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AN ASSESSMENT OF THE HYDROLOGIC SIGNATURES OF HYDRIC SOIL AND WETLAND COMMUNITY INDICATORS FROM A NETWORK OF NATURAL PLANT COMMUNITIES IN NORTHEASTERN FLORIDA

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Well C-1033 (61) at Bayard Point Conservation Area by Travis Richardson.

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Contents

Abbreviations & Acronyms

AMO	Atlantic Multi-decadal Oscillation
BH	Bayhead
CUP	Consumptive Use Permitting
CY	Cypress
DM	Deep Marsh
FAC	Florida Administrative Code
FS	Florida Statutes
ft	feet
HDS	Hydrologic Data Services
HH	Hydric Hammock
HMD	Hydrometeorological Database
HS	Hardwood Swamp
id	identifier
MFLs	Minimum Flows and Levels
MH	Mesic Hammock
NGVD	National Geodetic Vertical Datum
QA	Quality Assurance
SJRWMD	St. Johns River Water Management District
SM	Shallow Marsh
TS	Transitional Shrub
UPL	Upland
USDA, NRCS	U.S. Department of Agriculture, Natural Resources Conservation Service
WMA	Wildlife (Water) Management Area
WP	Wet Prairie

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INTRODUCTION

Hydrology (water level frequency, duration and magnitude) is the principle determinant of the development and maintenance of soil morphology and the structure of wetland vegetative communities (Mitsch and Gosselink 1993). Vegetation community types and dominant species are strongly correlated with depth and duration of inundation and saturation, and are often good indicators of soil type and hydrologic regime (Castilli et al. 2000, Richardson and Vepraskas 2001). In addition, hydric soil indicators, the accumulation of organic matter, and the development of organic soils provide indicators of wetland hydrology (USDA, NRCS 2002). Despite the correlation of ecological structure and functions with the hydrologic regime, wetland hydrology is poorly characterized (Otte 2001, Jones Edmunds 2006).

Minimum Flows and Levels (MFLs) define an environmentally protective hydrologic regime that prevents significant ecological harm and identifies levels and/or flows above which water is available for reasonable beneficial use. MFLs take into account the ability of wetlands and aquatic communities to adjust to changes in the frequencies of hydrologic events. Therefore, MFLs allow for an acceptable level of change to occur relative to the existing hydrologic conditions. However, when use of water resources shifts the hydrologic conditions below those defined by the MFLs, significant ecological harm will likely occur. As it applies to wetland and aquatic communities, significant harm is a function of changes in the frequencies of water level and/or flow events of a defined duration causing unacceptable changes to ecological structures and/or functions.

MFLs assessment of allowable hydrologic shifts to drier conditions assumes that the range of hydrologic signatures is due to natural variation only. The first step in determining allowable shifts to drier conditions without causing significant harm is to adequately define the range of natural variation in the hydrologic signatures of wetland communities and hydric soil indicators. Accounting for other sources of variation in the hydrologic signature then becomes a prerequisite for application of these to the development of thresholds for MFLs determinations.

In response to concerns related to the possible impact of projected increases in water use on wetlands, a monitoring effort was begun in order to better understand relationships between hydrology and plant community structure and hydrology and soil morphology (Vergara 1994). A network of surfical aquifer (SA) monitoring wells was established in 1995 in natural areas in northeastern Florida that have experienced little hydrologic alteration from groundwater drawdown resulting from water supply development. A preliminary analysis based on five years of data confirmed the correlation of frequency and duration of water levels with plant community types with wetter community types having higher water levels for longer durations (Nagid 2001).

A sufficient period of record now exists to apply frequency analysis methods to define the hydrologic signatures of wetland plant communities and hydric soil indicators (Neubauer et al. 2004). This report assesses the hydrologic signatures of this network of natural area wetlands and provides a preliminary estimate of the natural variation of the hydrologic signatures of wetland plant communities and hydric soil indicators.

METHODS

Site Descriptions

The original study network consisted of a total of 39 paired study plots located in 8 plant communities distributed among 6 study areas: Bayard Point Conservation Area, Caravelle Wildlife Management Area (WMA), Lake George Wildlife Management Area (WMA), Ralph E. Simmons Water Management Area, Stokes Landing Conservation Area, and Welaka State Forest (SF) (Figure 1). A pair of surficial aquifer (SA) monitoring wells, one in the wetland and a second in the adjacent uplands, was installed at each site between February and June 1995 to a depth of approximately 3 meters (Nagid 2001). Water levels were recorded manually at approximately weekly intervals. The wells were surveyed to establish a vertical datum and continuous water level recorders installed in 2003. Water levels are now monitored and the data managed by SJRWMD's Division of Hydrologic Data Services (HDS). The data are stored in the Hydrometeorological Database (HMD) toolkit of SJRWMD Intraweb's Data Access System (DAS).

In this study, 21 of the 39 original wetlands were analyzed (Table 1). Seepage wetlands were dropped from consideration here because MFLs methodology specifically directs that seepage driven sites not be used in determining MFLs because these sites have a complex hydrology not wholly representative of the water body for which levels are being determined (SJRWMD 2006). All but two of the wetland plots in the R. E. Simmons WMA in Nassau County were previously identified as seepage wetlands and the remaining wetlands were dropped from further consideration on the basis of logistic constraints. Additionally, one seepage wetland from the Welaka State Forest site was also discarded.

In the original study, the plant communities and number of occurrences included: Cypress Fringe (4), Marsh Depression (5), Hardwood Depression (5), Hydric Hammock (5), Oak Hammock (5), Pine Flatwoods (6), Oak Scrub (3), and Pine Sandhill (6) (Nagid 2001). Wetland classification descriptors were revised in this study to follow the convention of Kinser (1996). Vegetation was originally sampled in 2000 within a 10-m by 10-m quadrat laid out in the wetland so that the surficial aquifer (SA) monitoring well marked one corner of the quadrat. MFLs staff revisited the wetlands in 2006 to obtain characteristic elevations of vegetation communities and hydric soil indicators along the length of a line transect from the center of the wetland to the adjacent upland (SJRWMD 2006).

Quality Assurance

A period-of-record hydrograph plot for each of the 21 wetland wells was reviewed for quality assurance. Outlier observations due to processing errors (151 Quality Assurance (QA) code for incomplete 24-hour data) were detected and removed. A review by Hydorlogic Data Services (HDS) QA-staff reported that there were no problems with the data. The portions of the period of record that were recorded weekly were converted to an interpolated daily period of record for the most common observation day (Figure 2).

Frequency analysis

Frequency analyses (Gordon et al. 1992, Haan 2002) were performed on the interpolated daily period-of-record hydrographs for each of the 21 wetland SA monitoring wells. A frequency analysis was performed for continuously exceeded (stays wet) stage events (water year July 1 to June 30) and continuously not exceeded (stays dry) stage events (water year October 1 to September 30). Using wet and dry water years improves the probability that extreme events fall entirely within one year rather than being split between two adjacent years.

The frequency analysis extracted a series of minima and maxima water levels for each of nine durations (1, 14, 30, 60, 90, 120, 183, 274, and 365 or 366 days) in each water year. The number of minima or maxima in each series is 365 (or 366) minus the number of days in the event duration plus one. For example, there are 352 observations in the series for a 14-day duration event. Exceedence events (stays wet) are the maximum water level of each series of minima, and non-exceedence events (stays dry) the minimum of each series of maxima. When the frequency analyses are complete, there is one maximum and one minimum event for each duration in each water year.

These annual exceedence and non-exceedence results are summarized as Weibull probabilities (Gordon et al. 1992, Haan 2002). The first step in calculating event probabilities is counting the number of (complete) water years in the period of record for each SA monitoring well. The probabilities of the exceedence (non-exceedence) events for each duration (1, 14, 30, 60, 90, 120, 183, 274, and 365 days) were then calculated as the ordinal (1, 2, 3, etc.) of the ordered events within water years sorted in descending (ascending) order for exceedence (non-exceedence) divided by the number of water years plus one.

The series of elevation and probability data pairs for each duration were then summarized as families of curves for elevation versus annual probability of exceedence and elevation versus annual probability of non-exceedence (Figure 3). Note that for exceedence, the short duration lines are on top and increased elevation corresponds to decreased probability. Conversely, for non-exceedence the short duration lines are on the bottom and decreased elevation corresponds to decreased probability.

The elevations for each wetland plant community and hydric soil indicator were applied to these plots (Figure 3) by “reading in” the elevation of interest (1.94 ft in this example, Appendix A, *hardwood swamp* mean elevation for well C-1034 (62)) and “reading out” the probabilities of each of the duration curves intercepted by the elevation (Neubauer et al. 2004). Probabilities falling between data points were determined by linear interpolation. The result is a single duration-probability point from each duration curve intercepted, and a series of points (a signature) for all durations intercepted for a particular wetland (see the curve for well C-1034 (62) in Figure 4). A single signature curve for exceedence and non-exceedence is thus obtained for each vegetation community or hydric soil indicator elevation observed at each wetland system investigated.

The individual signature curves from all vegetation communities and hydric soil indicators of a particular type were then summarized as families of signature curves (*hardwood swamp* mean elevation in Figure 4). A family of signatures was constructed for each wetland community or hydric soil indicator. Note that a particular indicator elevation may intercept most, some (four in this example), only one, or none of the duration curves, thus generating signature curves that vary from no point or a single point, to a well-defined curve covering nearly the full range of durations.

RESULTS & DISCUSSION

There were 54 unique hydric soil and vegetation community indicators identified among a total of 216 characteristic elevations compiled among 21 wetlands (Table 2 and Appendix A). Among the 54 unique indicators, 19 were represented by three or more observations. In general, there were more replicates of individual hydric soil indicators than wetland plant community indicators. *Transitional shrub* (TS) was the most commonly represented wetland plant community indicator.

Water level fluctuations at the wetlands investigated were the combined result of seasonal fluctuations of local rainfall and drought effects (Appendix B, Figures B.1 through B.21). The fluctuations in water levels captured by weekly observations are similar to those observed in the daily period of record. The effects of the drought years 2001-2004 are evident in most hydrographs, as is the decline in water levels in the recent 2006 drought. Many of the hydrographs display either a general decline or a pattern of successively deeper lows through approximately 2000. After about 2002 there is a general pattern of stable to increasing water levels marked by a reduced range of variation. Several Stokes Landing wells, however, appear to be an exception to this general pattern in that they have no pattern of stable to increasing water levels after about 2002 (Figures B.14, B.15, B.16, and B.18).

The corresponding stage duration curves display a range of patterns from low curvature continuous change over the range of water levels (Figure B.5) to marked nonlinearity at the extremes (Figure B.6), with some changing curve shape in the middle range (Figure B.8). Generally, the smooth continuous pattern characterized sites less subject to extreme water level variation associated with deficit or surplus rainfall, whereas sites with pronounced nonlinear tails represent sites more affected by large storms or cumulative rainfall deficits or surpluses.

Most notable about the exceedence and non-exceedence probability curves is that they range from about 90% to 10% due to a period of record of only 10 to 11 years (Appendix C, Figures C.1-C.21). This creates the impression that the curves are linear, or roughly so, although a few sites (e.g., Caravelle [Figures C.7-C.8] and Lake George [Figures C.9-C.12]) display a modest degree of curvature. A direct result of this data limitation is that a characteristic elevation will often intercept only some of the duration curves, often far less than the 9 or 10 possible. Note that the degree of vertical spread and separation in duration curves is a reflection of the degree of steepness of the stage duration curves (e.g., Figures B.1 and C.1 versus B.4 and C.4). Note that for exceedence, the short duration lines are on top and increased elevation corresponds to decreased probability. Conversely, for non-exceedence the short duration lines are on the bottom and decreased elevation corresponds to decreased probability. The families of curves for exceedence and non-exceedence are not exact inverses of each other due to the fact that they are based on different water years, July 1 to June 30 and October 1 to September 30, respectively. The result of these combined effects is that the signature curves for both exceedence and non-exceedence may have to be examined in order to ensure a complete understanding of characteristic signature hydrology.

There were 19 signature plots that had three or more sufficiently complete duration versus probability curves so as to allow some degree of comparison of hydrologic signatures for wetland plant community indicators (Appendix D, Figures D.1-D.37) and hydric soil indicators (Appendix E, Figures E.1-E.11). The community types with three or more signature curves for mean elevation are *cypress* (Figures D.4-D.5), *hardwood swamp* (Figures D.12-D.14), *shallow marsh* (Figures D.16-D.18), *transitional shrub* (Figures D.31-D.33), and *upland* edge (Figure D.34). The hydric soil indicators with three or more curves include: *dark surface* (Figure E.1), *histic epipedon* (Figure E.2), *histosol* (Figure E.3), *muck* (Figure E.7), *mucky mineral* (Figure E.8), and *stripped matrix* (Figure E.11).

The remaining exceedence and non-exceedence signatures contained one or two curves or partial curves only, and as little as a single or no point. These abridged and fragmented results stem from the combination of a limited probability range discussed above, and several indicators for hydric soil or a plant community occurring only once as point elevations. The plant communities and hydric soil indicators with insufficient signatures for range estimation are *bayhead* (Figures D.1-D.3), *hydric hammock* (Figure D.9-D.11), *mesic hammock* (Figure D.15), *salt marsh* (Figures D.19-D.30), *wet prairie* (Figures D.35-D.37), *hydrogen sulfide* (Figure E.6), *organic bodies* (Figure E.9), and *sandy redox* (Figure E.10).

Although there is a wide range of variation in the probability of exceedence or non-exceedence events of varying duration, the individual curves taken together for a particular plant community or soil indicator generally form a family of signature curves. For example, the probability of a 30-day flood event at the maximum elevation of a *Transitional shrub* community (Figure D.31) ranges from about 25% (1 in 4 years) to 75% (1 in 1.3 years), a difference of about 50% generally observed for durations of 1- to 90-days. The probability range narrows somewhat for longer duration events as curves drop out below about 10% probability, which is likely an artifact of the relatively short period of record. Probability curves based on longer periods of record would present a portrait of more complete curves and thus provide a clearer comparison of hydrologic signatures.

Altered Signatures

Hydrologic signatures for surface water inundation may be confounded by a number of factors such as site disturbance and altered hydrology. Thus, an assessment of indicator signatures first requires identifying these confounding factors. The hydrologic signatures of the maximum elevation of the *shallow marshes* (Figure D.16) appear to form a coherent grouping with the possible exception of the wetland at Lake George well P-4060 (39). The wetland was disturbed by site preparation for silviculture, which extends into the marsh below the surviving planted pine. The result of this disturbance is two-fold: (1) it is more difficult to delineate the edge of the marsh from what may have been wet prairie prior to disturbance, and (2) the furrows alter the sheet flow of storm runoff, thus altering surface water flooding in the marsh. Comparison with the signatures for mean elevation of *shallow marsh* (Figure D.17) shows well P-4060 (39) with a signature within the grouping of other *shallow marshes*, suggesting that the delineation is misplaced due to site disturbance. This result is further supported by the signatures for the *transitional shrub* maximum elevation at P-4060 (39) (Figure D.31). The *transitional shrub* signature is present as a single point, whereas all but one of the remaining wetlands are represented by curves of three or more points, suggesting that the delineation elevation has been affected by site disturbance. The effect of the site disturbance at P-4060 (39) may extend to the signature for the *upland* minimum elevation (Figure D.34) where the curve is located at the periphery of the grouping. Additionally, some of the anomalies with P-4060 (39) may also be a function of the steepness and coherence of the curves. In general, the greater the range of stage fluctuation, the steeper the signature curves with the result that there are more intersections (compare P-4049 (83) in Figure C.19).

The wetland at well C-1043 (71) was identified in the field on the basis of community appearance as a possible seepage slope. The hydrologic signature for the hydric soil indicator *stripped matrix* in this wetland falls outside of the grouping (Figure E.11) and has the ‘laid-over’ characteristic of a seepage slope where the site stays wet without surface water flooding (Richardson 2007). The seepage clearly affected the C-1043 (71) signature for *mucky mineral* (Figure E.8), and may have affected the signature of the maximum elevation of the *transitional shrub* community (Figure D.31) which occurs at the periphery of the grouping. As one proceeds down slope deeper into the wetland, the edge of the *hardwood swamp* community (Figure D.12) appears too dry when compared to other signatures, consistent with a delineation set too high because of the seepage effect. The C-1043 (71) signature for *muck* (Figure E.7), however, appears in the middle of the grouping because surface water hydrology is the dominant effect at the lower elevations. Note that in general, the seepage effects are somewhat less pronounced for non-exceedence.

Specific concerns exist for several other sites. Lake George WMA wetland P-4071 (53) burned severely, killing most cypress and black gum, and the communities do not appear to have recovered, making plant community delineation more difficult. The maximum elevation of the *hardwood swamp* signature is at the wet-side periphery of the group, indicating the community may be incorrectly delineated and the elevation range for this community is probably biased low (Figure D.12). This is also reflected in the *transitional shrub* mean elevation signature (Figure D.32), and the *transitional shrub* minimum elevation (Figure D.33), where the P-4071 (53) wetland occurs as an apparent outlier with a signature that is “too wet.” Welaka State Forest wetland P-4046 (80) displayed indications in the field of hydrologic impact from drainage; however, it has a very wet *hardwood swamp maximum* signature (Figure D.12). Surface water alterations, however, can significantly alter a signature and it is possible the site is becoming too wet compared to historic conditions. Silviculture and other two-rut roads, rail trails, and dikes can either act as upstream dams, or downstream drainage outlets because of borrows creating roadside ditches or low-invert culverts which divert or drain water. The coincidence of the *hardwood swamp* maximum elevation signatures (Figure D. 12) for wetlands with poor delineation [P-4071 (53)] and altered (wet) hydrology [P-4046 (80)] point out the difficulty in evaluating the variation in wetland signatures.

Wetland Signatures

With these confounding results identified, the wetland indicator signatures can now be evaluated for membership coherence and range. The hydrologic signatures for minimum *upland* elevation (Figure D.34) might be expected to form two or more natural subgroups, pine flatwoods versus sandhill pinelands and other uplands. Recall that a reading of the signatures based on abridged curves provides probabilities from 10 to 90% only. Although there is broad overlap of the probabilities for flood events shorter than 60 days, only the *upland* pine flatwoods [C-1030 (58), C-1033 (61), P-4054 (5), SJ2559 (7), and SJ2563 (15)] and one sandhill site had 90- and 120-day signature probabilities. Although the sandhill wetland P-4077 (76) in the Welaka SF showed no indication of seepage effects, the hydrograph and duration curve indicate a narrow range of fluctuation except during drought (Figure B.20), providing some of the hydrologic character of a flatwoods upland. The probability for a 120-day flood event in flatwoods (Figure D.34, exceedence) varies from about 10% (1 in 10 years) to 50% (1 in 2 years).

Moving down slope into the wetland, it is useful as a quality assurance step to check that the same pattern for *uplands* above is observed for the maximum elevation of the *transitional shrub* community (Figure D.31). The composition of the group of flatwoods changes by one member [SJ2573 (12) in place of P-4054 (5)], but still includes sandhill wetland P-4077 (76). However, the probability range for a 120-day flood event has narrowed, extending from about 10% (1 in 10 years) to 30% (1 in 3.3 years).), as compared to the range of about 10% to 50% for the minimum elevation of the flatwoods upland. The *transitional shrub* minimum signature for wetland P-4071 (53) may have been biased by the presence of a silviculture road acting as a water dam. The resulting bias in the mean signature is an uncommon example of a case where the mean signature fails to compensate for misidentification of the minimum and/or maximum extent of the community (Figures D.32 and D.33).

Farther down slope into the wetland, the maximum elevation of *shallow marsh* (Figure D.16) is represented by six signatures not including P-4060 (39) which is questionable because of disturbance. These six signatures are coherent except for wetland P-4062 (41), which is the *shallow marsh* fringe of a *cypress* community and appears to be more correctly classified as a *cypress* signature. The signatures would be expected to become more coherent as you move deeper into the wetland because the effects of seepage, fire, and disturbance are typically diminished. The signature curves for durations for 30- to 180-day flooding events range from about 1 in 1.3 to about 1 in 3 years, respectively, corresponding to a probability spread of about 30%. The *shallow marsh* mean elevation signatures benefit from averaging and appear more coherent (Figure D.17). Often the mean elevation for a community indicator is within a signature family because the effect of averaging is to reduce variability observed at the upper or lower limits of the indicator. The three *shallow marsh* minimum signatures are also tightly grouped (Figure D.18).

There are three *cypress* signatures, two of which [P-4062 (41) and P-4066 (45)] are very similar over durations from 1- to 270-days flood event, and a third [P-4056 (34)] with a drier signature (Figure D.4). In addition to cypress, the tree species composition in wetland P-4056 (34) includes Black Gum (obligate) Sweet Gum (facultative wet), and Red Maple (facultative), an association which could also be classified as a drier hardwood swamp. In contrast, wetlands P-4062 (41) and P-4066 (45) both lack Black Gum but share other hardwood species. Thus, the anomalous cypress signature may be a case where signature interpretation is confounded by category assignment and lack of specific knowledge of hydrologic range.

The signatures for the maximum elevation of *hardwood swamps* range widely (Figure D.12). Note that the signatures of wetlands C-1043 (71) and P-4046 (80) are both questionable due to site characteristics previously discussed. The middle three wetlands [C-1030 (58), C-1033 (61), and SJ2563 (15)] are depressions in flatwoods pine. The remaining three drier signatures are depressions in sandhills or uplands. Although the available sample suggests that the wetter signatures may segregate on the relative dominance of cypress and black gum, and the drier sites on the relative abundance of other hardwoods such as red maple and sweet gum, a more probable explanation is a species composition wherein each species has a wide hydrologic range. The signature group of *hardwood swamps* means (Figure D.13) fails to tighten the grouping observed for the maximum.

It is clear from these results that there is a wide range of signatures for most wetland community indicators of hydrology, even after discounting questionable (altered) signatures. A useful check here is to compare the minimum signature of the higher elevation wetland community with the maximum of the adjacent lower community. In general, the mean elevation indicators appear to offer a more stable and coherent pattern of signatures. Often the mean elevation for a community indicator is within a family of signatures because the effect of averaging is to reduce variability observed at the upper or lower limits of the indicator.

Hydric Soil Signatures

Moving into the wetland from the upland, the first hydric soil indicator encountered is *stripped matrix* (Figure E.11). The seepage signature, represented by wetland C-1043 (71), should be discarded because it does not represent the surface water flooding of interest in MFLs (see above). The remaining signatures display a broad range, with the two wettest signatures [SJ2570 (9) and P-4066 (45)] being observed adjacent to *cypress* and *salt marsh* communities, and the larger, more variable group being observed adjacent to *shallow marsh* and drier *hardwood swamps*. Note that the hydric soil indicators are point estimates, and have no maximum, minimum, or mean.

The hydric soil indicator *dark surface* clearly separates into two subgroups (Figure E.1). The probability range of the wetter signatures is variable over the range of durations, from about 1in 10 years to about 1 in 2 years. The drier signatures are also severely abridged, two points only and a single line segment defined by two points, so that no estimate of probability range is warranted. Because the criteria for identifying hydric indicators are well defined, these signature results are most probably the result of seepage effects and vegetation composition (Richardson 2007).

The signatures of the hydric soil indicator *mucky mineral* range widely and may segregate into two groups (Figure E.8). Four wetlands [P-4049 (83), P-4066 (45), P-4077 (76), and P-4062 (41)] display good coherence on the wetter side of the signature ranges from 1- to 270-day durations. A middle range of signatures has relatively high probabilities of being wet for relatively short durations, but become drier at longer durations. These may include C-1036 (64), P-4060 (39), P-4071 (53), SJ2559 (7), SJ2573 (12), and SJ2563 (15), but because of the abridged curves the limit of the drier members is not certain. It should be noted that SJ2559 (7), SJ2573 (12), and SJ2563 (15) are adjacent to the Tolomato River and C-1036 (64) is adjacent to the St. Johns River. Neubauer et al. (2004) showed that riverine sites typically displayed a pattern of higher exceedence probabilities for short duration flooding events and lower probabilities of long duration events as compared to lake systems. The remaining two wells within this group [P-4060 (39) and P-4071 (53)] may tend towards the riverine pattern because of a combination of factors including minor seepage, microtopography, site disturbance, and vegetation composition. Three signatures [C-1030 (58), C-1033 (61), C-1039 (67), and P-4056 (34)] form a cluster of outliers on the dry side of the probability ranges and appear to be affected by seepage or delineation errors.

The signatures of the hydric soil indicator *muck* ranges widely (Figure E.7). There is very good correspondence of the members in the wettest group of *muck* and *mucky mineral* (Figure E.8) signatures from wetter signature *hardwoods swamps*. This consistency is expected because both indicators occur deeper in the wetlands. The probability for these wetter signatures ranges from about 1 in 10 years to about 1 in 4 years, somewhat greater than indicated by the *mucky mineral* indicator. The drier range is again indeterminant because of the abridged signatures. The possible interpretation of the two signatures C-1039 (67) and P-4056 (34), composed of a point and a line segment of two points only in and for *mucky mineral* in Figure E.8, is either that the surface water hydrology has been altered and the hydric soils are not in equilibrium with the altered hydrology; or that, more likely in this case, the location of the indicator was affected by seepage.

The signatures of the hydric soil indicator *histic epipedon* range widely (Figure E.2). The wetter range signatures probabilities range from about 1 in 10 years to about 1 in 4 years. The range of the two drier wetlands appears wider but indeterminant. Only three of the wetlands with a *histic epipedon* were sufficiently deep to contain a *histosol* and one of the two drier wetlands with a *histic epipedon* has no *histosol* signature (compare Figures E.2 and E.3). For both of these hydric soil indicators, the signatures for C-1039 (67) again lie outside of the group, further suggesting that it is strongly affected by seepage.

Application to MFLs

The determination of allowable shifts to drier conditions assumes that the observed variation in hydrologic signature is due to natural variation of biological systems in response to hydrologic differences (SJRWMD 2006).

The hydrologic signature for a wetland indicator can be modified by natural and anthropogenic causes. Accounting for these disturbances and variation in hydrologic signatures then becomes a prerequisite for application of these curves to the assessment of significant harm and MFLs determinations. Controlling the causes of disturbance is largely a sampling problem, where site selection and sufficient period of record play a critical role in controlling unwanted variation. To this end, the MFLs Program has developed a manual of specific methodologies for site selection and field methods coupled with hydrologic model construction in order to develop a 50-year period of record (SJRWMD 2006). The discussion here, therefore, focuses on the suitability of the network signature results as best available data for the assessment of hydrologic change and harm.

The original sampling design for the network considered the confounding effects of groundwater pumping impacts and selected sites in natural areas with little or no water supply development. However, apparently inadequate consideration was made of the potential for surface water alterations to affect hydrology in as much as two sites display well-defined indications of impact in the absence of groundwater pumping. This reinforces the advisory in the MFLs methods manual that site selection consider surface water alterations (SJRWMD 2006). The caution to consider seepage affects is already prominent in the sandhill lakes methods manual and these sites were not included in this analysis (Richardson 2007). Burn history and land management practices also deserve similar caution notes.

Accounting for the effects of the Atlantic Multi-decadal Oscillation (AMO) (Kelly 2004) and other long-term climate oscillations requires a model of wetland hydrology. The hydrographs for a majority of the wetlands suggest that the sample period of record reflects the end of a dry cycle and the beginning of a wet cycle corresponding to the AMO. The value of these sites in assessing signatures would nonetheless be greatly enhanced with the development of long-term wetland hydrologic models, primarily because a longer period of record would more clearly define the hydrologic signature curves for each plant community. Consideration of these wetlands for MFLs determinations in the future would appear to be a major factor in any decision to significantly upgrade the “best available” status of these wetland monitoring sites with long-term hydrologic models.

A broad set of hydrologic signatures for wetland communities is not possible within the constraints of abridged hydrologic signatures (i.e., 10-year period of record). Most of the hydrologic signature curves for wetland community indicators display some degree of truncation. The result of moderately to severely abridged signatures is that the probability range cannot be estimated over a broad range of surface water flooding durations. Although species within a community tolerate a range of hydrologic conditions, there is little or no support based on general plant physiology to assume that the abridged signatures sufficiently represent the signature range for the community as a whole (Otte 2001, Jones Edmunds 2006). However, the signatures should provide a reasonable estimate of hydrology between 10% and 90% probability for the plant communities and hydric soil indicators. Signature ranges are problematic for *transitional shrub* and *hardwood swamp*, two commonly encountered communities, because of truncation (Figures D.31-D.33 and D.12-D.14, respectively).

The *cypress* and *shallow marsh* communities, however, display relatively complete signature groupings. The signature grouping for *shallow marsh* communities is coherent, covers a relevant range of durations, and has a probability range of about 30%. Although specific tolerance ranges are lacking, the diversity of the broad suite of species observed in these marshes suggests that the group signature is representative of shallow marsh communities. This result provides the important first step in determining a threshold for an allowable shift to drier conditions. The two signatures for the *cypress* community, although coherent and covering a wide range of durations, is clearly not a sufficient sample upon which to develop thresholds. The usefulness of these signatures would be improved by consolidating the results with those from other data resources (e.g., Neubauer et al. 2004).

Compared to plant community indicators, hydric soil indicators are more robust indicators of hydrology and provide support for interpreting wetland sites. First, there is a larger sample of signatures upon which to judge allowable shifts. Second, soils integrate hydrology and develop in response to temporal changes in climate (Hurt et al. 2000, USDA, NRCS 2002). Third, hydric soil indicators likely identify narrower ranges of hydrology compared to vegetatively delineated wetland community boundaries because determination criteria are less subjective. Thus, families of hydric soil signatures might be expected to form tighter groupings. Nonetheless, careful consideration of possible site and hydrologic disturbance factors is required (see above). Unfortunately, in this study the hydrologic signature grouping for the highest hydric soil indicator *stripped matrix* is abridged due to the modest 10-year period of record. The remaining signature groupings for hydric soil indicators are generally more useful, although the drier signature ranges are also somewhat abridged.

The constraint of abridged signatures due to a modest 10-year period of record, particularly for wetlands with narrower stage ranges, is another argument for the development of long-term wetland hydrologic models. It can be argued that unless a 10-year period of record is not representative due to drought or surplus rainfall, the general form of the exceedence curve is fundamentally set. Nevertheless, a longer period of record would more clearly define the tails of the hydrologic signature curves. This is particularly the case for wetlands with a narrower range of fluctuations where there are fewer duration curves intersected to define the signature curve. The first step in determining allowable shifts to drier conditions without causing significant harm is adequately defining the range of natural variation in the hydrologic signatures of wetland communities and hydric soil indicators.

Quality Assurance Issues and Recommendations

A management question remains concerning the extent to which some irregularity in frequency curve families is an indication of a period of record not representative of normal rainfall or quality assurance issues with the time series data in the hydrometeorological database (Appendix B and compare Figures B.15 and C.15 in particular). Apparent hydrograph anomalies (i.e., no stage recovery from drought in an otherwise wet period) were the basis for the request to HDS for a quality assurance review. HDS staff reported that "I have reviewed the data you requested and have found no problems with the data" (e-mail, John Dennard 12/01/2006). The type of irregularity observed here might be an indication that average rainfall years are "missing" in the period of record, where locally there may have been a wet period followed by a dry period (personal communication, Price Robison 2/19/2007). This explanation is plausible because all of the questionable hydrographs are for wells in the Stokes Landing Conservation Area (Figures B.14, B.15, B16, and B.18). However, not all wetland wells in the Stokes Landing Conservation Area display indications of the anomaly (Figure B.17). Nevertheless, most MFLs and Ground Water Programs Division staff reviews of the draft report expressed some level of concern about the quality of the data. An alternative, and perhaps more probable, explanation is that the irregularities could be explained by datum shifts over time. Other plausible explanations include instrument calibration drift.

Because of the unique value of this data resource to the MFLs Program and the scientific community at large, as well as the considerable dollar investment by SJRWMD, resurveying the datum for every wetland and upland well in the entire network is recommended, regardless of any recommendation to retain or drop specific wells. A review of the HDS data processing and quality assurance procedures may be useful as well.

A minor data quality issue which the reader may have noticed in the figures is the spelling and punctuation errors in the site and station descriptor files maintained by HDS. An issue of greater concern is that these site and station files provide no linkage of the original well identifiers of Nagid (2001) and the current SJRWMD and HDS identifiers. Because these issues affect the quality of the data resource, it is recommended that the original well identifier be included in the HDS station identifier description file and these records be reviewed for spelling and punctuation. Because the original well identifiers are not unique among all identifiers, adding them to the SJRWMD station alias file is not recommended. A notation could, however, be made in the SJRWMD station file itself.

Network Recommendations

Recommendations for the natural areas network can now be made in light of these results. Some of the wetland and upland wells currently in the network are recommended to be retained (Table 3). Others are recommended to be discontinued (Table 4).

First, with regard to MFLs methodology, seepage dominated sites provide little information relevant to the MFLs program. The methodology manuals (SJRWMD 2006, Richardson et al. 2006) direct that the site selection process specifically avoid seepage sites because they do not reflect surface water flooding. Additionally, the distribution and number of wells at seepage sites is inadequate to study the groundwater baseflow processes for its own interest (Winter 1999). Based on this analysis, seepage sites, except wetland well C-1043 (71), which has useful deeper signatures, should be dropped from the monitoring effort.

Second, the surface water flooding of the salt marsh site is influenced by ocean tides making this well of reduced value to the MFLs Program. However, because of concerns about global warming and sea level rises, this site may be of great interest to climate and marine researchers if its existence was made known. Monitoring should be continued at this site and an effort made to contact research entities to make use of these unique data resources.

Third, the original sampling design was developed for purposes other than supporting the goals of the MFLs Program, which resulted in wetland sites [P-4060 (39), P-4071 (53), P-4046 (80)] with disturbance issues. Although the disturbance reduces somewhat the programmatic value of specific signatures, the site data as a whole has value because of the time series of hydrology and it is recommended that they be retained in the network.

Fourth, the upland well paired to each continued wetland well should also be retained in the network. A goal of the modeling effort in the Division of Groundwater Programs is groundwater models with an active surficial layer, and the coupled upland/wetland well pairs are an important data resource in model development. In addition, the Division of Ground Water Programs requests retaining an upland/wetland well pair in the Bayard Point area and a well cluster in the St. Mary’s basin. The well cluster in St. Mary’s defines an elevation gradient important in model calibration. Ground Water Programs may elect to replace upland wells SJ2561 (13), P-4059 (38), and P-4044 (78) which have been destroyed and are listed as inactive. Because several study areas (Figure 1) are on SJRWMD lands, site managers could be contacted concerning installation of replacement or additional wells which could increase the value of existing time series data.

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Table 1. Alphabetic listing of wetland sites and locations (Sources: Hydrologic Data Services station and site files, Nagid 2001)

HDS Station/well id	SJRWMD (Nagid)	Site name	Latitude	Longitude
16773281	C-1043 (71)	Bayard WMA Bayard Rd SF WL	29 56 30	81 37 60
16533248	C-1034 (62)	Bayard WMA Camp Rd SF WL	29 57 39	81 36 54
16493740	C-1030 (58)	Bayard WMA Tram Rd SF WL	29 57 57	81 37 51
16513247	C-1033 (61)	Bayard WMA Well Rd SF WL	29 57 39	81 36 51
16573253	C-1039 (67)	Bayard WMA at Camp SF WL	28 32 59	81 36 36
16543250	C-1036 (64)	Bayard WMA nr Camp SF WL	29 57 30	81 36 43
16253221	P-4056 (34)	Caravelle Rice Fd Rd SF WL	29 30 25	81 42 18
16273222	P-4057 (35)	Caravelle Boundary Rd SF WL	29 30 02	81 44 34
16323228	P-4062 (41)	Lk George Aces Rd SF WL	29 21 59	81 32 59
16353232	P-4066 (45)	Lk George Otter Rd SF WL	29 21 44	81 32 42
16443240	P-4071 (53)	Lk George TT 1 nr 2 SF WL	29 21 59	81 33 09
16303226	P-4060 (39)	Lk George Trck Trl 1 SF WL	29 22 04	81 32 38
16013196	P-4054 (5)	Ocala Nat Forest 77 SF WL	29 28 20	81 44 03
16023197	SJ2559 (7)	Stokes Raccoon Loop SF WL	29 59 59	81 21 36
16063201	SJ2563 (15)	Stokes Last Gate SF WL	29 59 47	81 21 35
16733278	SJ2573 (12)	Stokes Marsh Rd 1 SF WL	30 00 09	81 21 28
16043200	SJ2562 (14)	Stokes Marsh Rd 3 SF WL	29 59 37	81 21 30
16713275	SJ2570 (9)	Stokes Pavilion Rd SF WL	30 00 19	81 21 33
16633264	P-4049 (83)	Welaka SF Appaloosa Trail SF WL	29 27 14	81 38 55
16613257	P-4077 (76)	Welaka SF Fire Break SF WL	29 27 46	81 39 05
16653261	P-4046 (80)	Welaka SF Paso Fino Trail SF WL	29 26 57	81 39 09

Table 2. The unique hydric soil and wetland vegetation indicators of hydrology in natural plant communities of northeastern Florida. Wetland community abbreviations follow the convention of Kinser (1996)

Indicator Name	**Indicator Description**	**Number of occurrences**
10” muck	landward extent of maximum muck	1
13” muck	landward extent of maximum muck	1
BH_max	maximum bayhead elevation	1
BH_mean	mean bayhead elevation	1
BH_min	minimum bayhead elevation	2
CY_max	maximum cypress swamp elevation	3
CY_mean	mean cypress swamp elevation	3
CY_min	minimum cypress swamp elevation	2
dark surface	S7 - landward extent	8
DM_max	maximum elevation of deep marsh	3
DM_mean	mean elevation of deep marsh	2
HH_max	minimum mesic hammock elevation	1
HH_mean	maximum hydric hammock elevation	1
HH_min	mean hydric hammock elevation	2
histic epipedon	A2 - landward extent	8
histosol	A1 - landward extent of histosol	3
histosol_max	A1 - landward extent of histosol	1
histosol_min	A1 - waterward extent of histosol	1
HS_max	maximum cypress swamp elevation	8
HS_mean	mean cypress swamp elevation	8
HS_min	minimum cypress swamp elevation	3
hydrogen sulfide	A4 - landward extent	1
lichen line	lichen line shot on cypress tree	1
MH_max	maximum mesic hammock elevation	1
MH_mean	mean mesic hammock elevation	1
MH_min	minimum mesic hammock elevation	2
muck	A8 - landward extent	15
mucky mineral	A7 - landward extent	15
organic bodies	A6 - landward extent of organic	2
SaltMarsh1_max	maximum salt marsh 1 elevation	2
SaltMarsh1_mean	mean salt marsh 1 elevation	2
SaltMarsh1_min	minimum salt marsh 1 elevation	1
SaltMarsh2_max	maximum salt marsh 2 elevation	1
SaltMarsh2_mean	mean salt marsh 2 elevation	1
SaltMarsh2_min	minimum salt marsh 2 elevation	1
SaltMarsh3_max	maximum salt marsh 3 elevation	1
SaltMarsh3_mean	mean salt marsh 3 elevation	1
SaltMarsh3_min	minimum salt marsh 3 elevation	1

SaltMarsh4_max	maximum salt marsh 4 elevation	1
SaltMarsh4_mean	mean salt marsh 4 elevation	1
SaltMarsh4_min	minimum salt marsh 4 elevation	1
sandy redox	S5 - landward extent	2
SM_max	maximum shallow marsh elevation	7
SM_mean	mean shallow marsh elevation	7
SM_min	minimum shallow marsh elevation	3
stripped matrix	S6 - landward extent	17
top royal fern	point shot on top of royal fern	1
TS_max	maximum transitional shrub elevation	15
TS_mean	mean transitional shrub elevation	15
TS_min	minimum transitional shrub elevation	15
UPL_min	minimum upland elevation	16
WP_max	maximum wet prairie 1 elevation	1
WP_mean	mean wet prairie 1 elevation	1
WP_min	minimum wet prairie 1 elevation	1
Total		216

Table 3. Wetland and upland wells recommended to have monitoring continued. Wells SJ2561 (13), P-4059 (38), and P-4044 (78) have been destroyed and are listed as inactive

	Wetland well			Upland well		
Study area	**HDS**	**SJRWMD (Nagid)**	**Latitude/Longitude**	**HDS**	**SJRWMD (Nagid)**	**Latitude/Longitude**
Bayard WMA	16533248	C-1034 (62)	29 57 39 81 36 54	16533255	C-1040 (73)	29 57 22 81 37 14
Bayard WMA	16493740	C-1030 (58)	29 57 57 81 37 51	16493245	C-1031 (59)	29 57 55 81 37 52
Bayard WMA	16513247	C-1033 (61)	29 57 39 81 36 51	16513246	C-1032 (60)	29 57 39 81 36 51
Bayard WMA	16573253	C-1039 (67)	28 32 59 81 36 36	16573252	C-1038 (66)	29 57 27 81 36 36
Bayard WMA	16543250	C-1036 (64)	29 57 30 81 36 43	16543249	C-1035 (63)	29 57 30 81 36 43
Bayard WMA	16773281	C-1043 (71)	29 56 30 81 37 60		-	-
Bayard WMA	16763282	C-1044 (72)	29 55 05 81 40 27	16763280	C-1042 (69)	29 55 05 81 40 27
Caravelle	16253221	P-4056 (34)	29 30 25 81 42 18	16253220	P-4055 (33)	29 29 25 81 42 18
Caravelle	16273222	P-4057 (35)	29 30 02 81 44 34	16273223	P-4058 (36)	29 30 03 81 44 29
Lk George	16323228	P-4062 (41)	29 21 59 81 32 59	16323227	P-4061 (40)	29 21 59 81 32 59
Lk George	16353232	P-4066 (45)	29 21 44 81 32 42	16353230	P-4065 (44)	29 21 44 81 32 42
Lk George	16443240	P-4071 (53)	29 21 59 81 33 09	16443239	P-4070 (52)	29 21 59 81 33 09
Lk George	16303226	P-4060 (39)	29 22 04 81 32 38	16303225	P-4059 (38)	29 22 04 81 32 38
Ocala Nat For	16013196	P-4054 (5)	29 28 20 81 44 03	16013283	P-4079 (6)	29 28 21 81 44 05
St. Marys	16223219	N-0300 (32)	30 49 13 81 56 10	16203215	N-0296 (28)	30 48 55 81 56 01
St. Marys	16153224	N-0301 (37)	30 47 56 81 57 07	16203216	N-0297 (29)	30 48 55 81 56 01
St. Marys	16093206	N-0287 (20)	30 47 19 81 57 47-	16223217	N-0298 (30)	30 49 13 81 56 10
St. Marys		-	-	16223218	N-0299 (31)	30 49 13 81 56 10
Stokes Landing	16023197	SJ2559 (7)	29 59 59 81 21 36	16023198	SJ2560 (8)	29 59 58 81 21 36
Stokes Landing	16063201	SJ2563 (15)	29 59 47 81 21 35	16063202	SJ2564 (16)	29 59 45 81 21 39
Stokes Landing	16733278	SJ2573 (12)	30 00 09 81 21 28	16733277	SJ2572 (11)	30 00 10 81 21 29
Stokes Landing	16043200	SJ2562 (14)	29 59 37 81 21 30	16043199	SJ2561 (13)	29 59 36 81 21 31
Stokes Landing	16713275	SJ2570 (9)	30 00 19 81 21 33	16713276	SJ2571 (10)	30 00 21 81 21 32
Welaka SF	16633264	P-4049 (83)	29 27 14 81 38 55	16633259	P-4044 (78)	29 27 12 81 38 54
Welaka SF	16613257	P-4077 (76)	29 27 46 81 39 05	16613256	P-4076 (75)	29 27 45 81 39 06
Welaka SF	16653261	P-4046 (80)	29 26 57 81 39 09	16653260	P-4045 (79)	29 26 57 81 39 09

Table 4. Natural areas network wells to be discontinued after re-surveying

HDS	SJRWMD (Nagid)			
Station/well id		**Site name**	**Latitude**	**Longitude**
16753279	C-1045 (57)	Bayard WMA Main Rd SF WL	29 58 80	81 38 60
16543251	C-1037 (65)	Bayard WMA nr Camp SF WL	29 57 30	81 36 43
15993194	P-4052 (3)	Caravelle Midden Rd SF WL	29 29 24	81 43 17
15993195	P-4053 (4)	Caravelle Midden Rd SF WL	29 29 24	81 43 17
16323229	P-4063 (42)	Lk George Aces Rd SF WL	29 21 59	81 32 59
16413236	V-4029 (49)	Lk George Barrs Rd SF WL	29 20 16	81 33 52
16413237	V-4030 (50)	Lk George Barrs Rd SF WL	29 20 16	81 33 52
16413238	V-4031 (51)	Lk George Barrs Rd SF WL	29 20 16	81 33 52
16593254	P-4075 (70)	Lk George HF Camp Rd SF WL	29 23 54	81 36 36
16383233	P-4067 (46)	Lk George Middle Rd SF WL	29 21 23	81 34 42
16383234	P-4068 (47)	Lk George Middle Rd SF WL	29 21 23	81 34 42
16383235	P-4069 (48)	Lk George Middle Rd SF WL	29 21 23	81 34 42
16353231	P-4064 (43)	Lk George Otter Rd SF WL	29 21 44	81 32 42
16463241	P-4072 (54)	Lk George Trck Trl 2 SF WL	29 22 28	81 33 36
16463242	P-4073 (55)	Lk George Trck Trl 2 SF WL	29 22 28	81 33 36
16463243	P-4074 (56)	Lk George Trck Trl 2 SF WL	29 22 28	81 33 36
15973192	P-4050 (DHQ1)	SJRWMD HQ Tr nr Palatka SF WL	29 39 59	81 41 49
15973193	P-4051 (DHQ2)	SJRWMD HQ Tr nr Palatka SF WL	29 39 59	81 41 49
16153210	N-0291 (24)	St Marys Main Rd SF WL	30 47 56	81 57 07
16153211	N-0292 (25)	St Marys Main Rd SF WL	30 47 56	81 57 07
16093204	N-0285 (18)	St Marys West Rd SF WL	30 47 19	81 57 47
16093205	N-0286 (19)	St Marys West Rd SF WL	30 47 19	81 57 47
16173212	N-0293 (26)	St Marys nr Park SF WL	30 48 53	81 57 23
16173213	N-0294 (26A)	St Marys nr Park SF WL	30 48 53	81 57 23
16173214	N-0295 (27)	St Marys nr Park SF WL	30 48 53	81 57 23
16123207	N-0288 (21)	St Marys nr Shed SF WL	30 47 35	81 56 23
16123208	N-0289 (22)	St Marys nr Shed SF WL	30 47 35	81 56 23
16123209	N-0290 (23)	St Marys nr Shed SF WL	30 47 35	81 56 23
16083203	SJ2565 (17)	Stokes Marsh Rd 2 SF WL	29 59 56	81 21 29
16633258	P-4078 (77)	Welaka SF Apaloosa Tr SF WL	29 27 14	81 38 55
16673262	P-4047 (81)	Welaka SF Mustang Tr SF WL	29 27 17	81 39 02
16673263	P-4048 (82)	Welaka SF Mustang Tr SF WL	29 27 17	81 39 02

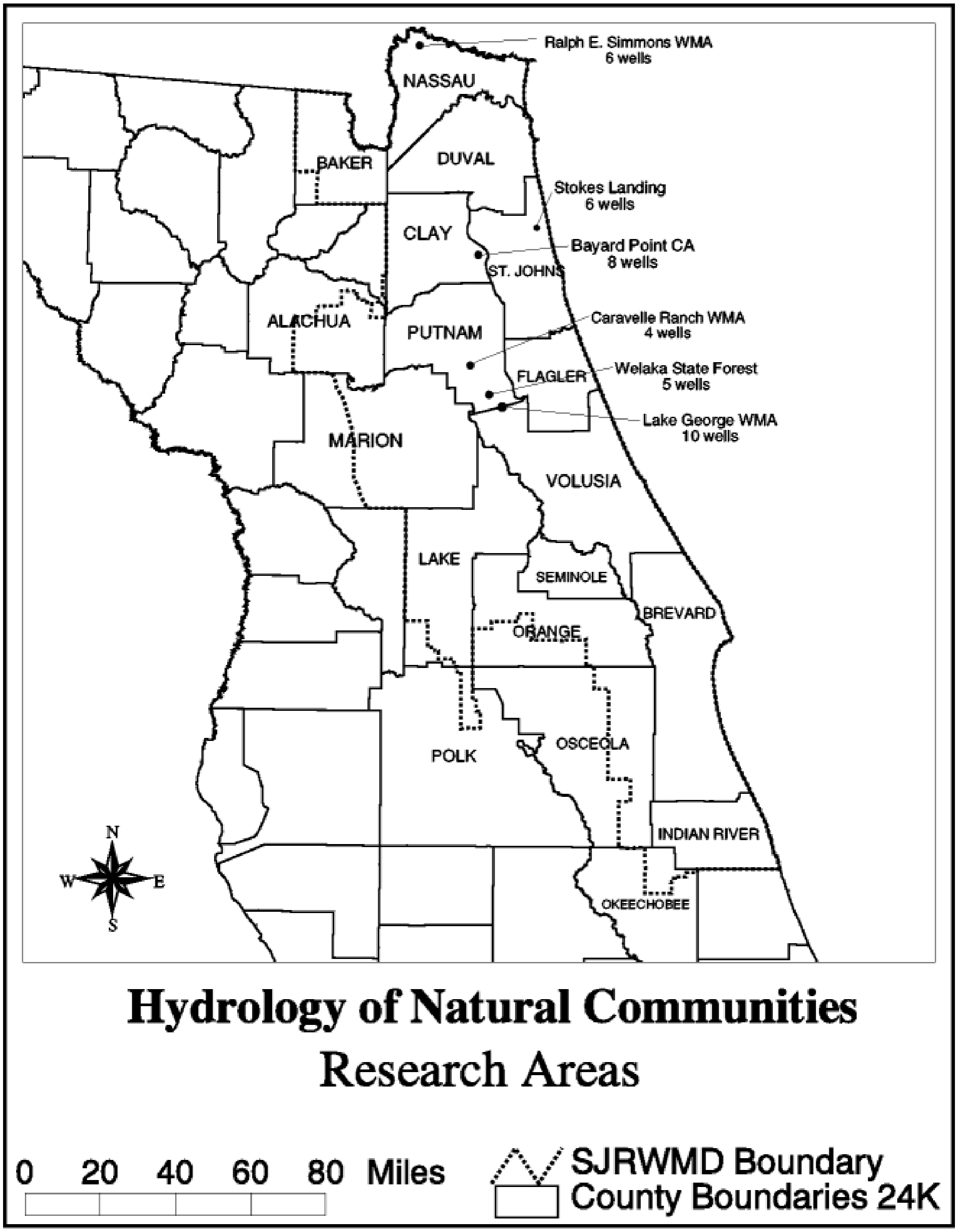


Figure 1. Site location map for six study areas in St. Johns River Water Management District (Source: courtesy of S. Nagid)

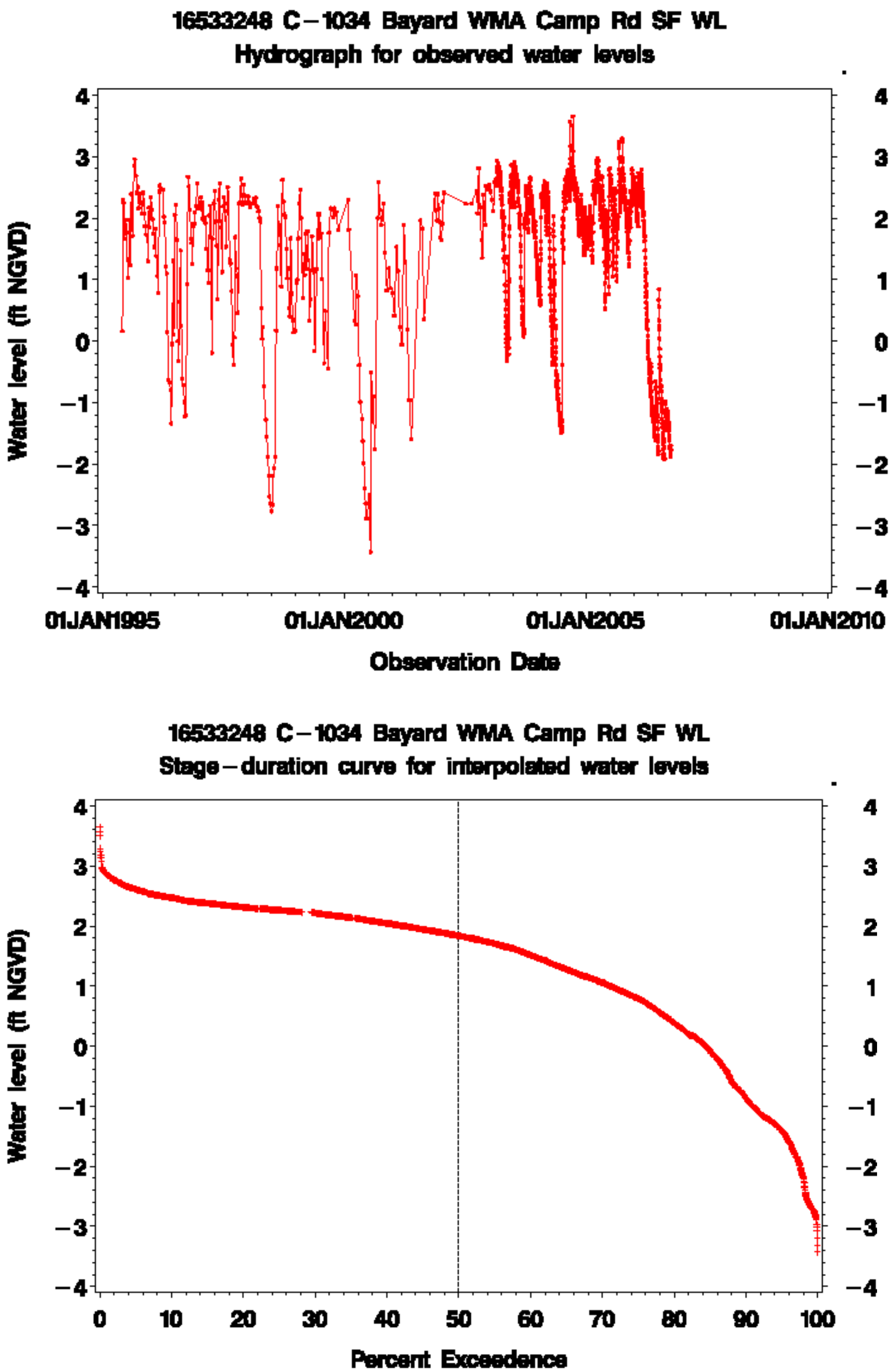


Figure 2. Example hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) [well C-1034 (62)]

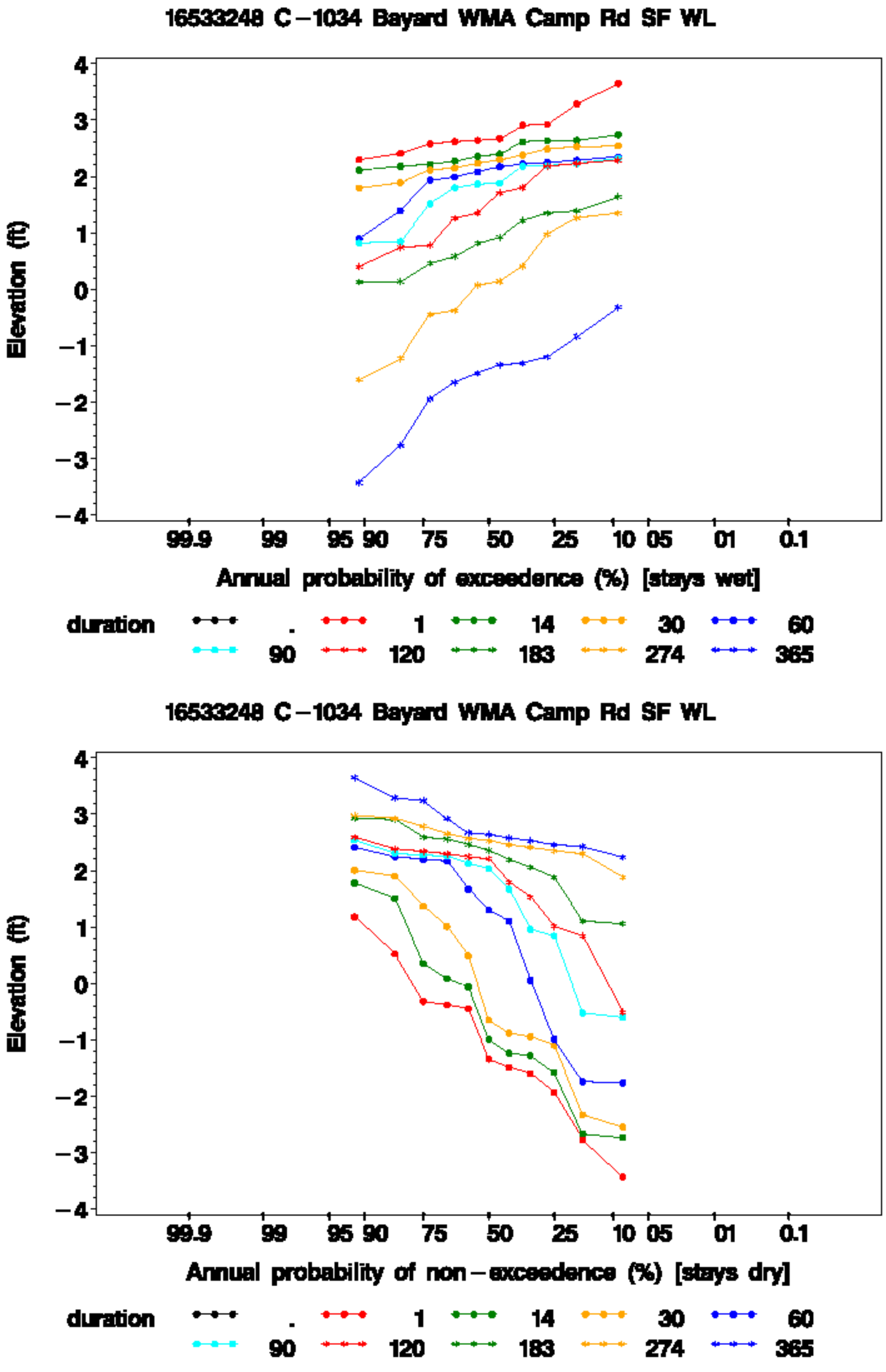
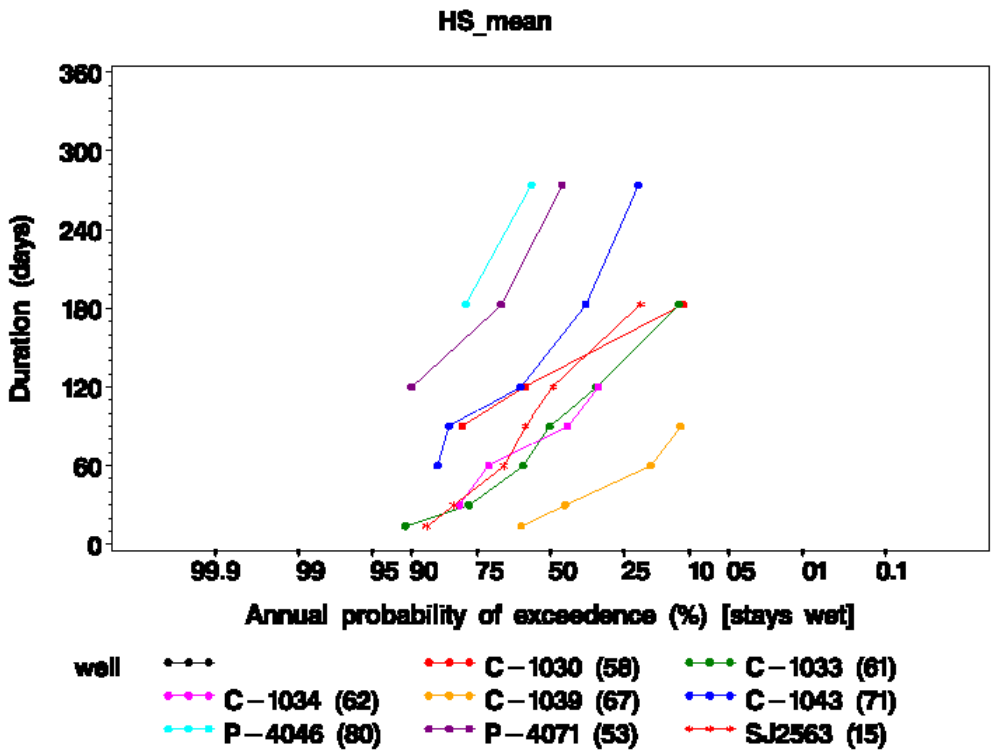


Figure 3. Examples of water level exceedence (top) and non-exceedence (bottom) probability plots [well C-1034 (62)]



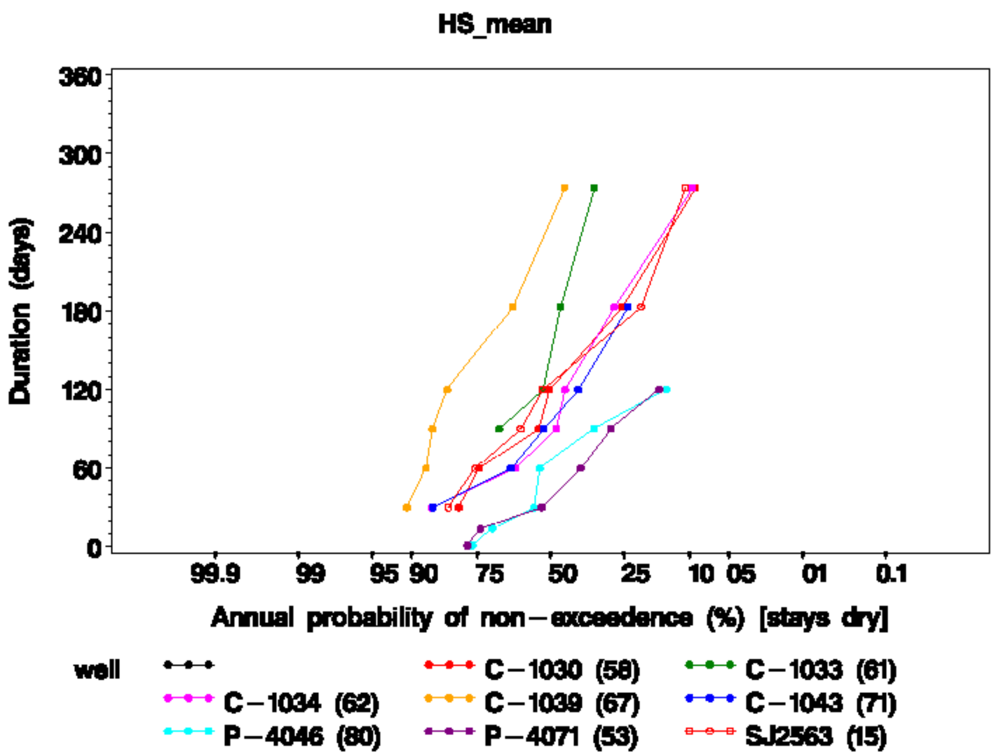


Figure 4. Examples of signature plots of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *hardwood swamp* mean elevation (HS_mean)

APPENDIX A

Appendix A. The elevations of hydric soil and wetland indicators of hydrology in natural plant communities of northeastern Florida. HDS Station is Hydrologic Data Services station number. Wetland identifier is SJRWMD's county well identifier plus the original study well number in parentheses. Wetland community abbreviations follow the convention of Kinser (1996).

HDS Station	Wetland Identifier	Indicator Name	Indicator Description	Elevation (ft NGVD)
16013196	P-4054 (05)	UPL_min	average minimum upland elevation	14.76
16023197	SJ2559 (07)	UPL_min	minimum upland elevation	4.62
16023197	SJ2559 (07)	SaltMarsh1_max	maximum shallow marsh elevation	4.67
16023197	SJ2559 (07)	SaltMarsh1_mean	mean shallow marsh elevation	4.15
16023197	SJ2559 (07)	mucky mineral	A7 - landward extent	4.42
16023197	SJ2559 (07)	stripped matrix	A4 - landward extent	4.32
16023197	SJ2559 (07)	muck	A8 - landward extent	3.91
16043200	SJ2562 (14)	UPL_min	minimum upland elevation	6.58
16043200	SJ2562 (14)	TS_max	maximum transitional shrub elevation	6.57
16043200	SJ2562 (14)	TS_mean	mean transitional shrub elevation	6.35
16043200	SJ2562 (14)	TS_min	minimum transitional shrub elevation	6.17
16043200	SJ2562 (14)	WP_max	maximum wet prairie 1 elevation	6.17
16043200	SJ2562 (14)	WP_mean	mean wet prairie 1 elevation	5.80
16043200	SJ2562 (14)	WP_min	minimum wet prairie 1 elevation	5.64
16043200	SJ2562 (14)	stripped matrix	S6 - landward extent	6.02
16043200	SJ2562 (14)	top royal fern	point shot on top of royal fern	7.10
16063201	SJ2563 (15)	UPL_min	minimum upland elevation	6.31
16063201	SJ2563 (15)	TS_max	maximum transitional shrub elevation	6.37
16063201	SJ2563 (15)	TS_mean	mean transitional shrub elevation	6.04
16063201	SJ2563 (15)	TS_min	minimum transitional shrub elevation	5.66
16063201	SJ2563 (15)	HS_max	maximum hardwood swamp elevation	5.66
16063201	SJ2563 (15)	HS_mean	mean hardwood swamp elevation	5.25
16063201	SJ2563 (15)	stripped matrix	S6 - landward extent	5.88
16063201	SJ2563 (15)	dark surface	S7 - landward extent	7.97
16063201	SJ2563 (15)	mucky mineral	A7 - landward extent	5.88
16253221	P-4056 (34)	HH_min	minimum elevation of hydric hammock	2.53
16253221	P-4056 (34)	TS_max	maximum transitional shrub elevation	2.66
16253221	P-4056 (34)	TS_mean	mean transitional shrub elevation	2.45
16253221	P-4056 (34)	TS_min	minimum transitional shrub elevation	2.34
16253221	P-4056 (34)	CY_max	maximum cypress swamp elevation	2.47
16253221	P-4056 (34)	CY_mean	mean cypress swamp elevation	1.80
16253221	P-4056 (34)	mucky mineral	A7 - landward extent	3.13
16253221	P-4056 (34)	dark surface	S7 - landward extent	3.13
16253221	P-4056 (34)	muck	A8 - landward extent	2.98
16273222	P-4057 (35)	UPL_min	minimum upland elevation	17.13
16273222	P-4057 (35)	MH_max	maximum mesic hammock elevation	17.13
16273222	P-4057 (35)	MH_mean	mean mesic hammock elevation	15.63
16273222	P-4057 (35)	MH_min	minimum mesic hammock elevation	14.26
16273222	P-4057 (35)	HH_max	maximum hydric hammock elevation	14.26
16273222	P-4057 (35)	HH_mean	mean hydric hammock elevation	14.01
16273222	P-4057 (35)	stripped matrix	S6 - landward extent	17.99
16273222	P-4057 (35)	organic bodies	A6 - landward extent of organic	17.96

16273222	P-4057 (35)	mucky mineral	A7 - landward extent	17.79
16273222	P-4057 (35)	muck	A8 - landward extent	17.69
16303226	P-4060 (39)	UPL_min	minimum upland elevation	33.10
16303226	P-4060 (39)	TS_max	maximum transitional shrub elevation	33.20
16303226	P-4060 (39)	TS_mean	mean transitional shrub elevation	33.06
16303226	P-4060 (39)	TS_min	minimum transitional shrub elevation	32.80
16303226	P-4060 (39)	SM_max	maximum shallow marsh elevation	32.80
16303226	P-4060 (39)	SM_mean	mean shallow marsh elevation	32.05
16303226	P-4060 (39)	stripped matrix	S6 - landward extent	34.10
16303226	P-4060 (39)	mucky mineral	A7 - landward extent	32.20
16303226	P-4060 (39)	muck	A8 - landward extent	32.00
16323228	P-4062 (41)	UPL_min	minimum upland elevation	33.18
16323228	P-4062 (41)	TS_max	maximum transitional shrub elevation	33.18
16323228	P-4062 (41)	TS_mean	mean transitional shrub elevation	32.82
16323228	P-4062 (41)	TS_min	minimum transitional shrub elevation	32.29
16323228	P-4062 (41)	CY_max	maximum cypress swamp elevation	32.29
16323228	P-4062 (41)	CY_mean	mean cypress swamp elevation	31.28
16323228	P-4062 (41)	CY_min	minimum cypress swamp elevation	30.20
16323228	P-4062 (41)	SM_max	maximum shallow marsh elevation	30.20
16323228	P-4062 (41)	SM_mean	mean shallow marsh elevation	29.44
16323228	P-4062 (41)	SM_min	minimum shallow marsh elevation	29.19
16323228	P-4062 (41)	mucky mineral	A7 - landward extent	31.60
16323228	P-4062 (41)	muck	A8 - landward extent	31.46
16323228	P-4062 (41)	histic epipedon	A2 - landward extent	29.42
16323228	P-4062 (41)	10 muck	landward extent of maximum muck	29.27
16323228	P-4062 (41)	lichen line	lichen line shot on cypress tree	33.31
16353232	P-4066 (45)	UPL_min	minimum upland elevation	33.09
16353232	P-4066 (45)	TS_max	maximum transitional shrub elevation	33.09
16353232	P-4066 (45)	TS_mean	mean transitional shrub elevation	32.38
16353232	P-4066 (45)	TS_min	minimum transitional shrub elevation	31.99
16353232	P-4066 (45)	CY_max	maximum cypress swamp elevation	32.10
16353232	P-4066 (45)	CY_mean	mean cypress swamp elevation	30.28
16353232	P-4066 (45)	CY_min	minimum cypress swamp elevation	29.45
16353232	P-4066 (45)	DM_max	maximum elevation of deep marsh	29.74
16353232	P-4066 (45)	stripped matrix	S6 - landward extent	31.45
16353232	P-4066 (45)	mucky mineral	A7 - landward extent	30.83
16353232	P-4066 (45)	dark surface	S7 - landward extent	30.60
16353232	P-4066 (45)	muck	A8 - landward extent	30.10
16353232	P-4066 (45)	histic epipedon	A2 - landward extent	29.64
16353232	P-4066 (45)	histosol	A1 - landward extent of histosol	29.56
16443240	P-4071 (53)	UPL_min	minimum upland elevation	27.71
16443240	P-4071 (53)	TS_max	maximum transitional shrub elevation	27.90
16443240	P-4071 (53)	TS_mean	mean transitional shrub elevation	27.30
16443240	P-4071 (53)	TS_min	minimum transitional shrub elevation	27.02
16443240	P-4071 (53)	HS_max	maximum cypress swamp elevation	27.39
16443240	P-4071 (53)	HS_mean	mean cypress swamp elevation	27.10
16443240	P-4071 (53)	HS_min	minimum cypress swamp elevation	26.93
16443240	P-4071 (53)	stripped matrix	S6 - landward extent	27.64
16443240	P-4071 (53)	mucky mineral	A7 - landward extent	27.21
16443240	P-4071 (53)	dark surface	S7 - landward extent	27.21
16443240	P-4071 (53)	muck	A8 - landward extent	27.02
16443240	P-4071 (53)	histic epipedon	A2 - landward extent	27.19

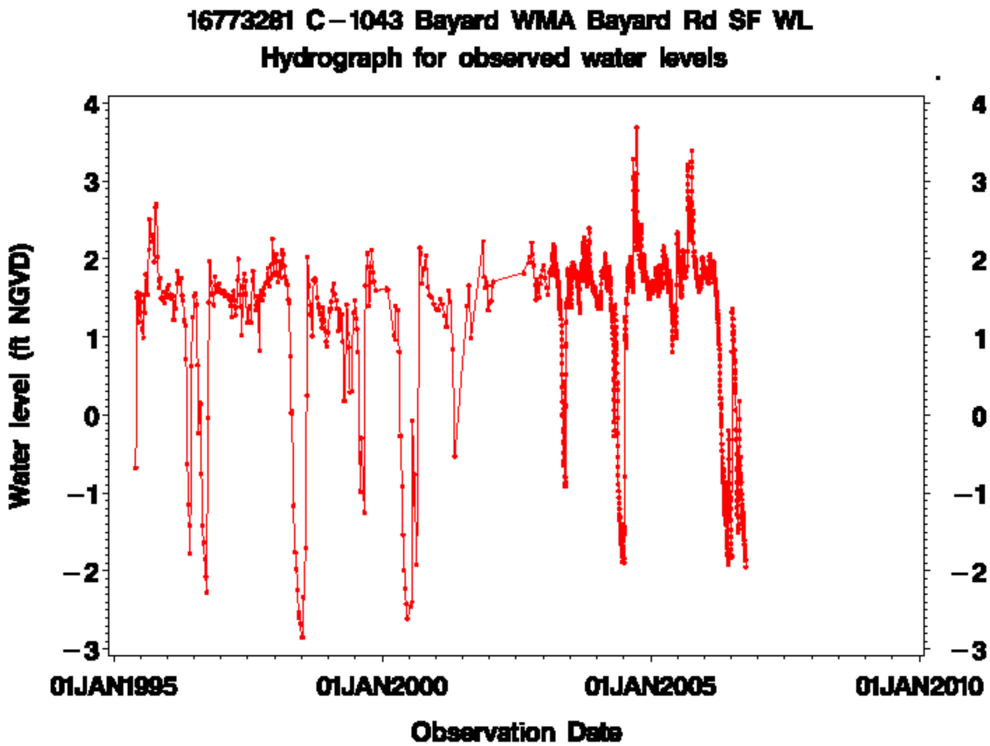
16493740	C-1030 (58)	UPL_min	minimum upland elevation	10.09
16493740	C-1030 (58)	TS_max	maximum transitional shrub elevation	10.09
16493740	C-1030 (58)	TS_mean	mean transitional shrub elevation	9.96
16493740	C-1030 (58)	TS_min	minimum transitional shrub elevation	9.88
16493740	C-1030 (58)	HS_max	maximum hardwood swamp elevation	9.88
16493740	C-1030 (58)	HS_mean	mean hardwood swamp elevation	9.60
16493740	C-1030 (58)	HS_min	minimum hardwood swamp elevation	9.05
16493740	C-1030 (58)	stripped matrix	S6 - landward extent	12.70
16493740	C-1030 (58)	dark surface	S7 - landward extent	11.90
16493740	C-1030 (58)	mucky mineral	A7 - landward extent	11.11
16493740	C-1030 (58)	muck	A8 - landward extent	9.97
16493740	C-1030 (58)	histic epipedon	A2 - landward extent	9.41
16513247	C-1033 (61)	UPL_min	minimum upland elevation	5.62
16513247	C-1033 (61)	TS_max	maximum transitional shrub elevation	5.62
16513247	C-1033 (61)	TS_mean	mean transitional shrub elevation	5.48
16513247	C-1033 (61)	TS_min	minimum transitional shrub elevation	5.05
16513247	C-1033 (61)	HS_max	maximum hardwood swamp elevation	5.05
16513247	C-1033 (61)	HS_mean	mean hardwood swamp elevation	4.32
16513247	C-1033 (61)	HS_min	minimum hardwood swamp elevation	3.82
16513247	C-1033 (61)	SM_max	maximum shallow marsh elevation	3.96
16513247	C-1033 (61)	SM_mean	mean shallow marsh elevation	3.63
16513247	C-1033 (61)	stripped matrix	S6 - landward extent	7.51
16513247	C-1033 (61)	organic bodies	A6 - landward extent of organic	6.61
16513247	C-1033 (61)	mucky mineral	A7 - landward extent	6.06
16513247	C-1033 (61)	muck	A8 - landward extent	4.71
16533248	C-1034 (62)	UPL_min	minimum upland elevation	2.34
16533248	C-1034 (62)	TS_max	maximum transitional shrub elevation	2.34
16533248	C-1034 (62)	TS_mean	mean transitional shrub elevation	2.17
16533248	C-1034 (62)	TS_min	minimum transitional shrub elevation	1.94
16533248	C-1034 (62)	HS_max	maximum hardwood swamp elevation	2.46
16533248	C-1034 (62)	HS_mean	mean hardwood swamp elevation	1.94
16533248	C-1034 (62)	stripped matrix	S6 - landward extent	2.20
16533248	C-1034 (62)	sandy redox	S5 - landward extent	1.74
16533248	C-1034 (62)	muck	A8 - landward extent	1.92
16543250	C-1036 (64)	BH_min	minimum bayhead elevation	3.15
16543250	C-1036 (64)	SM_max	maximum shallow marsh elevation	3.16
16543250	C-1036 (64)	SM_mean	mean shallow marsh elevation	2.61
16543250	C-1036 (64)	stripped matrix	S6 - landward extent	3.49
16543250	C-1036 (64)	dark surface	S7 - landward extent	3.06
16543250	C-1036 (64)	mucky mineral	A7 - landward extent	3.06
16543250	C-1036 (64)	muck	A8 - landward extent	2.94
16573253	C-1039 (67)	MH_min	minimum upland elevation	1.96
16573253	C-1039 (67)	TS_max	maximum transitional shrub elevation	2.08
16573253	C-1039 (67)	TS_mean	mean transitional shrub elevation	1.87
16573253	C-1039 (67)	TS_min	minimum transitional shrub elevation	1.69
16573253	C-1039 (67)	HS_max	maximum hardwood swamp elevation	1.81
16573253	C-1039 (67)	HS_mean	mean hardwood swamp elevation	1.68
16573253	C-1039 (67)	dark surface	S7 - landward extent	2.66
16573253	C-1039 (67)	mucky mineral	A7 - landward extent	2.66
16573253	C-1039 (67)	muck	A8 - landward extent	2.30
16573253	C-1039 (67)	histic epipedon	A2 - landward extent	1.67
16573253	C-1039 (67)	histosol	A1 - landward extent of histosol	1.62

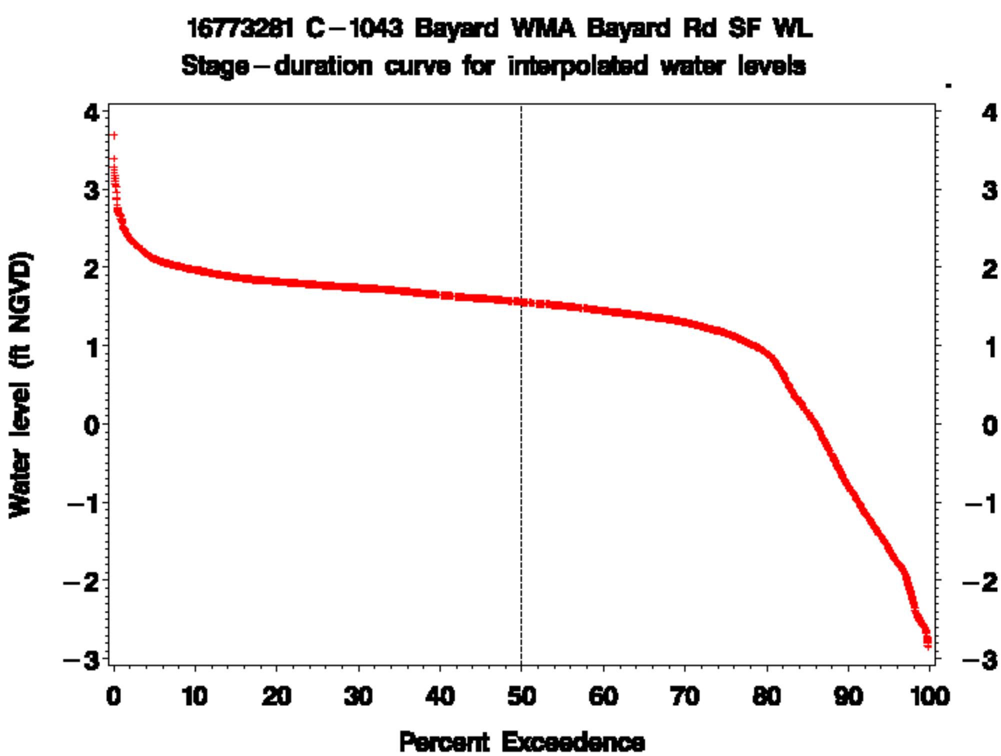
16613257	P-4077 (76)	UPL_min	minimum upland elevation	30.99
16613257	P-4077 (76)	TS_max	maximum transitional shrub elevation	30.99
16613257	P-4077 (76)	TS_mean	mean transitional shrub elevation	30.71
16613257	P-4077 (76)	TS_min	minimum transitional shrub elevation	30.26
16613257	P-4077 (76)	SM_max	maximum shallow marsh elevation	30.26
16613257	P-4077 (76)	SM_mean	mean shallow marsh elevation	28.38
16613257	P-4077 (76)	SM_min	minimum shallow marsh elevation	27.39
16613257	P-4077 (76)	DM_max	maximum elevation of deep marsh	27.39
16613257	P-4077 (76)	DM_mean	mean elevation of deep marsh	27.33
16613257	P-4077 (76)	stripped matrix	S6 - landward extent	30.75
16613257	P-4077 (76)	mucky mineral	A7 - landward extent	30.33
16613257	P-4077 (76)	dark surface	S7 - landward extent	29.64
16613257	P-4077 (76)	muck	A8 - landward extent	28.62
16613257	P-4077 (76)	histic epipedon	A2 - landward extent	27.62
16613257	P-4077 (76)	13 muck	landward extent of maximum muck	27.35
16633264	P-4049 (83)	UPL_min	minimum upland elevation	26.85
16633264	P-4049 (83)	TS_max	maximum transitional shrub elevation	26.85
16633264	P-4049 (83)	TS_mean	mean transitional shrub elevation	26.37
16633264	P-4049 (83)	TS_min	minimum transitional shrub elevation	25.83
16633264	P-4049 (83)	SM_max	maximum shallow marsh elevation	25.83
16633264	P-4049 (83)	SM_mean	mean shallow marsh elevation	23.65
16633264	P-4049 (83)	SM_min	minimum shallow marsh elevation	22.88
16633264	P-4049 (83)	DM_max	maximum elevation of deep marsh	23.41
16633264	P-4049 (83)	DM_mean	mean elevation of deep marsh	23.31
16633264	P-4049 (83)	stripped matrix	S6 - landward extent	26.14
16633264	P-4049 (83)	mucky mineral	A7 - landward extent	24.49
16633264	P-4049 (83)	muck	A8 - landward extent	24.09
16633264	P-4049 (83)	histic epipedon	A2 - landward extent	23.47
16633264	P-4049 (83)	histosol	A1 - landward extent of histosol	23.17
16653261	P-4046 (80)	UPL_min	minimum upland elevation	10.48
16653261	P-4046 (80)	BH_max	maximum bayhead elevation	10.90
16653261	P-4046 (80)	BH_mean	mean bayhead elevation	9.79
16653261	P-4046 (80)	BH_min	minimum bayhead elevation	8.88
16653261	P-4046 (80)	HS_max	maximum hardwood swamp elevation	9.02
16653261	P-4046 (80)	HS_mean	mean hardwood swamp elevation	8.66
16653261	P-4046 (80)	stripped matrix	S6 - landward extent	10.00
16653261	P-4046 (80)	histosol_max	A1 - landward extent of histosol	9.04
16653261	P-4046 (80)	histosol_min	A1 - waterward extent of histosol	8.79
16653261	P-4046 (80)	histic epipedon	A2 - landward extent	8.51
16713275	SJ2570 (09)	SaltMarsh1_max	maximum salt marsh 1 elevation	4.55
16713275	SJ2570 (09)	SaltMarsh1_mean	mean salt marsh 1 elevation	3.59
16713275	SJ2570 (09)	SaltMarsh1_min	minimum salt marsh 1 elevation	3.32
16713275	SJ2570 (09)	SaltMarsh2_max	maximum salt marsh 2 elevation	3.32
16713275	SJ2570 (09)	SaltMarsh2_mean	mean salt marsh 2 elevation	3.08
16713275	SJ2570 (09)	SaltMarsh2_min	minimum salt marsh 2 elevation	2.84
16713275	SJ2570 (09)	SaltMarsh3_max	maximum salt marsh 3 elevation	2.84
16713275	SJ2570 (09)	SaltMarsh3_mean	mean salt marsh 3 elevation	2.80
16713275	SJ2570 (09)	SaltMarsh3_min	minimum salt marsh 3 elevation	2.79
16713275	SJ2570 (09)	SaltMarsh4_max	maximum salt marsh 4 elevation	2.79
16713275	SJ2570 (09)	SaltMarsh4_mean	mean salt marsh 4 elevation	2.74
16713275	SJ2570 (09)	SaltMarsh4_min	minimum salt marsh 4 elevation	2.73
16713275	SJ2570 (09)	stripped matrix	S6 - landward extent	3.94

16713275	SJ2570 (09)	hydrogen sulfide	A4 - landward extent	2.84
16733278	SJ2573 (12)	HH_min	minimum upland elevation	4.16
16733278	SJ2573 (12)	TS_max	maximum transitional shrub elevation	4.16
16733278	SJ2573 (12)	TS_mean	mean transitional shrub elevation	4.02
16733278	SJ2573 (12)	TS_min	minimum transitional shrub elevation	3.84
16733278	SJ2573 (12)	SM_max	maximum shallow marsh elevation	3.84
16733278	SJ2573 (12)	SM_mean	mean shallow marsh elevation	3.69
16733278	SJ2573 (12)	stripped matrix	S6 - landward extent	4.16
16733278	SJ2573 (12)	mucky mineral	A7 - landward extent	4.76
16773281	C-1043 (71)	UPL_min	minimum upland elevation	2.07
16773281	C-1043 (71)	TS_max	maximum transitional shrub elevation	2.29
16773281	C-1043 (71)	TS_mean	mean transitional shrub elevation	1.84
16773281	C-1043 (71)	TS_min	minimum transitional shrub elevation	1.56
16773281	C-1043 (71)	HS_max	maximum hardwood swamp elevation	2.29
16773281	C-1043 (71)	HS_mean	mean hardwood swamp elevation	1.46
16773281	C-1043 (71)	stripped matrix	S6 - landward extent	2.07
16773281	C-1043 (71)	sandy redox	S5 - landward extent	1.99
16773281	C-1043 (71)	muck	A8 - landward extent	1.54

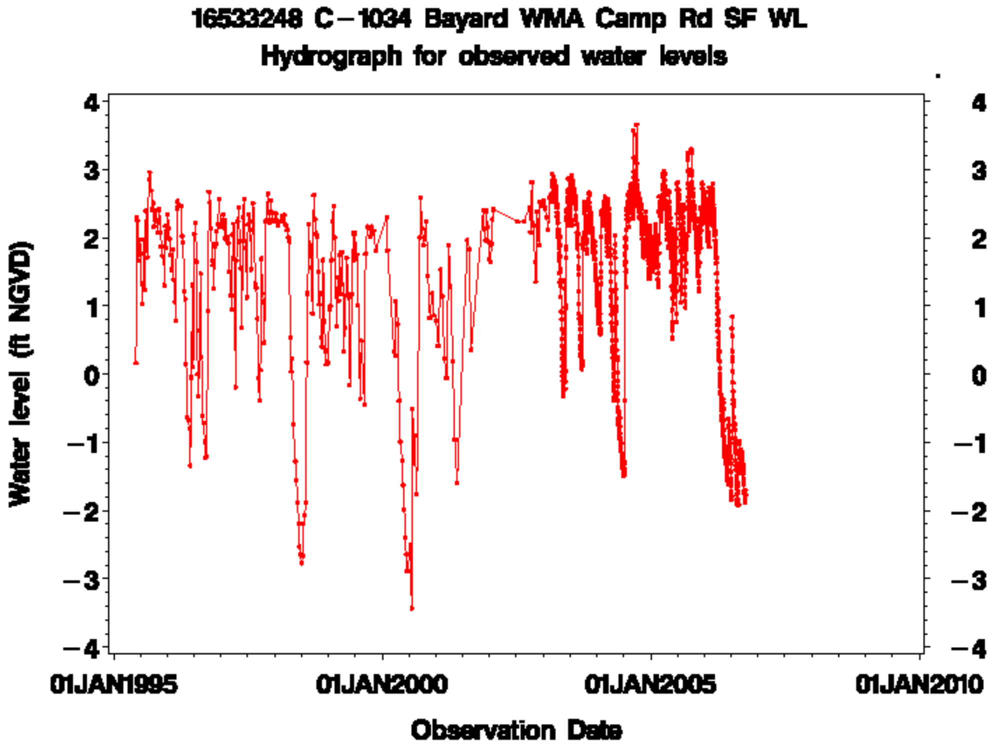
APPENDIX B

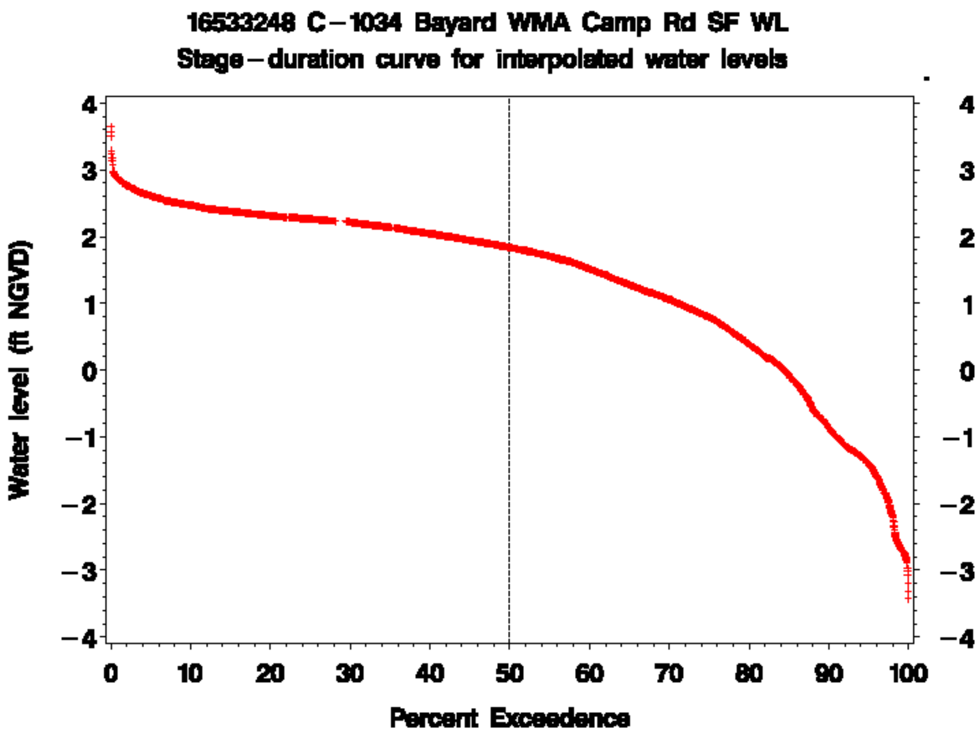
Appendix B.1. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well C-1043



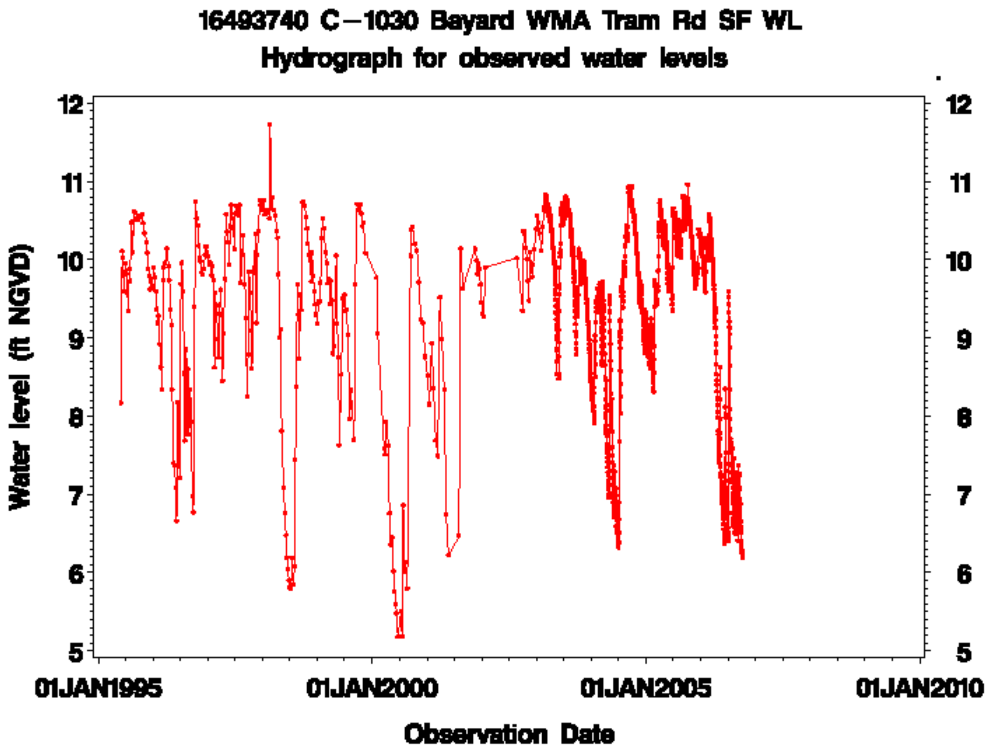


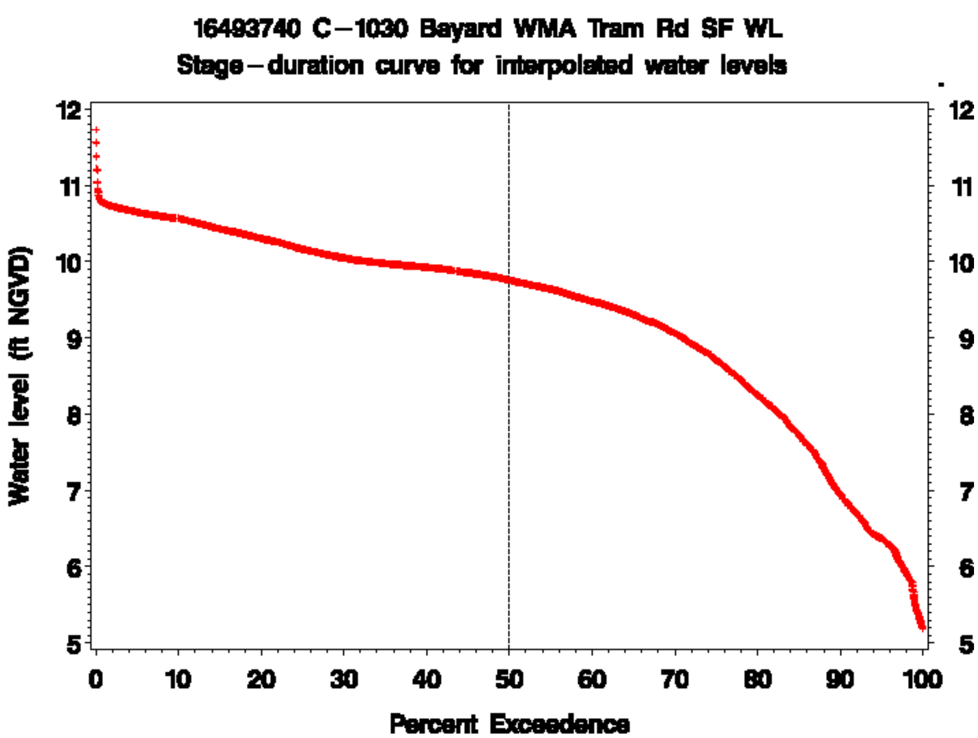
Appendix B.2. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well C-1034



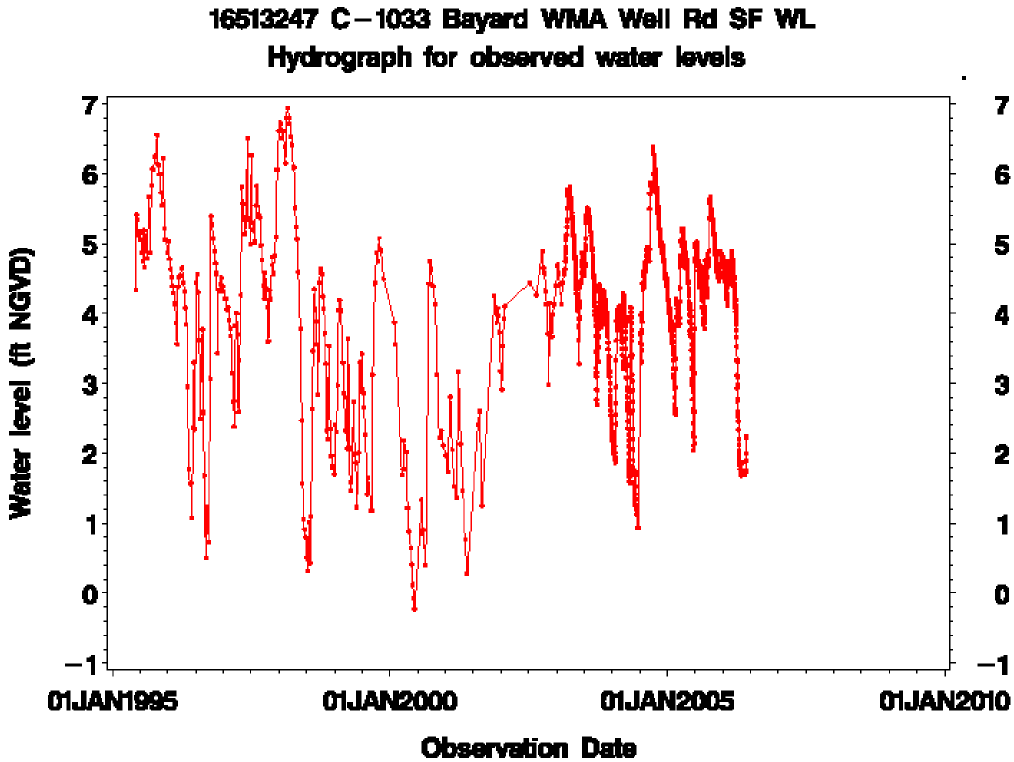


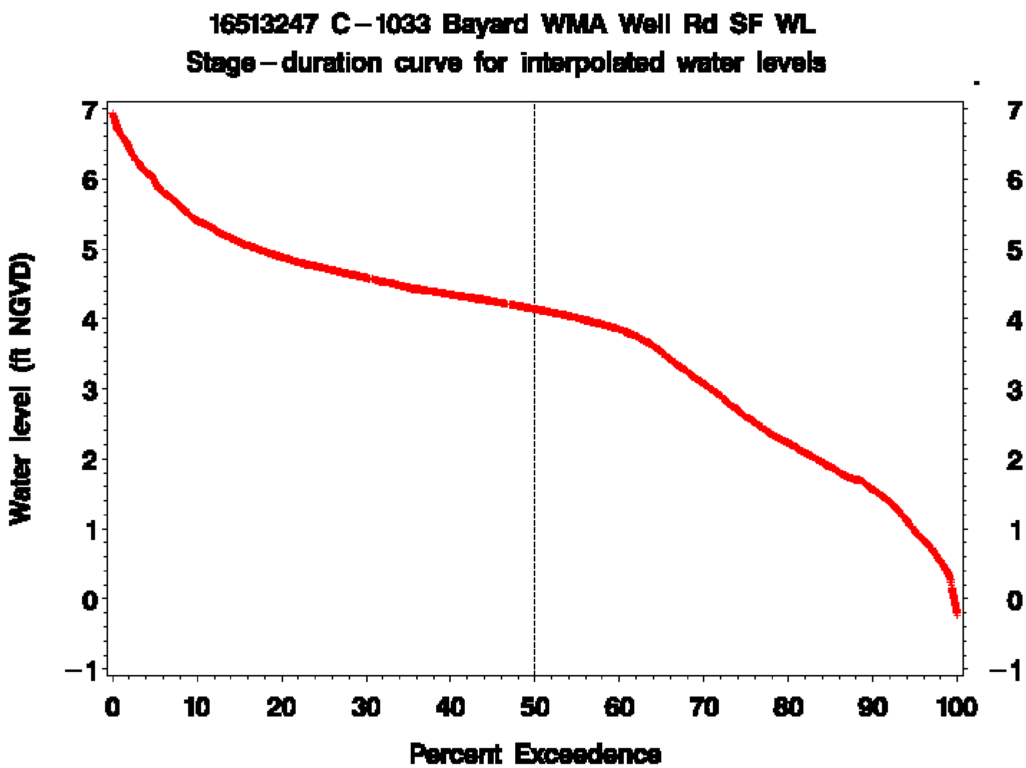
Appendix B.3. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well C-1030



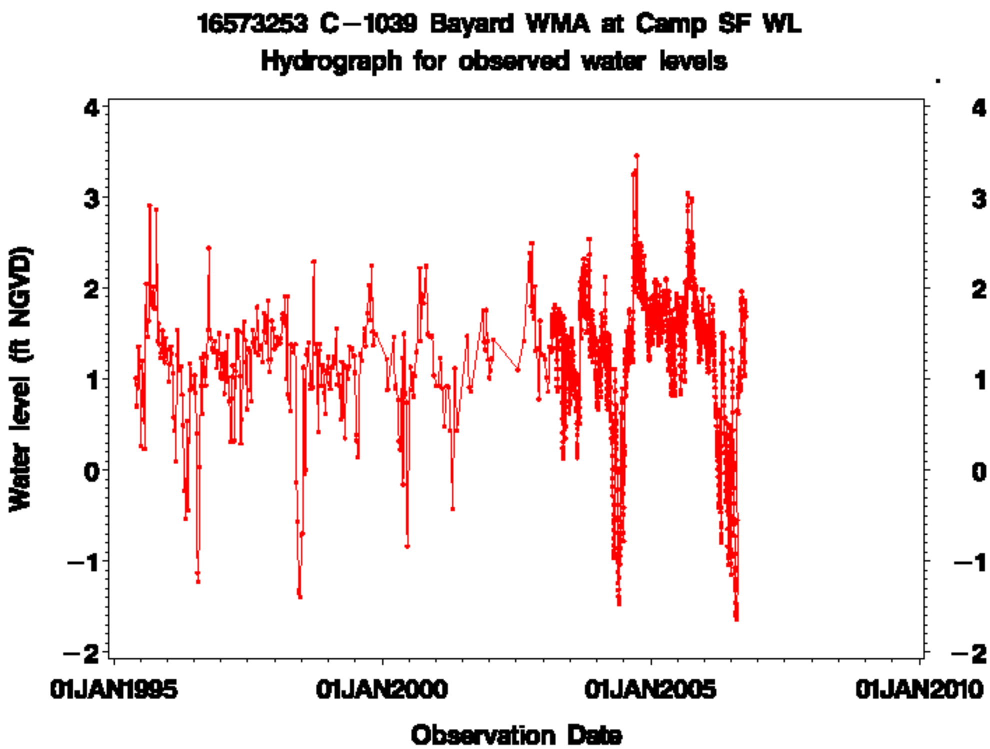


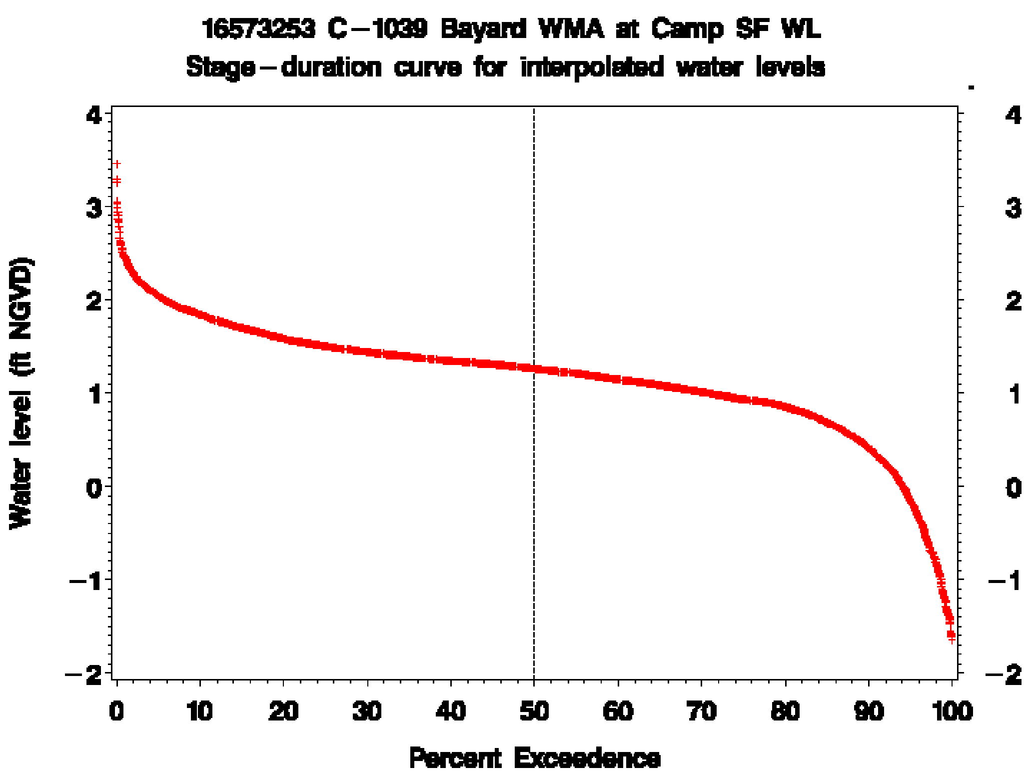
Appendix B.4. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well C-1033



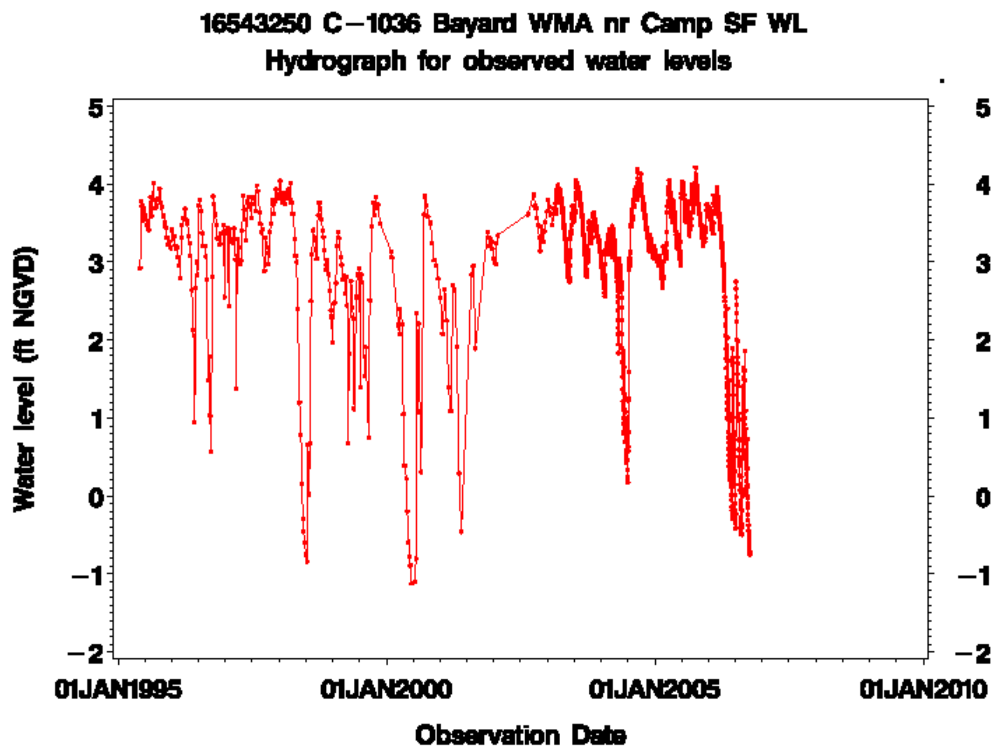


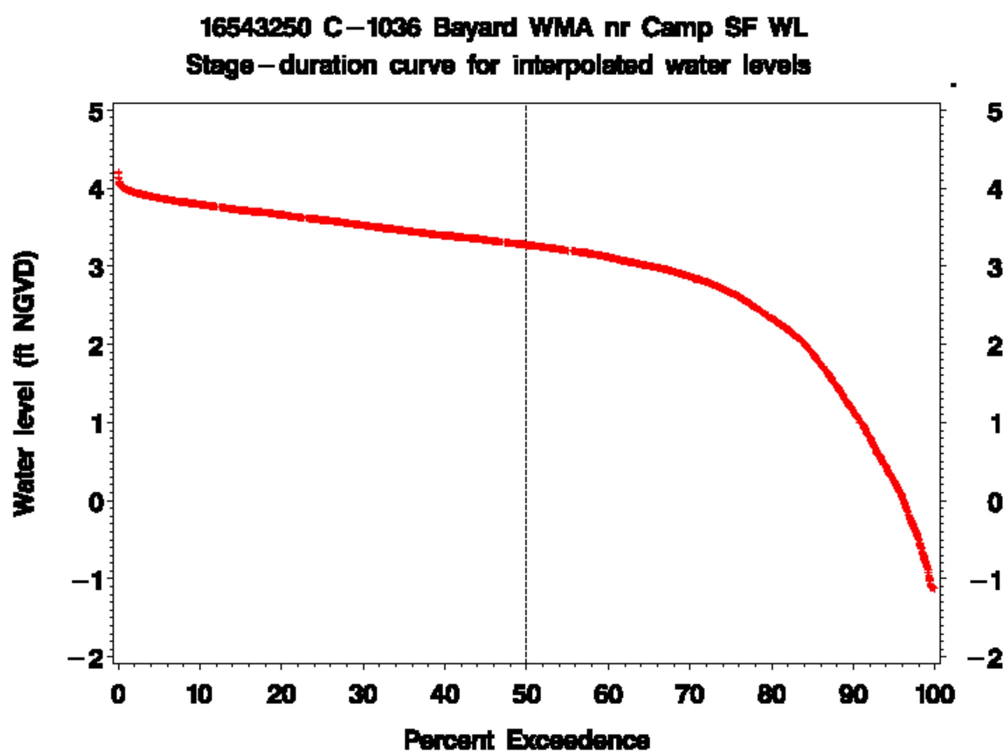
Appendix B.5. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well C-1039



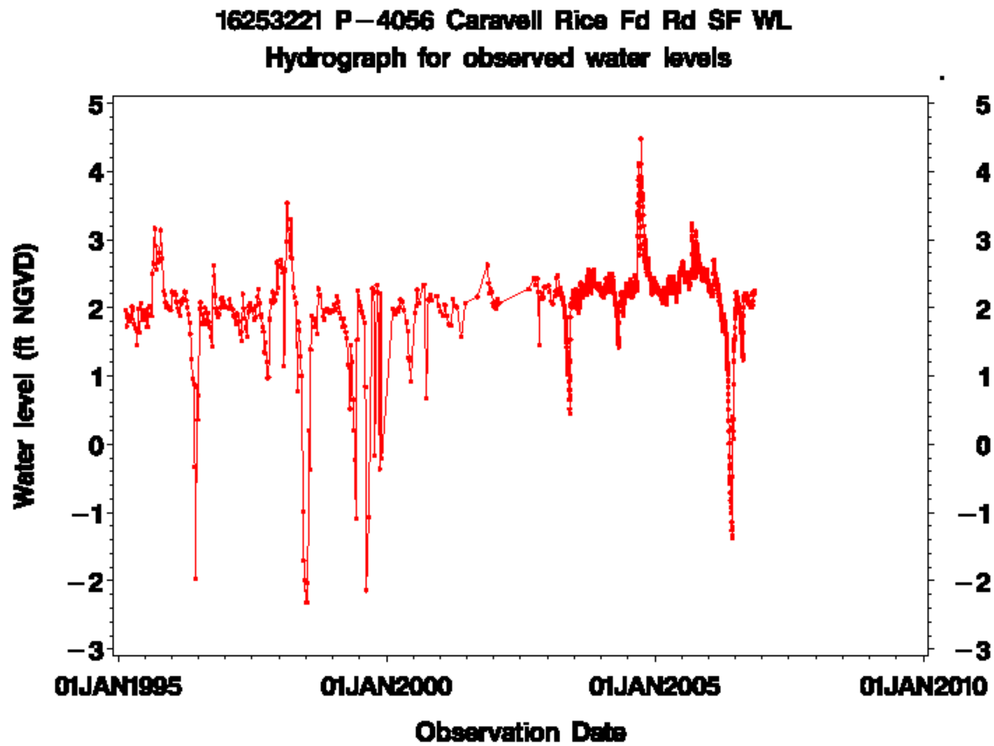


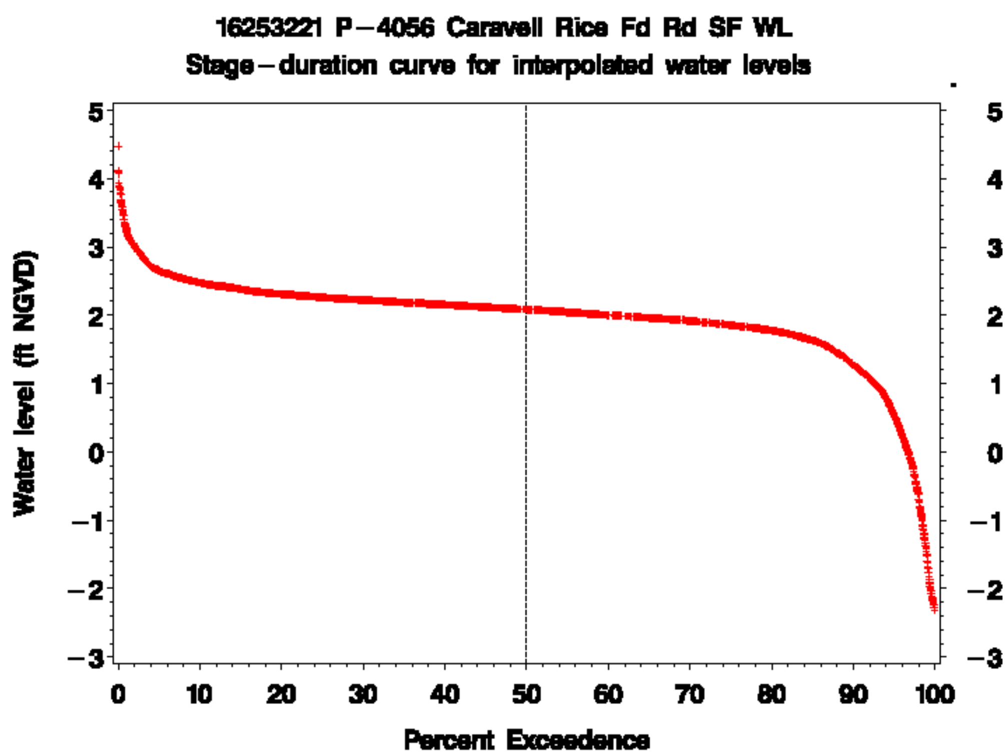
Appendix B.6. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well C-1036



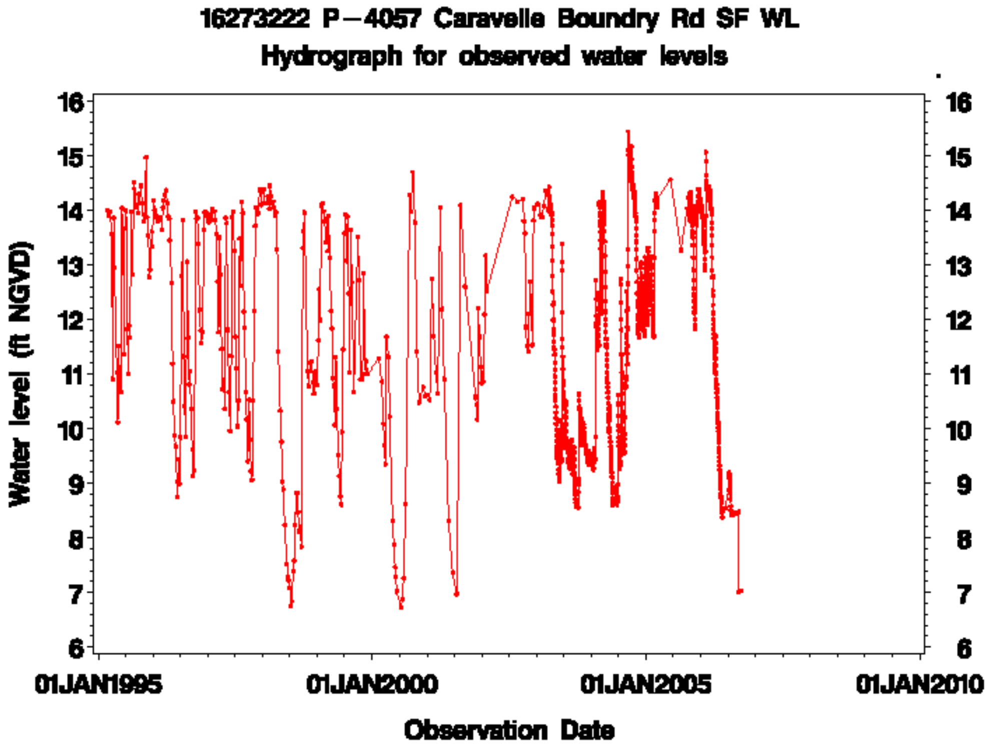


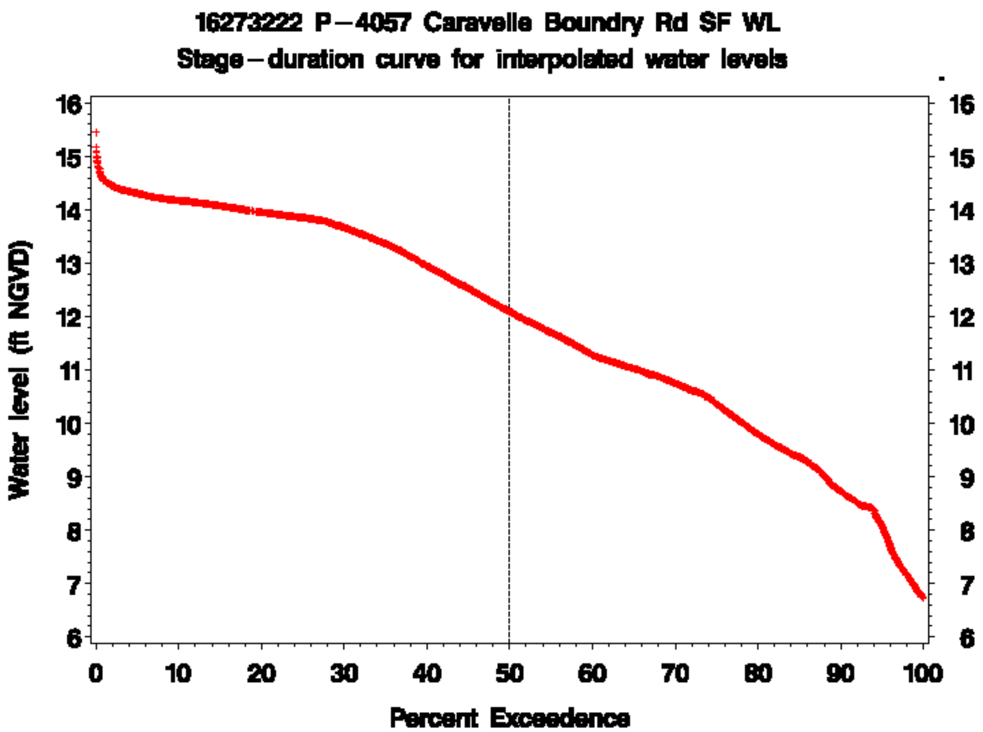
Appendix B.7. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well P-4056



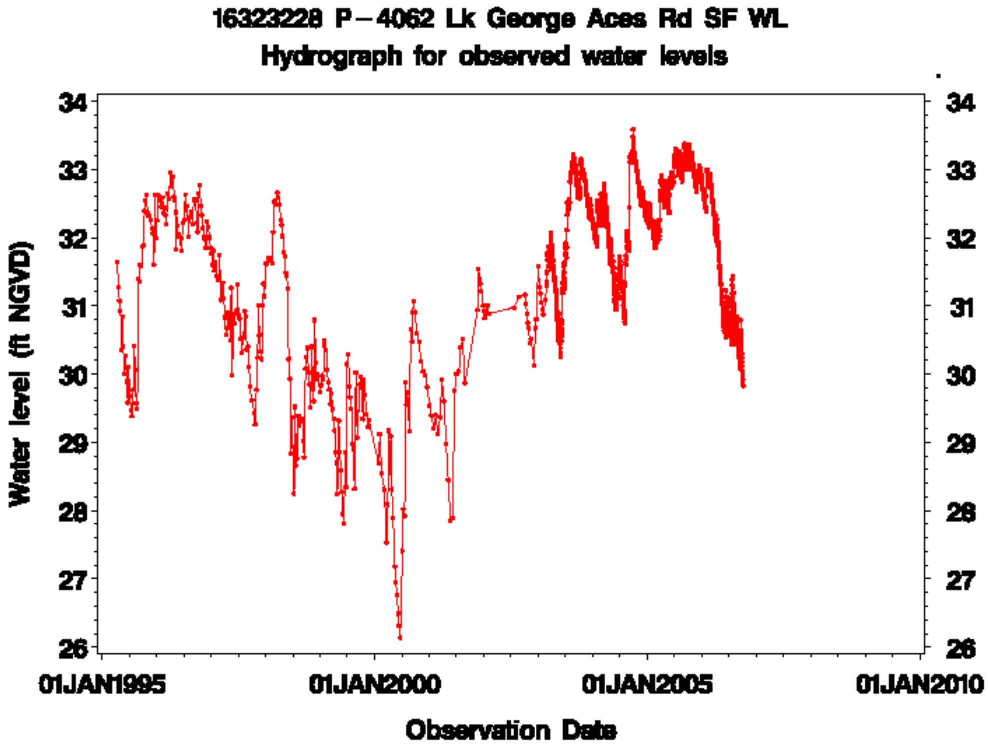


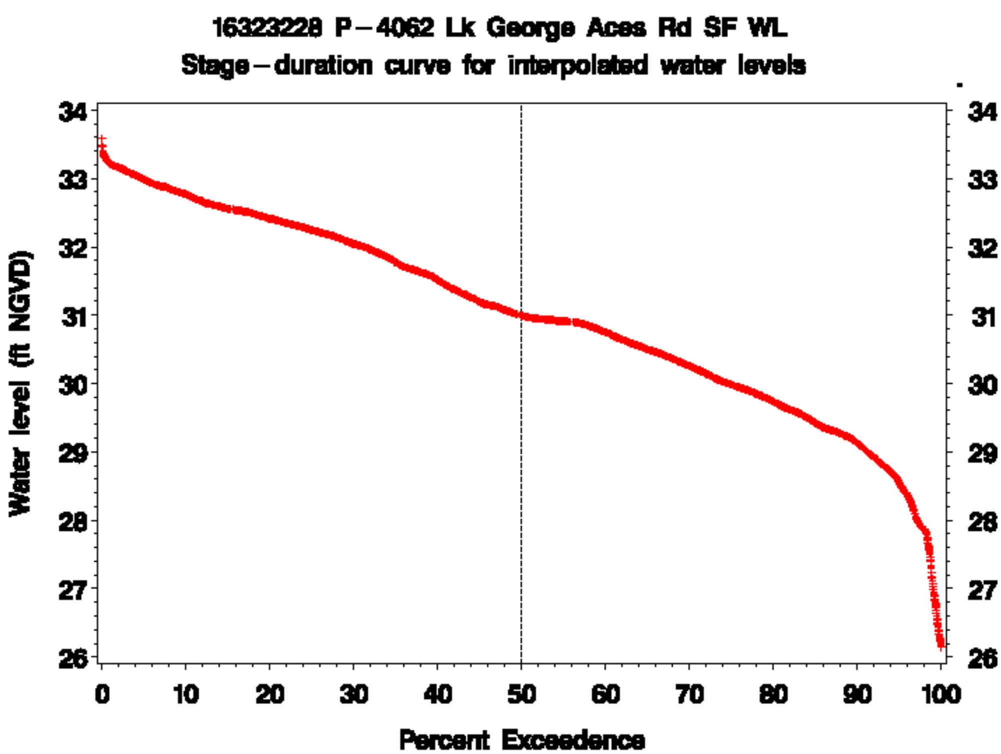
Appendix B.8. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well P-4057



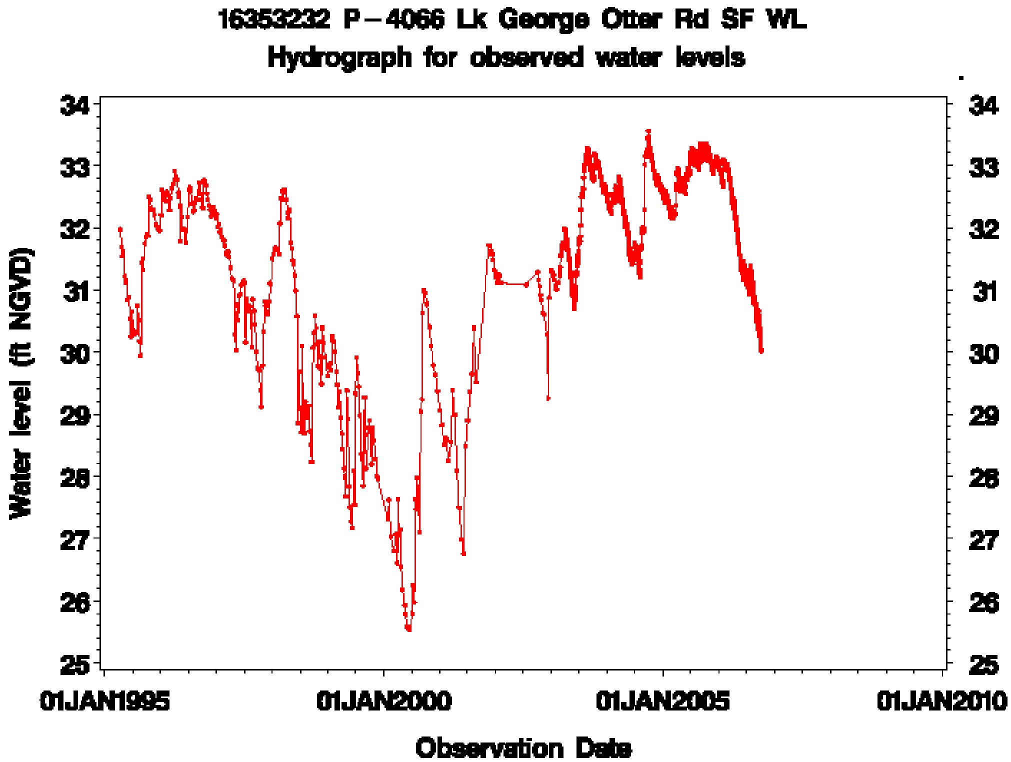


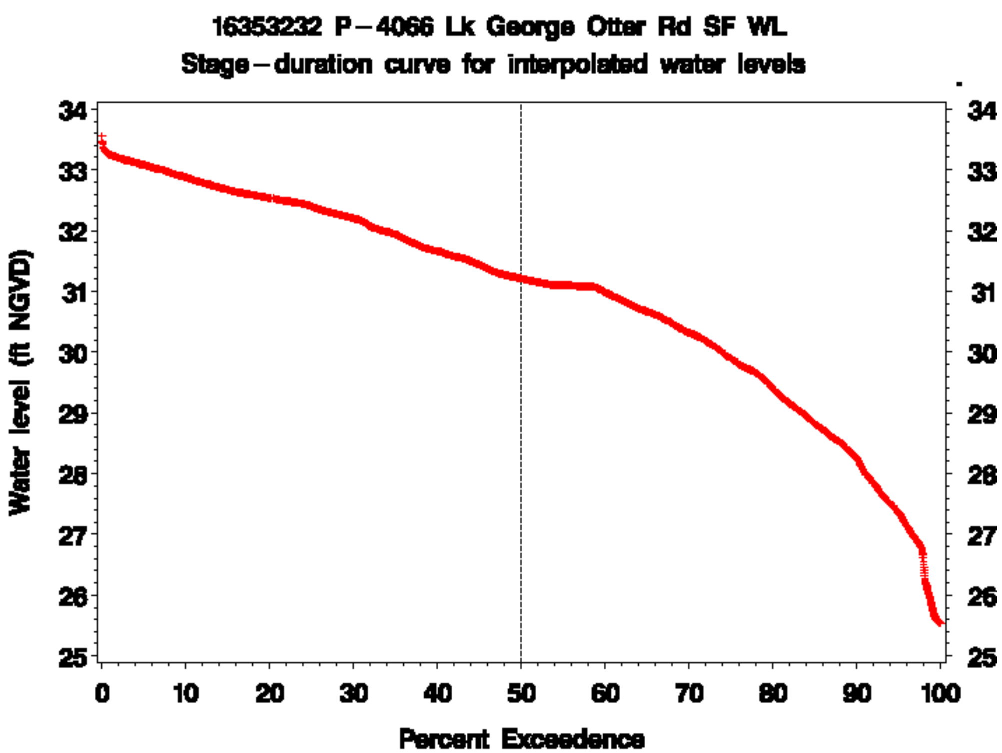
Appendix B.9. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well P-4062



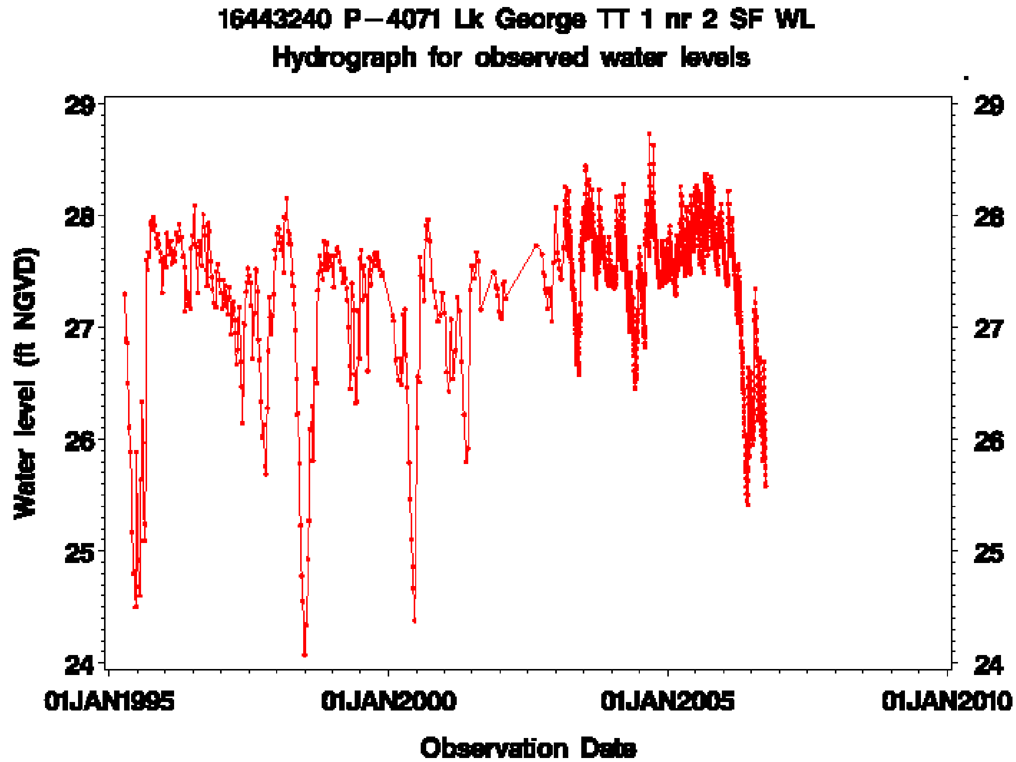


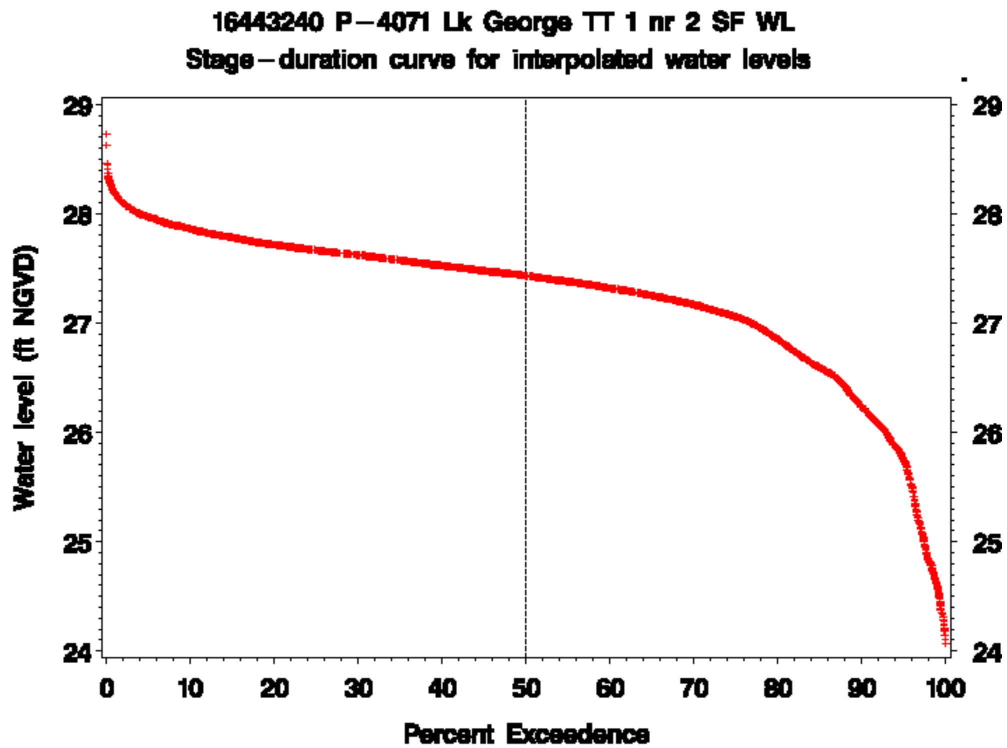
Appendix B.10. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well P-4066



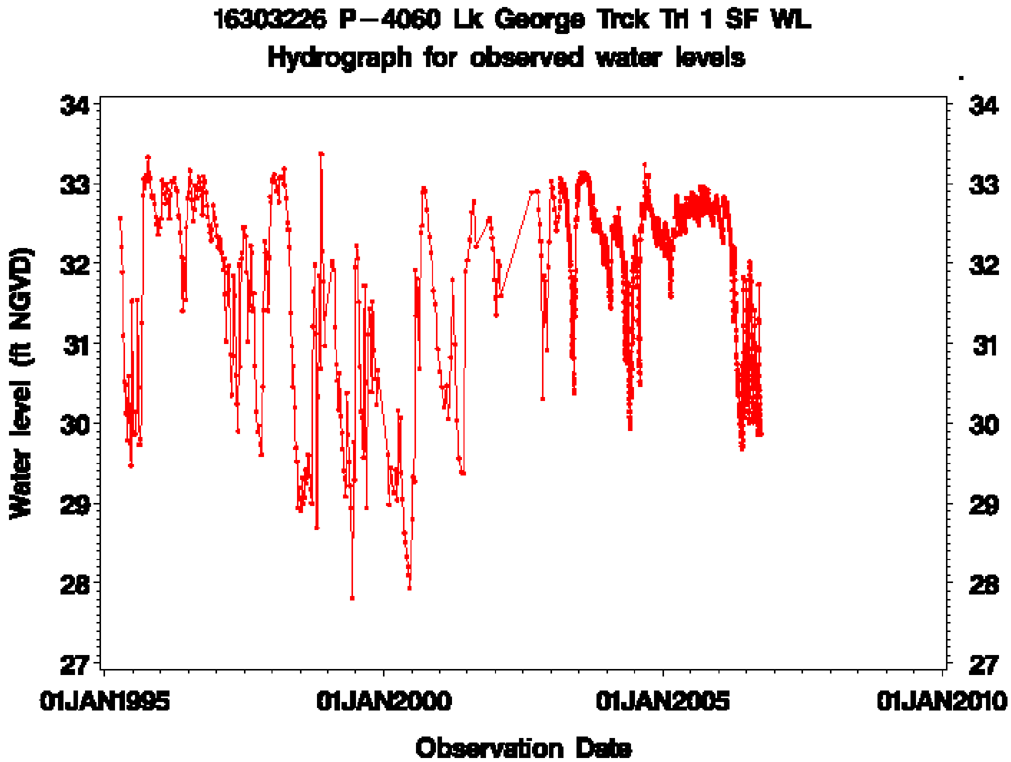


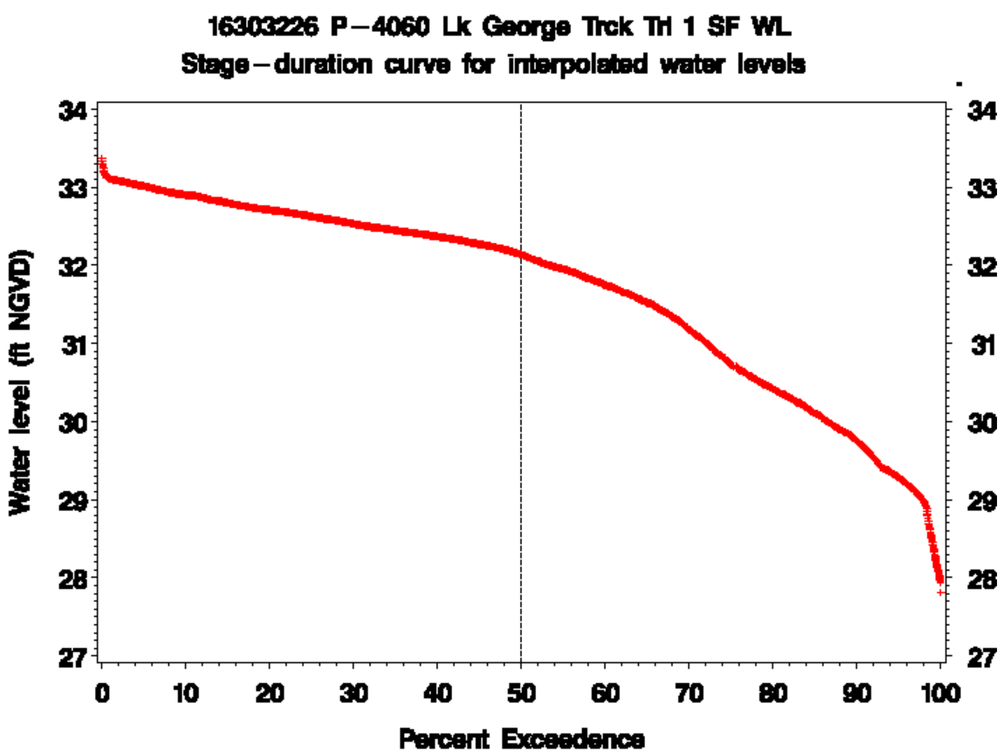
Appendix B.11. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well P-4071



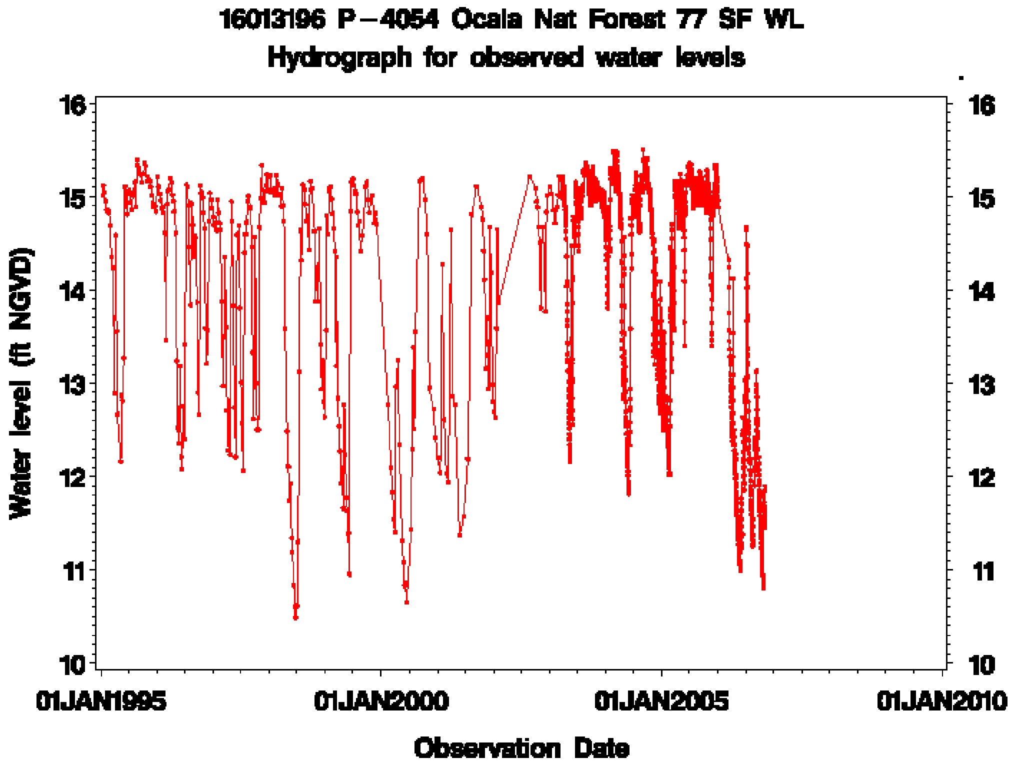


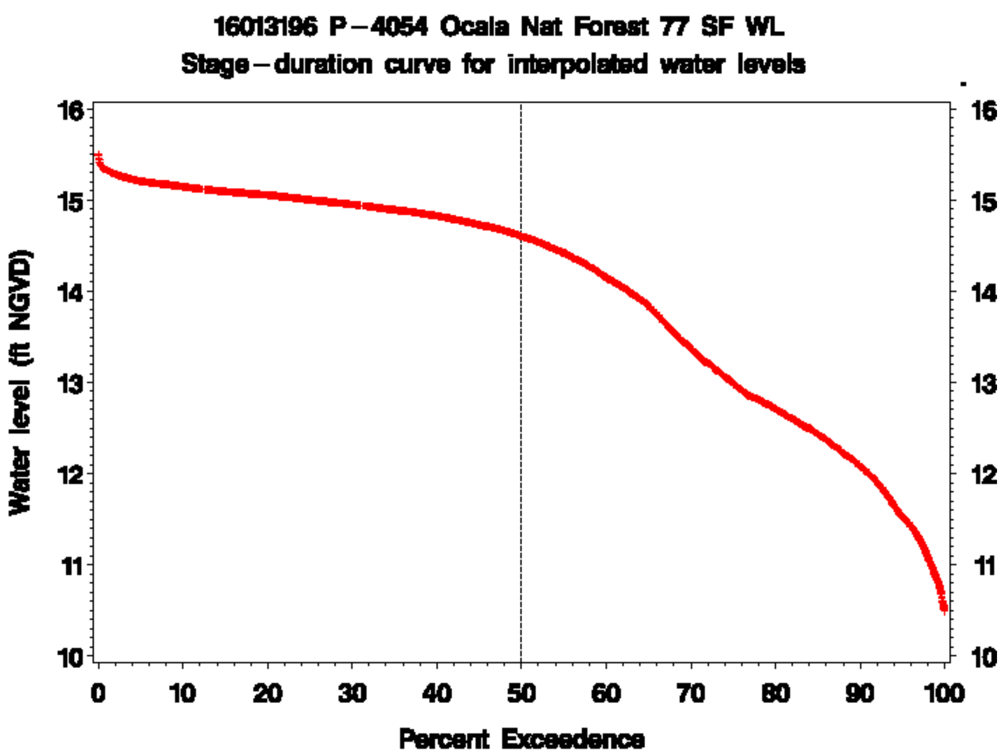
Appendix B.12. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well P-4060



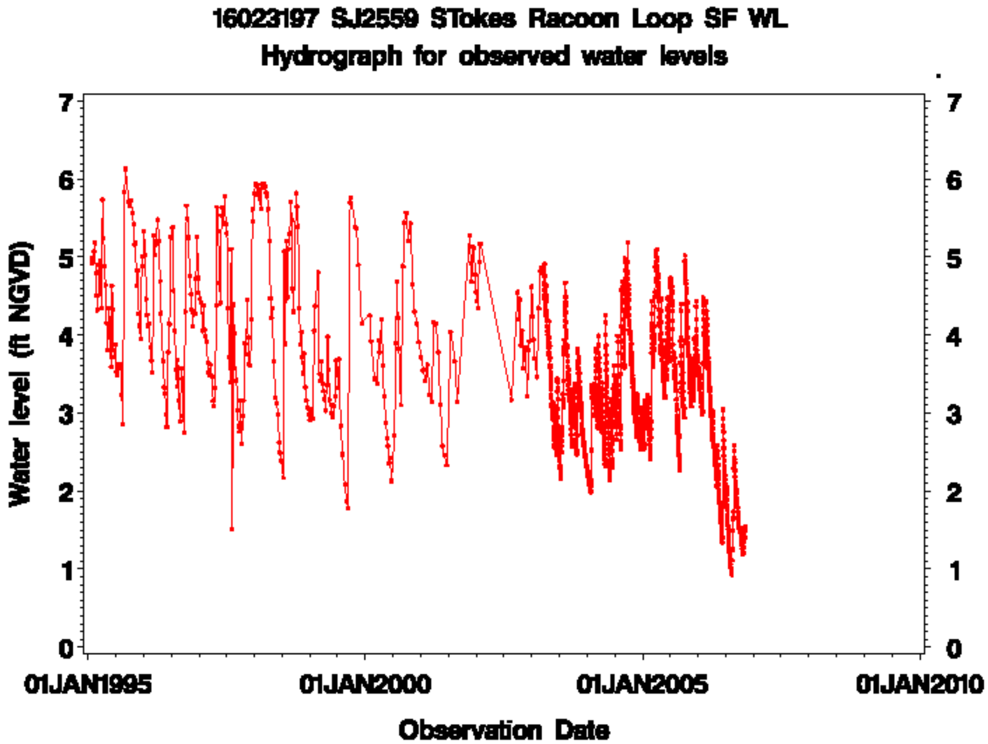


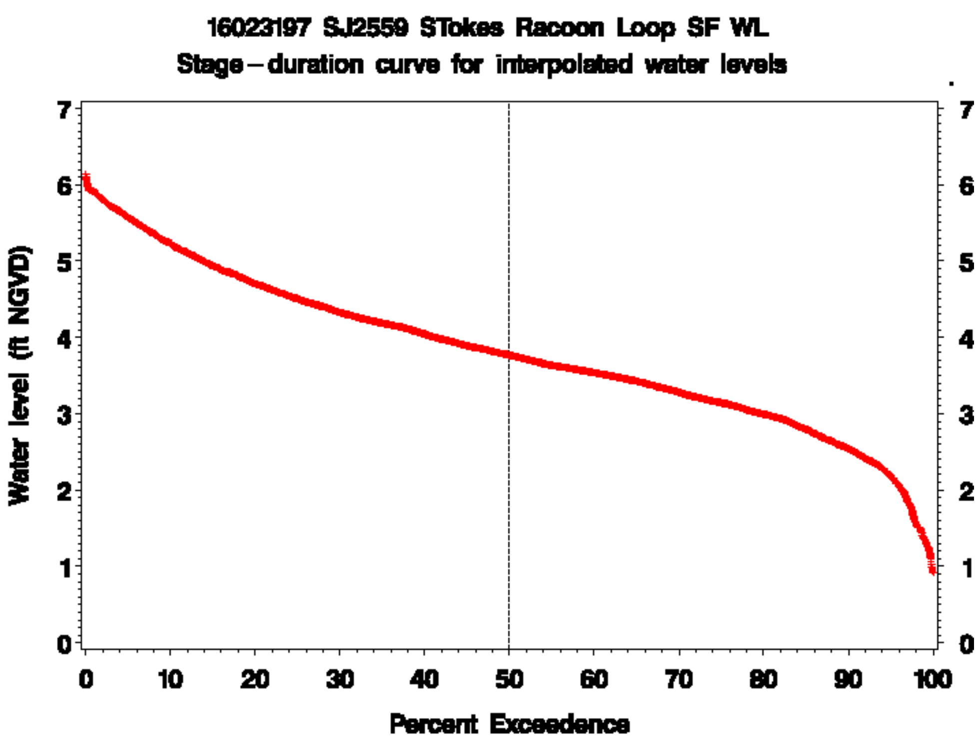
Appendix B.13. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well P-4054



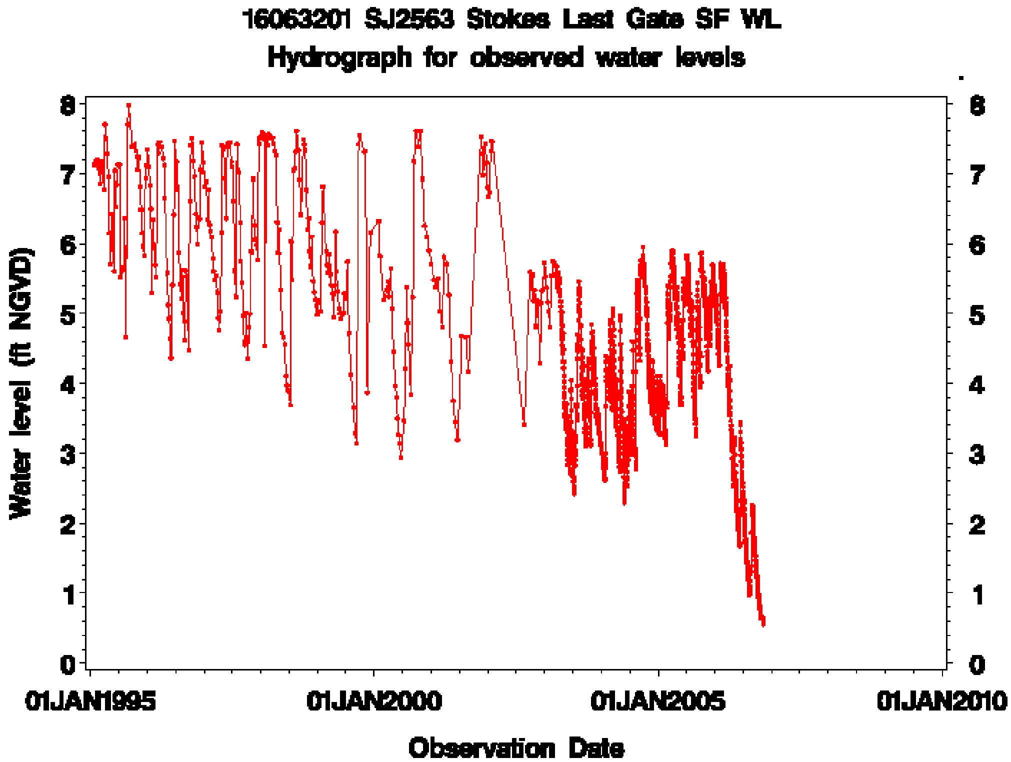


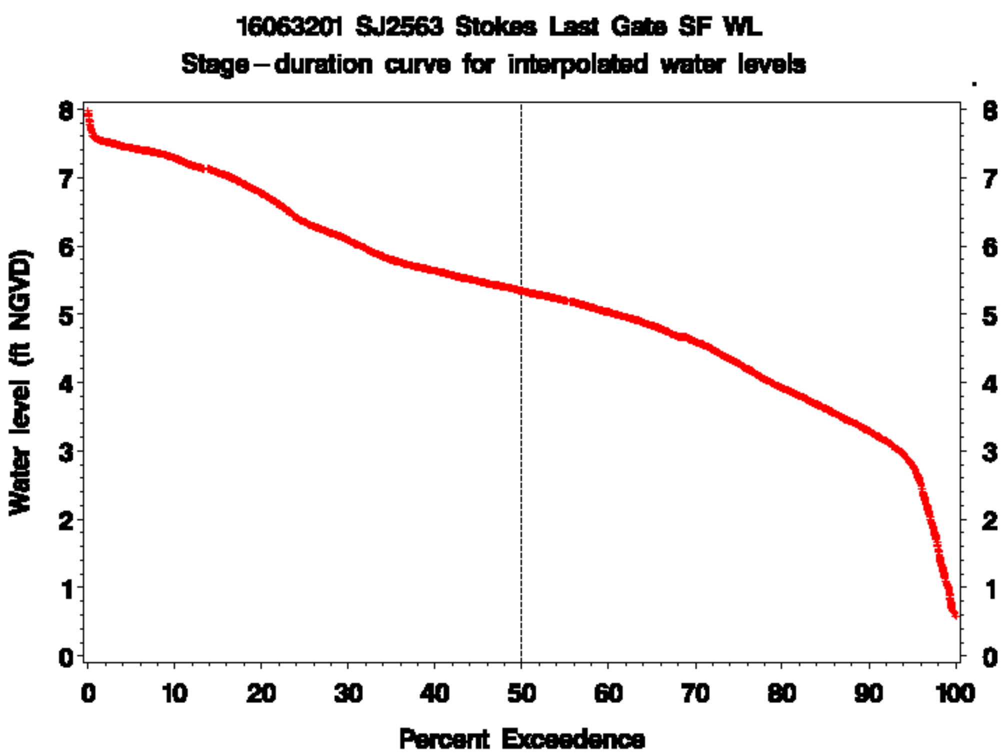
Appendix B.14. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well SJ2559



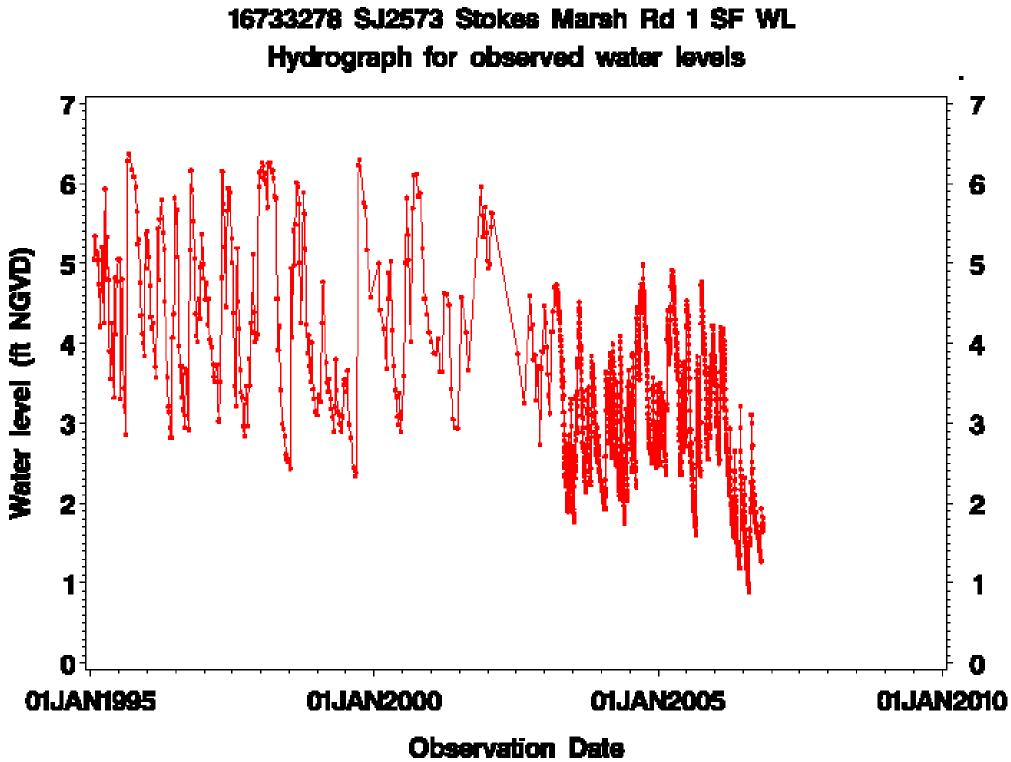


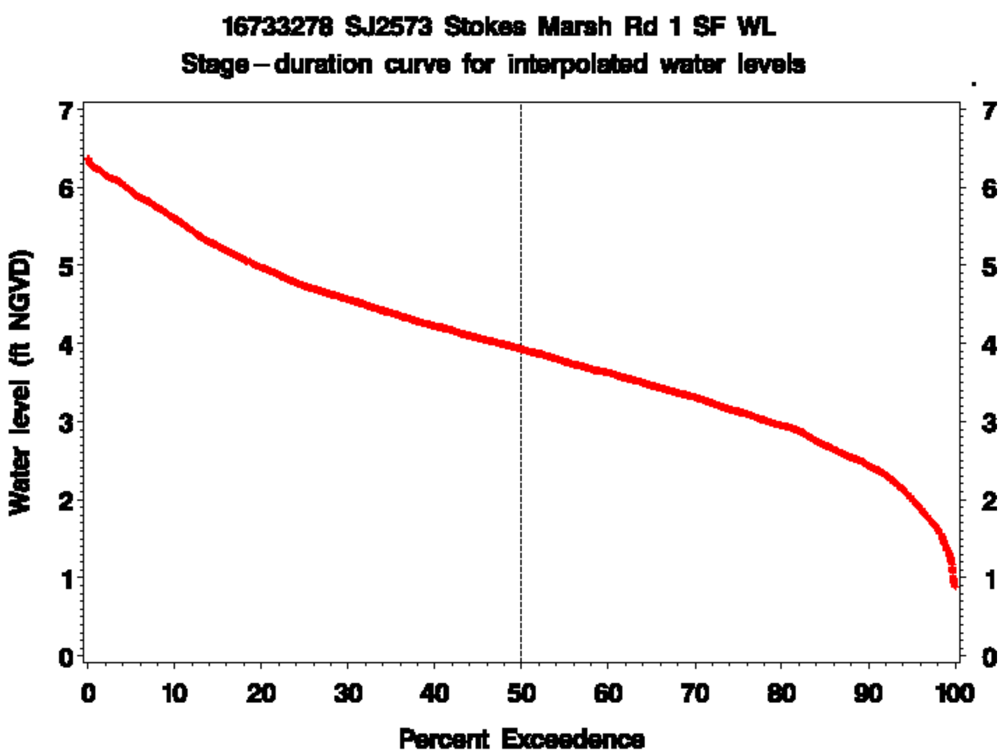
Appendix B.15. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well SJ2563



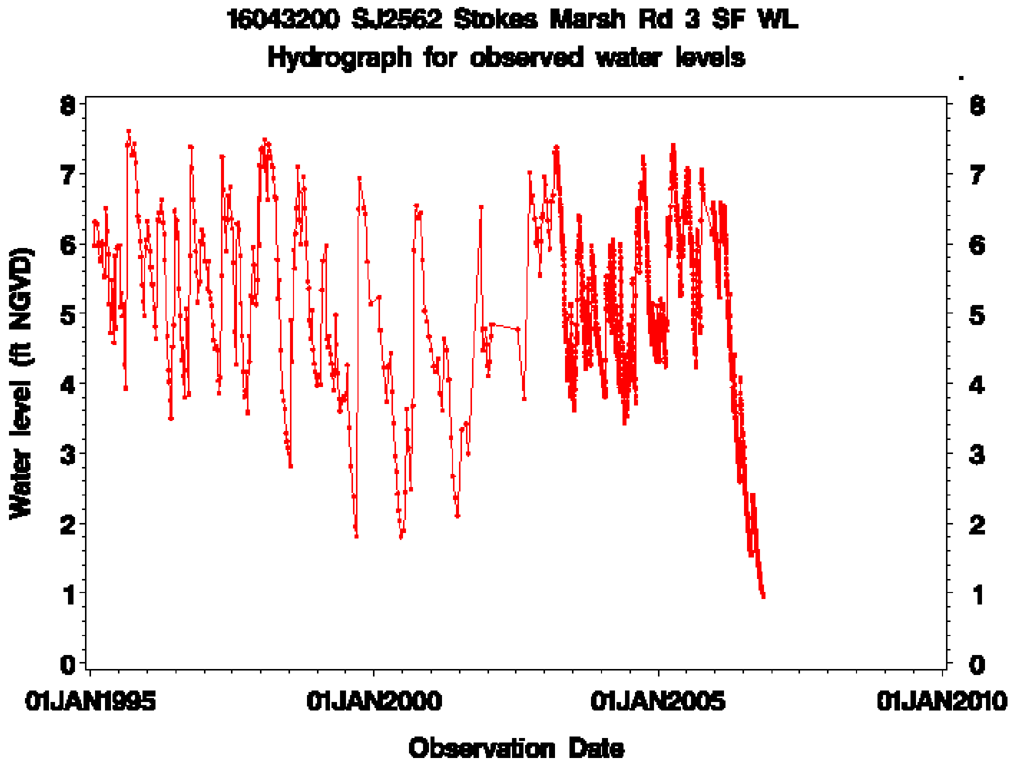


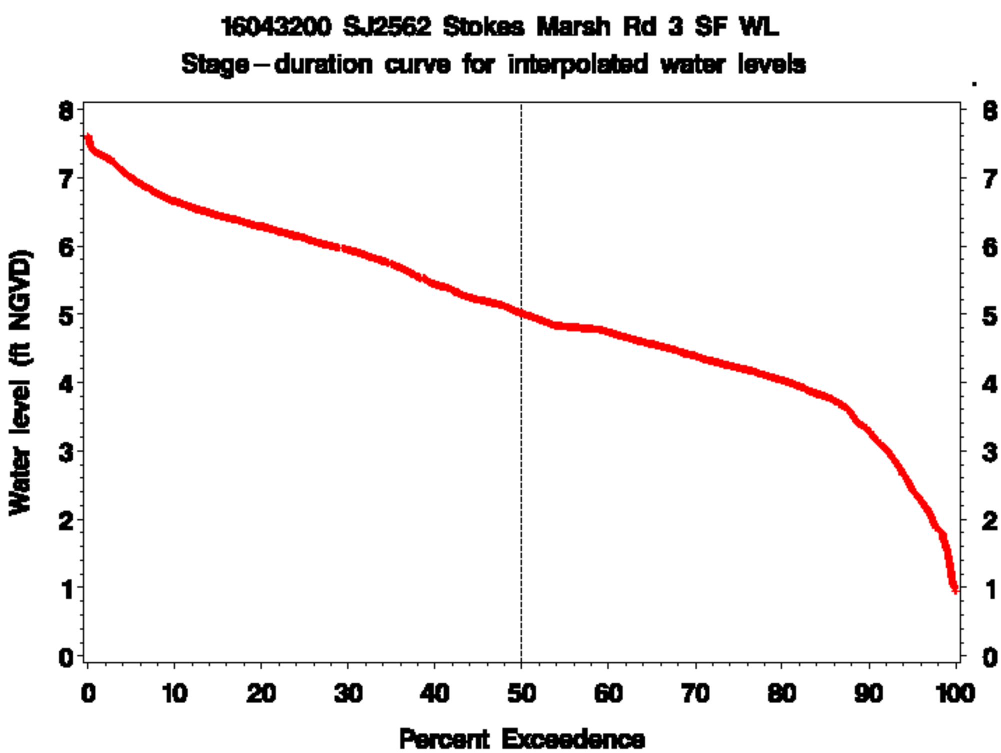
Appendix B.16. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well SJ2573



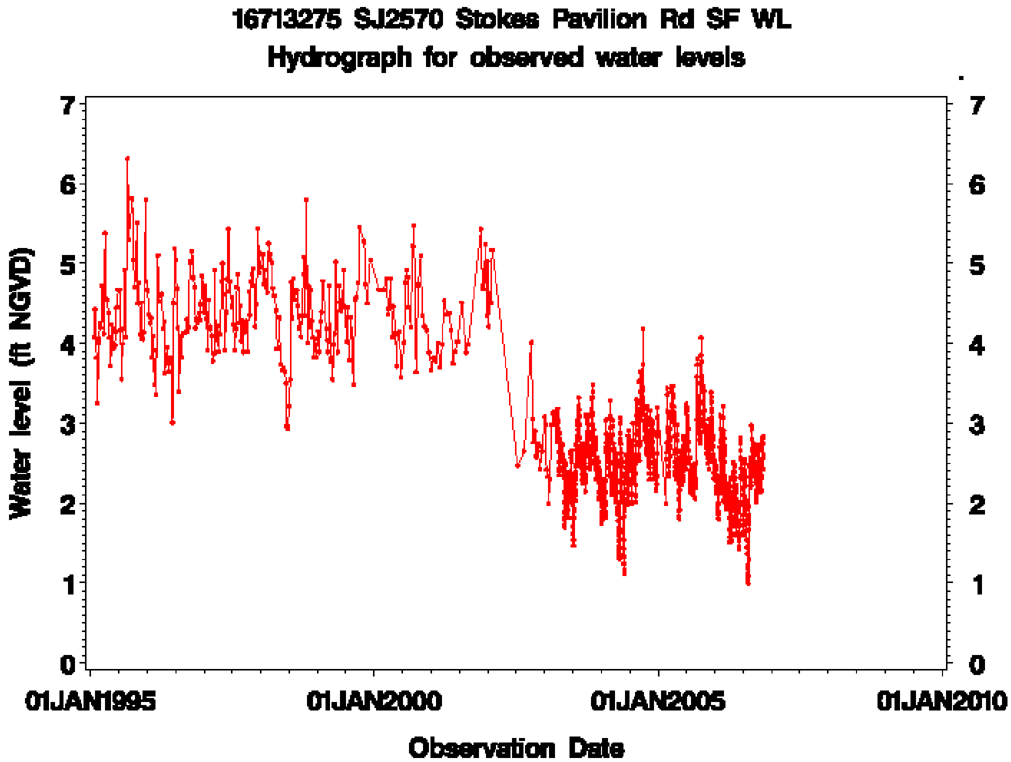


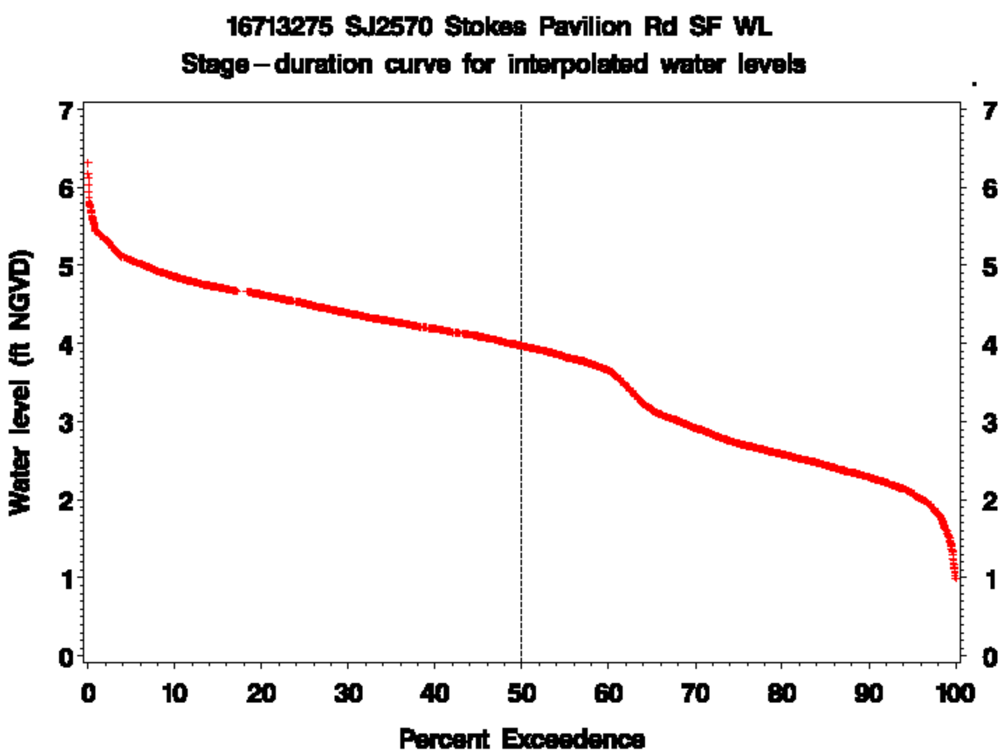
Appendix B.17. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well SJ2562



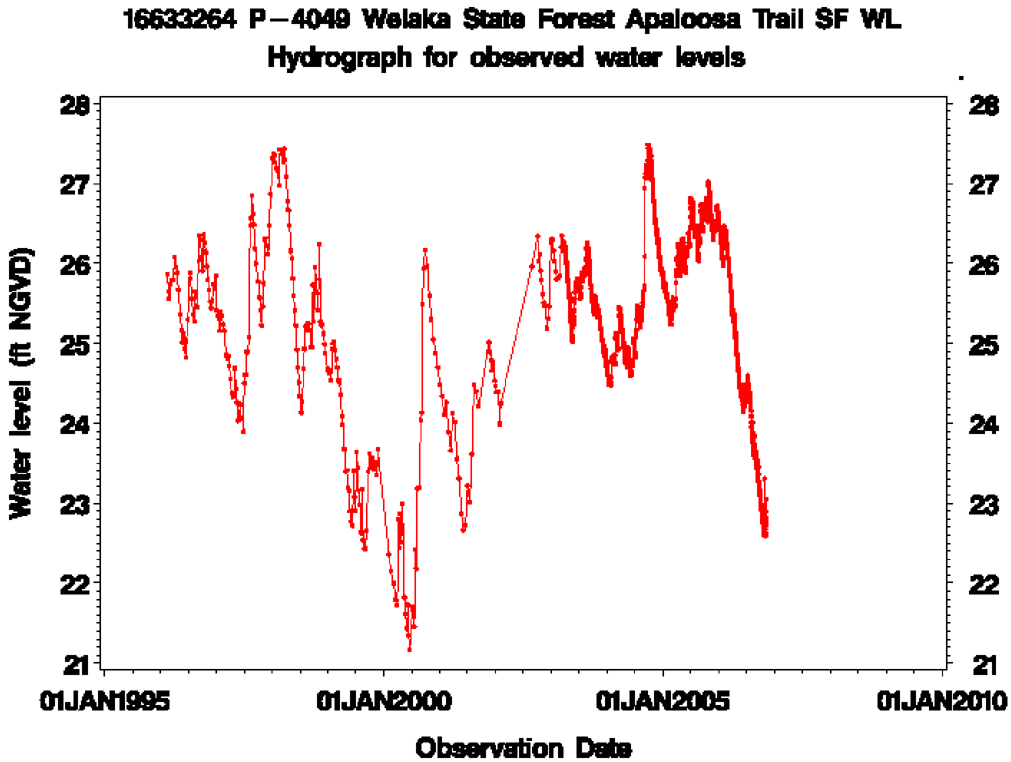


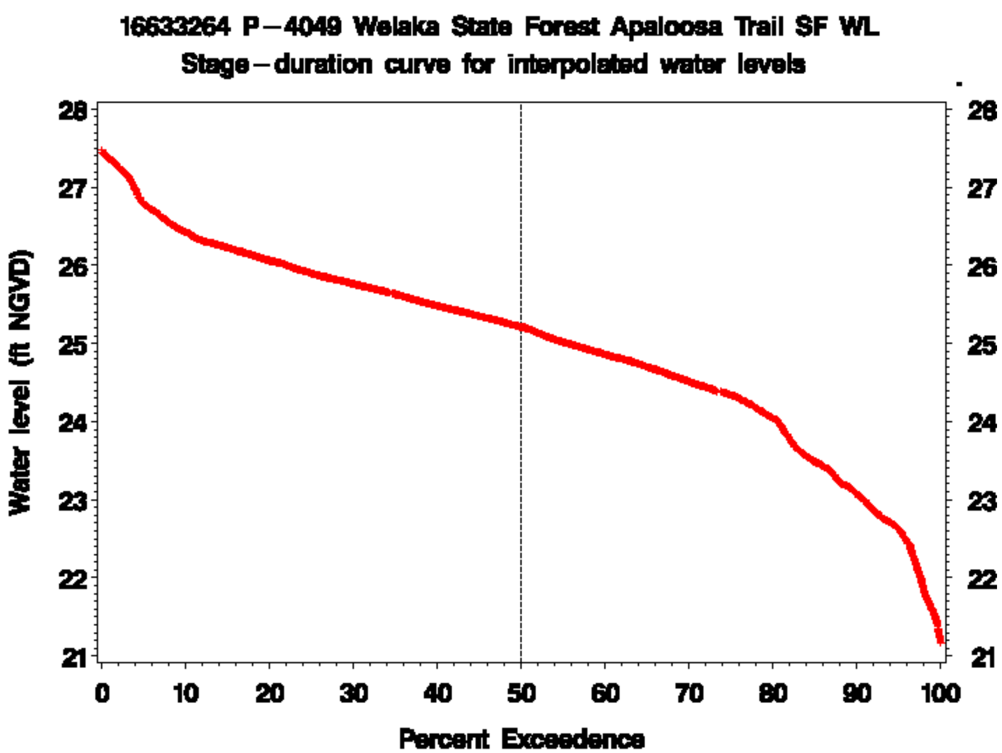
Appendix B.18. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well SJ2570



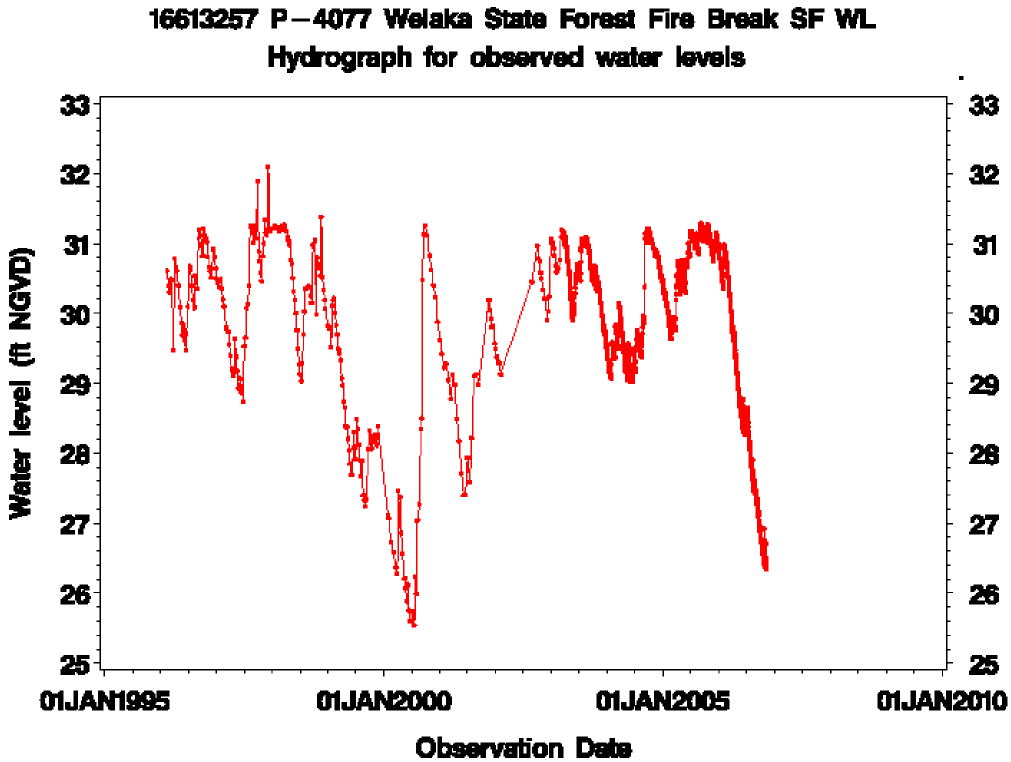


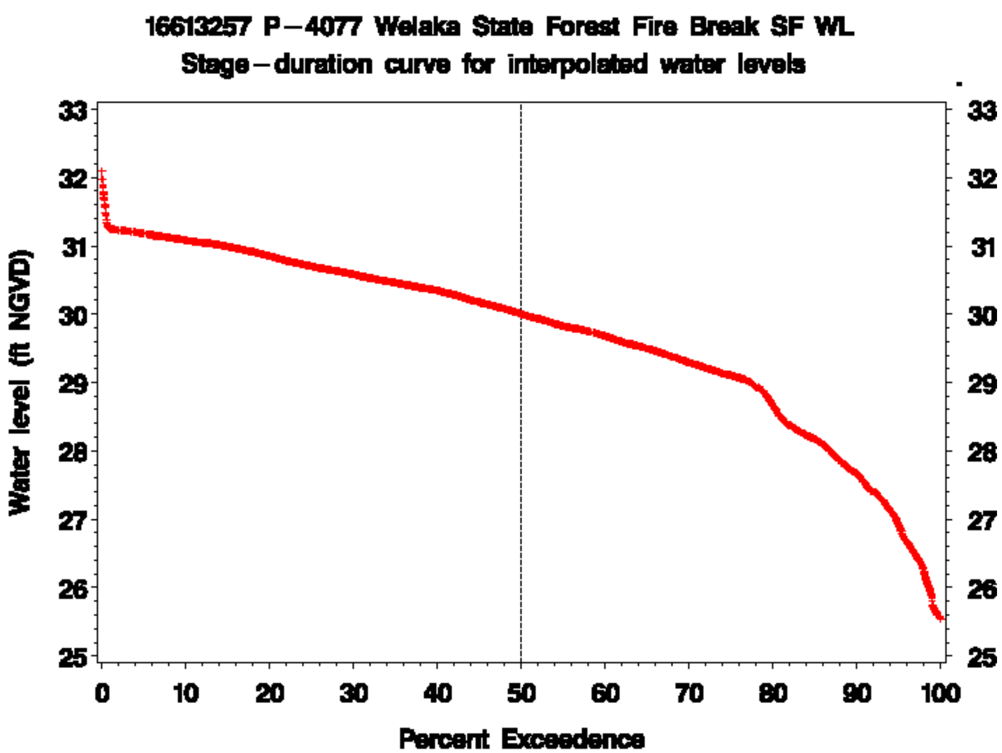
Appendix B.19. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well P-4049



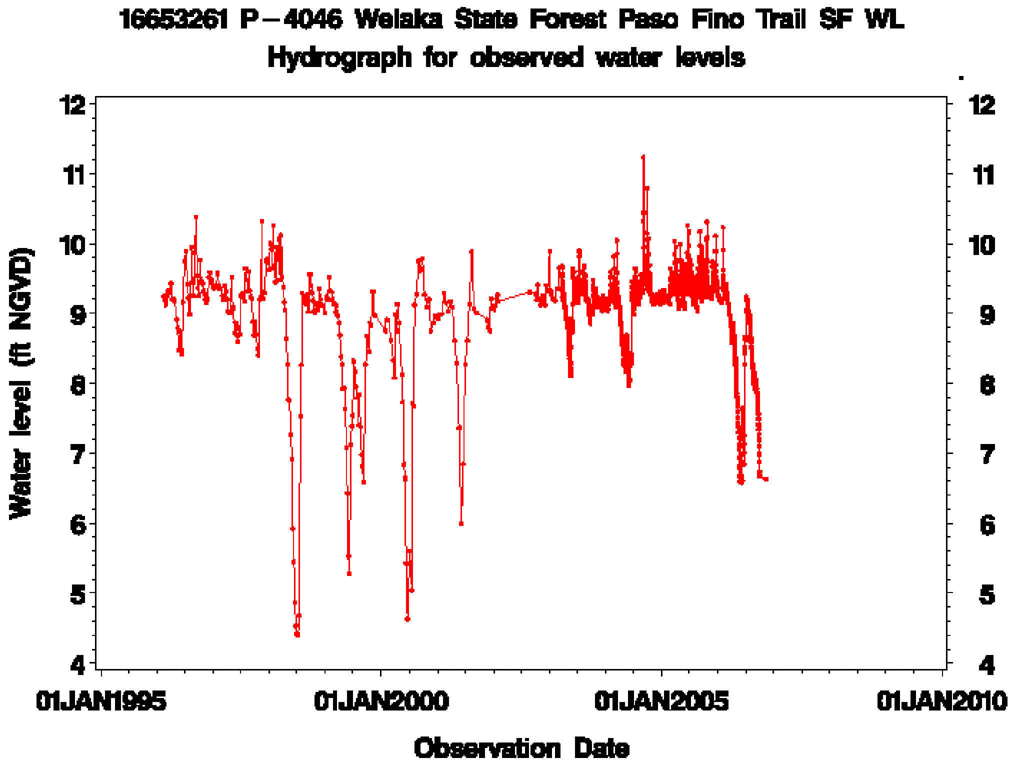


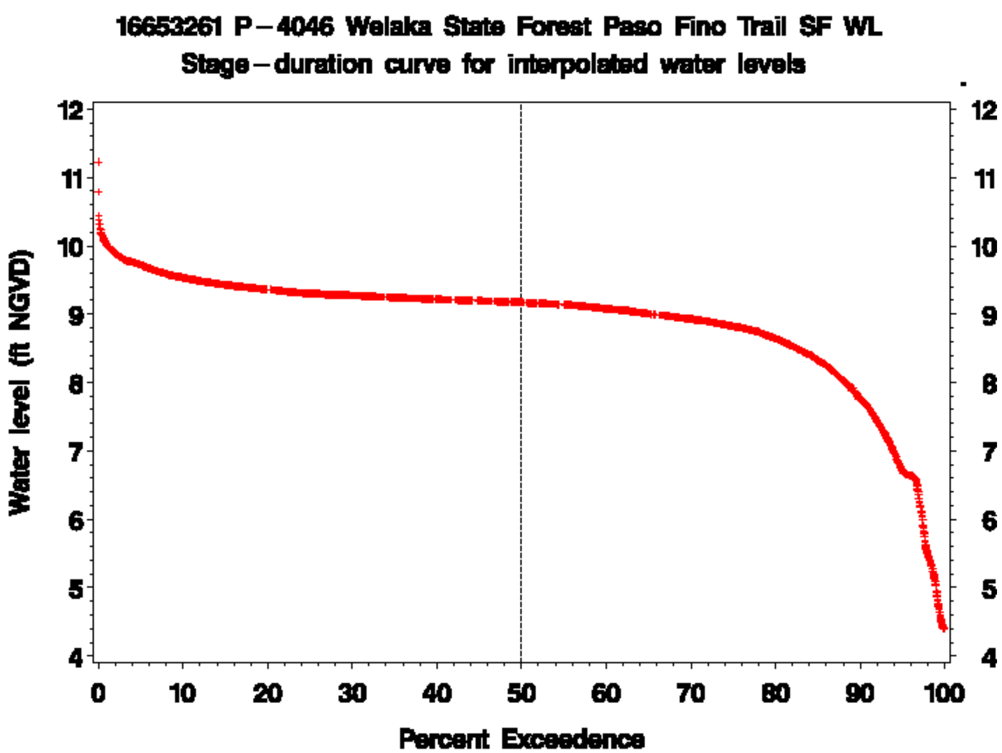
Appendix B.20. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well P-4077





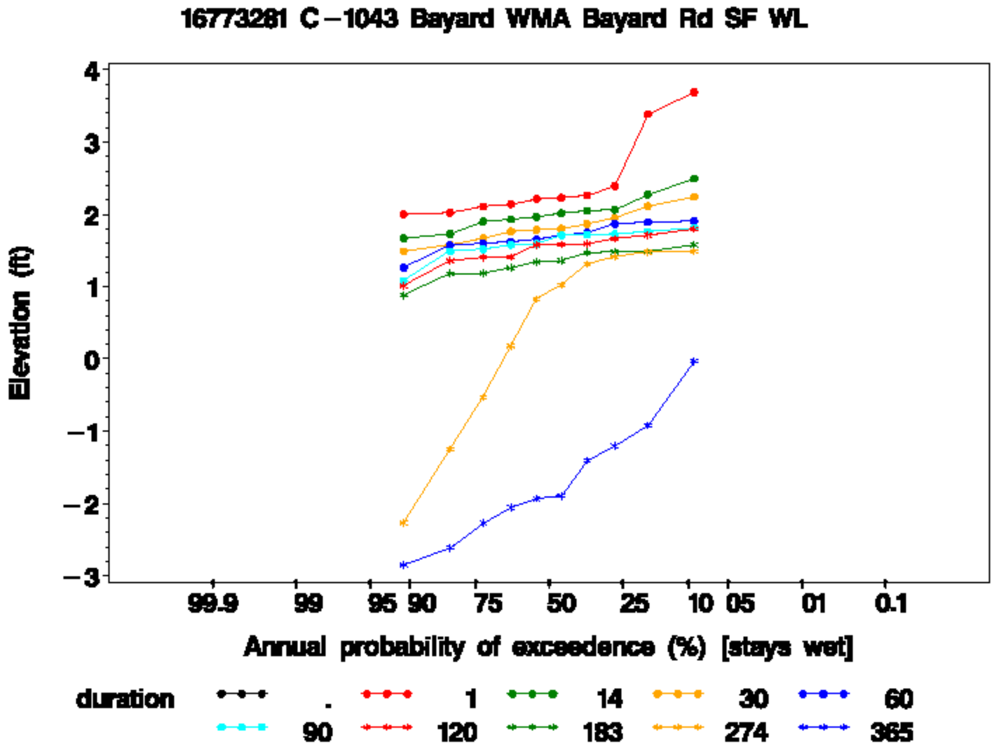
Appendix B.21. Hydrograph of observed water levels (top) and stage-duration curve for interpolated water levels (bottom) for well P-4046

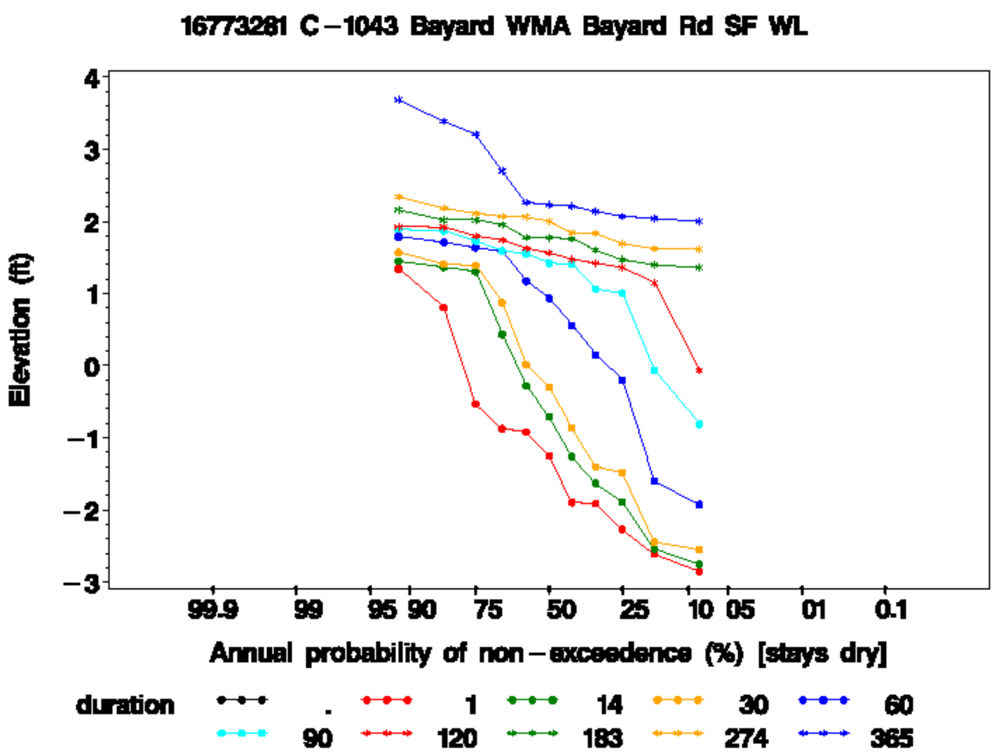




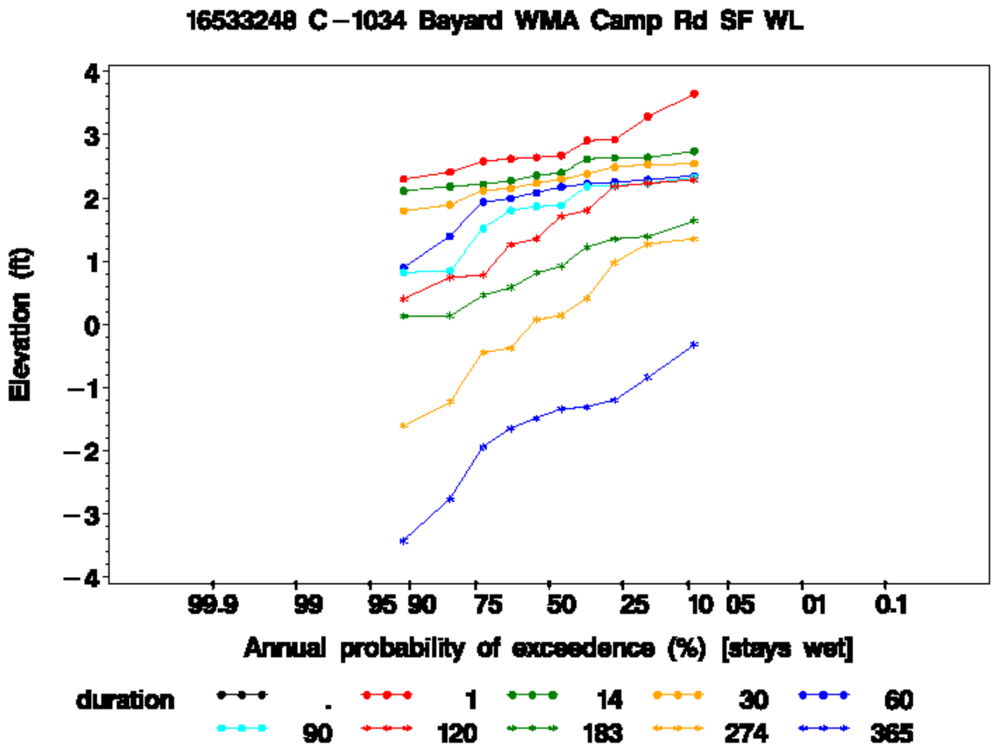
APPENDIX C

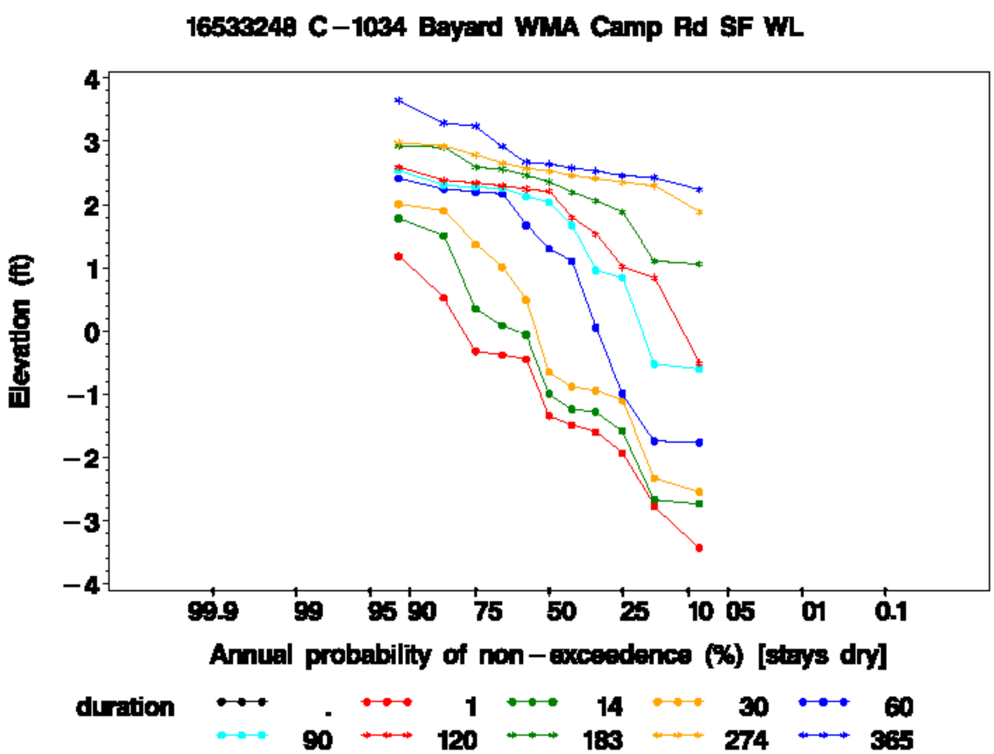
Appendix C.1. Water level exceedence (top) and non-exceedence (bottom) probability plots for well C-1043



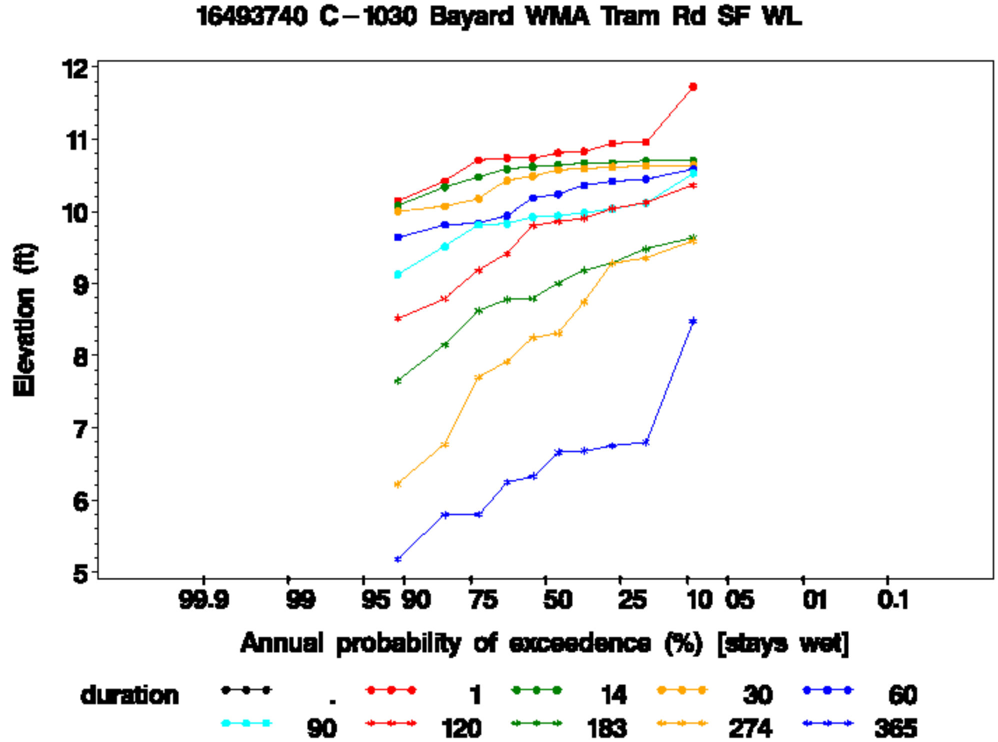


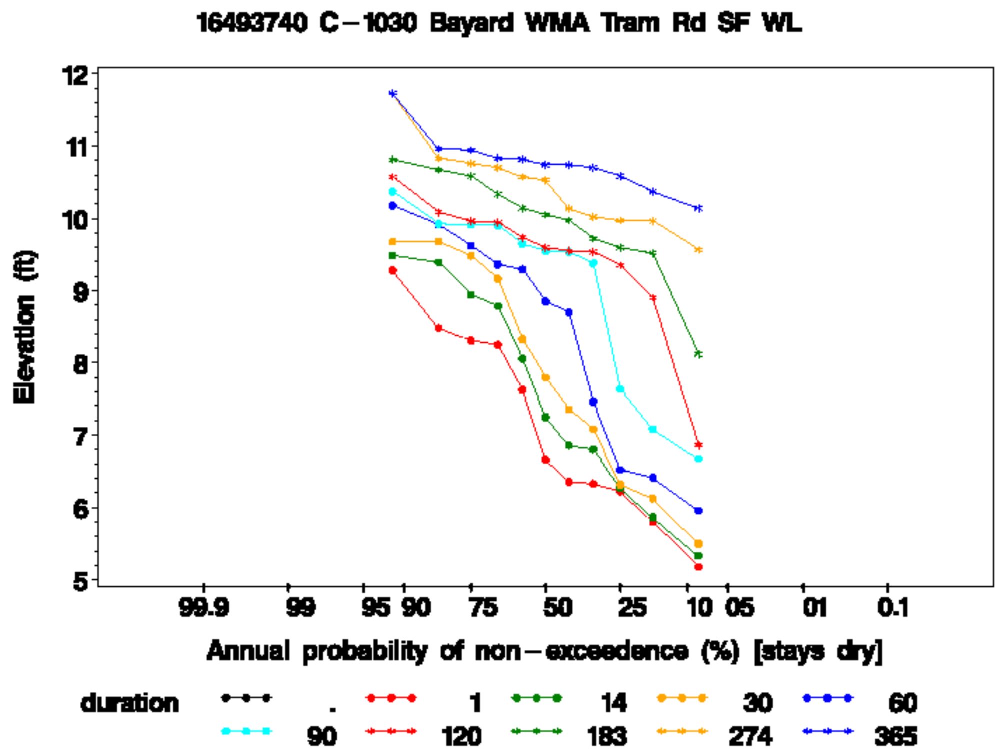
Appendix C.2. Water level exceedence (top) and non-exceedence (bottom) probability plots for well C-1034



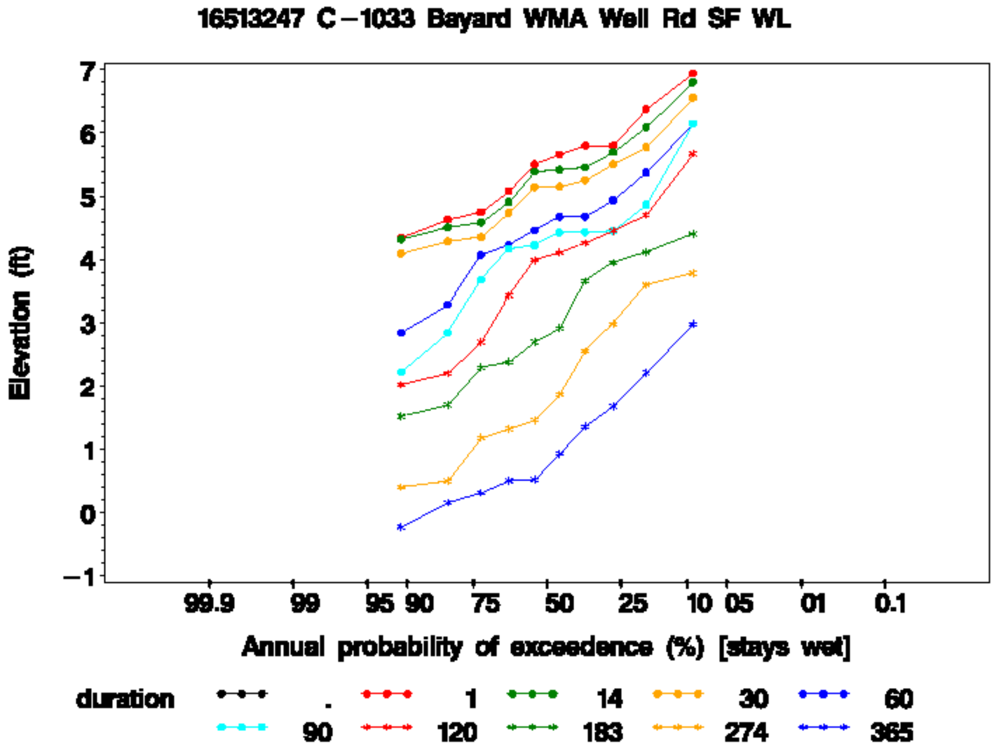


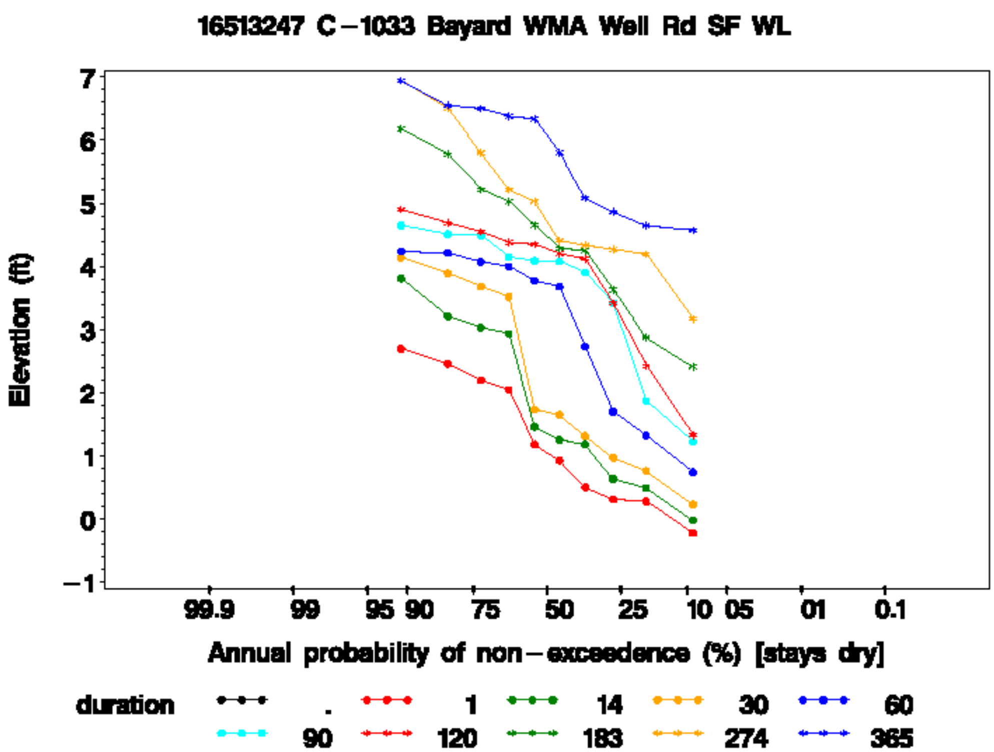
Appendix C.3. Water level exceedence (top) and non-exceedence (bottom) probability plots for well C-1030



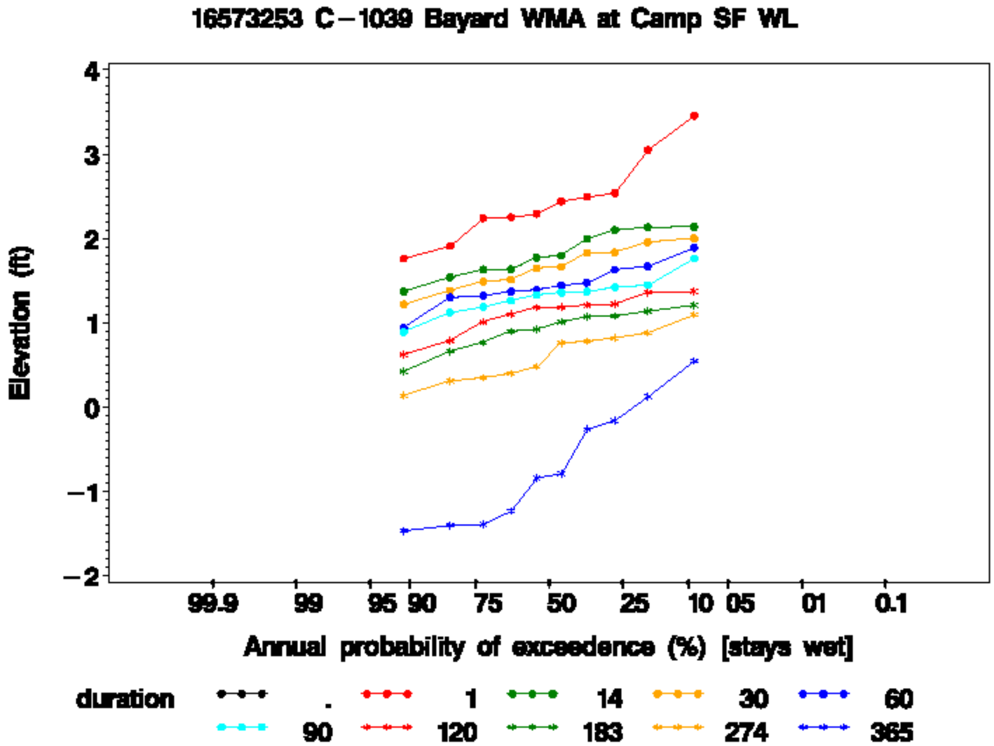


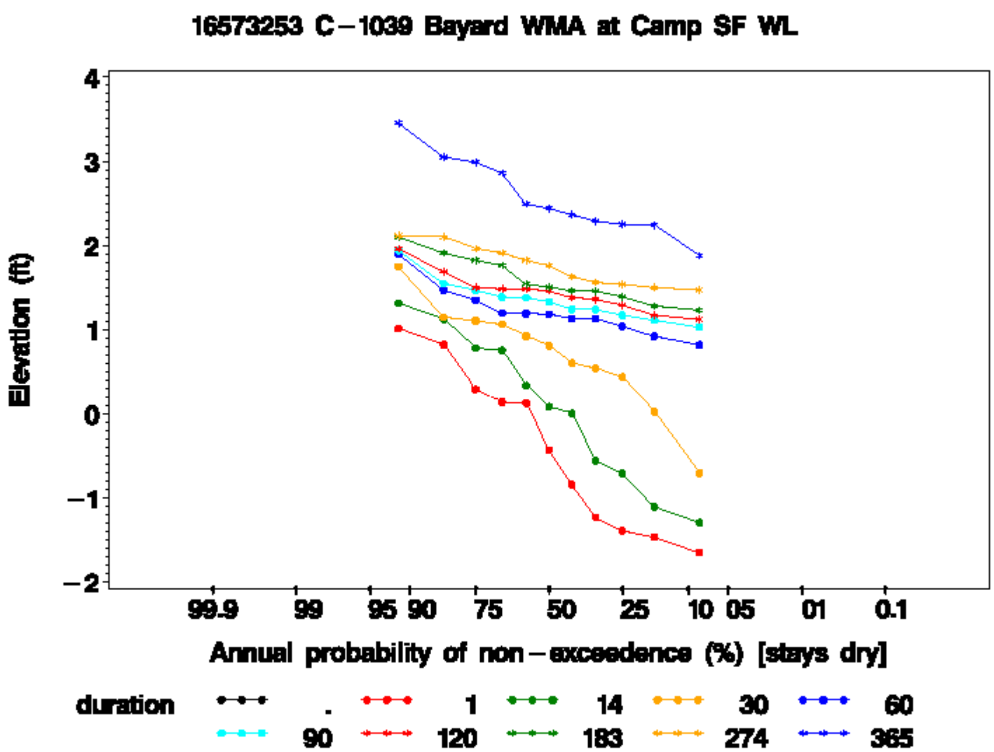
Appendix C.4. Water level exceedence (top) and non-exceedence (bottom) probability plots for well C-1033



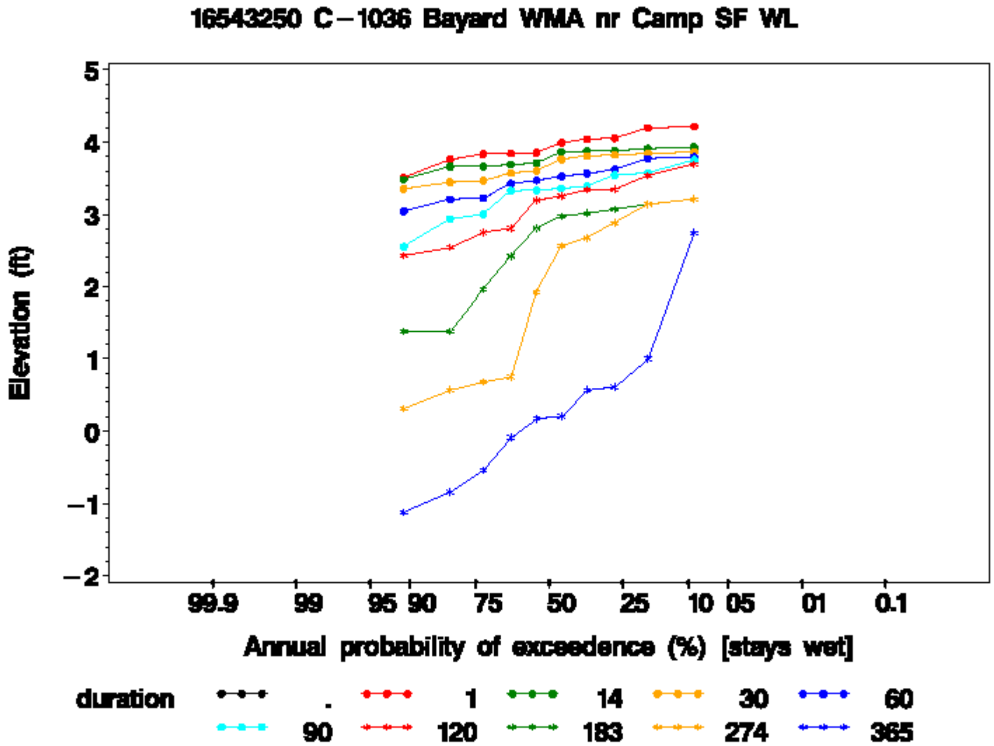


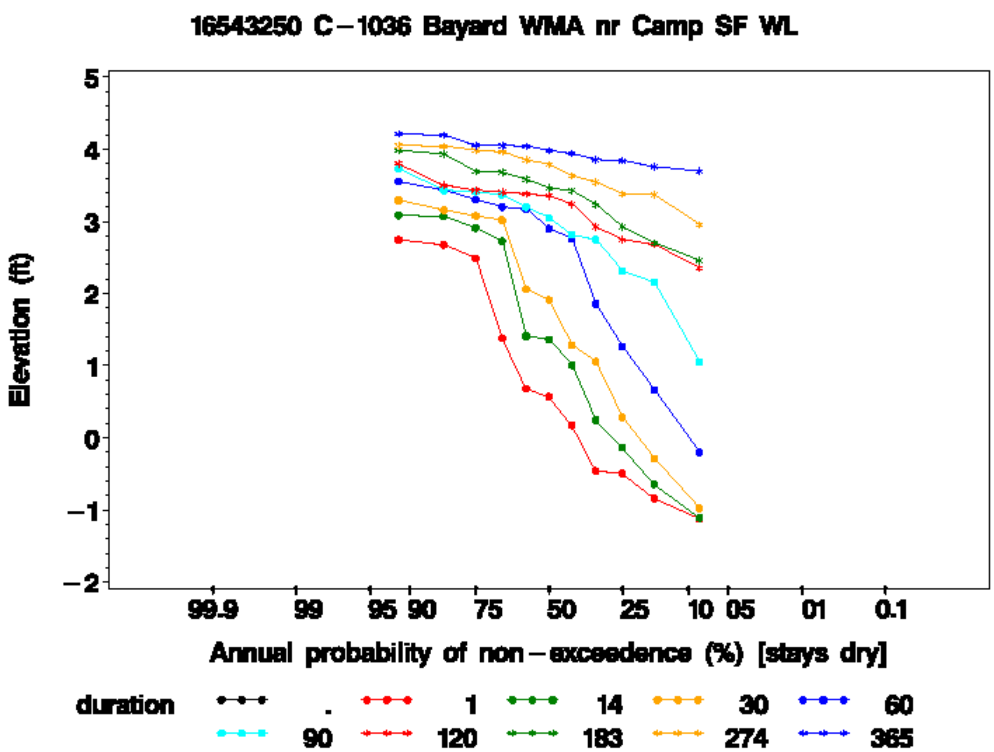
Appendix C.5. Water level exceedence (top) and non-exceedence (bottom) probability plots for well C-1039



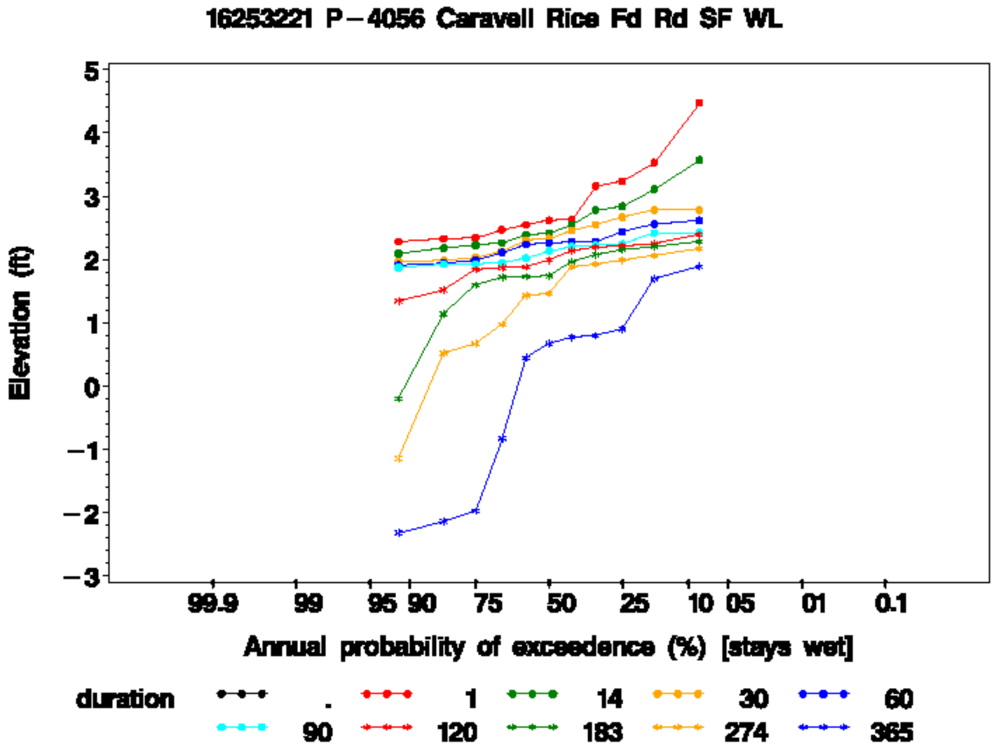


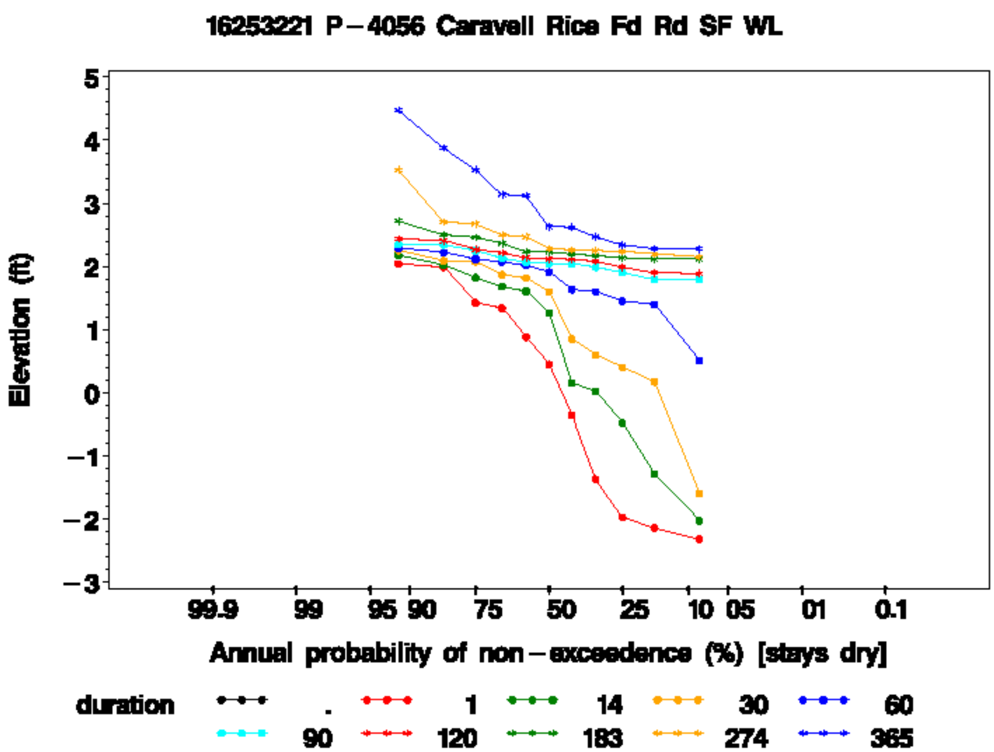
Appendix C.6. Water level exceedence (top) and non-exceedence (bottom) probability plots for well C-1036



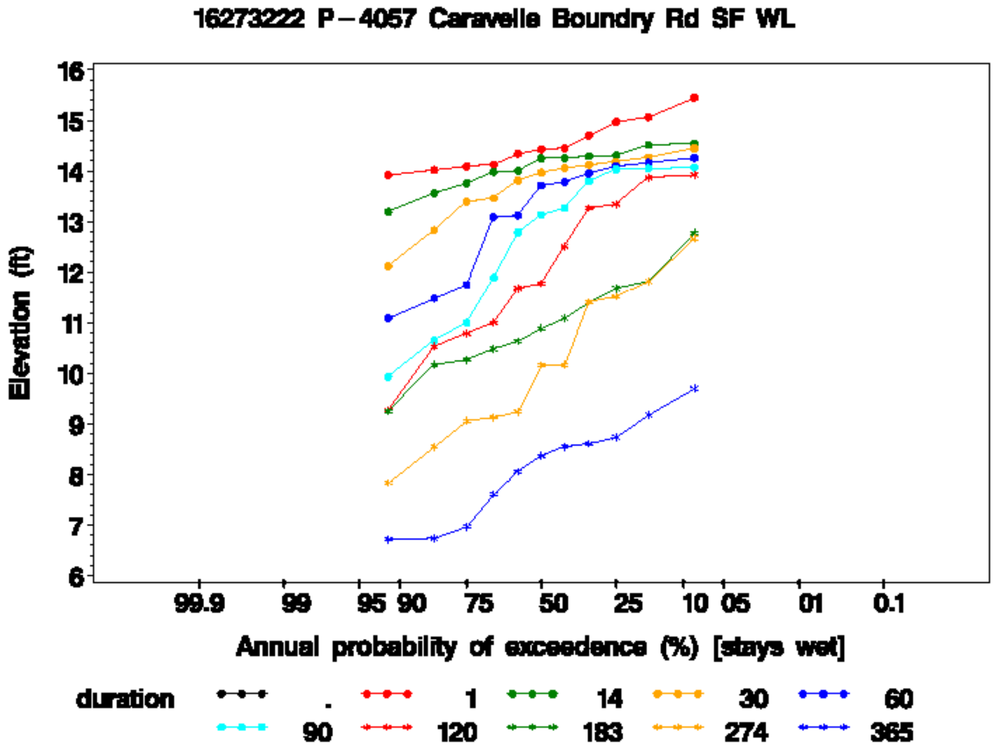


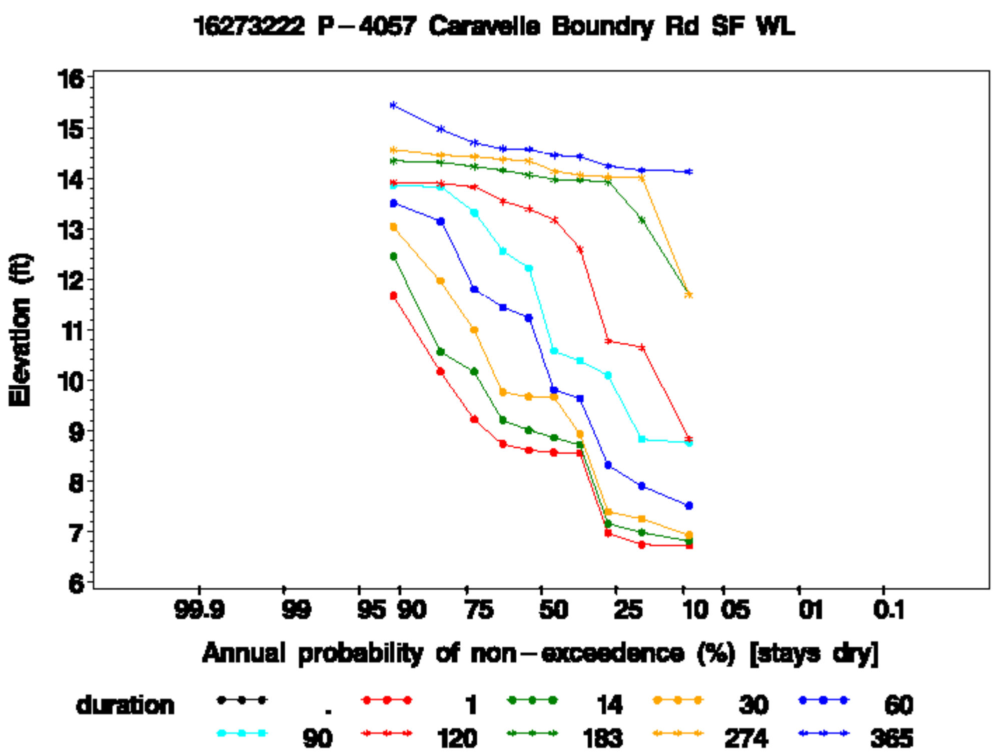
Appendix C.7. Water level exceedence (top) and non-exceedence (bottom) probability plots for well P-4056



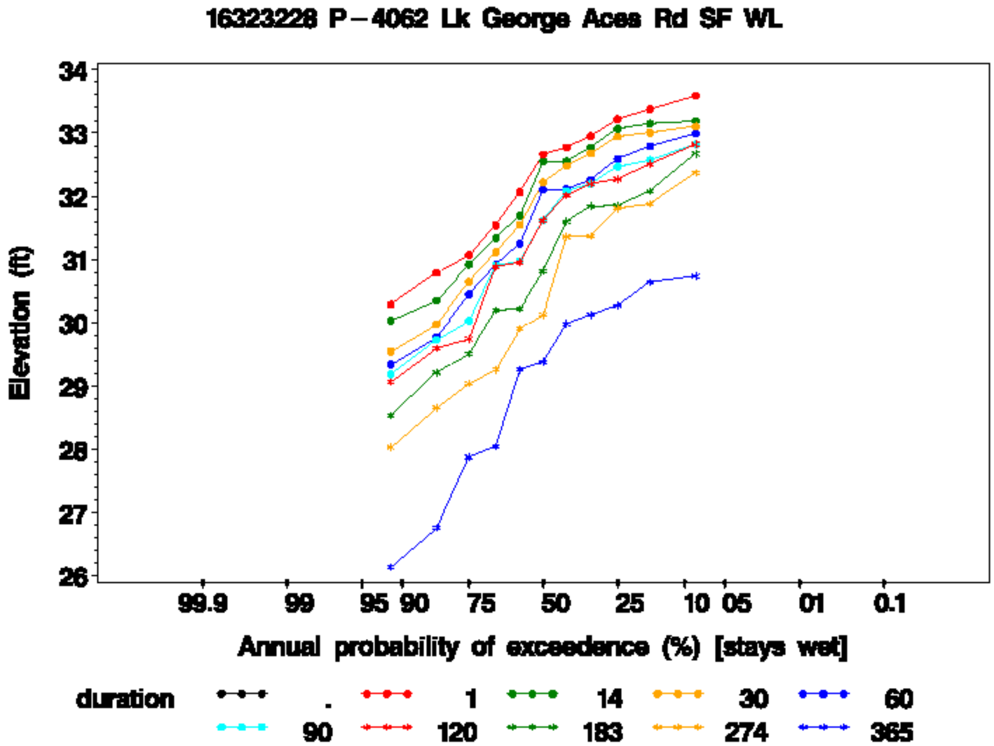


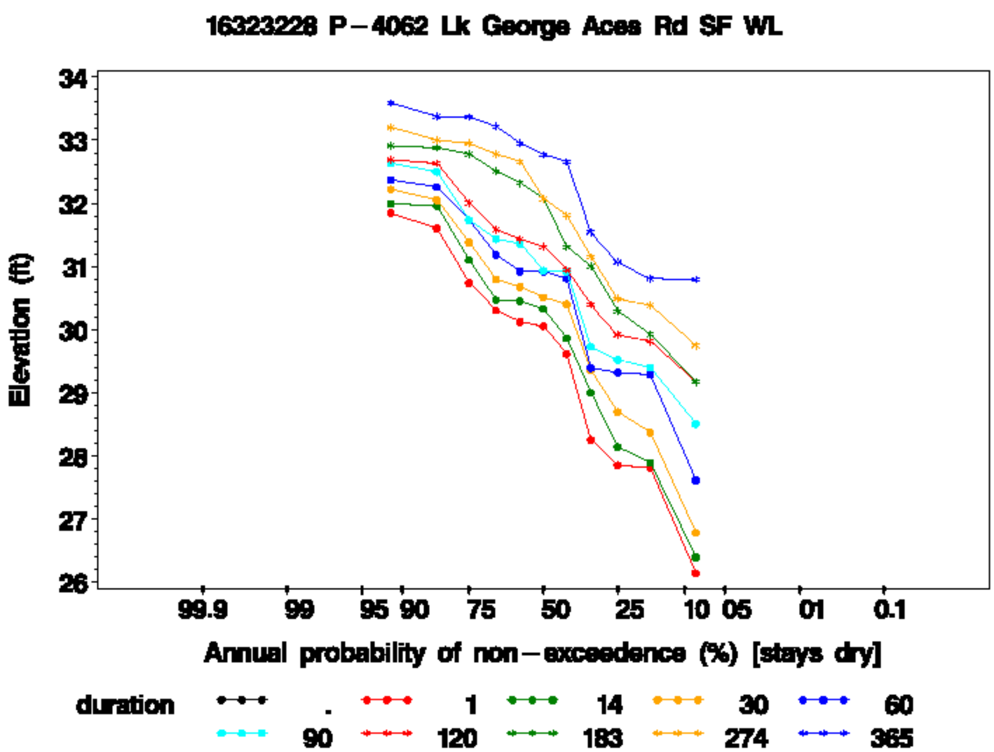
Appendix C.8. Water level exceedence (top) and non-exceedence (bottom) probability plots for well P-4057



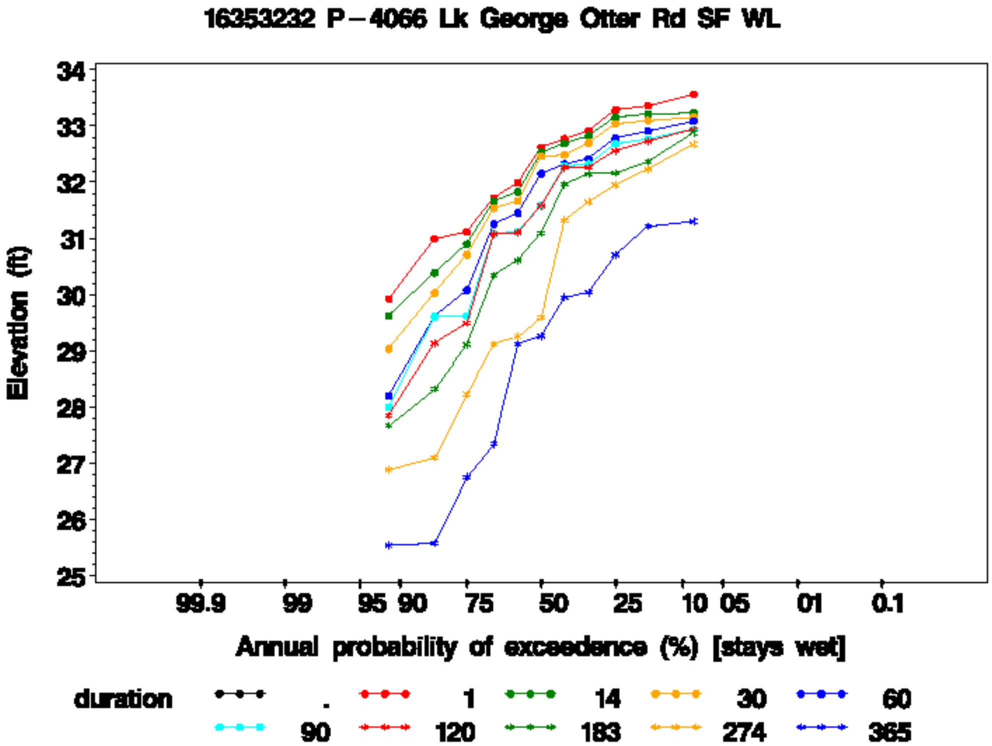


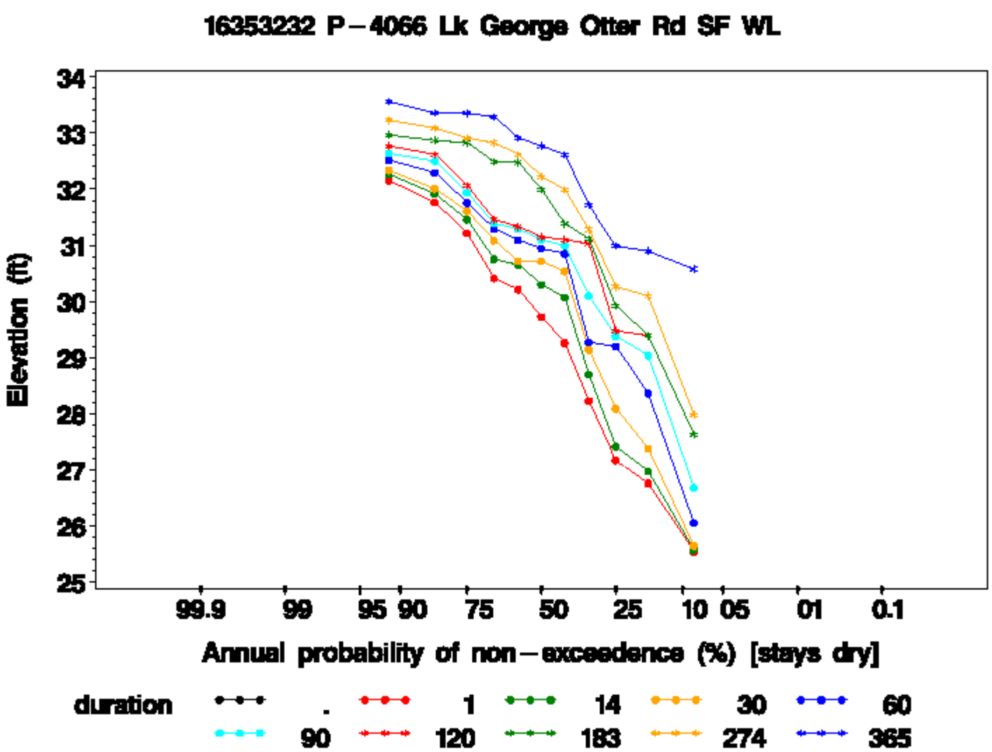
Appendix C.9. Water level exceedence (top) and non-exceedence (bottom) probability plots for well P-4062



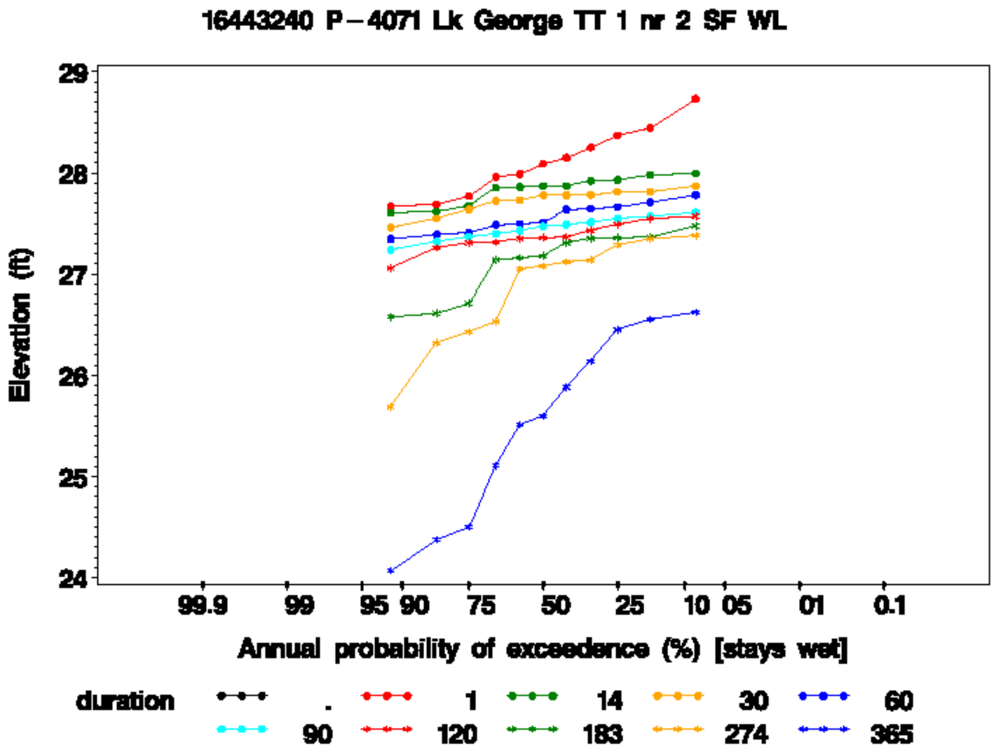


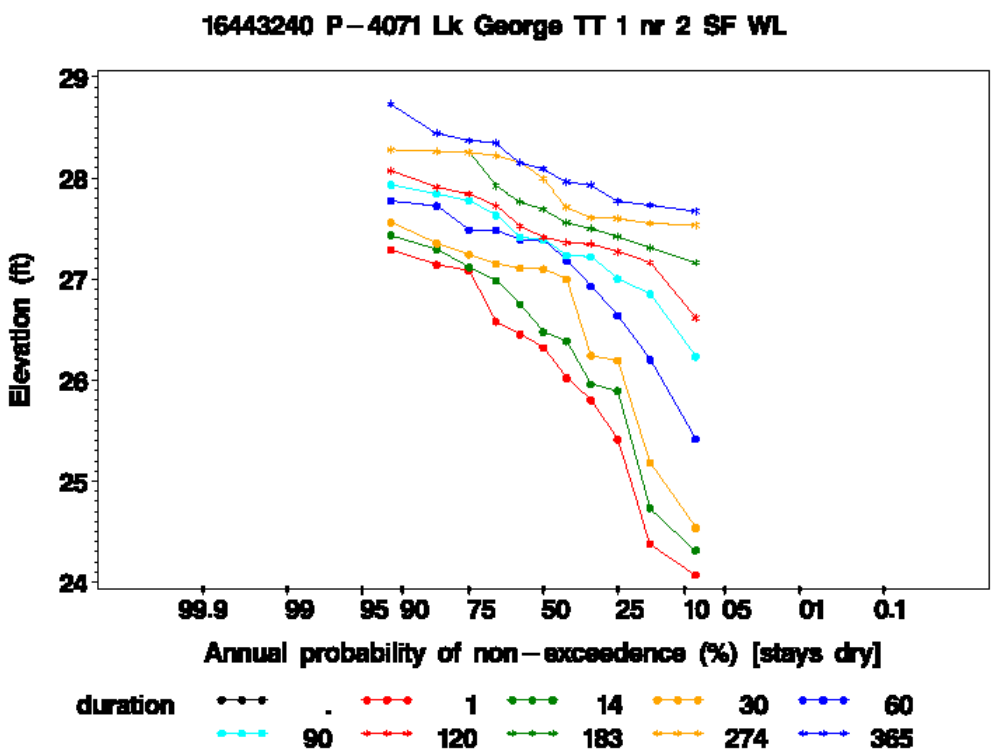
Appendix C.10. Water level exceedence (top) and non-exceedence (bottom) probability plots for well P-4066



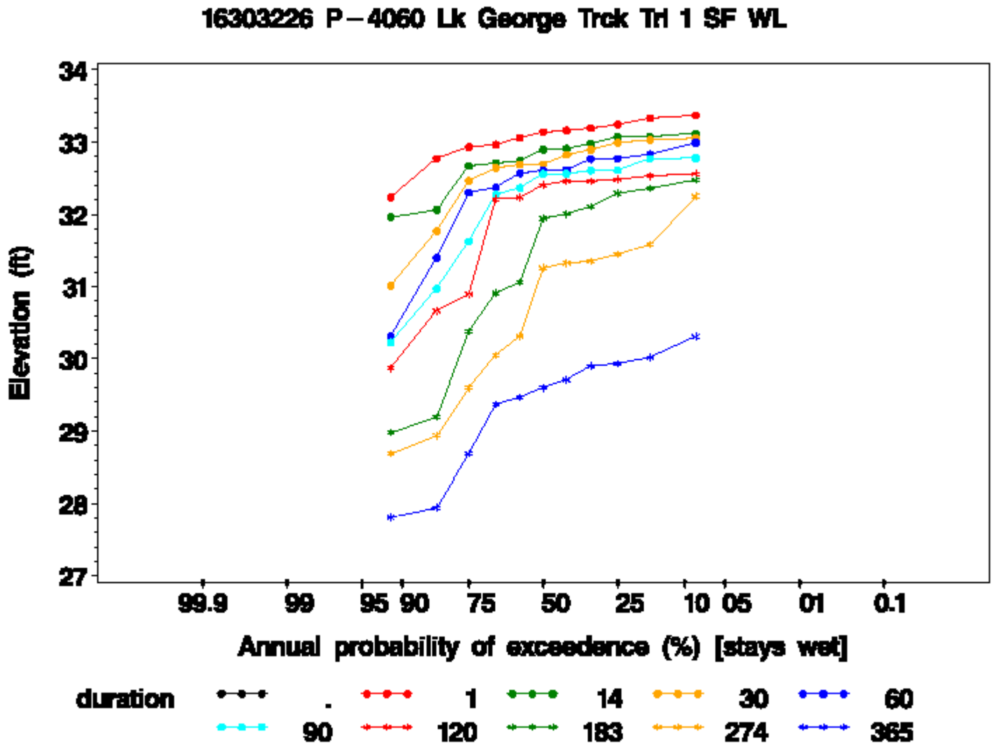


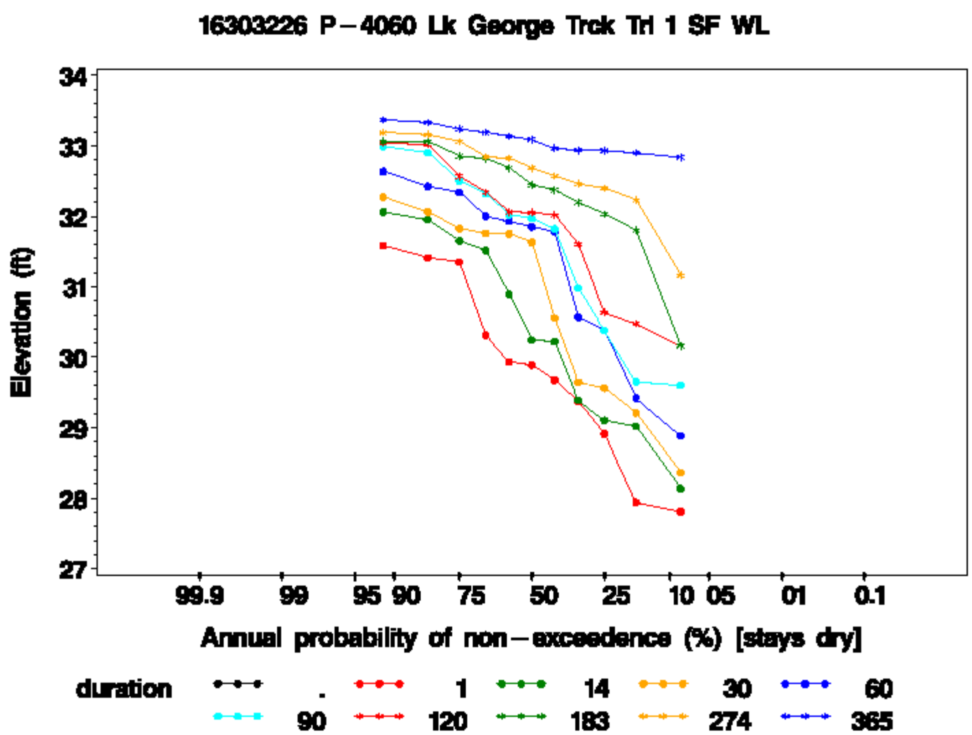
Appendix C.11. Water level exceedence (top) and non-exceedence (bottom) probability plots for well P-4071



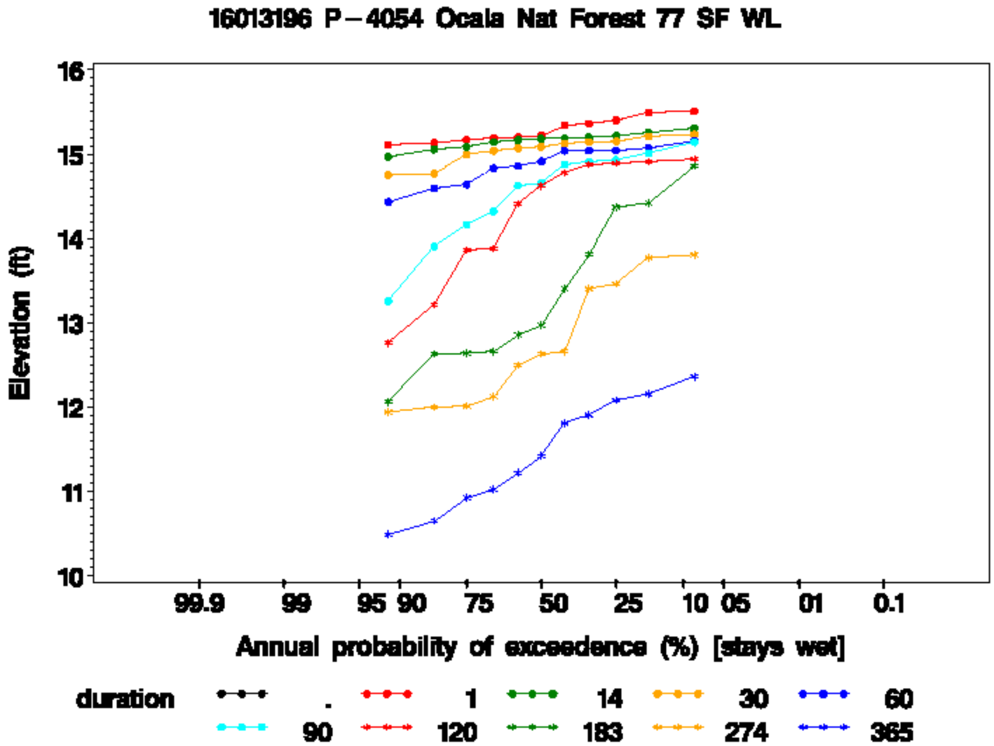


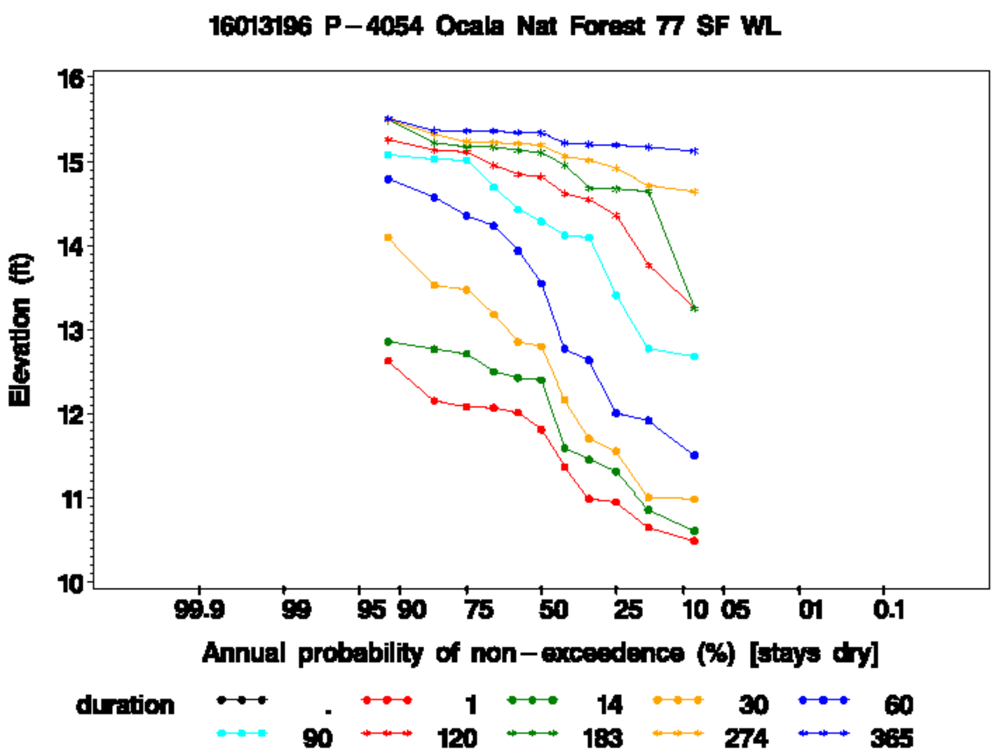
Appendix C.12. Water level exceedence (top) and non-exceedence (bottom) probability plots for well P-4060



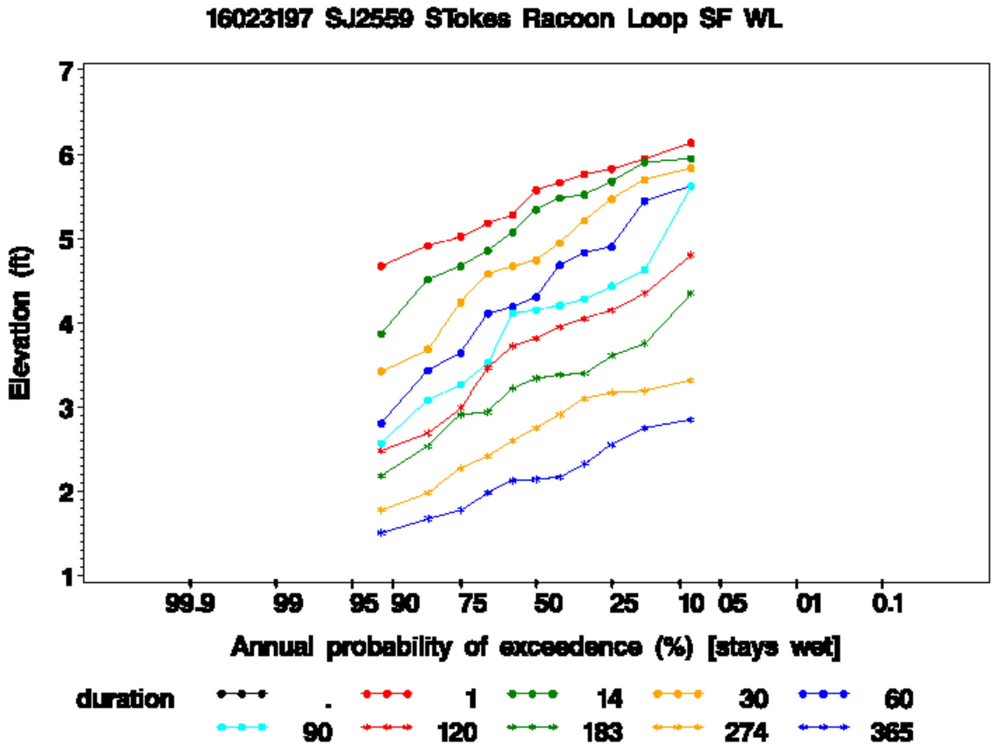


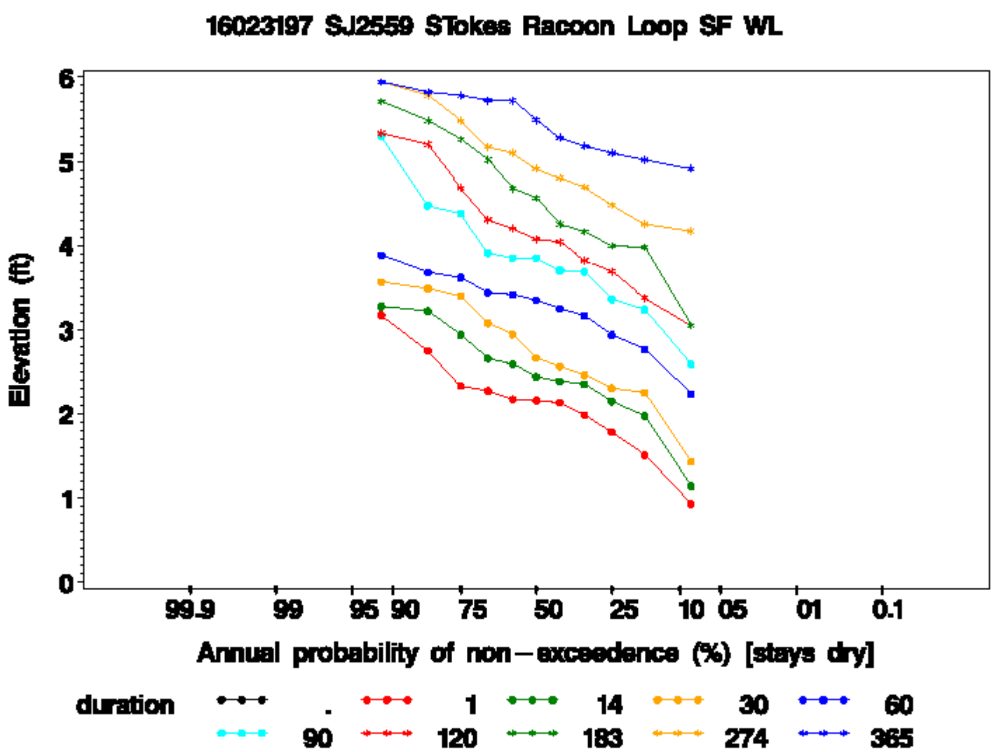
Appendix C.13. Water level exceedence (top) and non-exceedence (bottom) probability plots for well P-4054



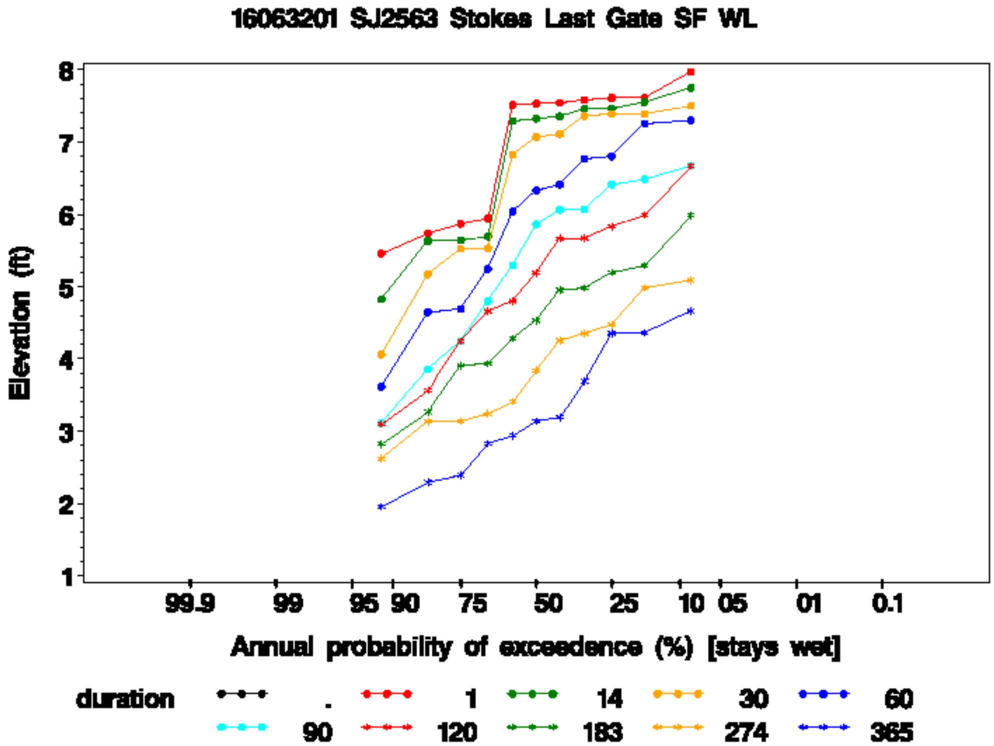


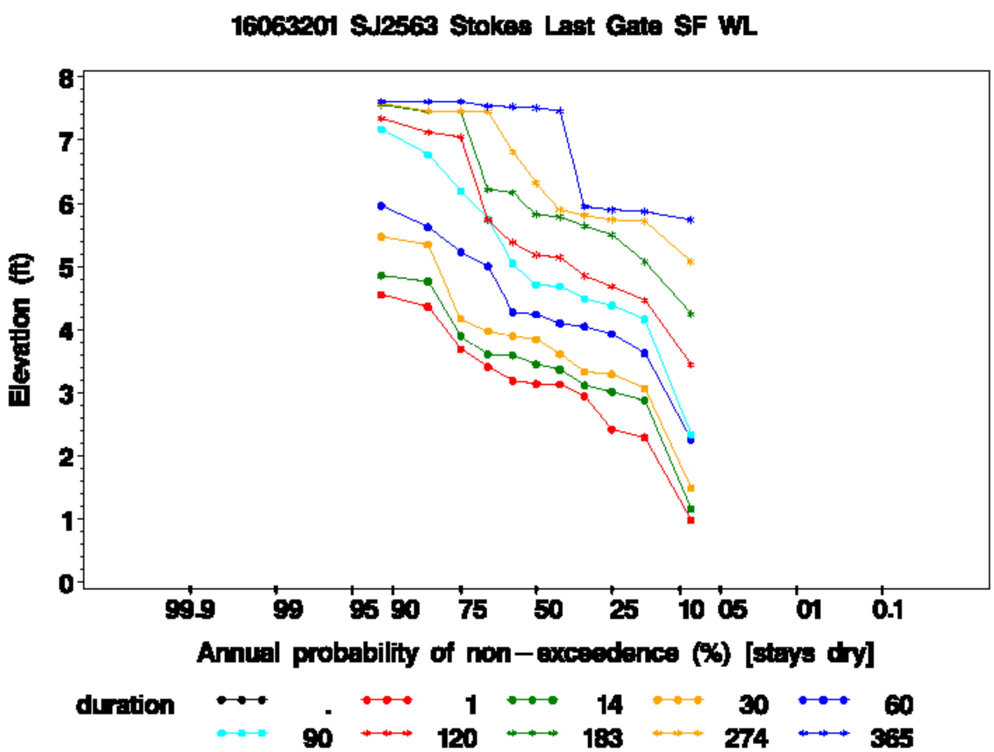
Appendix C.14. Water level exceedence (top) and non-exceedence (bottom) probability plots for well SJ2559



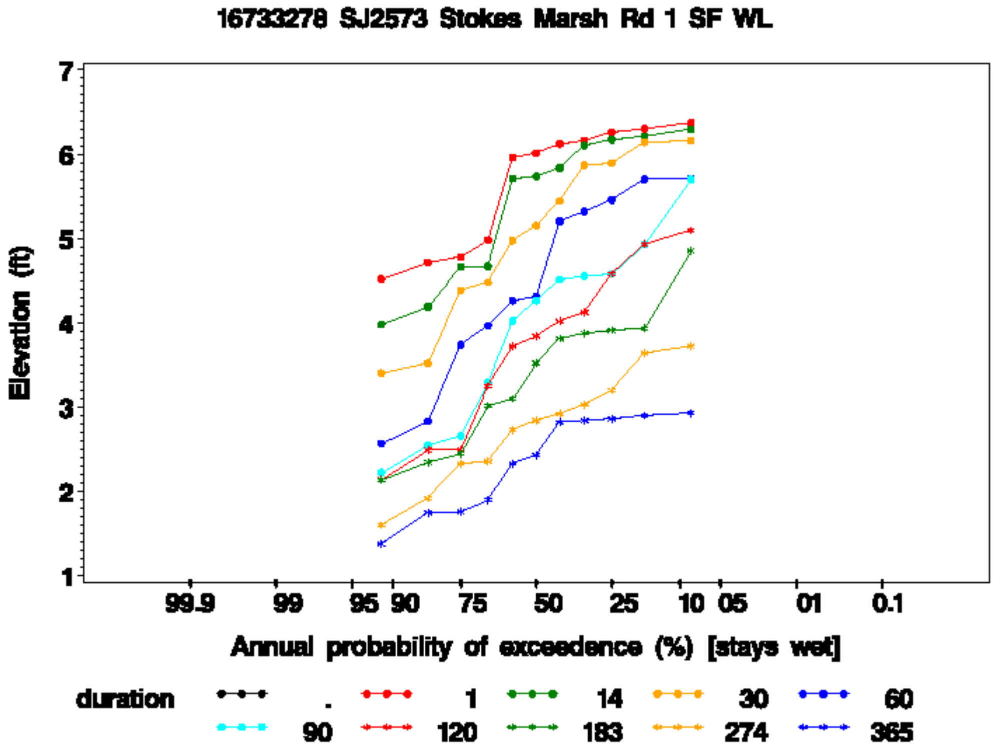


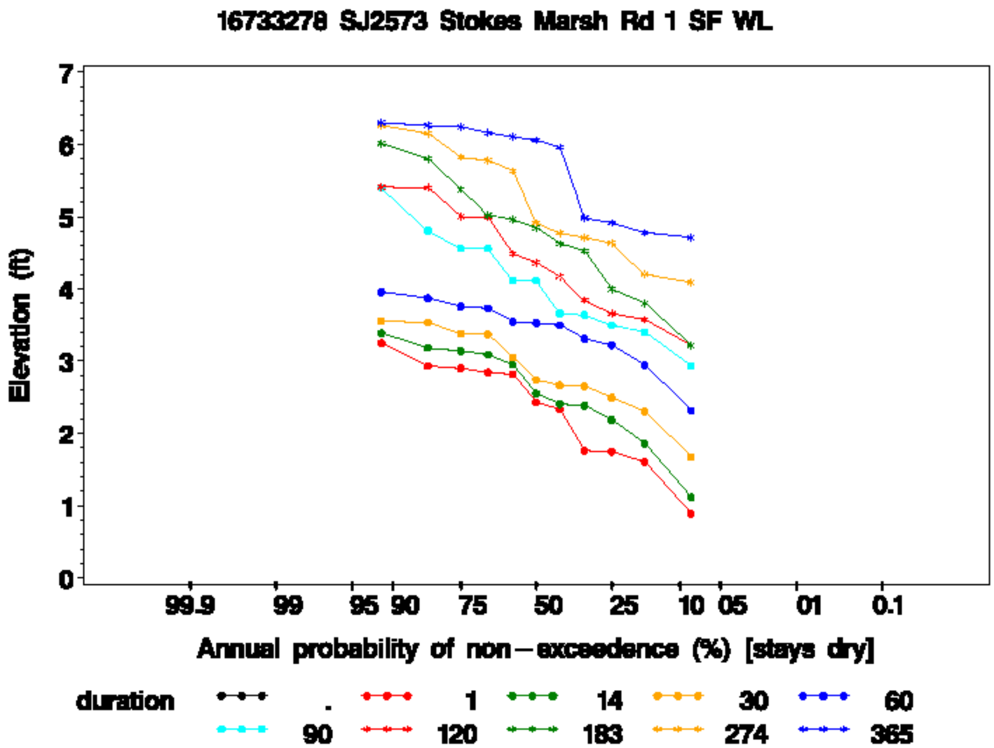
Appendix C.15. Water level exceedence (top) and non-exceedence (bottom) probability plots for well SJ2563



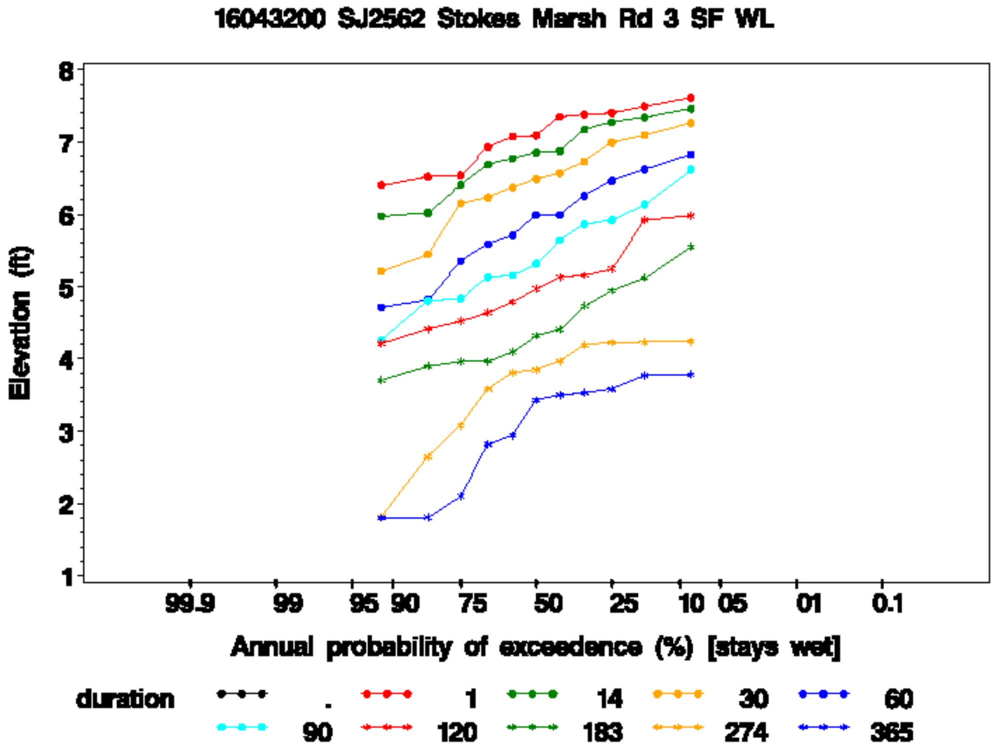


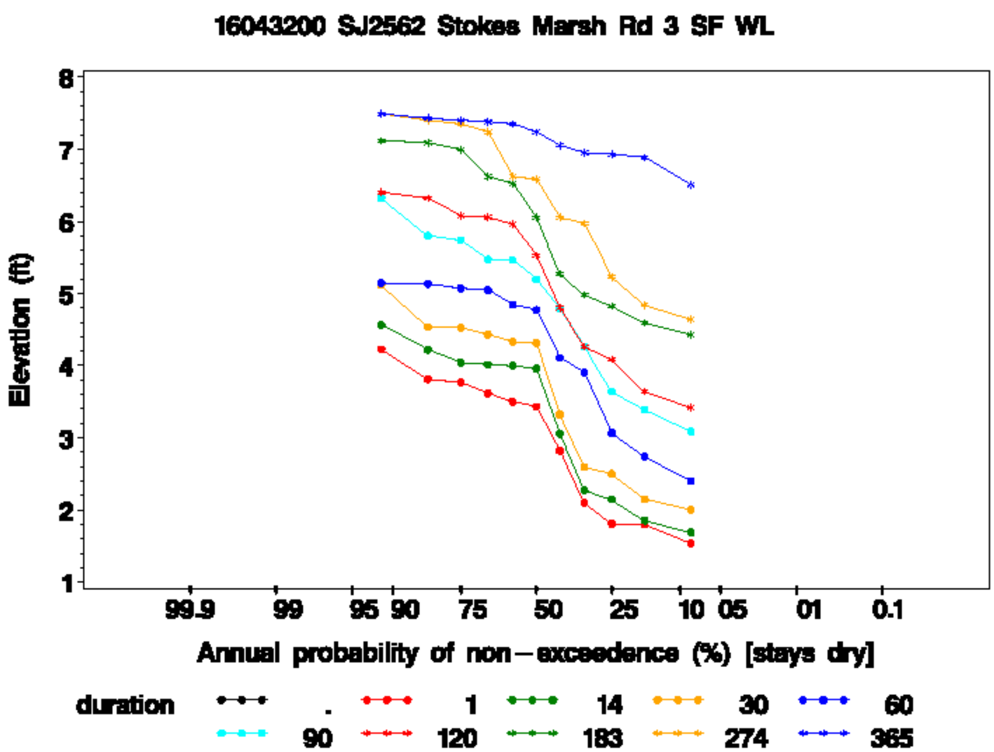
Appendix C.16. Water level exceedence (top) and non-exceedence (bottom) probability plots for well SJ2573



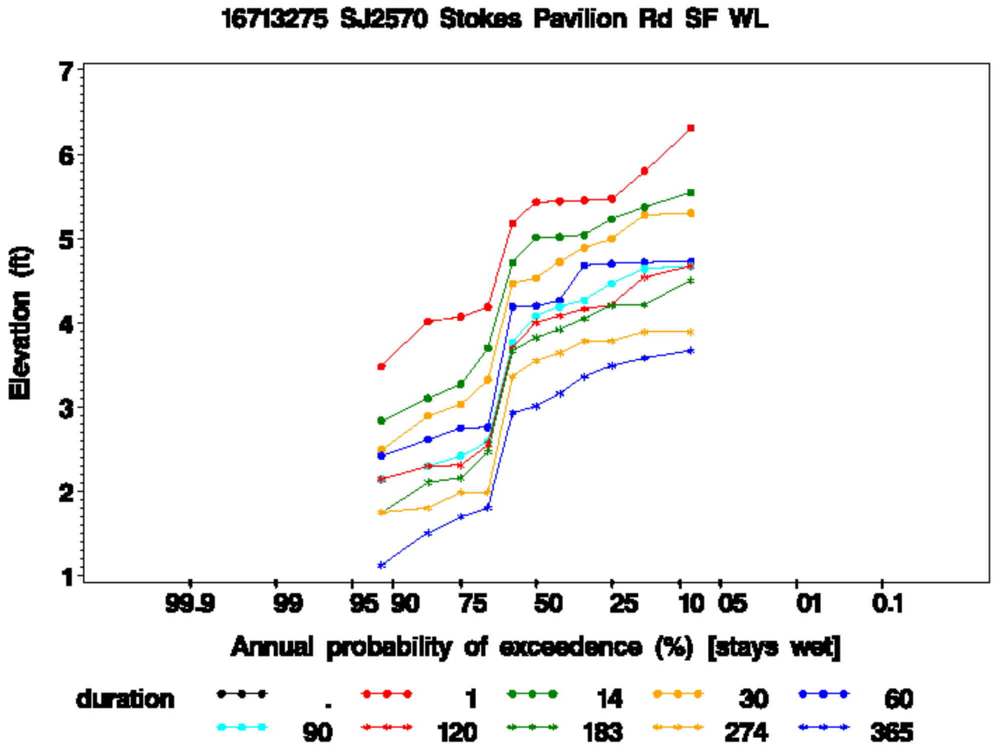


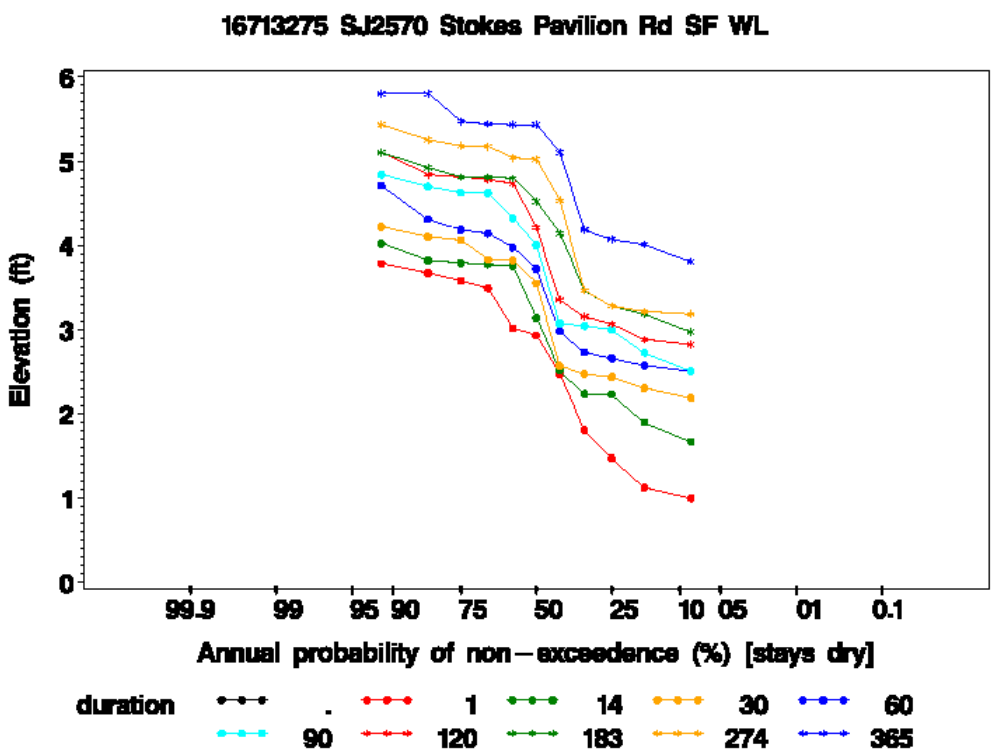
Appendix C.17. Water level exceedence (top) and non-exceedence (bottom) probability plots for well SJ2562



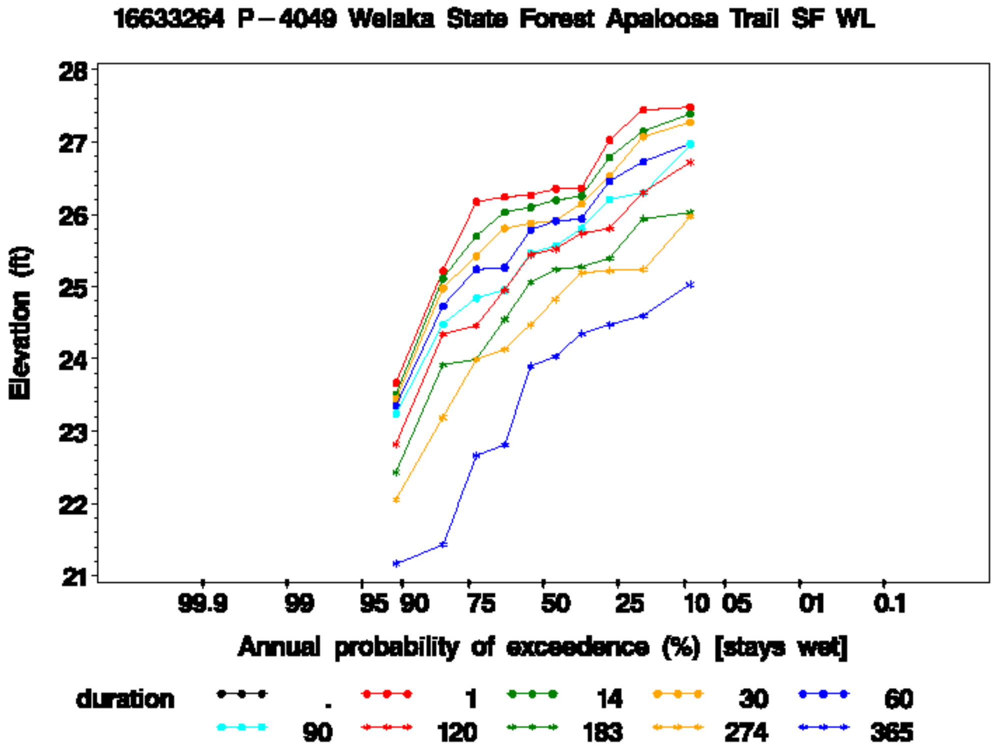


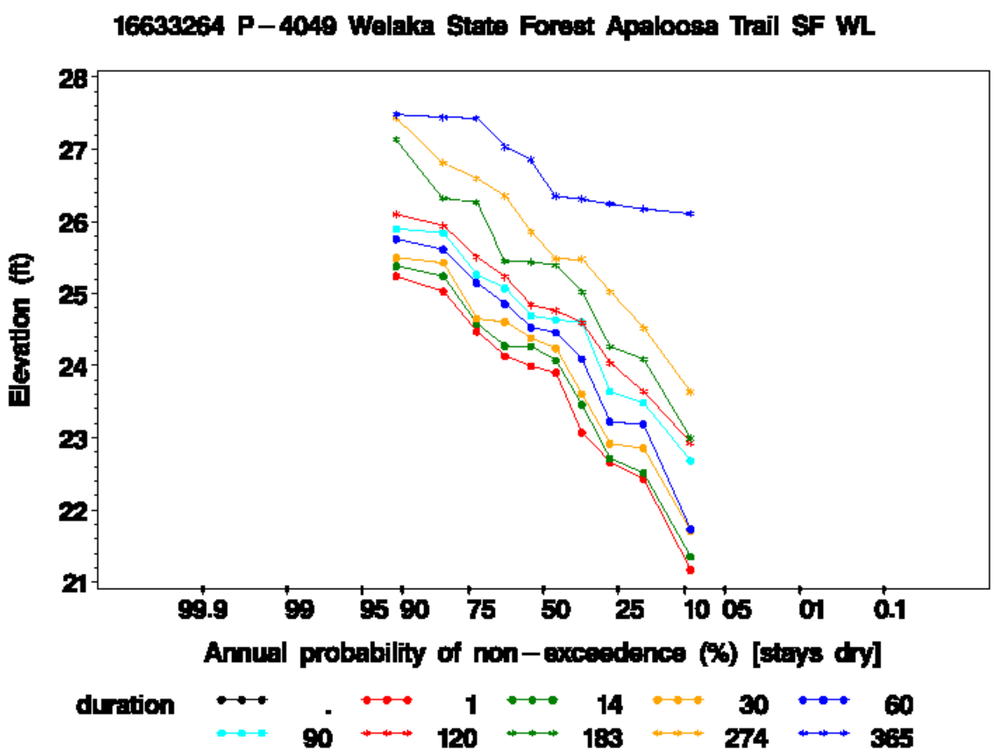
Appendix C.18. Water level exceedence (top) and non-exceedence (bottom) probability plots for well SJ2570



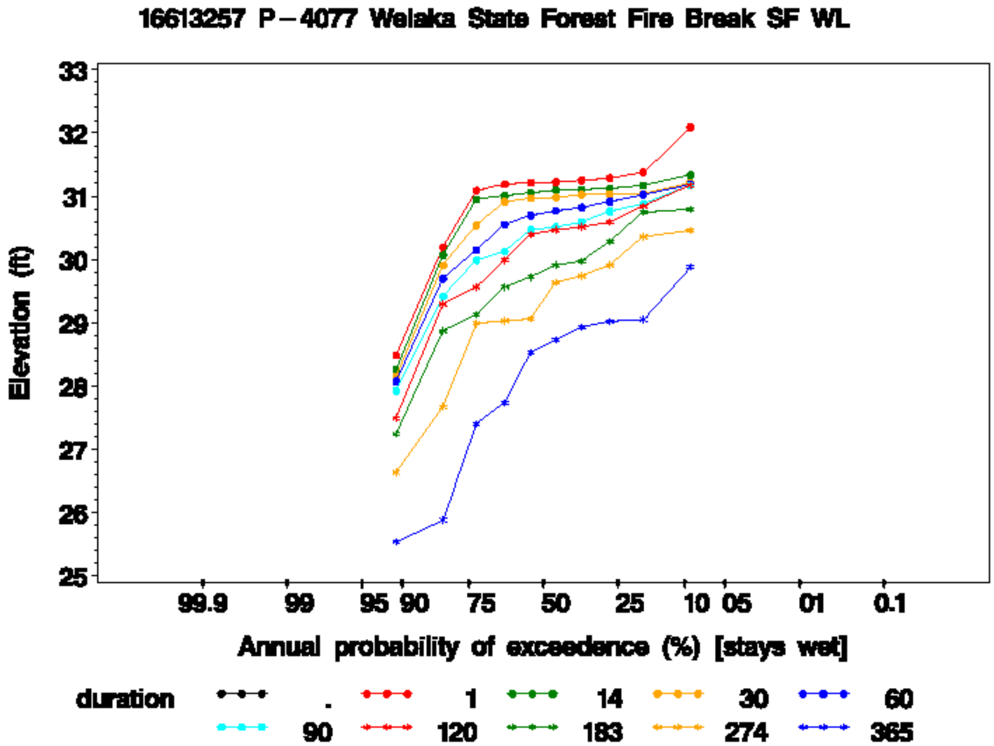


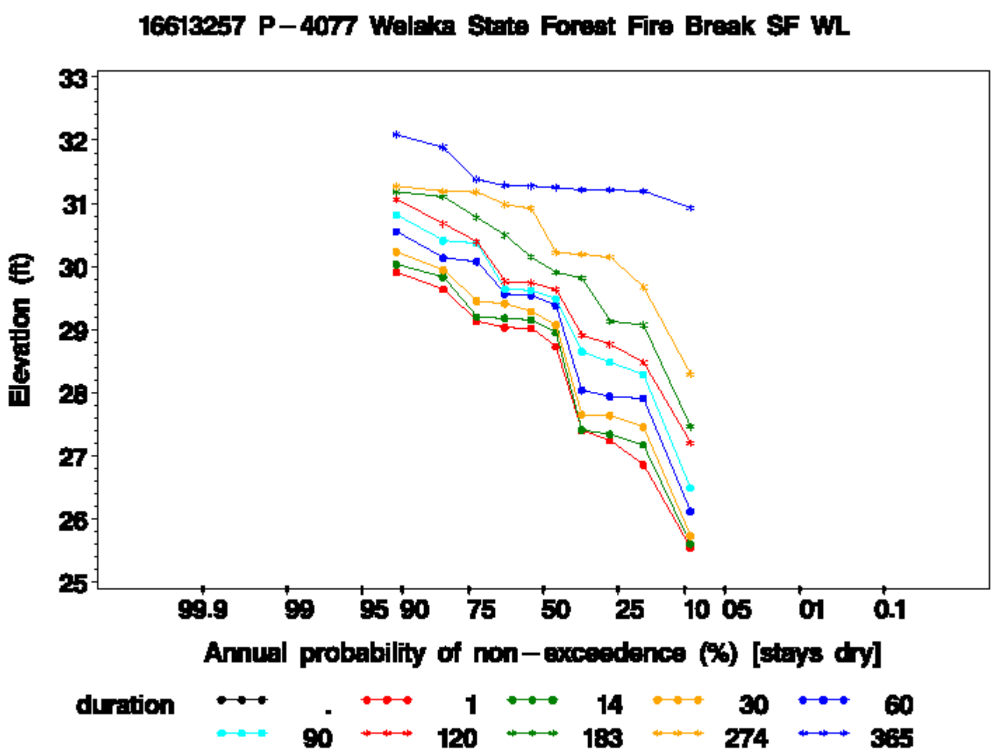
Appendix C.19. Water level exceedence (top) and non-exceedence (bottom) probability plots for well P-4049



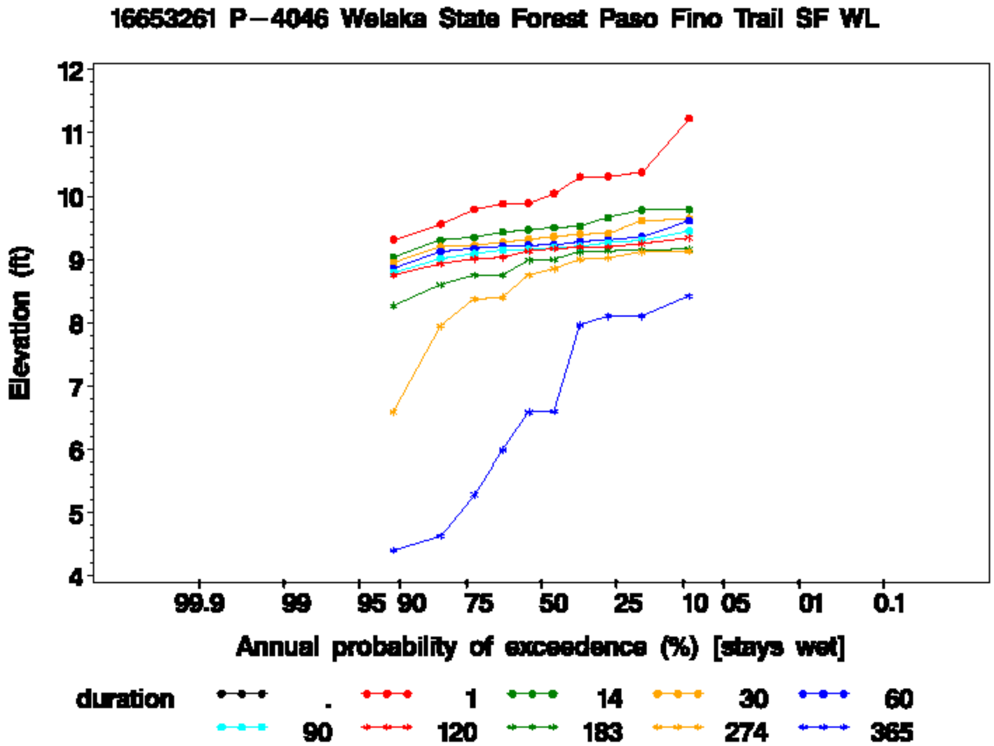


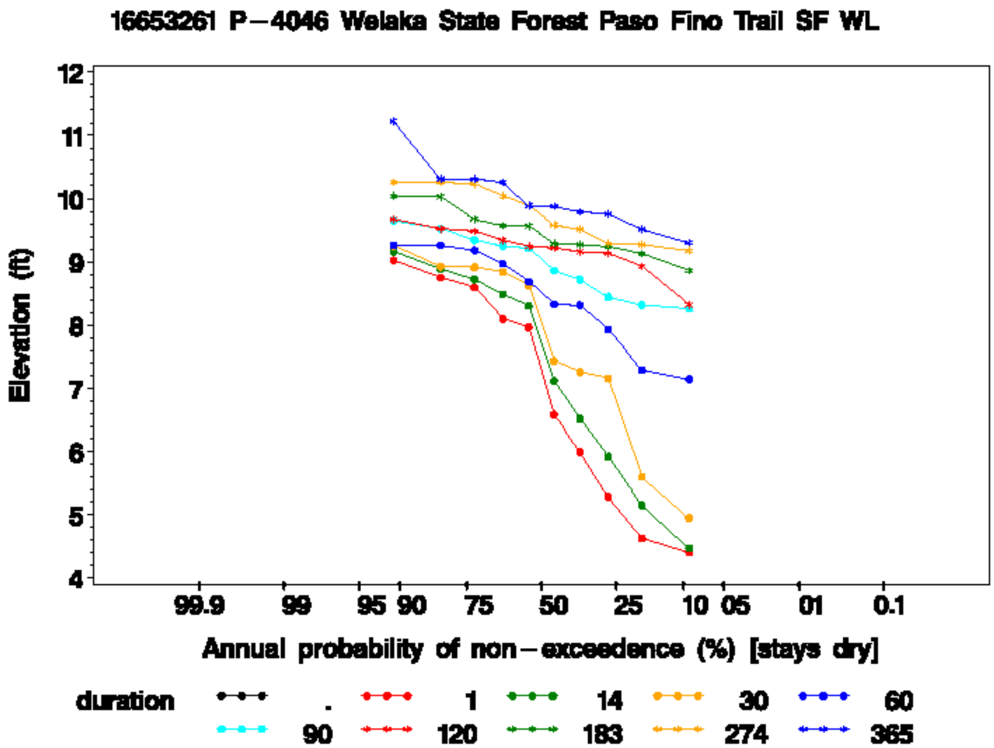
Appendix C.20. Water level exceedence (top) and non-exceedence (bottom) probability plots for well P-4077





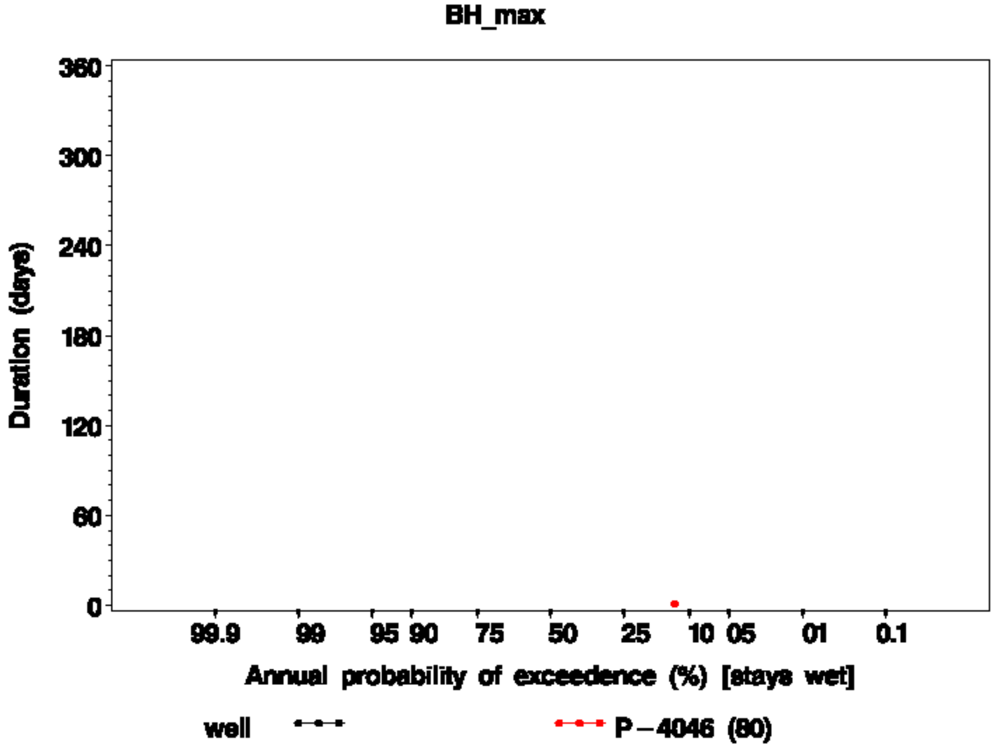
Appendix C.21. Water level exceedence (top) and non-exceedence (bottom) probability plots for well P-4046

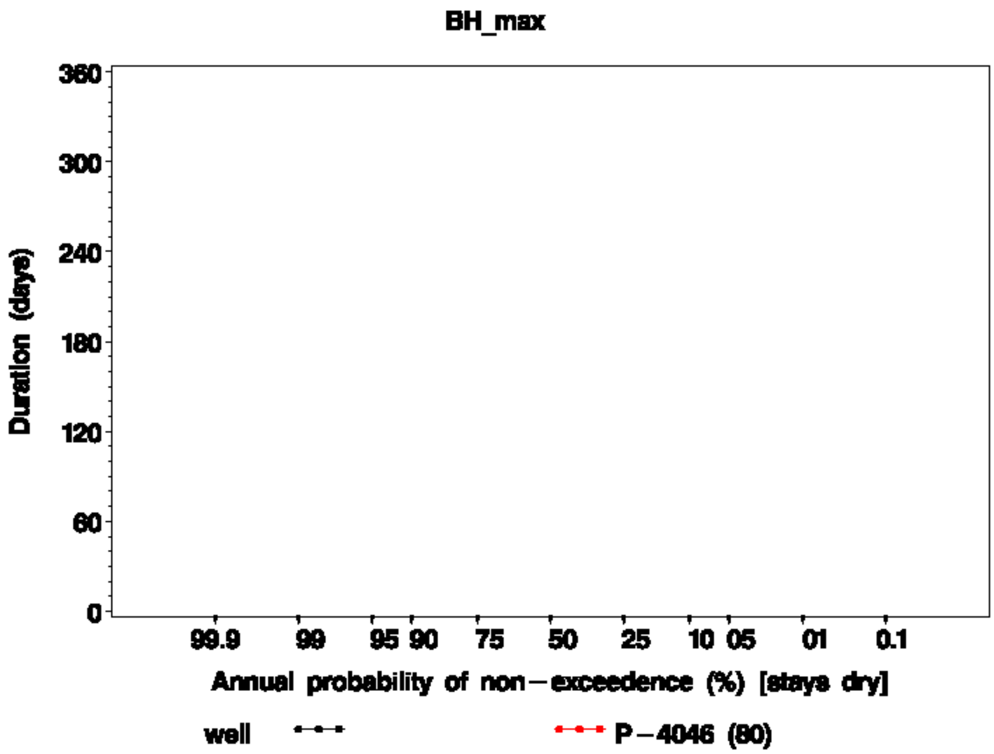




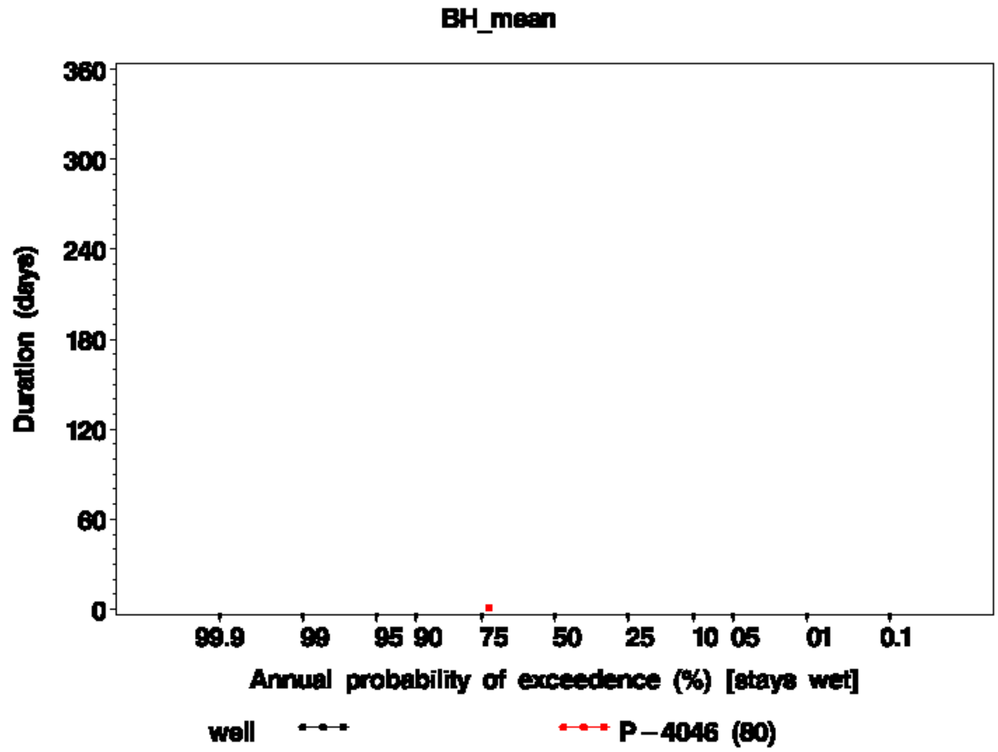
APPENDIX D

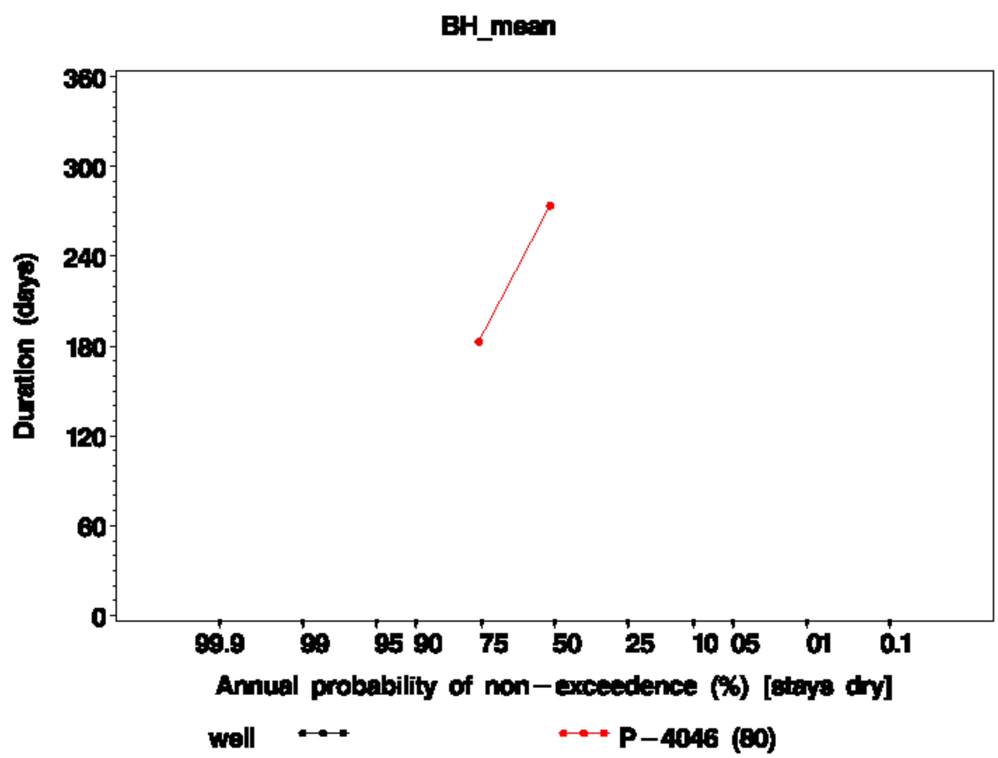
Appendix D.1. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *bayhead maximum* elevation (BH_max)



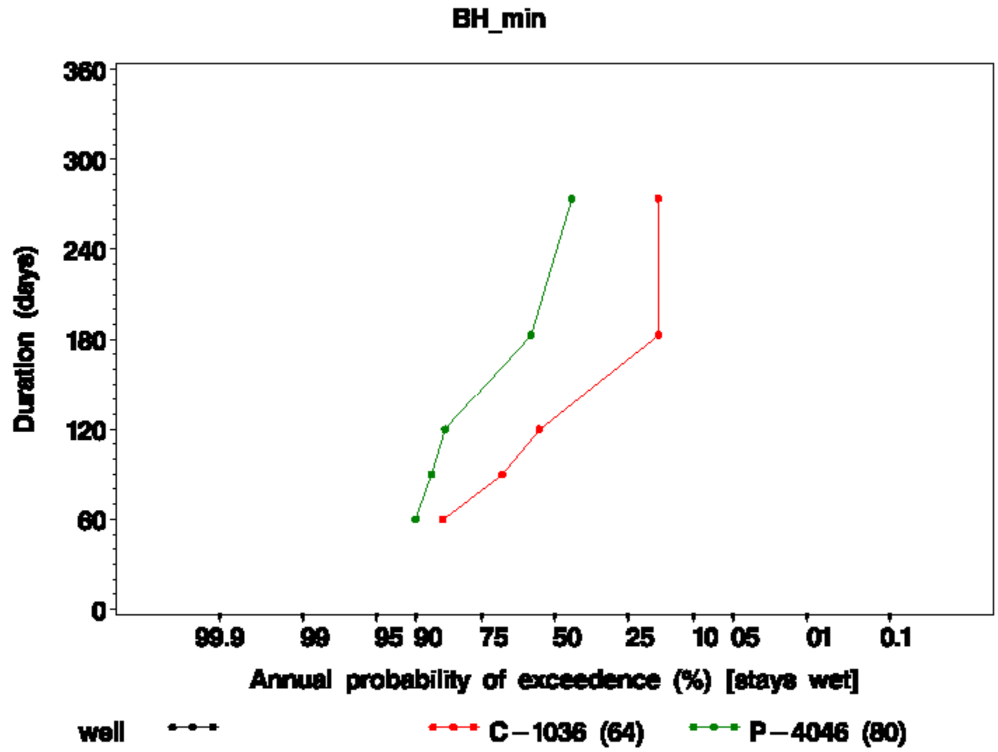


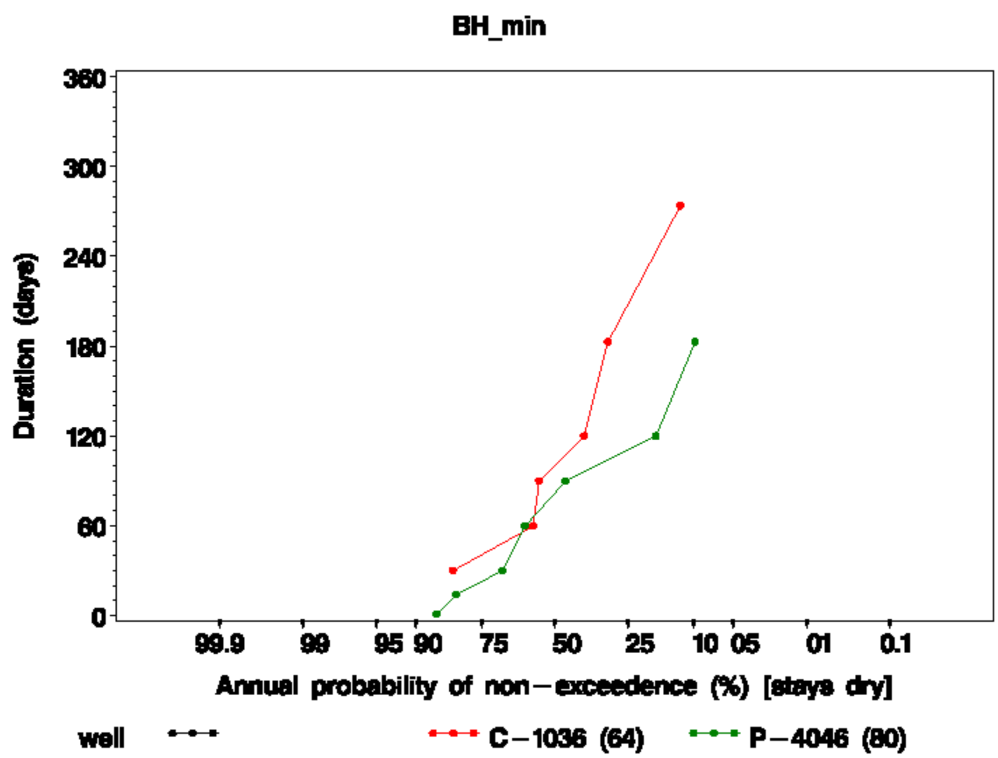
Appendix D.2. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *bayhead mean* elevation (BH_mean)



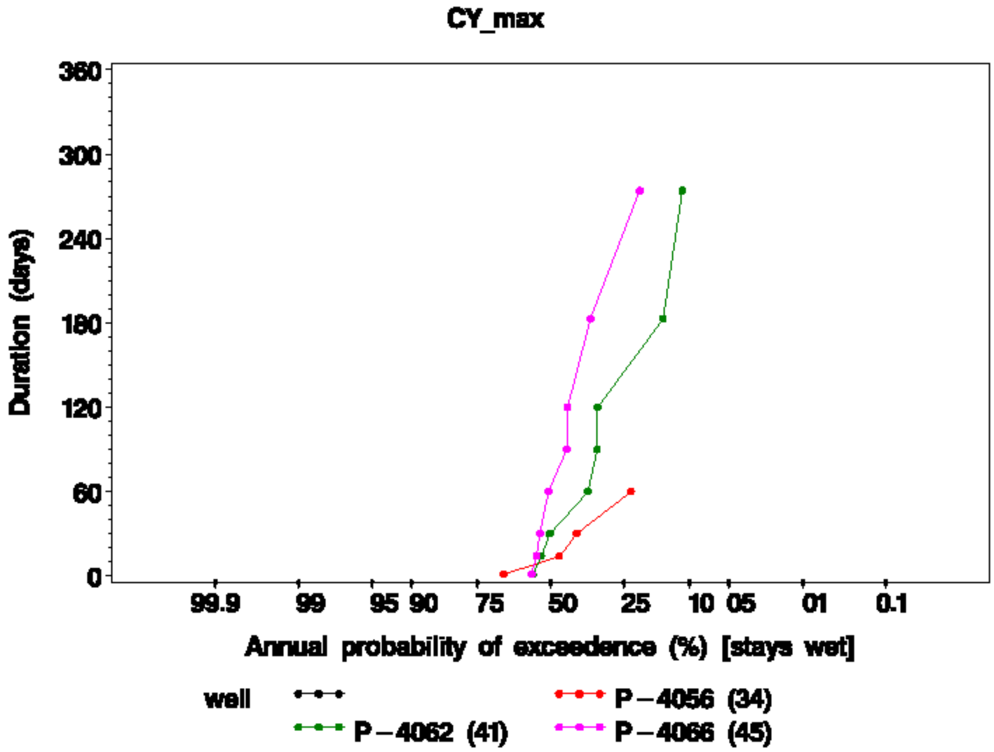


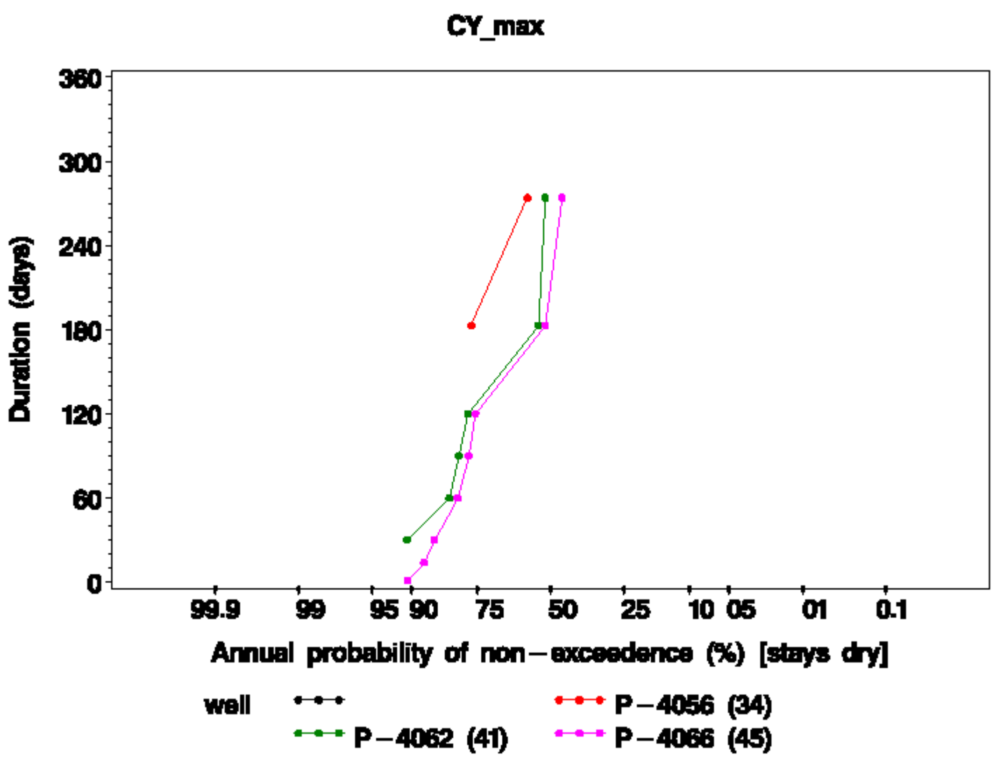
Appendix D.3. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *bayhead minimum* elevation (BH_min)



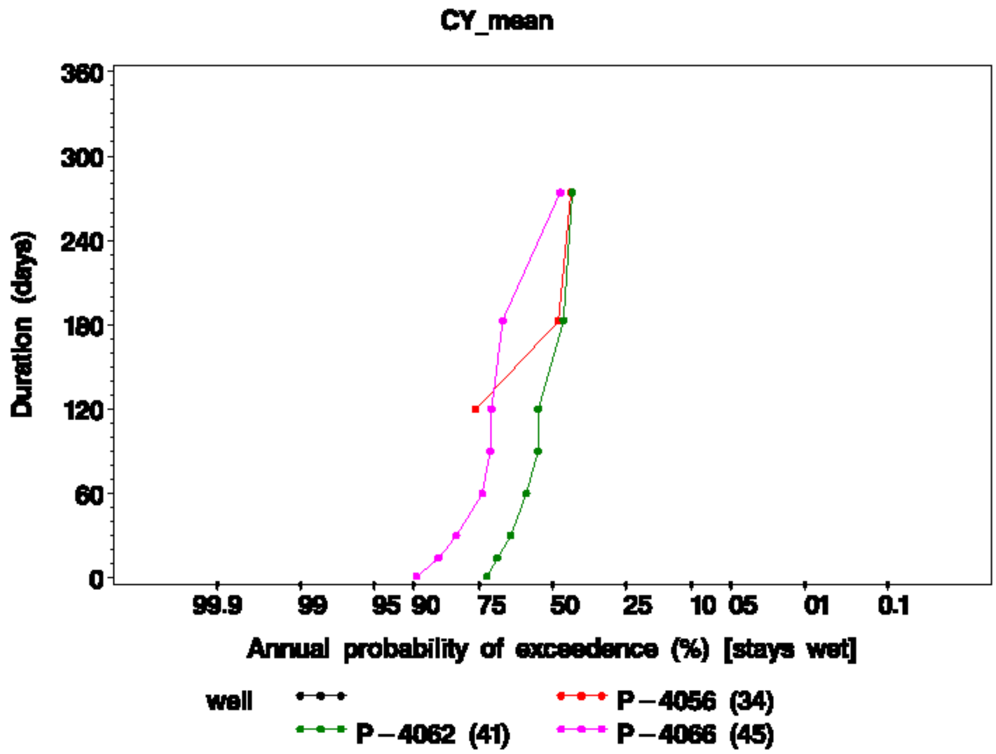


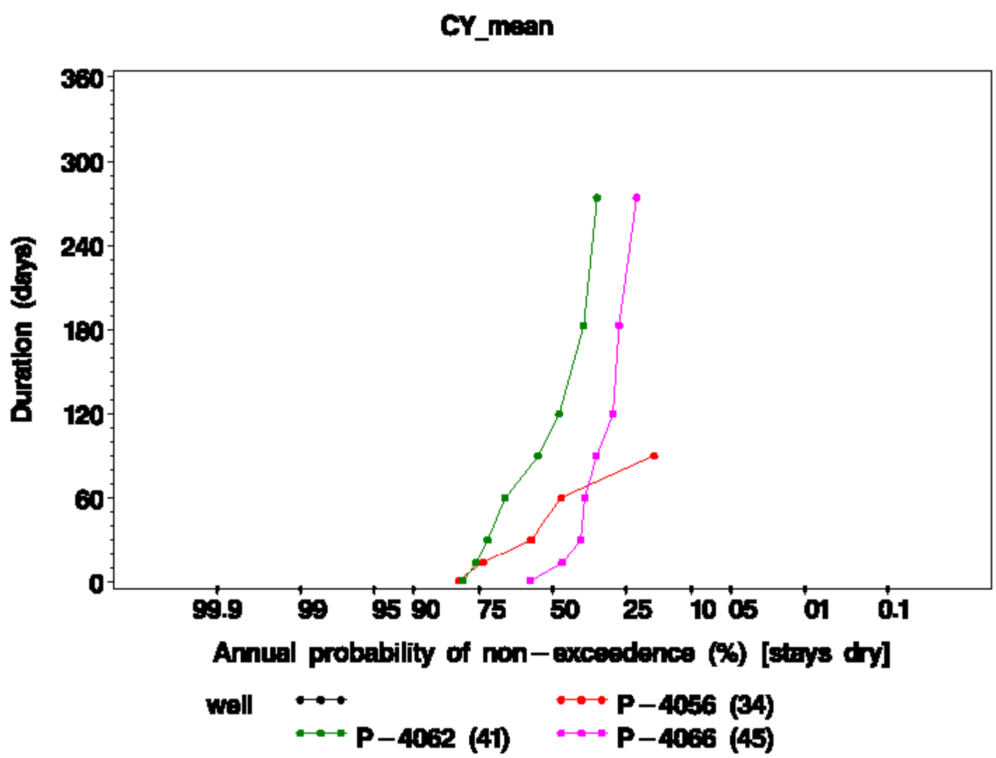
Appendix D.4. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *cypress maximum* elevation (CY_max)



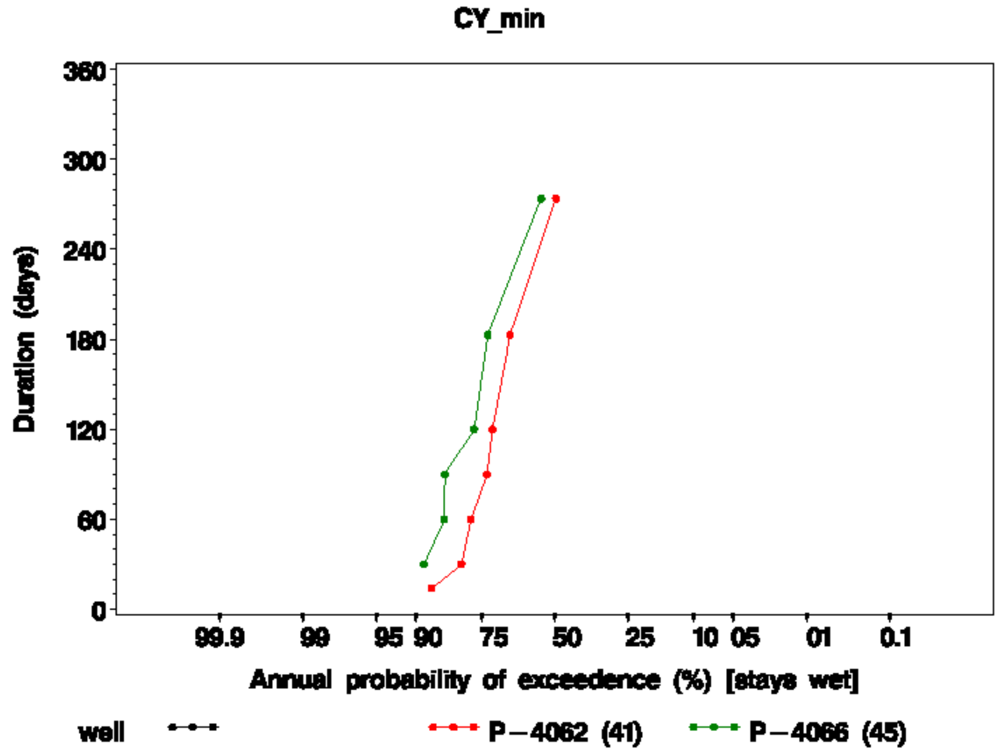


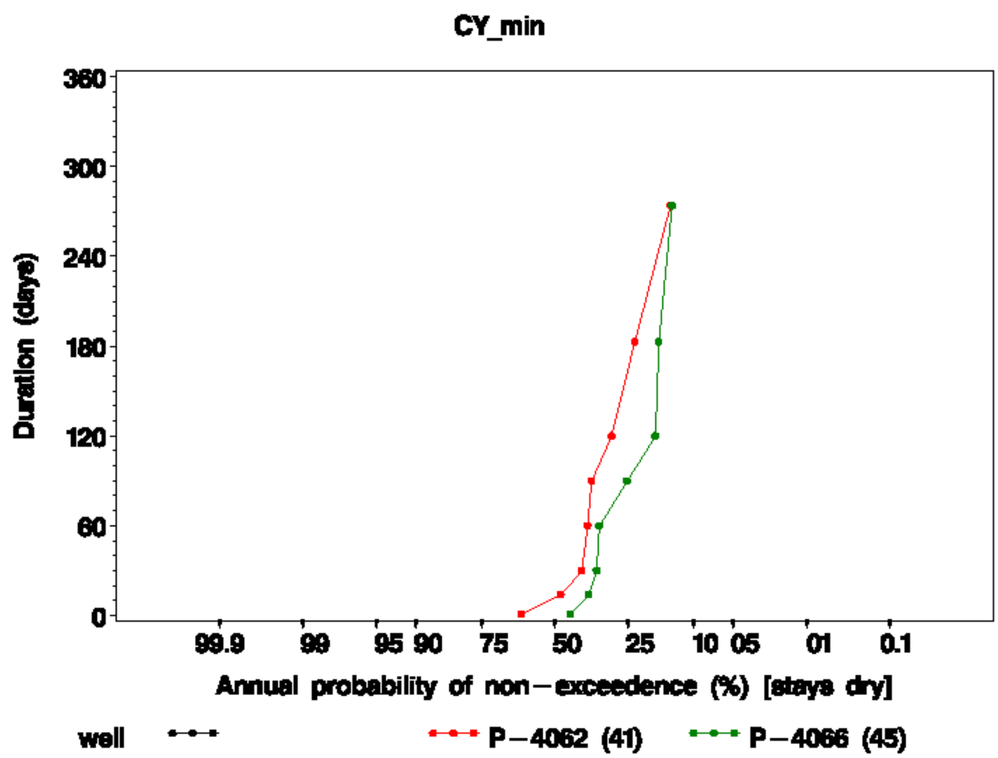
Appendix D.5. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *cypress mean* elevation (CY_mean)



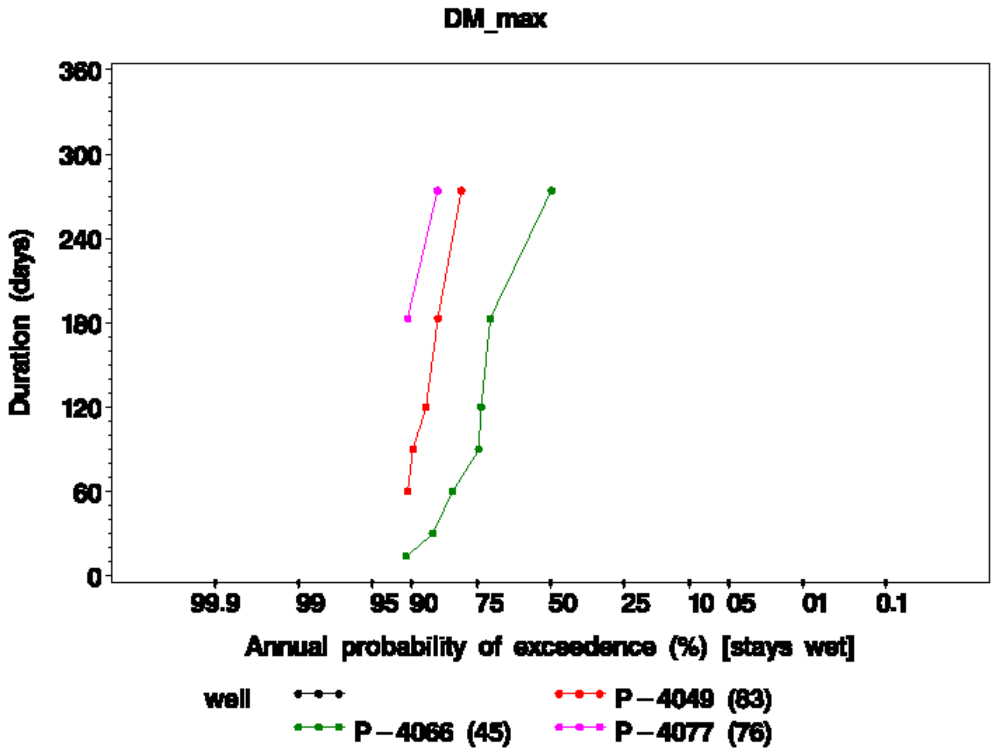


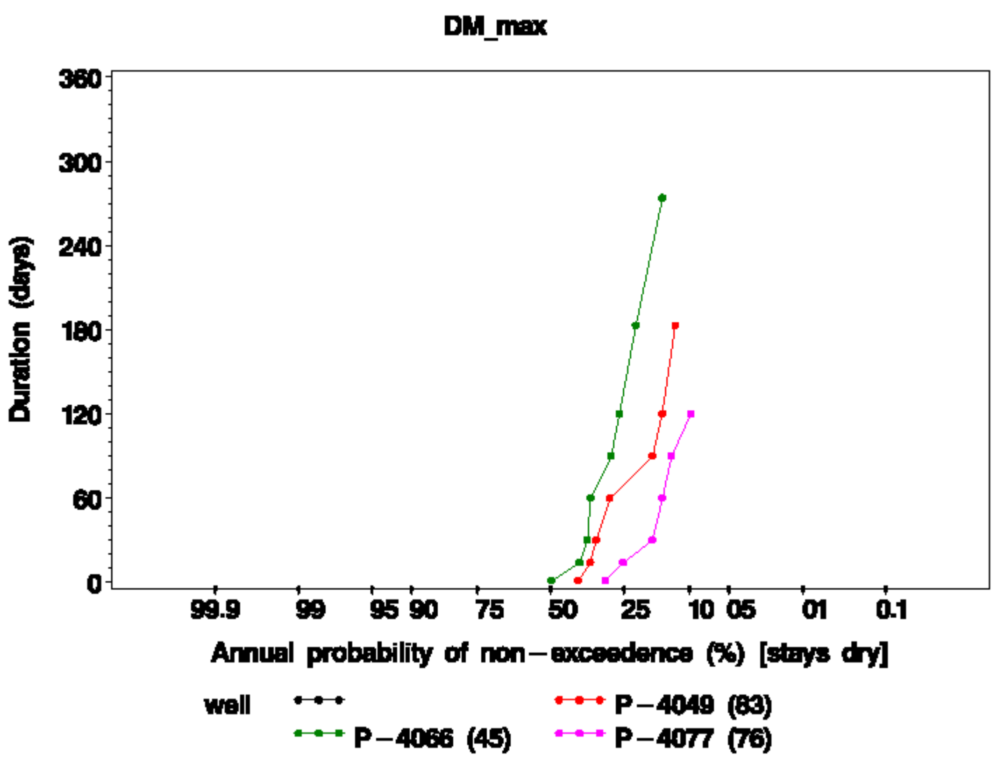
Appendix D.6. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *cypress minimum* elevation (CY_min)



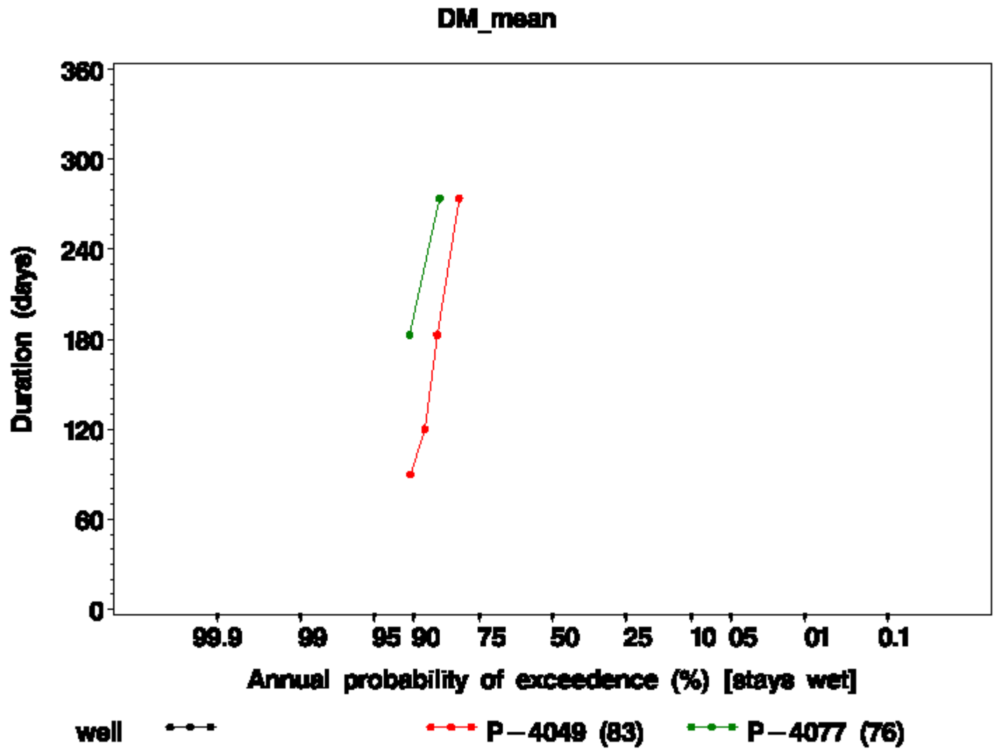


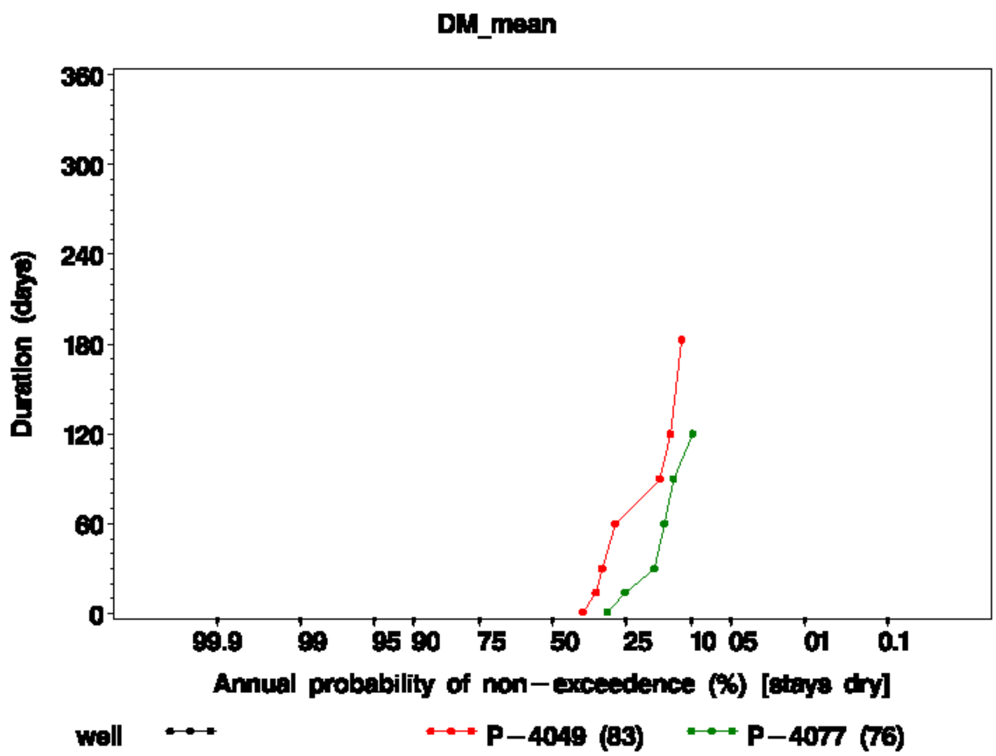
Appendix D.7. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *deep marsh maximum* elevation (DM_max)



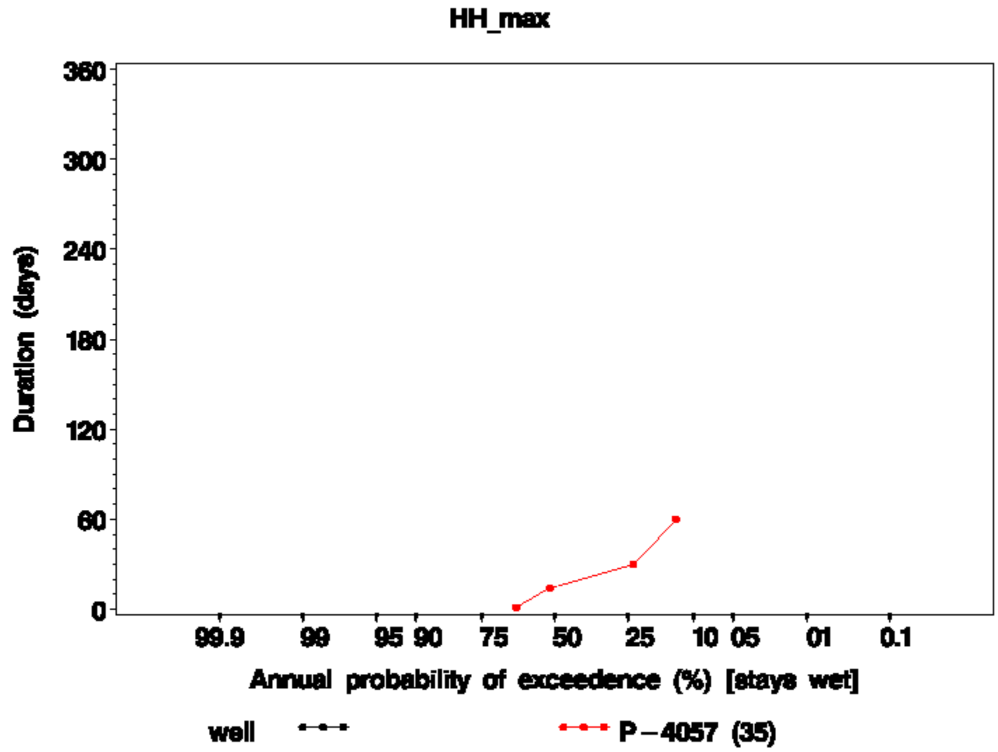


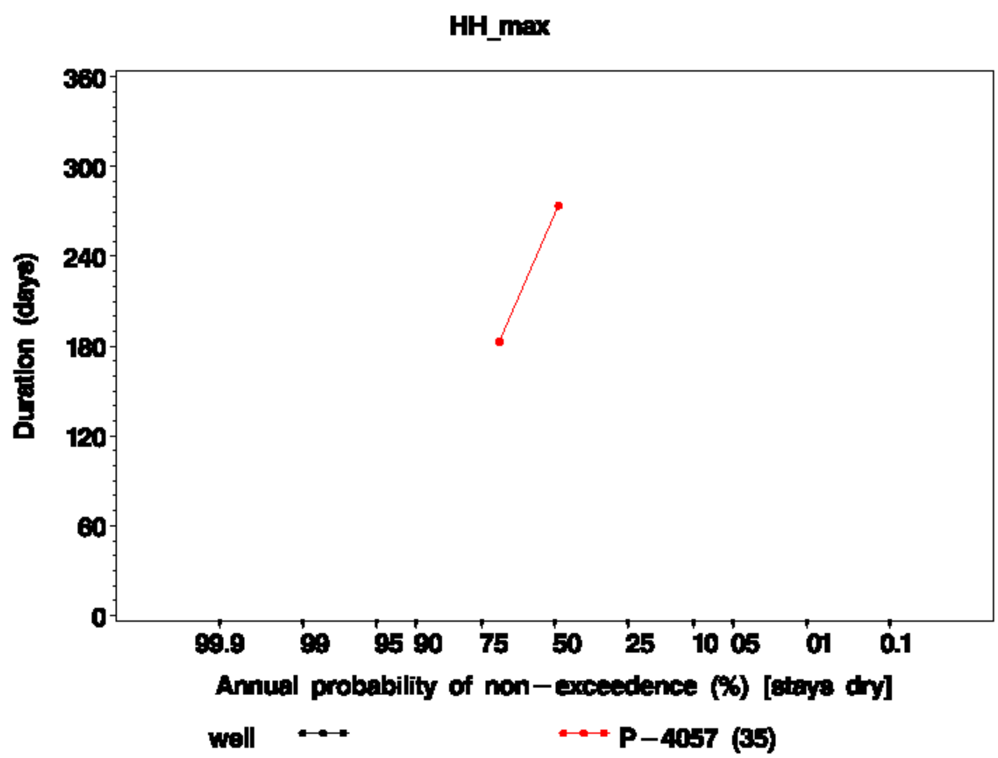
Appendix D.8. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *deep marsh mean* elevation (DM_mean)



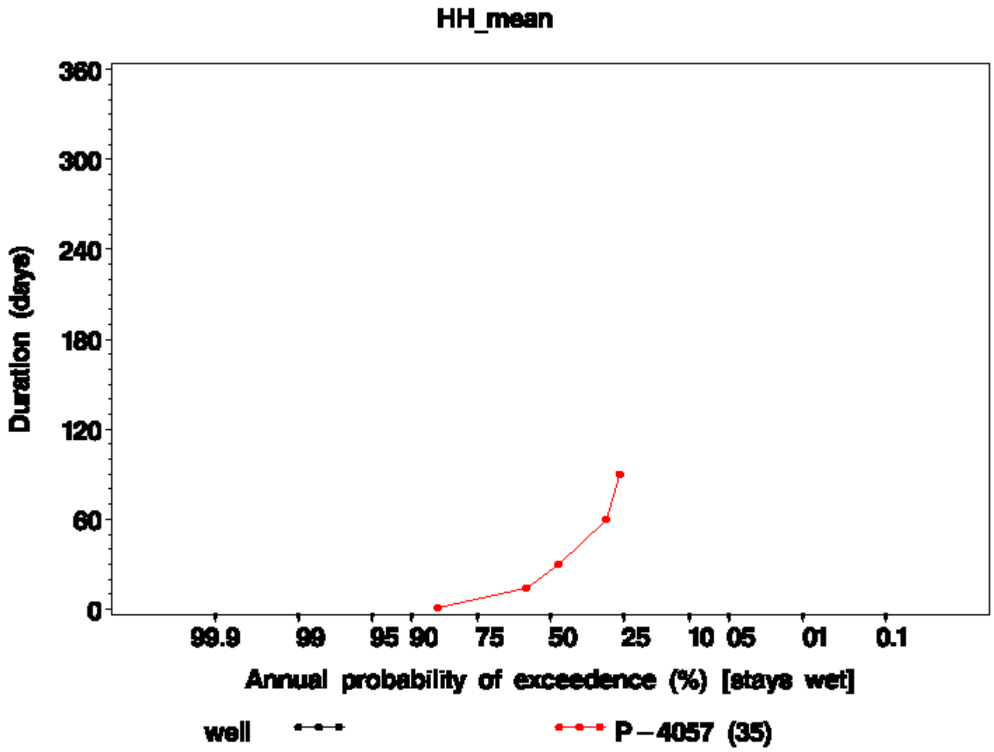


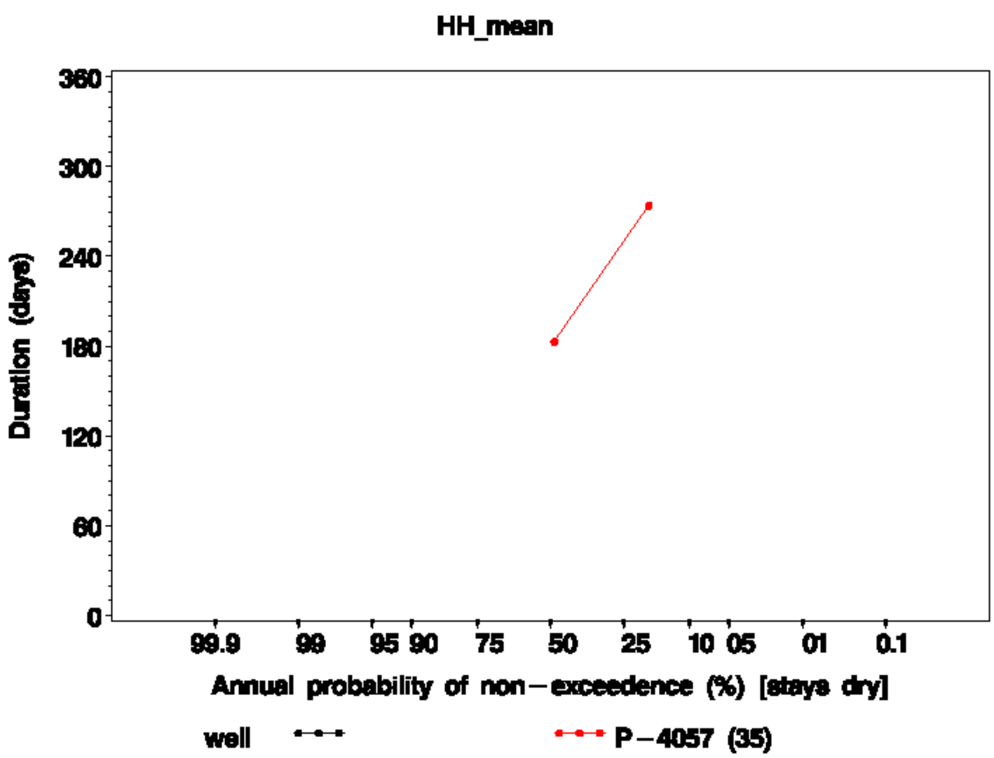
Appendix D.9. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *hydric hammock maximum* elevation (HH_max)



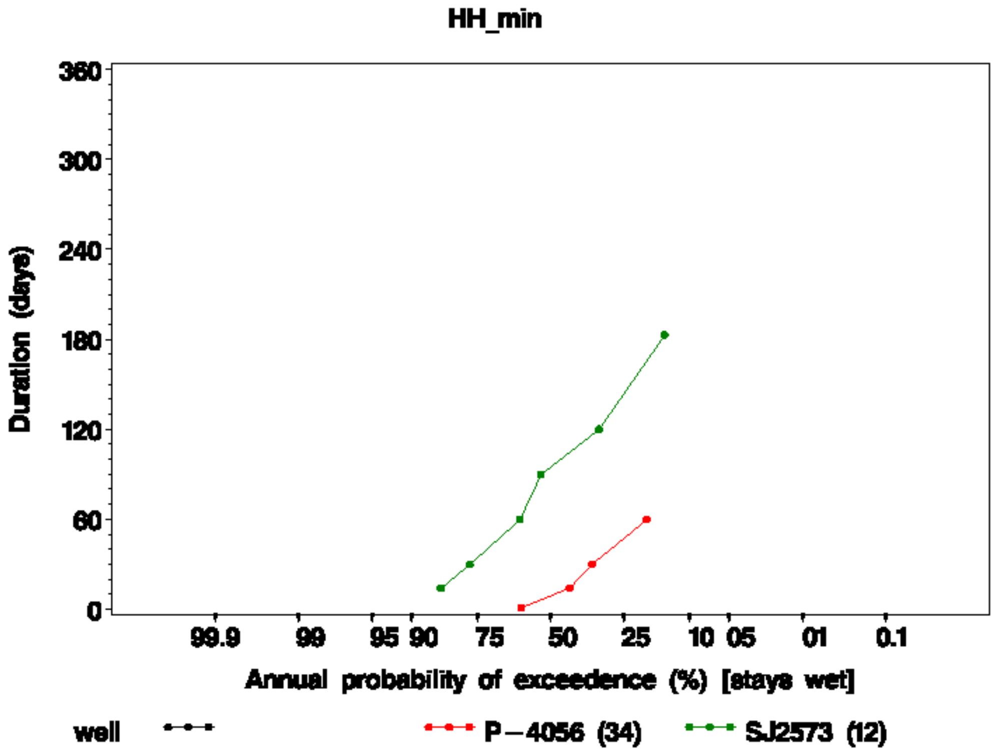


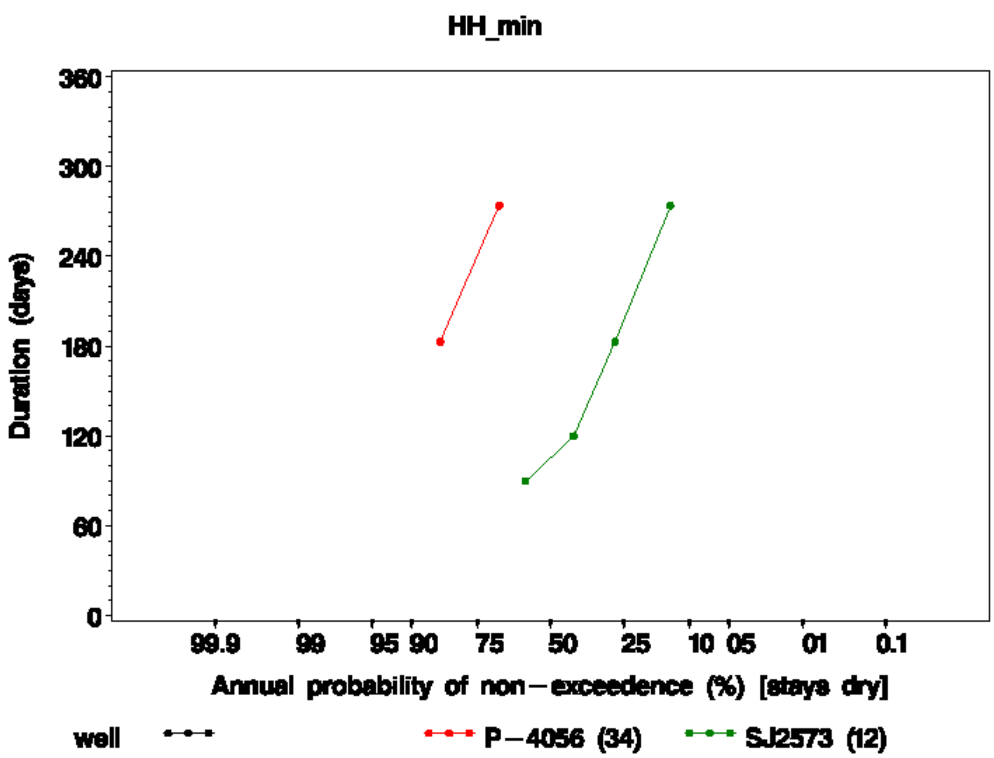
Appendix D.10. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *hydric hammock mean* elevation (HH_mean)



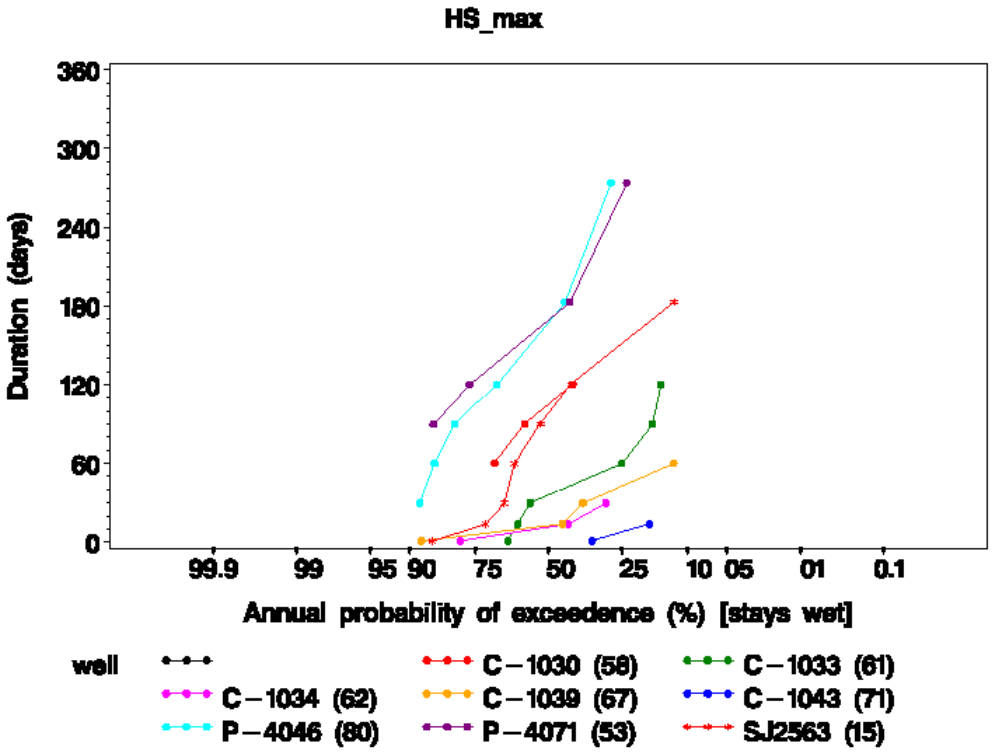


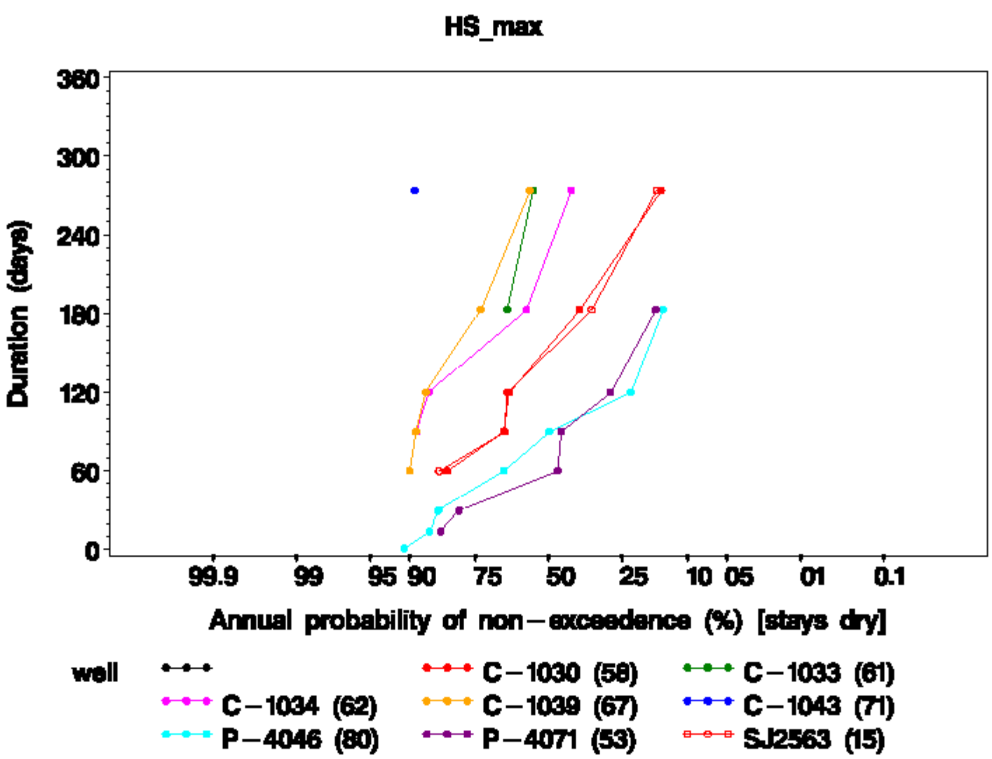
Appendix D.11. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator hydric *hammock minimum* elevation (HH_min)



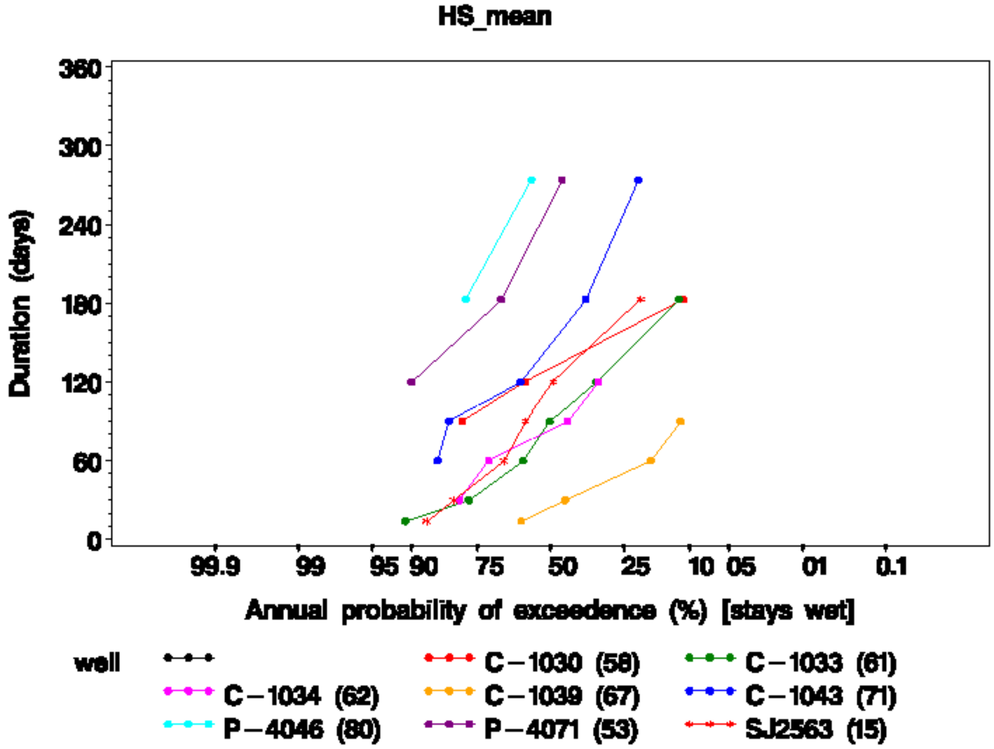


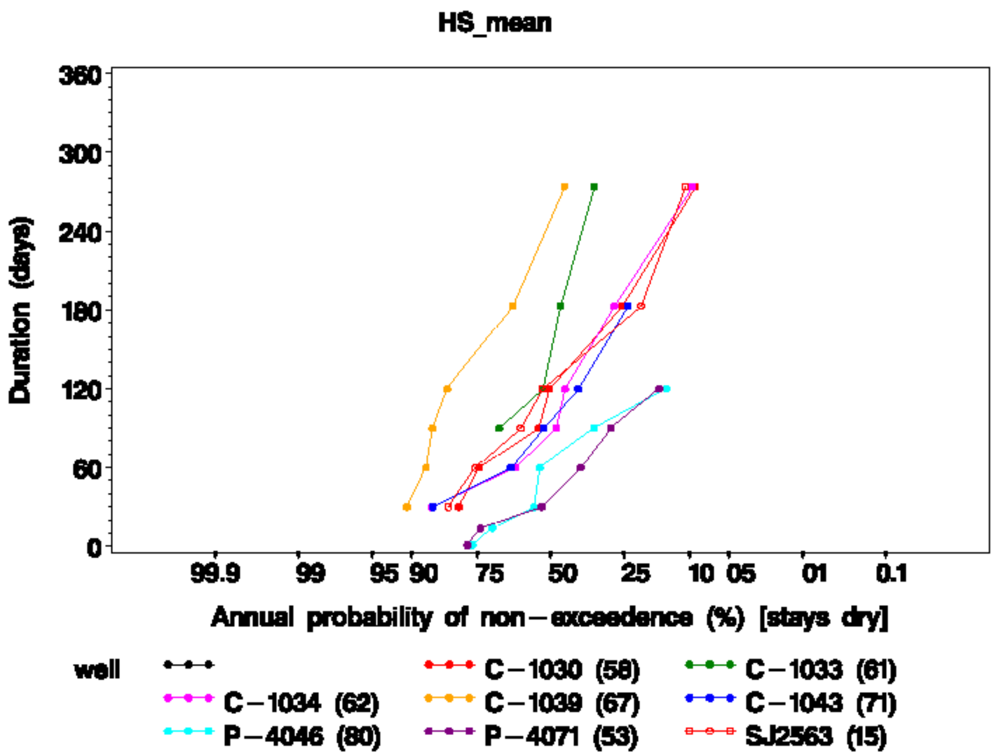
Appendix D.12. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *hardwood swamp maximum* elevation (HS_max)



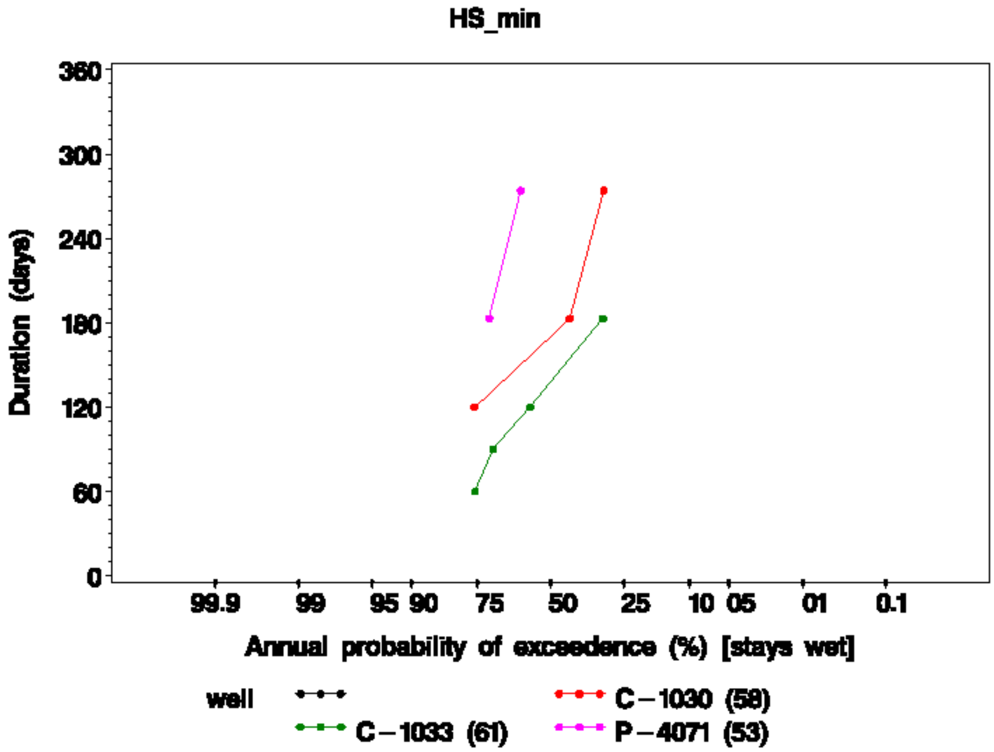


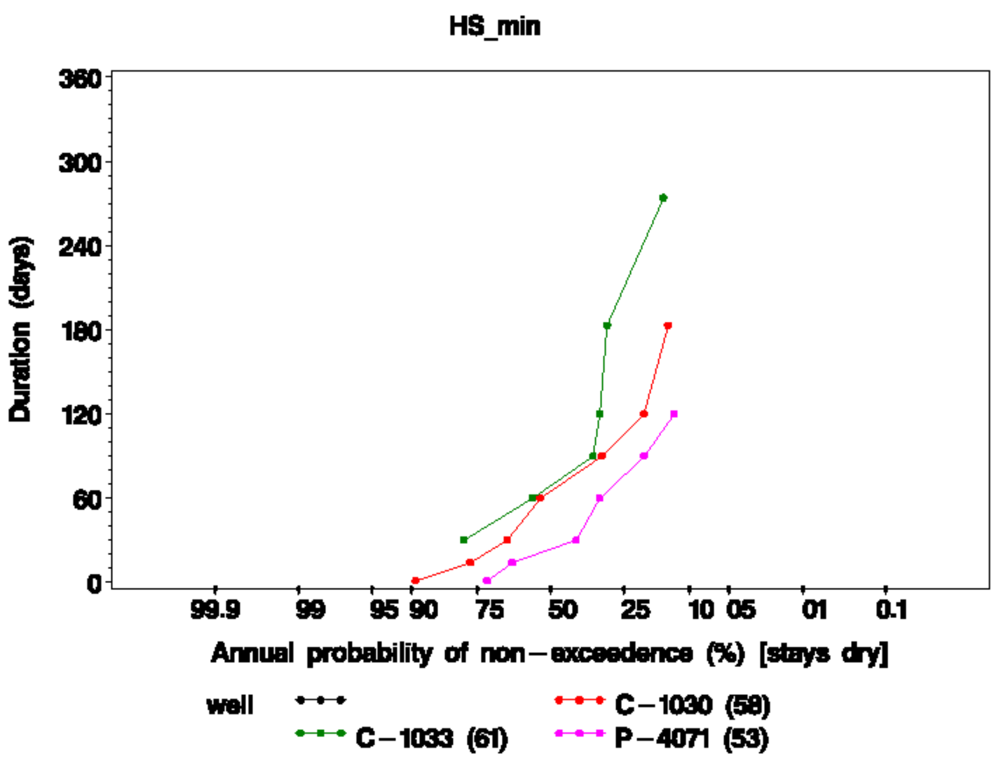
Appendix D.13. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *hardwood swamp mean* elevation (HS_mean)



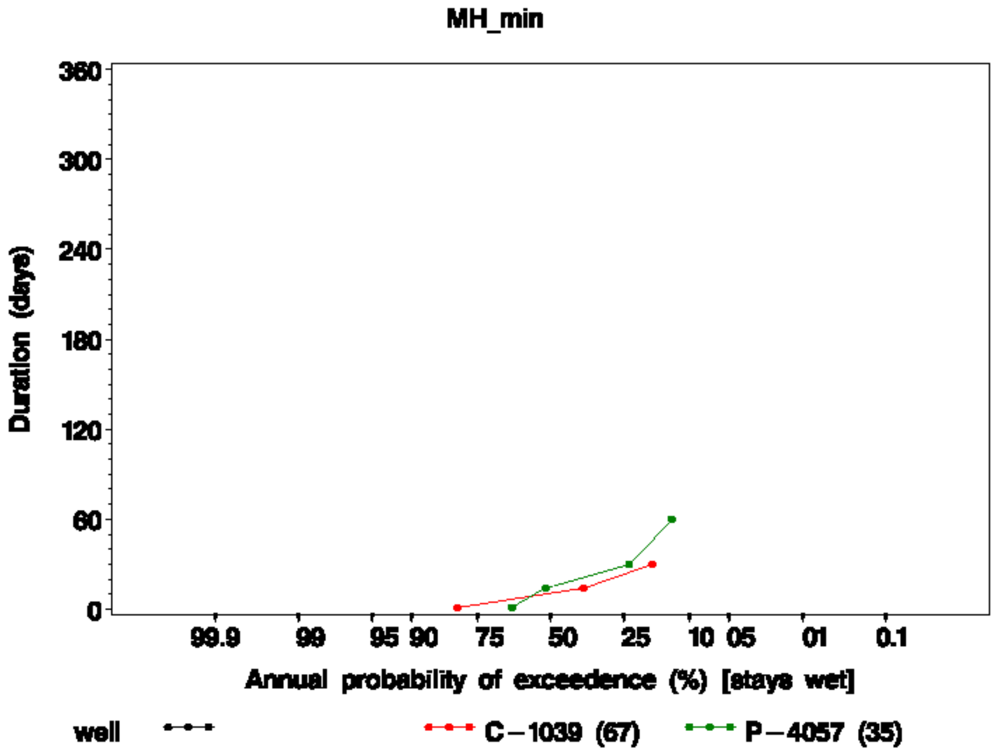


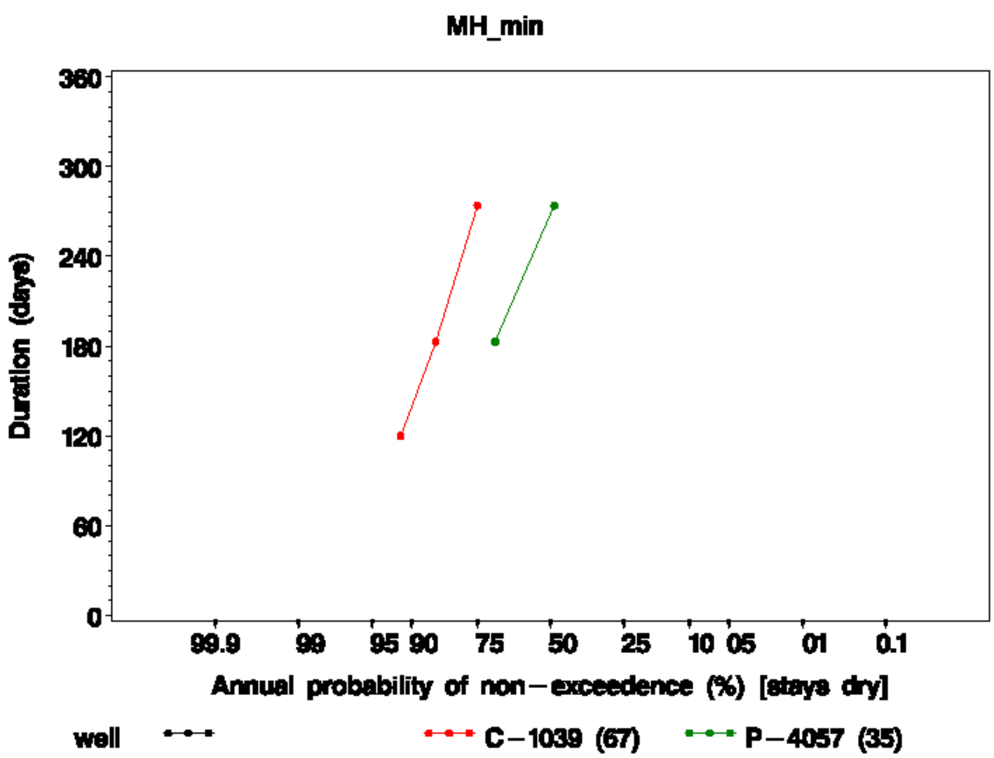
Appendix D.14. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *hardwood swamp minimum* elevation (HS_min)



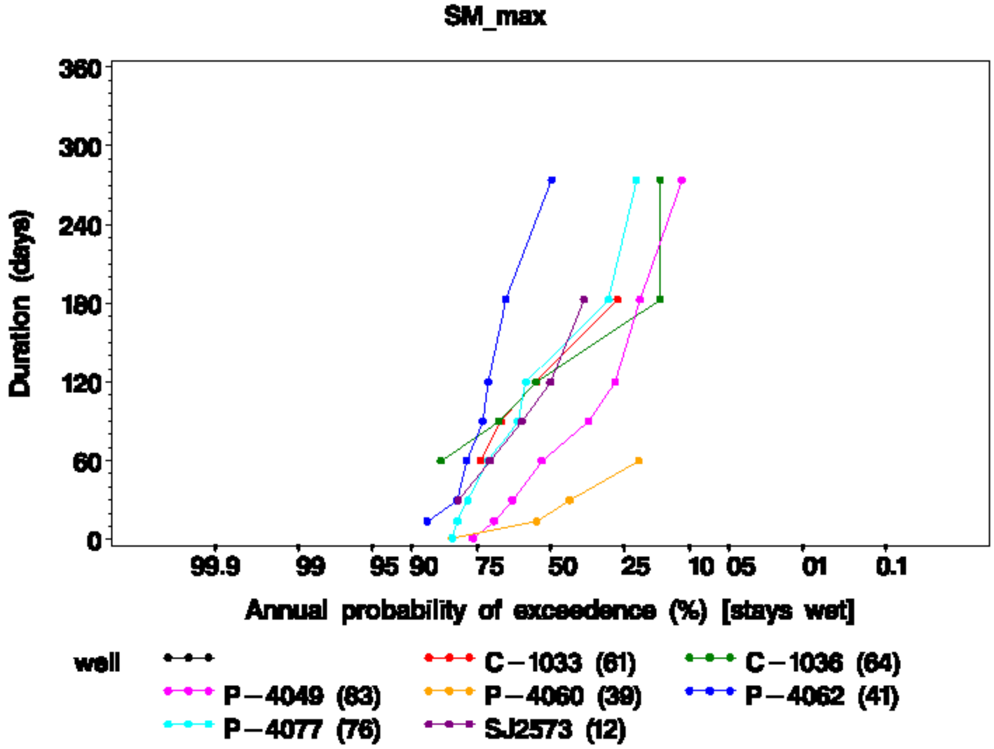


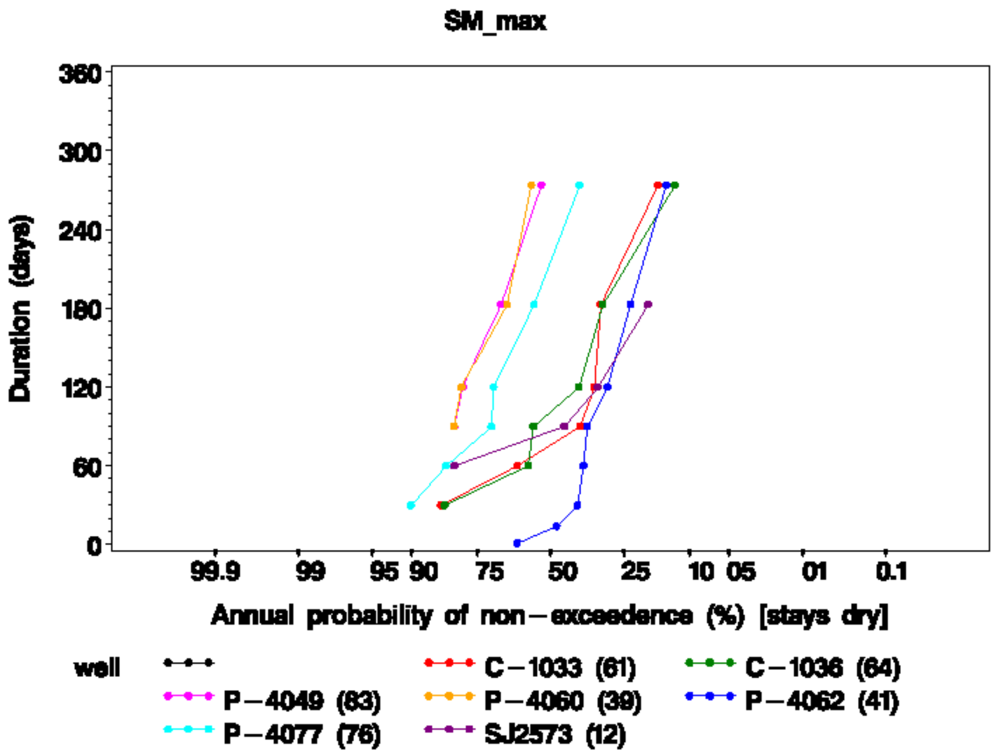
Appendix D.15. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *mesic hammock minimum* elevation (MH_min)



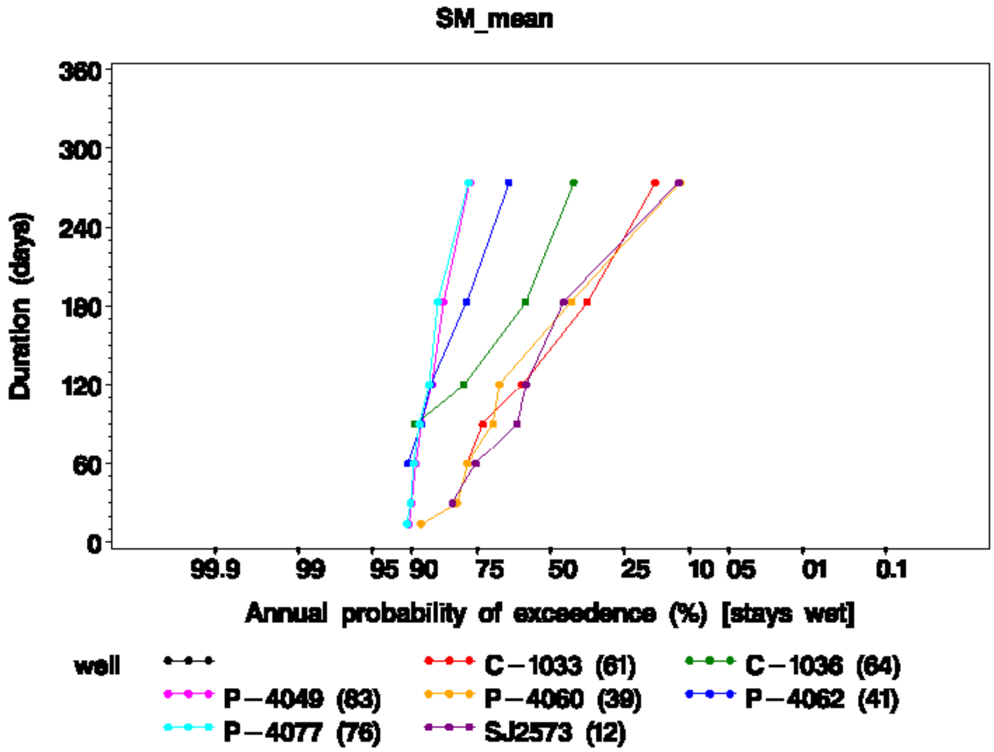


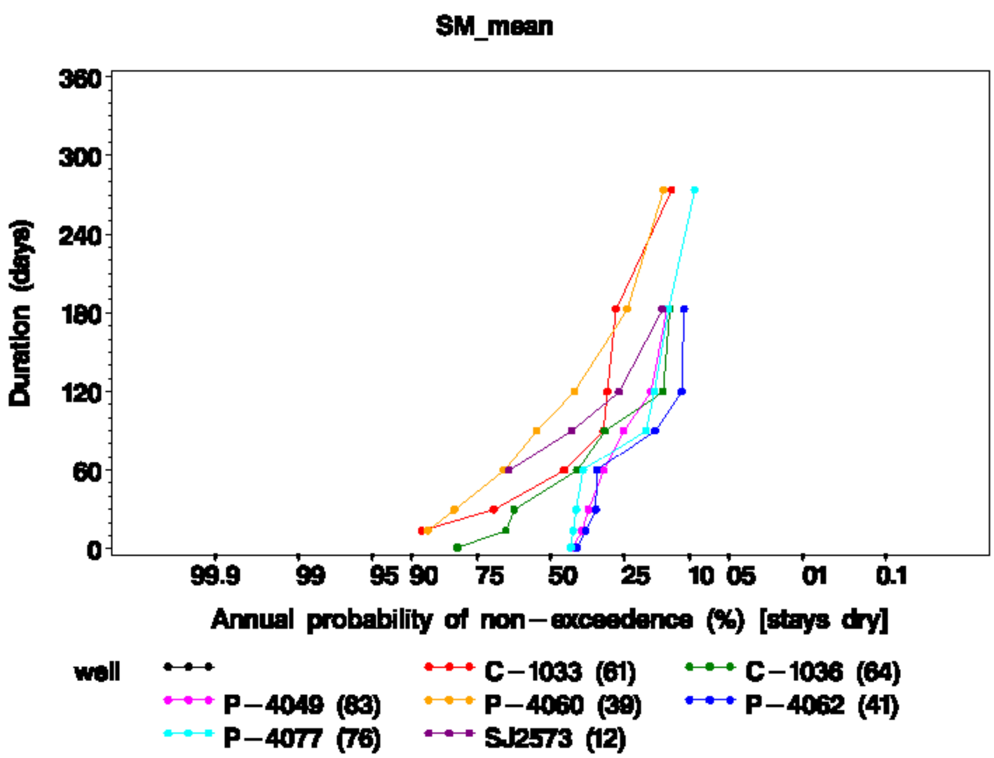
Appendix D.16. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *shallow marsh maximum* elevation (SM_max)



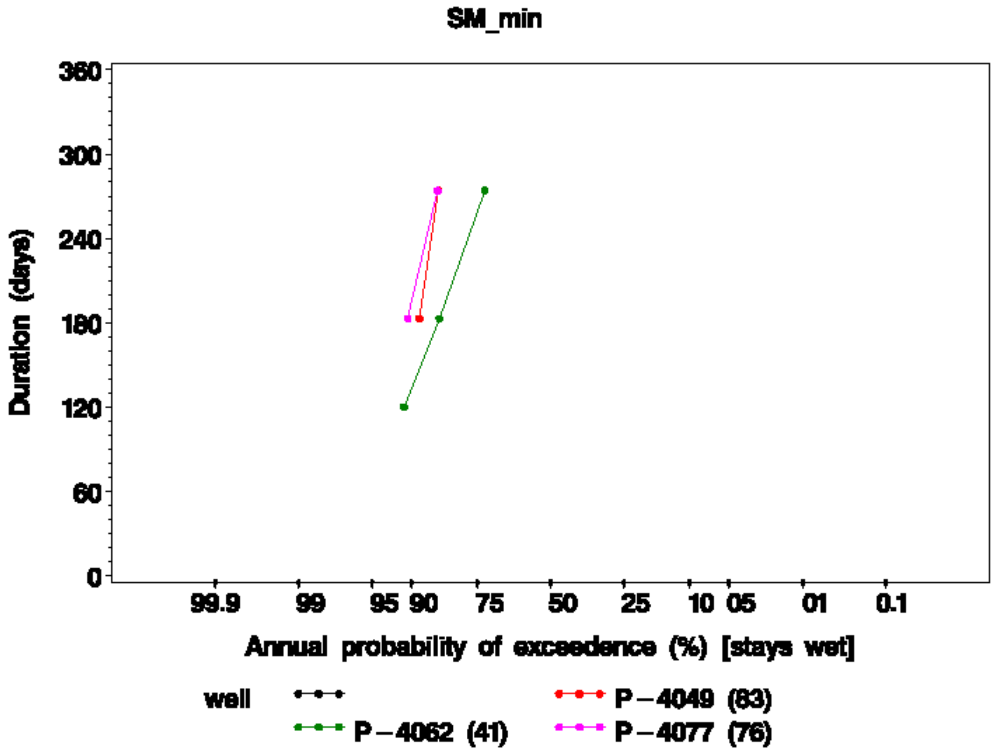


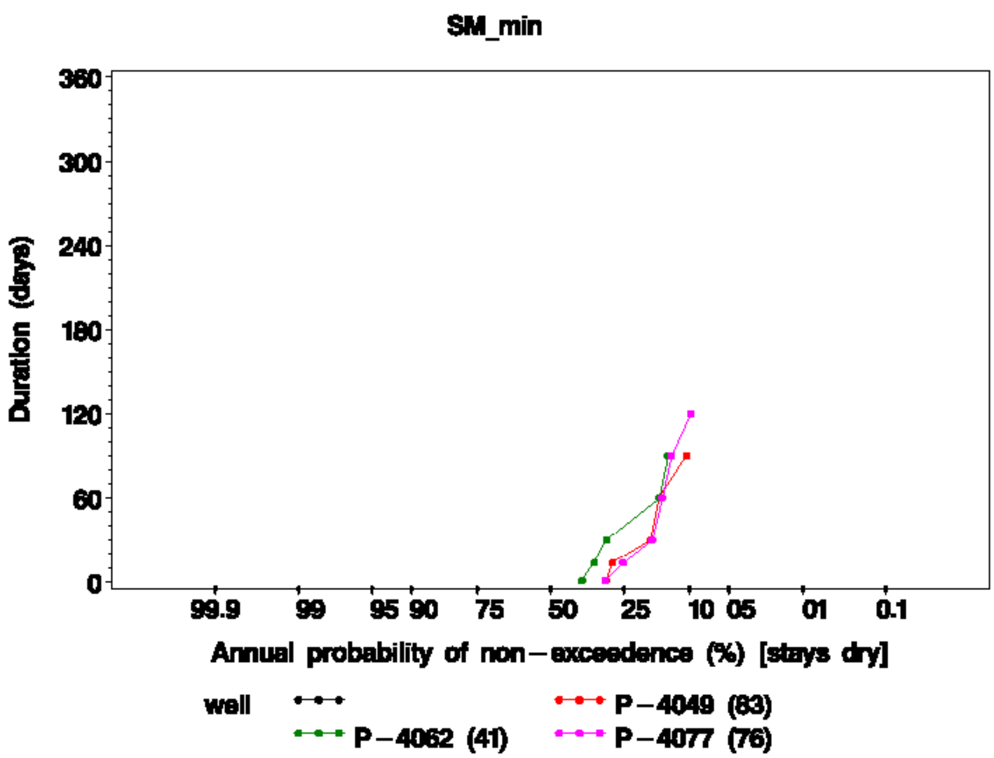
Appendix D.17. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *shallow marsh mean* elevation (SM_mean)



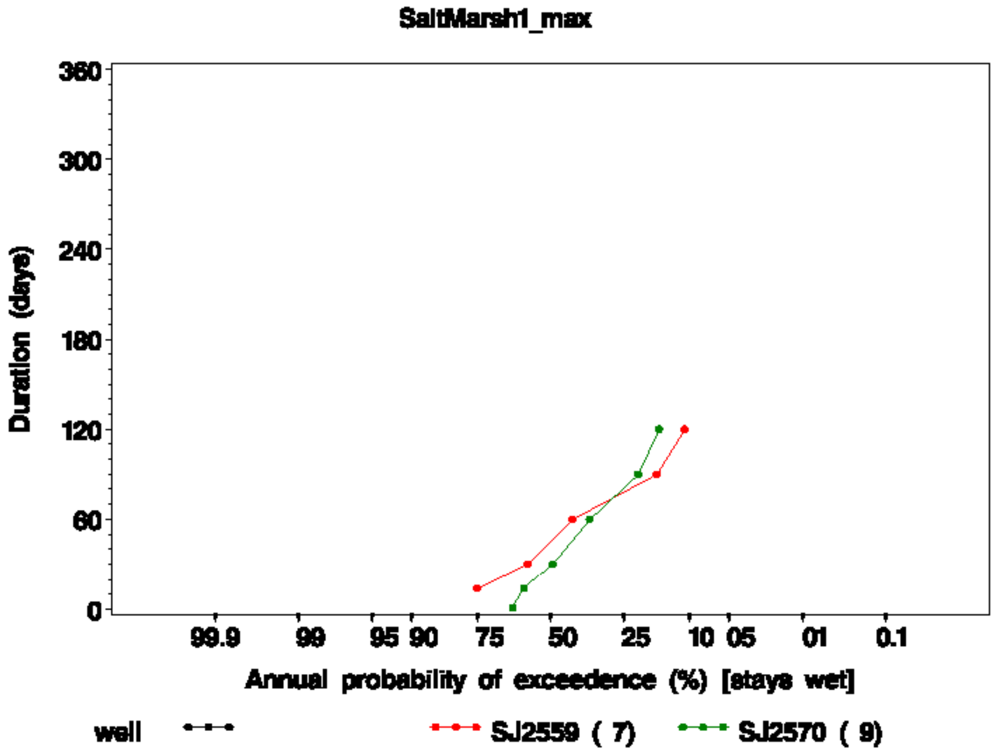


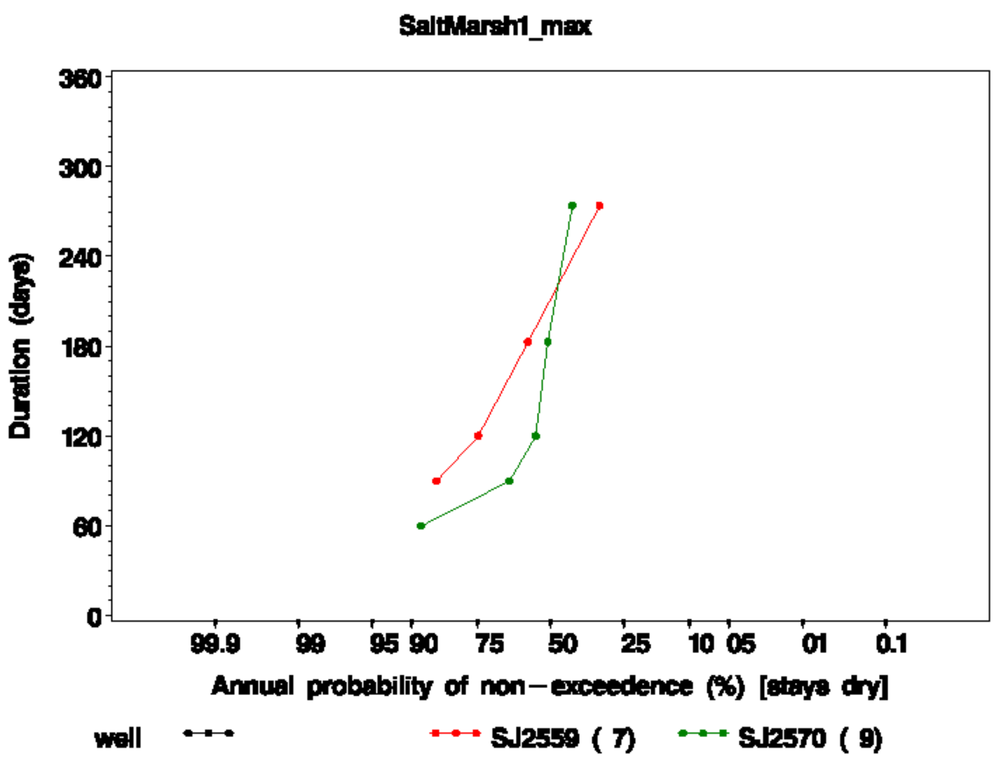
Appendix D.18. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *shallow marsh minimum* elevation (SM_min)



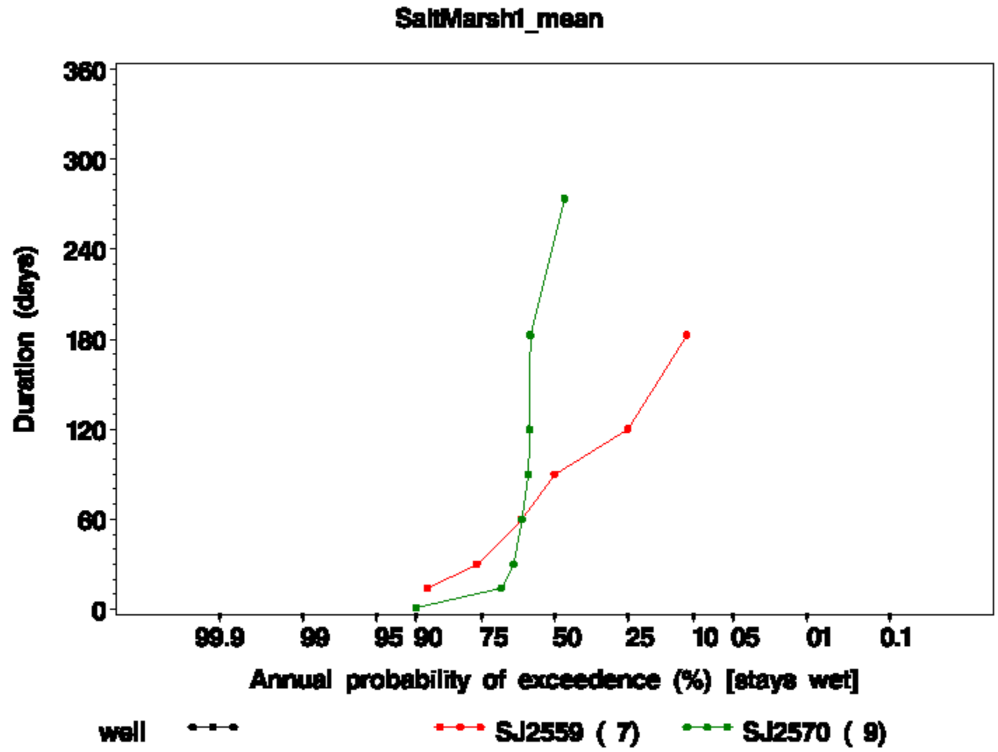


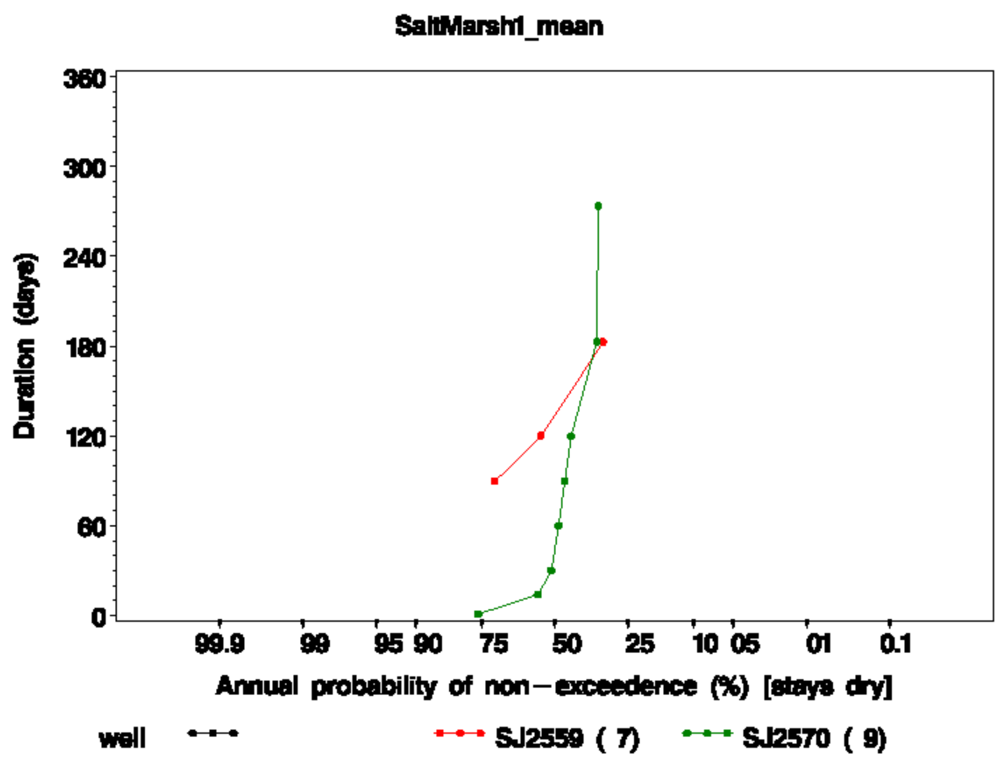
Appendix D.19. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *salt marsh 1 maximum* elevation (SaltMarsh1_max)



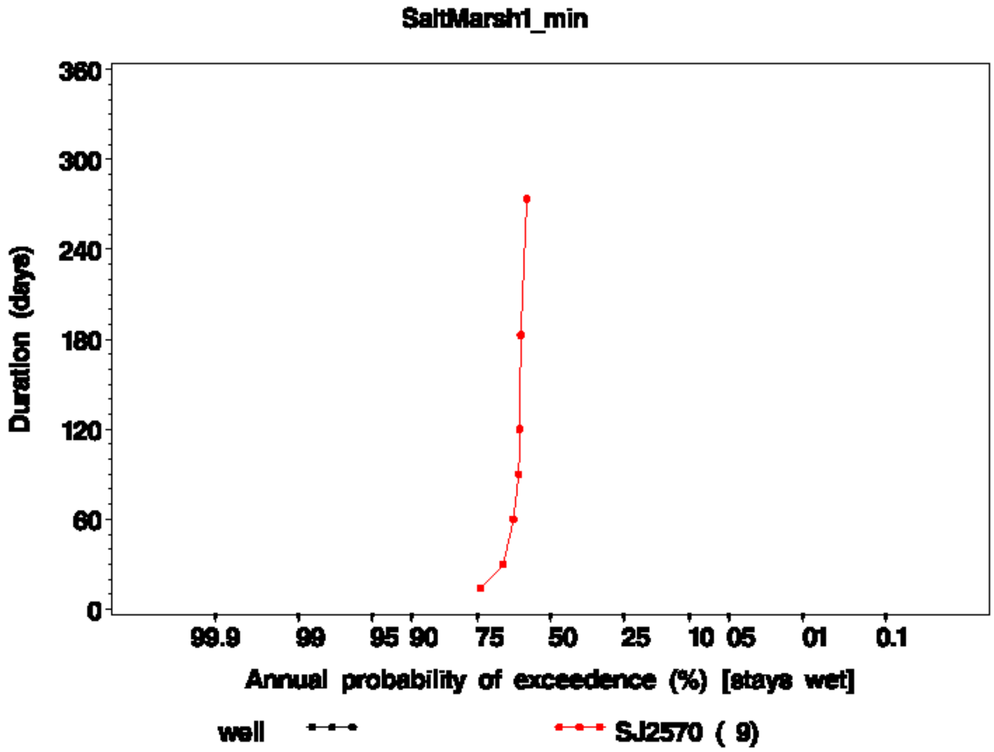


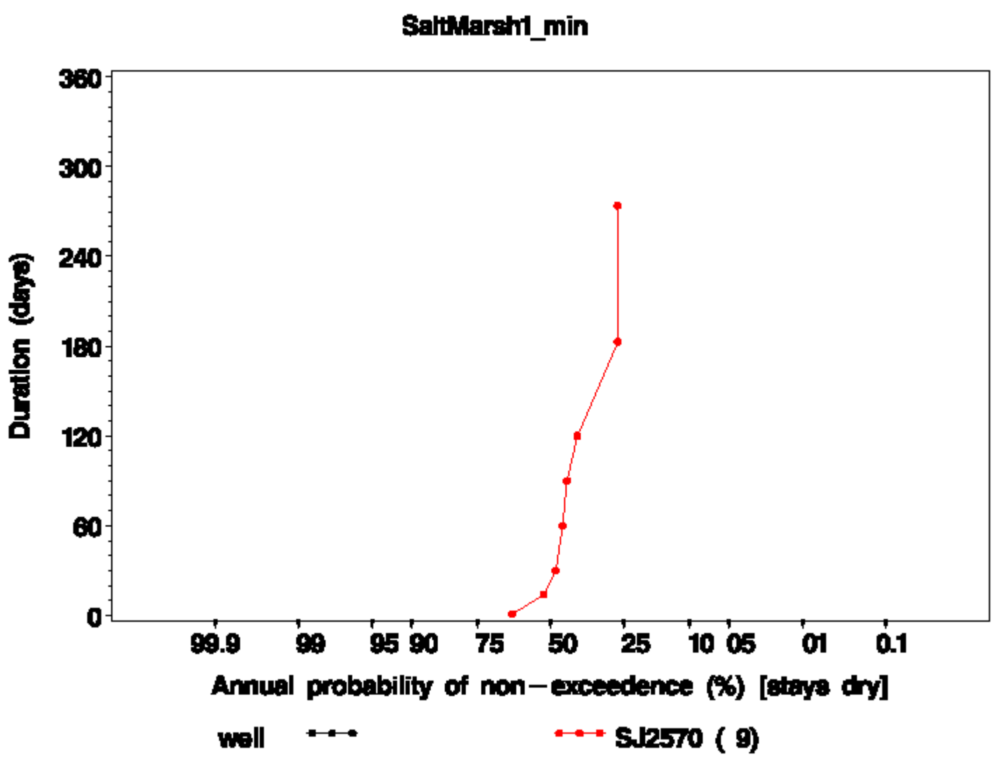
Appendix D.20. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *salt marsh 1 mean* elevation (SaltMarsh1_mean)



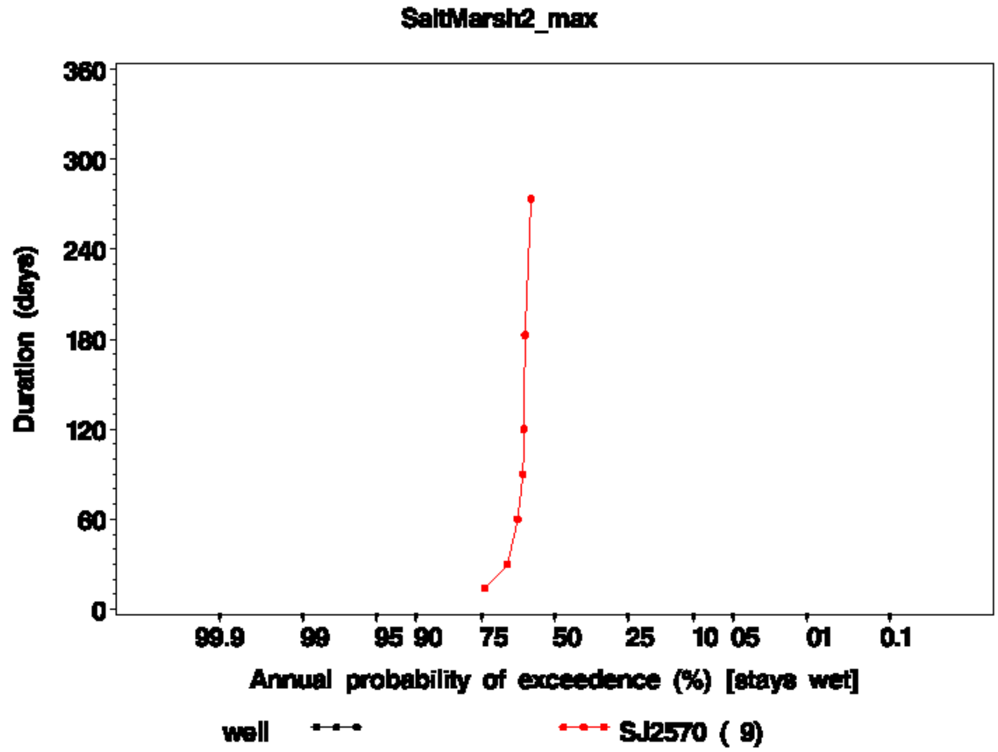


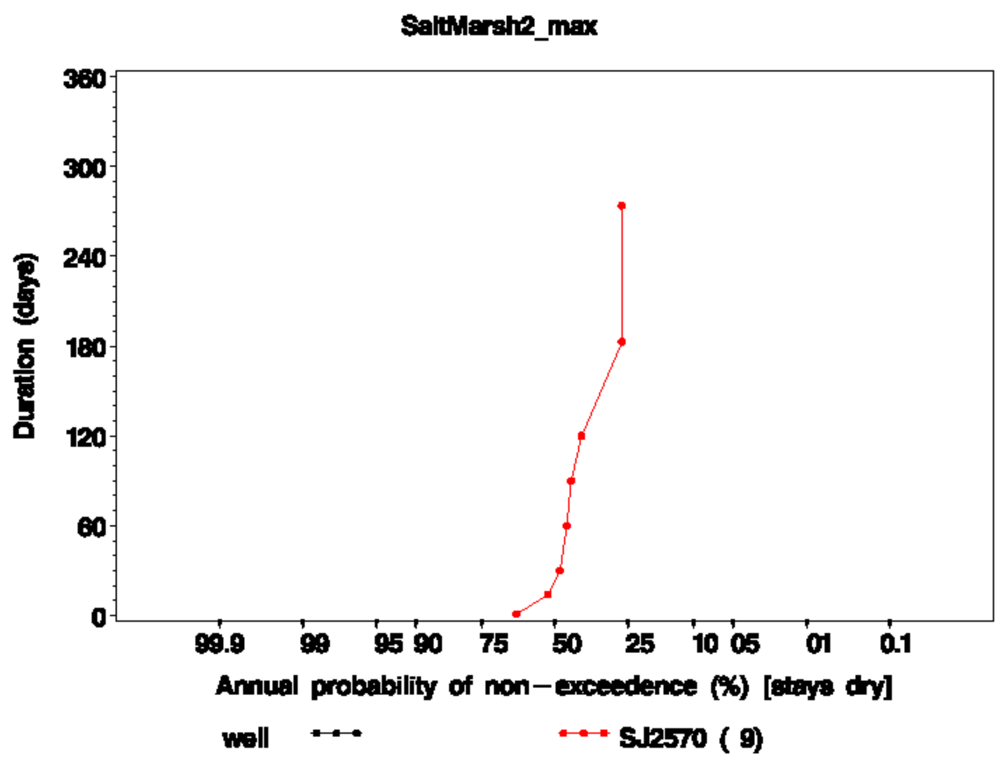
Appendix D.21. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *salt marsh 1 minimum* elevation (SaltMarsh1_min)



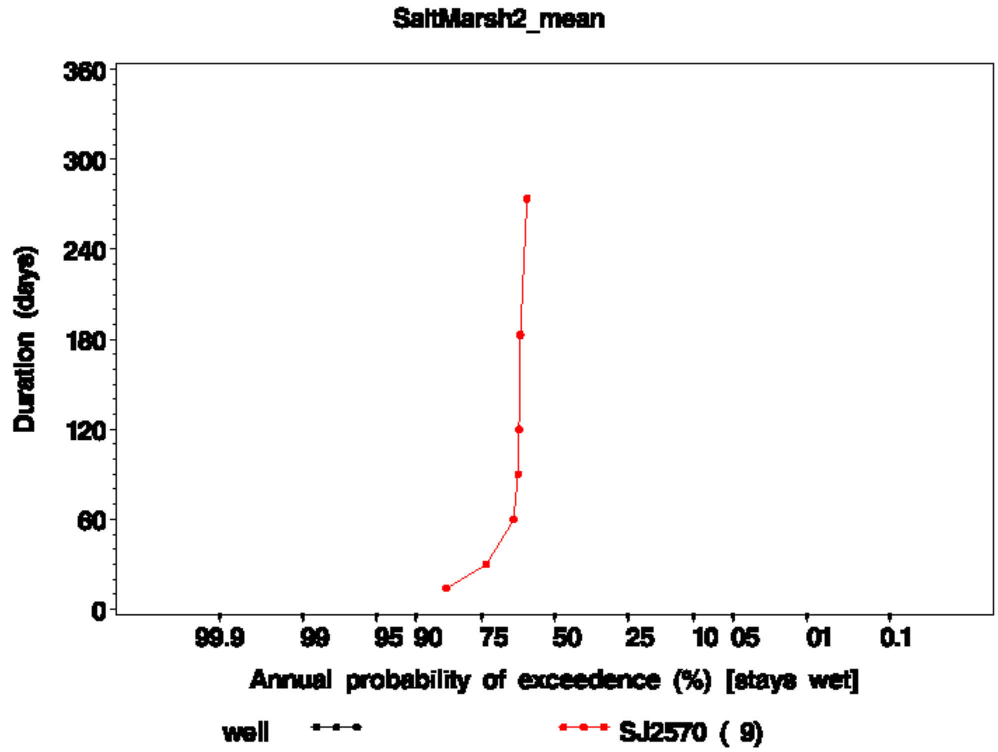


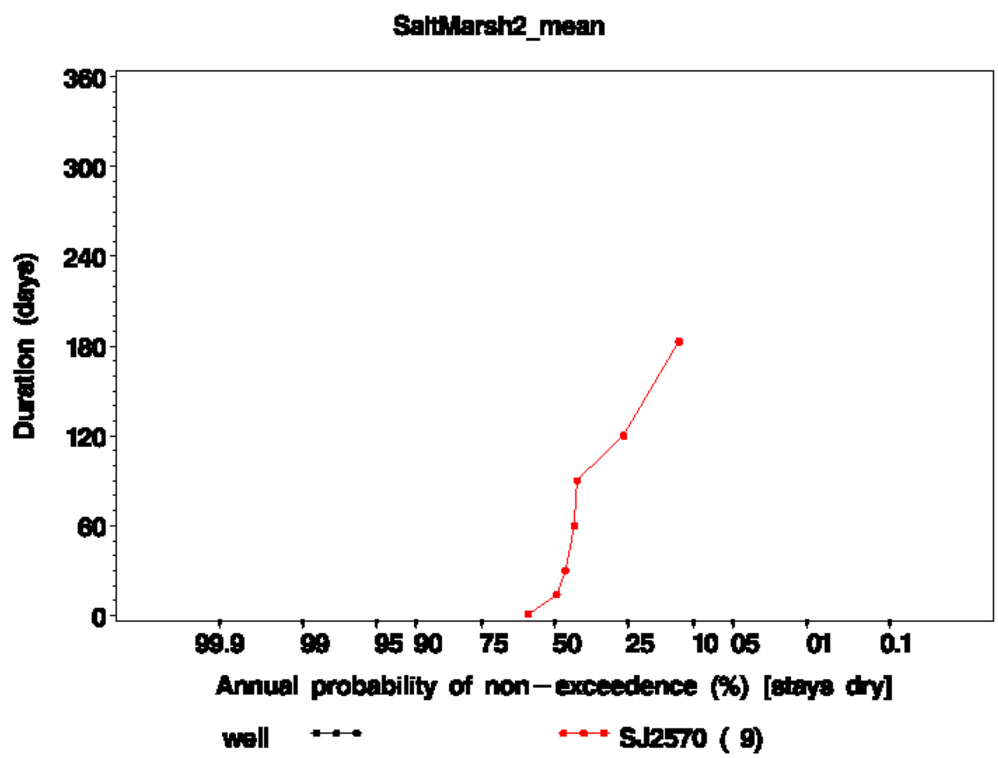
Appendix D.22. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland *indicator salt marsh 2 maximum* elevation (SaltMarsh2_max)



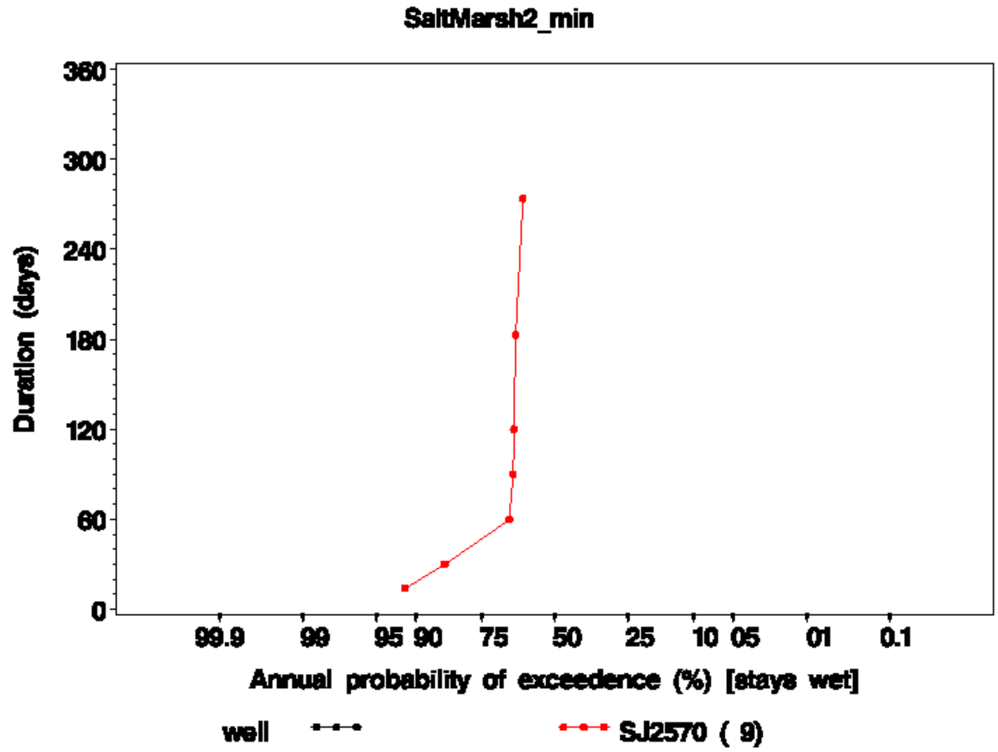


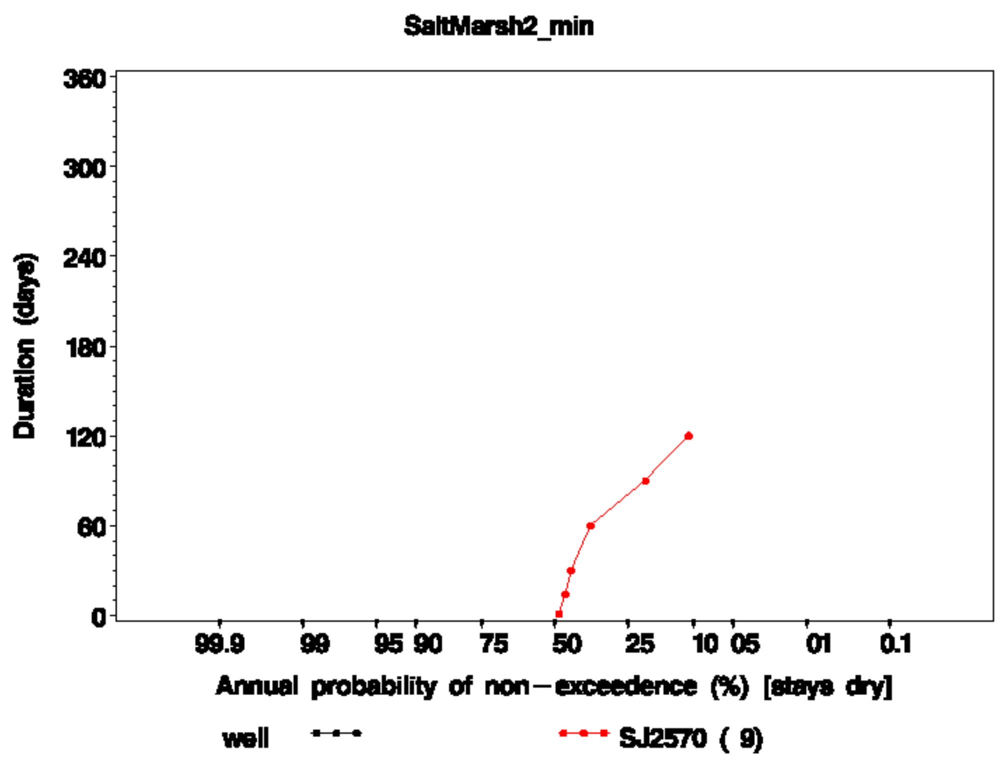
Appendix D.23. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *salt marsh 2 mean* elevation (SaltMarsh2_mean)



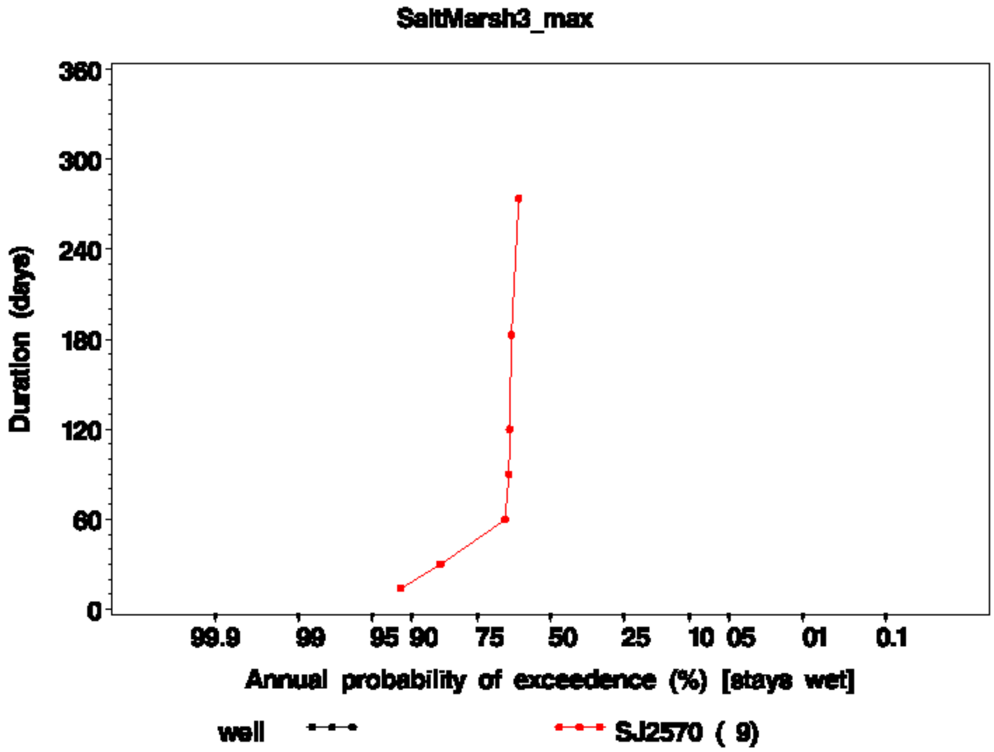


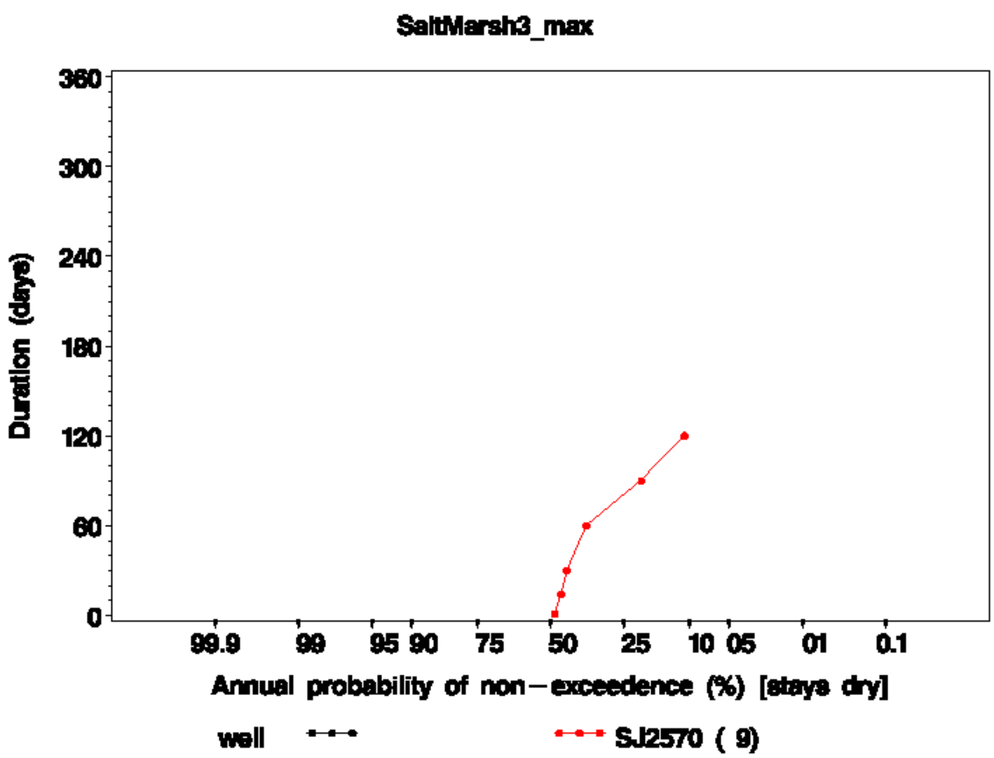
Appendix D.24. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *salt marsh 2 minimum* elevation (SaltMarsh2_min)



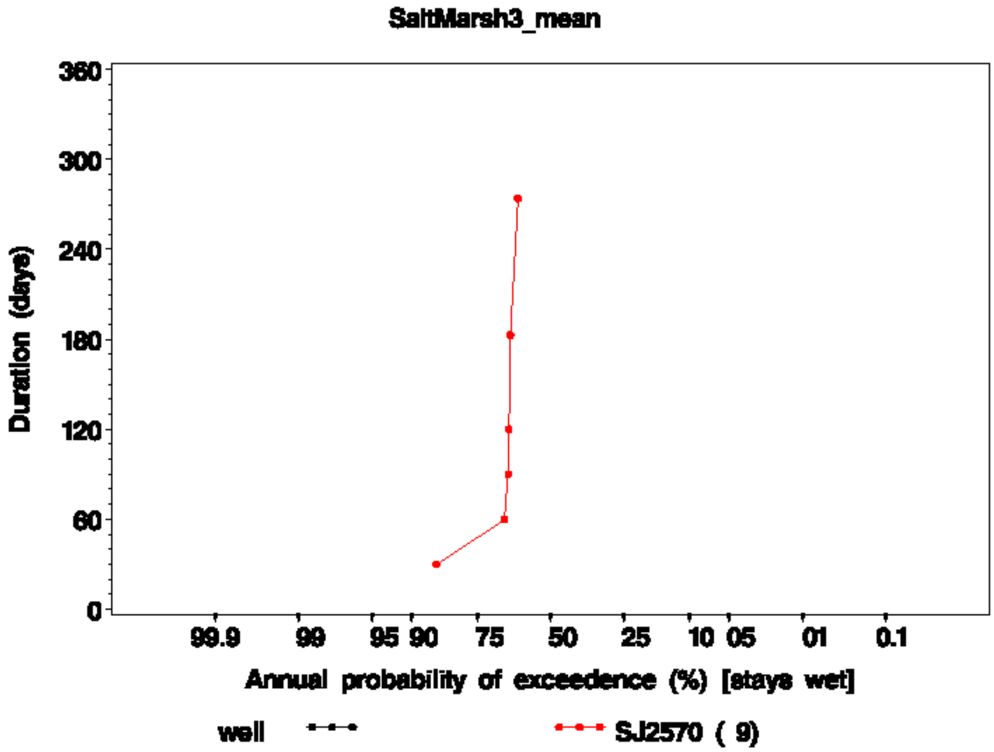


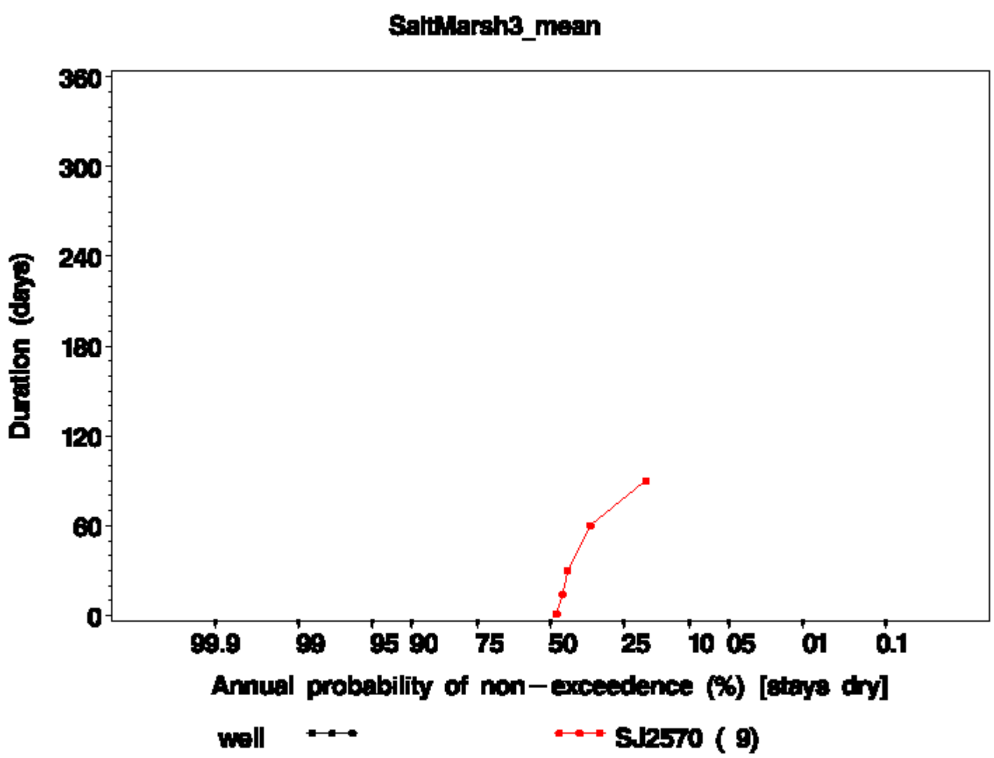
Appendix D.25. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *salt marsh 3 maximum* elevation (SaltMarsh3_max)



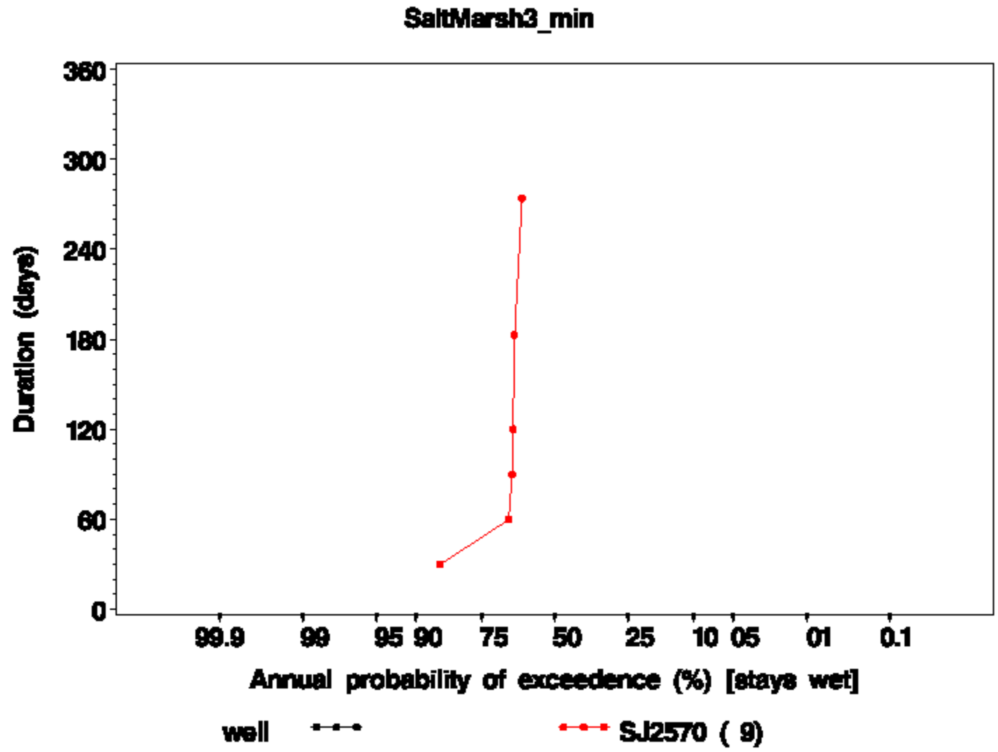


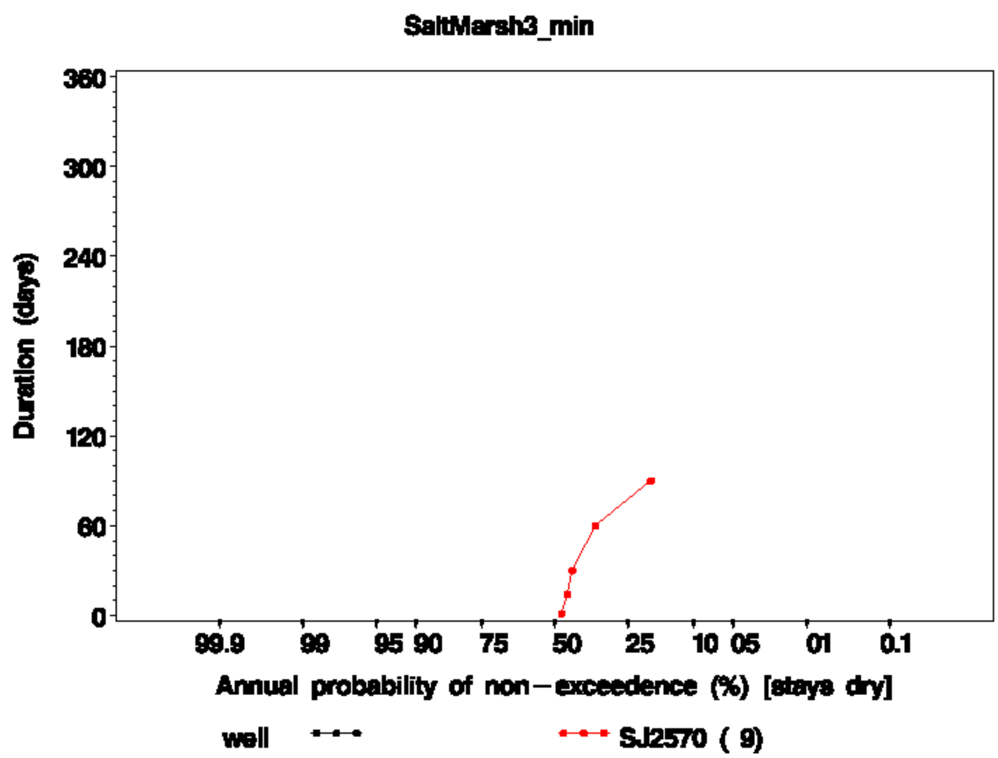
Appendix D.26. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *salt marsh 3 mean* elevation (SaltMarsh3_mean)



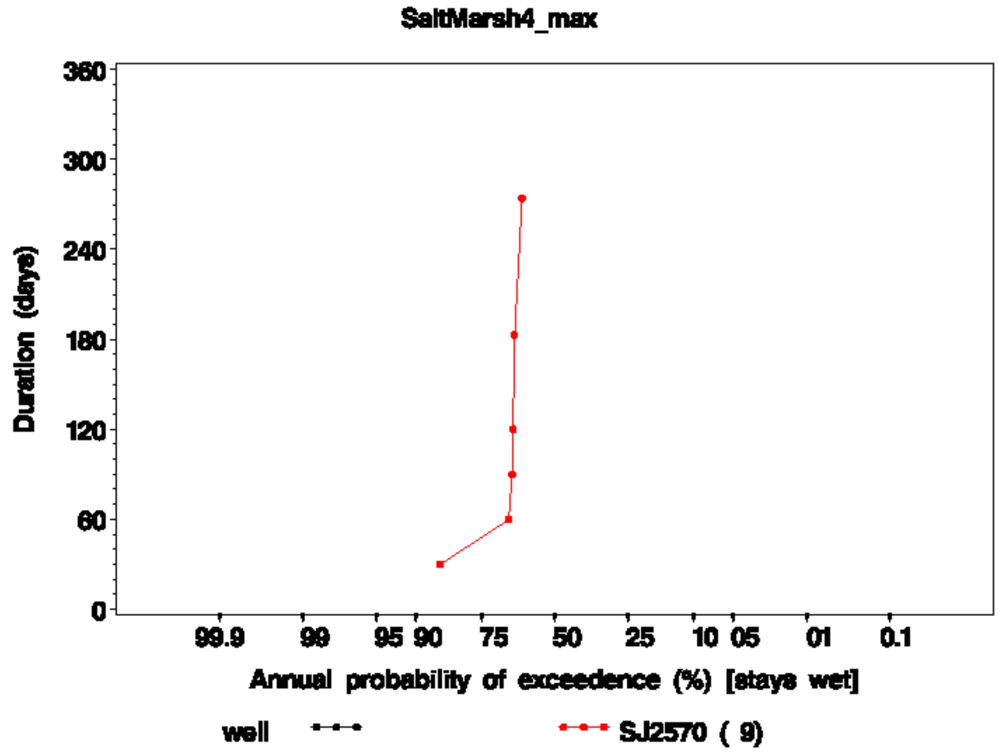


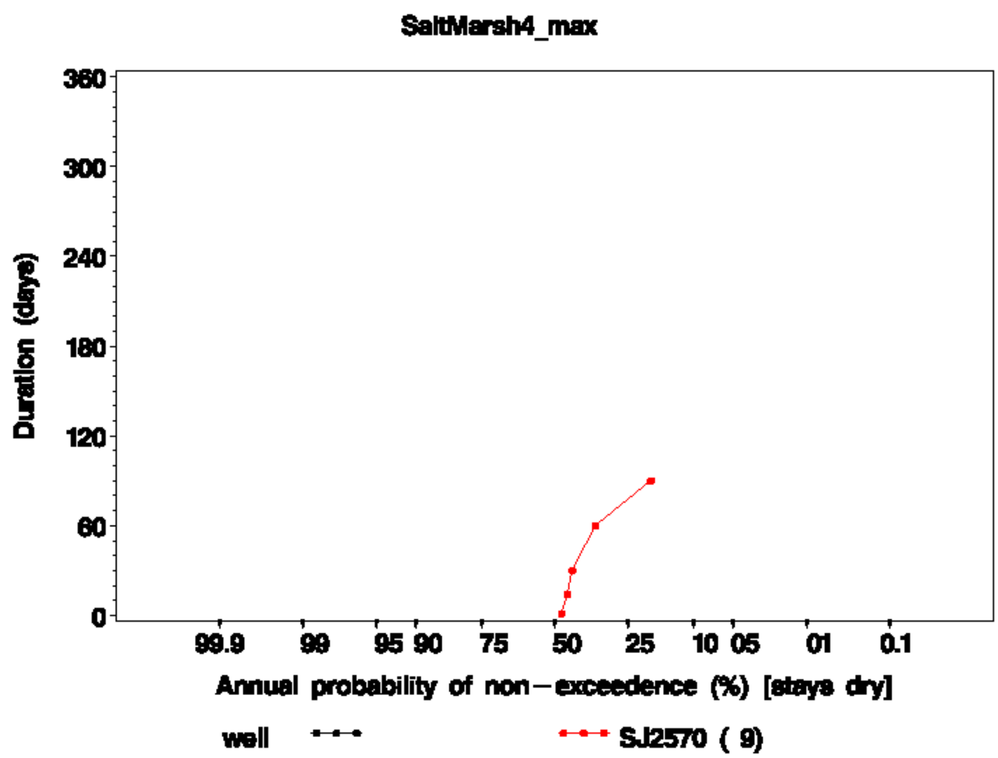
Appendix D.27. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *salt marsh 3 minimum* elevation (SaltMarsh3_min)



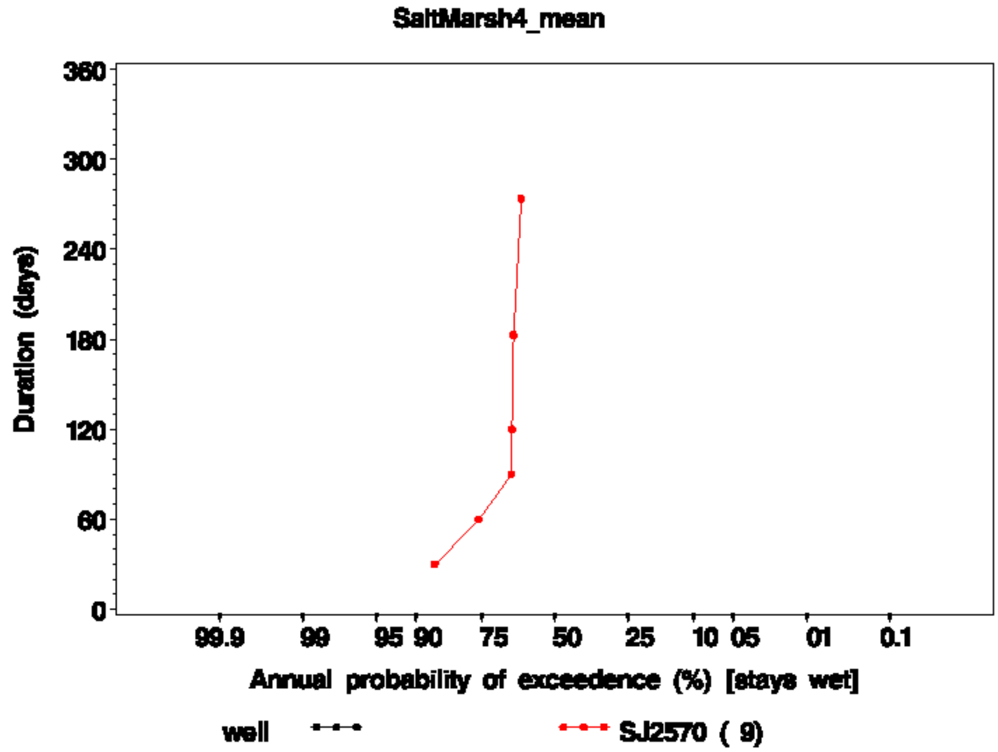


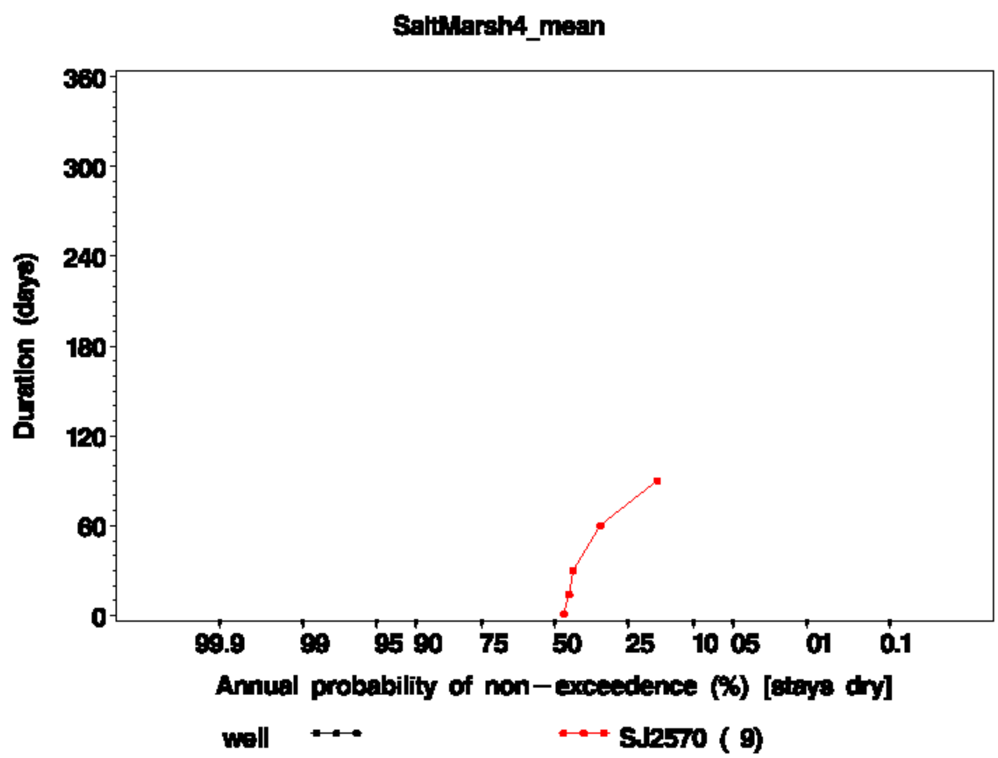
Appendix D.28. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *salt marsh 4 maximum* elevation (SaltMarsh4_max)



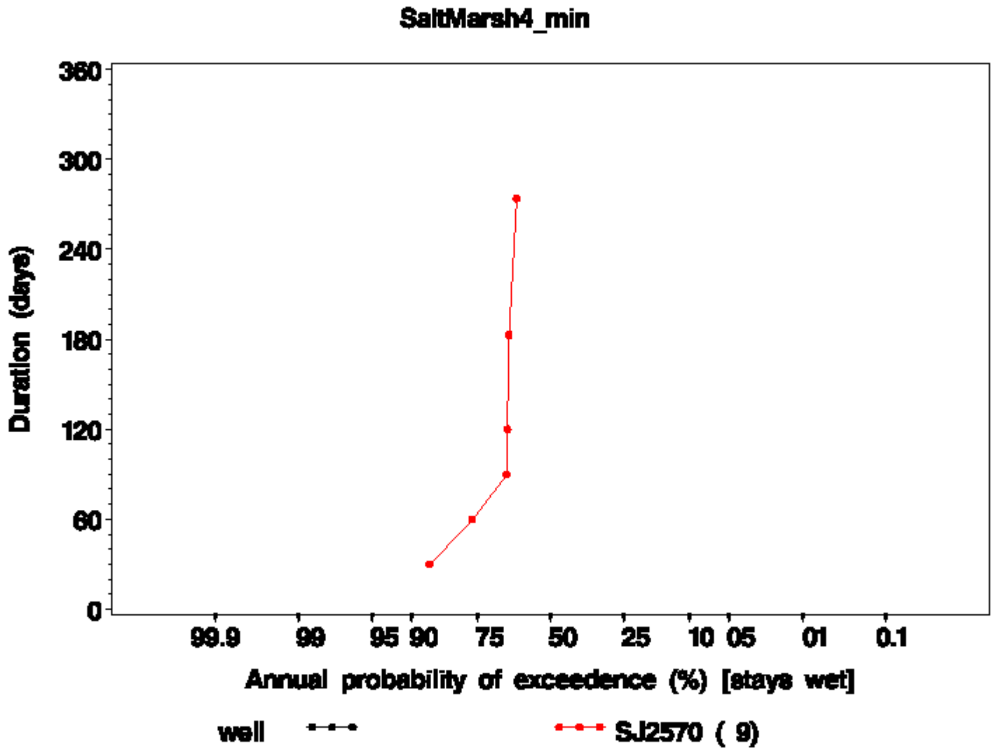


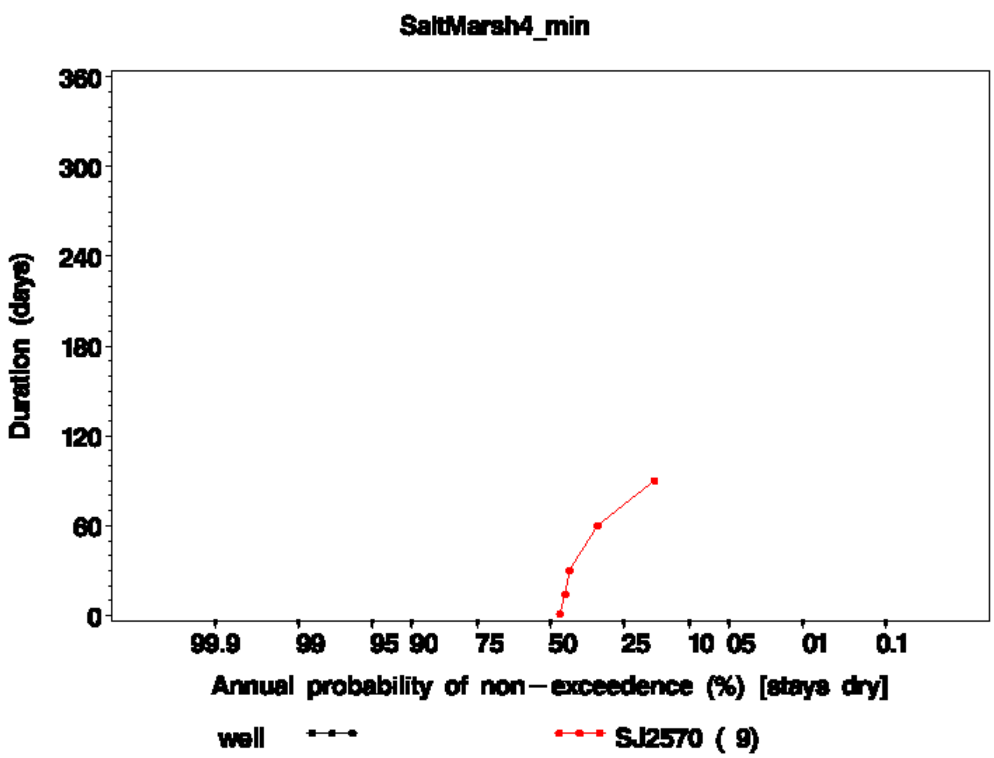
Appendix D.29. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *salt marsh 4 mean* elevation (SaltMarsh4_mean)



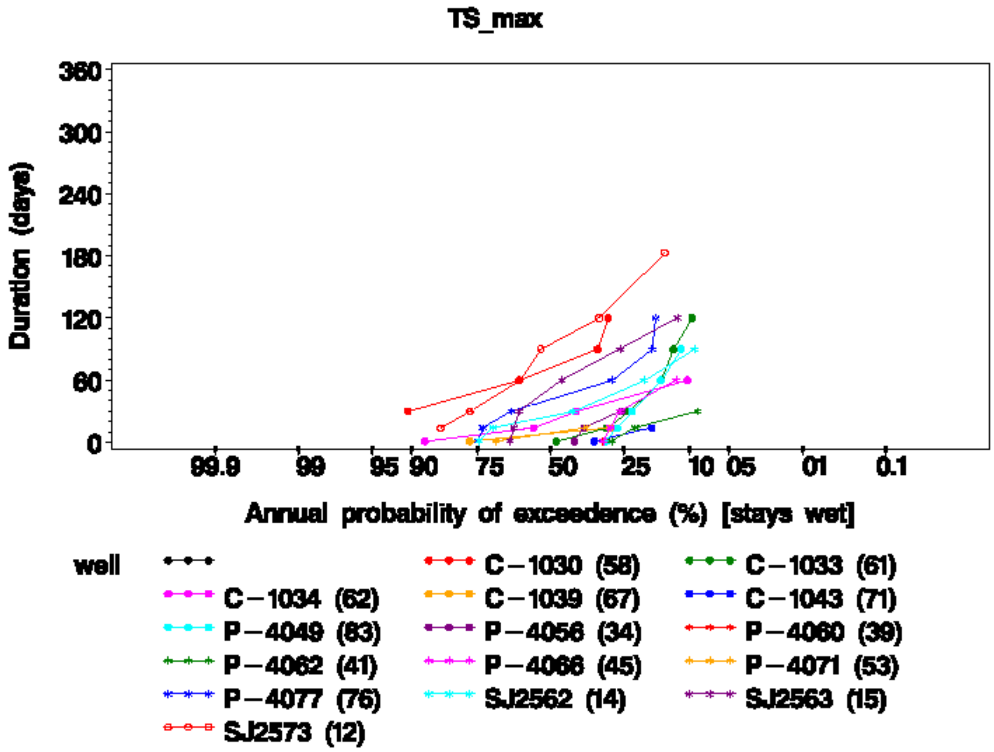


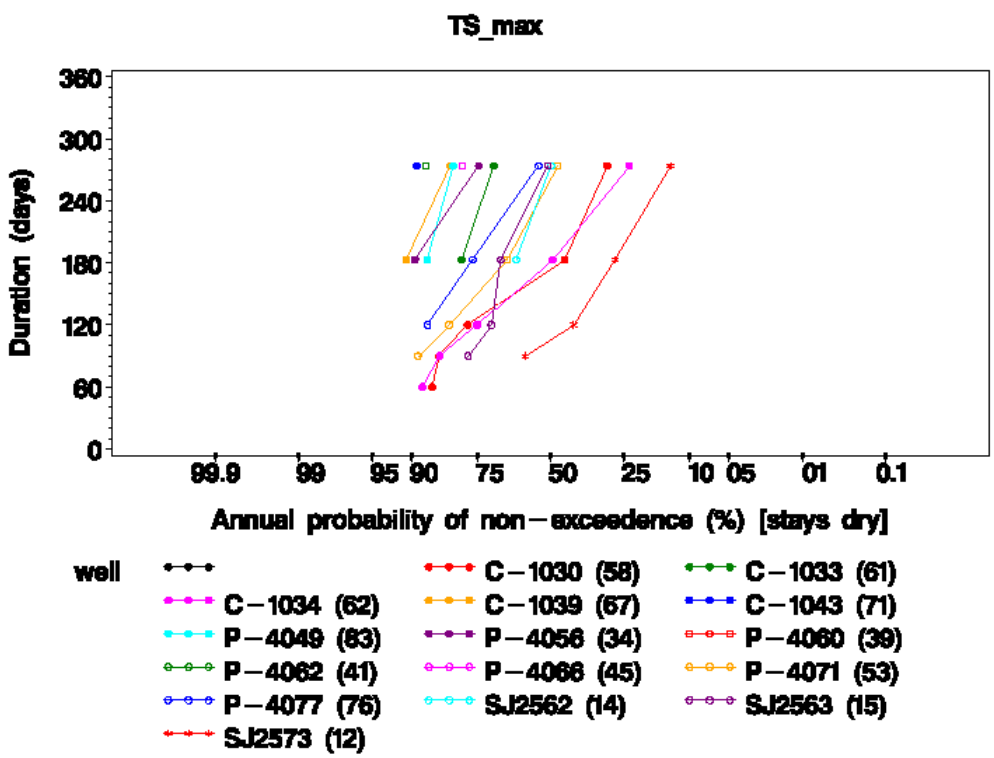
Appendix D.30. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *salt marsh 4 minimum* elevation (SaltMarsh4_min)



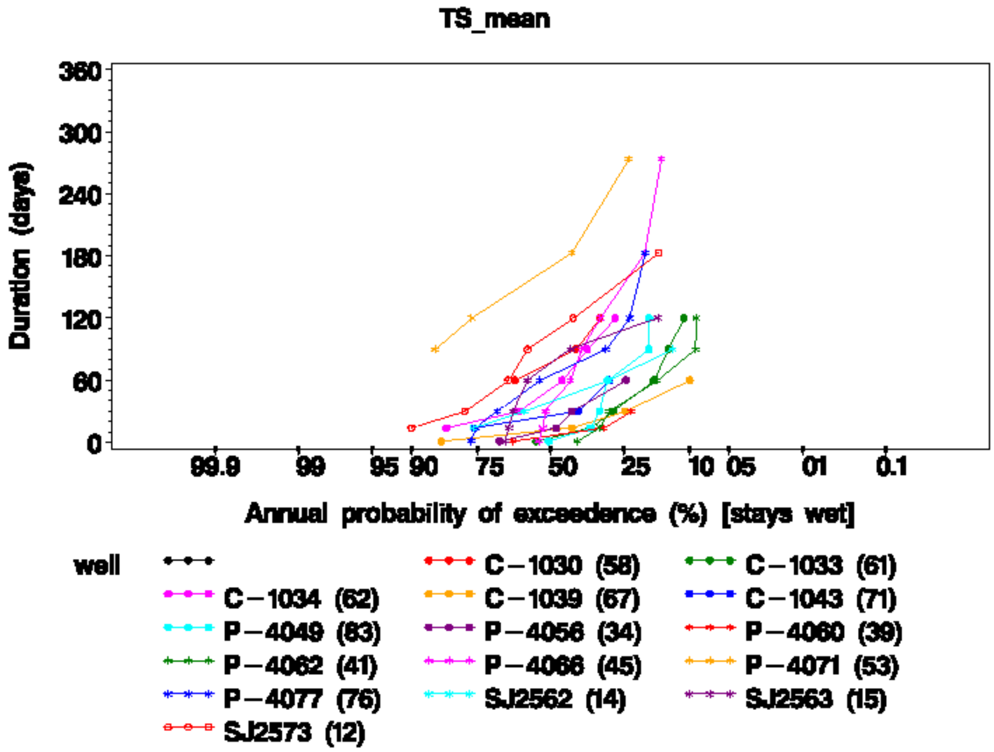


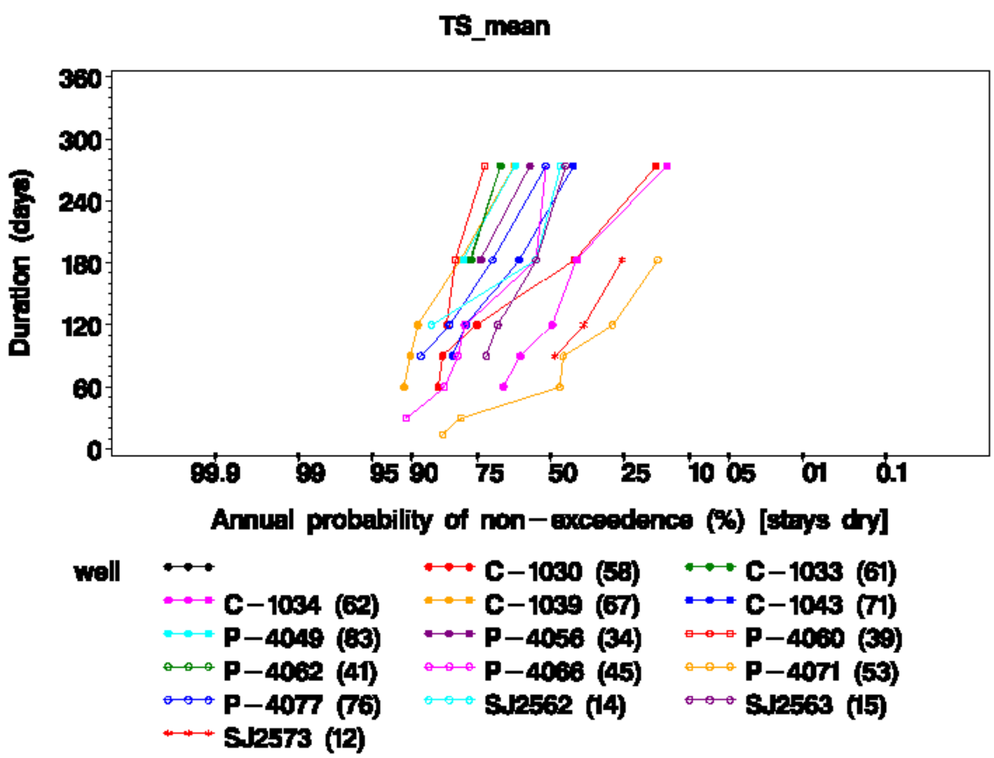
Appendix D.31. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *transitional shrub maximum* elevation (TS_max)



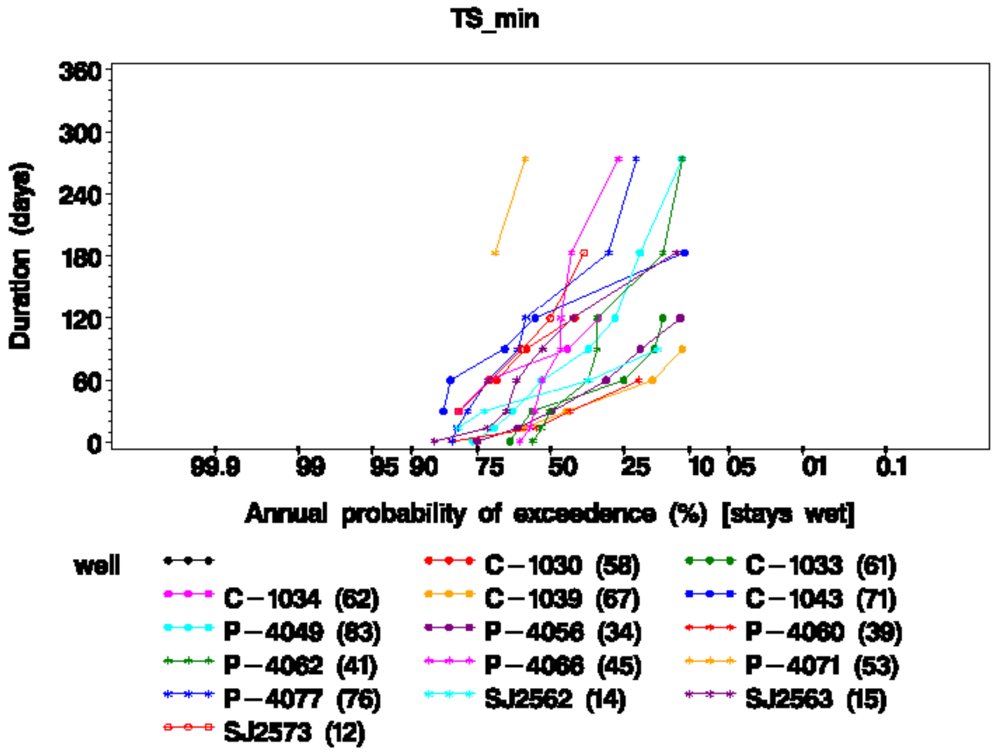


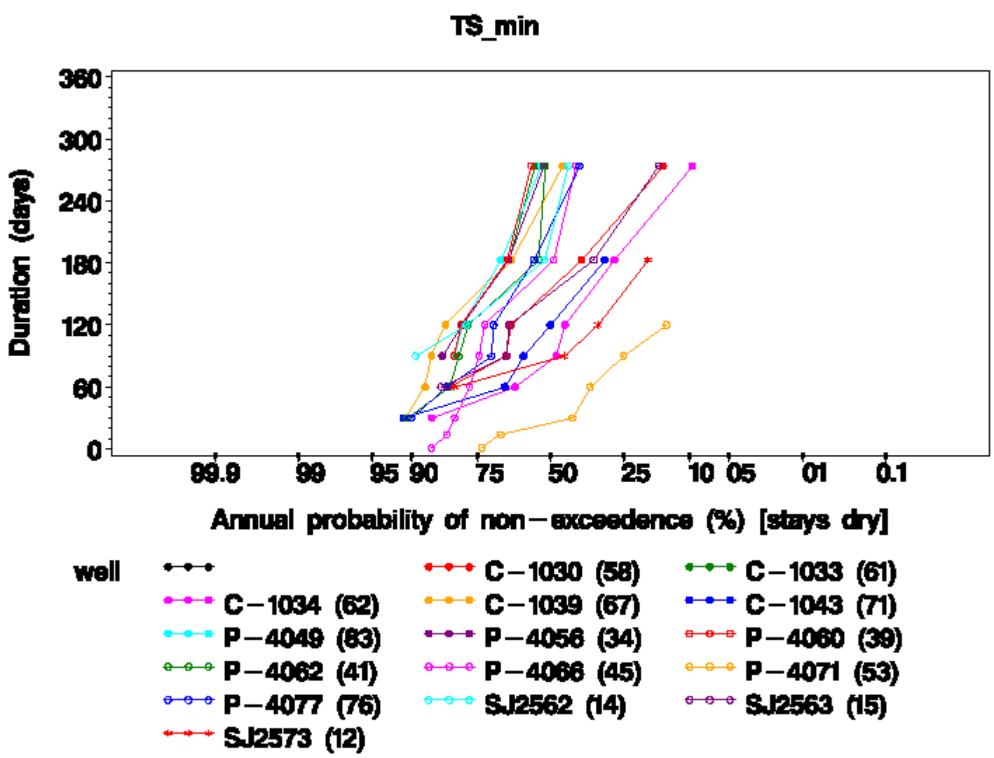
Appendix D.32. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *transitional shrub mean* elevation (TS_mean)



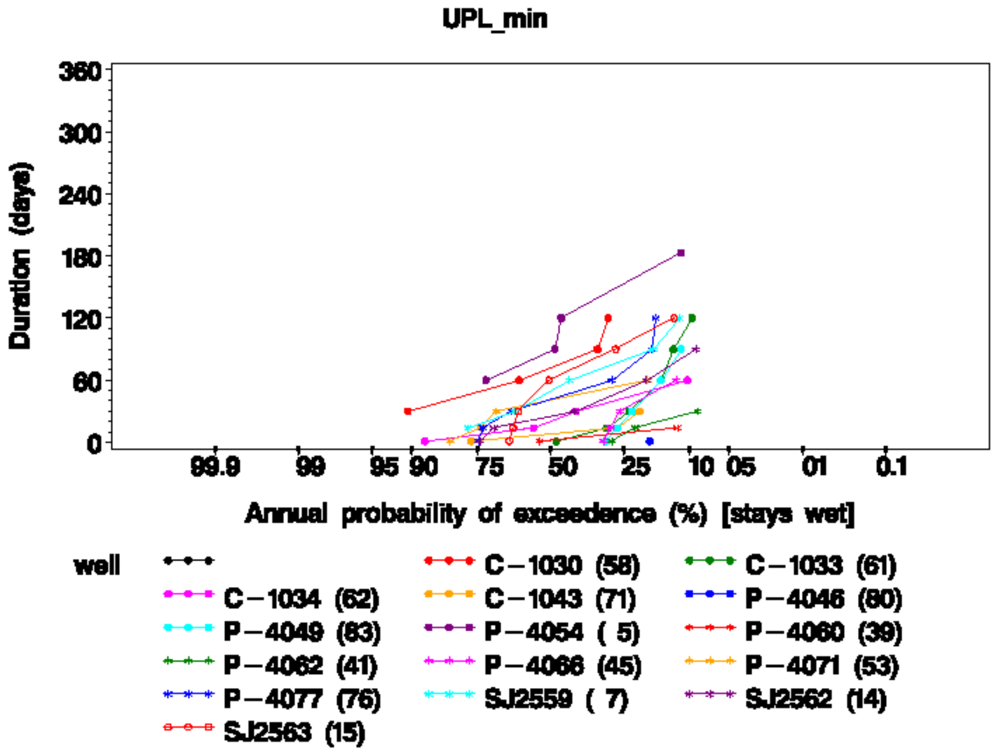


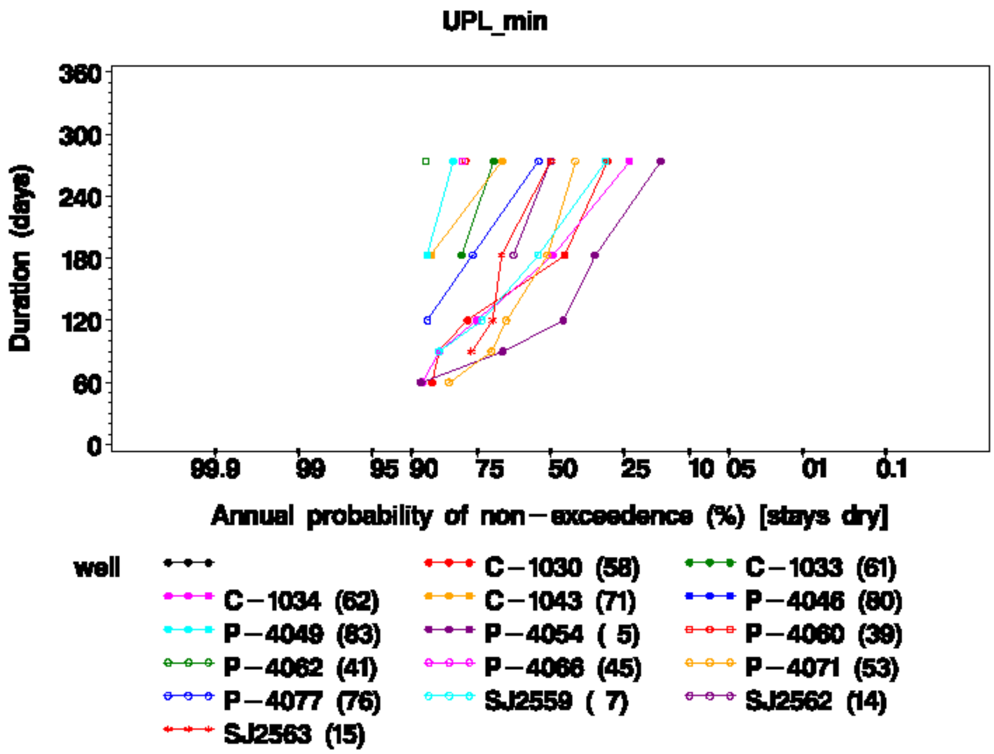
Appendix D.33. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *transitional shrub minimum* elevation (TS_min)



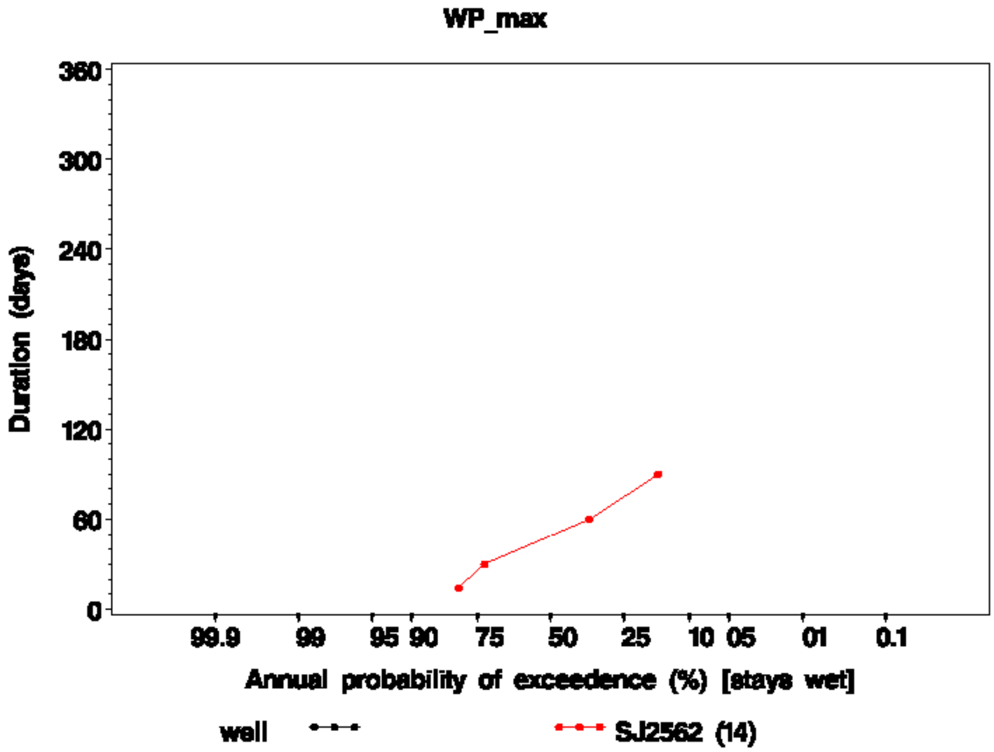


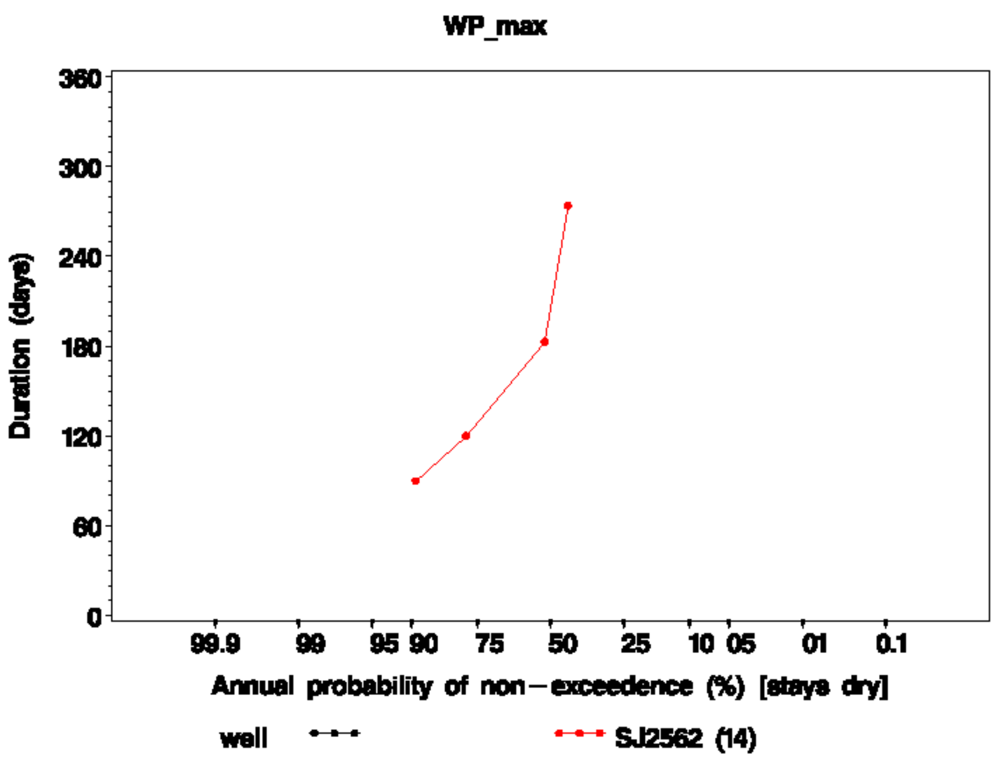
Appendix D.34. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *upland minimum* elevation (UPL_min)



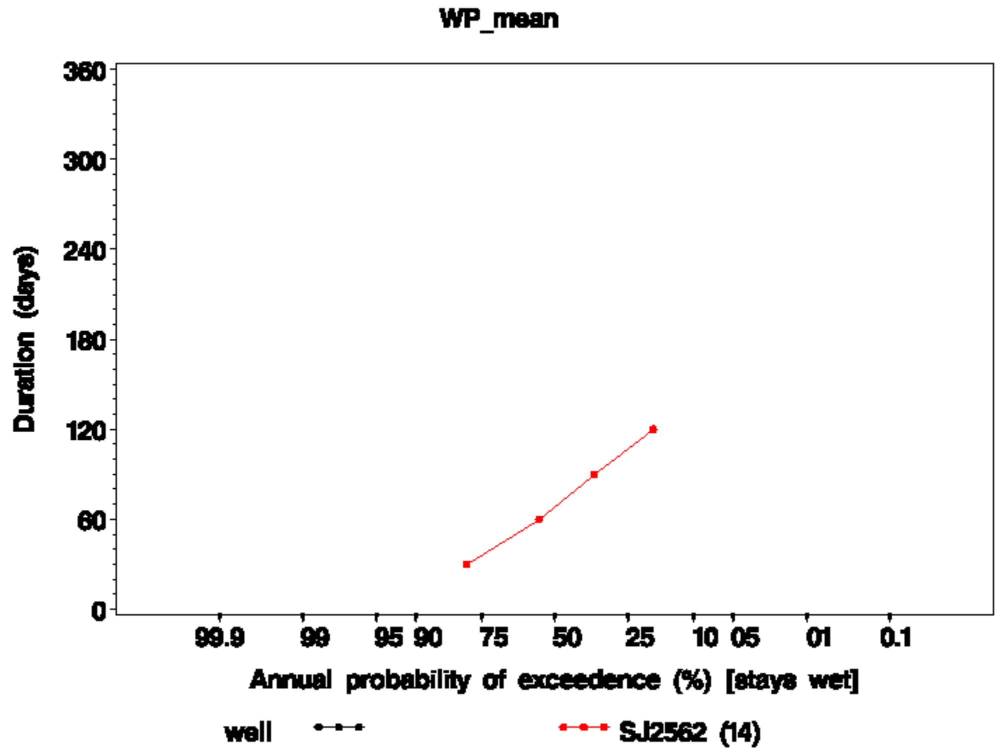


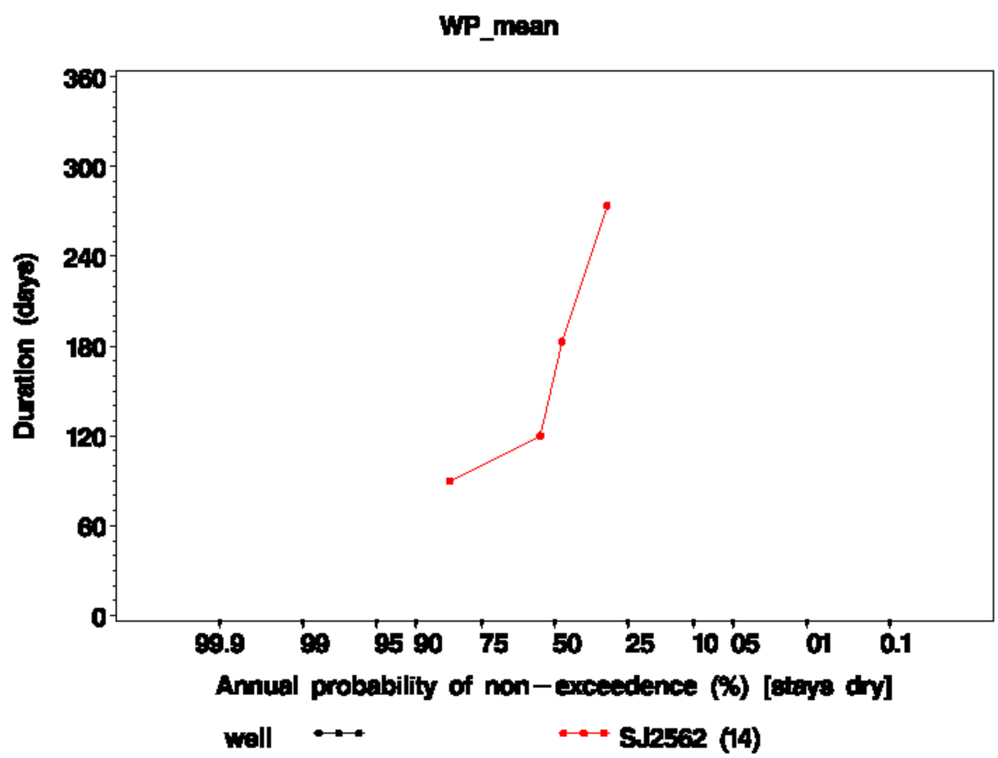
Appendix D.35. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *wet prairie maximum* elevation (WP_max)



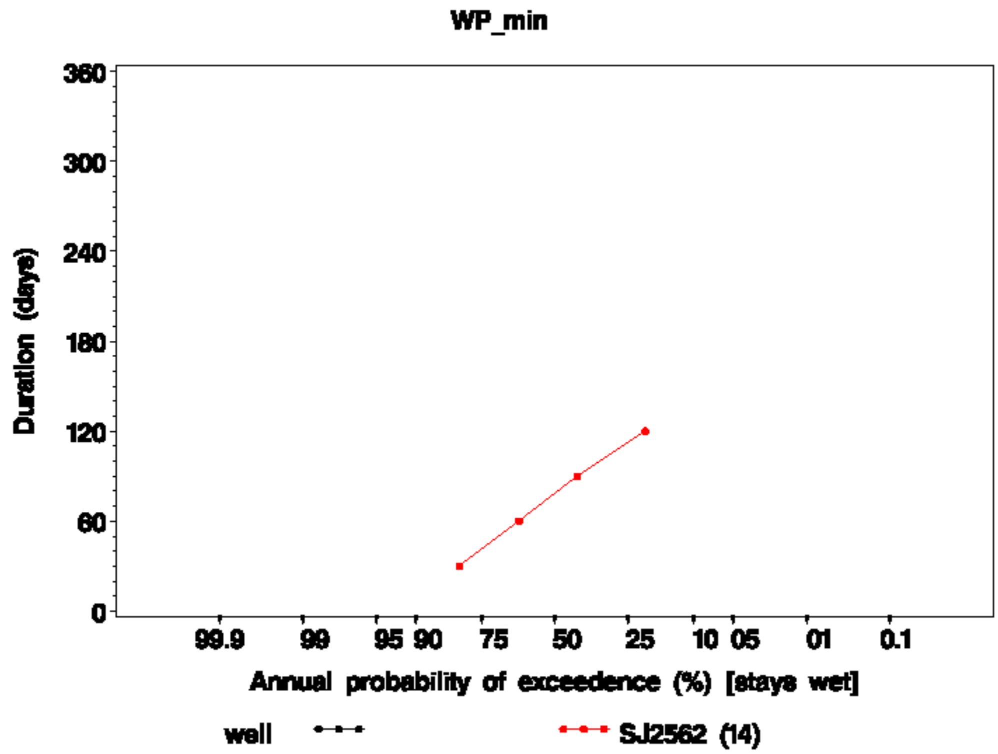


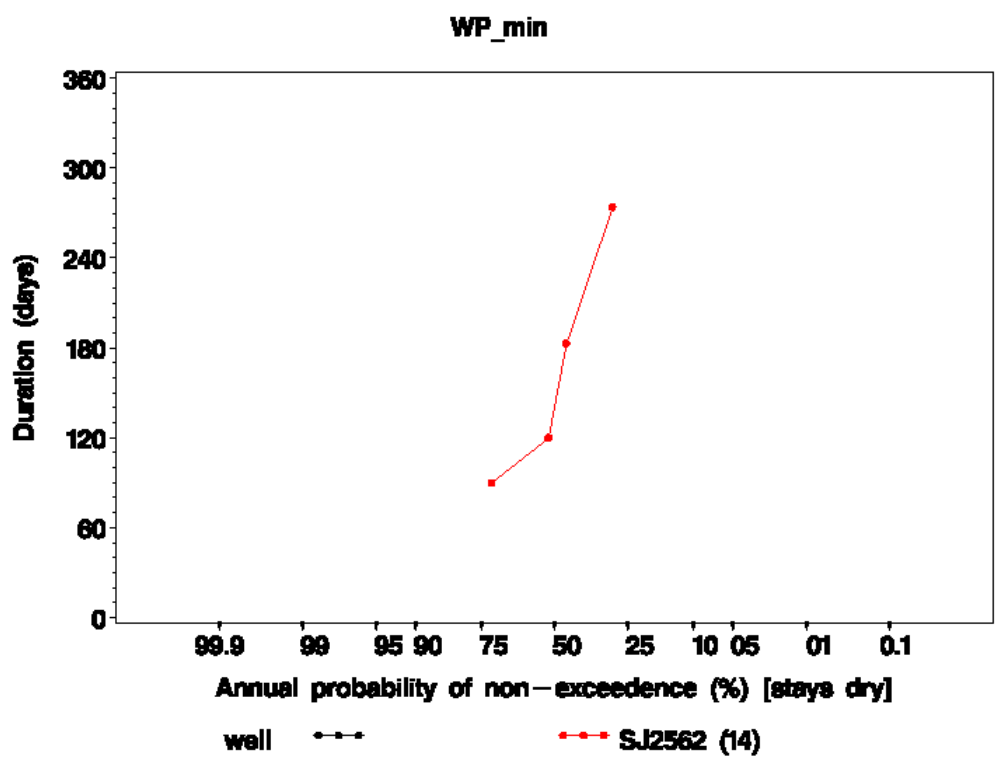
Appendix D.36. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *wet prairie mean* elevation (WP_mean)





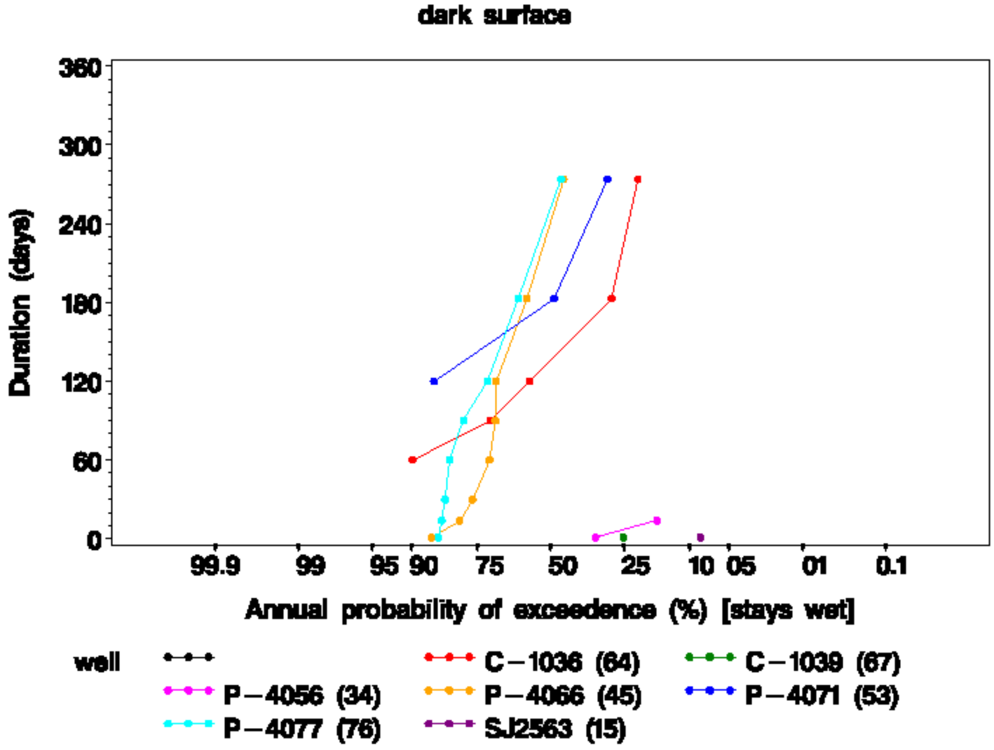
Appendix D.37. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the wetland indicator *wet prairie minimum* elevation (WP_min)

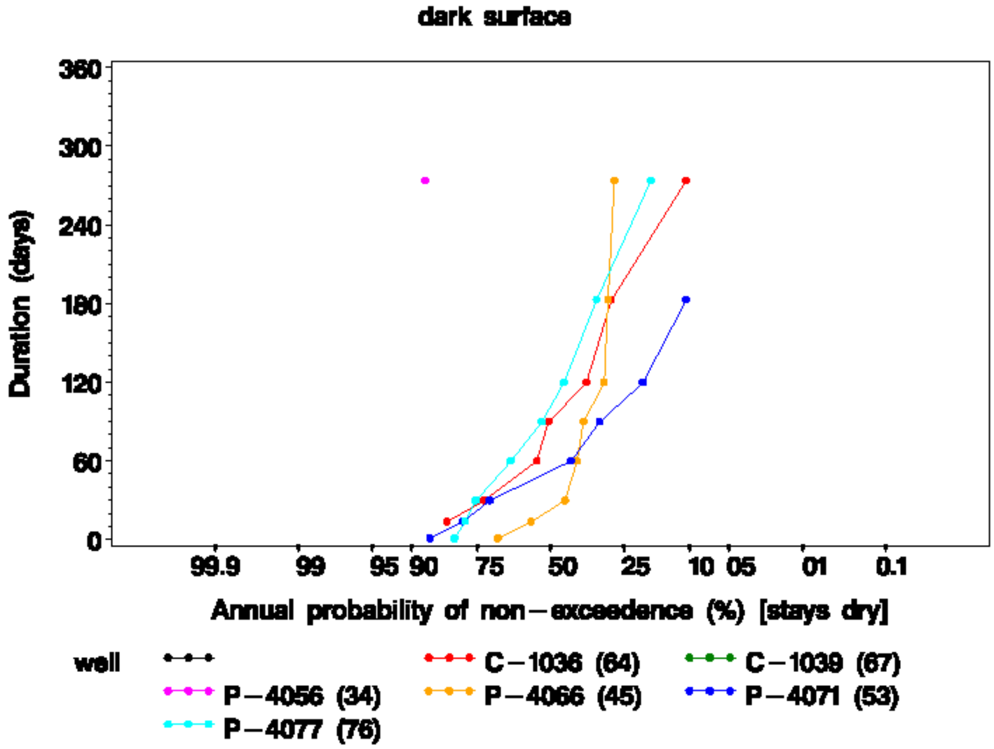




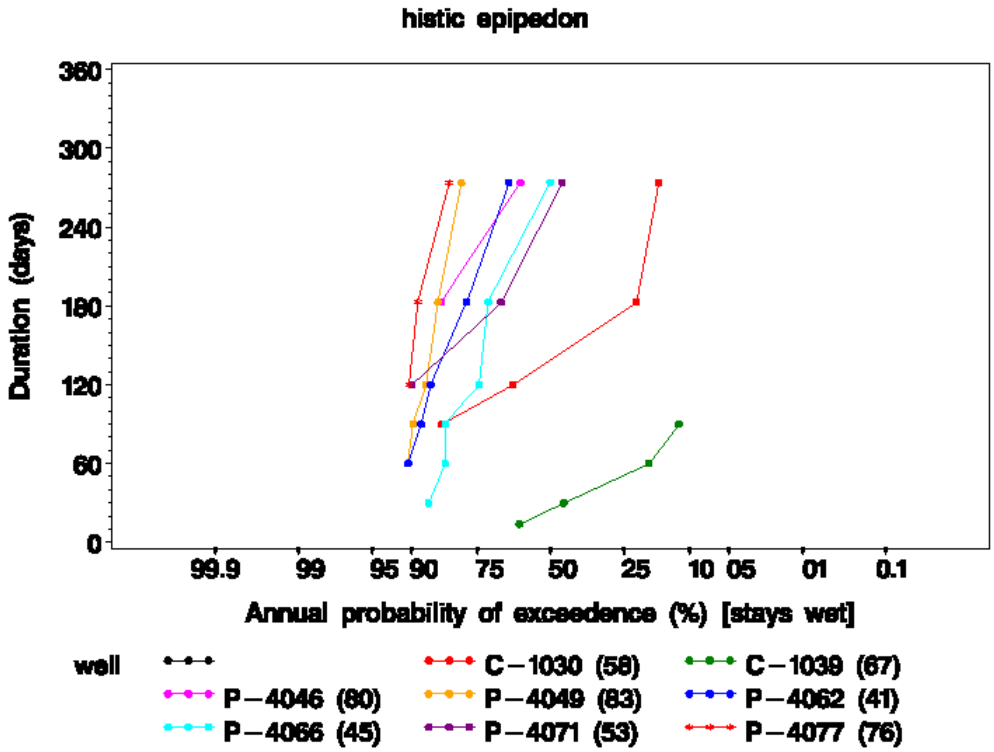
APPENDIX E

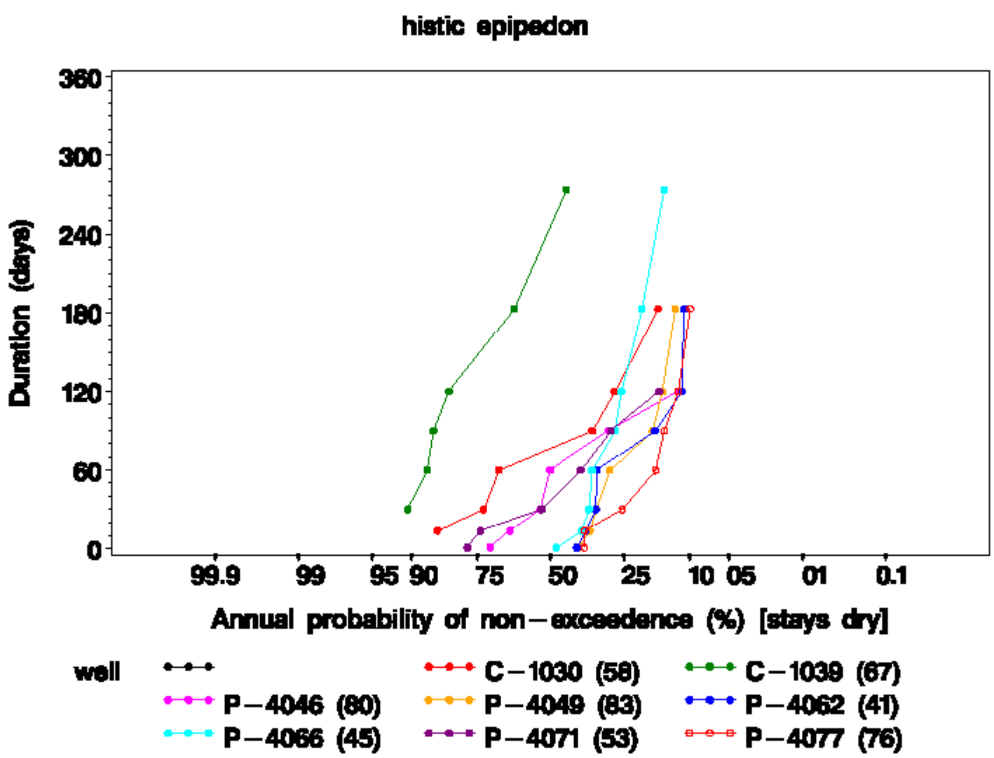
Appendix E.1. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the hydric soil indicator *dark surface* elevation



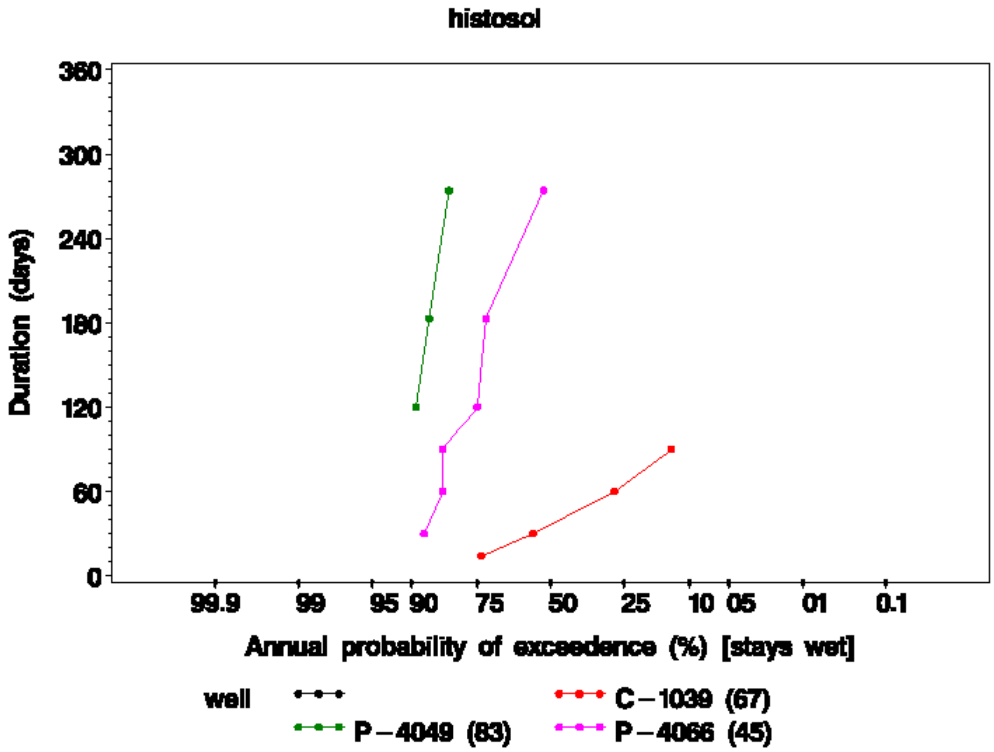


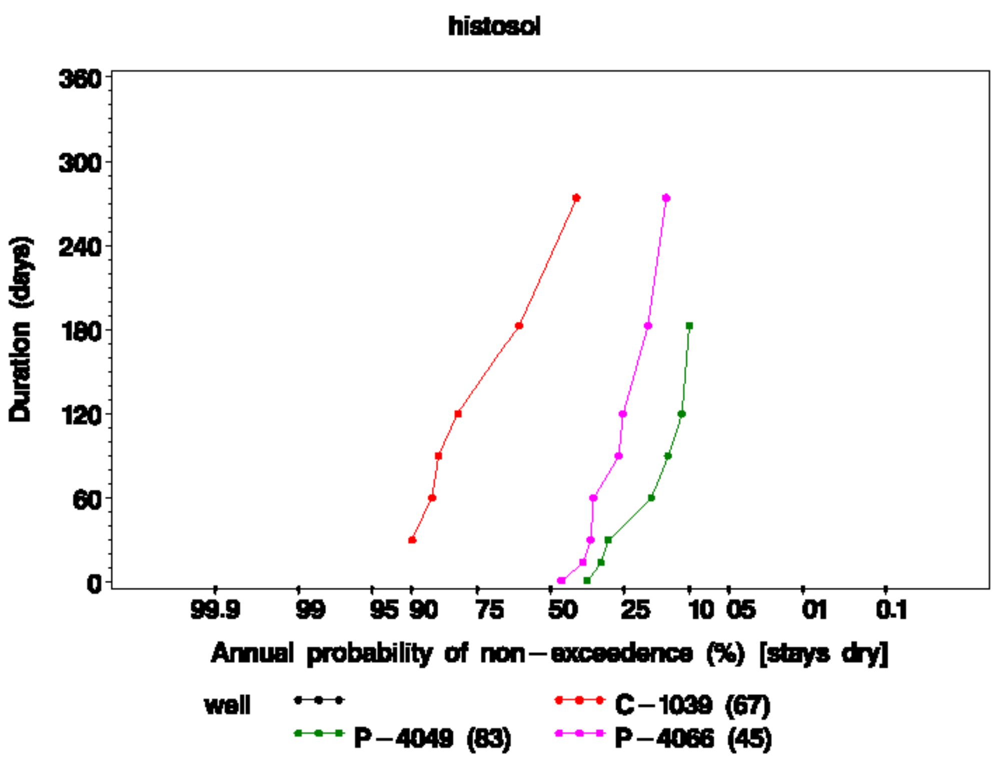
Appendix E.2. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the hydric soil indicator *histic epipedon* elevation



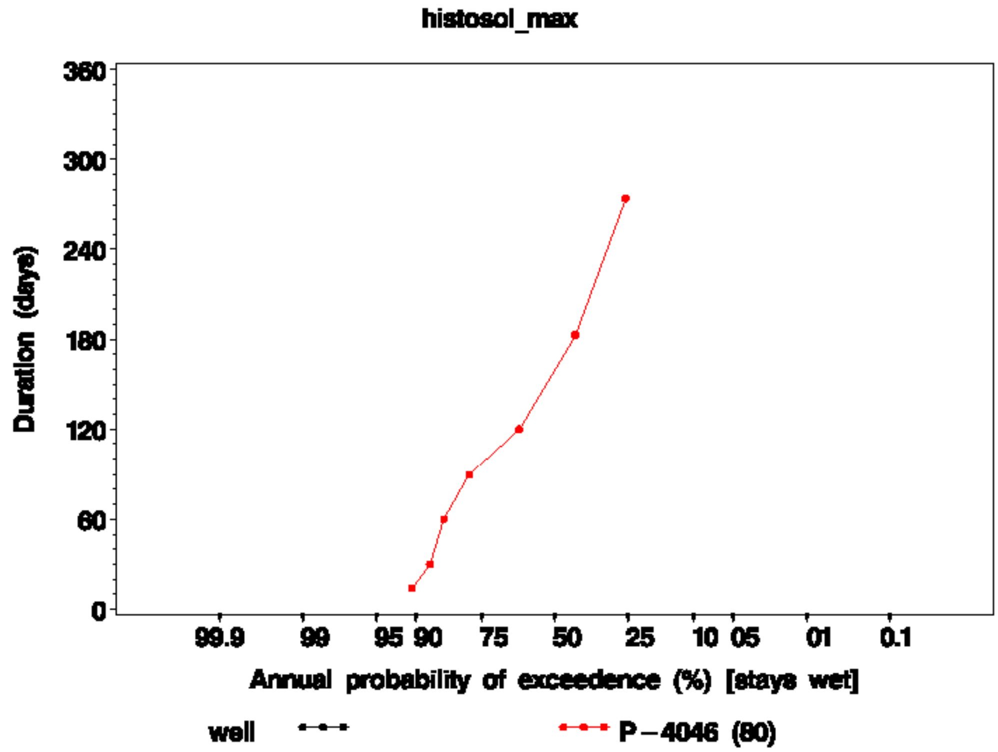


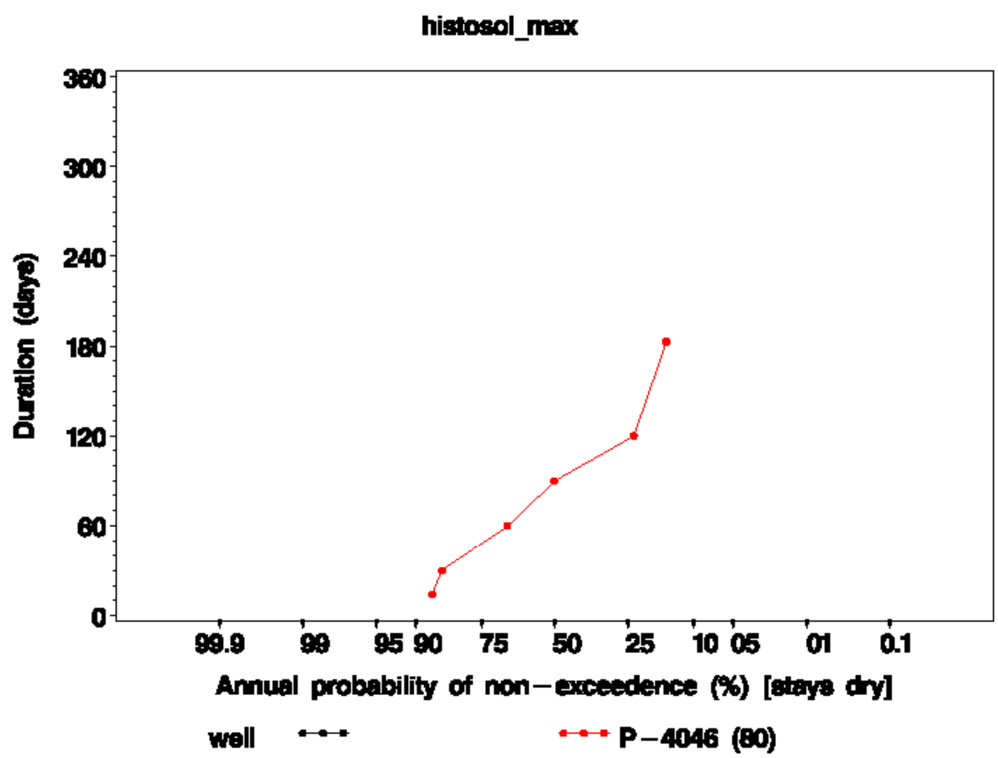
Appendix E.3. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the hydric soil indicator *histosol* elevation



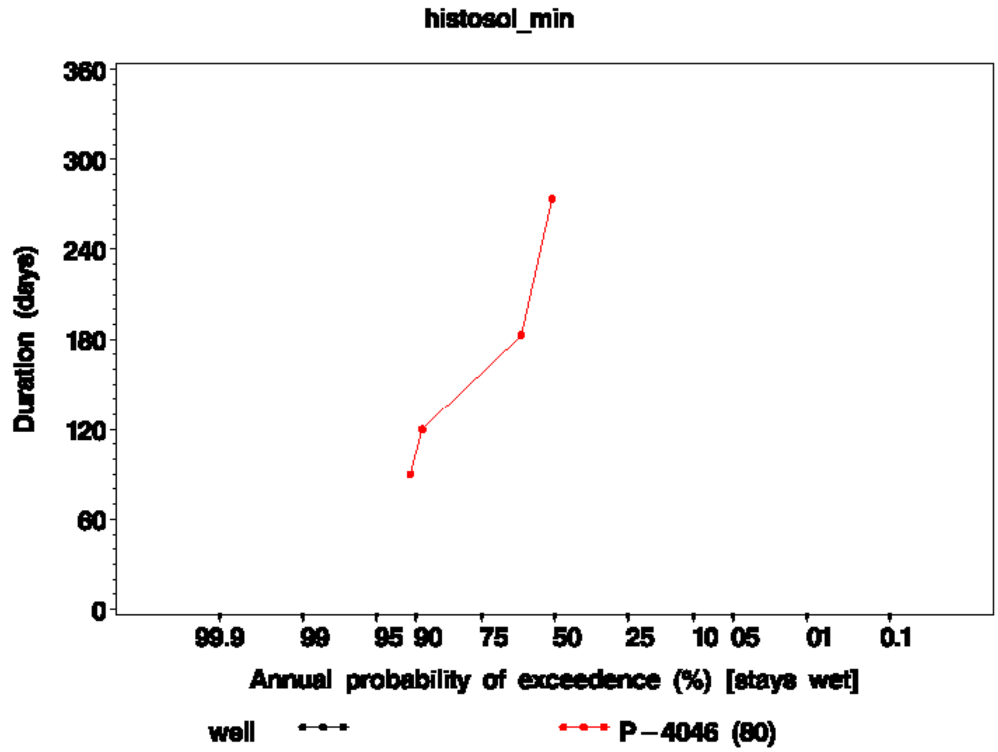


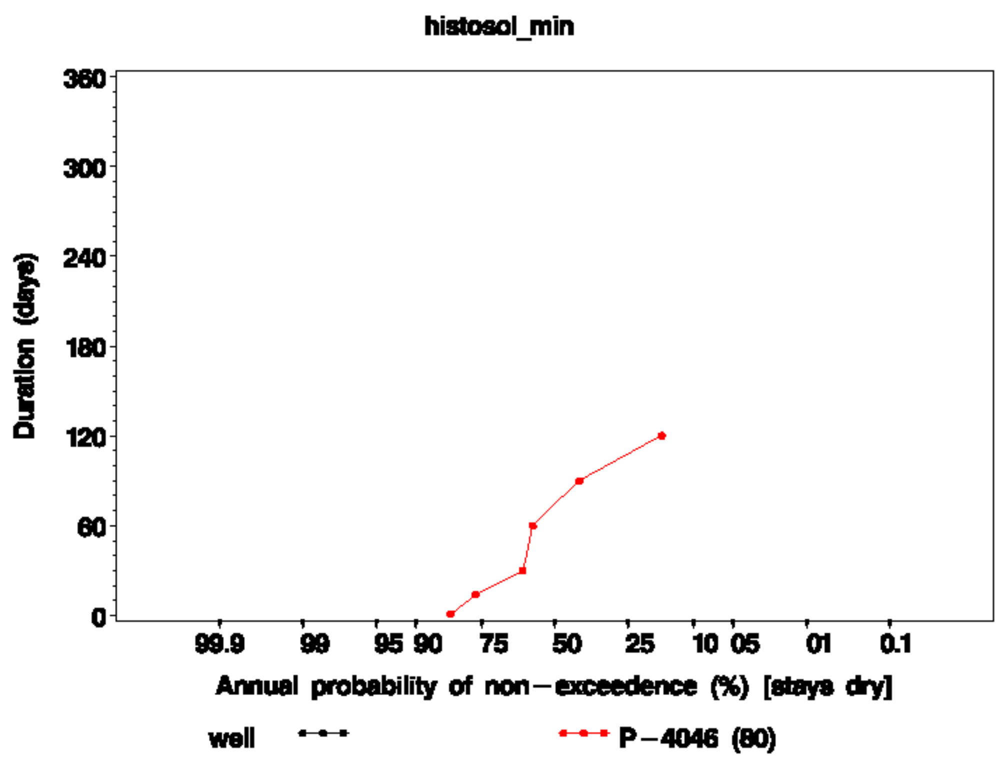
Appendix E.4. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the hydric soil indicator *histosol maximum* elevation



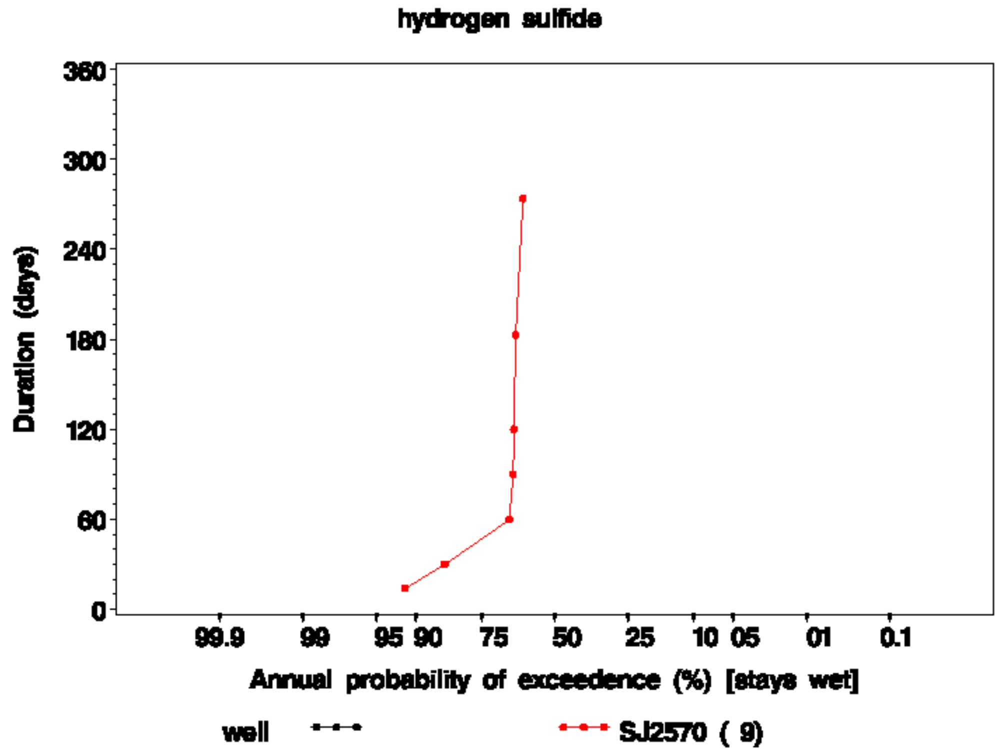


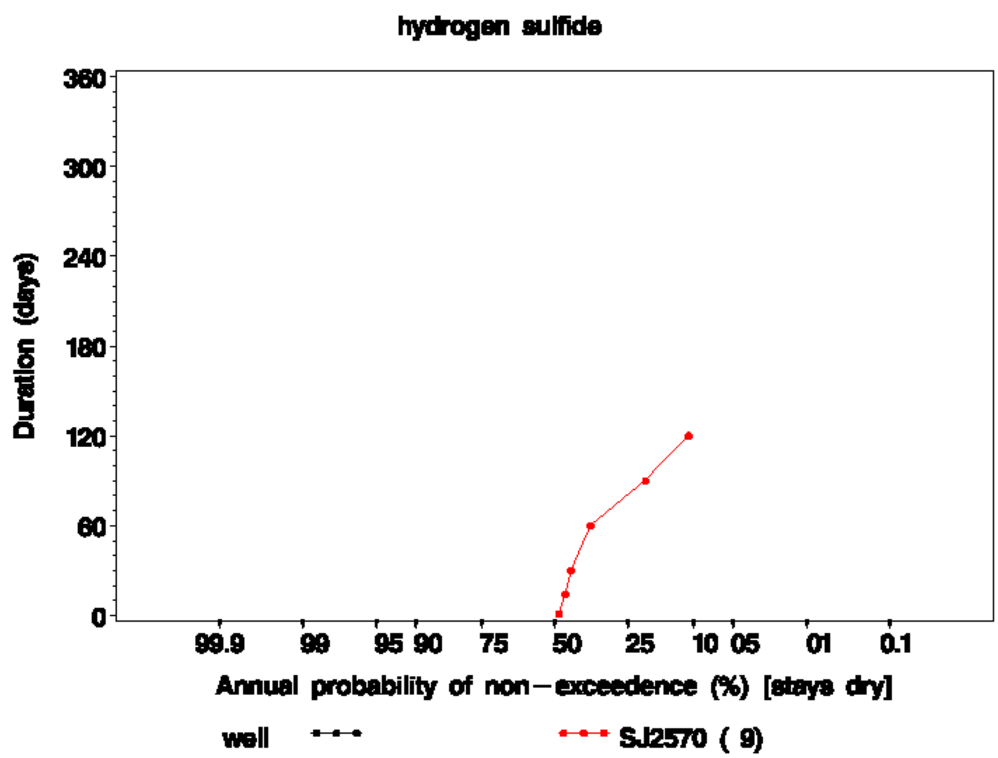
Appendix E.5. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the hydric soil indicator *histosol minimum* elevation



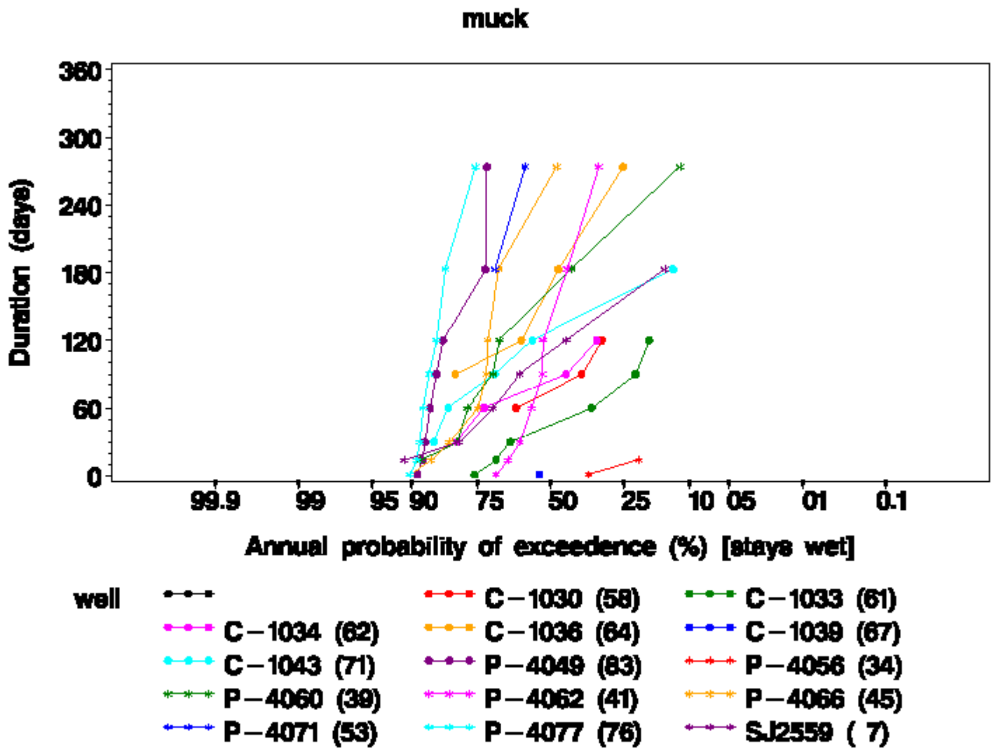


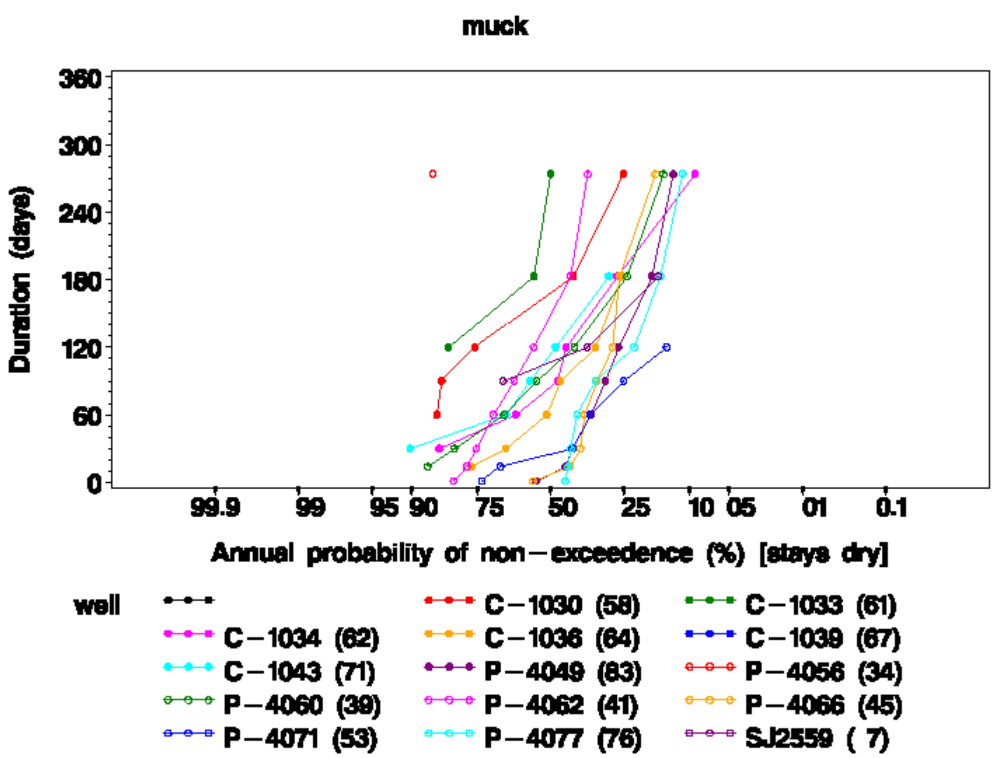
Appendix E.6. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the hydric soil indicator *hydrogen sulfide* elevation



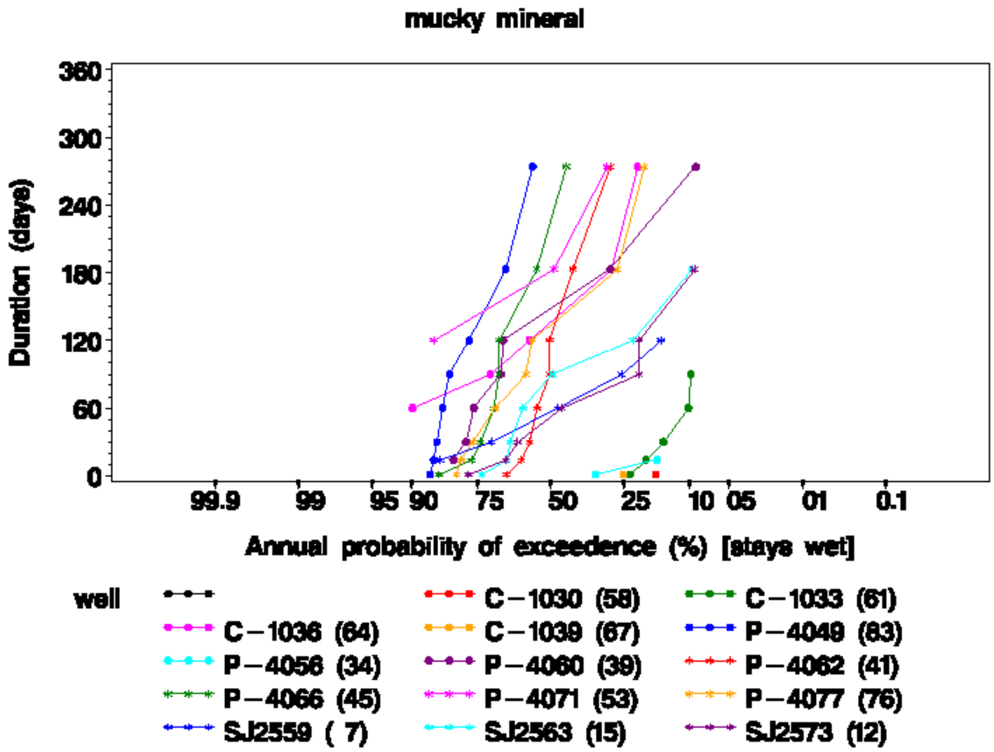


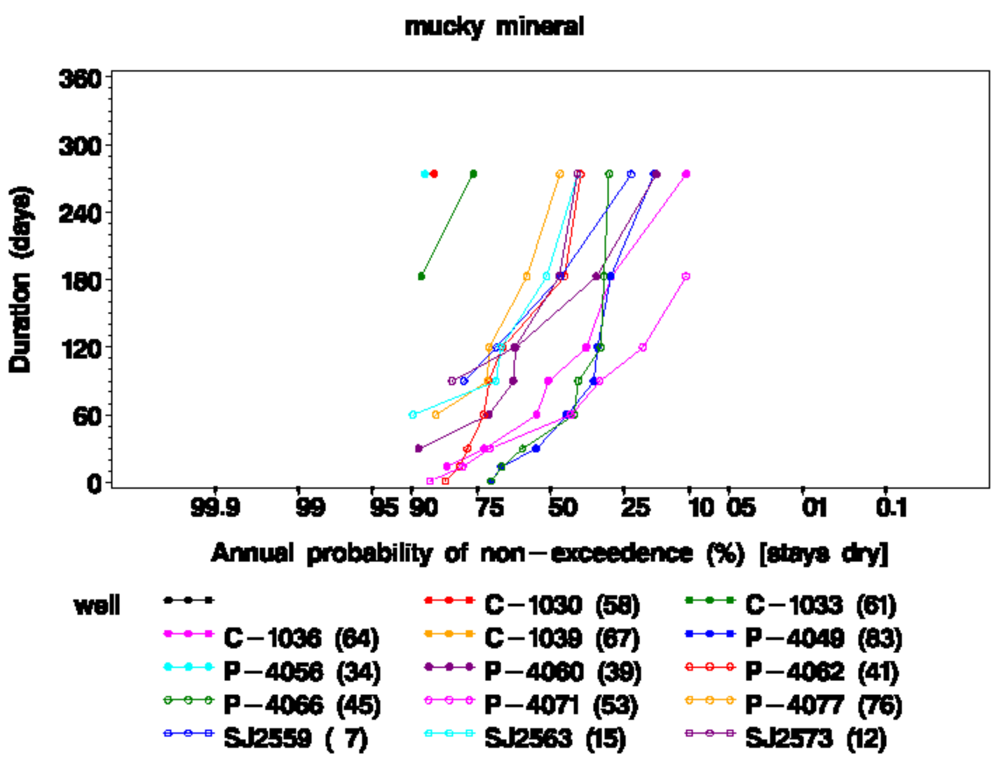
Appendix E.7. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the hydric soil indicator *muck* elevation



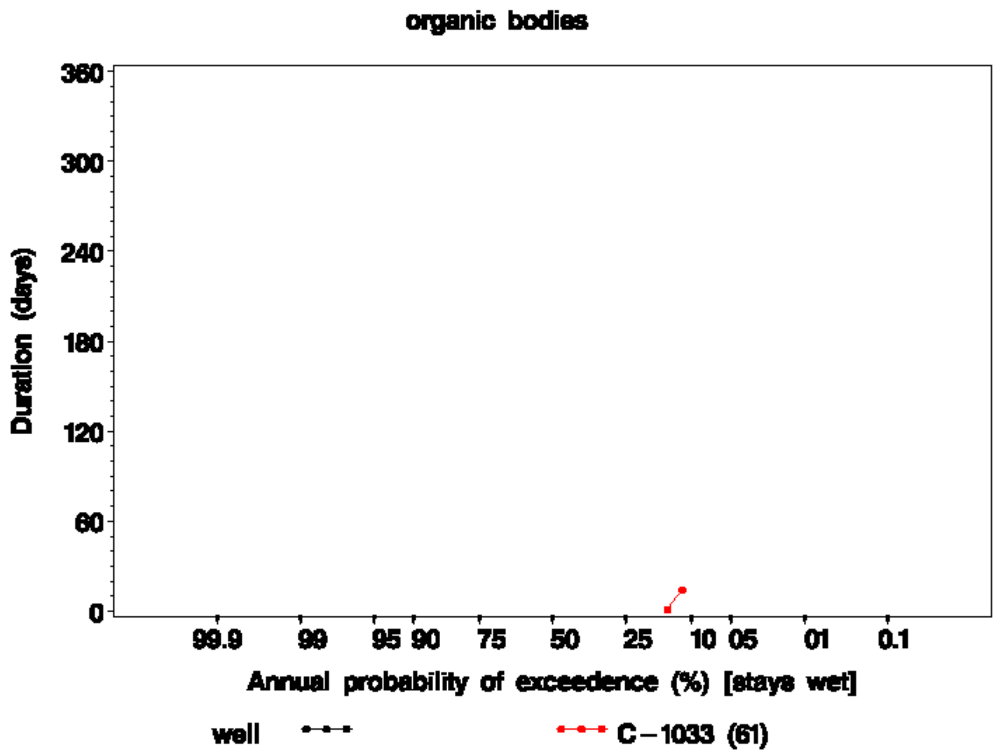


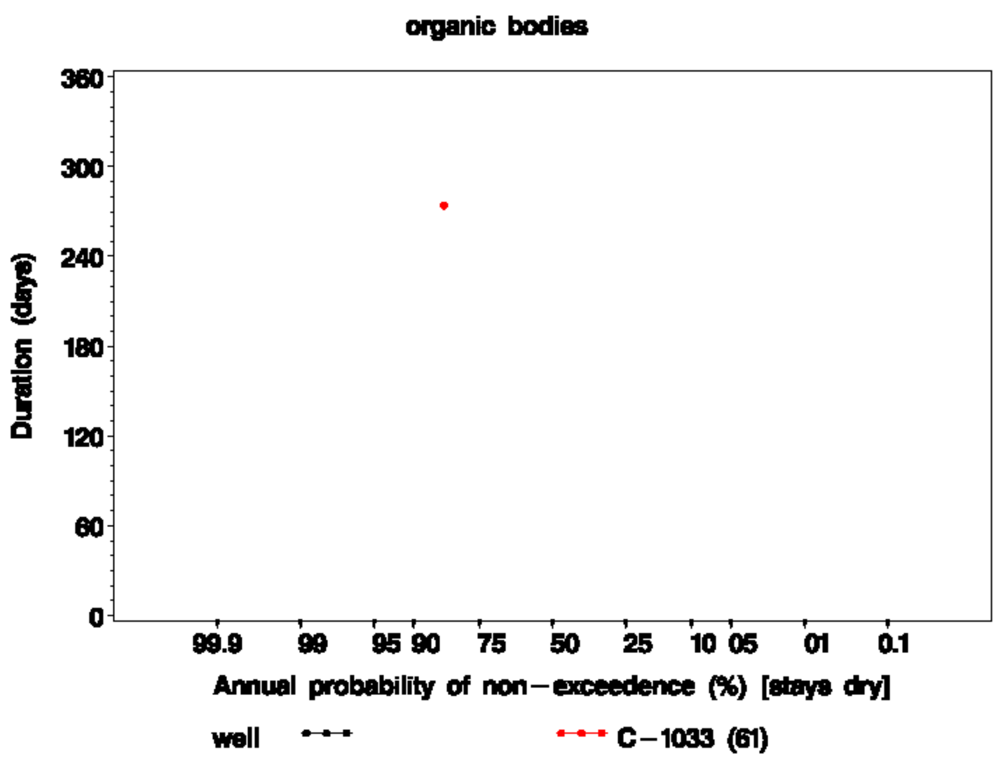
Appendix E.8. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the hydric soil indicator *mucky mineral* elevation



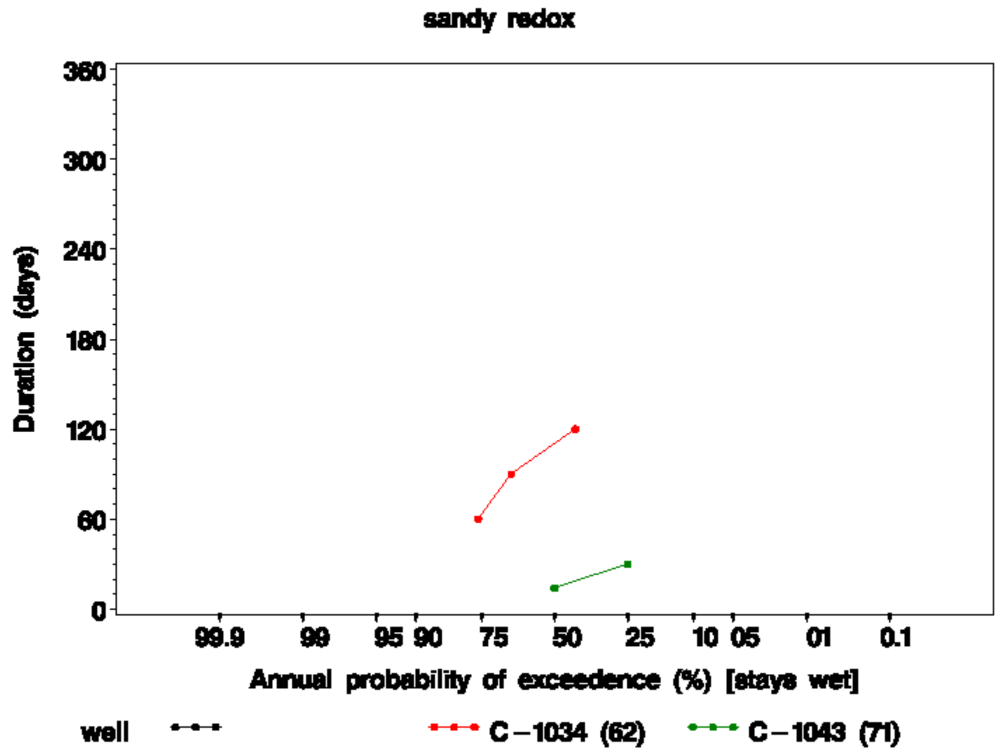


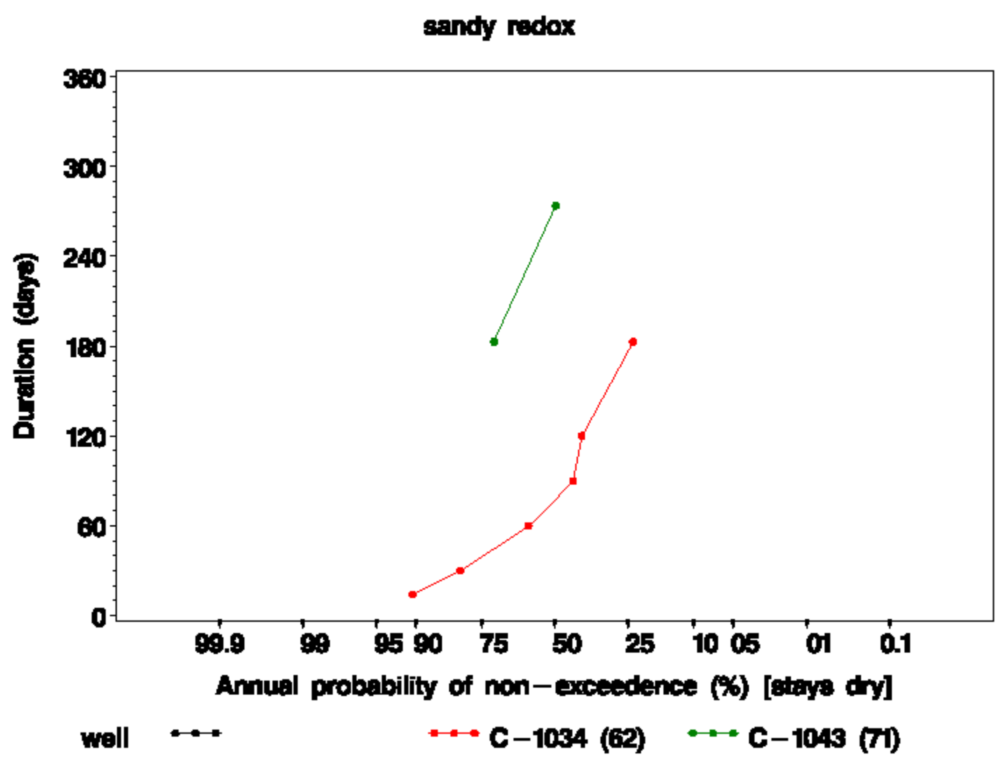
Appendix E.9. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the hydric soil indicator *organic bodies* elevation





Appendix E.10. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the hydric soil indicator *sandy redox* elevation





Appendix E.11. Signature plot of exceedence (top) and non-exceedence (bottom) probabilities of the hydric soil indicator *stripped matrix* elevation