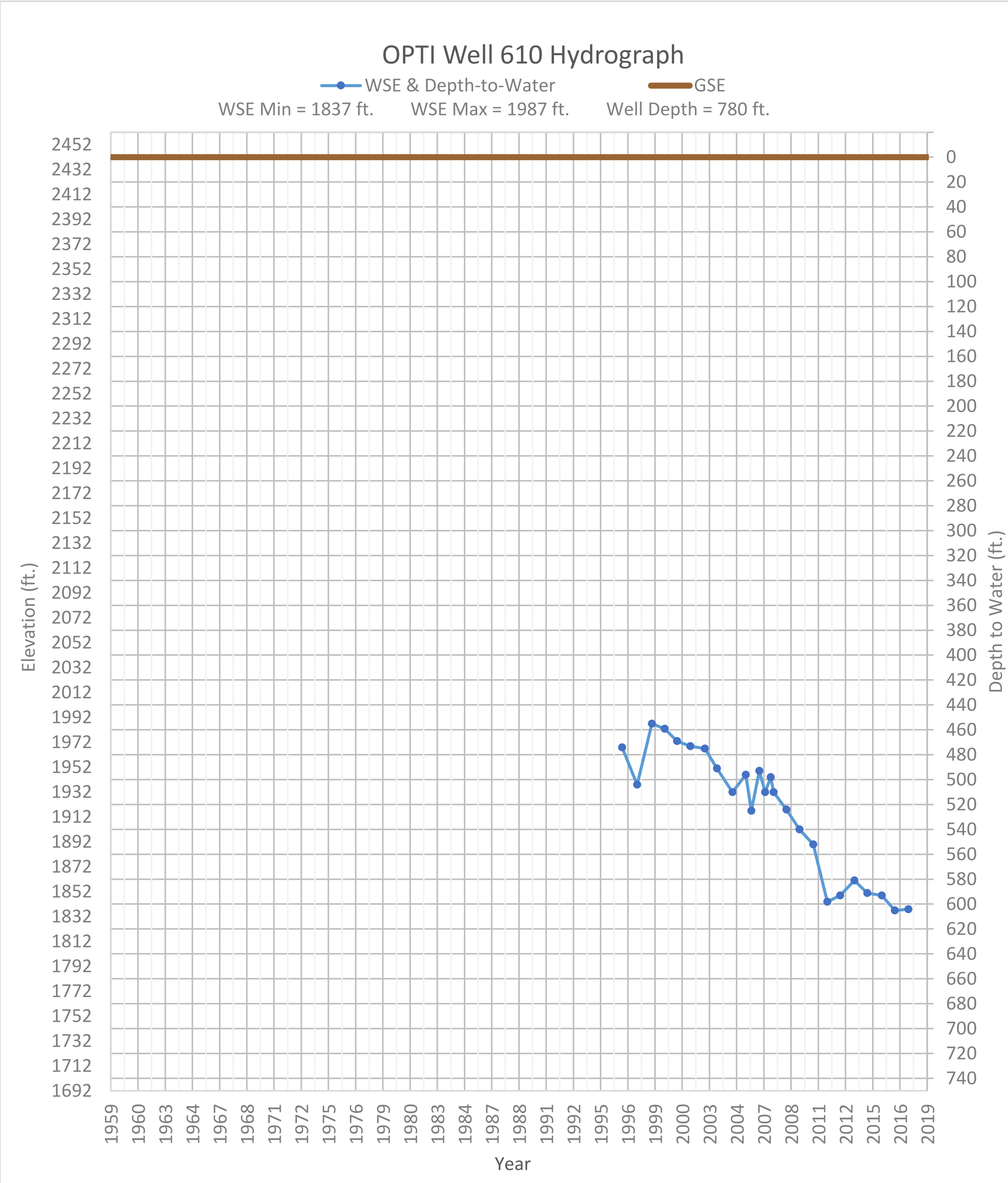

OPTI Well 606 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1812 ft.
WSE Max = 1925 ft.
Well Depth = 804 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 607 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1751 ft.
WSE Max = 1925 ft.
Well Depth = 775 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 608 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1789 ft.
WSE Max = 1954 ft.
Well Depth = 745 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 609 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1721 ft.
WSE Max = 1937 ft.
Well Depth = 970 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 610 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1837 ft.
WSE Max = 1987 ft.
Well Depth = 780 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2452
2432
2412
2392
2372
2352
2332
2312
2292
2272
2252
2232
2212
2192
2172
2152
2132
2112
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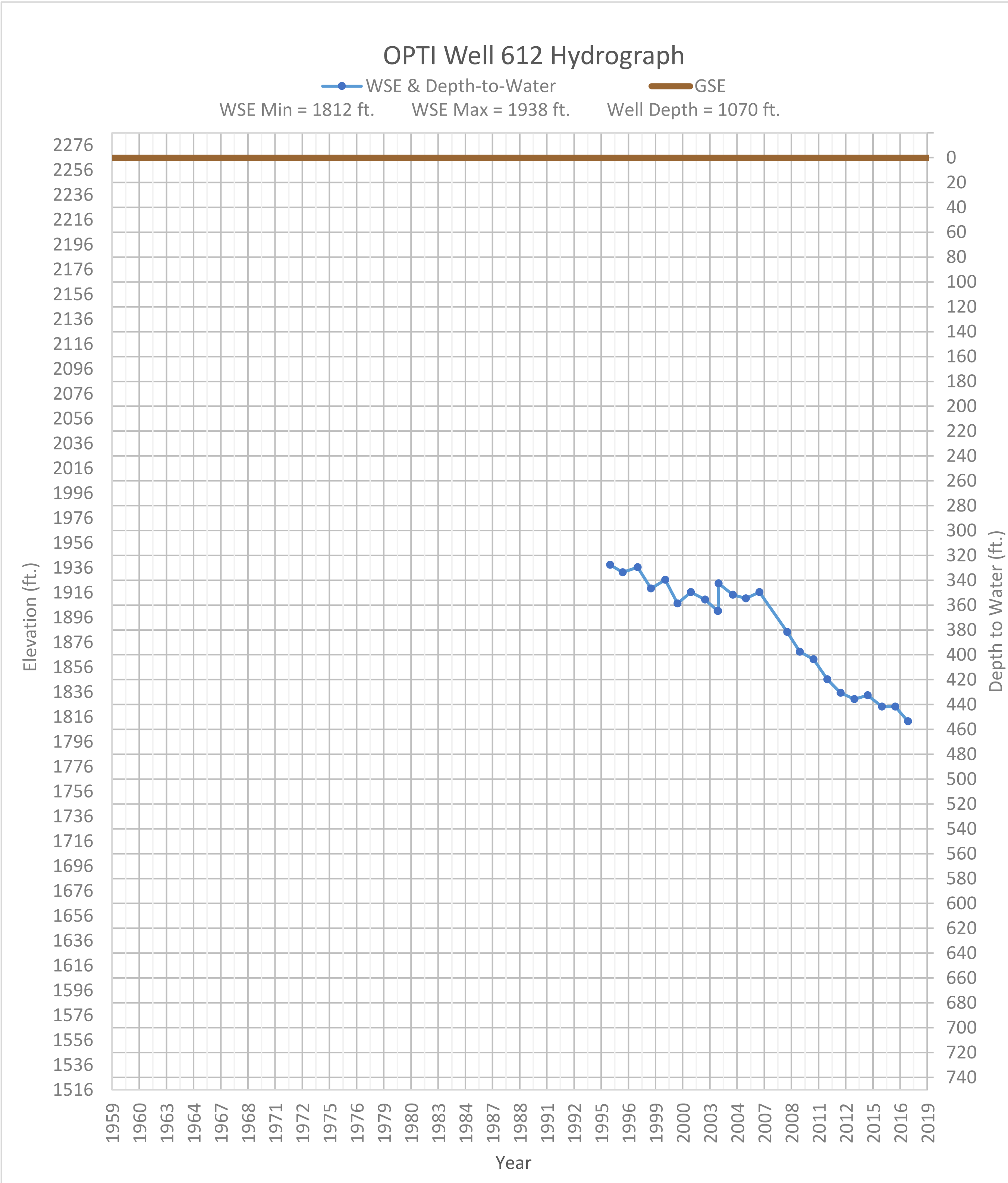
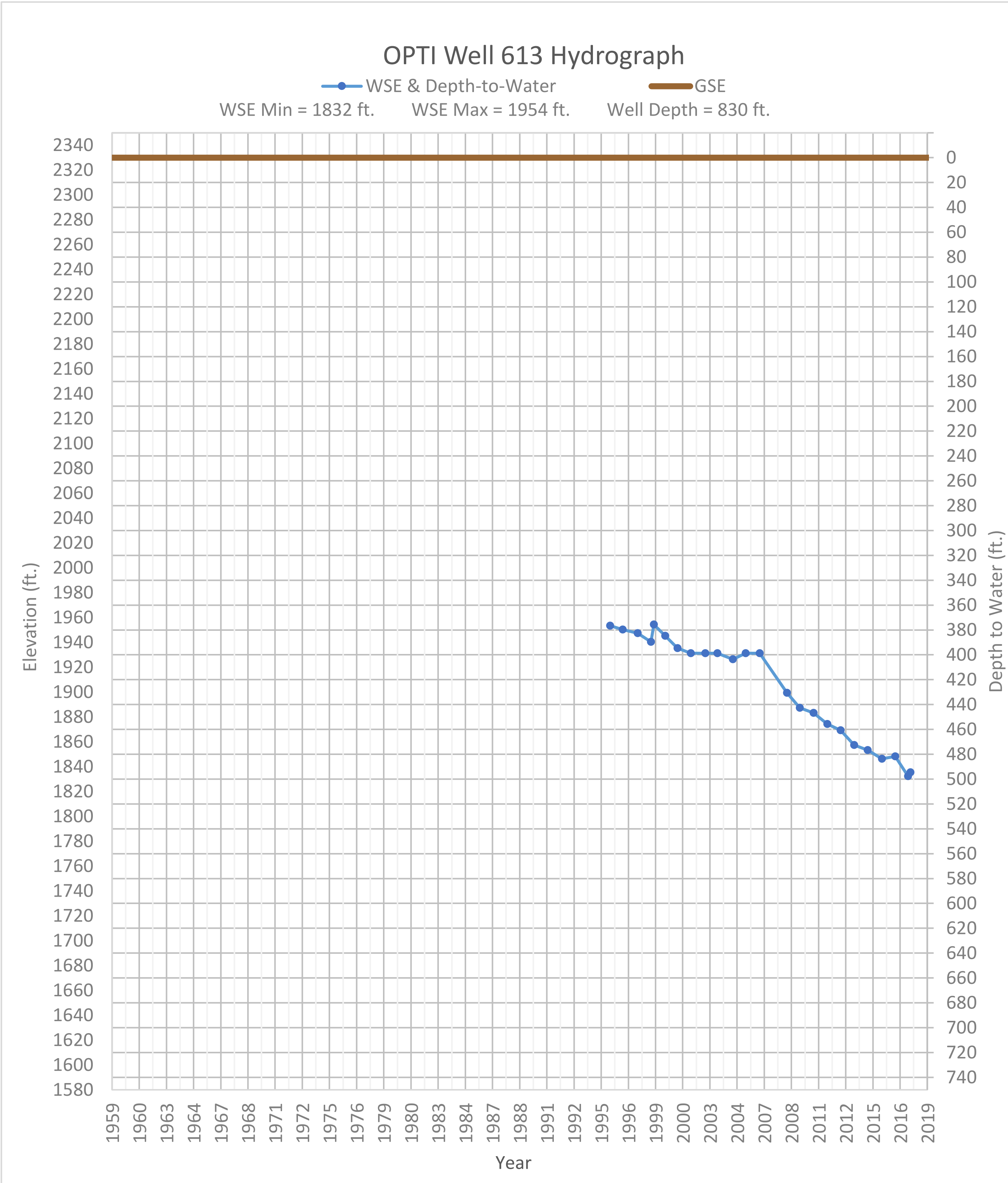
OPTI Well 611 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1871 ft.
WSE Max = 1956 ft.
Well Depth = 550 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 612 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1812 ft.
WSE Max = 1938 ft.
Well Depth = 1070 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 613 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1832 ft.
WSE Max = 1954 ft.
Well Depth = 830 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 614 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1838 ft.
WSE Max = 1957 ft.
Well Depth = 745 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2347
2327
2307
2287
2267
2247
2227
2207
2187
2167
2147
2127
2107
2087
2067
2047
2027
2007
1987
1967
1947
1927
1907
1887
1867
1847
1827
1807
1787
1767
1747
1727
1707
1687
1667
1647
1627
1607
1587
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
1959
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1963
1964
1967
1968
1971
1972
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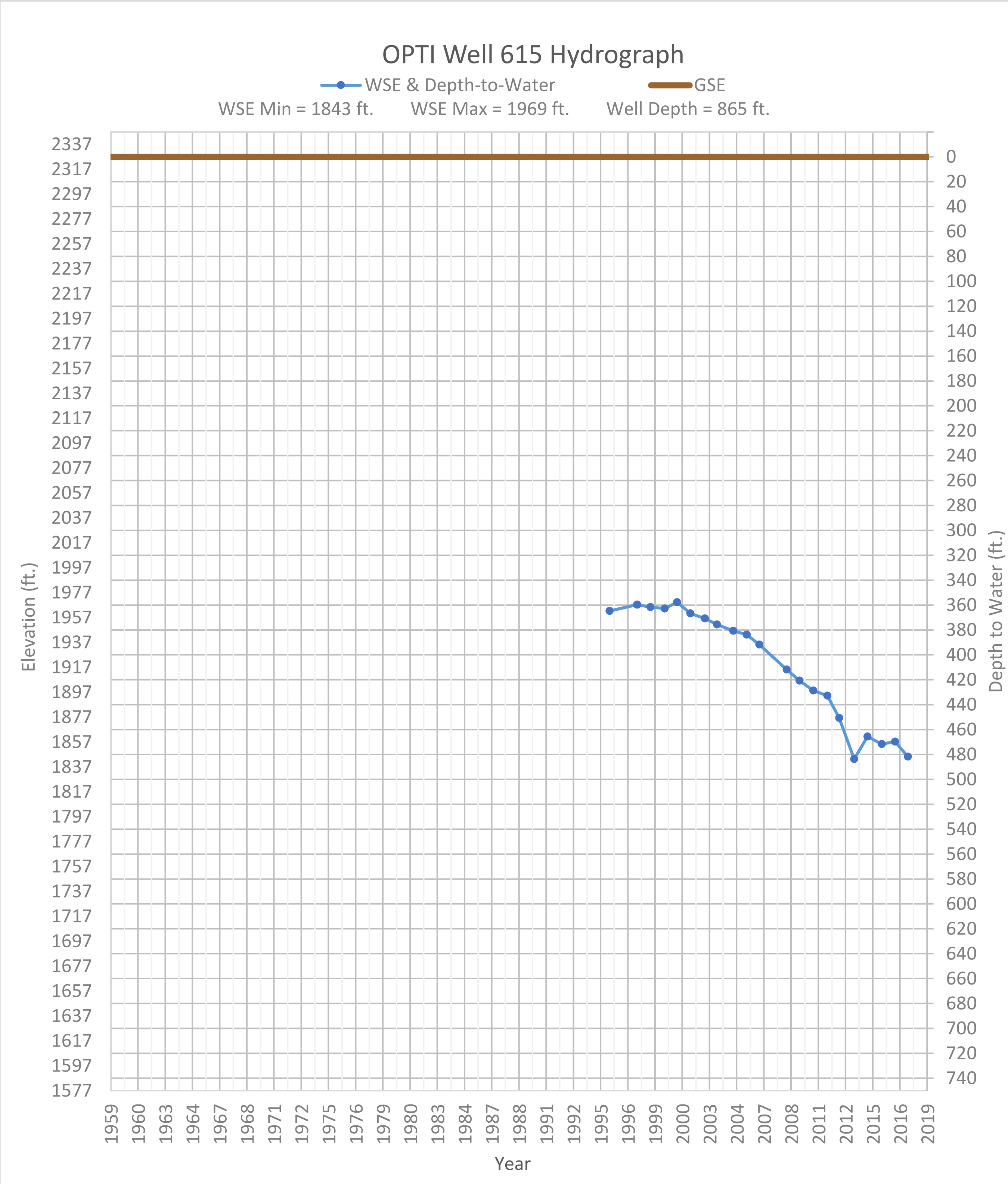
2008
2011
2012
2015
2016
2019


OPTI Well 615 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1843 ft.
WSE Max = 1969 ft.
Well Depth = 865 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2337
2317
2297
2277
2257
2237
2217
2197
2177
2157
2137
2117
2097
2077
2057
2037
2017
1997
1977
1957
1937
1917
1897
1877
1857
1837
1817
1797
1777
1757
1737
1717
1697
1677
1657
1637
1617
1597
1577
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
1959
1960
1963
1964
1967
1968
1971
1972
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2000
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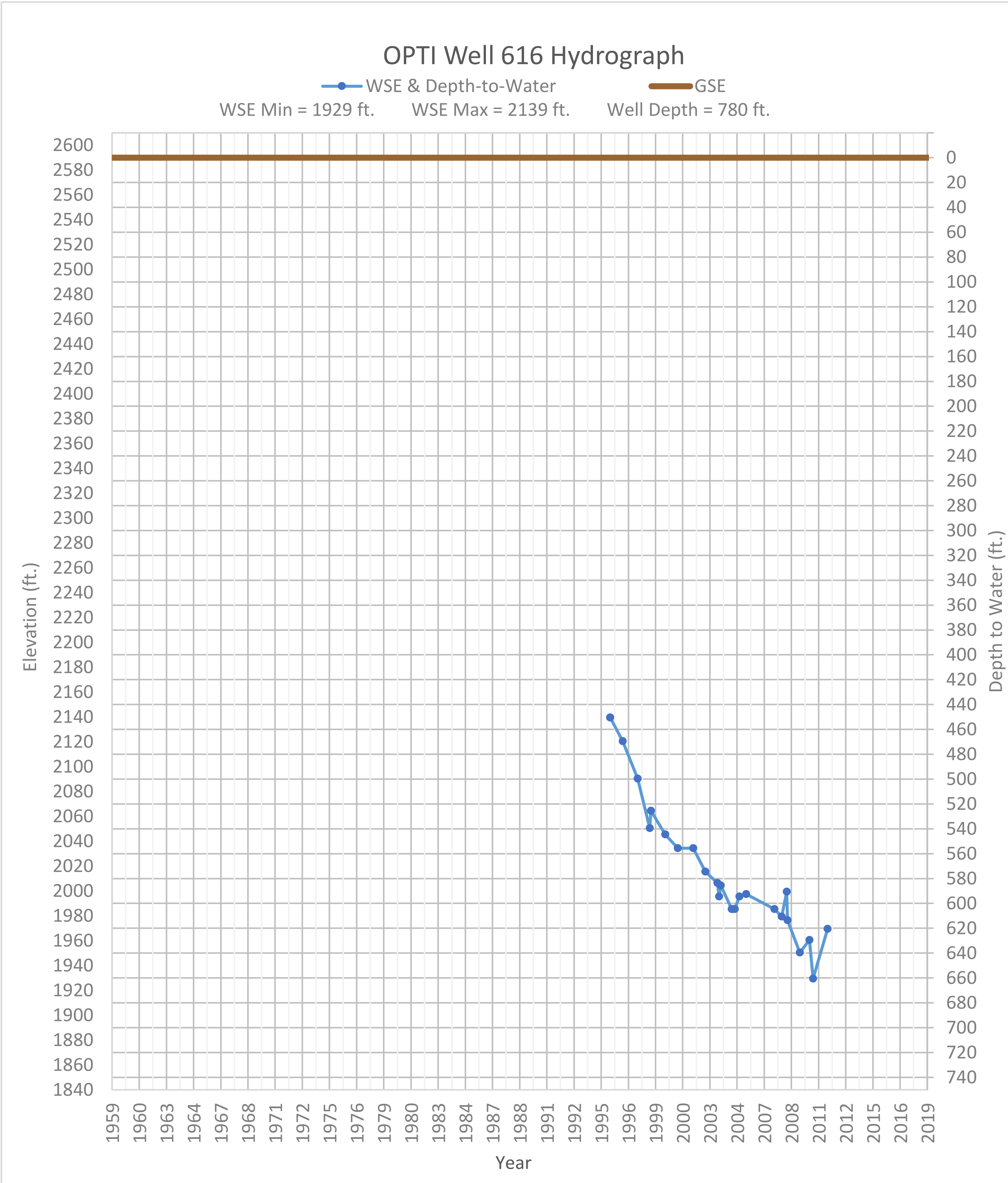
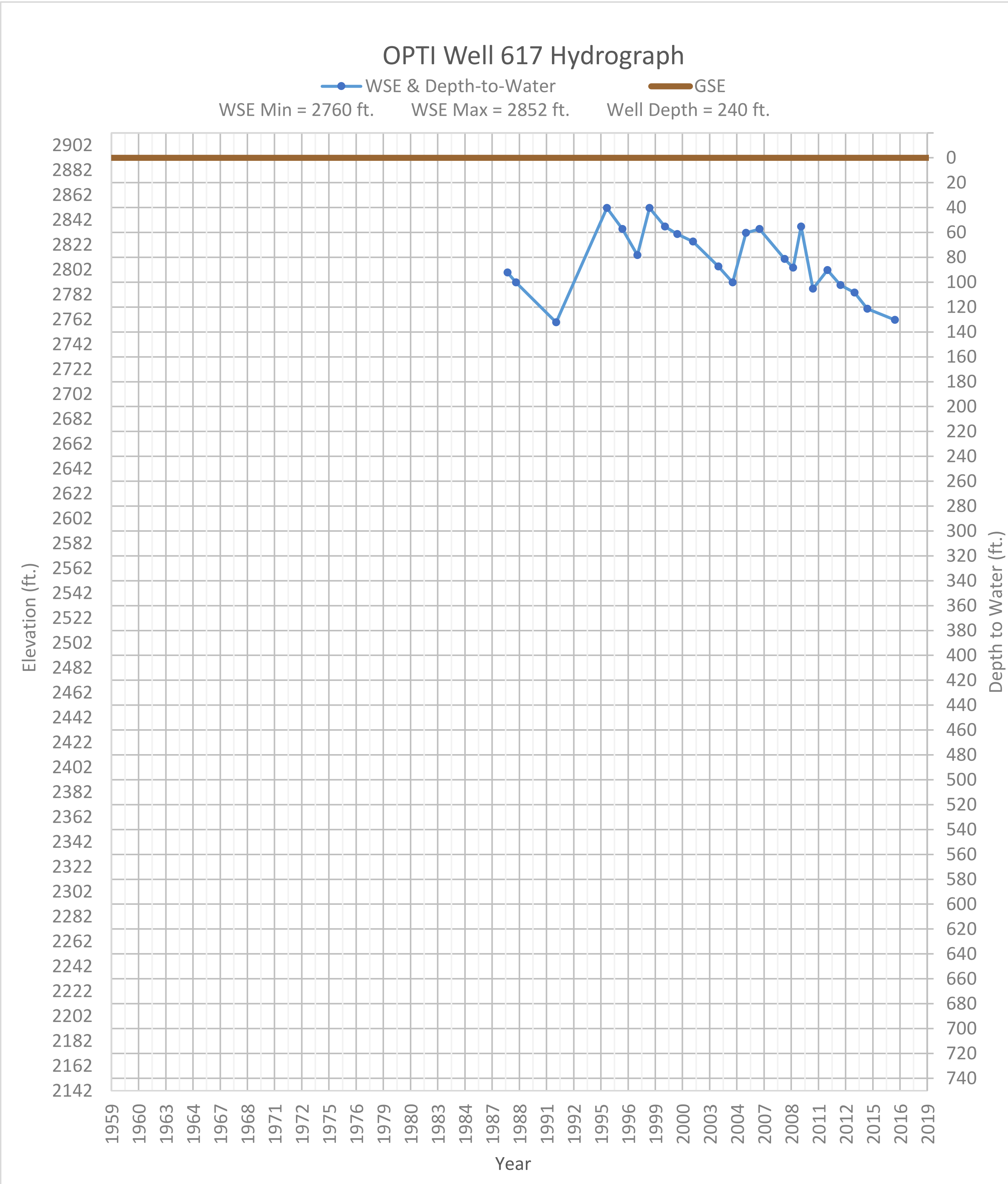
2008
2011
2012
2015
2016
2019



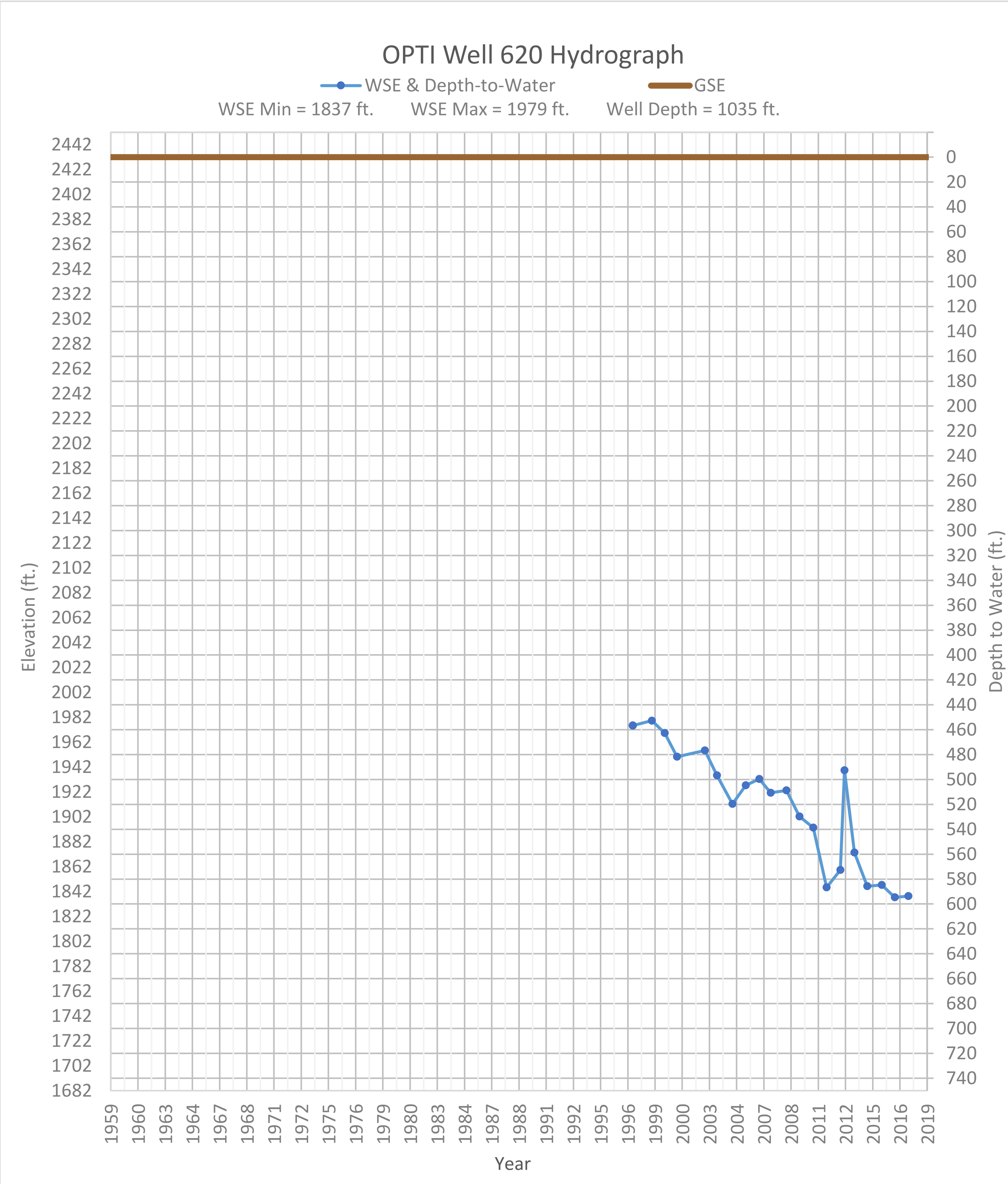
OPTI Well 616 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1929 ft.
WSE Max = 2139 ft.
Well Depth = 780 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



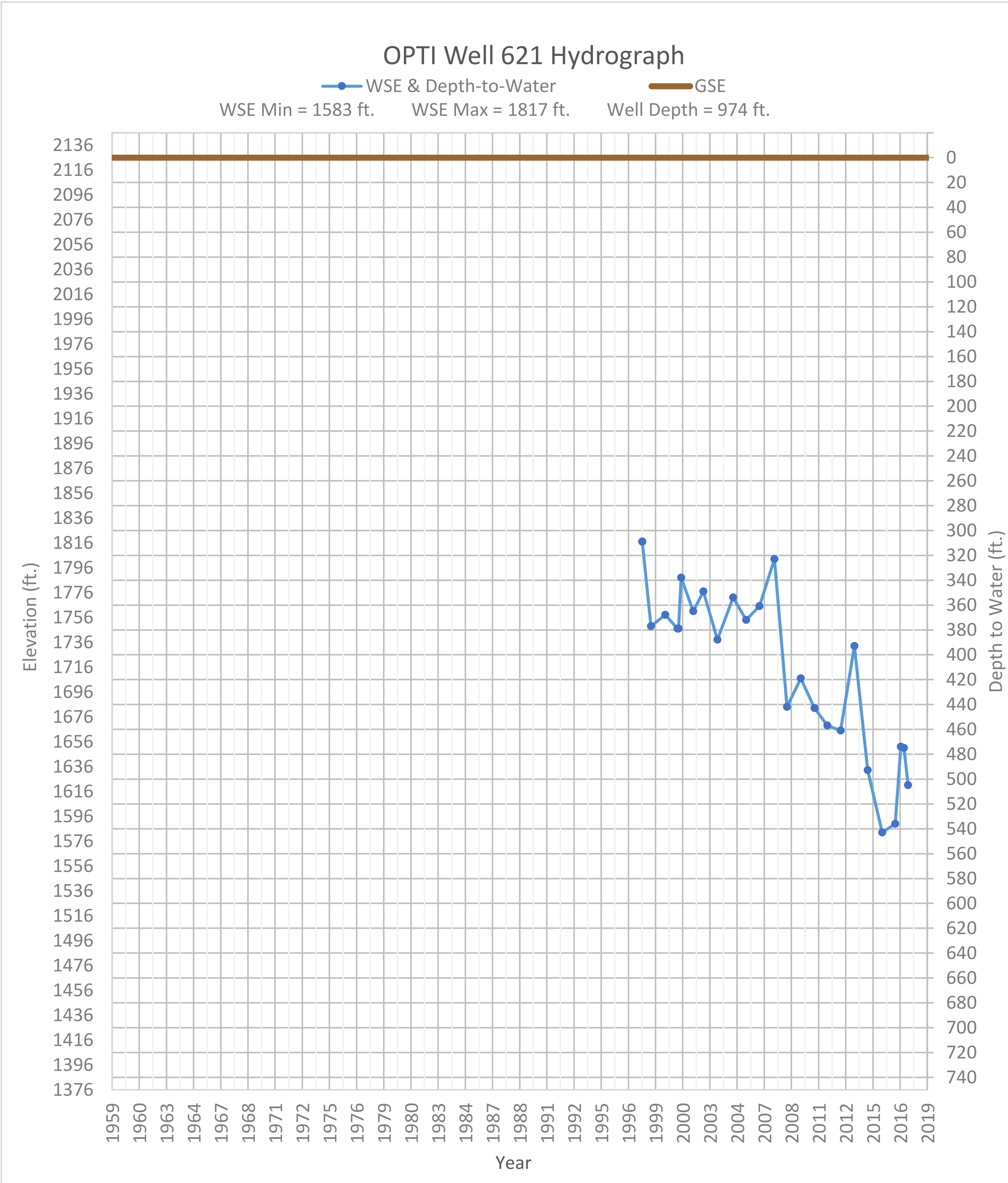
OPTI Well 617 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2760 ft.
WSE Max = 2852 ft.
Well Depth = 240 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

OPTI Well 618 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1613 ft.
WSE Max = 1894 ft.
Well Depth = 927 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 619 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1826 ft.
WSE Max = 1977 ft.
Well Depth = 1040 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 620 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1837 ft.
WSE Max = 1979 ft.
Well Depth = 1035 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 621 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1583 ft.
WSE Max = 1817 ft.
Well Depth = 974 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2136
2116
2096
2076
2056
2036
2016
1996
1976
1956
1936
1916
1896
1876
1856
1836
1816
1796
1776
1756
1736
1716
1696
1676
1656
1636
1616
1596
1576
1556
1536
1516
1496
1476
1456
1436
1416
1396
1376
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
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680
700
720
740
1959
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1996
1999
2000
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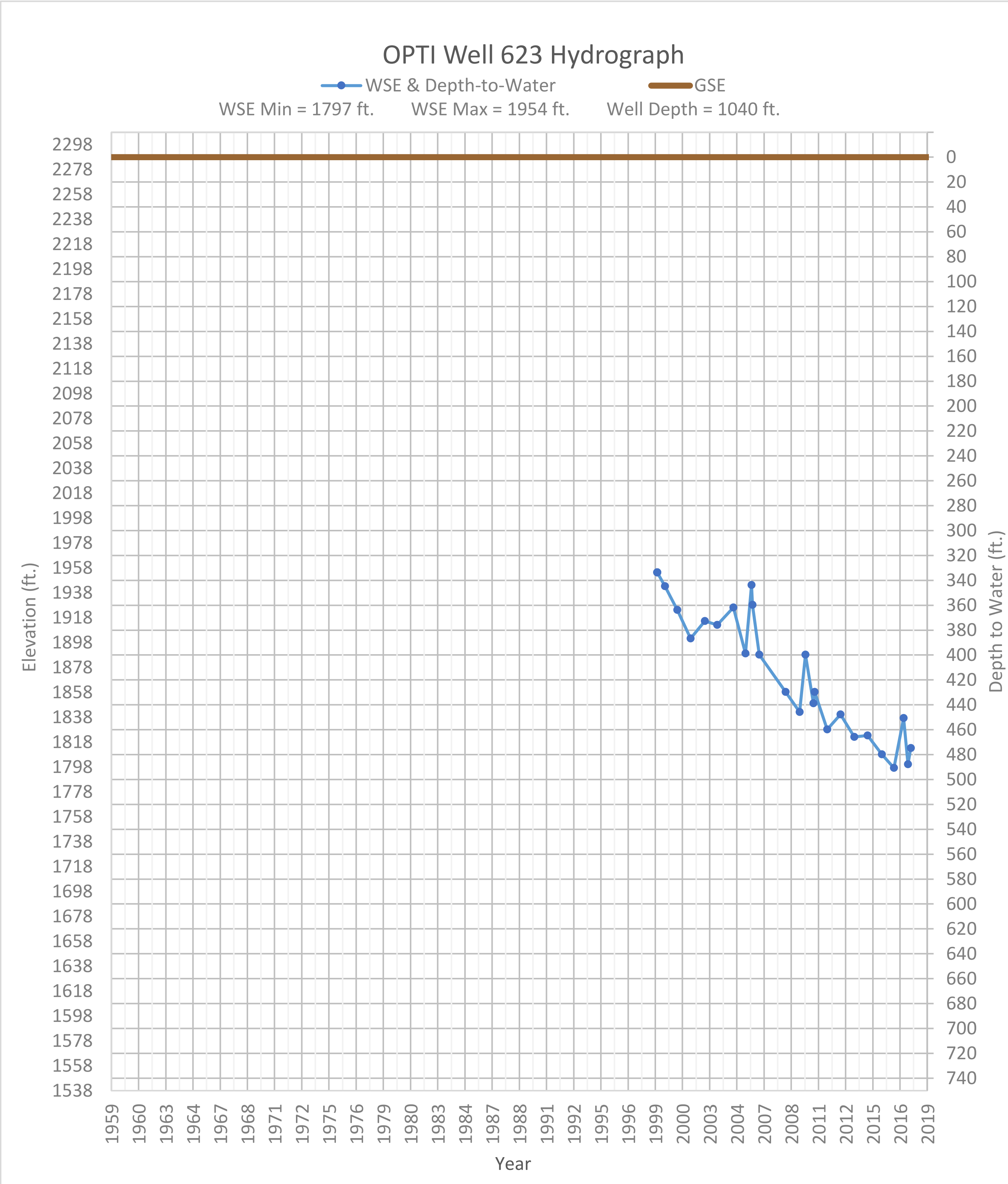
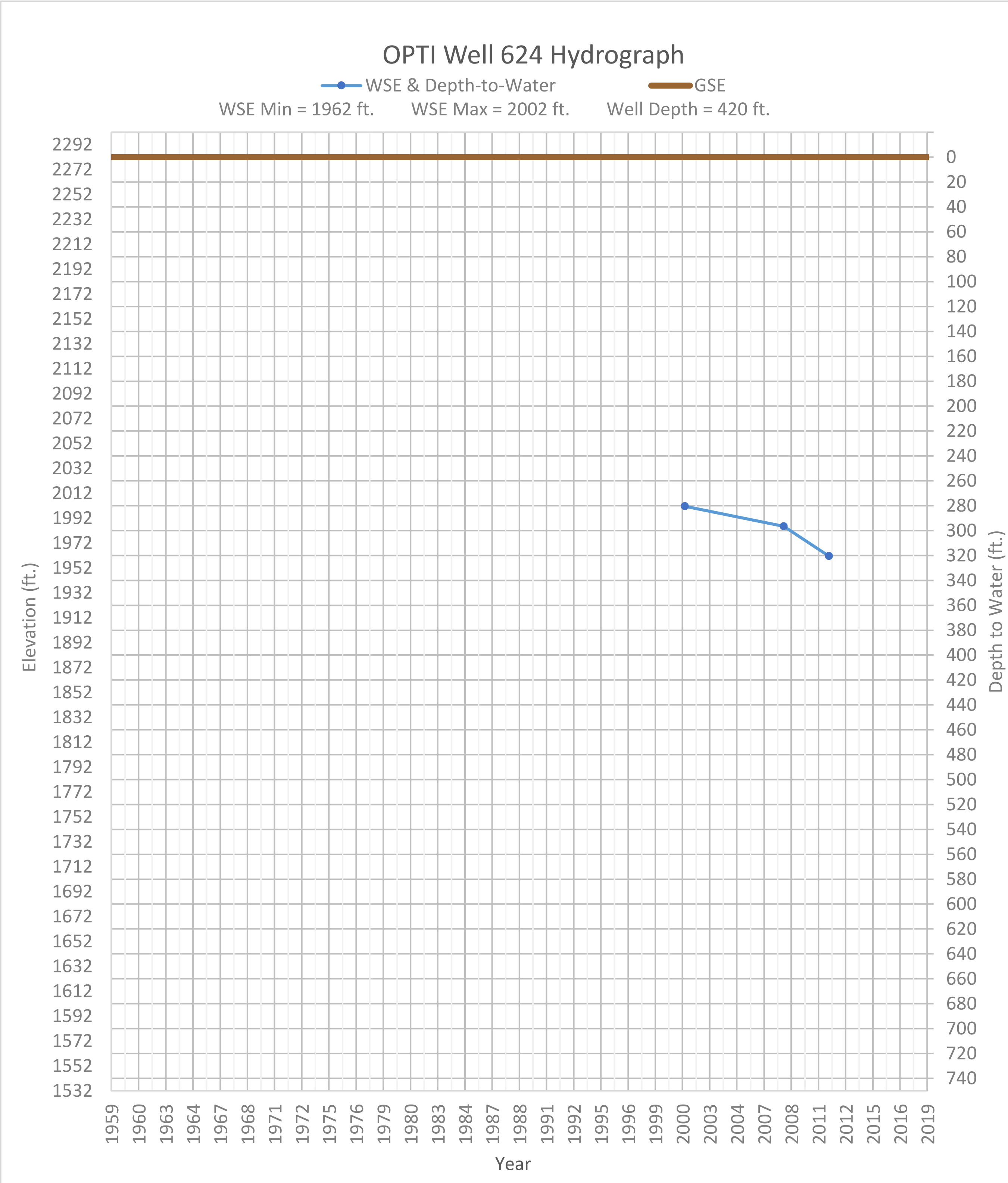
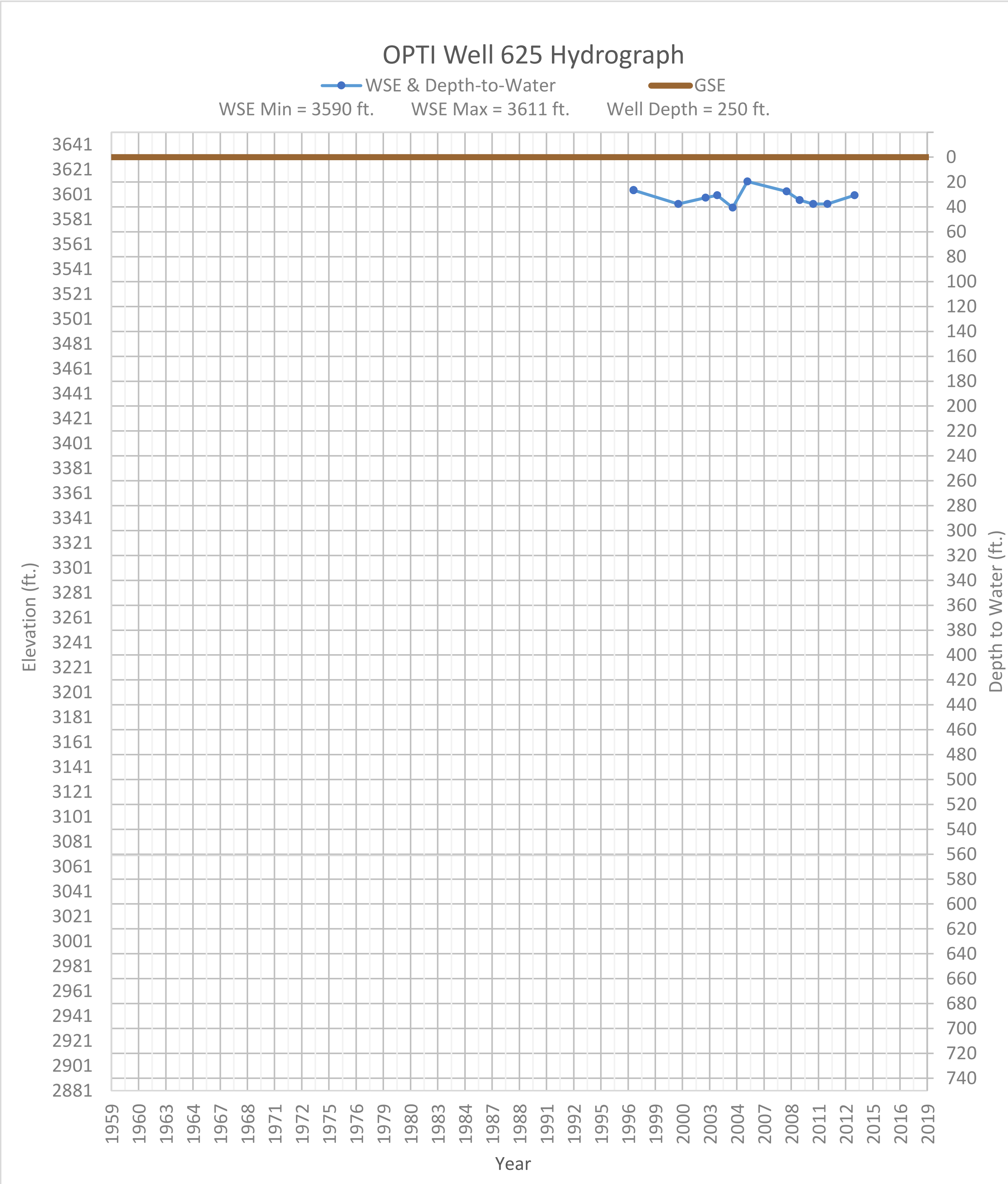
2004
2007
2008
2011
2012
2015
2016
2019

OPTI Well 622 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1794 ft.
WSE Max = 1952 ft.
Well Depth = 1200 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 623 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1797 ft.
WSE Max = 1954 ft.
Well Depth = 1040 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 624 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1962 ft.
WSE Max = 2002 ft.
Well Depth = 420 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 625 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3590 ft.
WSE Max = 3611 ft.
Well Depth = 250 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 626 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3636 ft.
WSE Max = 3652 ft.
Well Depth = 120 ft.
Elevation (ft.)
3685
3665
3645
3625
3605
3585
3565
3545
3525
3505
3485
3465
3445
3425
3405
3385
3365
3345
3325
3305
3285
3265
3245
3225
3205
3185
3165
3145
3125
3105
3085
3065
3045
3025
3005
2985
2965
2945
2925
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
Year
1959
1960
1963
1964
1967
1968
1971
1972
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1983
1984
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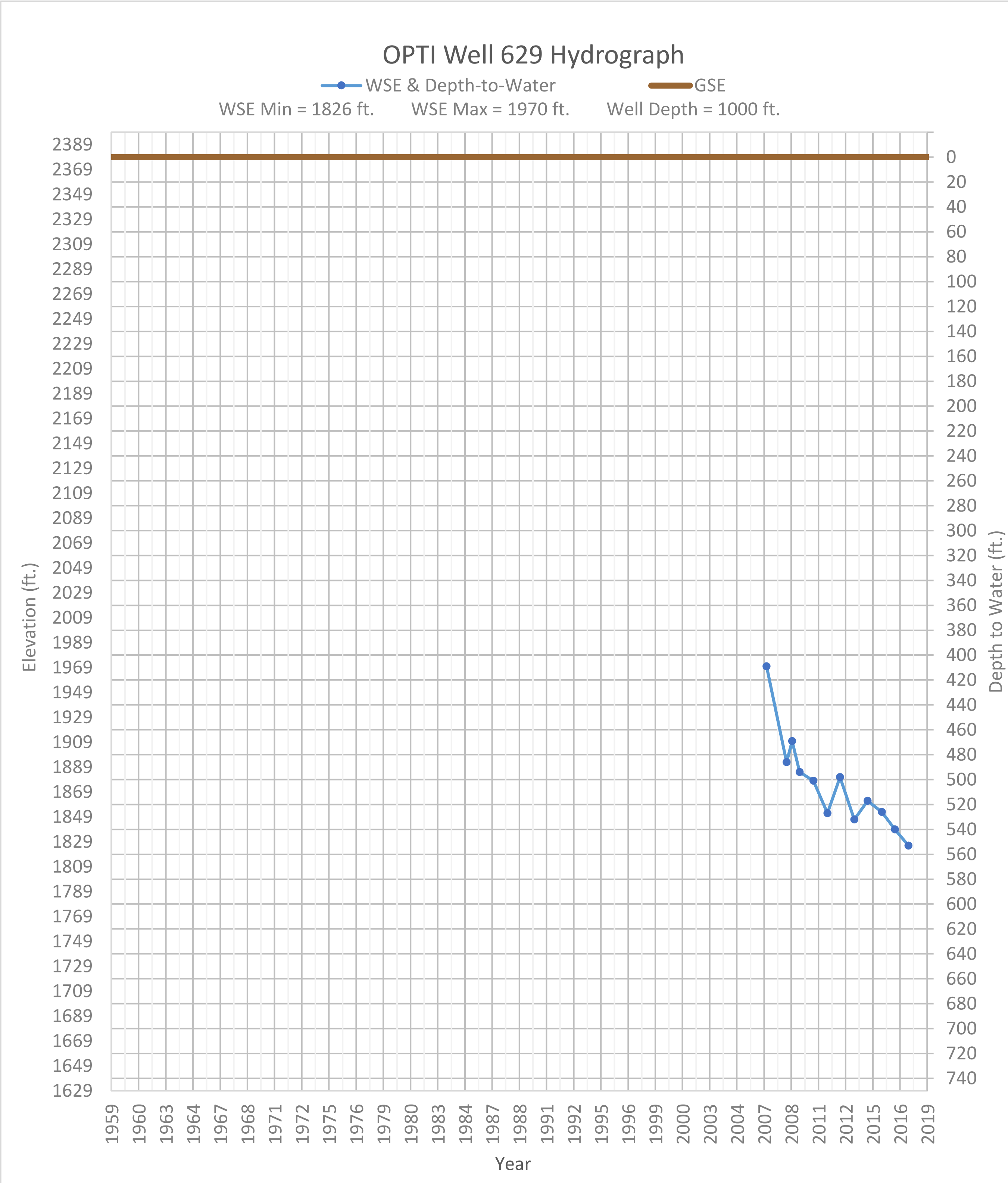
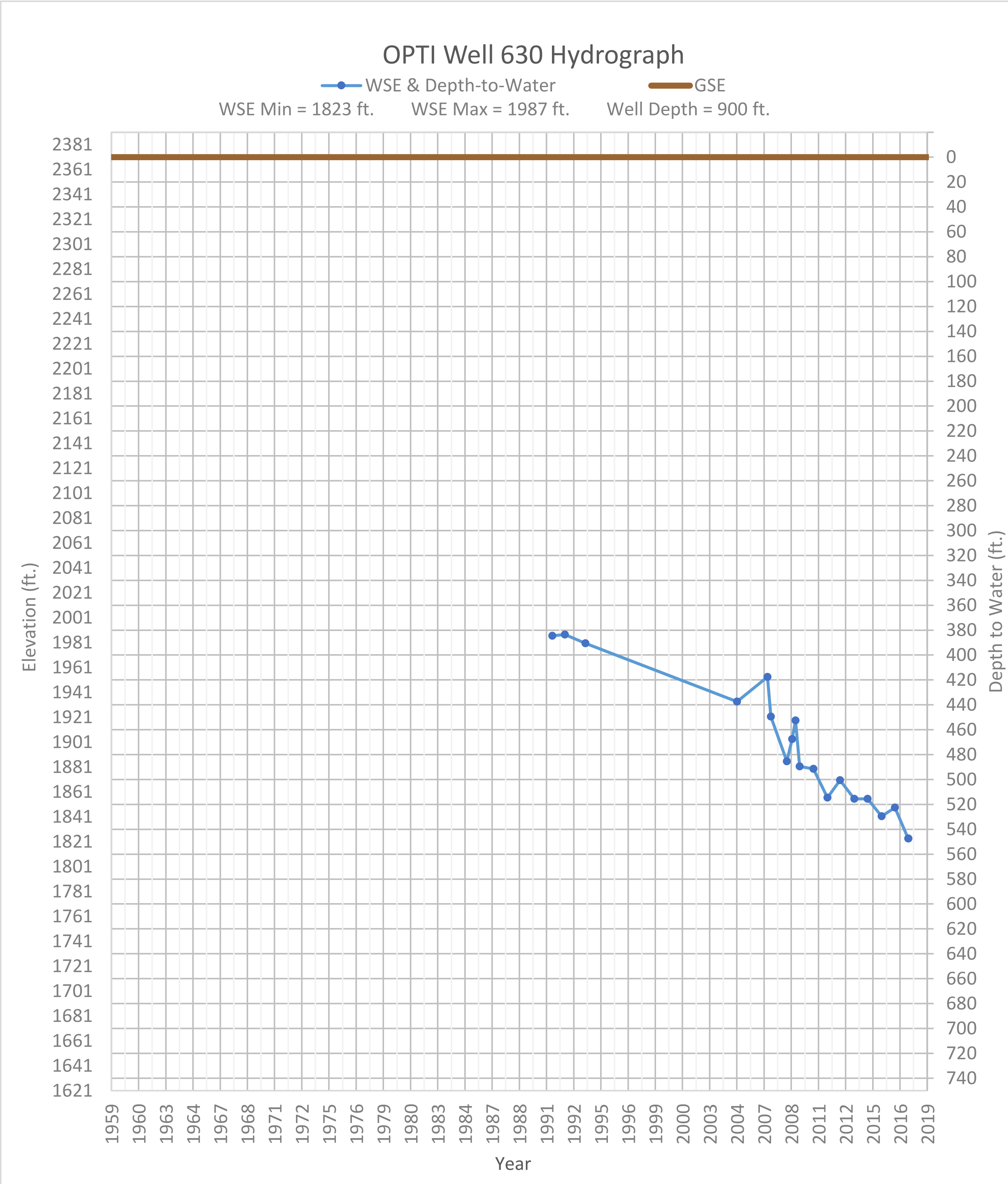
2008
2011
2012
2015
2016
2019


OPTI Well 627 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1730 ft.
WSE Max = 2076 ft.
Well Depth = 960 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

OPTI Well 628 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1792 ft.
WSE Max = 2078 ft.
Well Depth = 941 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

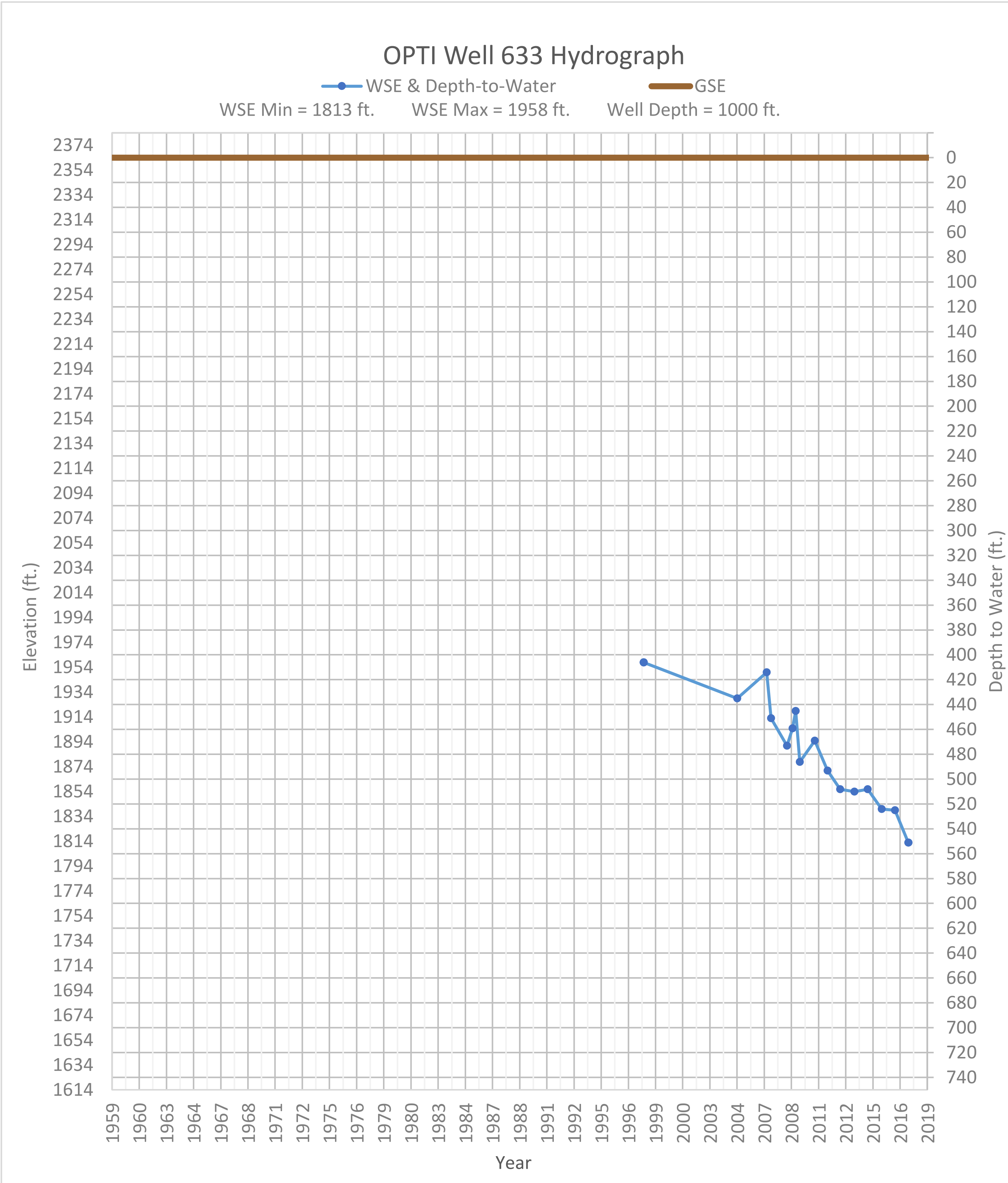

OPTI Well 629 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1826 ft.
WSE Max = 1970 ft.
Well Depth = 1000 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

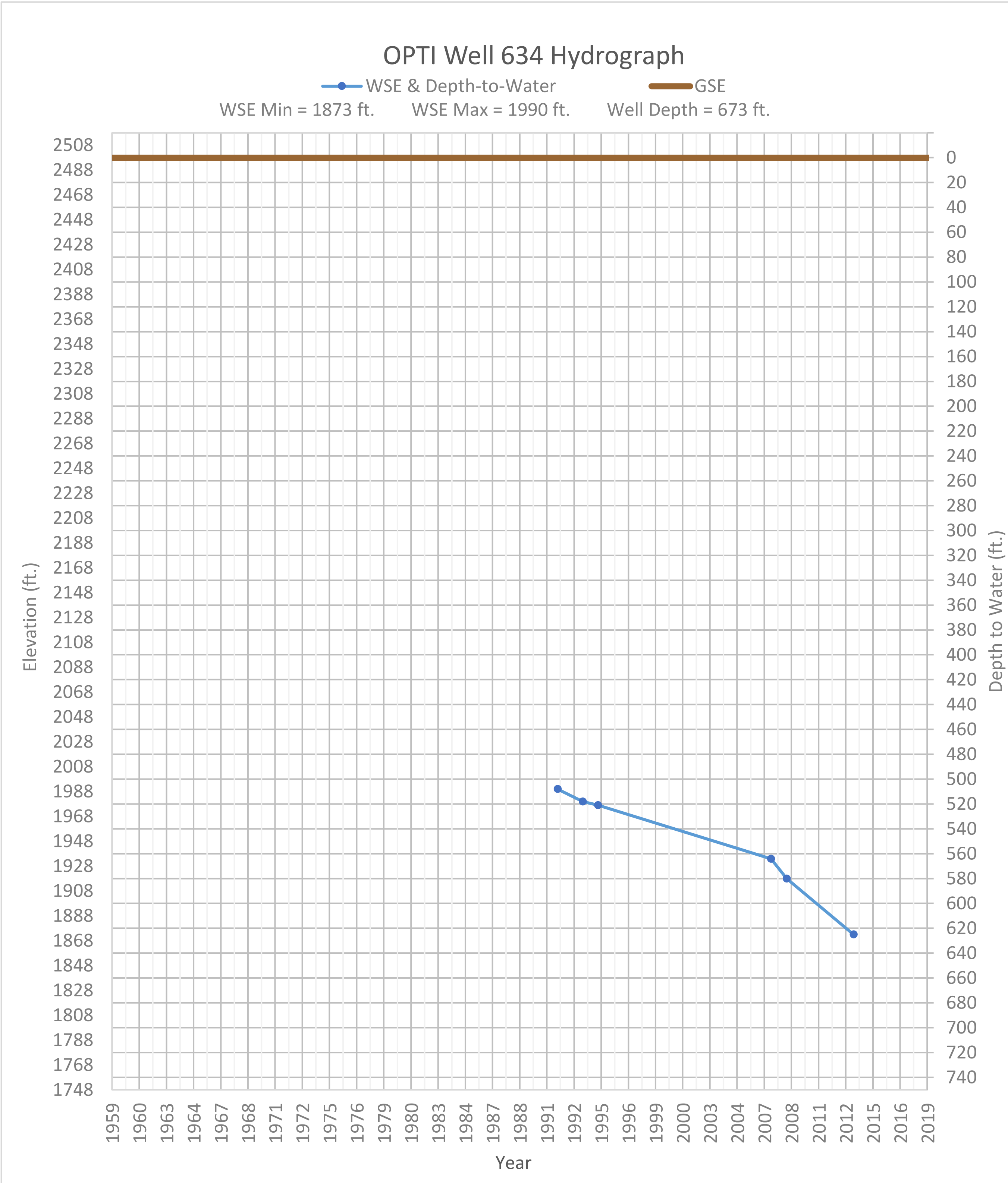


OPTI Well 630 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1823 ft.
WSE Max = 1987 ft.
Well Depth = 900 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

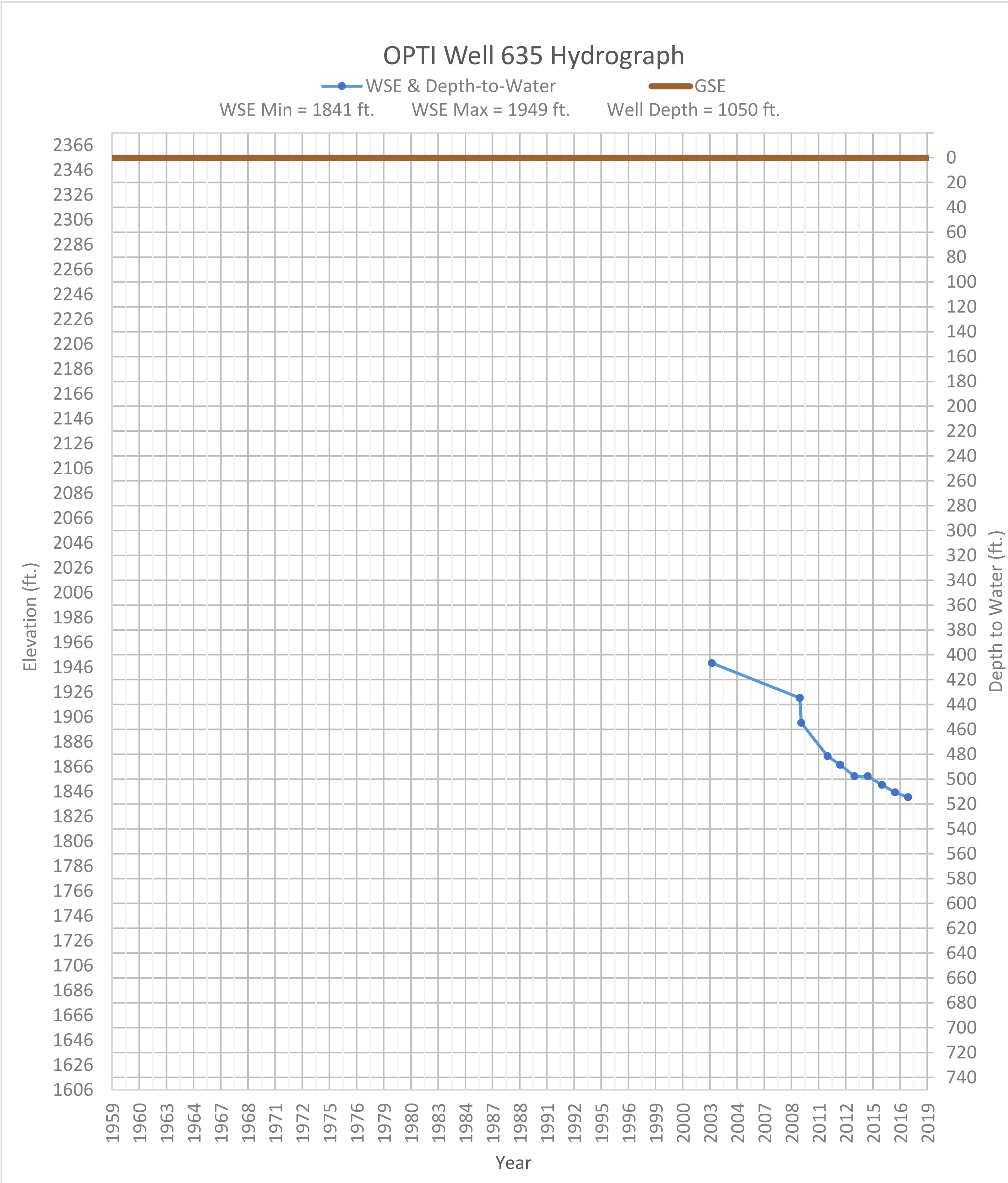
OPTI Well 631 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1830 ft.
WSE Max = 2033 ft.
Well Depth = 960 ft.
Elevation (ft.)
2377
2357
2337
2317
2297
2277
2257
2237
2217
2197
2177
2157
2137
2117
2097
2077
2057
2037
2017
1997
1977
1957
1937
1917
1897
1877
1857
1837
1817
1797
1777
1757
1737
1717
1697
1677
1657
1637
1617
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
Year
1959
1960
1963
1964
1967
1968
1971
1972
1975
1976
1979
1980
1983
1984
1987
1988
1991
1992
1995
1996
1999
2000
2003
2004
2007
2008
2011
2012
2015
2016
2019

OPTI Well 632 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1837 ft.
WSE Max = 2252 ft.
Well Depth = 960 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

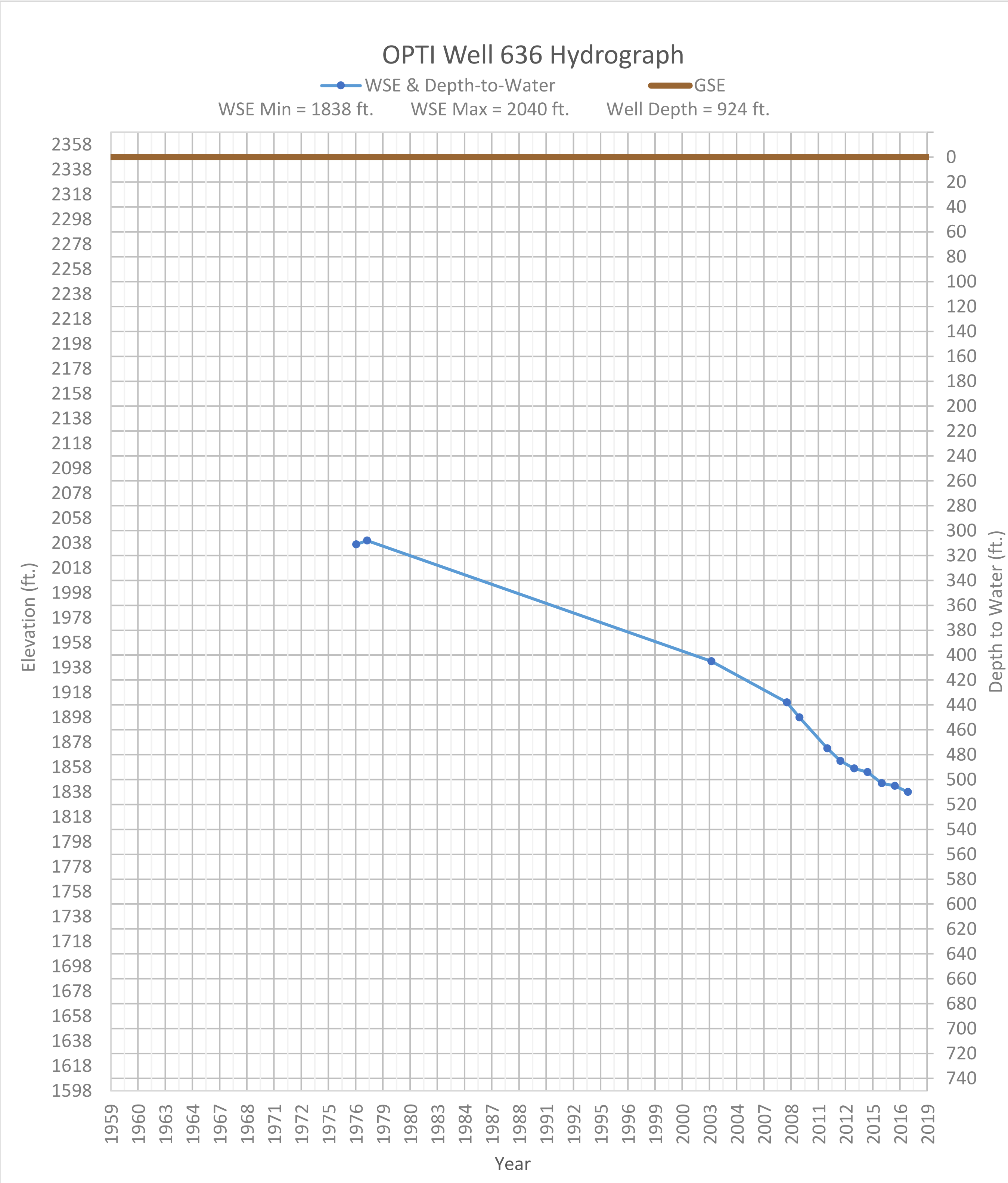

OPTI Well 633 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1813 ft.
WSE Max = 1958 ft.
Well Depth = 1000 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

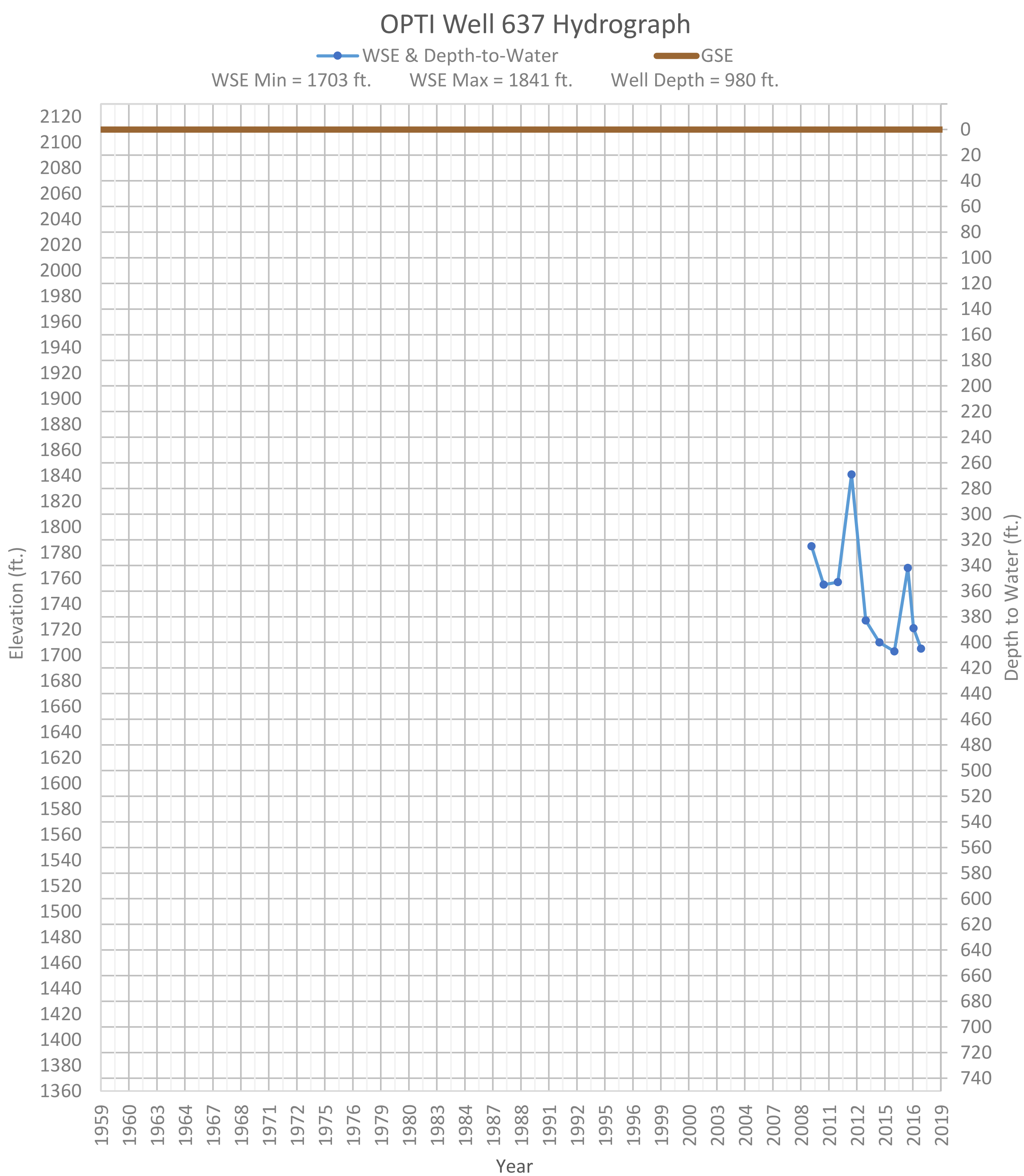


OPTI Well 634 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1873 ft.
WSE Max = 1990 ft.
Well Depth = 673 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

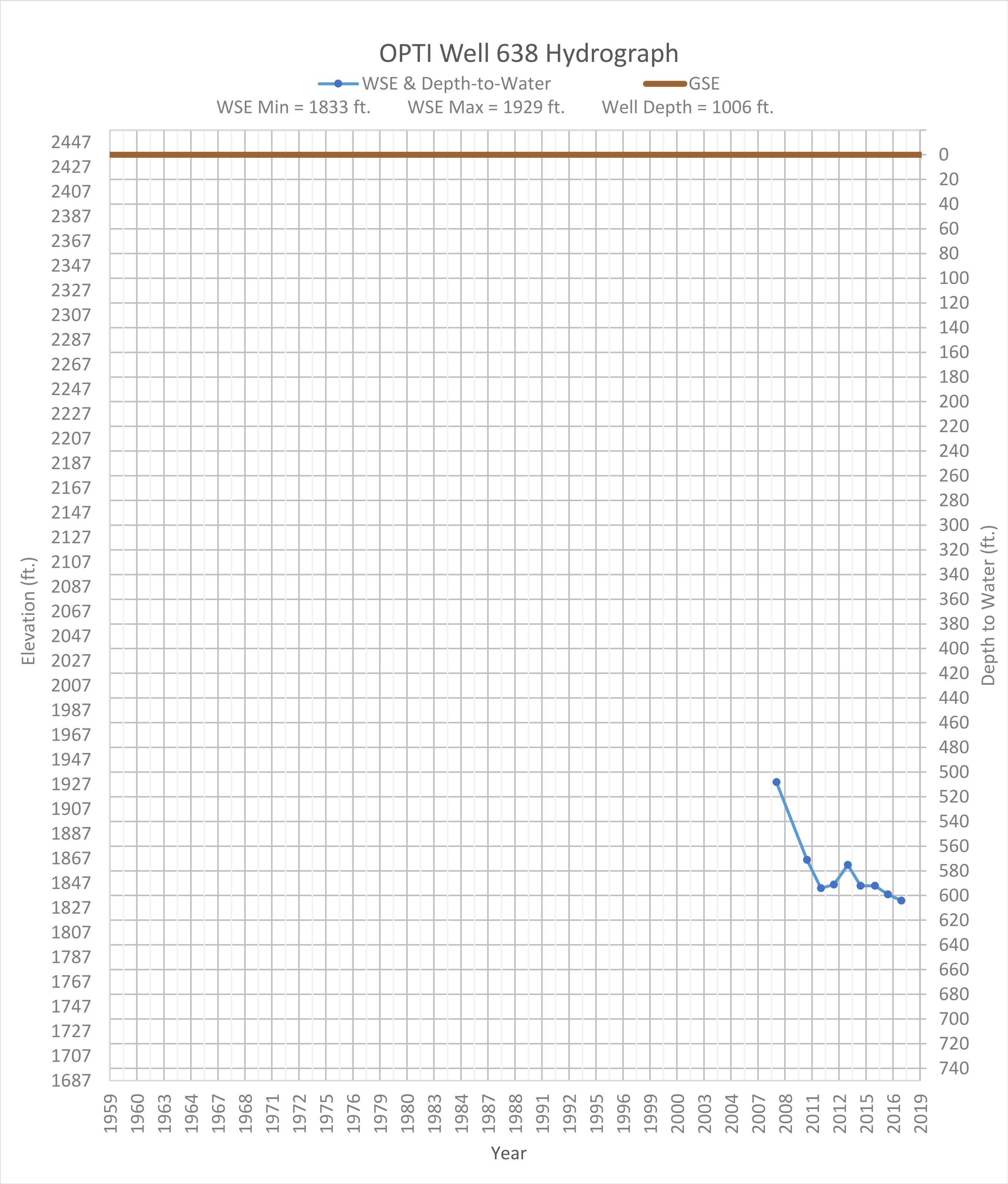


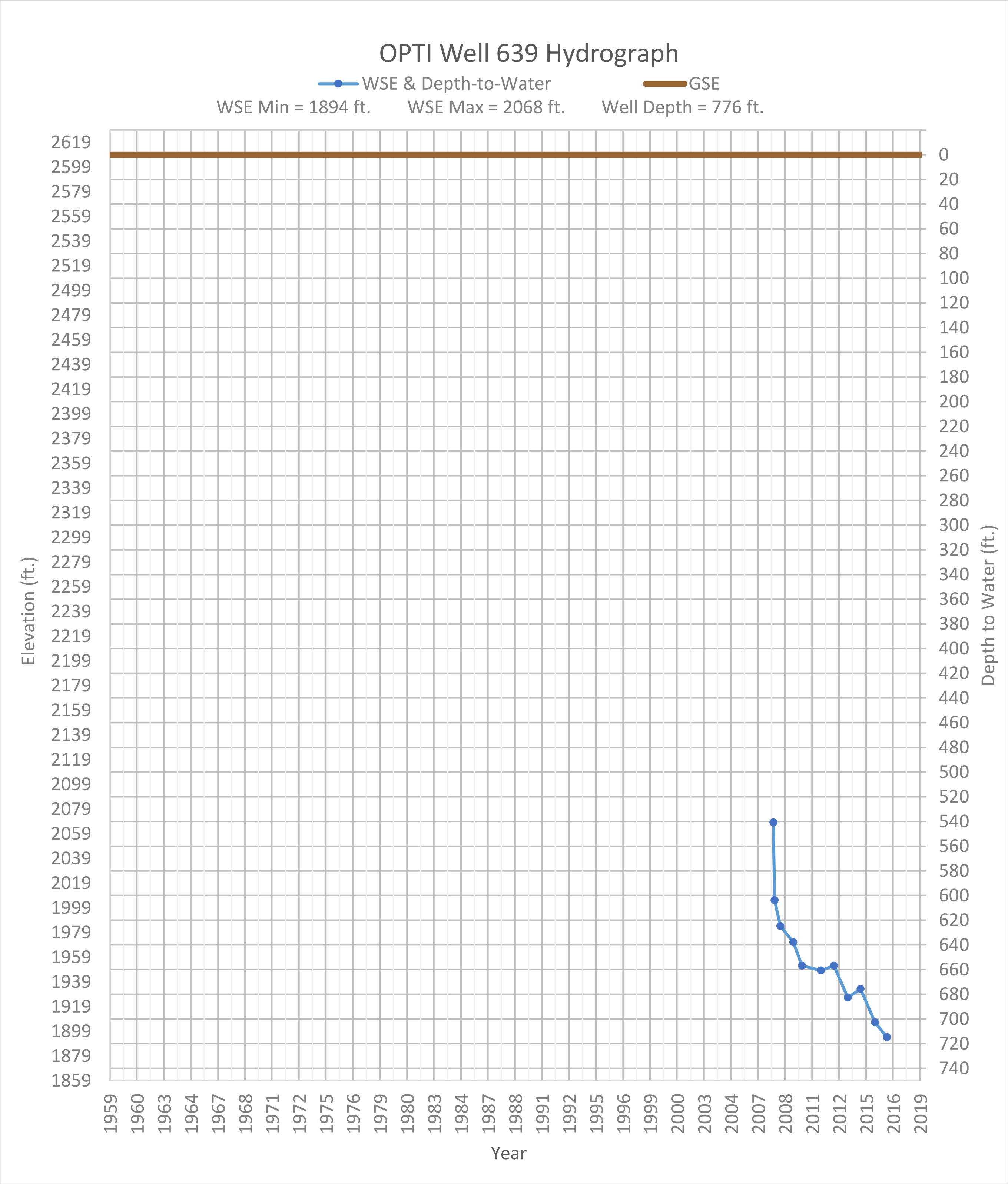
OPTI Well 635 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1841 ft.
WSE Max = 1949 ft.
Well Depth = 1050 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 636 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1838 ft.
WSE Max = 2040 ft.
Well Depth = 924 ft.
Elevation (ft.)
2358 2338 2318 2298 2278 2258 2238 2218 2198 2178 2158 2138 2118 2098 2078 2058 2038 2018 1998 1978 1958 1938 1918 1898 1878 1858 1838 1818 1798 1778 1758 1738 1718 1698 1678 1658 1638 1618 1598
Depth to Water (ft.)
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
Year
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019

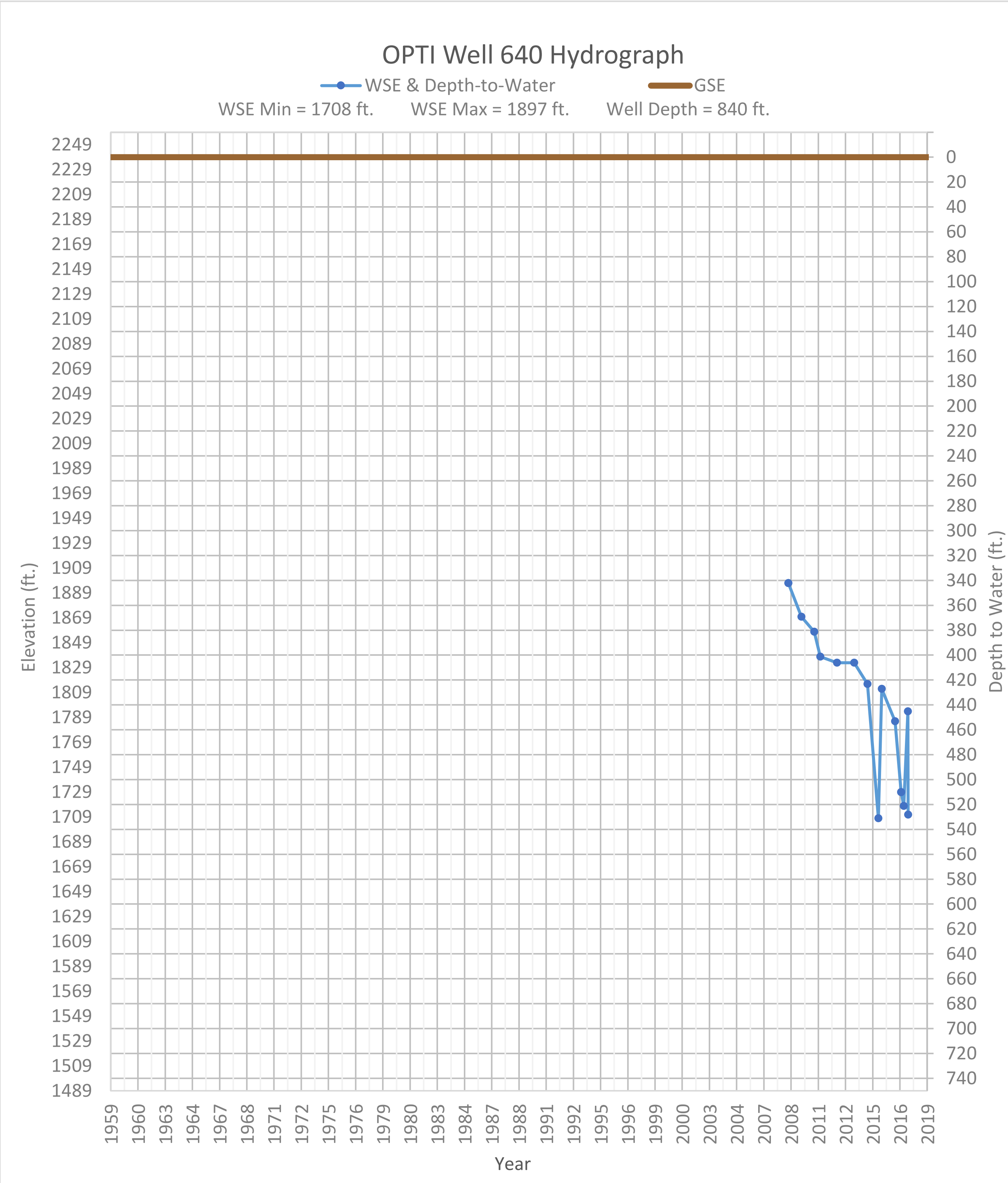


OPTI Well 637 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1703 ft.
WSE Max = 1841 ft.
Well Depth = 980 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 638 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1833 ft.
WSE Max = 1929 ft.
Well Depth = 1006 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 639 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1894 ft.
WSE Max = 2068 ft.
Well Depth = 776 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 640 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1708 ft.
WSE Max = 1897 ft.
Well Depth = 840 ft.
Elevation (ft.)
2249
2229
2209
2189
2169
2149
2129
2109
2089
2069
2049
2029
2009
1989
1969
1949
1929
1909
1889
1869
1849
1829
1809
1789
1769
1749
1729
1709
1689
1669
1649
1629
1609
1589
1569
1549
1529
1509
1489
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
Year
1959
1960
1963
1964
1967
1968
1971
1972
1975
1976
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1983
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1992
1995
1996
1999
2000
2003
2004
2007
2008
2011
2012
2015
2016
2019


OPTI Well 641 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1762 ft.
WSE Max = 1864 ft.
Well Depth = 800 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2214
2194
2174
2154
2134
2114
2094
2074
2054
2034
2014
1994
1974
1954
1934
1914
1894
1874
1854
1834
1814
1794
1774
1754
1734
1714
1694
1674
1654
1634
1614
1594
1574
1554
1534
1514
1494
1474
1454
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
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680
700
720
740
1959
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1996
1999
2000
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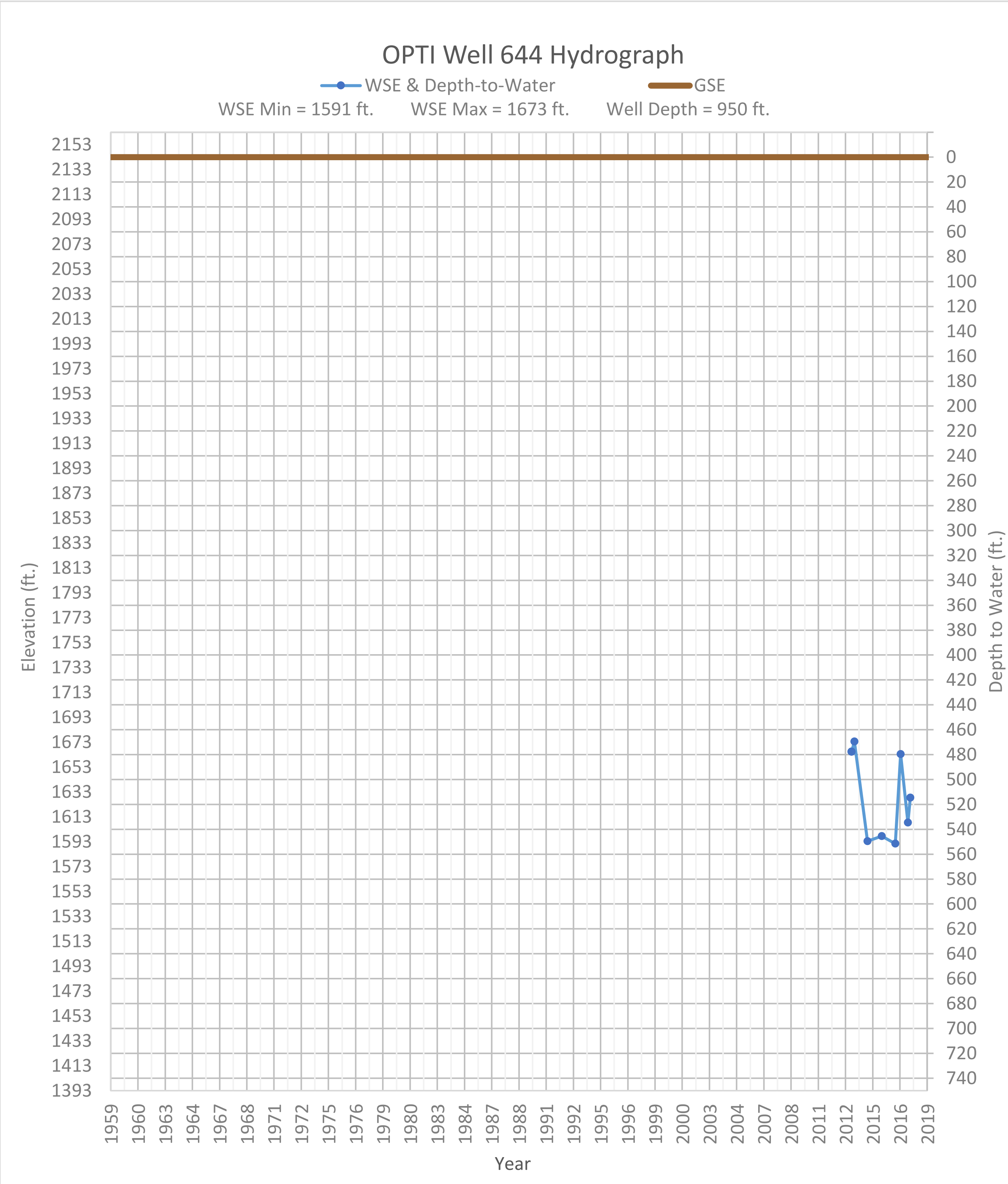
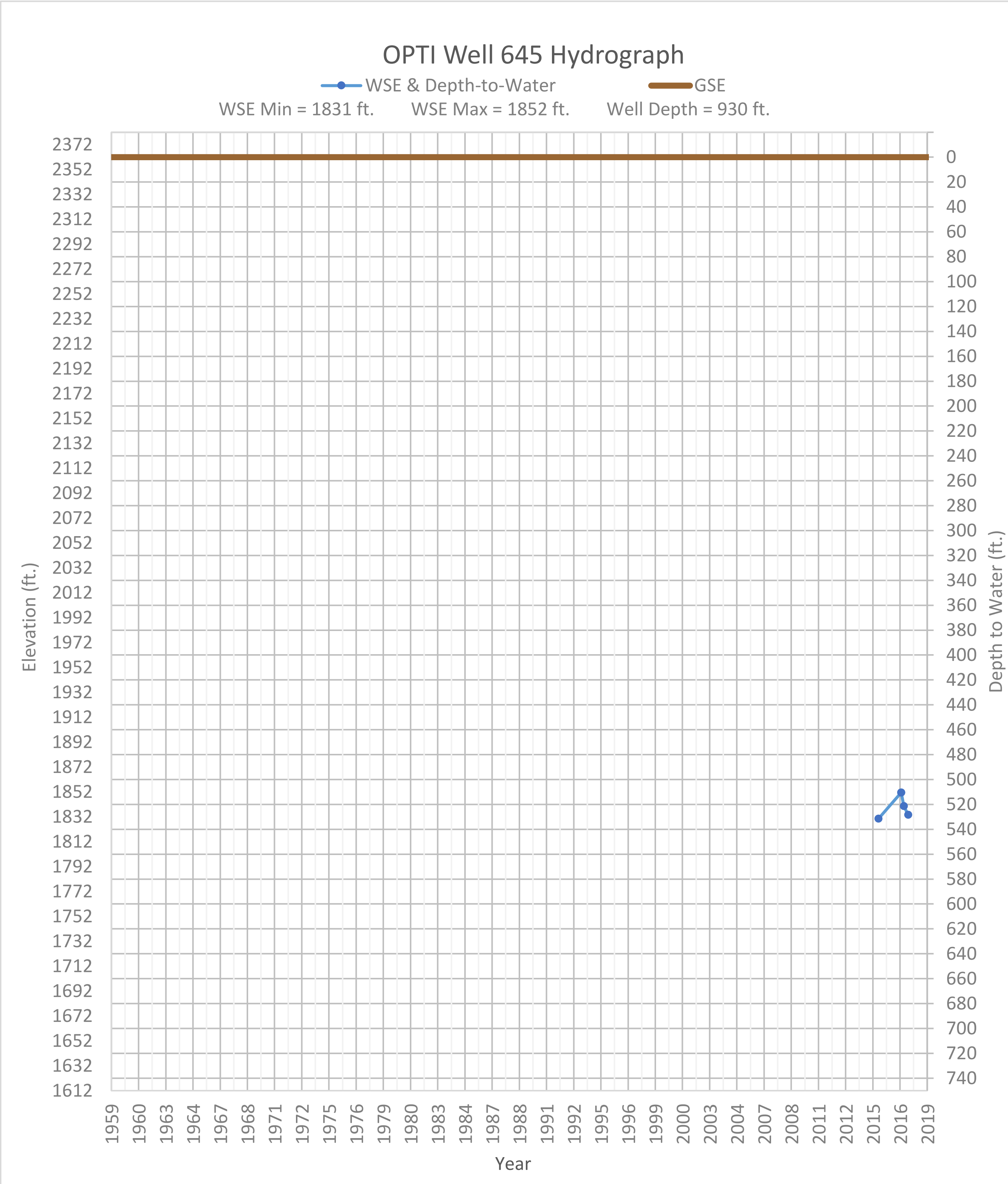
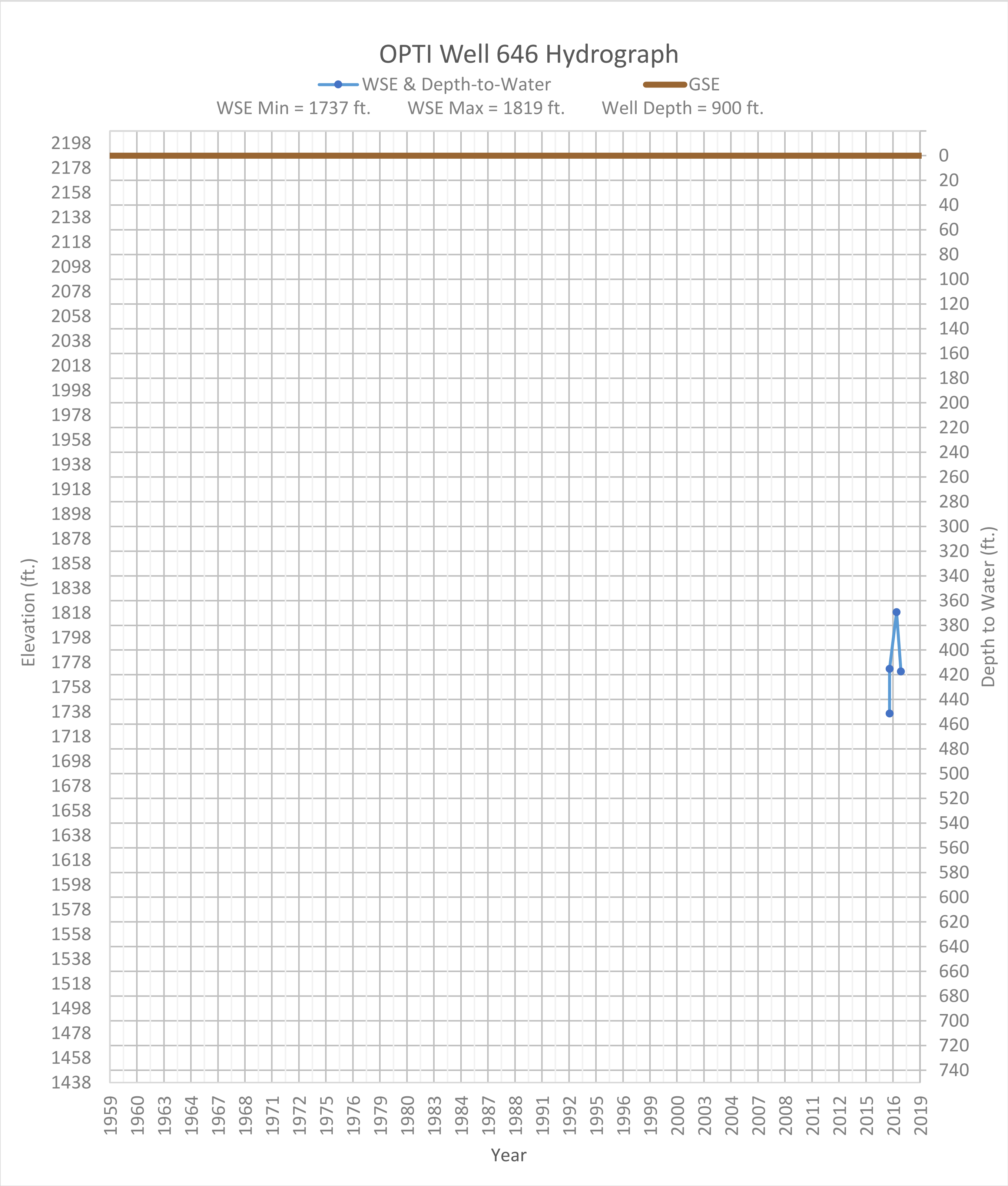
2004
2007
2008
2011
2012
2015
2016
2019

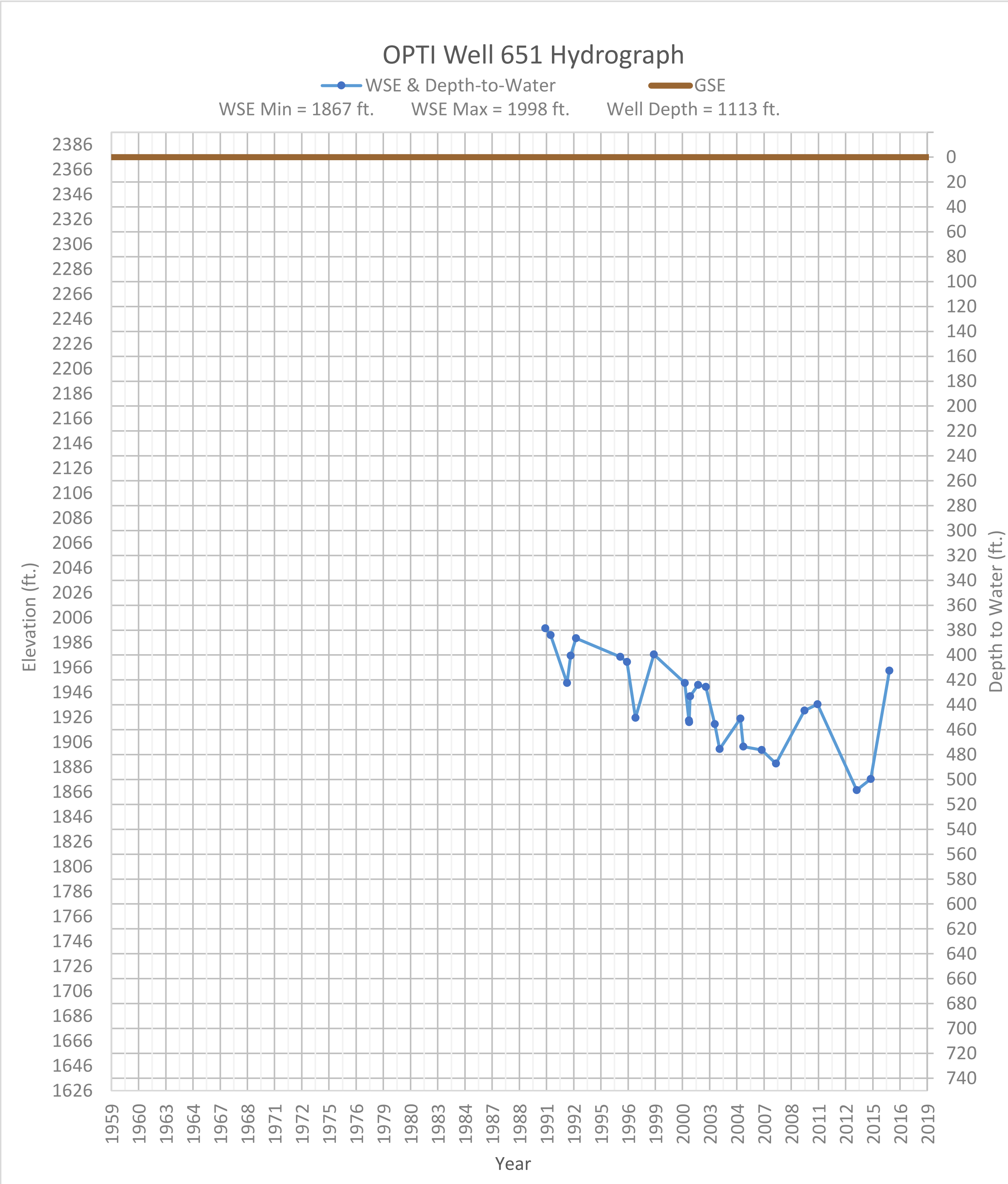
OPTI Well 642 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1745 ft.
WSE Max = 1907 ft.
Well Depth = 1000 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

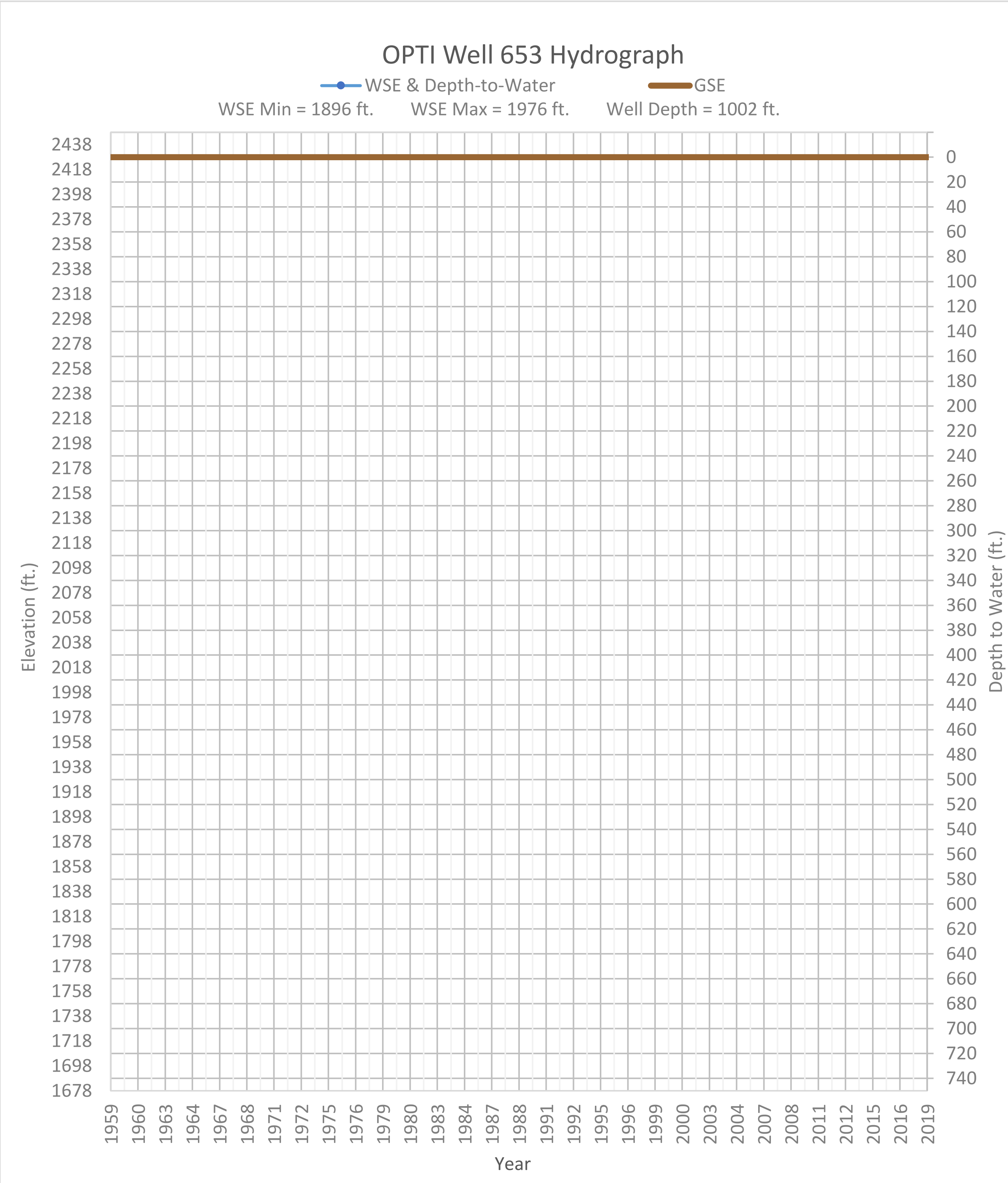


OPTI Well 644 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1591 ft.
WSE Max = 1673 ft.
Well Depth = 950 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 645 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1831 ft.
WSE Max = 1852 ft.
Well Depth = 930 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 646 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1737 ft.
WSE Max = 1819 ft.
Well Depth = 900 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 651 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1867 ft.
WSE Max = 1998 ft.
Well Depth = 1113 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 653 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1896 ft.
WSE Max = 1976 ft.
Well Depth = 1002 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2438
2418
2398
2378
2358
2338
2318
2298
2278
2258
2238
2218
2198
2178
2158
2138
2118
2098
2078
2058
2038
2018
1998
1978
1958
1938
1918
1898
1878
1858
1838
1818
1798
1778
1758
1738
1718
1698
1678
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
1959
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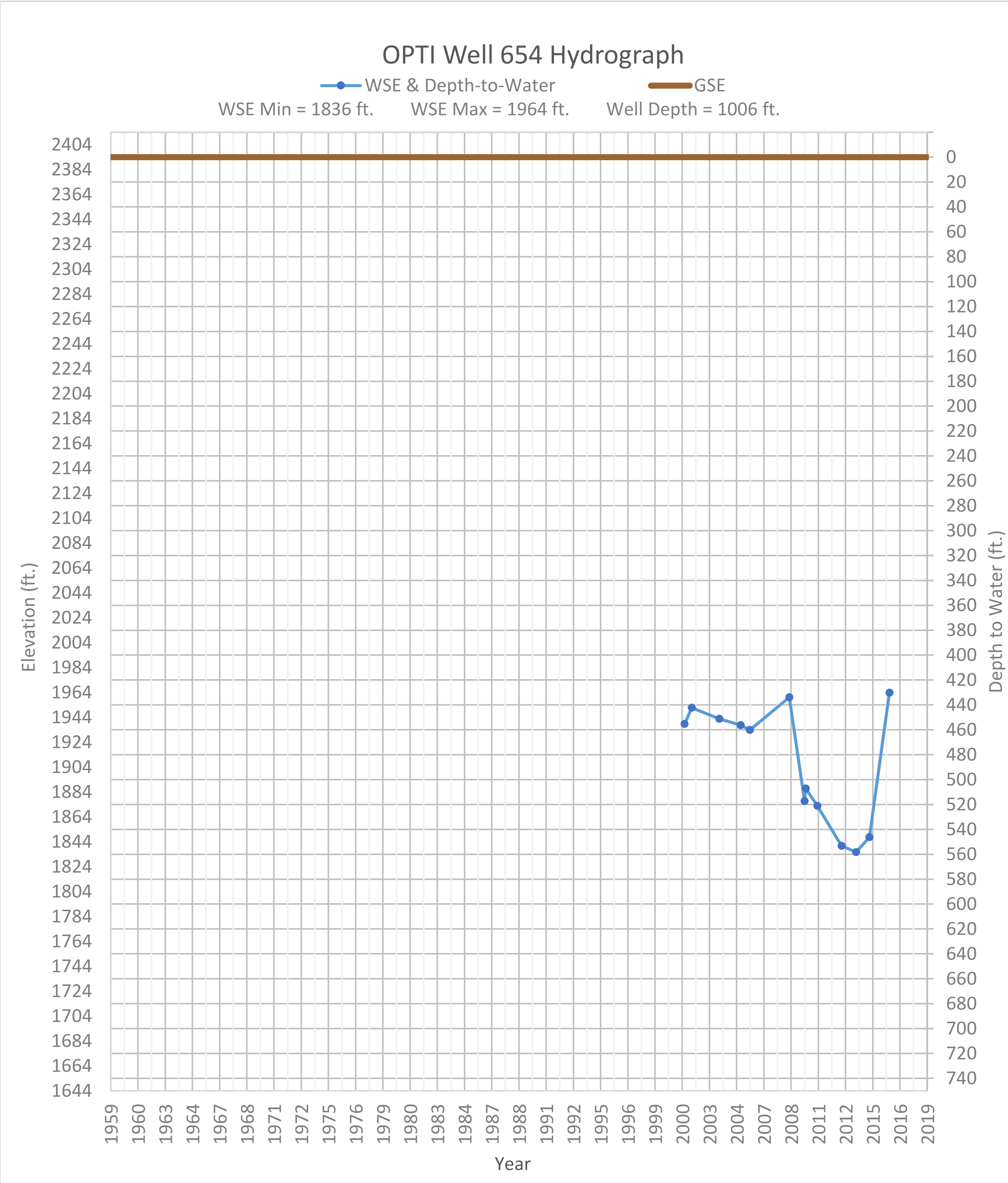
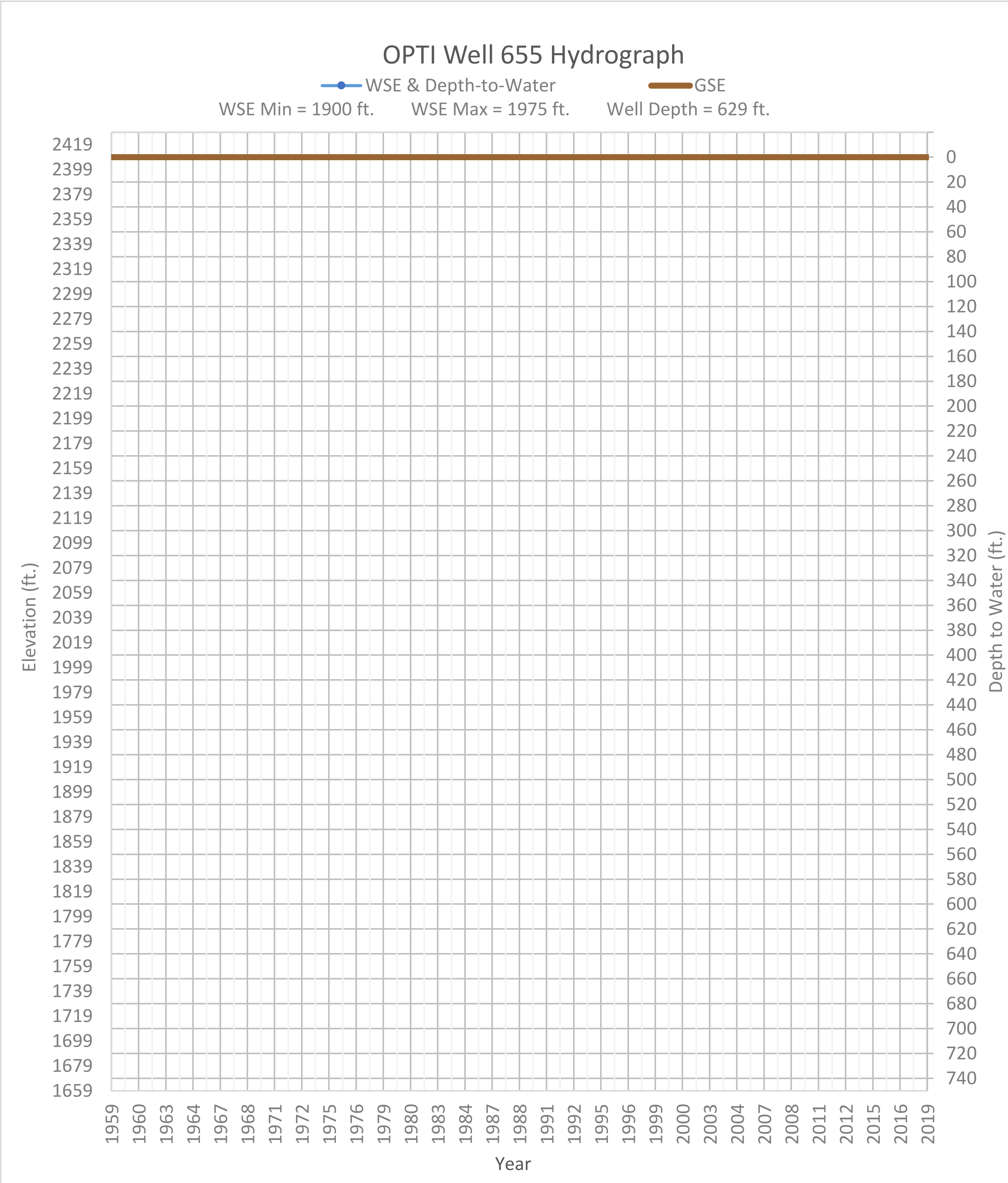
2016
2019



OPTI Well 654 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1836 ft.
WSE Max = 1964 ft.
Well Depth = 1006 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 655 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1900 ft.
WSE Max = 1975 ft.
Well Depth = 629 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2419
2399
2379
2359
2339
2319
2299
2279
2259
2239
2219
2199
2179
2159
2139
2119
2099
2079
2059
2039
2019
1999
1979
1959
1939
1919
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1659
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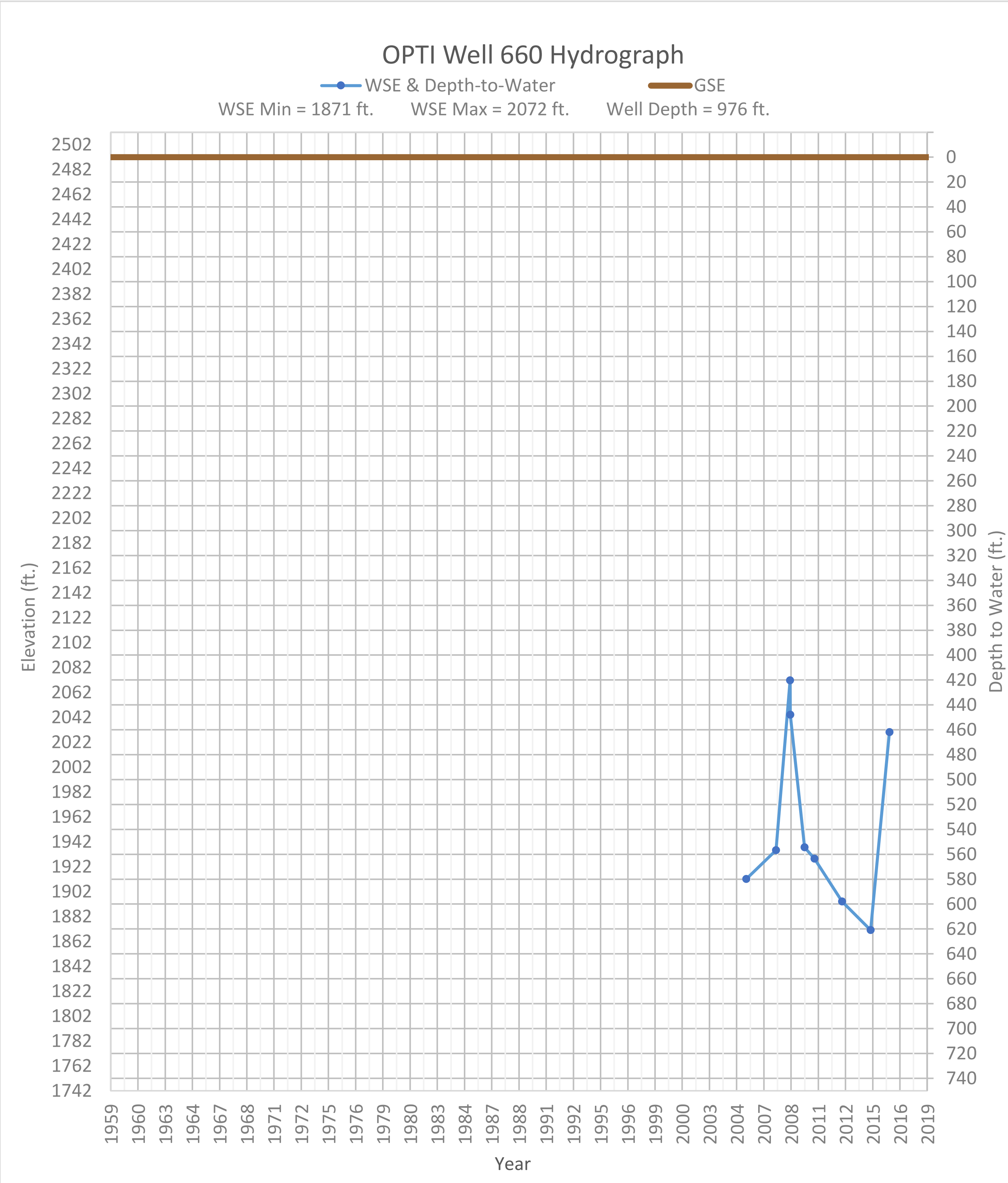
2016
2019

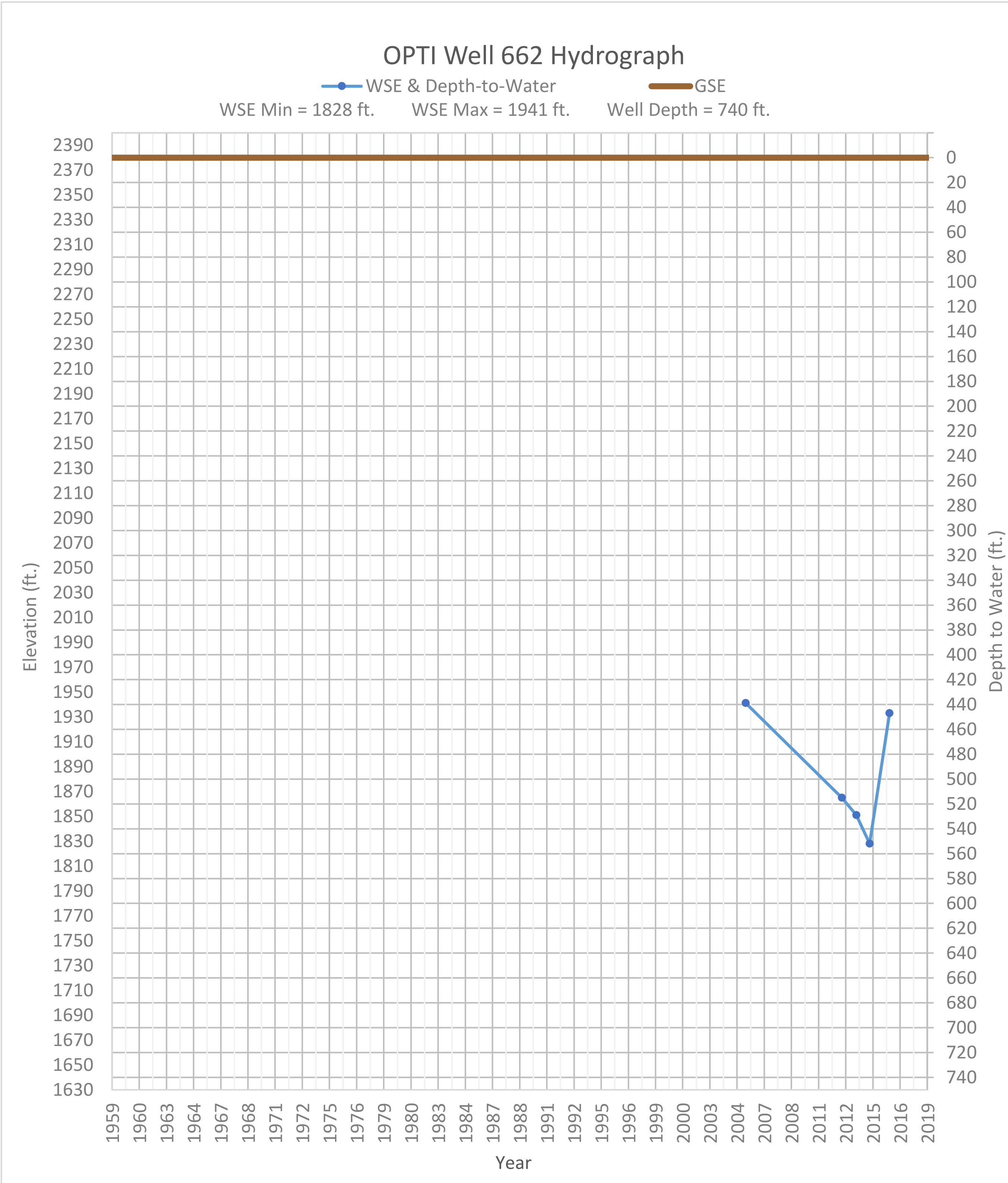

OPTI Well 656 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1916 ft.
WSE Max = 1979 ft.
Well Depth = 930 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

OPTI Well 657 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1804 ft.
WSE Max = 2000 ft.
Well Depth = 932 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2355 2335 2315 2295 2275 2255 2235 2215 2195 2175 2155 2135 2115 2095 2075 2055 2035 2015 1995 1975 1955 1935 1915 1895 1875 1855 1835 1815 1795 1775 1755 1735 1715 1695 1675 1655 1635 1615 1595
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019

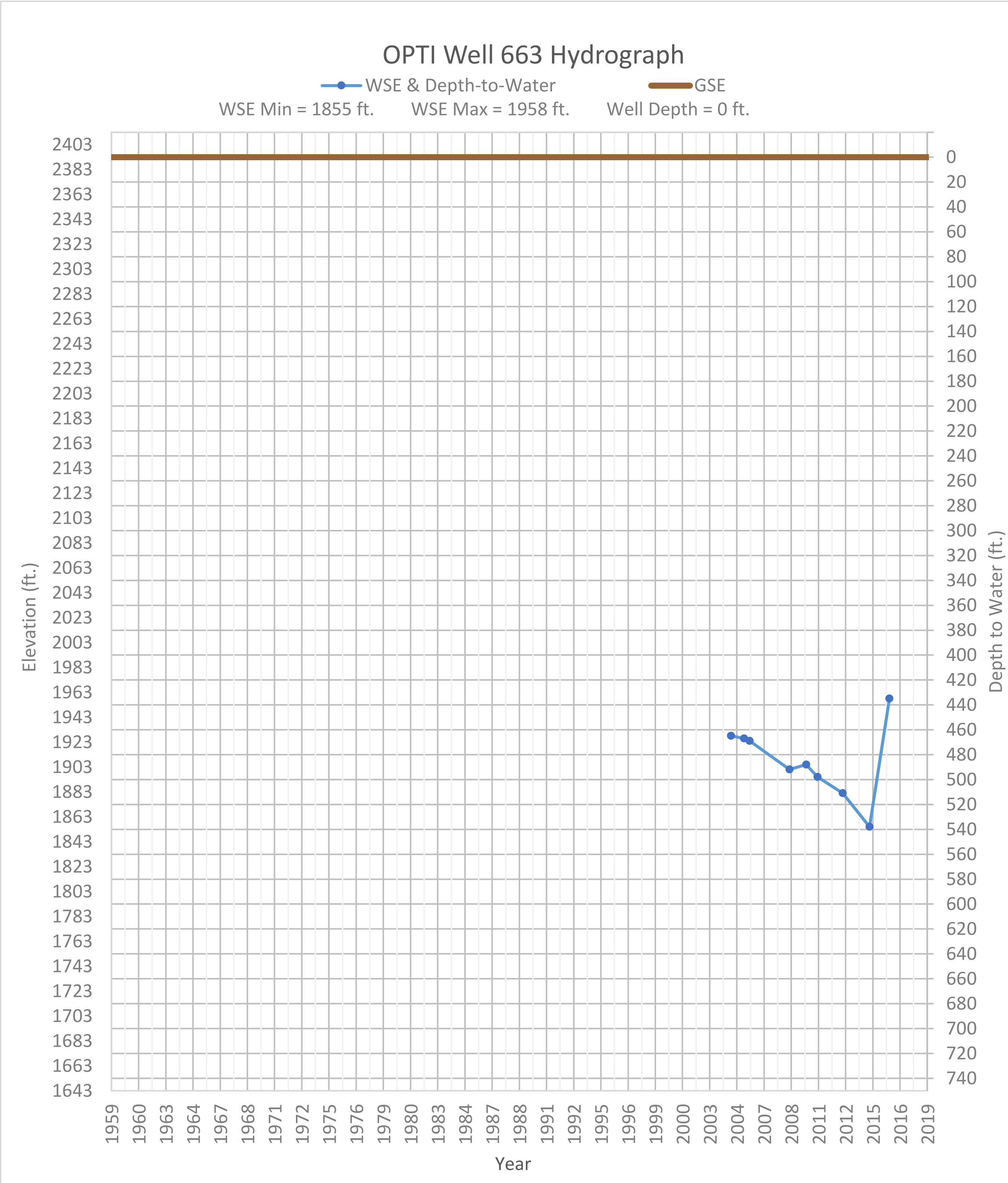
OPTI Well 659 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1861 ft.
WSE Max = 1962 ft.
Well Depth = 869 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 660 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1871 ft.
WSE Max = 2072 ft.
Well Depth = 976 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

OPTI Well 661 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1875 ft.
WSE Max = 2002 ft.
Well Depth = 1000 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 662 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1828 ft.
WSE Max = 1941 ft.
Well Depth = 740 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2390 2370 2350 2330 2310 2290 2270 2250 2230 2210 2190 2170 2150 2130 2110 2090 2070 2050 2030 2010 1990 1970 1950 1930 1910 1890 1870 1850 1830 1810 1790 1770 1750 1730 1710 1690 1670 1650 1630
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019


OPTI Well 663 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1855 ft.
WSE Max = 1958 ft.
Well Depth = 0 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2403
2383
2363
2343
2323
2303
2283
2263
2243
2223
2203
2183
2163
2143
2123
2103
2083
2063
2043
2023
2003
1983
1963
1943
1923
1903
1883
1863
1843
1823
1803
1783
1763
1743
1723
1703
1683
1663
1643
0
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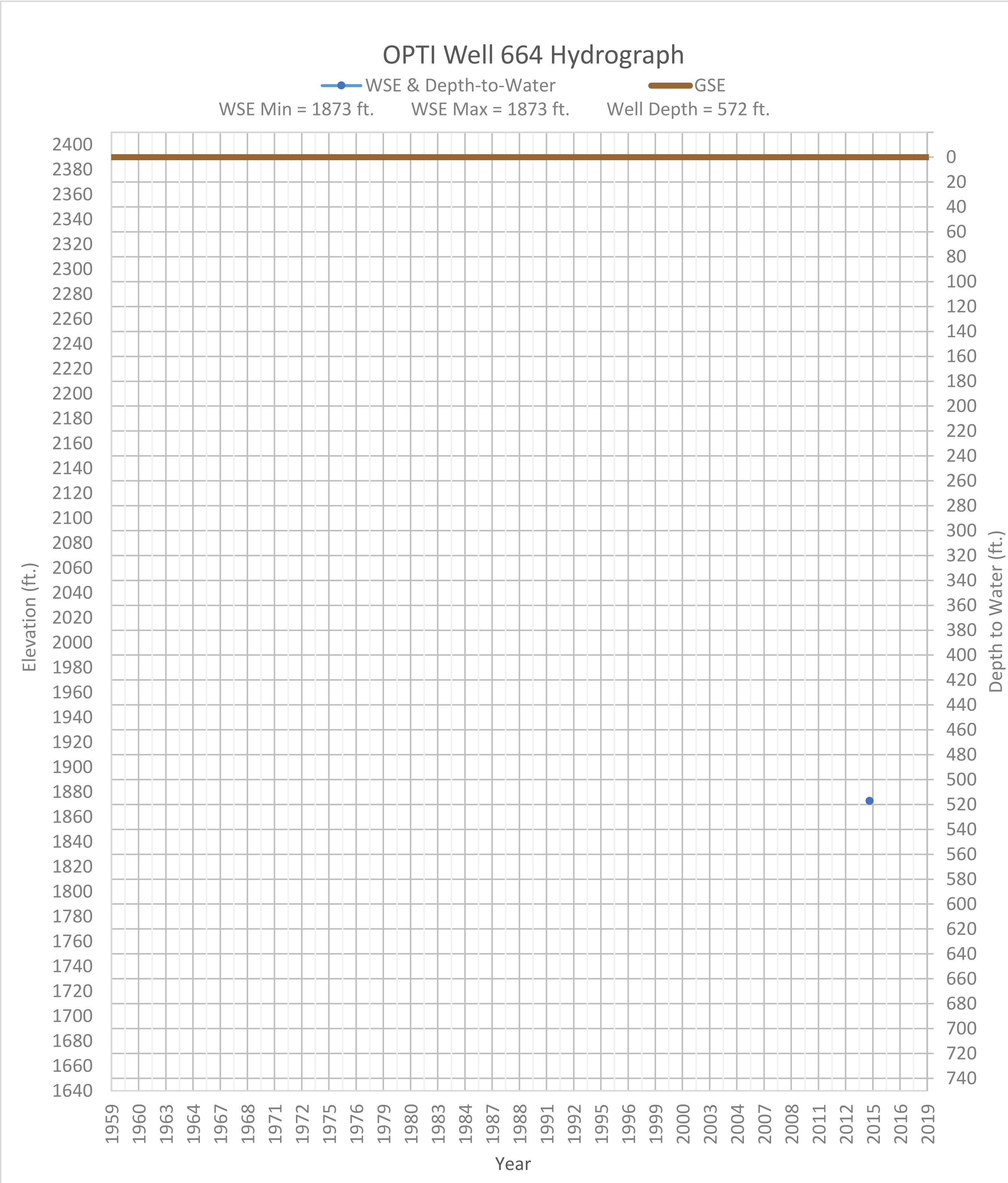

OPTI Well 664 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1873 ft.
WSE Max = 1873 ft.
Well Depth = 572 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2400
2380
2360
2340
2320
2300
2280
2260
2240
2220
2200
2180
2160
2140
2120
2100
2080
2060
2040
2020
2000
1980
1960
1940
1920
1900
1880
1860
1840
1820
1800
1780
1760
1740
1720
1700
1680
1660
1640
0
20
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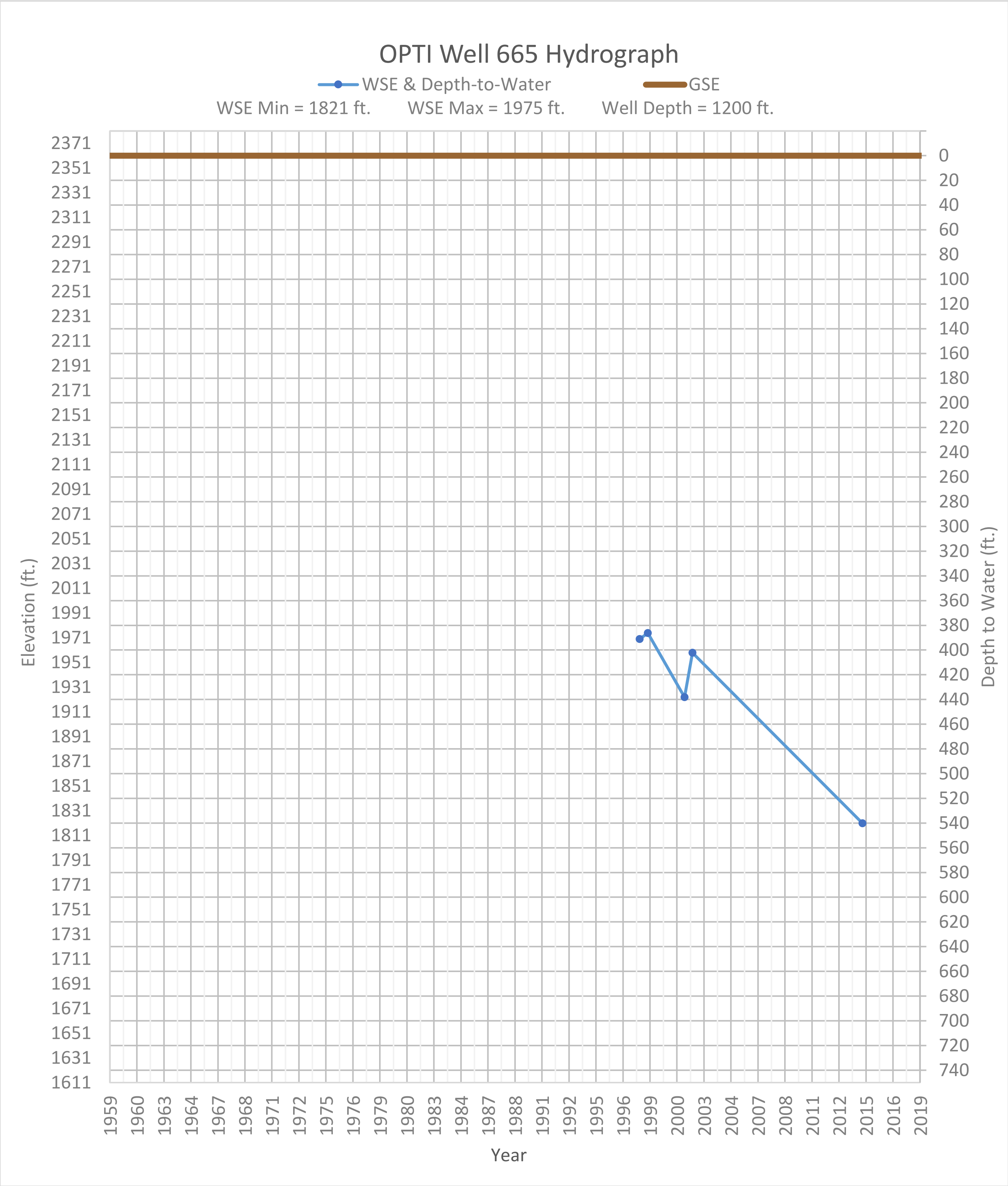
OPTI Well 665 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1821 ft.
WSE Max = 1975 ft.
Well Depth = 1200 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

OPTI Well 666 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1910 ft.
WSE Max = 1972 ft.
Well Depth = 1157 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

OPTI Well 667 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1829 ft.
WSE Max = 2219 ft.
Well Depth = 1083 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2326
2306
2286
2266
2246
2226
2206
2186
2166
2146
2126
2106
2086
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
1786
1766
1746
1726
1706
1686
1666
1646
1626
1606
1586
1566
0
20
40
60
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120
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160
180
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240
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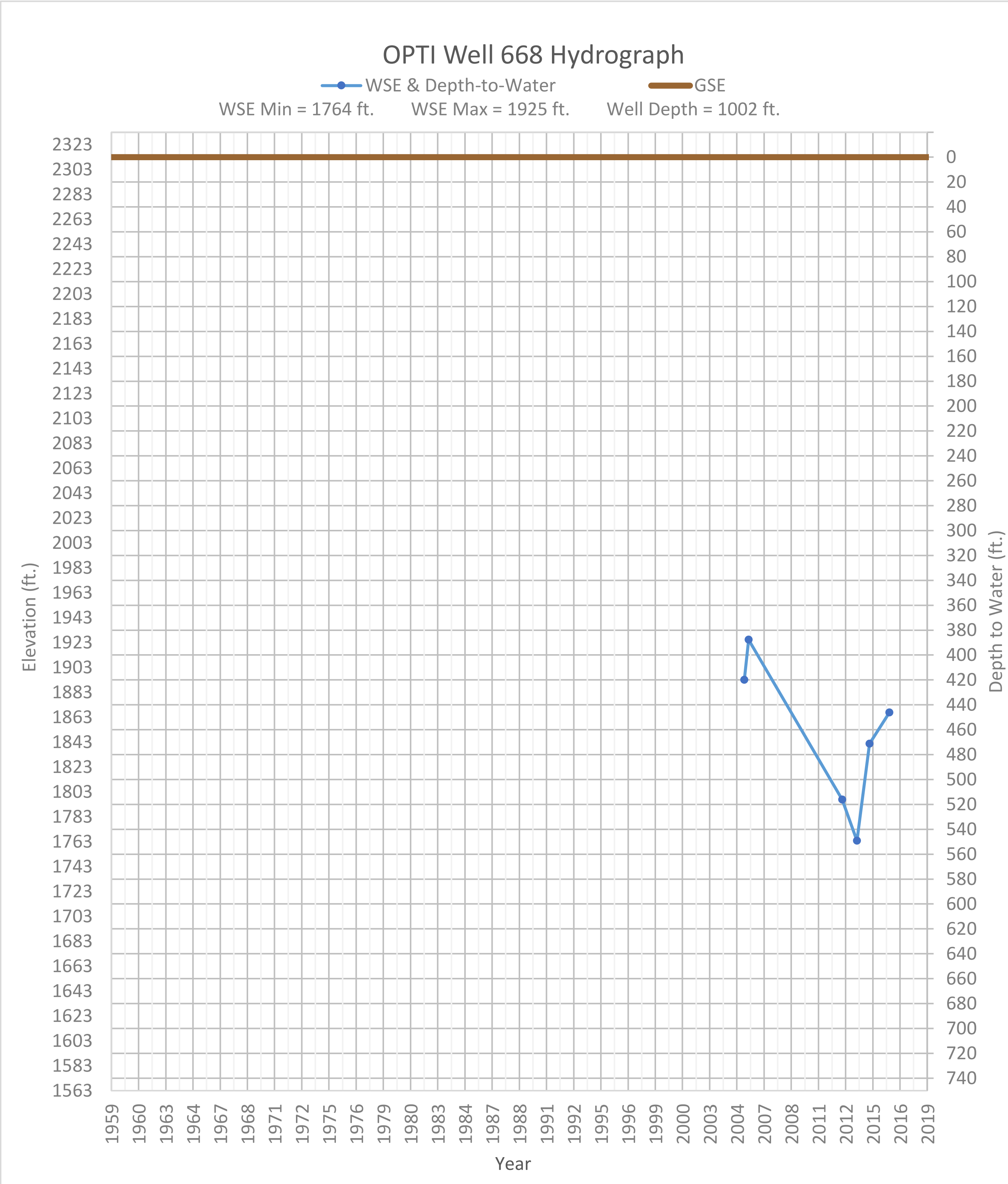
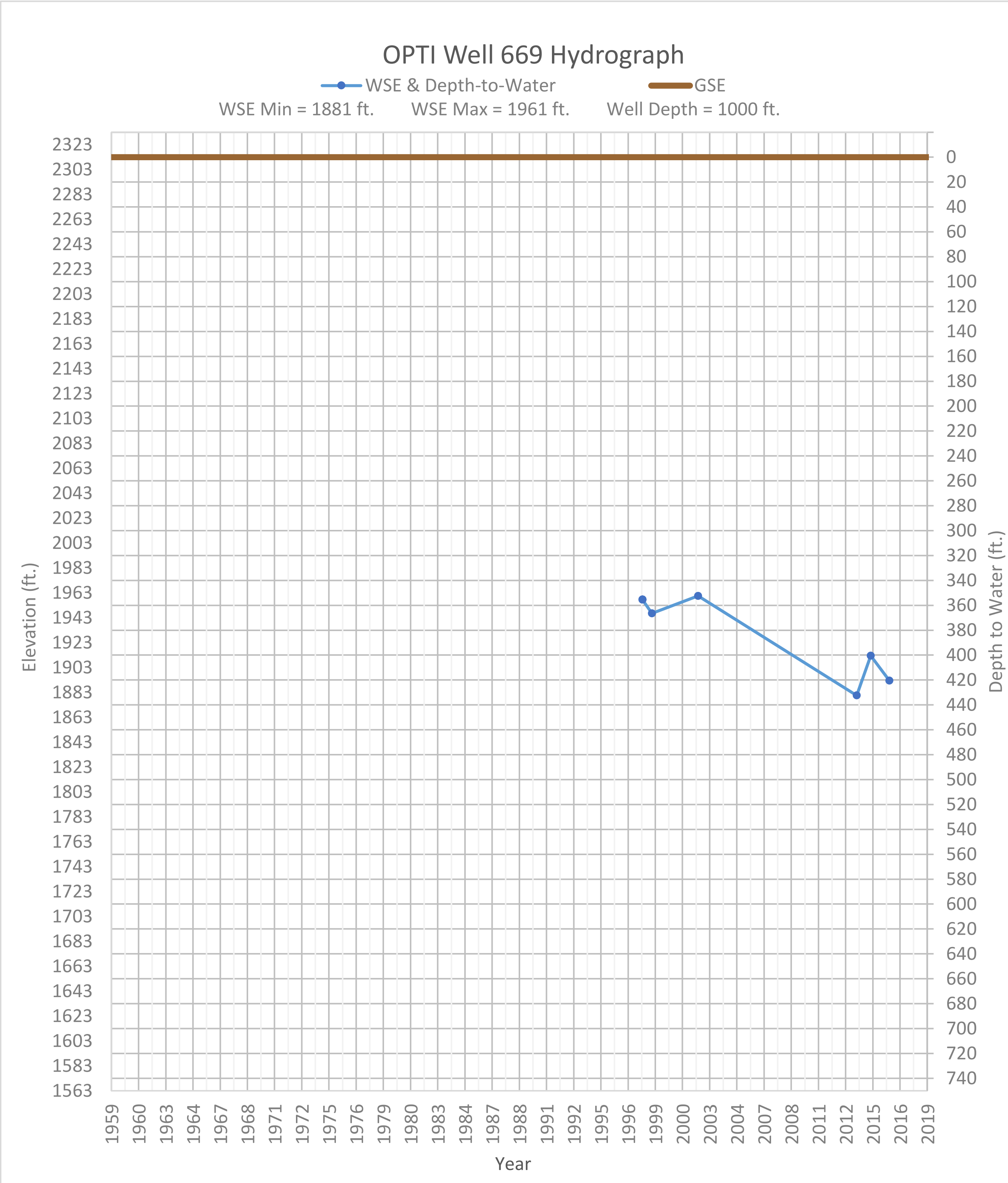
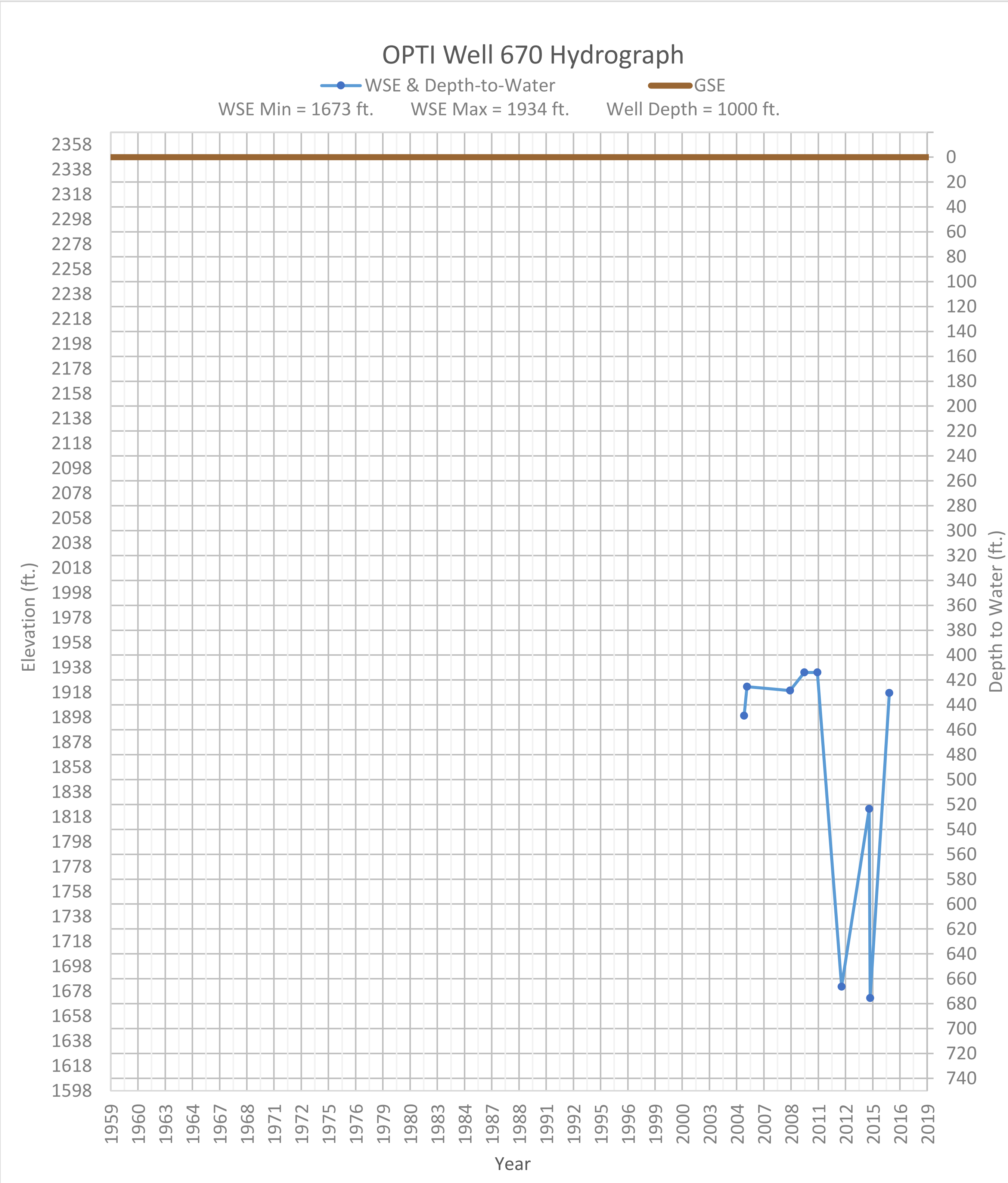

OPTI Well 668 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1764 ft.
WSE Max = 1925 ft.
Well Depth = 1002 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 669 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1881 ft.
WSE Max = 1961 ft.
Well Depth = 1000 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 670 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1673 ft.
WSE Max = 1934 ft.
Well Depth = 1000 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2358
2338
2318
2298
2278
2258
2238
2218
2198
2178
2158
2138
2118
2098
2078
2058
2038
2018
1998
1978
1958
1938
1918
1898
1878
1858
1838
1818
1798
1778
1758
1738
1718
1698
1678
1658
1638
1618
1598
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40
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160
180
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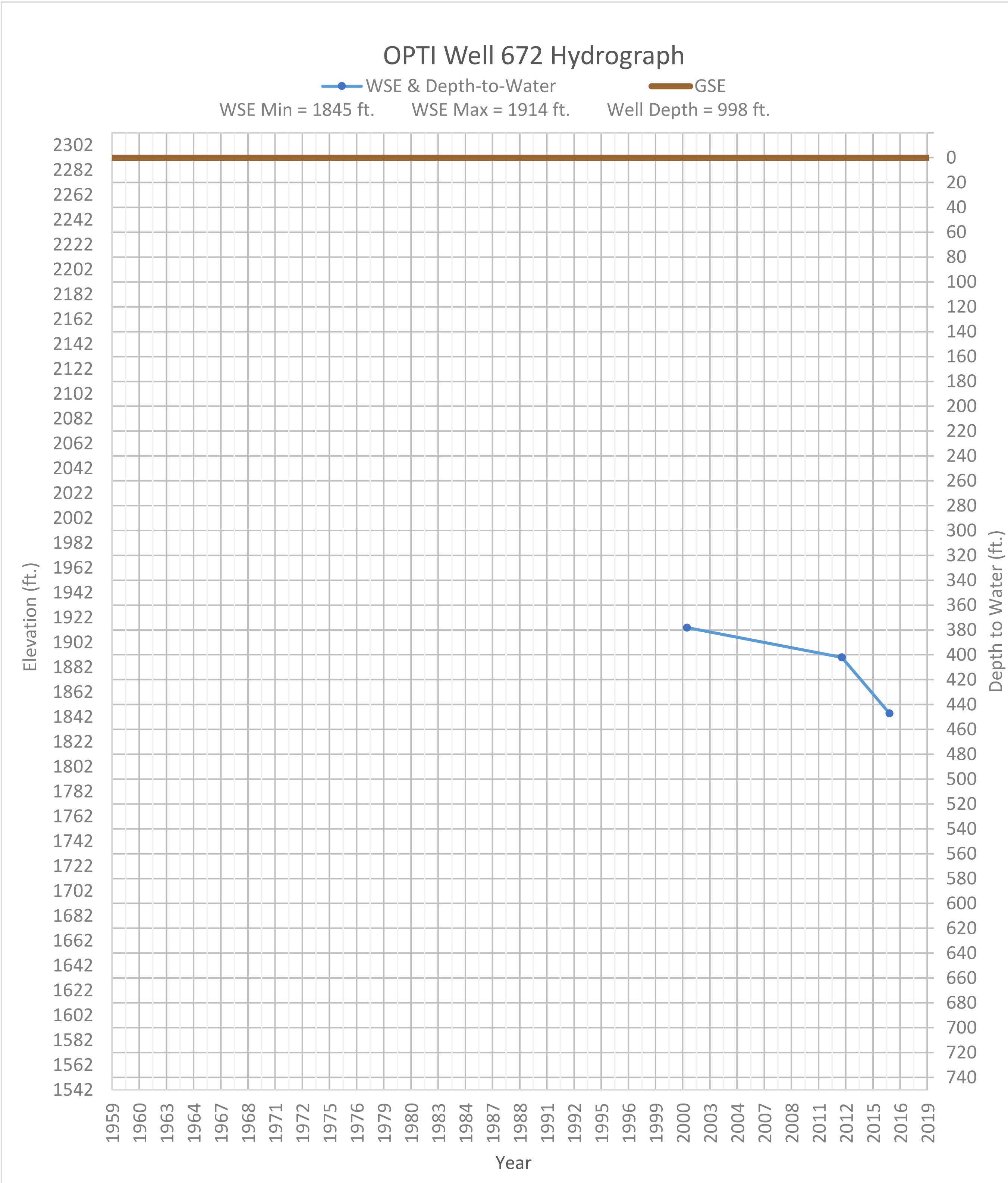
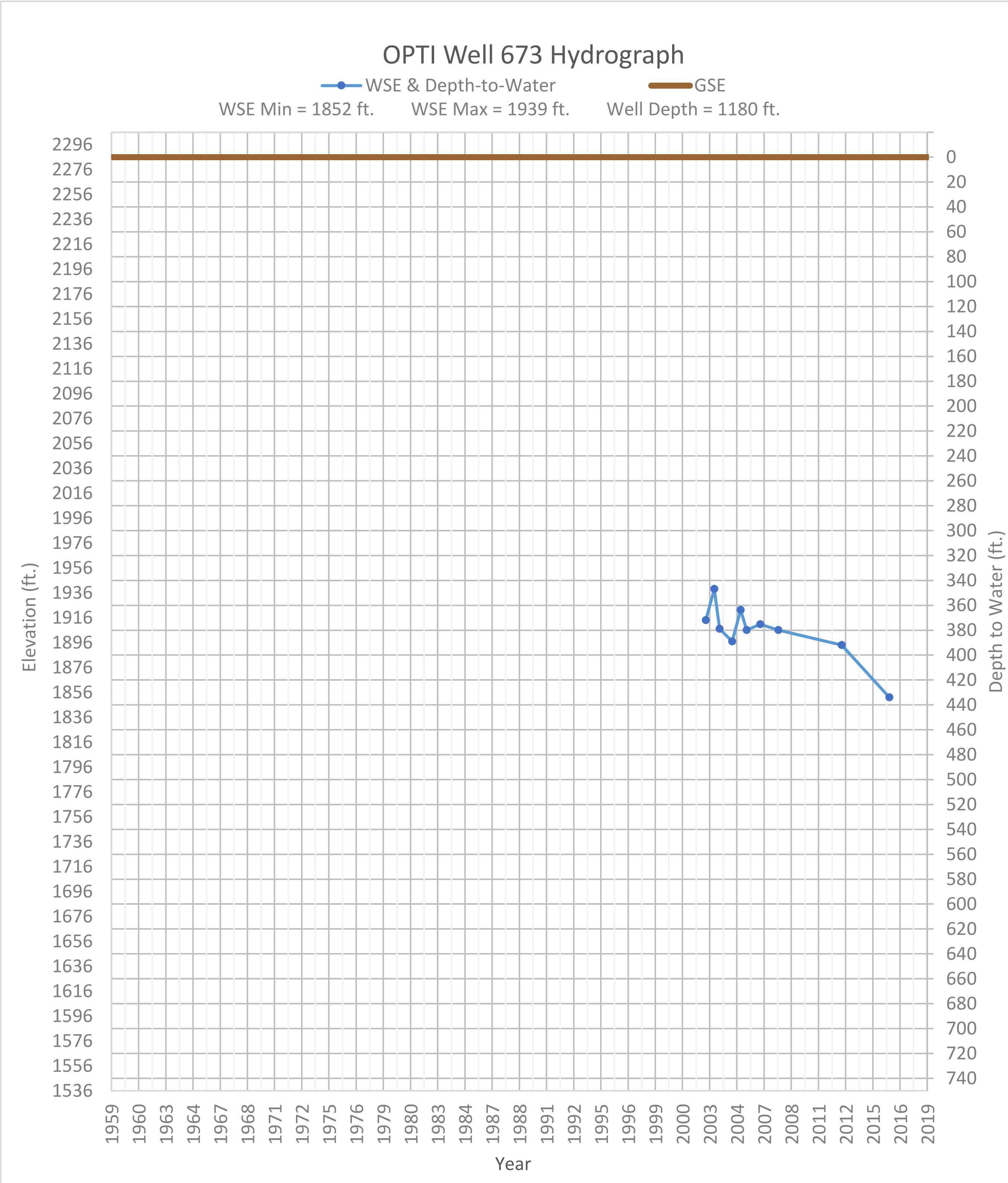
OPTI Well 671 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1852 ft.
WSE Max = 1992 ft.
Well Depth = 1002 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 672 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1845 ft.
WSE Max = 1914 ft.
Well Depth = 998 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 673 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1852 ft.
WSE Max = 1939 ft.
Well Depth = 1180 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2296
2276
2256
2236
2216
2196
2176
2156
2136
2116
2096
2076
2056
2036
2016
1996
1976
1956
1936
1916
1896
1876
1856
1836
1816
1796
1776
1756
1736
1716
1696
1676
1656
1636
1616
1596
1576
1556
1536
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2016
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OPTI Well 674 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1809 ft.
WSE Max = 1960 ft.
Well Depth = 1100 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

OPTI Well 675 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1859 ft.
WSE Max = 1951 ft.
Well Depth = 1203 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

OPTI Well 676 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1740 ft.
WSE Max = 1960 ft.
Well Depth = 735 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2312
2292
2272
2252
2232
2212
2192
2172
2152
2132
2112
2092
2072
2052
2032
2012
1992
1972
1952
1932
1912
1892
1872
1852
1832
1812
1792
1772
1752
1732
1712
1692
1672
1652
1632
1612
1592
1572
1552
0
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40
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80
100
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140
160
180
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2008
2011
2012
2015
2016
2019


OPTI Well 677 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1890 ft.
WSE Max = 1949 ft.
Well Depth = 941 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2309
2289
2269
2249
2229
2209
2189
2169
2149
2129
2109
2089
2069
2049
2029
2009
1989
1969
1949
1929
1909
1889
1869
1849
1829
1809
1789
1769
1749
1729
1709
1689
1669
1649
1629
1609
1589
1569
1549
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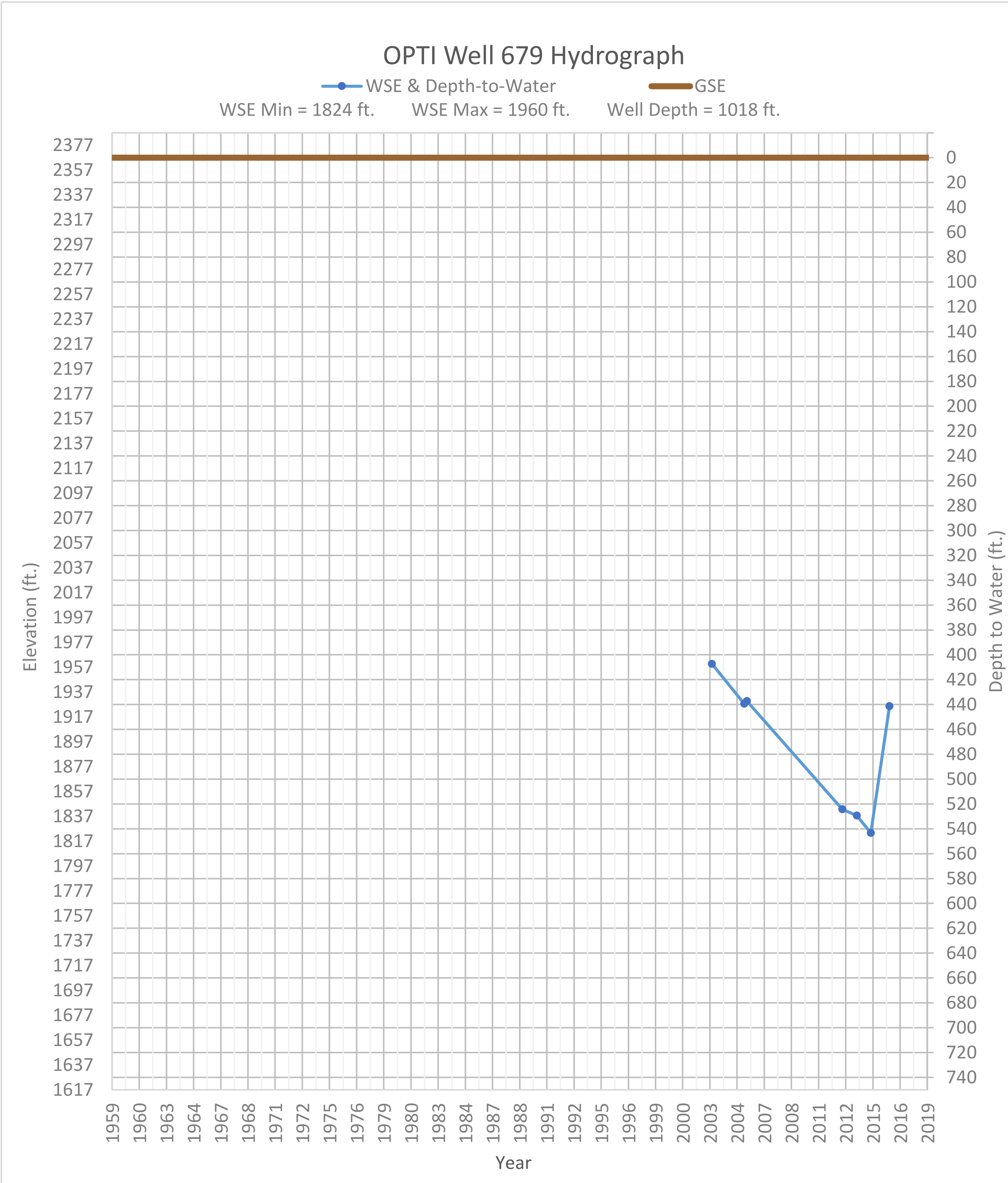
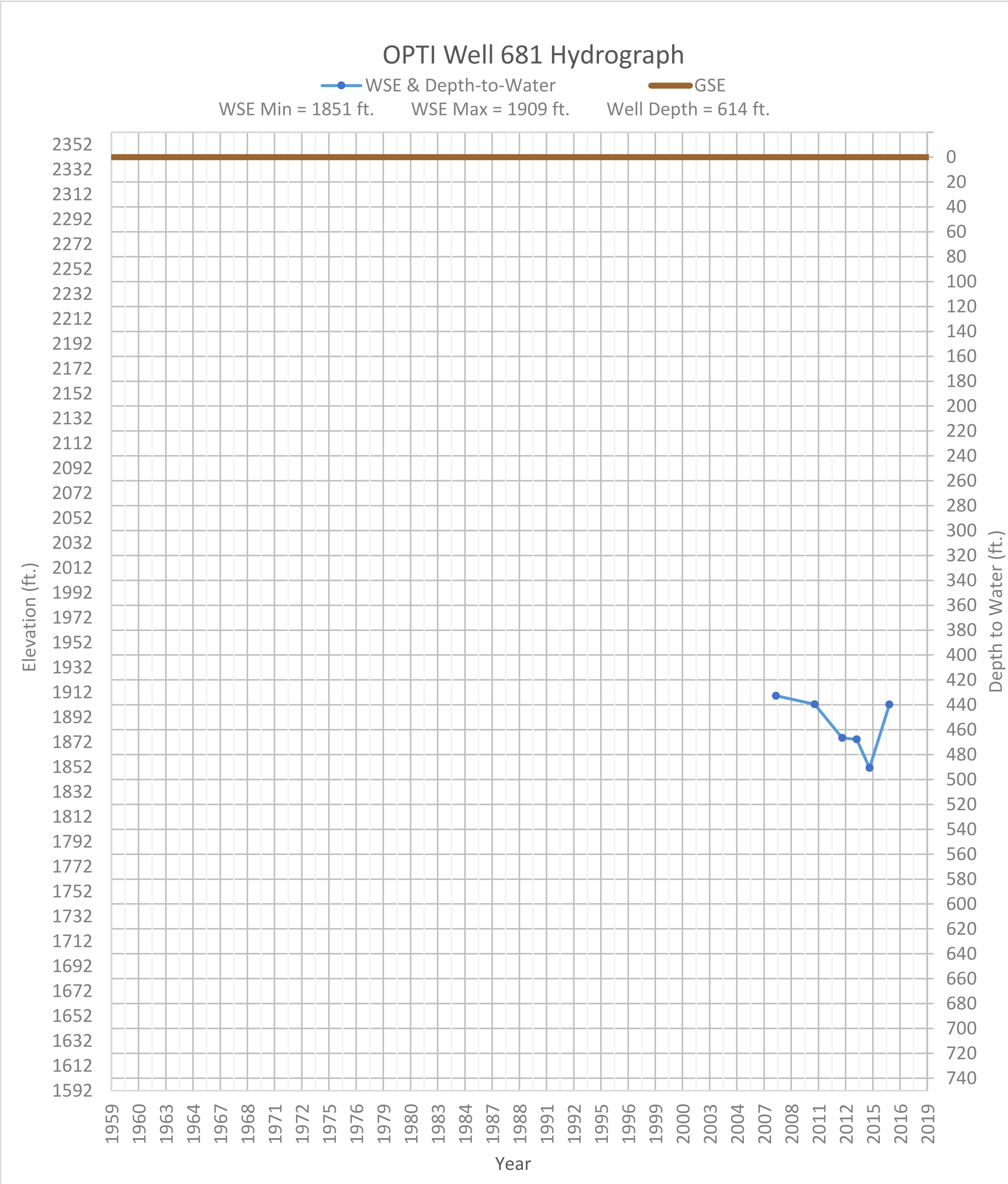
2015
2016
2019

OPTI Well 678 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1881 ft.
WSE Max = 2167 ft.
Well Depth = 881 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 679 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1824 ft.
WSE Max = 1960 ft.
Well Depth = 1018 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 681 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1851 ft.
WSE Max = 1909 ft.
Well Depth = 614 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 682 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1934 ft.
WSE Max = 1993 ft.
Well Depth = 1300 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2340
2320
2300
2280
2260
2240
2220
2200
2180
2160
2140
2120
2100
2080
2060
2040
2020
2000
1980
1960
1940
1920
1900
1880
1860
1840
1820
1800
1780
1760
1740
1720
1700
1680
1660
1640
1620
1600
1580
0
20
40
60
80
100
120
140
160
180
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220
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380
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1959
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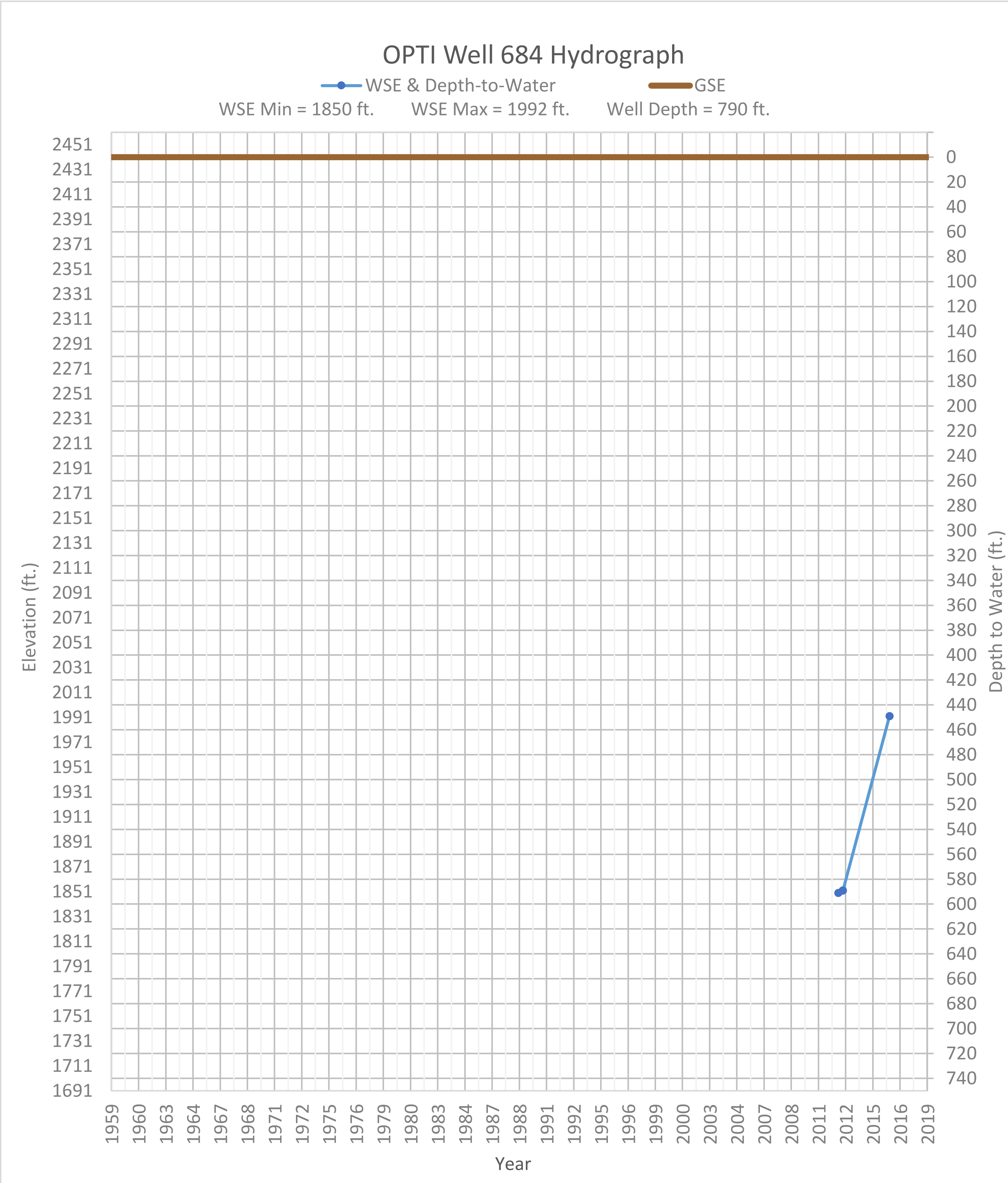
2007
2008
2011
2012
2015
2016
2019


OPTI Well 683 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1918 ft.
WSE Max = 1990 ft.
Well Depth = 1045 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 684 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1850 ft.
WSE Max = 1992 ft.
Well Depth = 790 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2451
2431
2411
2391
2371
2351
2331
2311
2291
2271
2251
2231
2211
2191
2171
2151
2131
2111
2091
2071
2051
2031
2011
1991
1971
1951
1931
1911
1891
1871
1851
1831
1811
1791
1771
1751
1731
1711
1691
0
20
40
60
80
100
120
140
160
180
200
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260
280
300
320
340
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380
400
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440
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540
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640
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680
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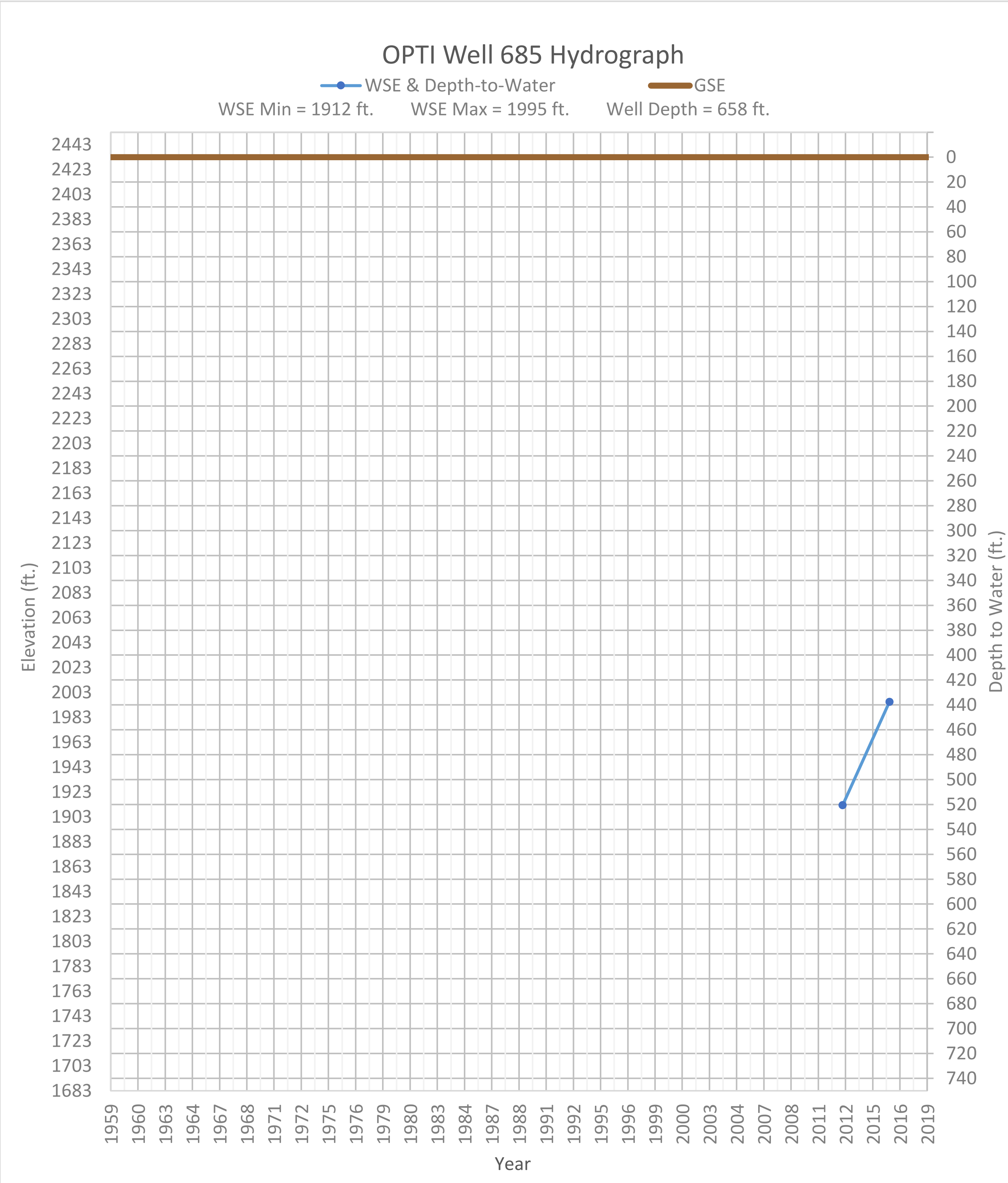
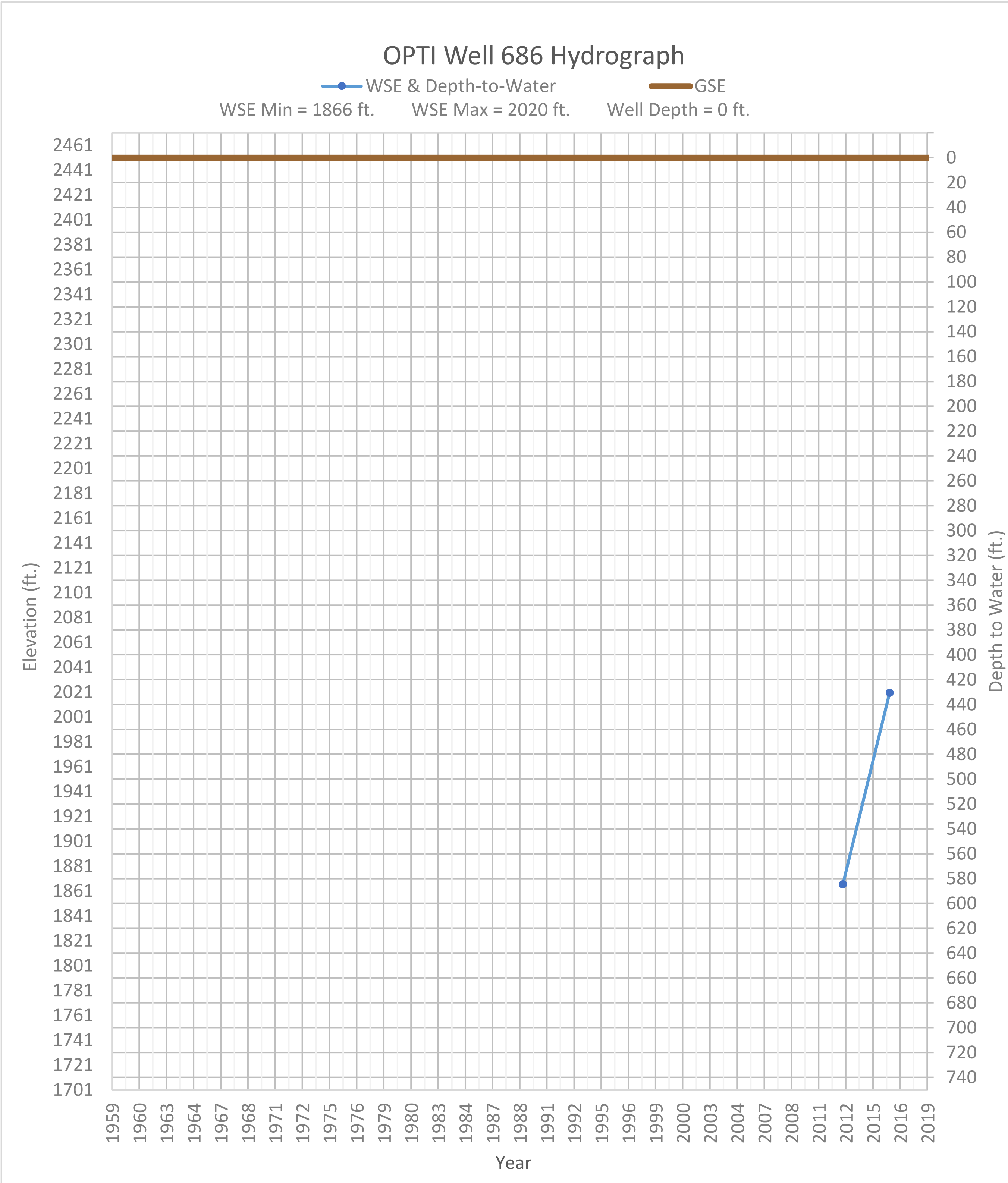

OPTI Well 685 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1912 ft.
WSE Max = 1995 ft.
Well Depth = 658 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 686 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1866 ft.
WSE Max = 2020 ft.
Well Depth = 0 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2461
2441
2421
2401
2381
2361
2341
2321
2301
2281
2261
2241
2221
2201
2181
2161
2141
2121
2101
2081
2061
2041
2021
2001
1981
1961
1941
1921
1901
1881
1861
1841
1821
1801
1781
1761
1741
1721
1701
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
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320
340
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1959
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2004
2007
2008
2011
2012
2015
2016
2019

OPTI Well 687 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1781 ft.
WSE Max = 2101 ft.
Well Depth = 1195 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2308
2288
2268
2248
2228
2208
2188
2168
2148
2128
2108
2088
2068
2048
2028
2008
1988
1968
1948
1928
1908
1888
1868
1848
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1808
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1768
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700
720
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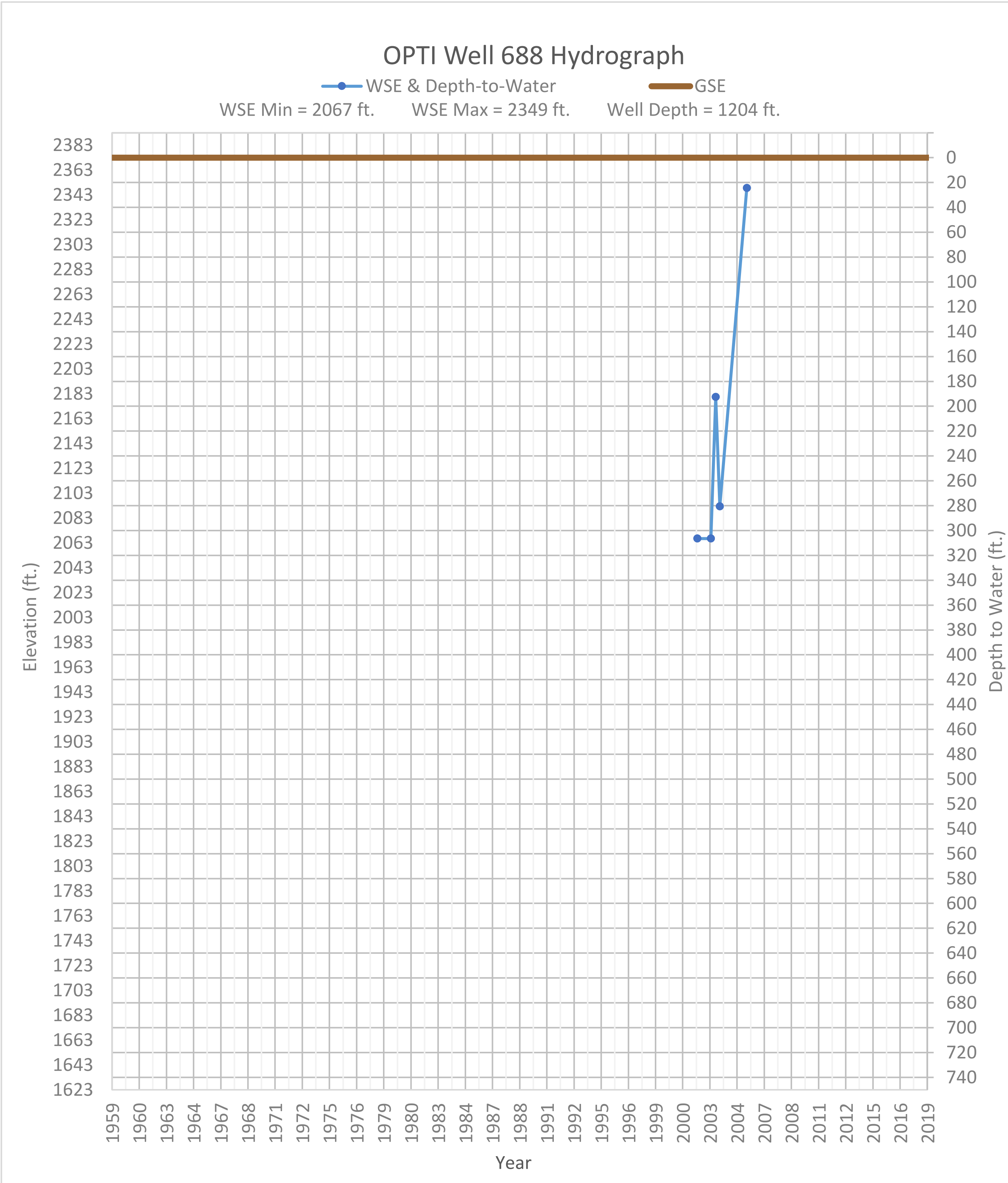
2019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WSE & Depth-to-Water
GSE
WSE Min = 2067 ft.
WSE Max = 2349 ft.
Well Depth = 1204 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2383
2363
2343
2323
2303
2283
2263
2243
2223
2203
2183
2163
2143
2123
2103
2083
2063
2043
2023
2003
1983
1963
1943
1923
1903
1883
1863
1843
1823
1803
1783
1763
1743
1723
1703
1683
1663
1643
1623
0
20
40
60
80
100
120
140
160
180
200
220
240
260
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340
360
380
400
420
440
460
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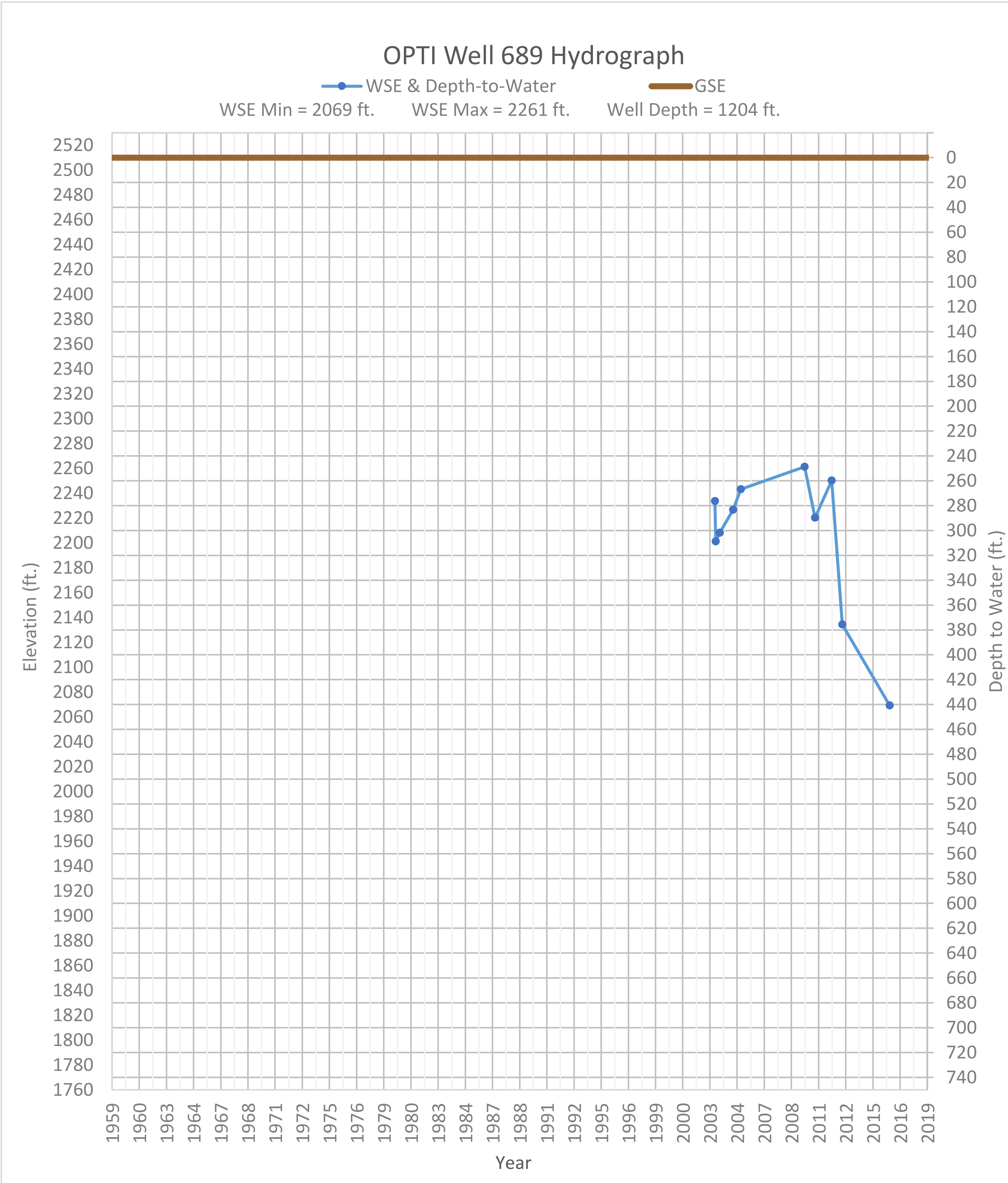
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WSE & Depth-to-Water
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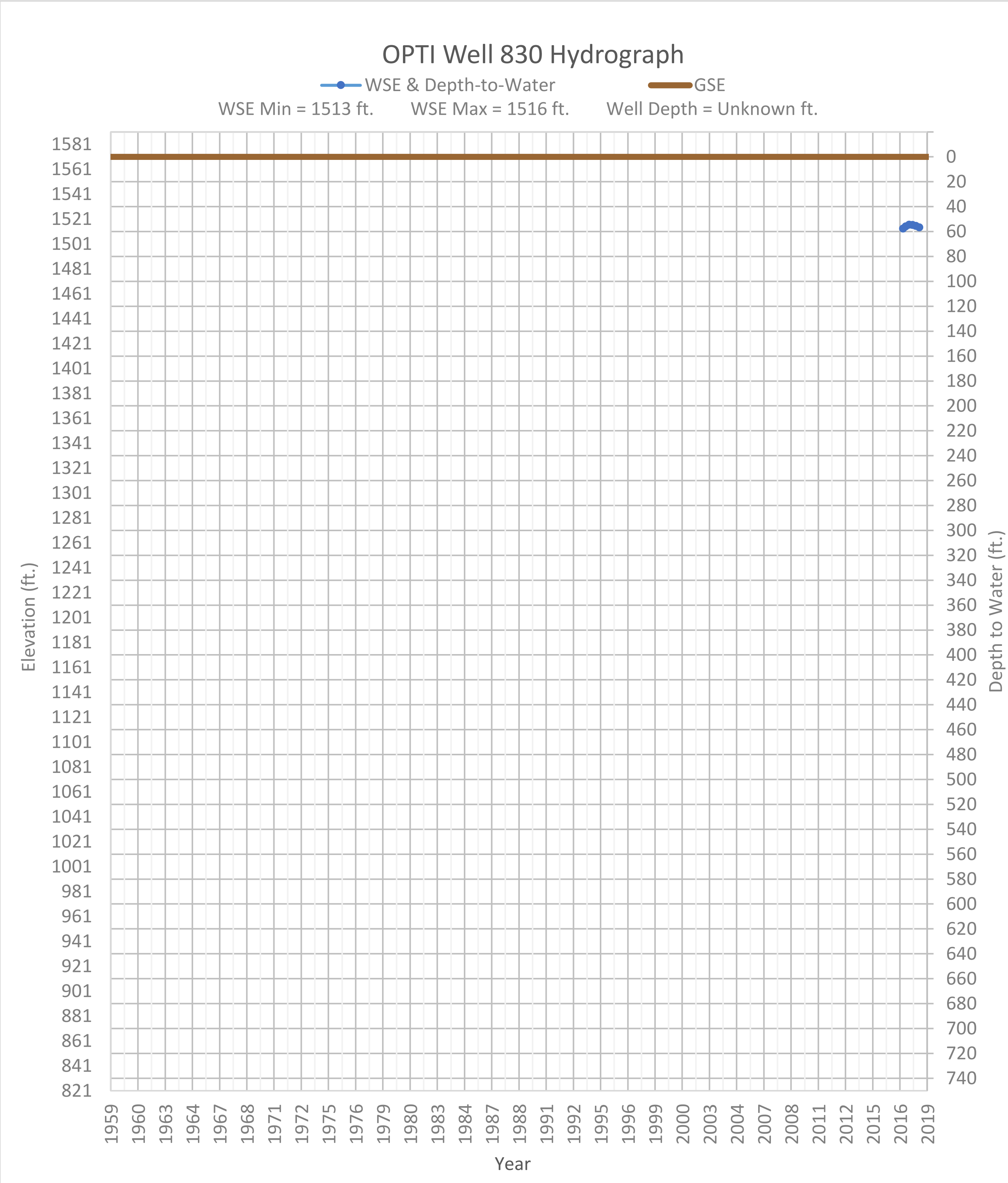
WSE Max = 2261 ft.
Well Depth = 1204 ft.
Elevation (ft.)
Depth to Water (ft.)
Year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WSE & Depth-to-Water
GSE
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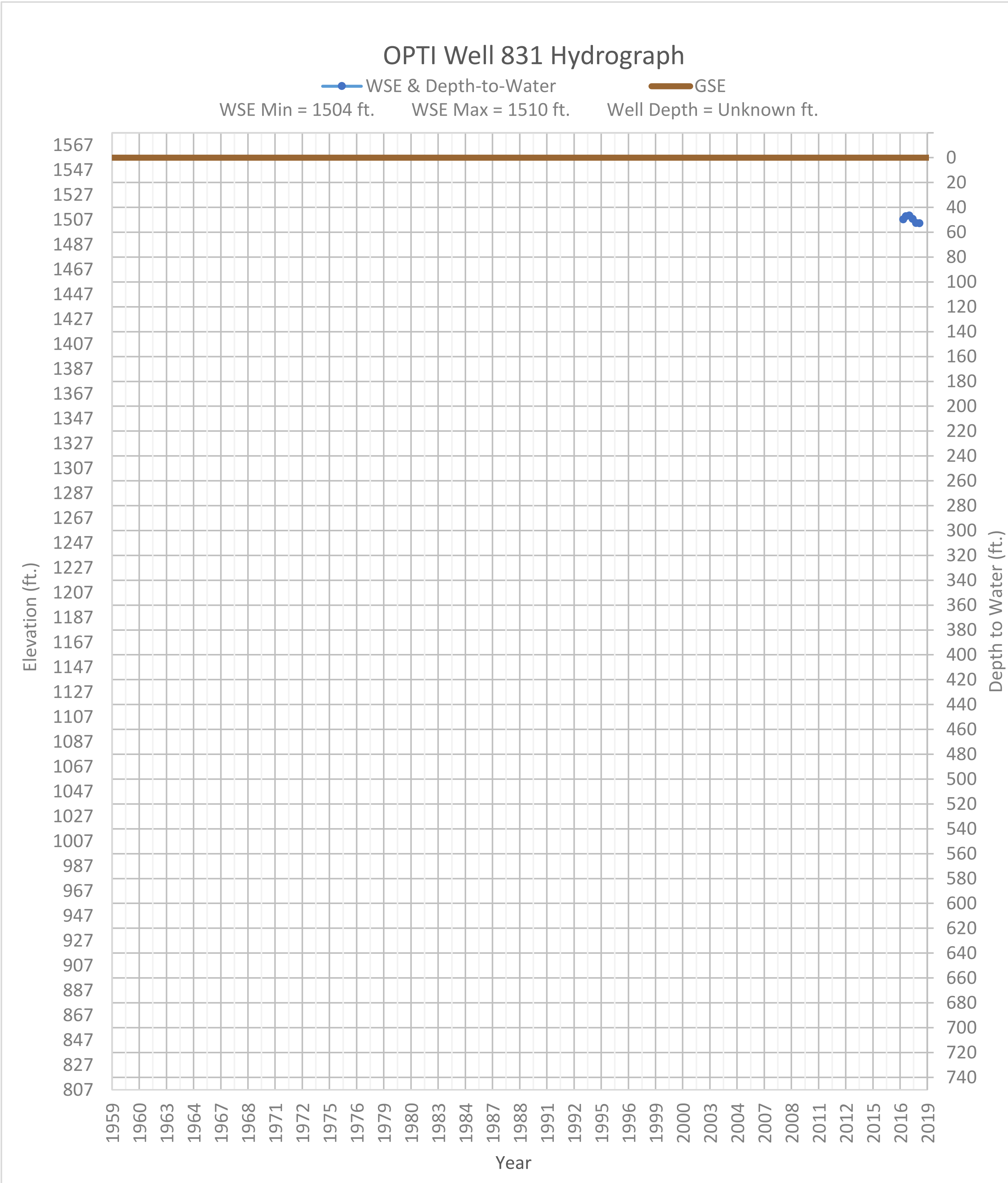
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 831 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1504 ft.
WSE Max = 1510 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1567
1547
1527
1507
1487
807
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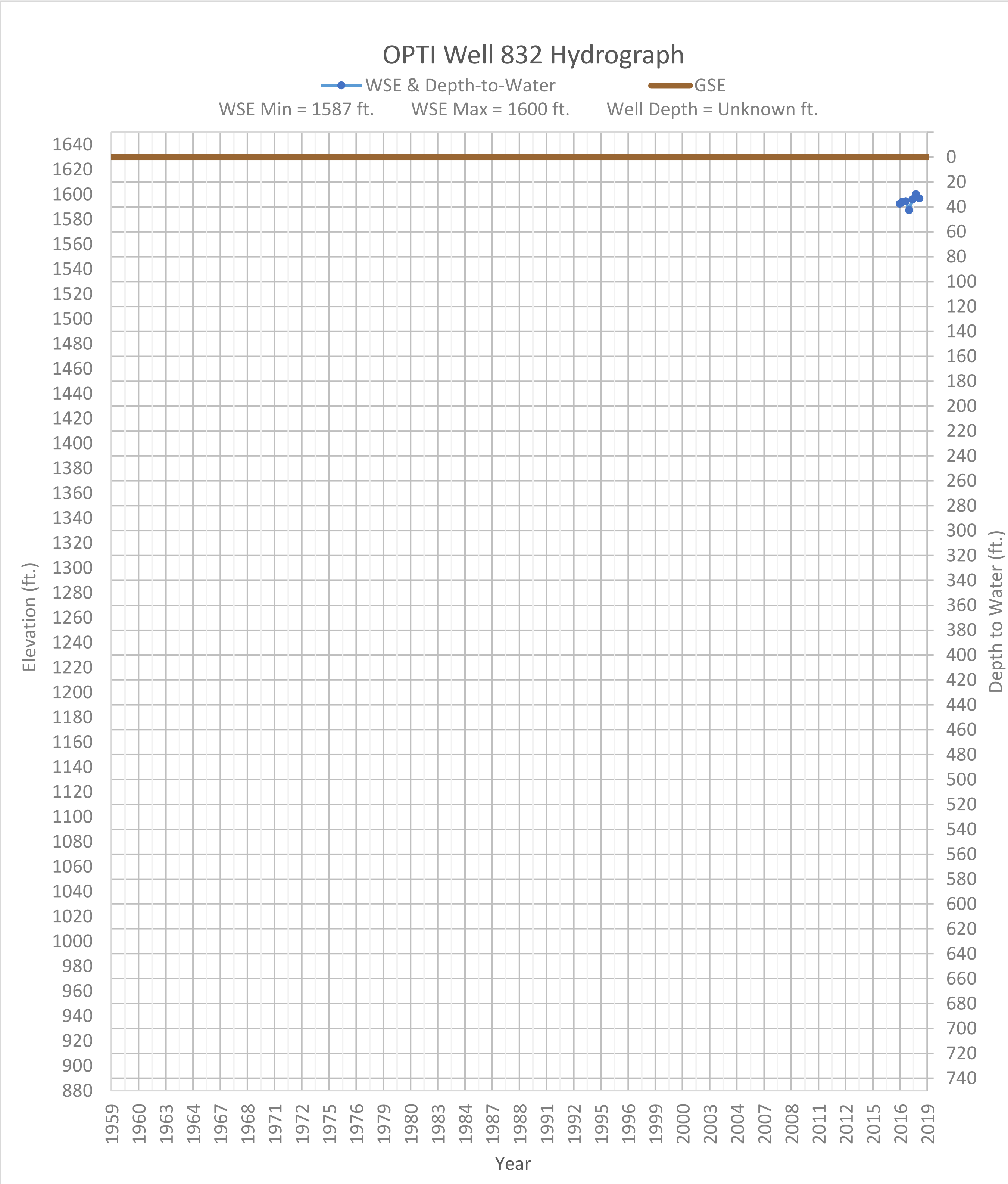
2019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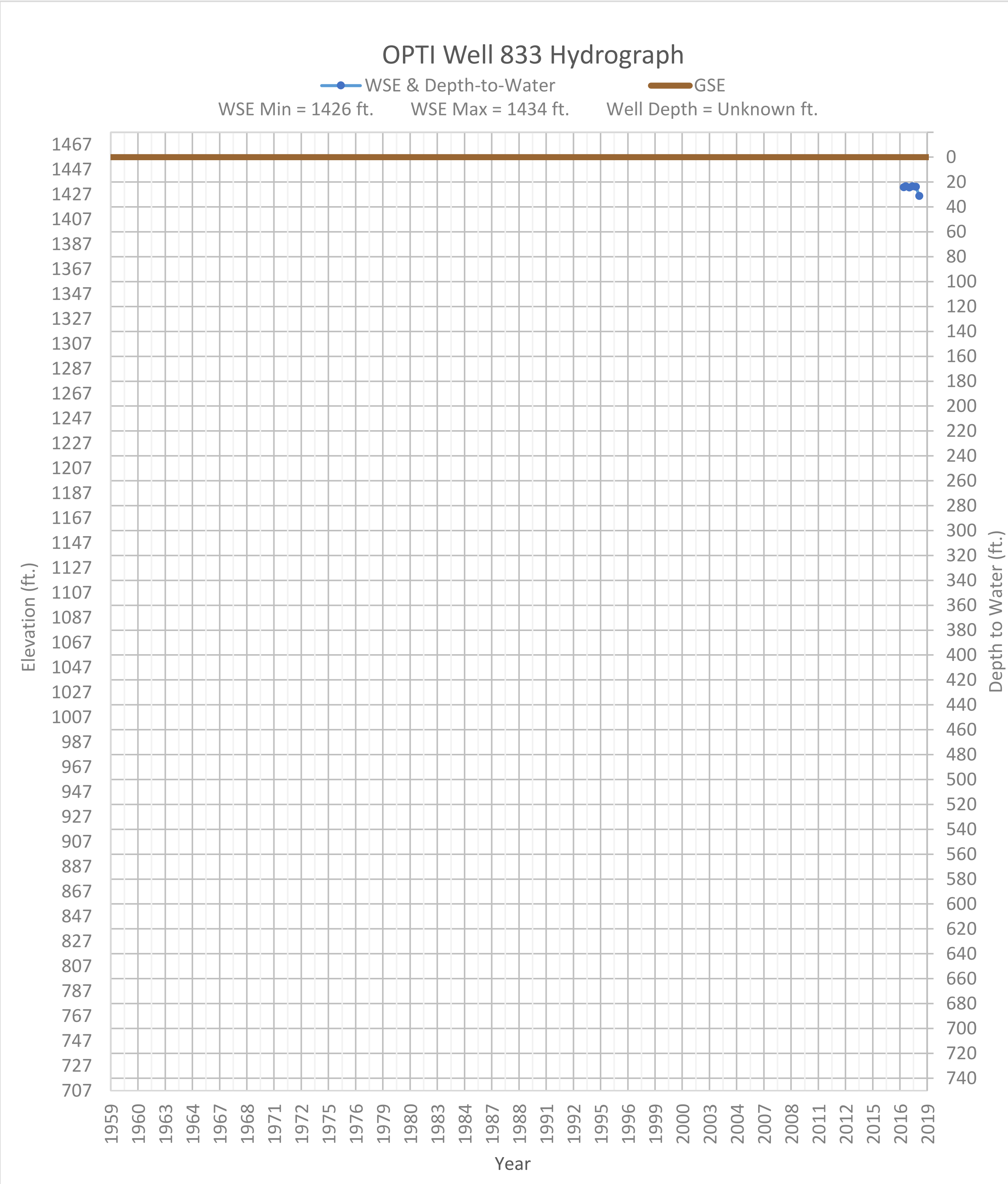
WSE & Depth-to-Water
GSE
WSE Min = 1587 ft.
WSE Max = 1600 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 833 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1426 ft.
WSE Max = 1434 ft.
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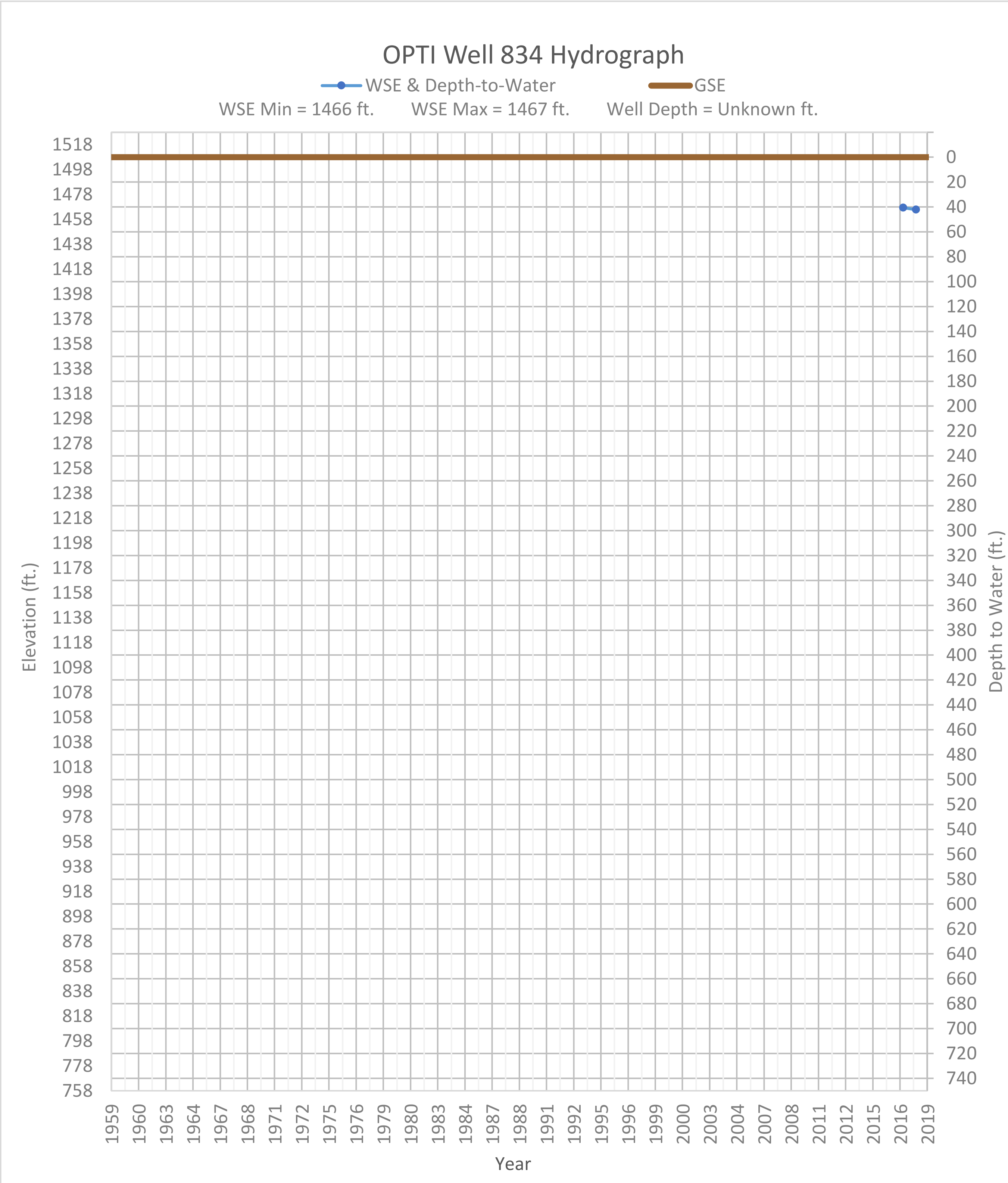
Elevation (ft.)
Depth to Water (ft.)
Year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WSE & Depth-to-Water
GSE
WSE Min = 1466 ft.
WSE Max = 1467 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 835 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1518 ft.
WSE Max = 1533 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1565
1545
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1485
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1325
1305
1285
1265
1245
1225
1205
1185
1165
1145
1125
1105
1085
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1025
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965
945
925
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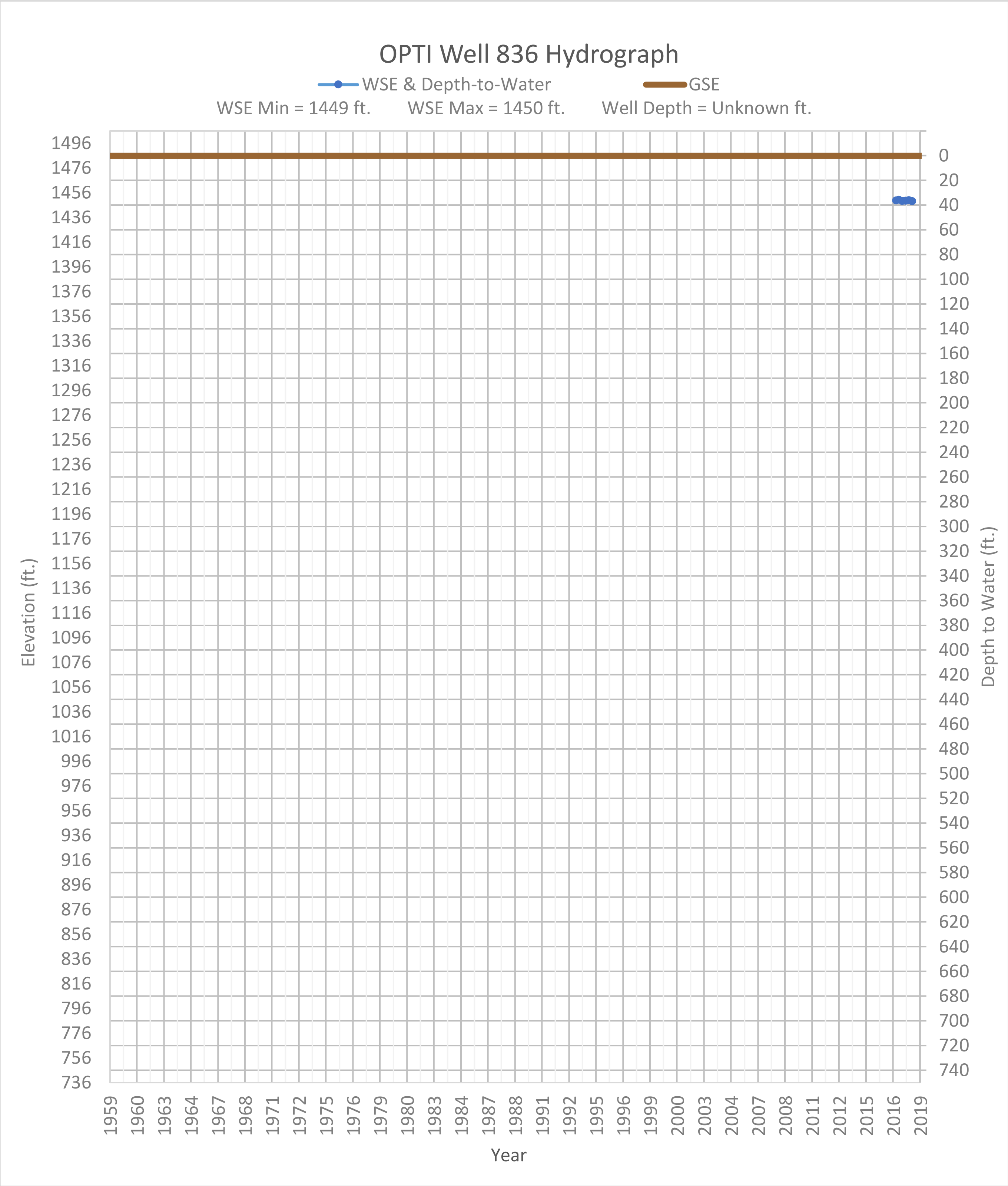

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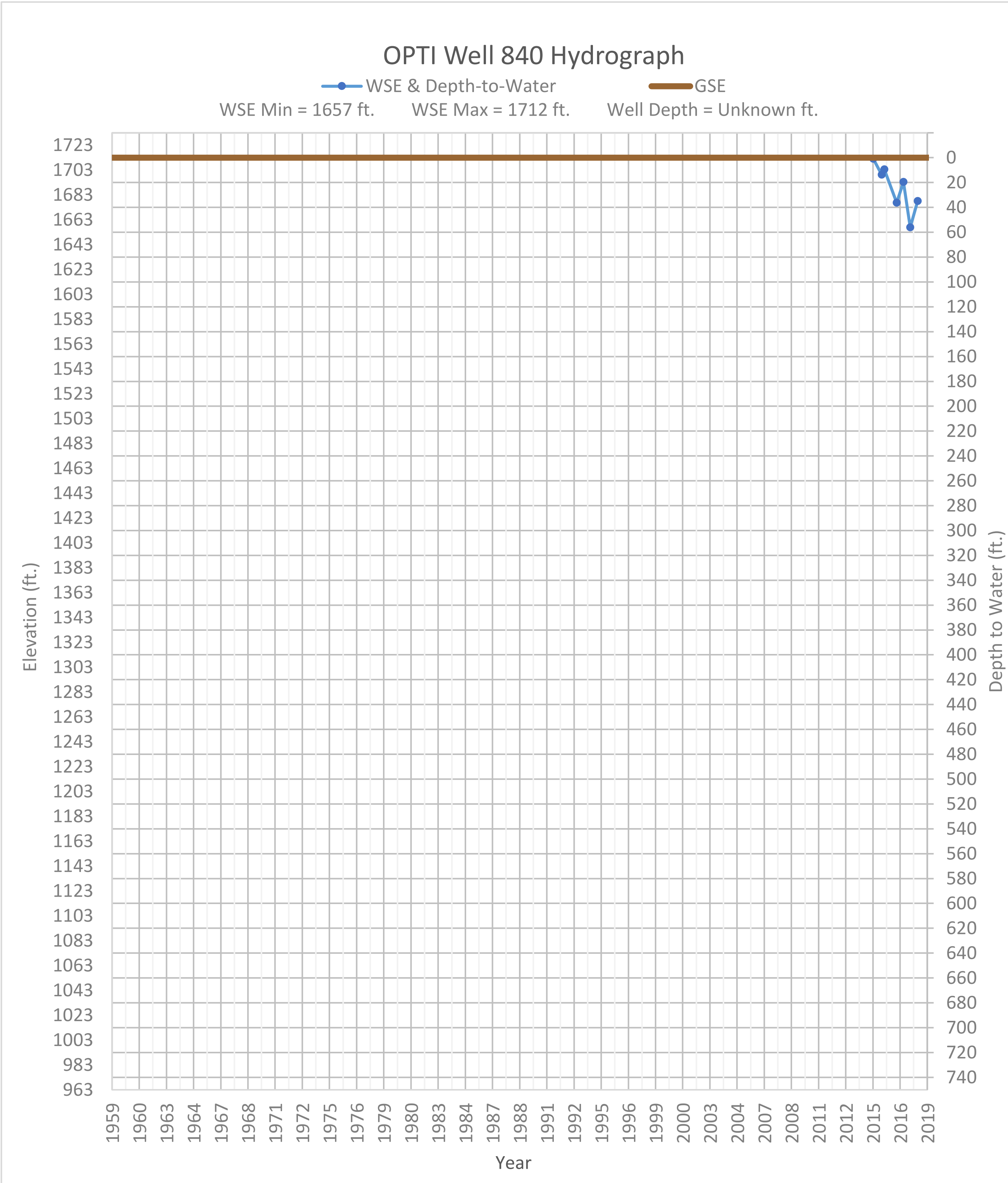
Elevation (ft.)
Depth to Water (ft.)
Year



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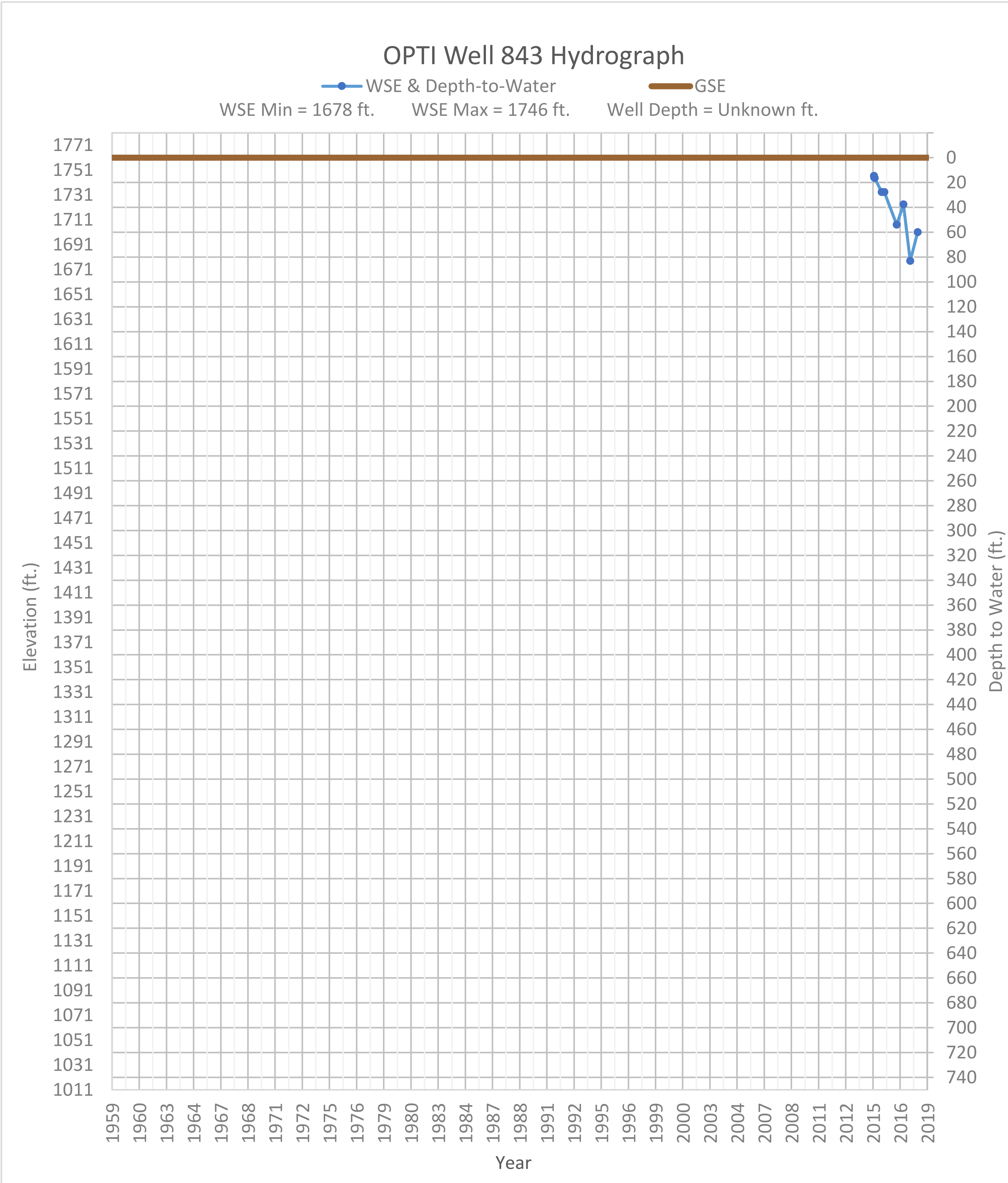
WSE & Depth-to-Water
GSE
WSE Min = 1657 ft.
WSE Max = 1712 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 841 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1701 ft.
WSE Max = 1740 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 842 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1698 ft.
WSE Max = 1751 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 843 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1678 ft.
WSE Max = 1746 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1771
1751
1731
1711
1691
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1531
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1491
1471
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1431
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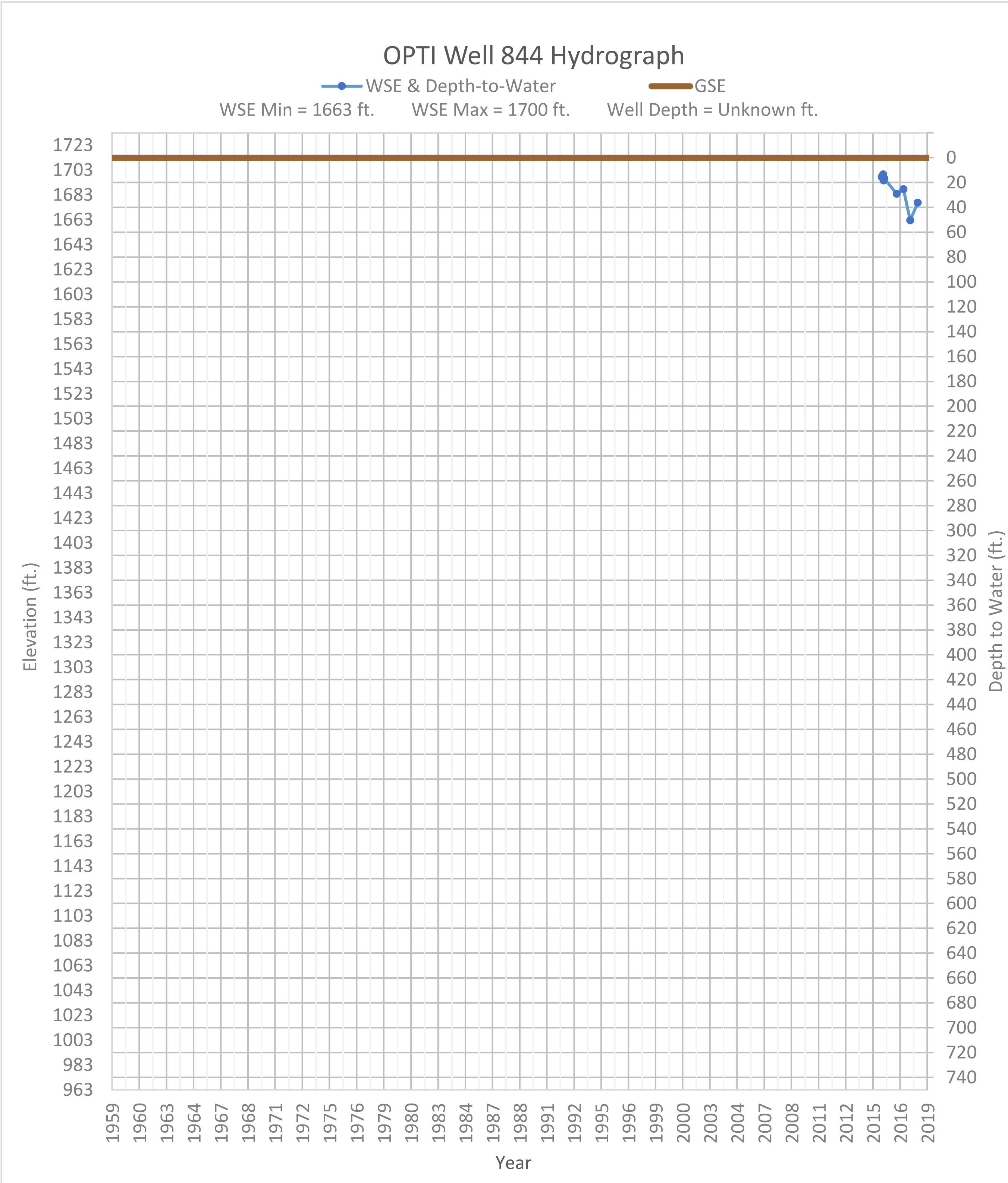
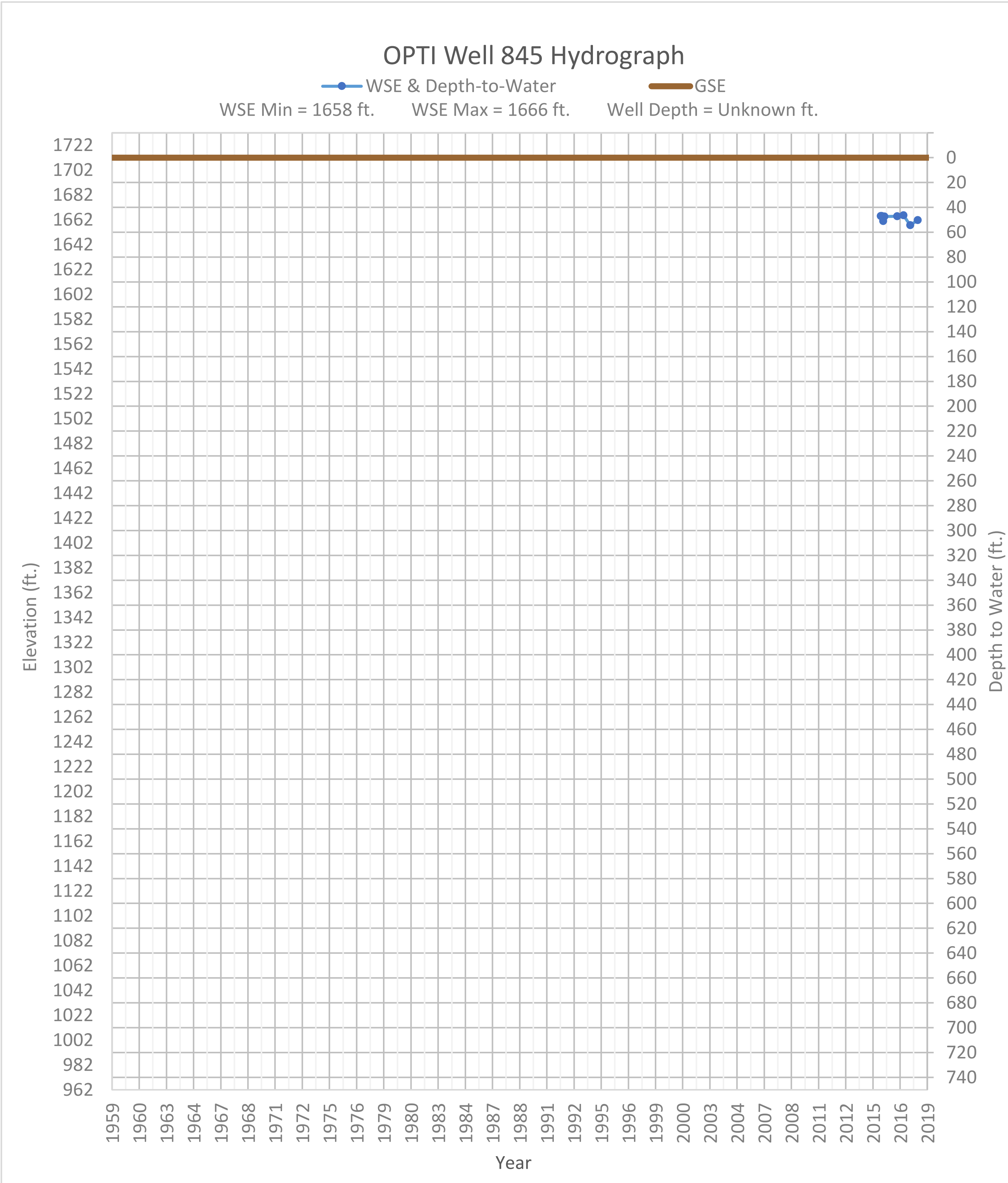
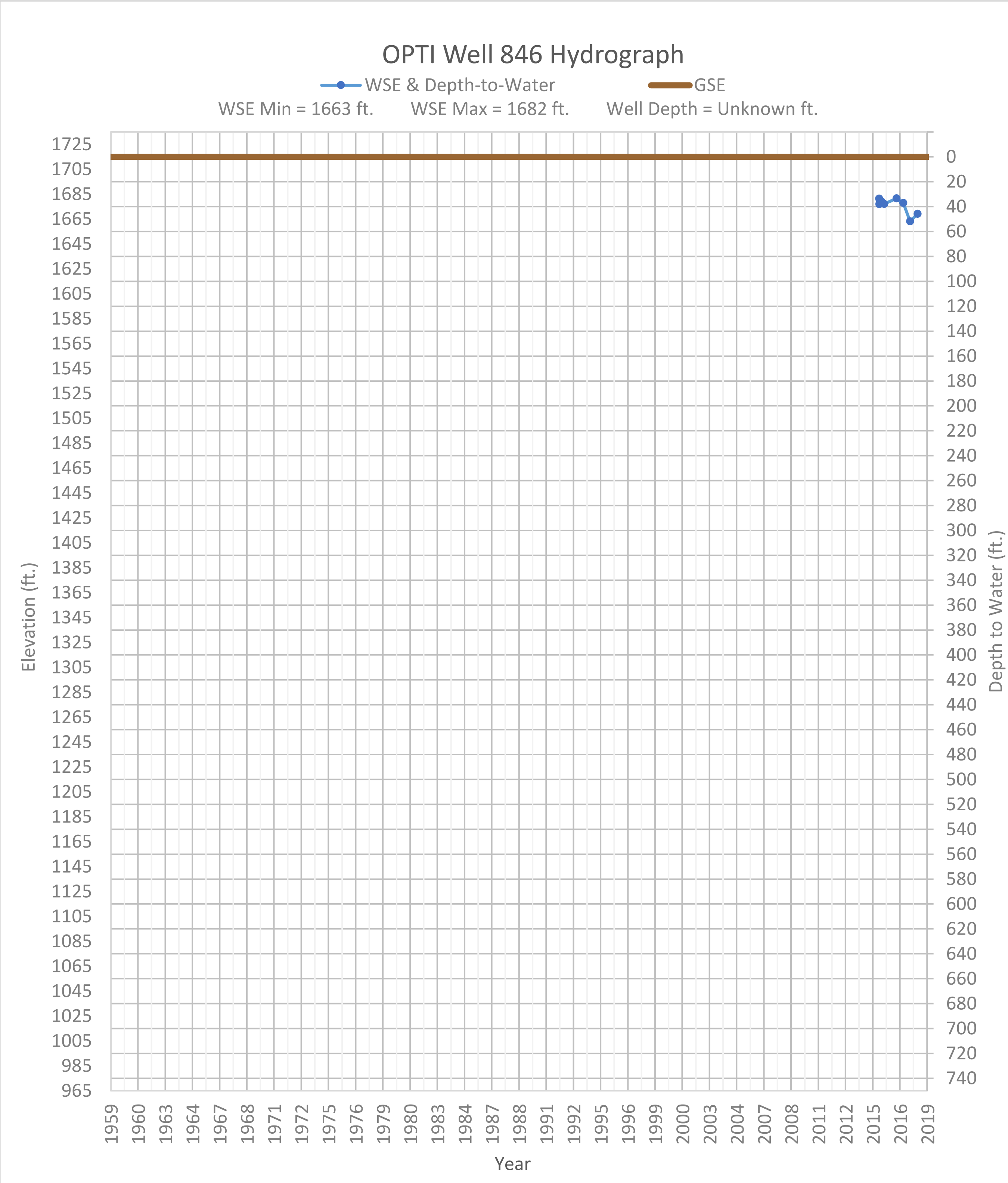
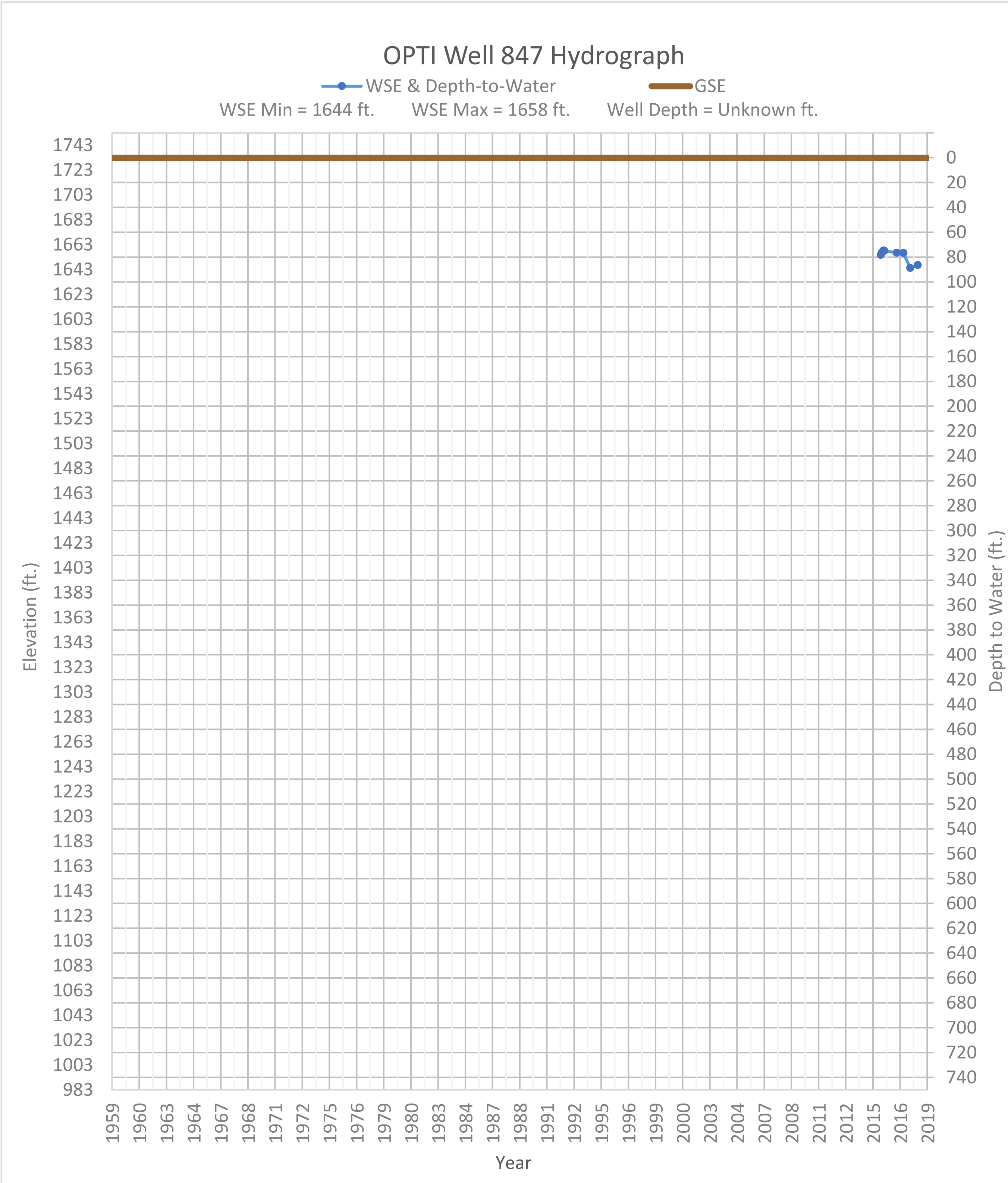

OPTI Well 844 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1663 ft.
WSE Max = 1700 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year

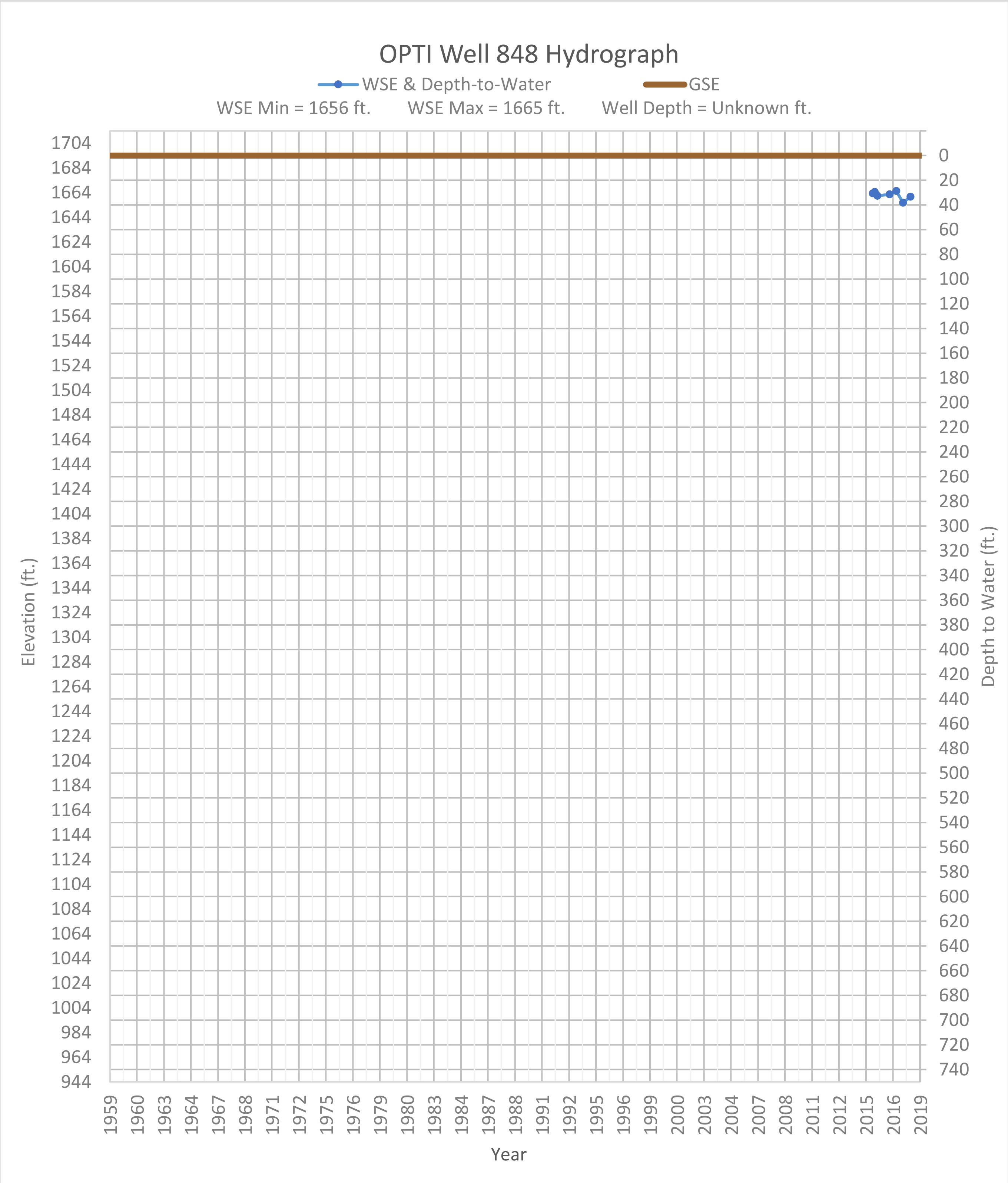


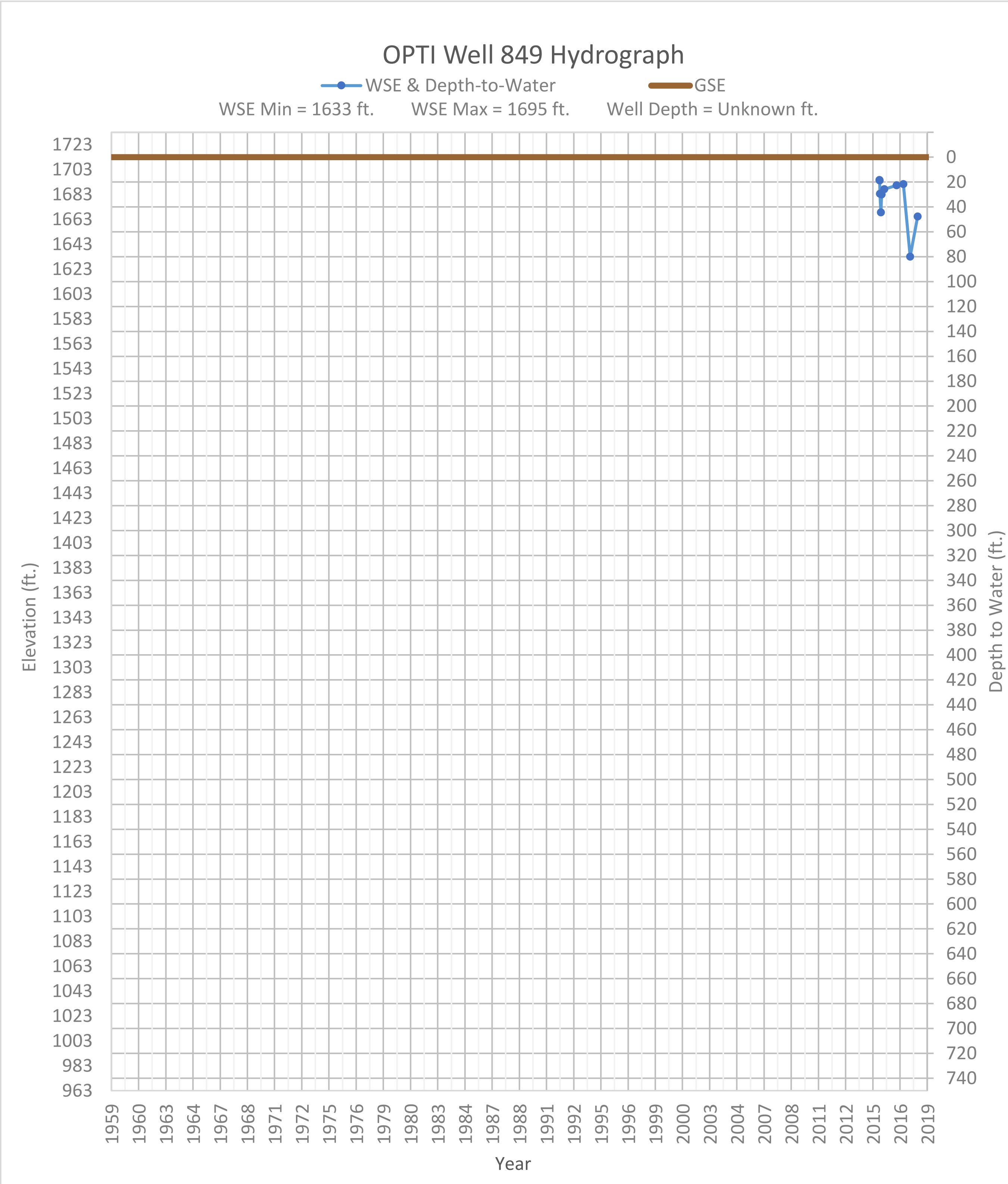
OPTI Well 845 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1658 ft.
WSE Max = 1666 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 846 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1663 ft.
WSE Max = 1682 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 847 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1644 ft.
WSE Max = 1658 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 848 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1656 ft.
WSE Max = 1665 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 849 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1633 ft.
WSE Max = 1695 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 850 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1654 ft.
WSE Max = 1701 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year

Chapter 2
Appendix B

White Paper: Subsidence and Subsidence Monitoring Techniques

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Subsidence White Paper

Author: C. Micah Eggleton - *Environmental Planner* at Woodard & Curran, September 19, 2017.
meggleton@woodardcurran.com

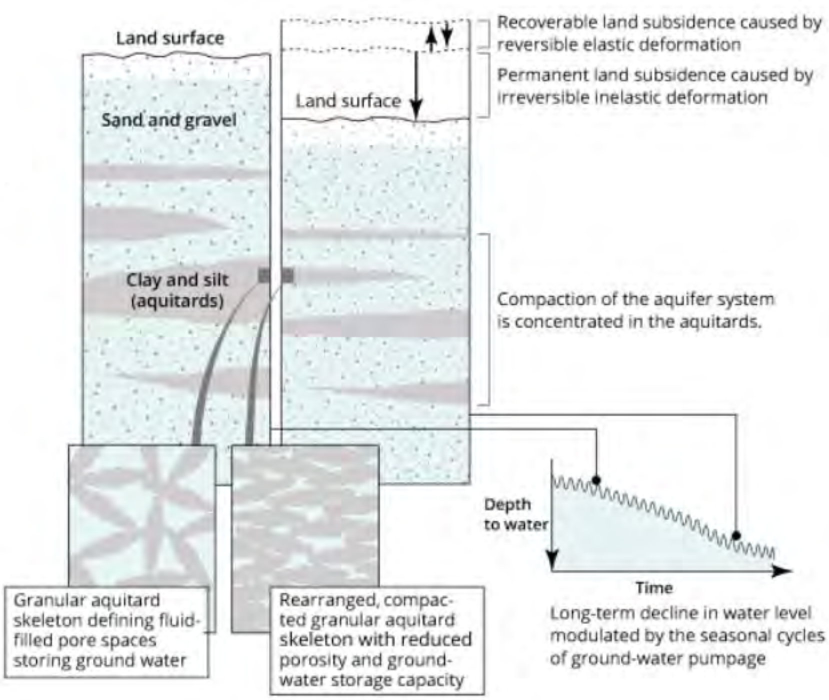
What is Subsidence?

Land subsidence is the sinking or downward settling of the earth's surface, not restricted in rate, magnitude, or area involved. Subsidence is often a result of over-extraction of subsurface water. In these cases, subsidence generally occurs over a large to very large area (10's to 100's of km^2) and may happen over several years.

How Subsidence Occurs

Groundwater saturates the sediments in the subsurface where groundwater is present. Sediments in water bearing units are commonly made up of sands, gravels, silts, and clays. Aquitards are composed of clay materials, and may have multiple thin layers or larger extensive, and/or thicker layers. Groundwater in these materials fills the pore spaces and supports the material's structure. As groundwater levels decline, the sands, gravels, silts, and clays in water bearing units are dewatered, and the water's support of the structure of the materials is removed. Clays in particular rearrange when dewatered and clay grains orient in a similar direction, which reduces the amount of pore space and thus, the clay compacts. As the clays compact, ground surface elevation begins to drop.

Figure 1: Subsidence and Compaction Process



Source: USGS, Ladn Subsidence: Cause and Effect. 9/17/2017. https://ca.water.usgs.gov/land_subsidence/california-subsidence-cause-effect.html#pumping

This is problematic all over the world but is of particular concern in California agricultural communities such as the Cuyama Basin. Cuyama Basin subsidence may have effects on agriculture in a few ways.

1. Water delivery systems that may deliver irrigation water can be affected by land subsidence. Surface canals or gravity lines may not have enough elevation gradient to transport water or may even have reverse flows due to changes in ground surface elevation.
2. Infrastructure such as buildings and roads may be de-leveled and need repair

Figure 2: Subsidence Visualized

Source: USGS, https://ca.water.usgs.gov/land_subsidence/

Not all groundwater pumping results in permanent subsidence. Groundwater reservoirs have an *elastic* and *inelastic* range of stress. Within the elastic range of stress, water levels in a groundwater storage unit can fluctuate without damaging the storage unit's ability to recharge to its original capacity. If water levels in a storage system dip into the inelastic range, the clays compact and cause inelastic land subsidence.

Clays and silts, such as those present in the Younger Alluvium, Older Alluvium, and Upper Morales Formations, generally have lower elastic capabilities, meaning they are not able to recover to their original volume once water has been removed. Once clays and silts are heavily compacted, they often cannot return to their previous saturation capacity even if groundwater levels are increased; this permanently reduces the storage capacity of the aquifer. This loss of aquifer is limited to the water that was stored in the compressed clays, and storage capacity lost is limited to the water that was stored in clays that were compressed, which is reflected in the amount of subsidence measured. Water stored in clay materials is generally not available for use by wells.

Methods of Measuring Land Subsidence

Measurements of elevations, aquifer-system compaction, and water levels are used to improve our understanding of the processes responsible for land-surface elevation changes. Elevation or elevation-change measurements are fundamental to monitoring land subsidence and have been measured by using interferometric synthetic aperture radar (InSAR), continuous GPS (CGPS) measurements, extensometers, and spirit-leveling surveying.

Interferometric Synthetic Aperture Radar (InSAR)

InSAR is a method and product of remote sensing imagery that measure changes in land-surface altitude by sending radar signals (historically C-band but new equipment often uses L- or X-band) to the land surface and measuring the return time of that signal. Changes in land surface elevation are calculated by taking the difference between two SAR images of the same area taken at different times. The difference between the two shows the ground-surface displacement (range change) between the two time periods.

The spatial resolution of InSAR is dependent on the location and resolution of the remote imagery, and whether it is taken from a plane or by orbiting satellite. At its finest resolution, InSAR has a sampling pixel of approximately 25’ by 25’ from satellites. The resolution of vertical displacement is dependent upon meteorological, observational, and other conditions, but is typically within a few centimeters to millimeters.

Raw InSAR data requires specialized computer programs to process and view. Some agencies and organizations, such as the California Water Science Center, provide InSAR imagery online. Direct data downloads are possible, but require registration approved with UNAVCO as an affiliate with an institution engaged in SAR research to download data. Data is available for anyone to browse online, and there are several agencies/institutes that publish data for specific regions.

Currently, InSAR imagery is obtained via specialized radar equipment on an aircraft and managed by NASA’s Jet Propulsion Laboratory (JPL). In December 2021, the satellite NISAR is scheduled to launch; NISAR will provide coverage every 12 days and all NASA data will be free.

Continuous Global Positing System (CGPS)

CGPS stations continuously measure the three-dimensional position of a sensor. There are more than 1,000 sensors in Western North America, with hundreds in California. Most sensors are managed by the Plate Boundary Observatory/UNAVCO and by Scripps Orbit and Permanent Arrary Center (SOPAC), but other groups such as Caltrans also operate sensors. These monitoring stations help measure tectonic movements as well as subsidence, which means data is taken in the X, Y, and Z axis.

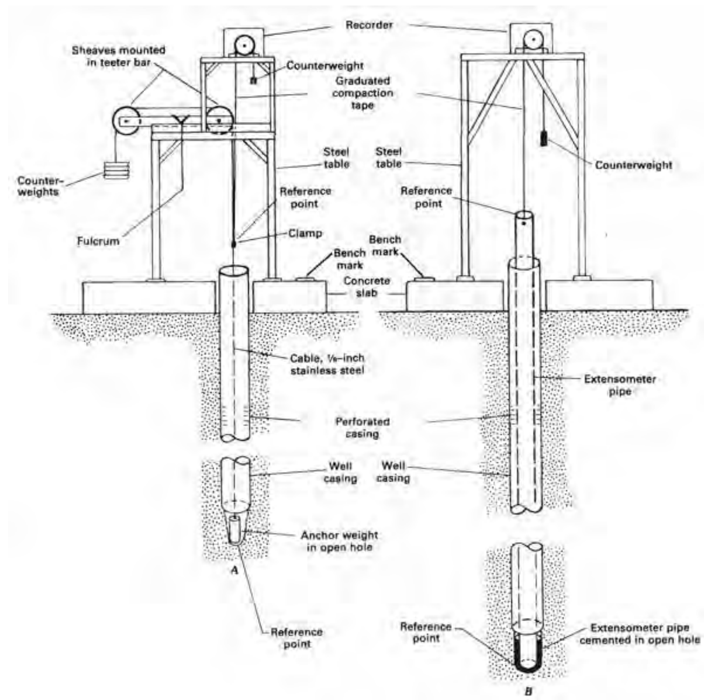
Measurements are typically taken every 15 seconds and are processed to produce a daily position. The CGPS system has data/information published online, however, some use is limited and registration is required for certain data access.

Currently, subsidence measurements in and immediately around the Cuyama Basin are taken through CGPS instrumentation.

Spirit Leveling

This is the oldest method of measuring subsidence and was used long before electronic aids such as GPS. The primary tool is a Spirit Level in combination with a telescope and graduated vertical rods. Measurements are based on one reference point. This technique is best used for smaller survey areas (5 miles or less) and areas where high spatial density is desired. This is a good option for localized surveying and where cost is a priority.

Extensometers



Extensometers are *one dimensional* indicators of change in a specified depth. In regards to land subsidence, they often measure the change in an aquifer system within a specific depth range – that is to say, if the extensometer extends 20 meters into the ground, it can only measure the change in compaction (or expansion) within those 20m. It is also important to understand that extensometers measure compaction/expansion, *not* elevation.

Between the 1950s and 1970s, more than two dozen extensometers were installed in California's Central Valley by the USGS, with additional units installed since then.

Most extensometers are constructed as cable or pipe borehole extensometers (see the figure to the right above). They function by having a cable or pipe extend to the bottom of a drilled hole to the measuring depth at a specific reference point. At the top of this cable or pipe is a reference point, and attached to the reference point is another cable that extends to the top of a platform near the ground surface, around a wheel, and to a counter weight which maintains tension on all cables. As the ground elevation and bottom reference point change in relation to one another, the wheel turns as the counter weight either drops or rises. This change in the position of the counter weight is equal to the amount of compaction between the two reference points.

Although simple in theory, extensometers can be costly to install due to the drilling that is required and robust equipment needed. In addition, multiple extensometers are often needed to measure compaction across a range of depths and to determine which portion of the subsurface is compacting.

Piezometers

Piezometers measure the hydraulic pressure in a groundwater system. Piezometers are paired with extensometers or CGPS data to analyze stress-strain characteristics of a groundwater system. These systems allow for the calculation of the *skeletal storage coefficient*, which is the standard measure of an aquifer's storage directly related to the compressibility of the soil/storage system. This is what largely controls how "recoverable" an aquifer system is when it is recharged with water.

If water levels continue to decline into the inelastic range of stress, it can become possible to compute the *inelastic storage coefficient* that governs the permanent compaction of the aquifer system. If water levels fluctuate into both of these ranges seasonally or annually, it may be possible to calculate both.

Chapter 2
Appendix C

Cuyama Basin Water Resources Model Documentation

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Attachments

Appendix C — Cuyama Basin Water Resources Model Documentation

Introduction

Goals of Model Development

The Cuyama Basin Water Resources Model (CBWRM) was developed to evaluate the recent historical, current, and projected surface water and groundwater conditions in the Cuyama Groundwater Basin (Basin), and simulate various scenarios as part of the Basin's *Groundwater Sustainability Plan* (GSP). The fine temporal and spatial scale of the CBRWM allows the Cuyama Basin Groundwater Sustainability Agency (CBGSA) and its stakeholders to evaluate the effect of changing groundwater conditions in different parts of the Basin.

The CBWRM was developed in consultation with members of the Technical Forum, which includes technical staff and consultants representing a range of public and private entities in the Basin. Technical Forum members are listed in Chapter 1, Section 1.3. The Technical Forum held 14 monthly conference calls over the course of CBWRM development, and model data and outputs were provided to Technical Forum members to facilitate review and feedback on model development. This allowed Technical Forum members to review and comment on all major aspects of CBWRM development.

Basin Overview

The Basin encompasses an area of approximately 378 square miles, and includes the communities of New Cuyama and Cuyama, which are located along State Route (SR) 166 and Ventucopa, which is located along SR 33. Figure C-1 shows the Cuyama Basin and its key geographic features. The Basin encompasses an approximately 55-mile stretch of the Cuyama River, which runs through the Basin for much of its extent before leaving the Basin to the northwest and flowing toward the Pacific Ocean. The Basin also encompasses reaches of Wells Creek in its north-central area, Santa Barbara Creek in the south-central area, and the Quatal Canyon drainage and Cuyama Creek in the southern area of the Basin. Primary land use and development in the Basin is agricultural use, which mostly occurs in the central portion east of New Cuyama, and along the Cuyama River near SR 33 through Ventucopa. Additionally, there has recently been new agricultural development in the western part of the Basin.

CBRWM Platform

The CBWRM was developed based on the Integrated Water Flow Model (IWFM) software platform. The IWFM is an open-source, finite element simulation code that supports triangular and quadrilateral elements (Dogrul et al., 2017b). IWFM was specifically designated in the Sustainable Groundwater Management Act (SGMA) regulations as a model supported by the California Department of Water Resources (DWR) for evaluation of the integrated surface water and groundwater resources a basin, including detailed water budget development that meets SGMA requirements. IWFM has been used throughout California for planning and management of water resources, including GSP development. IWFM is also used for DWR's California Central Valley Groundwater-Surface Water Simulation Model

(C2VSim), which is the fine-grid version that is being refined and enhanced by DWR to support SGMA activities throughout the Central Valley at the regional scale (DWR, 2018).

The IWFM Demand Calculator (IDC) is the stand-alone root zone component of IWFM that simulates land surface and root zone flow processes (Dogrul et al., 2017b). It calculates agricultural and urban water demands using inputs including climatic conditions, soil hydrologic conditions, and land use types and cropping patterns. The IDC can be used as a stand-alone model, or it can be combined with IWFM. When combined, the full IWFM model simulates the integrated system of land surface processes and groundwater system and the stream system, as well as interaction among these systems.

CBWRM Development

Model Input Data

The CBWRM historical model simulates Basin hydrologic conditions on a daily time step from water year 1995 through water year 2017 (i.e., October 1, 1994 through September 30, 2017). Table C-1 lists CBWRM files and corresponding major data sources.

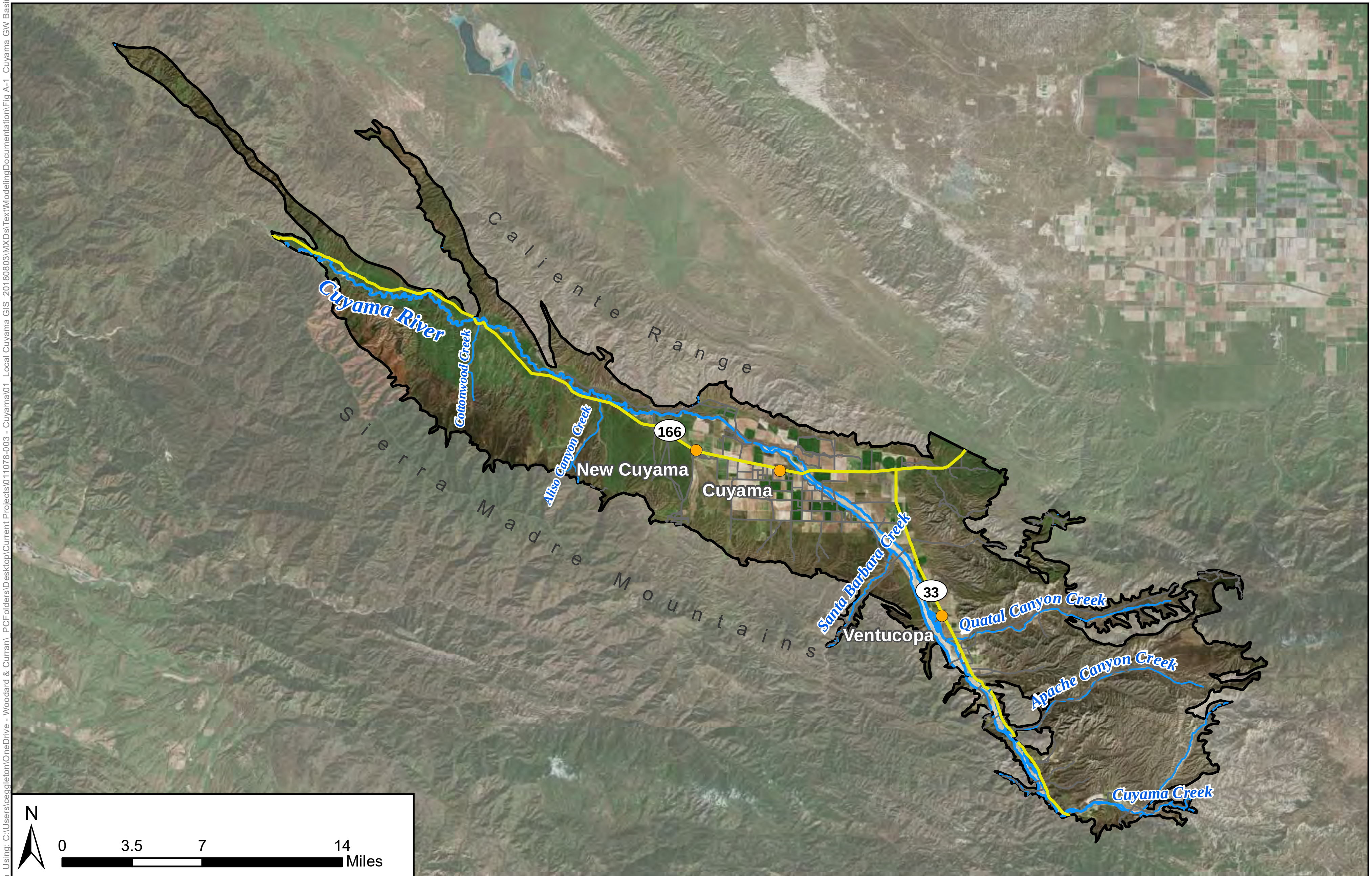

Figure C-1 - Cuyama Valley Groundwater Basin

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

WOODARD & CURRAN

Legend

- Towns
- Cuyama Basin
- Highways
- Local Roads
- Cuyama River
- Streams/Creeks

Table C-1: CBWRM Major Model Data

Major Data Category	Minor Data Category	Data Source
Hydrogeological Data	Geologic Stratification	Diblee Maps and Cuyama Valley Hydrologic Model (CUVHM)
Stream Data	Stream Configuration	National Hydrography Dataset (NHD)
	Streamflow Records	United States Geological Survey (USGS) and California Data Exchange Center (CDEC) Stream Gages
Hydrological Data	Precipitation	Parameter-Elevation Relationships on Independent Slopes Model (PRISM)
Agricultural Water Demand	Land Use and Cropping Patterns	• DWR • Private Landowners • CBGSA-developed data
	Evapotranspiration	California Irrigation Management Information System (CIMIS)
	Soil Properties	Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO)
Urban Water Demand	Population	United States Census Bureau
	Per Capita Water Use	Cuyama Community Services District (CCSD) Local Information
Water Supply	Groundwater Pumping	CCSD
Other	Initial GW Level Conditions	• DWR Water Data Library • Private landowners
	Small Watersheds	NHD
	GW Level Records for Calibration Wells	• DWR Water Data Library • Private landowners

Analysts developed the 50-year hydrologic period of water years 1968 through 2017 for use in CBWRM to meet SGMA requirements for long-term water budget representation for current and projected Basin conditions.

CBWRM Grid

Analysts developed the finite element grid using the Groundwater Modeling System (GMS) software' the grid development module. The model grid network is composed of a combination of quadrilateral and triangular elements, which allows a detailed representation of various hydrologic, geologic, and jurisdictional features required for development of information about land and water use, water supply, groundwater conditions, and water budget. The CBWRM grid and the specific features used in grid development are shown in Figure C-2. These features include the following:

- The Basin boundary as defined in DWR's Bulletin 118 (DWR, 2004)
- Hydrologic and hydrogeologic features (i.e., Cuyama River and minor streams, faults, and outcroppings)
- The Cuyama Community Services District (CCSD) boundary
- Cuyama Water District boundary

The CBWRM grid contains 6,582 elements with an average element area of 36.8 acres. Primary objectives during grid development were to maintain a manageable number of elements and nodes for model computational performance, to optimize resolution for data analysis, and to contain relatively finer resolution along rivers, which allows for better simulation of stream-aquifer interaction to optimize the model run time and to streamline model output.

Stream Configuration and Watersheds

The CBWRM surface hydrology is represented by nine model stream reaches, representing the Cuyama River. The USGS has two active gages that record flows in the Cuyama River watershed upstream of Lake Twitchell. These include one gage on the Cuyama River downstream of the Basin (ID 11136800), which is located just upstream of Lake Twitchell. This gage has 58 recorded years of streamflow measurements from 1959 to 2017. The other active gage is south of the city of Ventucopa along Santa Barbara Canyon Creek (ID 11136600), and this partial record is limited to seven years (i.e., from 2010 to 2017). In addition, limited data are available from four deactivated gages, as shown in Chapter 1.

The inflow from upper watershed areas originates from ungaged watersheds. Figure C-3 shows the upper watershed areas included in the model. Flows from ungaged watersheds surrounding the Basin are estimated using a simplified rainfall runoff module incorporated in the small watersheds module of the CBWRM. This module simulates the surface water and groundwater contributions from the small watersheds using daily precipitation rates and runoff and infiltration characteristics assigned to each ungaged watershed. The portion of flow from the small watershed that enters the model domain as surface runoff is directed to drain into simulated streams. The portion of flow from small watersheds that infiltrates to ground contributes to the main groundwater system as boundary flows.

All subsurface inflows from these small watersheds are routed to the top model layer in each watershed (Layer 3 in most watersheds) along specified groundwater nodes, with a user-defined maximum percolation rate at each node. Excess flows that do not infiltrate to groundwater enter the simulated streams at user-specified locations. The hydrologic conditions of these small watersheds used to estimate the subsurface and surface flows are represented using parameters (e.g., precipitation, surface layer soil parameters, runoff coefficient) for each watershed. The soil parameters and runoff coefficients were estimated using data from SSURGO (USDA, 2017a).

Precipitation

Rainfall data for the CBWRM area are derived from the PRISM database (PRISM Climate Group, 2018). The database contains monthly precipitation data starting from 1895 and daily precipitation data from December 1, 1981 on a 4-kilometer grid throughout the model area. To develop data for the daily time step of the CBWRM, monthly precipitation data for the 1968 to 1981 time period was downscaled to daily temporal resolution with a similar water year type analysis using the recorded Cuyama River flows. Each of the model elements was mapped to the nearest PRISM reference node, which are uniformly distributed across the model domain. The resulting average annual precipitation is shown in Figure C-4.

Figure C-5 shows the Basin averaged annual rainfall in the model area and the cumulative departure from mean, which is an indication of long-term rainfall trends in the area. The average annual precipitation during the 50-year hydrologic sequence from October 1967 to September 2017 was 13.1 inches, which ranges from an annual average of 11.4 inches in the valley floor to 14.8 inches in the upper watershed areas.

Attachment C-2 describes the climate change scenarios analyzed for projected future conditions, and the modifications made to the precipitation data to reflect the effects of climate change.

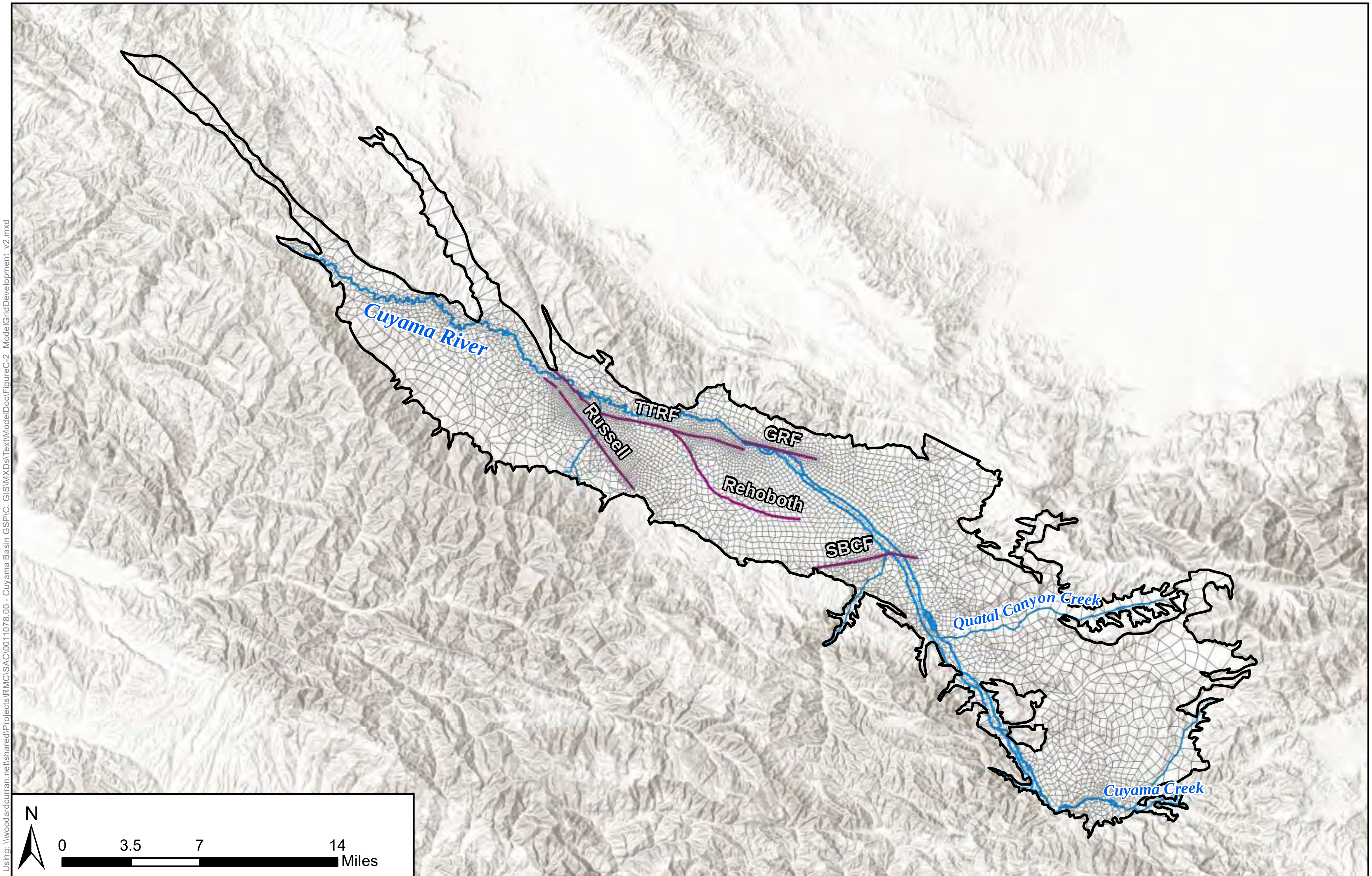

Figure C-2 - Cuyama Valley Groundwater Basin IWFM Grid Development Features

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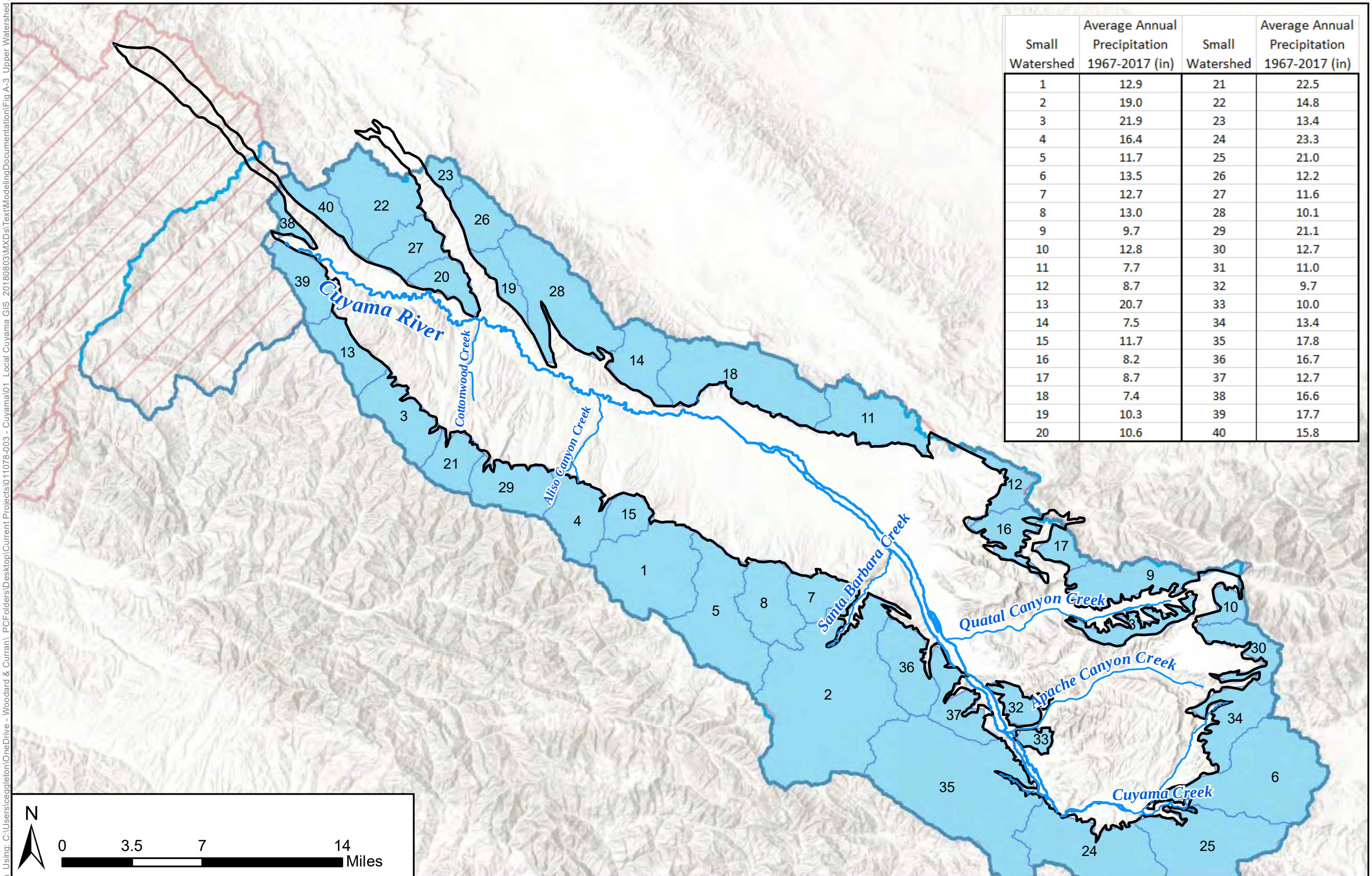
Legend

- Cuyama Basin
- Model Grid
- Faults in CBWRM
- Cuyama River
- Streams/Creeks



Small Watershed	Average Annual Precipitation 1967-2017 (in)	Small Watershed	Average Annual Precipitation 1967-2017 (in)
1	12.9	21	22.5
2	19.0	22	14.8
3	21.9	23	13.4
4	16.4	24	23.3
5	11.7	25	21.0
6	13.5	26	12.2
7	12.7	27	11.6
8	13.0	28	10.1
9	9.7	29	21.1
10	12.8	30	12.7
11	7.7	31	11.0
12	8.7	32	9.7
13	20.7	33	10.0
14	7.5	34	13.4
15	11.7	35	17.8
16	8.2	36	16.7
17	8.7	37	12.7
18	7.4	38	16.6
19	10.3	39	17.7
20	10.6	40	15.8

Figure C-3 - Cuyama Valley Groundwater Basin Upper Watershed Areas in the IWFM Model

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Legend

- Cuyama Basin
- Cuyama River
- Streams/Creeks
- Contributes to Cuyama GW Basin
- Does Not Contribute to Cuyama GW Basin
- Watershed
- Small Watersheds (HUC 12)

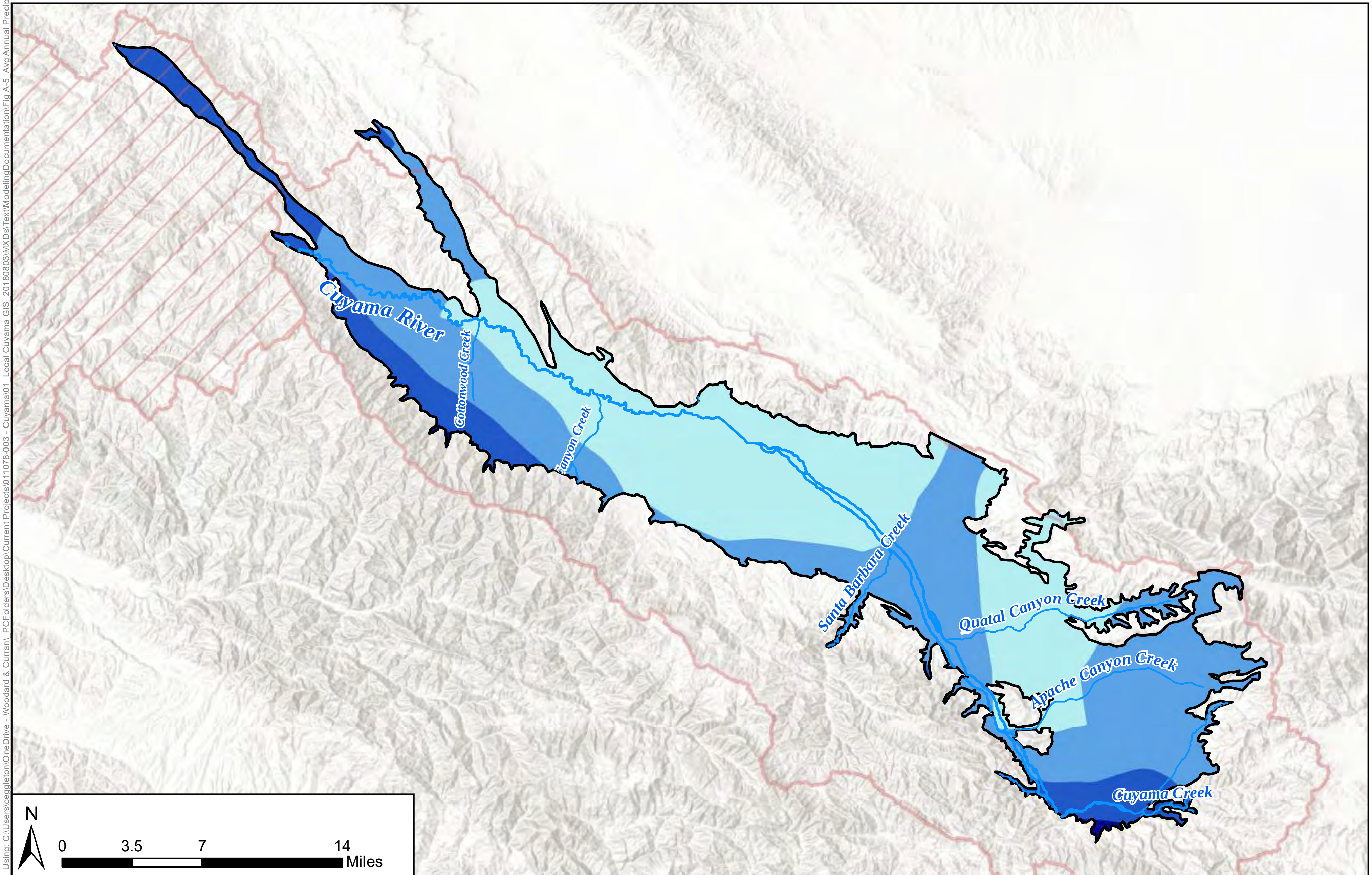

Figure C-4 - Cuyama Valley Groundwater Basin Average Annual Precipitation

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Legend

- Cuyama Basin
- Cuyama River
- Streams/Creeks
- Contributes to Cuyama GW Basin
- Does Not Contribute to Cuyama GW Basin

Average Annual Precipitation (.in)

- 5.1 - 10
- 11 - 15
- 16 - 20
- 21 - 25

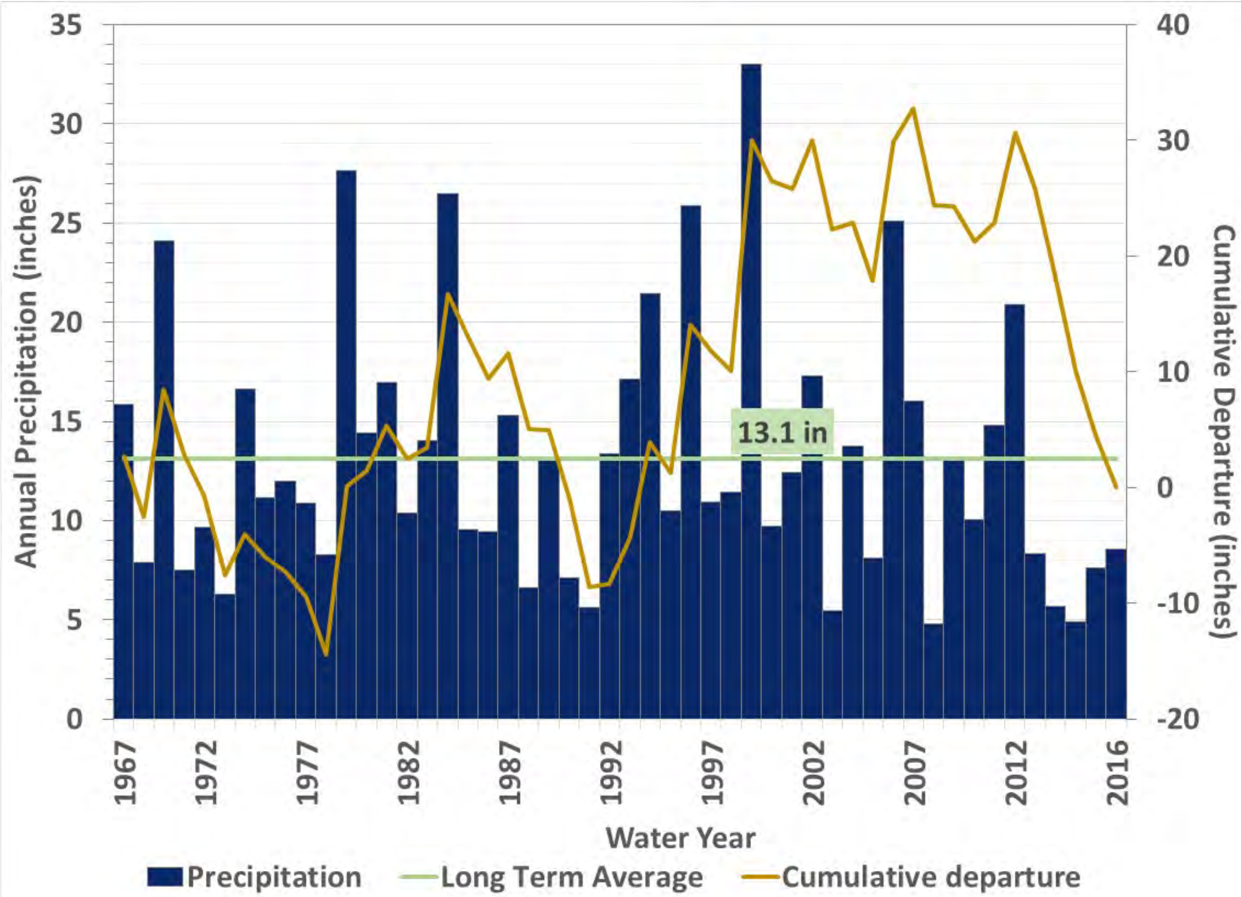

Figure C-5: 50-Year Historical Precipitation and Cumulative Departure from Mean Precipitation

Root Zone Soil Parameters

Soil properties specified in the CBWRM are field capacity, wilting point, total porosity, saturated hydraulic conductivity, and pore size distribution index. These soil properties are specified for each model element, and were used to calculate runoff and infiltration from both rainfall and applied water at each model time step.

DWR's IWFM Soil Data Builder (DWR, 2017) was used in conjunction with the SSURGO (USDA, 2017a) soil data to determine the five soil parameters for each model element. The IWFM Soil Data Builder extracts the SSURGO data relevant to the model area and associates it with each model grid element. For the elements where SSURGO data was incomplete, analysts used the USDA's Digital General Soil Map of the United States (STATSGO2) data (USDA, 2017b) to complement SSURGO parameters.

CBRWM elements are associated with the four hydrologic soil groups according to their runoff potential and infiltration characteristics. NRCS defines these hydrological soil groups as follows (NRCS, 2009):

- **Group A** – Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil. Group A soils typically have less than 10 percent clay and more than 90 percent sand or gravel and have gravel or sand textures. Some soils having loamy sand, sandy loam, loam or silt loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.
- **Group B** – Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded. Group B soils typically have between 10 and 20 percent clay and 50 to 90 percent sand and have loamy sand or sandy loam textures. Some soils having loam, silt loam, silt, or sandy clay loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.
- **Group C** – Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission through the soil is somewhat restricted. Group C soils typically have between 20 and 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures. Some soils having clay, silty clay, or sandy clay textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.
- **Group D** – Soils in this group have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted. Group D soils typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures. In some areas, they also have high shrink-swell potential.

Land Use and Cropping Patterns

Land use and cropping patterns are key data sets that support estimation of monthly agricultural water requirements over the period of model simulation. Consistent with the DWR's C2VSim, the CBWRM includes 23 irrigated crop categories and four general land use categories. The general land use categories include urban landscape (e.g., residential areas, school fields, roads, etc.), water surface (e.g., streams, lakes, and reservoirs), riparian vegetation (e.g., native vegetation in the vicinity of surface water), and native vegetation. The 23 irrigated crop categories are combined into six summary-level crop group with similar water use and/or irrigation practices, which also provides a simpler representation of crop group types for planning and policy purposes. Table C-2 lists the land use categories.

Table C-2: Land Use Categories

Land Use Type	Model Category	Grouped Categories
Irrigated Crops	• Apple • Berry • Citrus • Olive • Pistachio • Misc. Deciduous • Misc. Subtropical Fruits	Fruit and Nut Trees
	Vineyards	Vineyards
	• Alfalfa • Mixed Pasture	Alfalfa and Irrigated Pasture
	• Misc. Grain • Misc. Grass • Wheat	Grain
	• Dry Beans • Corn • Misc. Field Crops • Safflowers	Field Crops
	• Carrot • Cole • Mixed Greens • Lettuce • Melons • Onion • Potatoes • Misc. Truck Crops	Truck Crops
	Idle and Fallow Lands	Idle
Other Land Use	• Urban Landscape • Water Surface • Riparian Vegetation • Native Vegetation	

Spatial land use data were used to specify land use types and crop acreages for each model element for each year of simulation. The following data sources were used:

- 1996 data from historical DWR county land use surveys[1]
- 2014 and 2016 data that were developed for DWR using remote sensing data by LandIQ[2]
- 2000, 2003, 2006, 2009, 2012 data that were developed for the CBGSA using remote sensing data; development of these datasets is documented in Attachment C-1.
- Data provided by private landowners for portions of the Basin between 1992 and 2017

Figure C-6 shows the spatial distribution of the major land use categories in the Basin for 2016.[3] Estimated land use in 2016 includes approximately 36,500 acres of irrigated land use. Figure C-7 shows the historical trend of land use categories in the Basin and the projected assumed annual land use pattern for the 50-year hydrologic period used for the projected condition model scenario. The projected annual land use categories are developed based on the 2017 crop categories and acreage values as the basis, with adjustments made for known acreage changes in 2018. Permanent crop acreages were assumed to remain unchanged from 2017-18 values, while annual crop acreages reflect annual variability that was developed based on an autoregressive moving average model that uses the historical land use data sets. The autoregressive moving average was developed such that long-term average acreage for each annual crop type remained unchanged from 2017 values.

[1] https://www.water.ca.gov/Programs/Water-Use-And-Efficiency/Land-And-Water-Use/Land-Use-Surveys
[2] https://gis.water.ca.gov/app/CADWRLandUseViewer/
[3] Figures for other years can be found in Chapter 1

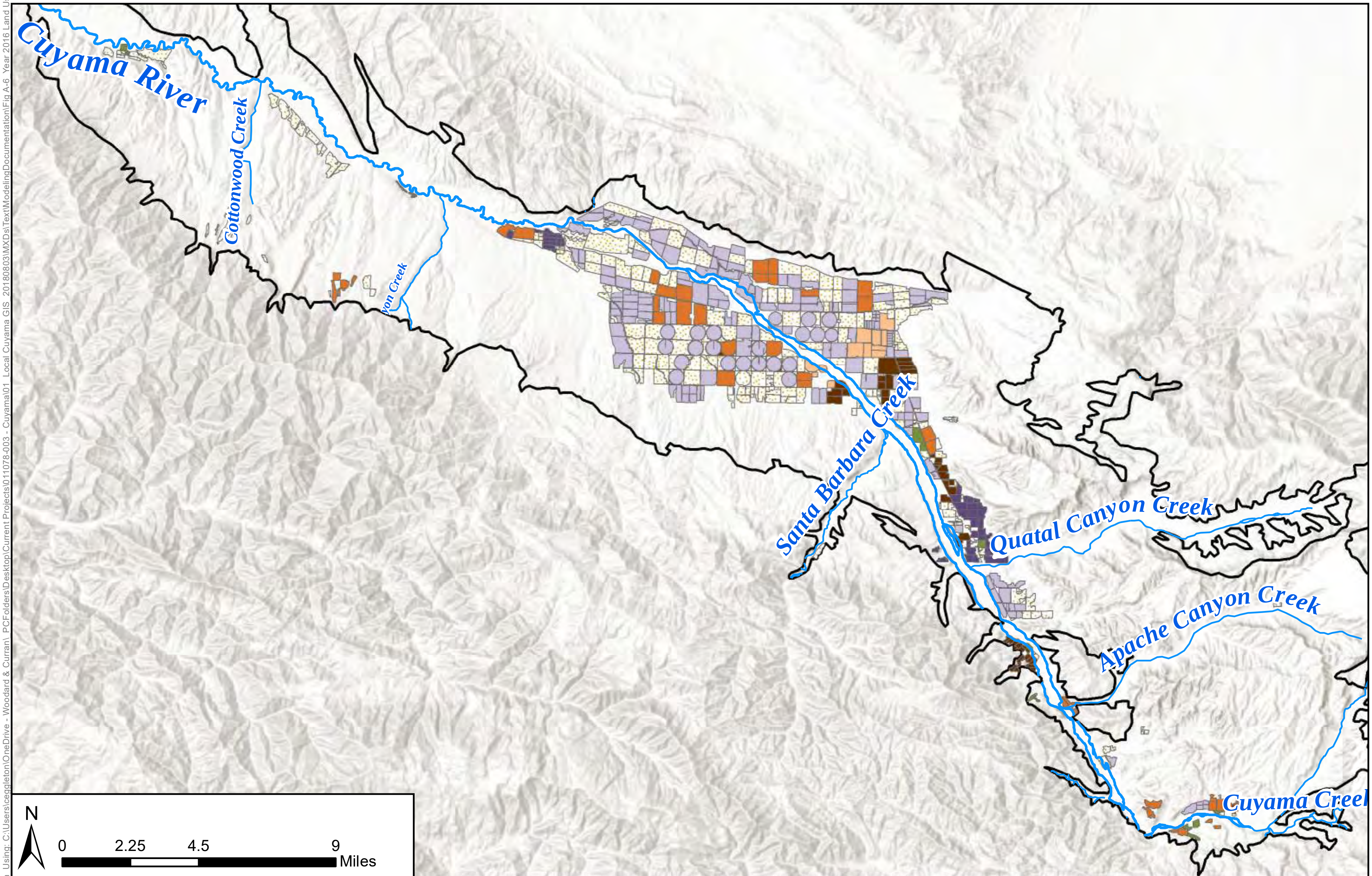

Figure C-6 - Cuyama Valley Groundwater Basin Year 2016 Land Use

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Legend

- Cuyama Basin
- Cuyama River
- Streams/Creeks

Land Use from 2016 Crop Mapping

- Alfalfa and Irrigated Pasture
- Fruit and Nut Trees
- Field Crops
- Truck Crops
- Vineyard
- Grain
- Idle

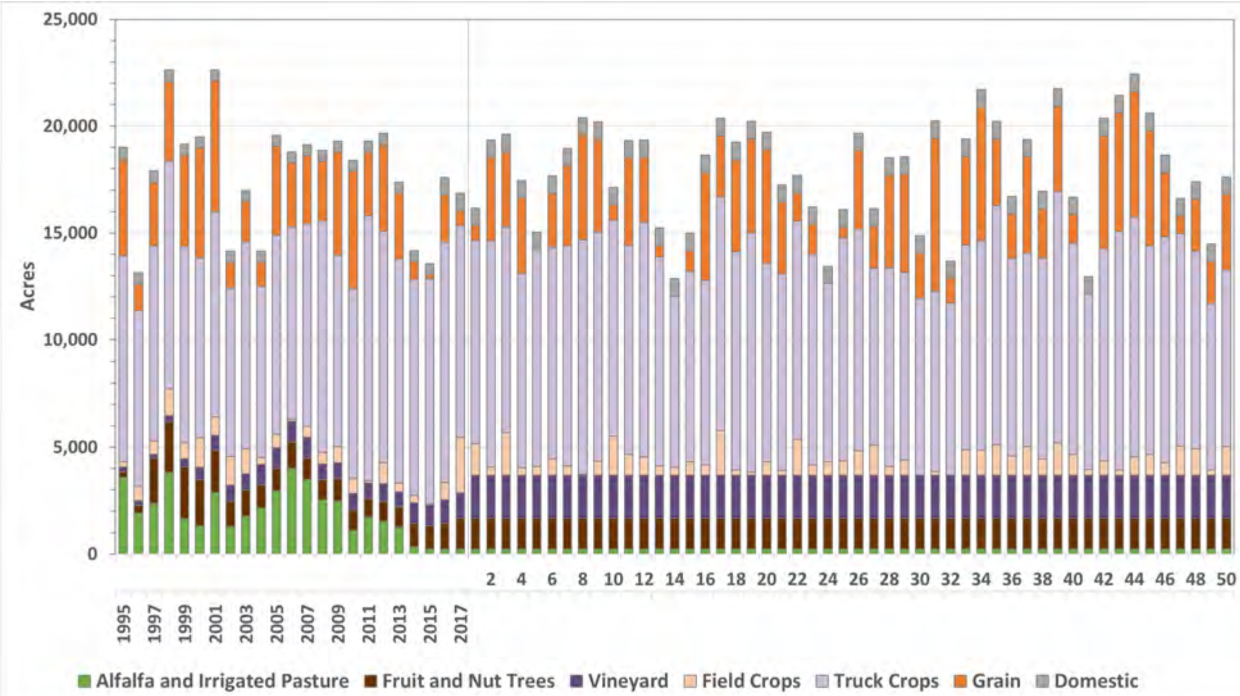


Figure C-7: Historical and Projected Land Use in the Basin

Evapotranspiration

The crop evapotranspiration (ET) requirement is an important factor in agricultural demand estimation. Every land use category must have evapotranspiration assigned for the simulation period. Due to changes in cropping patterns and irrigation practices over time during the historical calibration period, the ET data are specified as a time series during the entire calibration period. ET values are based on the reference evapotranspiration data from Cuyama CIMIS Station. The reference evapotranspiration was converted to crop evapotranspiration using crop coefficients, supplemented by information developed using the Mapping EvapoTranspiration at High Resolution with Internalized Calibration (METRIC) methodology (as described in Attachment C-3). Crop coefficients for each land use category were developed using a daily root zone water balance model (as described in Attachment C-4). This model is driven by the Landsat Normalized Difference Vegetation Index (NDVI) data set, which was originally developed for the Kaweah Delta Water Conservation District in Tulare and Kings counties. The model simulates the rootzone processes on a daily time step, and using remote sensing data, it can capture changes in the timing and intensity of cropping over time.

In the CBWRM, ET represents the net vertical water flux from the land surface and root zone through the upper model layer. Figure C-8 shows the range in annual evapotranspiration rates for each crop category. For climate change scenarios analyzed for projected future conditions, evapotranspiration rates were modified to reflect the effects of anticipated temperature change (Attachment C-2).

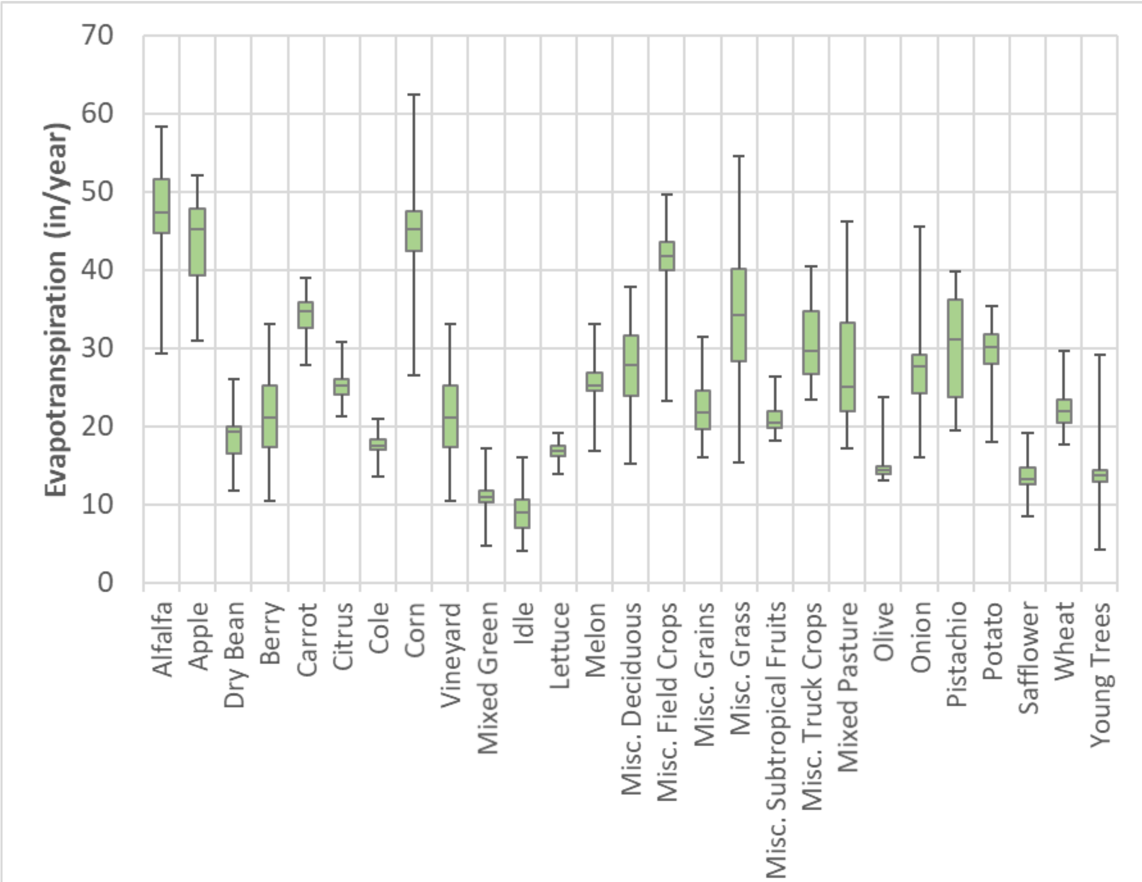


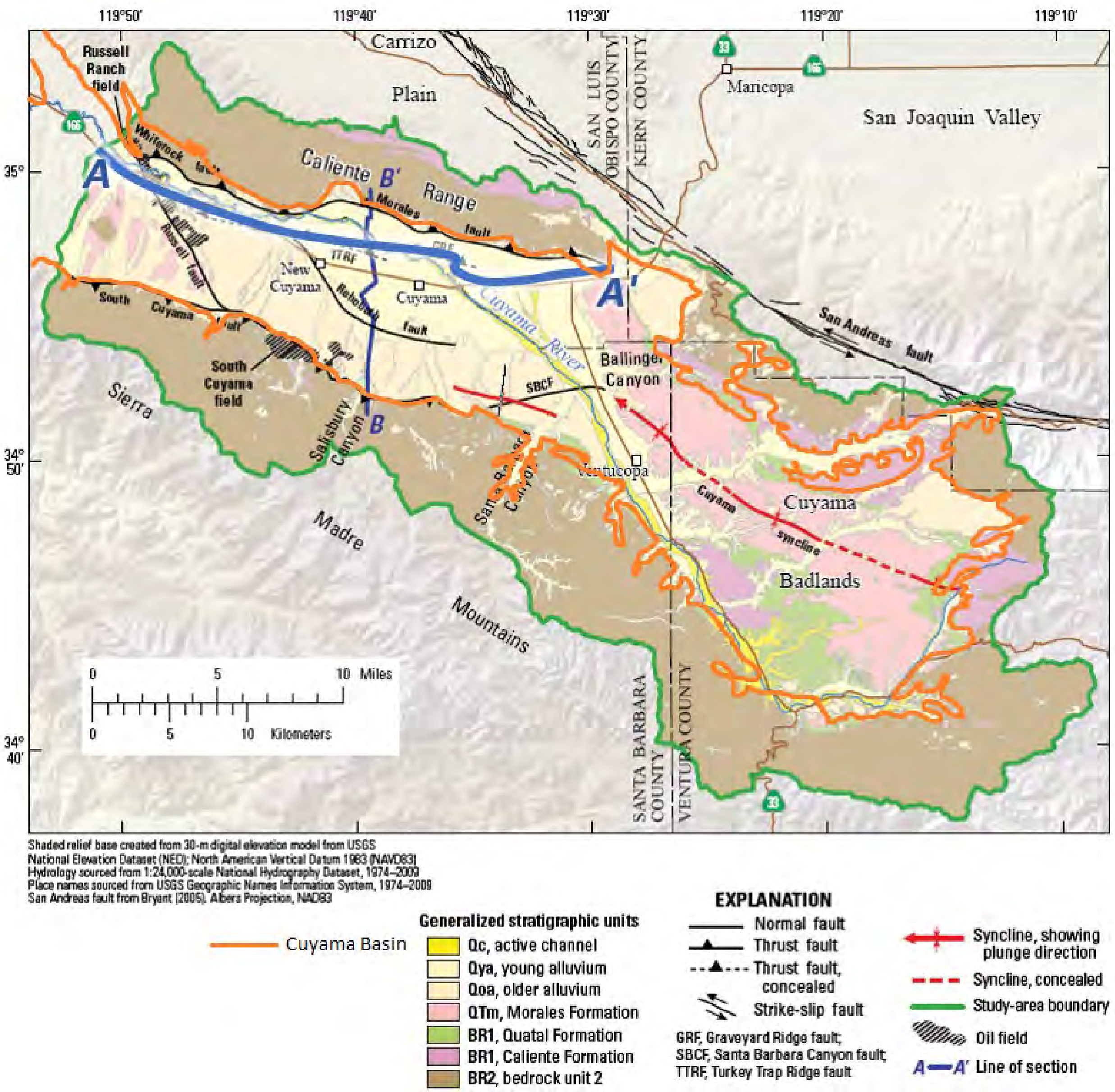
Figure C-8: Annual Evapotranspiration for Each Land Use Type

CBWRM Layering

The CBWRM subsurface zone is characterized by the following three model layers, representing geologic stratification from ground surface to bedrock (listed from top to bottom below) as follows:

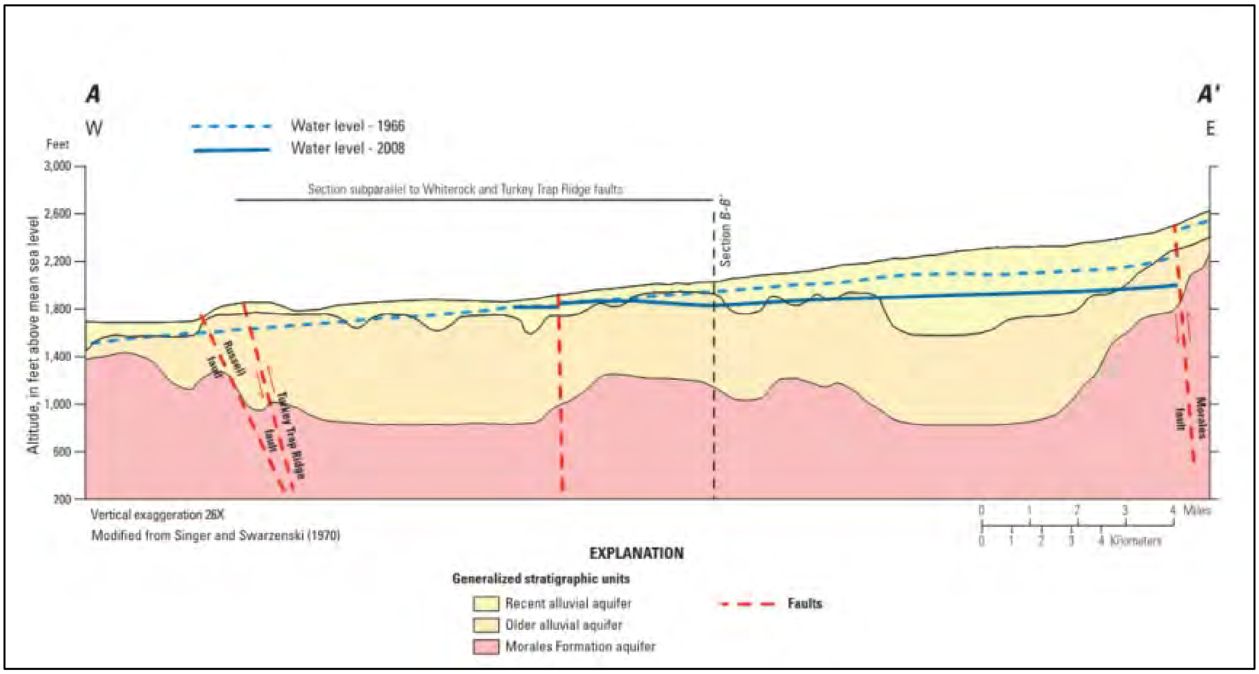
- Layer 1: Recent Alluvial aquifer
- Layer 2: Older Alluvial aquifer
- Layer 3: Morales Formation aquifer

These layers are primarily based on geologic stratification as defined by the USGS (USGS, 2015). They were refined using additional data sets as described in Chapter 2, Section 2.1 of the GSP. Figure C-9 shows the locations of cross sections across the central portion of the Basin as prepared by the USGS in 2013 (USGS, 2013). Figure C-10 shows a west-east cross section that runs near the towns of New Cuyama and Cuyama labeled A-A', and Figure C-11 shows a south-north cross section labeled B-B'. Figures C-12 through C-14 show the extents and thicknesses of layers 1, 2 and 3 in the CBWRM model.



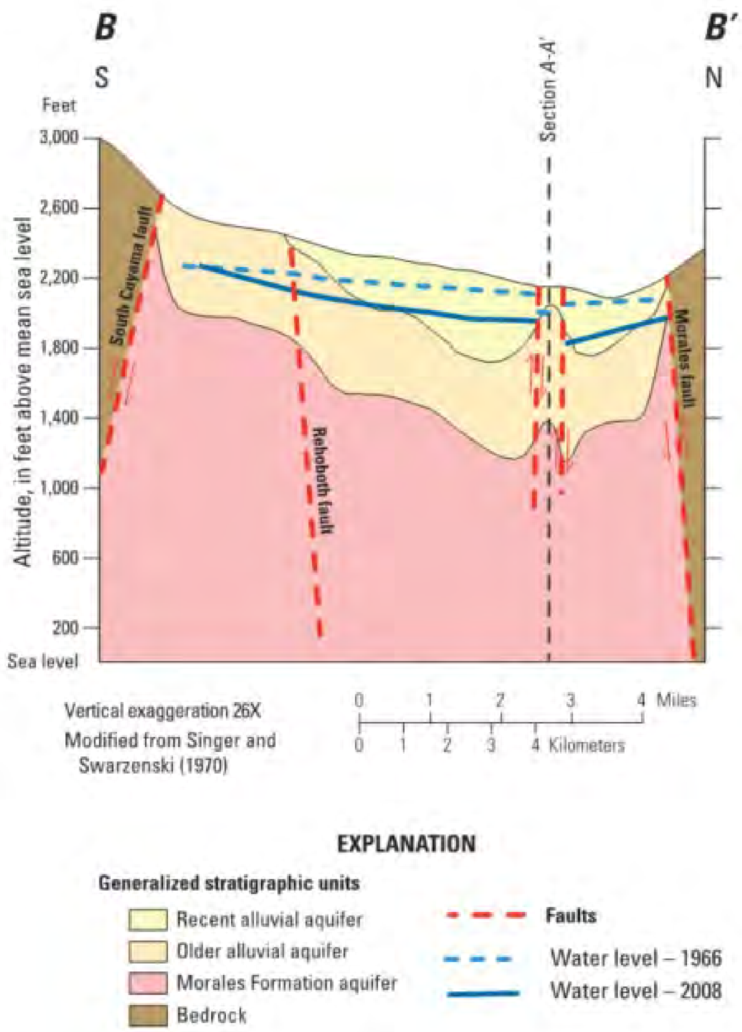
Source: USGS, 2015.

Figure C-9: Location of USGS 2015 Cross Sections



Source: USGS, 2015

Figure C-10: USGS Cross Section A-A'



Source: USGS, 2015

Figure C-11: USGS Cross Section B-B'

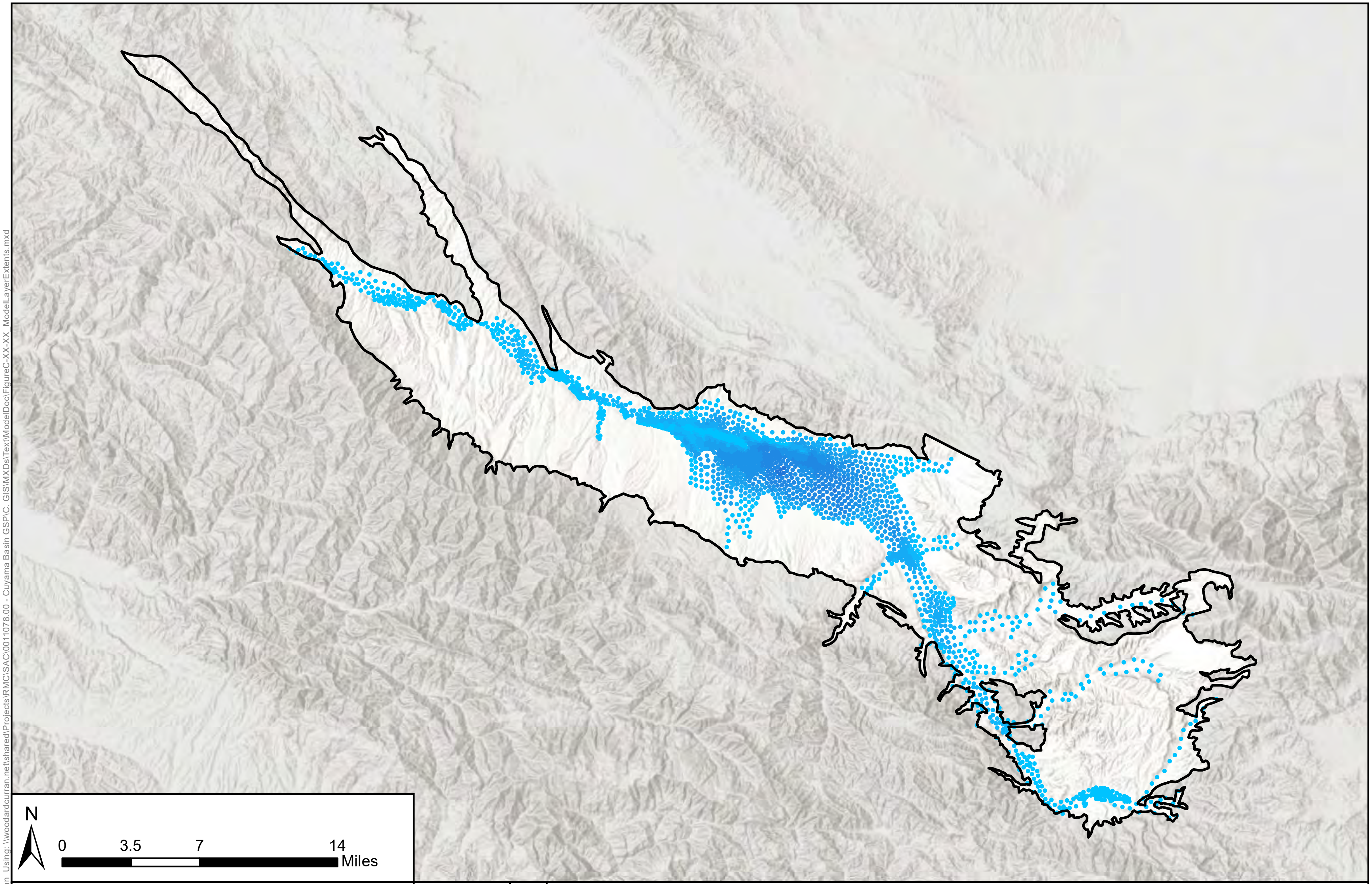


Figure C-12 - CBWRM Layer 1 Extent and Thickness

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Legend

Layer 1 Thickness (ft)

- 10 - 100
- 101 - 200
- 201 - 300
- 301 - 400
- 401 - 500
- 501 - 600
- 601 - 700
- 701 - 800
- 801 - 900
- 901 - 1000
- 1001 - 1100
- 1101 - 1200

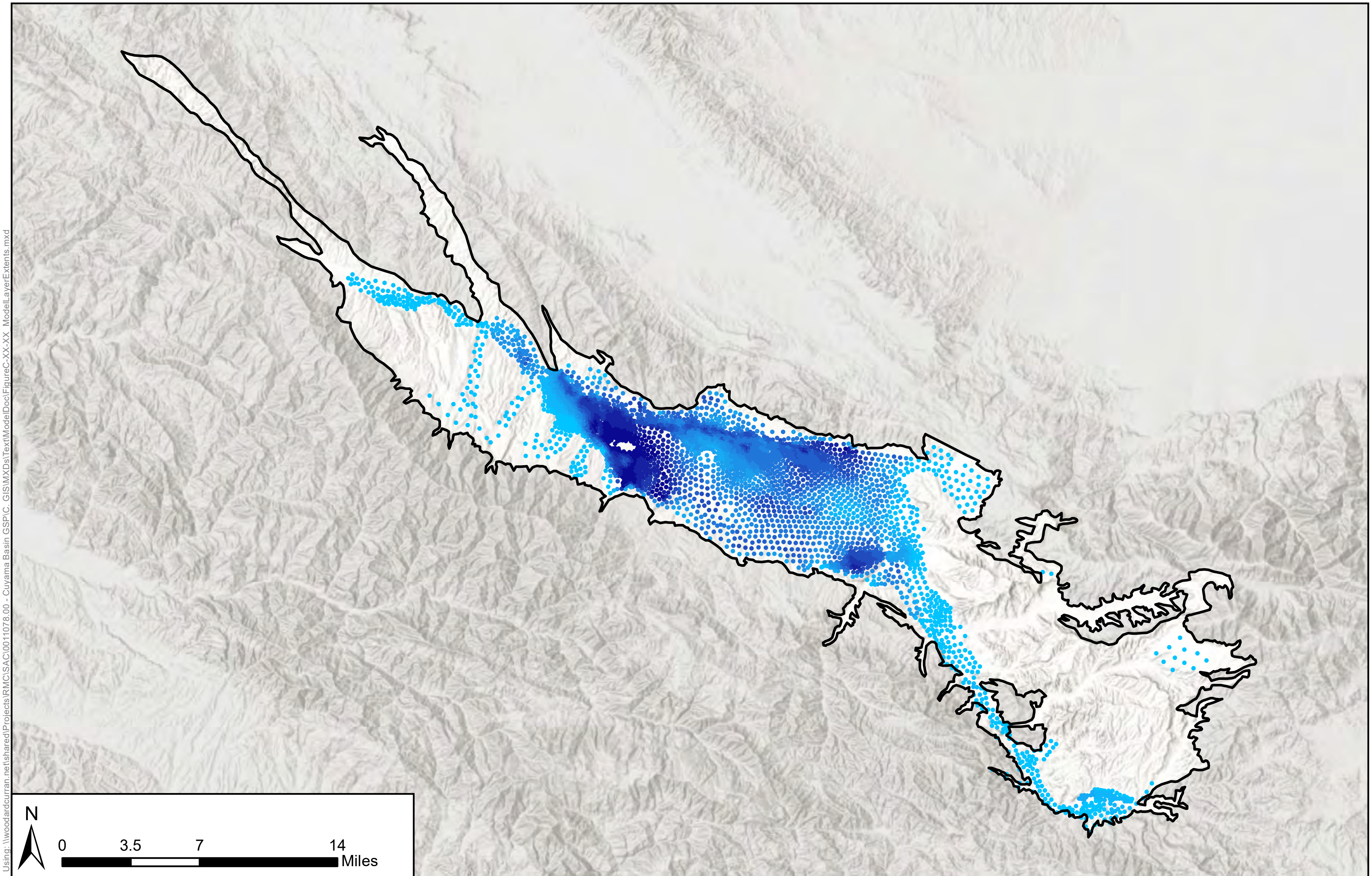

Figure C-13 - CBWRM Layer 2 Extent and Thickness

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Legend

Layer 2 Thickness (ft)

- 10 - 100
- 101 - 200
- 201 - 300
- 301 - 400
- 401 - 500
- 501 - 600
- 601 - 700
- 701 - 800
- 801 - 900
- 901 - 1000
- 1001 - 1100
- 1101 - 1200

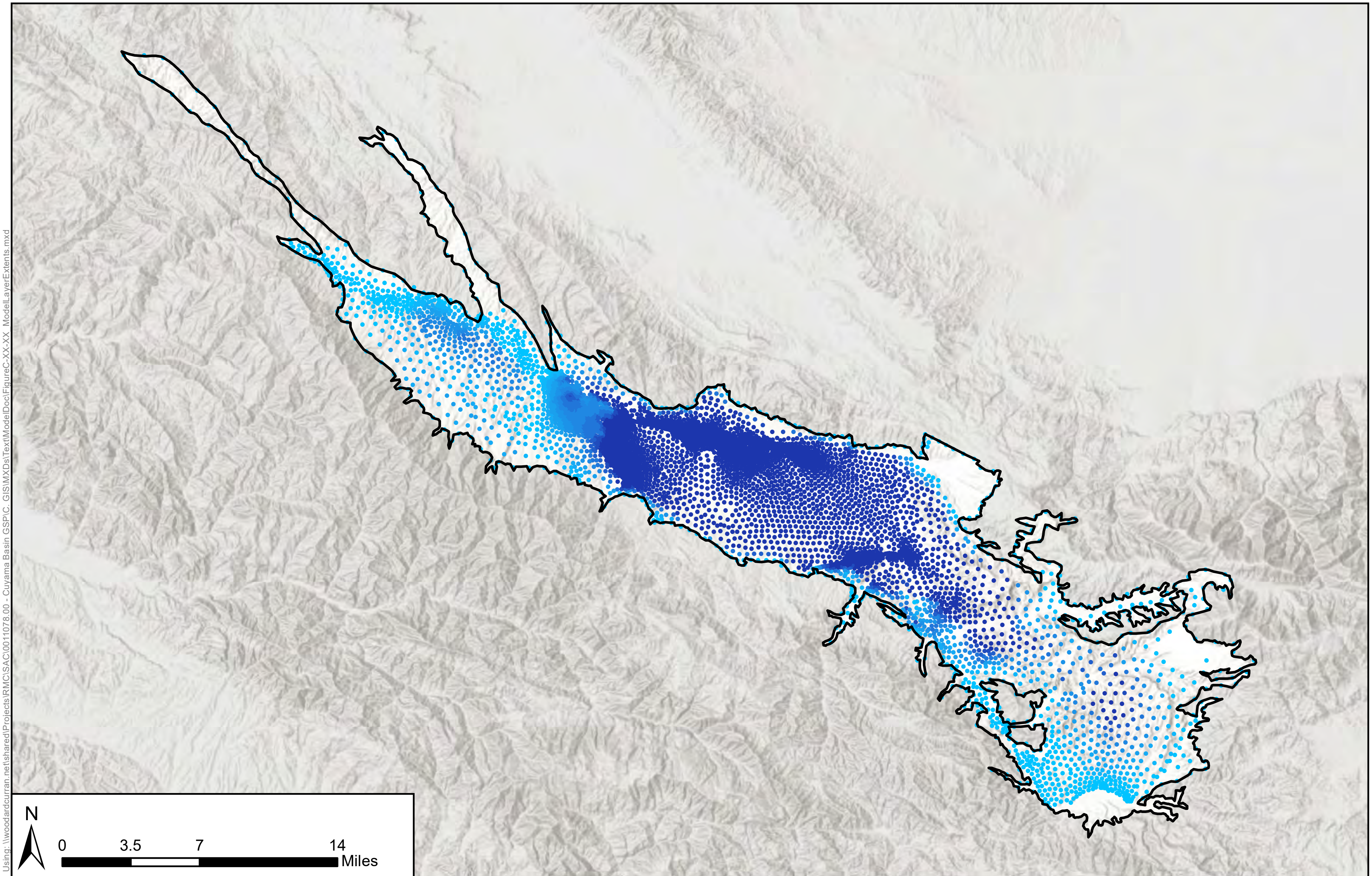

Figure C-14 - CBWRM Layer 3 Extent and Thickness

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Legend

Layer 3 Thickness (ft)

- 10 - 100
- 101 - 200
- 201 - 300
- 301 - 400
- 401 - 500
- 501 - 600
- 601 - 700
- 701 - 800
- 801 - 900
- 901 - 1000
- 1001 - 1100
- 1101 - 1200

Figure Exported: 6/20/2019 By: mceyhan Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0011078.00 - Cuyama Basin GSP\C. GIS\MXDs\TextModelDoc\FigureC-XX-XX_ModelLayerExtents.mxd

Boundary Conditions

As discussed in the previous section, both surface and subsurface inflows within the ungaged watershed areas tributary to the main Basin are simulated using small watersheds module of the CBWRM. No flow boundary conditions were assumed for the rest of the domain boundary.

Initial Conditions

Groundwater heads for each model node and each layer at the beginning of the historical simulation (i.e., October 1, 1994) were developed using groundwater level data described in Chapter 2, Section 2.2. Due to the lack of information on well depth and/or perforation for many of the wells used, groundwater heads for each model layer are assumed to be the same. During the calibration process, some refinements were made by layer, as needed. This assumption, however, results in the use of first few years of simulation for start-up period to stabilize the simulated groundwater levels. Therefore, the model calibration period effectively ends up to be the 20-year period of water years 1996 through 2015.

Water Supply and Demand Data

The following sections describe the data and methodology for the CBWRM water demand and supply calculations. Agricultural water demands were calculated in the IDC portion of IWFM. Agricultural and domestic supplies are specified in the CBWRM's groundwater pumping data.

Agricultural Water Demand

Agricultural water demand is the amount of irrigation water that is required to satisfy the crops' evapotranspiration requirement after rainfall. The IDC is designed to estimate the agricultural water demand for each model element through consumptive use methodology. The IDC calculations rely on model input data for historical crop acreage, irrigation practices, soil moisture requirements, effective rainfall (the portion of rainfall available for crop consumptive use), crop evapotranspiration, and localized soil parameters. This data was compiled, analyzed, synthesized, and processed for input into CBWRM.

Domestic Water Use

IDC calculates urban water demand based on population and per capita water use, and the breakdown of indoor versus outdoor water use by month. For the Basin, the per capita water use was estimated using historical pumping estimates provided by the CCSD (CCSD 2010 to 2017) and population records published for the CCSD service area. Domestic water use during the historical period ranges between 100 and 200 acre-feet per year (AFY).

CBRWM Calibration

The goals of CBRWM calibration were as follows:

- Achieve a reasonable water budget for each component of the hydrologic cycle modeled (i.e., land and water use, soil moisture, stream flow, and groundwater) that is acceptable by the stakeholders to support the development of the GSP
- Maximize the agreement between simulated and observed groundwater levels at select well locations, and simulated and observed streamflow hydrographs at select gaging stations

These objectives are achieved through verification of model input data and adjustment of model parameters.

CBRWM calibration begins after data analysis and input data file development are completed. The calibration effort can be broken down into subsets that align with packages within the IWFM platform. As an integrated surface water and groundwater model, the results of each part of the simulation are dependent on one another. The model calibration can be considered a systematic process that includes the following activities:

- Calibrate water demand estimates for agricultural and urban sectors
- Calibrate surface water features, including the small watershed runoff, boundary flows, and streamflows
- Calibrate overall water budgets for the model area, and model subregions
- Calibrate simulated groundwater levels to observed groundwater levels
- Compare calibration performance with the calibration targets
- Conduct additional refinements to model as necessary

The CBWRM was calibrated to historical groundwater elevation data, with the calibration informed by local data provided by private landowners and other stakeholders.

Due to uncertainty in the initial conditions, a one-year warm-up period was included to allow groundwater levels to stabilize. Thus, the model calibration period for the CBWRM is October 1995 through September 2015, or water years 1996 through 2015 (i.e., 20 years).

Calibration of IDC and Root-Zone Parameters

The goal of IDC calibration is to estimate a reasonable urban and agricultural demand and develop the components of a balanced root zone budget. IDC calibration serves as the foundation of IWFM calibration as demand estimates directly affect the estimates of groundwater pumping. This part of the calibration effort focused primarily on refining individual budget items, while maintaining reasonable root zone parameters.

The calibrated IDC was used to estimate monthly agricultural water demand at each model element during the model hydrologic period. To adjust agricultural demand, elemental root zone parameters were adjusted in accordance with the hydrologic soil group. Figure C-15 shows estimates of annual agricultural water demand in the Basin from water year 1998 to water year 2017. The average annual agricultural water demand during these years is estimated to be approximately 59,000 AFY. The year-to-year variability in estimated agricultural demand reflects the variabilities in land use, precipitation, and temperature experienced historically in the Basin.

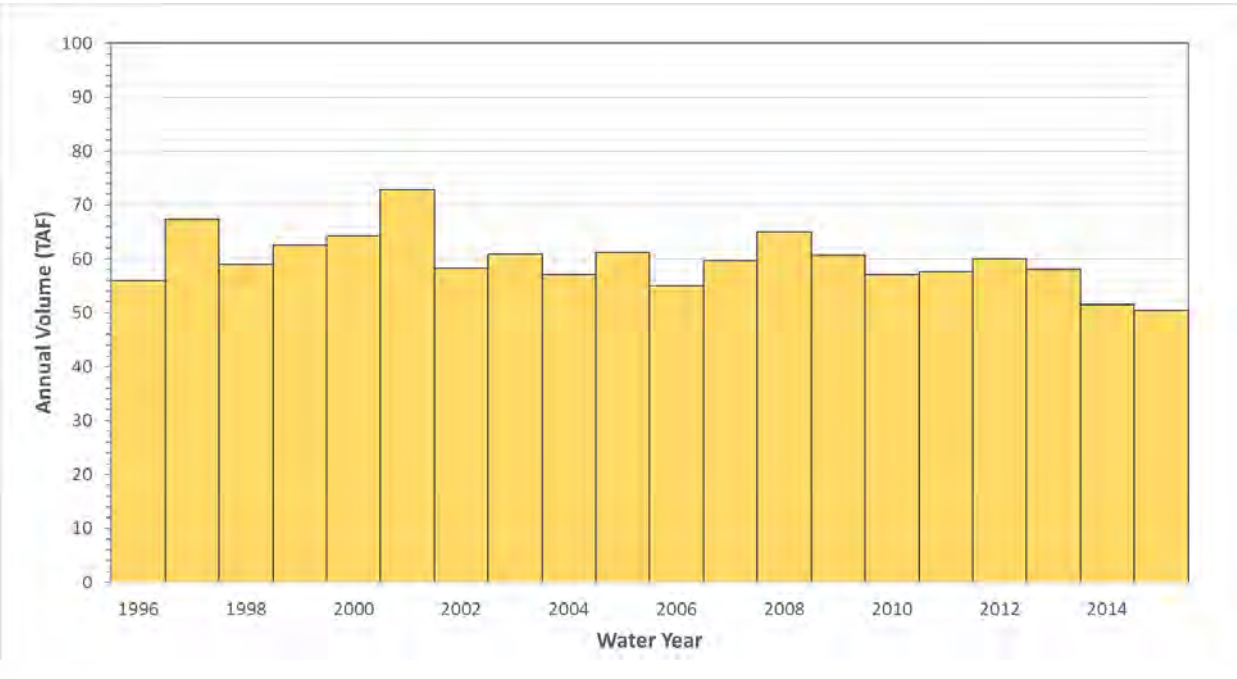

Figure C-15: Annual Agricultural Water Demand

Calibration of Surface Water Features

As discussed above, small watersheds were used to simulate inflows into the model from ungaged watersheds. The small watershed were split between surface water runoff that enters the stream system, percolation that occurs during transport to the streams, and baseflow entering the groundwater system at the model boundary.

In addition to the surface water flows coming from small watersheds, surface water runoff generated over the groundwater basin is collected in the stream network to simulate streamflows and stream-aquifer interaction. Stream-aquifer interaction is calculated based on stream stage, groundwater levels, and channel properties such as streambed hydraulic conductance.

As discussed above, limited streamflow data are available to perform calibration on surface water flows in the model. One USGS gage is available on the Cuyama River downstream of the Basin (ID 11136800), which is located just upstream of Lake Twitchell. The flows from this gage were adjusted to estimate flows at the downstream boundary of the Basin. These adjusted flows as well as available streamflow data from deactivated and active gages on small watersheds were then compared to the flows resulting from the model calibration process.

Calibration of Water Budgets

The aim of the calibration process is to ensure an accurate representation of the hydrologic characteristics of the Basin, confirmed through the analysis of the resulting water budgets. A water budget balances all supplies, demands, and any subsequent change in storage occurring within that specific portion of the hydrologic cycle. IWFM automatically outputs budgets at the subregion scale for processes involving groundwater, the surface layer, streams, the root zone, and small watersheds. IWFM can output select budget information down to a single element or any specific grouping of elements. This feature was used during the calibration process to prepare water budget information by certain geographic areas for planning and comparison purposes.

During this step of the calibration process, CBRWM results are reviewed and summarized into monthly and annual (by water year) budgets. Two key hydrologic components that were reviewed most frequently during the calibration process were the groundwater budget and the land and water use budget. During extensive analysis of water budgets, key model datasets and parameters were adjusted (including parameters related to soil and root zone, small watershed and boundary flows, stream system, and aquifer system), to better match the conceptual understanding of the Basin. CBWRM water budget results are summarized in the following sections.

Land Surface Water Budget

The following components are included in the land surface water budget:

- Inflows:
  - Precipitation
  - Applied Water
- Outflows:
  - Evapotranspiration (Agricultural and Native Vegetation)
  - Domestic Water Use
  - Deep Percolation
  - Runoff

Figure C-16 shows the annual time series of historical land surface inflows and outflows during the calibration period. The Basin experienced about 282,000 AF of inflows each year, of which 223,000 AF is from precipitation and the remainder is from applied water. About 223,000 AFY was consumed as evapotranspiration and domestic use, with the remainder either recharging the groundwater aquifer as deep percolation, stream seepage or leaving the Basin as river flow.

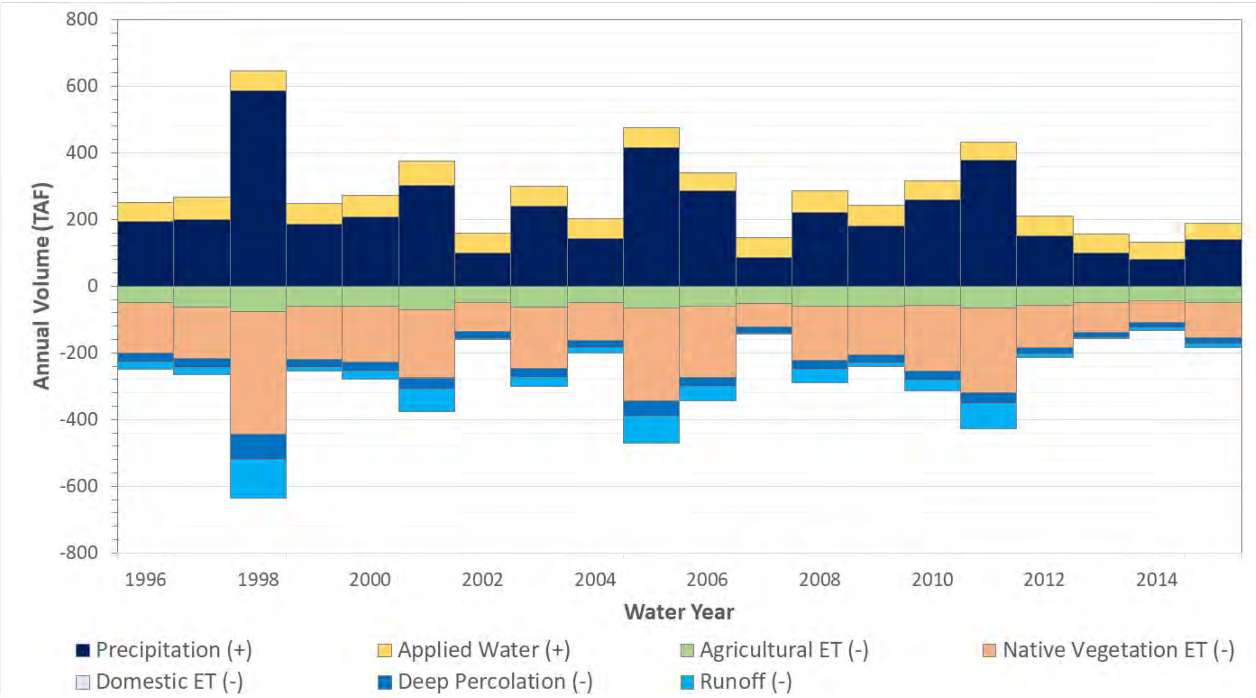

Figure C-16: Land Surface Water Budget Annual Time Series in the Calibration Period

Groundwater Budget

The following components are included in the groundwater water budget:

- Inflows:
  - Deep percolation
  - Gain from stream
  - Subsurface inflow
- Outflows:
  - Groundwater pumping

Figure C-17 shows the annual time series of groundwater inflows and outflows during the calibration period. The Basin average annual historical groundwater budget has greater outflows than inflows, leading to an average annual deficit in groundwater storage of 24,000 AF. The groundwater storage decreases consistently over time, despite year-to-year variability in groundwater inflows.

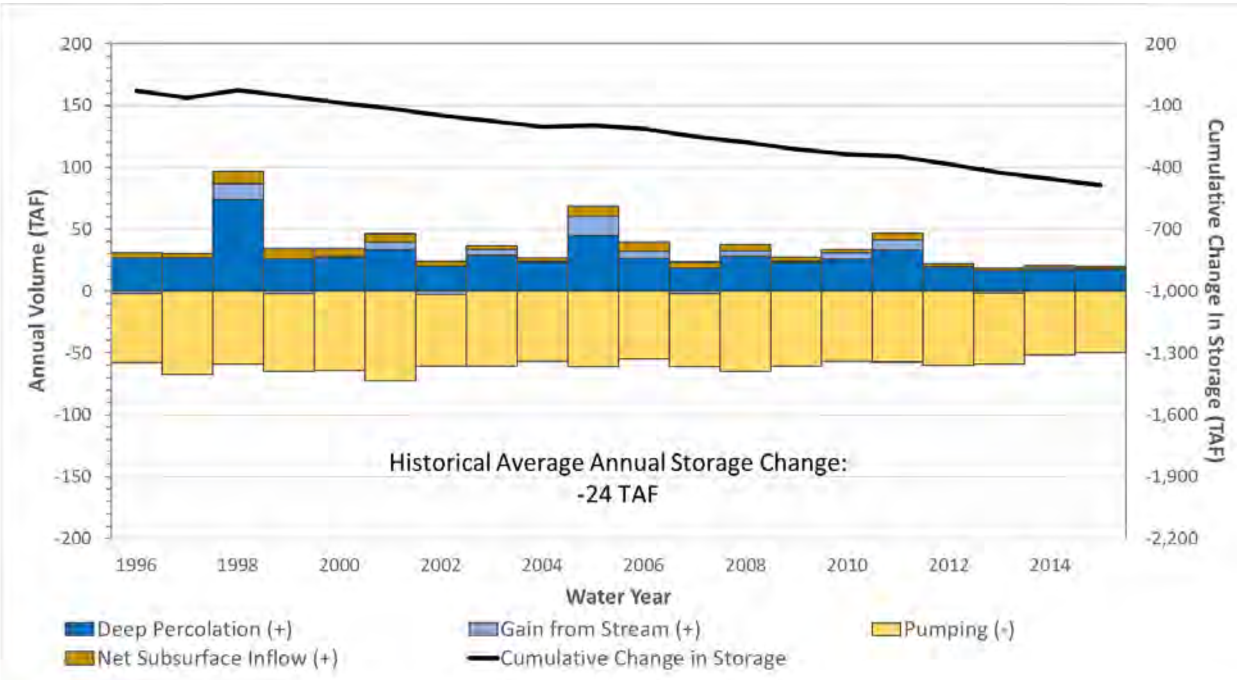

Figure C-17: Groundwater Budget Annual Time Series in the Calibration Period

Groundwater Level Calibration

The goal of groundwater level calibration is to achieve reasonable agreement between the simulated and observed values (in this case, groundwater levels at the calibration wells). Within the CBWRM, 65 wells were used to evaluate the model calibration at both a regional and local scale. These wells are included in the CBGSA's Opti data management system. The calibration wells were selected based on their period of record and availability of observation data, spatial distribution across the model, and trends of nearby wells. These calibration wells are shown in Figure C-18.

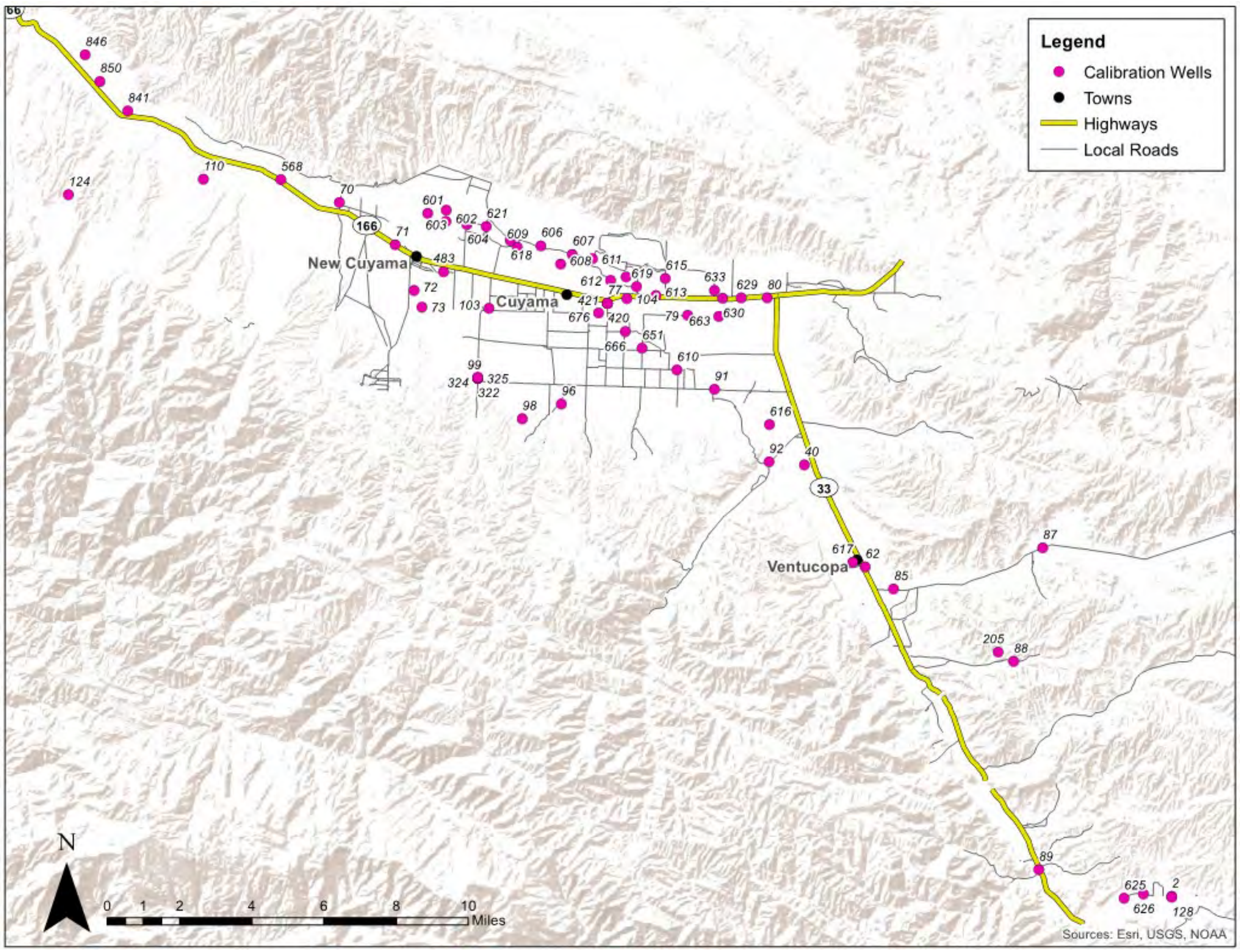

Figure C-18: Location of Calibration Wells

Simulated groundwater levels were calibrated to observed levels through systematic adjustments to aquifer parameters including hydraulic conductivity, specific storage, and specific yield. The goal of groundwater level calibration is to achieve the maximum agreement between simulated and observed groundwater elevations at calibration wells while maintaining aquifer parameters within reasonable range. The groundwater level calibration is performed in two stages as follows:

- The initial calibration effort is focused on the regional scale to verify hydrogeological assumptions made during model data development and confirm the accuracy of general groundwater flow directions. During this stage, simulated groundwater elevation trends, flow directions, and groundwater gradients are compared to those that can be synthesized form the reported data.
- The second stage of calibration of groundwater levels is to compare the simulated and observed groundwater levels at each calibration well. This comparison provides information on the overall model performance during the simulation period. The simulated groundwater elevations at the calibration wells were compared with corresponding observed values for concurrence in long-term trends as well as seasonal fluctuations.

The results of the groundwater level calibration indicate that CBWRM reasonably simulates long-term hydrologic responses under various hydrologic conditions, and the short-term monthly or seasonal fluctuations. Attachment 3 shows a selection of calibration wells with their resulting groundwater level hydrographs.

Figures C-19 and C-20 show a statistical comparison of the final simulated and observed groundwater levels across the entire Basin. As shown in these figures, the model results show a strong correlation with the observed data.

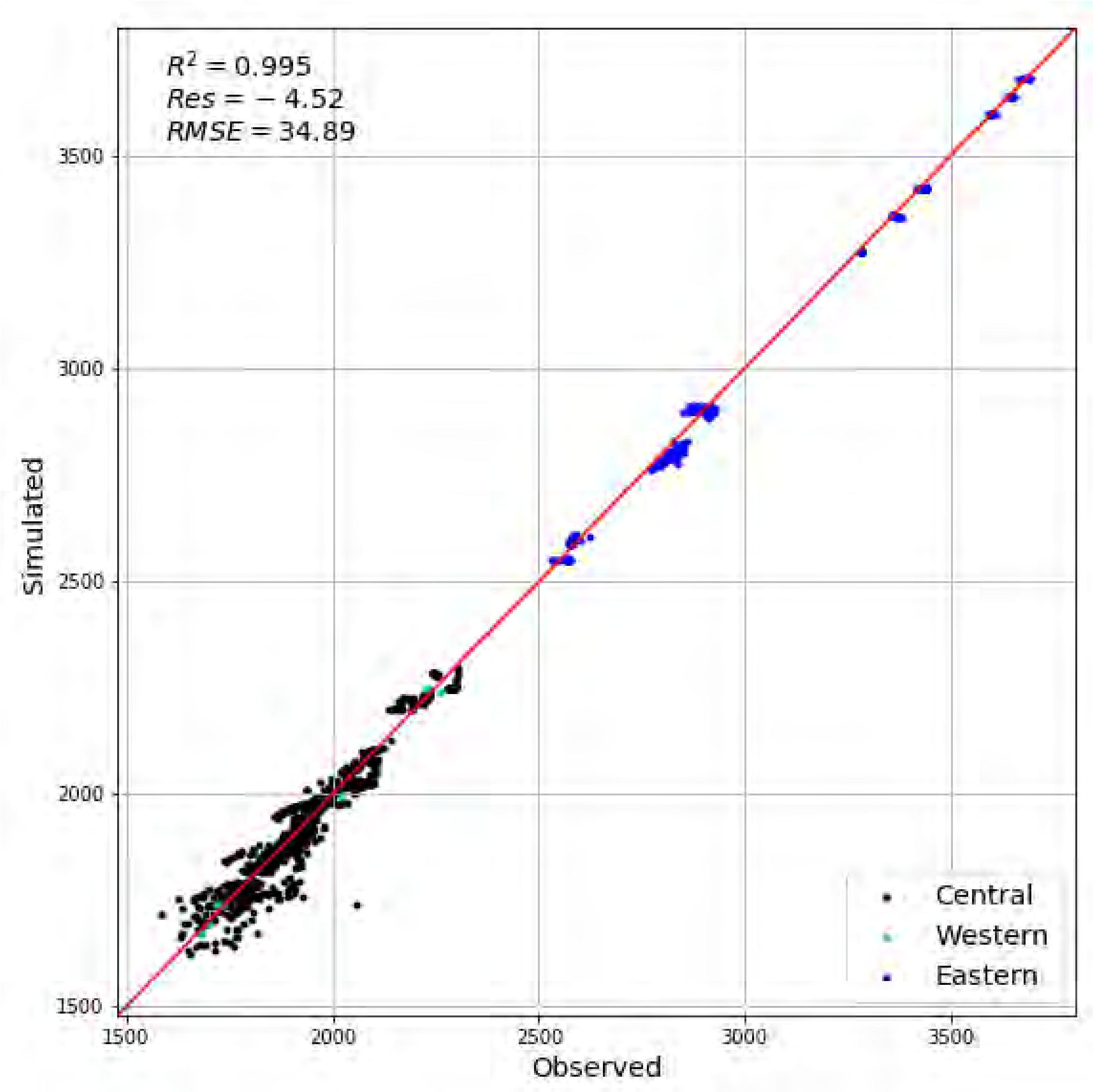

Figure C-19: Comparison of Simulated and Observed Groundwater Levels

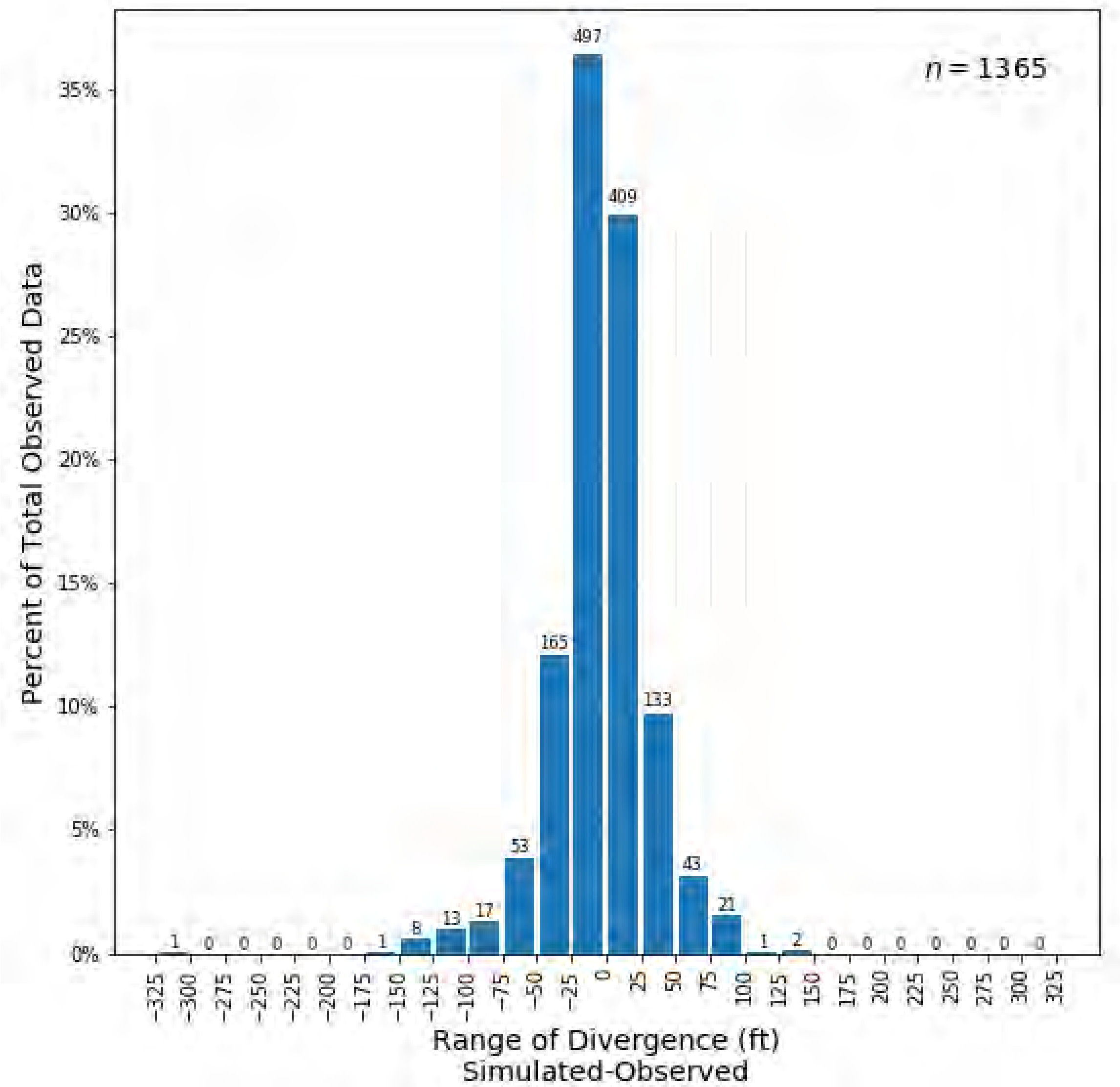

Figure C-20: Histogram of Divergence of Simulated Groundwater Levels from Observed Data

Uncertainty and Sensitivity Assessment

To incorporate the uncertainty that originates from various model inputs such as hydraulic parameters, land use, irrigation practices and agricultural demand, an ensemble of perturbed simulation results were analyzed to quantify the overall effect on the groundwater storage change over the historical simulation period.

Table C-3 shows the range of aquifer hydraulic parameters used in CBWRM as compared to reported values from historical USGS studies. The ranges of horizontal hydraulic conductivity used in CBWRM for layers 1 and 2 is similar to the USGS values. In layer 3, it was necessary to set CBWRM values lower than the reported USGS values in order to provide a good match with historical groundwater levels. The specific yield and specific storage values used in CBWRM are consistent with typical values used for similar geologic formations.

Table C-3: Range of Aquifer Parameters in CBWRM as Compared to Reported Values

Study	Horizontal Hydraulic Conductivity (feet/day)			Specific Yield	Specific Storage
	Layer 1	Layer 2	Layer 3		
CBWRM	$3.0x10^{-1}$ to $2.4x10^{1}$	$1.0x10^{-2}$ to $1.0x10^{1}$	$1.1x10^{-4}$ to $3.5x10^{-2}$	0.08 to 0.25	10-6 to 10-4
USGS Pumping Tests[a]	$1.9x10^{-1}$ to $5.3x10^{1}$	$5.3x10^{-2}$ to $2.6x10^{1}$	$6.6x10^{-2}$ to $2.7x10^{-1}$	N/A	N/A
USGS Slug Tests[a]	N/A	$1.5x10^{0}$ to $2.8x10^{1}$	$1.6x10^{0}$ to $9.9x10^{0}$	N/A	N/A

[a]USGS, 2013b

Table C-4 shows the sensitivity of Basin-wide storage change to various model parameters. Groundwater pumping was tested by simulating plus or minus 20 percent of the baseline value, while the other parameters were tested by multiplying the baseline values by 0.1 and 10 (for specific storage) or by 0.2 and 5 (for the other parameters). Basin-wide storage was found to be most sensitive to groundwater pumping, followed by soil percolation potential and streambed seepage potential.

Table C-4: Sensitivity of Basin-wide Storage Change to Different Parameters

Parameter	Change Factor	Maximum Range (AF)	Deviation of Maximum Range (percent)	Minimum Range (AF)	Deviation of Minimum Range (percent)	Range of Deviation (percent)
Groundwater Pumping	±20	34,945	+45	13,114	-46	91
Aquifer Hydraulic Conductivity	x0.2/x5.0	26,050	+8	23,103	-4	12
Specific Yield for Shallow Aquifer System	x0.2/x5.0	26,124	+8	23,384	-3	11
Specific Storage for Semi-confined Aquifer Systems	x0.1/x10.0	24,153	0	23,985	0	<1
Streambed Seepage Potential	x0.2/x5.0	29,368	+22	20,054	-17	39
Soil Percolation Potential	x0.2/x5.0	26,688	+11	17,118	-29	40
Tributary Watershed Flows	x0.2/x5.0	25,107	+4	24,103	0	4

Accounting for these uncertainties in combination with comparisons of observed and simulated groundwater elevations, the upper and lower bounds for the cumulative groundwater storage change are presented in Figure C-21 below. The upper and lower bounds for the average groundwater storage change that result in a similar correlation of observed and simulated groundwater elevations are estimated to range from 22,000 to 27,000 AFY.

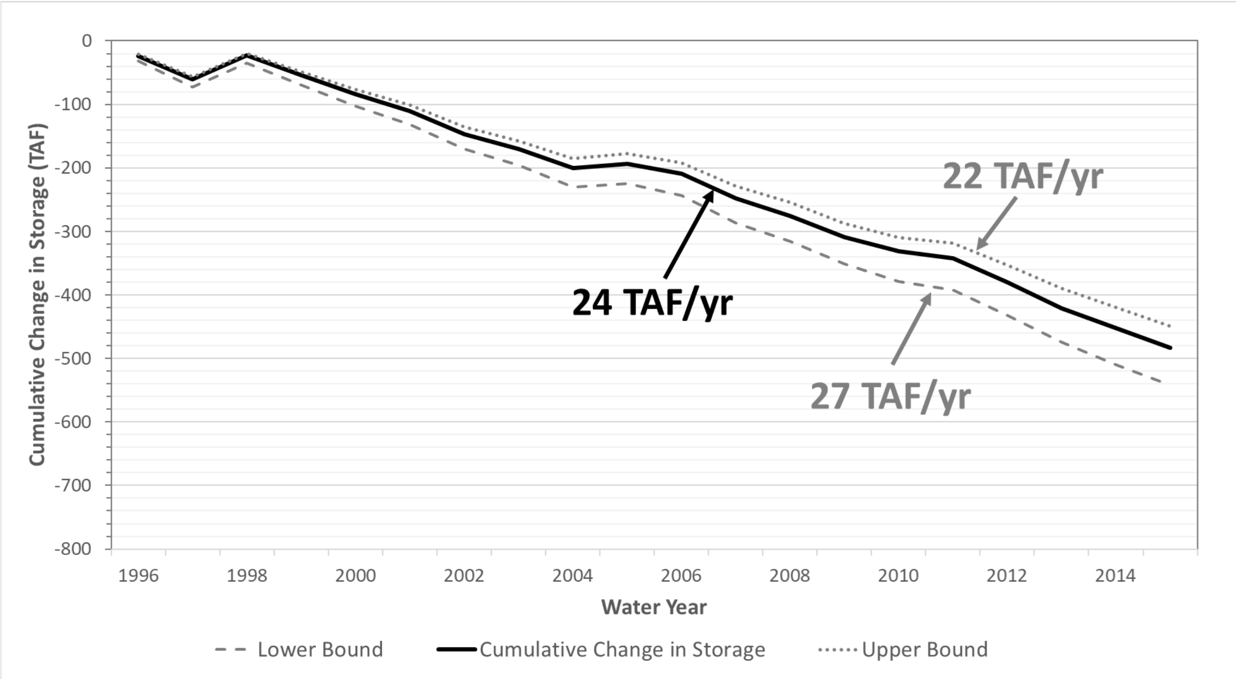

Figure C-21: Lower and Upper Bounds for the Groundwater Storage Change

Conclusions and Recommendations

The CBWRM is the latest analytical model based on DWR's state-of-the science modeling platform, IWFM. The CBWRM has relied on data sets from various sources, and was developed to support GSP development with the primary purpose of assessing hydrologic and groundwater conditions in the Basin during the recent historical period from water 1998 to water year 2017. CBWRM also assesses hydrologic and groundwater conditions under the Basin's current level of development and under projected conditions.

Based on analysis, the following conclusions are made:

1- CBRWM is reasonably calibrated, and reflects a reasonable representation of the Basin's hydrologic and hydrogeologic conditions
2- CBRWM calibration meets the intended need to support GSP development
3- GSP stakeholders and the Technical Forum have reviewed model development and calibration results, and have agreed that the CBWRM, as it stands, is an appropriate tool to be used for assessment of and planning for sustainable groundwater conditions in the Basin.

The following recommended actions would support future model updates:

- **Continue engagement with local stakeholders**. Continue working with local agencies and groundwater users in the Basin to further understand the local operations of the groundwater system and improve representation of groundwater users in the model by collecting additional data. Specific data to be considered are irrigation practices outside the main District areas, groundwater level data, information on the well profiles and characteristics.
- **Perform additional hydrogeological conceptualization.** Specific areas can benefit from additional hydrogeologic investigations. These include eastern part of the basin in the vicinity of the Ventucopa area, as well as the western part of the model, downgradient from the Russel Fault. In addition, data about effectiveness of the fault system in the area are very sparse. Additional targeted groundwater exploration and/or groundwater level monitoring should focus on the areas near the fault systems.
- **Improve streamflow record collection.** Currently, there are no long-term streamflow gaging stations within the CBWRM. As part of GSP implementation, at least two streamflow gaging stations should be installed and monitored regularly, so that Basin inflows and outflows are properly monitored.
- **Improve representation of small watersheds.** Surface water flow from and evapotranspiration losses in the ungaged watersheds represent a relatively large portion of the Basin water budgets. Additional investigations on the native vegetation ET, and runoff conditions in the ungaged watersheds can improve model representation of this feature.
- **Develop groundwater pumping estimates.** As groundwater pumping is the primary outflow from the groundwater system, an accurate representation of outflow significantly improve CBWRM performance. A pilot project is recommended to monitor and measure groundwater use and well discharge for select parcels based on cropping patterns and geographic location relative to the river and relative to other hydrologic features, such as faults.

  Incorporate future data into model calibration. Data will be collected using the CBGSA's groundwater monitoring network, and should be used to re-assess and improve the HCM, CBWRM parameter values and CBWRM calibration, especially in areas of the Basin where little or no data exist currently. In addition, model predictions should be compared to actual future climate and water availability conditions to provide insights into model performance.

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Attachment C-1

Land Use and Consumptive Water Use of Cuyama Groundwater Basin for Water Years 1996 Through 2016

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