DUCKS UNLIMITED

YOLO BYPASS USFWS EASEMENTS
Impact Analysis from the Big Notch Project

Prepared for:

United States Fish and Wildlife Service

Bureau of Reclamation

July 18, 2024

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1 INTRODUCTION

The Bureau of Reclamation (Reclamation), in partnership with the California Department of Water Resources (DWR), is implementing the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project) to increase the availability of floodplain habitat for juvenile salmonids, as well as to reduce migratory delays and loss of fish at Fremont Weir and other structures in the Yolo Bypass. DWR is the lead agency for acquiring the requisite flowage easements to allow for operation of the Project starting in the Fall of 2023.

U.S. Fish and Wildlife Service (USFWS) owns eight conservation easements on 17 individual parcels in the Yolo Bypass which may be affected by the Project. (Figure A). The USFWS' conservation easements further the National Wildlife Refuge Systems' mission to administer a national network of lands and waters for the conservation, management and, where appropriate, restoration of the fish, wildlife and plant resources and their habitats within the United States for the benefit of present and future generations of Americans. These easements were obtained by USFWS from private landowners within the Yolo Bypass for the purpose of protecting migratory bird habitat, administered as part of the National Wildlife Refuge System. Conservation easements are agreements between the landowner and USFWS which allows for the landowner to retain private ownership of a parcel, while maintaining development of that parcel limited to agree upon conservation standards.

As proposed, operations of the Project will increase the frequency, depth, and duration of flooding on several USFWS Conservation easements. To achieve operations of the Project, it will be necessary for DWR to acquire flowage easements on the existing USFWS conservation easements impacted by the Project. Per the USFWS Conservation Easement Document, owners must receive prior authorization from the USFWS before entering into third-party agreements (including DWR flowage easements) that may impact the USFWS easement interests. USFWS is required per the USFWS Service Manual (603 FW 2) to complete a compatibility determination for DWR flowage easements and associated Project operation impacts to USFWS conservation easements prior to authorizing DWR Flowage Easements. A compatibility determination is a written determination signed and dated by the refuge manager and Assistant Regional Director of Refuges signifying that a proposed or existing use of a national wildlife refuge is a compatible use or is not a compatible use.

1.1 BIG NOTCH PROJECT

The purpose of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project, also referred to as the Big Notch Project (BNP), is to enhance floodplain rearing habitat and fish passage in the Yolo Bypass and/or suitable areas of the lower Sacramento River. The project's intention is to allow water to enter the Yolo Bypass region more frequently, at lower river stages. Ideally, moving this additional water into the floodplains within the Bypass will provide juvenile salmon with more high-quality habitat that will increase their survival chances as they migrate to the Pacific Ocean. The project constructed a headworks structure, an outlet channel, and downstream channel improvements. Each of these facilities are components of the three different channel alignments (east, center, and west) in the Yolo Bypass. Each alignment would terminate downstream into the existing Tule Pond.

The Project will allow increased flow from the Sacramento River to enter the Yolo Bypass through a gated opening (i.e., notch) on the east side of the Fremont Weir. The Fremont Weir at the location of the Project, has an approximate elevation of 32 feet North American Vertical Datum of 1988 (NAVD 88). The notch constructed has three gates to control water moving through the facility into the Yolo Bypass. The invert of the new lowest gate is at an elevation of 14 feet NAVD 88, which is approximately 18 feet below the crest of the existing Fremont Weir. The invert of the other two gates is an elevation of 18 feet NAVD 88. The Project will connect the new, gated notch to Tule Pond with a channel that parallels the existing Yolo Bypass east levee. Gate operations could begin each year on November 1 based on river conditions. Gate operations to increase inundation could continue through March 15 of each year, based on hydrologic conditions. The Project will operate to allow flows through the Project's headworks structure up to 6,000 cubic feet per second (cfs). The gated notch is also expected to provide open channel flow for adult fish passage, juvenile emigration, and floodplain inundation. In addition to the abovementioned features, this Project includes a supplemental fish passage facility on the west side of the Fremont Weir that will operate following Fremont Weir overtopping events and downstream channel improvements to allow fish to pass through Agricultural Road Crossing 1 and Tule Channel immediately north of Agricultural Road Crossing 1.

1.2 EASEMENTS

The U.S. Fish and Wildlife Service (USFWS) owns eight conservation easements on 17 individual parcels in the Yolo Bypass which may be affected by the Project. The USFWS' conservation easements further the National Wildlife Refuge System's mission to administer a national network of lands and waters for the conservation, management, and, where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans. These easements were obtained by USFWS from private landowners within the Yolo Bypass for the purpose of protecting migratory bird habitat, administered as part of the National Wildlife Refuge System. Conservation easements are agreements between the landowner and USFWS which allow for the landowner to retain private ownership of a parcel, while maintaining development of that parcel limited to agree upon conservation standards.

As proposed, operations of the Project will increase the frequency and duration of flooding on several USFWS Conservation easements. To achieve operations of the Project, it will be necessary for DWR to acquire flowage easements on the existing USFWS conservation easements impacted by the Project. Per the USFWS Conservation Easement Document, landowners must receive prior authorization from the USFWS before entering into third party agreements (including DWR flowage easements) that may impact the USFWS easement interests. USFWS is required per the USFWS Service Manual (603 FW 2) to complete a compatibility determination for DWR flowage easements and associated Project operation impacts to USFWS conservation easements prior to authorizing DWR Flowage Easements. A compatibility determination is a written determination signed and dated by the refuge manager and Assistant Regional Director of Refuges signifying that a proposed or existing use of a national wildlife refuge is a compatible use or is not a compatible use.

While this study is funded by, and intended to evaluate impacts to USFWS easements, other conservation easements occur within the Yolo Bypass that were developed for the purposes of providing wetland habitat.

1.3 OBJECTIVES

The objective of this analysis is to provide USFWS with data to make a determination if the operations of the Project are consistent with the terms, conditions and intent of the conservation easements established on lands within the Yolo Bypass. The intent for the easement is for wetland habitat to be managed and maintained in perpetuity. If landowners do not have the opportunity to benefit from these managed wetlands through recreation activities such as hunting, the incentive and cost to provide high quality habitat and food resources for waterfowl will likely diminish and potentially result in the loss of habitat and resources.

1.4 LIMITATIONS OF ANALYSIS

The model developed by Cbec Eco Engineering used in this analysis utilizes a digital elevation model that was purposefully modified such that the wetland units and surrounding water control infrastructure are “plumbed to drain”. Meaning water control structures through containment berms that typically vary in size from 24-36 inches in diameter are represented in the model as 50-foot-wide trapezoidal breaches. In a few key locations, the model contains drainage canals and drain points that do not actually exist. These modifications likely have significantly increased the speed at which water moves across the landscape, and therefore the duration of flooding experienced by wetlands units within the model to be bias low. Additionally, the model assumes initial conditions are dry, despite many wetland units and rice fields being flooded by October 2 when normal water conditions exist. Therefore, the model is likely missing approximately 25,000 acre-feet of water. Despite these limitations, we expect that the number of flood events experienced by wetland units within the model was likely representative when compared to real-world conditions.

Another hydraulic model of the study area was developed by MBK engineers. This model takes a different set of assumptions when considering the drain limited aspects of the Yolo Bypass and represents each wetland unit as a closed cell instead of the “plumbed to drain” approach. We attempted to include this model in our analysis to create a more balanced approach to our analysis by comparing both model outputs. Recognizing that one model represents an overestimate of drain speed within the Bypass and the other representing an under drained bypass, reality is likely somewhere between the two different model approaches. A comparison would have provided additional insight into the importance that these different assumptions about drainage play within the project area. However, DU was unable to gain permission to release critical data to MBK to effectively re-run their model to then compare the two model outputs.

Therefore, the analysis presented herein is derived solely from the hydraulic model developed by Cbec Eco Engineering. As with any model, a simplified landscape had to be used to facilitate model construction and allow for reasonable processing times which ultimately limits the ability of these model results to fully represent current conditions within the study area. We sought to mitigate model limitations by focusing our analysis on comparisons between wetland units and across water years. Thus, assumptions made within the model framework are applied as consistently as possible, reducing the impact of the multiple sources of bias on calculated values. Despite these efforts, users should be aware that significant inaccuracies or errors may exist within the model and consequently in this analysis. It is advised that any conclusions drawn from this analysis be approached with caution and validated through alternative means or expert consultation.

The developers and distributors of this analysis disclaim any liability for damages or losses resulting from its use, and users are solely responsible for the interpretation and application of its findings.

1.4.1 Stressors

Several new stressors have the potential to affect the impacts from the BNP, including but not limited to Elk horn slough restoration project, Food for Fish program, Egbert tract tidal restoration project, several additional tidal restoration projects proposed in the southern portion of the bypass. These cumulative landscape changes, in addition to climate change and sea level rise, can dramatically modify how water flows through the focal area, ultimately impacting the metrics we considered in our analysis. For example, modifications to areas that influence the Sacramento River stage north of the Yolo Bypass could influence flood timing and duration. Similarly, modifications to areas south of the Yolo Bypass that modify the tidal prism and ultimately inflows to the Toe Drain, could influence drain speed within the Bypass, either reducing or increasing drain times. Climate change could result in increased surface water runoff during winter months instead of being captured as snowpack, which would increase BNP operational opportunity, resulting in greater flooding within the Bypass.

1.5 IMPORTANCE OF YOLO BASIN TO WATERFOWL

Approximately 90% of California's Central Valley seasonal and floodplain wetlands have been destroyed or modified by agricultural conversion, development, and flood control efforts (Mitsch and Gosselink 2007; Frayer et al. 1989; Hanak et al. 2011). As a result, many wetlands dependent species have suffered population declines, including waterfowl – which have declined from 50 million historically to 6 million currently – -and native freshwater and pelagic fish species (Mount 1995; Reid and Heitmeyer 1995; Sommer et al. 2007). Waterfowl populations are most abundant within the Central Valley in winter, and primarily rely on seasonal wetlands and flooded rice agriculture to access the food resources required to survive winter (CVJV 2020). The Yolo Basin contains 11,554 acres of seasonal wetlands and up to 13,500 acres of winter flooded rice, which combined provide enough food resource to support approximately 3 million duck energy days between fall and spring. The 59 wetland units that form the basis of our analyses comprise approximately 35% of all the seasonal wetlands present in the Yolo Basin and are expected to support over 350 thousand duck energy days over winter.

1.6 IMPORTANCE OF HUNTING AND WETLAND MANGEMENT

The seasonal wetlands that support wintering waterfowl in California's Central Valley are shallowly flooded (approximately 12 inches deep to allow waterfowl to forage) from fall to early spring. These conditions rarely occur naturally in the highly modified landscape of California's Central Valley, instead these conditions are created through the efforts of private landowners and state and federal agencies. Generally, wetland management actions focus on the timing and depth of water, combined with mechanical disturbance to create conditions which produce the annual plant seeds and invertebrates that waterfowl favor (Fredrickson and Taylor 1982; Euliss and Harris 1987; Baldassarre and Bolen 2006). These management actions are expensive and time-intensive, there are also additional costs associated with maintaining the water management infrastructure required for seasonal wetlands. Private land managers are typically willing to pay these annual costs due to the benefits they provide waterfowl, yet these actions also benefit other wetland dependent wildlife species, including listed species such as the greater sandhill crane (*Antigone canadensis*), and giant garter snake (*Thamnophis gigas*) (Gilmer et al. 1982; Gildo et al. 2002; DiGaudio et al. 2015).

2 METHODS

We used hydraulic model data to assess how the operation of the big notch could impact flooding on 55 wetland units within the Yolo Bypass. We evaluated daily changes in water surface elevation between October 2nd to March 15th across 16 water years (1996-2011). Wetland unit specific water surface elevations were assessed at a fixed point within each unit under two scenarios, baseline conditions and with the operation of the big notch. Each water surface elevation reference point was located near the drain within each wetland unit.

To evaluate how changes in water depth within each wetland unit can impact wetland management actions, as well as landowner access and use of the units, we defined three depth thresholds; six inch increase, blind elevation, berm elevation. (Figure B) These depth thresholds were applied to all wetland units, but specific values varied significantly over the entire study area due to topographic trends. Moreover, these thresholds account for a range of impacts, from small impacts at the six inch increase threshold to large impacts at the berm elevation threshold.

The first depth category is intended to capture changes in water depth that would likely reduce or eliminate the ability of dabbling ducks to access food resources. We assumed each wetland unit was managed at a target depth of approximately 12 inches at the start of each water year, as this is a favorable depth for most dabbling ducks to access food resources (Taft et al. 2002; Baldassarre and Bolen 2006; Baschuk et al. 2011). Therefore, an additional six inches of water would likely result in water depths that would preclude dabbling ducks from foraging and reduce the value of these areas to wintering waterfowl (Taft et al. 2002; Baschuk et al. 2011). We added six inches to each unit's initial water surface elevation values to set the depth threshold for the first category. The second depth category captures impacts to waterfowl hunting infrastructure. Hunters lose the ability to hunt pit blinds (blinds that are buried in the ground to provide hunters with concealment) when water overtops and fills the blind with water. Additionally, being able to access, and the effectiveness of stand-up blinds (blinds that sit above the water and are typically concealed with vegetation) are reduced when water levels exceed the floor of the blind. Therefore, we measured all locatable blind elevations (top of pit blinds, floors of stand-up blinds) within each wetland unit, and averaged blind elevations to produce a unit-specific depth threshold for this category. There was a wide range of blind elevations largely driven by the variation in land elevations across the study site, however the average blind elevation typically corresponded to an increase of 17 inches over the target water depth of a wetland unit. The third depth category attempts to capture impacts to managed wetland infrastructure, including berm integrity and water control structures. These structures are critical to the management of the wetland and can be severely damaged or destroyed when submerged when water exceeds target depths. To determine the water depth that would correspond to these impacts we used Arc GIS to determine each wetland units' maximum exterior berm elevation. This approach provided us with a single elevation value that corresponds to the highest elevation observed on the exterior berm. We chose to use the maximum elevation as it was the most conservative way to estimate berm overtopping. Similar to the range of elevations seen in average blind elevation the maximum berm threshold had a significant amount, but the average difference between pond bottom elevation and maximum berm elevation was approximately 38 inches.

We used these three depth categories in combination with the daily water surface elevation data to calculate three flood metrics for each wetland unit; (1) duration, the total number of days that surface water elevation exceeded each threshold, (2) flood events, the total number of times surface water elevation exceed the corresponding threshold, and (3) hunting impact score, the weighted number of days, based on hunter perceptions, that water elevations exceeded each depth threshold.

We calculated the total duration and the number of flood events at each depth category for each wetland unit using the R package *RmarineHeatWaves* (Smit et al. 2018). We then summarized these data at the wetland unit level into the total number of flood events and the total duration of flood days at each depth category for all water years. We calculated hunting impact scores by assigning day values to each day between Oct. 2 – Mar. 15 (Figure DS). Day values, which ranged from one to five, were determined through interviewing landowners to determine which key periods of hunting. The primary factors that influenced day values were waterfowl numbers, hunter success, and cultural importance. Although the specific timing of California's waterfowl hunting seasons is set each year, opening weekend is traditionally the second to last weekend in October, and lasts until the end of January. We also considered the special hunt weekends for junior hunters and veteran hunters, which occur after the regular season ends. We found that waterfowl hunters in the wetland units we assessed favored opening weekend, and the months of December and January the most. We then summed all day scores at the wetland unit level over the water year for days which saw a water surface elevation exceeding the depth threshold. Despite the timeframe of flood impacts beginning before waterfowl season, and extending beyond the end of waterfowl season, the day scores were weighted such that the focus of this value falls within waterfowl hunting season. The total possible hunt impact score, assuming the water surface elevation exceeded the depth threshold for the entire water year was 533.

3 MODEL ANALYSIS RESULTS

We examined daily water surface elevations for 55 managed wetland, covering approximately 4,603 acres (~2,493 acres in the North Area, ~1,610 acres in the Center Area, and ~500 in the South Area) units over a 16-year period, from October 2nd to March 15th (1996-2012). Of the 59 wetland units included in our assessment, 38 contained hunting blinds. We assessed 158 blinds, of which, 47 were stand-up blinds and 111 were pit blinds. Our analysis relied on a single point assessment of daily water surface elevation, which did not allow for an evaluation of how the flood footprint size would vary by years or between scenarios. Instead, our approach provided an approximate water surface elevation for each wetland in its entirety.

The most impactful years under baseline conditions (1996, 1997, and 2005) were rather consistent across the different impact classes and depth thresholds, suggesting that major flood events during peak rainfall impacted all categories and depth thresholds similarly (Table 1). Interestingly, there was more variability in the most impactful water years when looking at the subset of years that had the largest difference between baseline impacts and big notch impacts, compared to baseline years. A total of 11 years were present in the top four most impactful big notch years, while 7 were present in baseline conditions. The fact that more unique years were present in the top 25% most impactful years within the big notch category indicates that the big notch will increase the number of years which produce impacts. Moreover, many of the subset of years that produced the largest increase in impacts due to the big notch occurred within a single impact class and depth threshold, whereas all but one year occurred in multiple impact classes and depth thresholds under baseline conditions. This variability across impact classes suggests that the study area will experience more moderate floods with higher frequency, compared to baseline conditions. While these moderate floods will likely be less impactful compared to the extensive levee to levee flooding that occurred in 1996 and 2005, they still have significant impacts to hunter access and wetland infrastructure.

Averaged annual differences between scenarios

We found that the difference between the baseline and big notch scenarios, when averaged across all 16 water years, varied significantly across wetland units (Figures 1-9). Some wetland units saw no difference between scenarios (big notch vs. baseline), while others saw large impacts within the big notch scenario. We saw consistency between the berm and six-inch impact classes at the wetland unit level, with across unit trends remaining rather consistent across impact classes. However, trends within the blind impact class were often less aligned with the other two impact classes. General trends within and across each Area (North, Center, South) were also clear; with the North Area showing the largest impact scores (Figures 1-3), the Center Area with intermediate scores (Figures 4-6), and the Southern Area showing marginal scores as a result of the big notch (Figures 7-9). Moreover, wetland units along the eastern margin of all areas tended to have higher impact scores than units along the western margin.

Averaged peak big notch impact years

Of the subset of years that had the largest increase in impacts due to the big notch, 1998 occurred most frequently across all combinations of impact classes and depth thresholds (7; Table 1). Similarly, the water years 2002, 2003, 2010, all occurred six times, indicating that these water years produced conditions which interacted with the big notch scenario to produce a significant increase in impacts over baseline conditions. We presented percentages to compare the additional impacts attributable to the big notch in peak impact years to average impacts under baseline conditions. Percentages greater than 100% indicate the top 25% of big notch impact years produced additional impacts that doubled those experienced by a wetland unit in an average year under baseline conditions (Figures 10-19). This examination of additional impacts caused by the big notch highlight wetland units most vulnerable to changes to the Fremont Weir.

A majority of the wetland units within the water years most impacted by the big notch experienced moderate flooding impacts. Wetland units to the west and south within the Northern Area saw larger increase in hunt impacts and flood duration due to the big notch in these water years than other units in the area (Figures 11 and 12). A trend that was present in the Central and Southern Areas was clear; the eastern most wetland units experienced an increase in all impact categories at the berm depth threshold, while units to the west experienced greater impacts at the six-inch depth category. This would be consistent with a general increase in flood depth across the landscape due to the big notch. Interestingly, the model results suggest the largest increase in flood events at the berm threshold will occur primarily in the central and southern wetland units within the Northern Area.

4 DISCUSSION

The analysis of model results highlights the variation in flood impacts caused by different water years. This variation can be seen across wetland units, many of which have average flood duration, hunt impact scores, or flood event counts that are similar or smaller to their standard deviation. Moreover, the figures (1-9) indicate that the impacts of flooding are spatially variable within each region. Some general trends in impacts were present, with the North Area containing wetland units that typically had larger average impacts (flood duration, hunt scores, flood events) across all depth thresholds, when compared to the other Areas. We also found that impact scores were typically larger in wetlands located in the eastern margins of each Area, while wetlands located further west tended to have lower scores.

The variation in impacts across water years makes identifying specific impacts attributable to the big notch across multiple years challenging. To better identify the impacts of the big notch, we focused on the four water years in which the difference in cumulative impacts (impacts across all wetland units) between baseline and the big notch scenarios were largest (Tabel 1). These “peak impact years” differed from the water years which resulting in the most extensive flooding (1996 and 2005), and instead highlight what types of impacts will be produced when water flows within the focal region interact with the big notch to produce the largest increase in impacts. This comparison demonstrates how certain wetland units may experience a two-fold increase in impacts in some water years, as a result of the big notch (Figures 10-18). These additional impacts were largest for wetland units that typically experienced low to moderate flooding impacts under baseline conditions.

A critical aspect of understanding the true impact of flooding events, specifically berm overtopping, that landowners experience is the additional loss of days due to the time required to prepare for a flood. This preparation phases often require landowners to move equipment to avoid damage or loss due to incoming floods. Moreover, once water surface elevations return to normal levels, roads and other infrastructure required for access and hunting require additional days until they can be safely used again. Our interviews with landowners suggest that, in general, an additional 14-20 days of lost access is added to flood events when accounting for this preparation and return phase. We considered all flood events would require approximately the same amount of additional time to prepare and recover from, so all scores are bias by the same amount. We didn't account for these times since we are more interested in comparing flood events, and water years within the model itself, to avoid magnifying model biases by extrapolating to real-world circumstances. Instead, the number of flood events could be used as a proxy to account for these additional lost days, where one flood event is likely equivalent to 14-20 additional days of lost access. However, due to the complexities associated with road access, soil moisture, rate of flooding, and antecedent conditions, we chose to not modify scores directly to avoid introducing additional assumptions.

However, this assumption is violated when the number of flood events occurring within a year differs amongst scenarios, which is why we included flood events as a metric. However, the insight gained by examining this metric is reduced when comparing averages across multiple years, particularly when comparing across scenarios which can increase flood duration causing multiple separate flood events to blend into a single prolonged flood event. Because of the importance and complexities surrounding flood events, additional examinations into what conditions combined with the big notch create additional flood events are needed.

Additionally, modifications to berms, water control structures, and changes to the watershed in areas outside of the focal region all impact the accuracy of predictions made using model data. Similarly, future changes to the wetland units within the focal region have the potential to modify water flow such that other wetland units see changes as well. – The system is connected. If you fiddle with one area, other areas are impacted. There is the risk that modification to one region to reduce impacts results in increased impacts to another region.

To better understand real-world flood outcomes that are caused by the big notch requires monitoring and data collection. This real-world data would allow for model corrections or updates that could be useful in determining outcomes resulting from future changes to the system. Moreover, real-time data collection of river-stage and water flows can reduce the consequences of flooding that landowners currently experience, by serving as a monitoring system that can accurately alert landowners to incoming floods.

5 RECOMMENDATIONS/PROPOSED IMPROVEMENTS

DU met with many landowners or key representatives for easement properties. These meetings were held with the landowners to better understand site conditions, operations, procedures for flood evacuation, and provide us with important perspectives to inform the analysis as well as potential improvements to offset impacts. General notes from our meetings with landowners and key takeaways were captured and incorporated into impact reduction recommendations were feasible. Attention is directed towards the amelioration of drainage infrastructure, facilitated by the strategic installation of water control structures and targeted enhancements to existing ditches. Additionally, access road and berm improvements to support winter access and more predictable road conditions and elevations are proposed.

As previously discussed, the model represents a highly drained system that does not fully capture the drainage challenges currently present within the bypass. While these recommendations focus substantially on improving drainage within the system, it is not feasible to implement the measures required to achieve the level of drainage represented in the model. Based on DU's observations, the results likely indicate that the impacts described represent a best-case scenario, and the proposed improvements are not likely adequate to fully offset additional flooding resulting from the operation of the Big Notch Project. A more refined hydraulic model could reduce the degree of uncertainty.

DU has provided the USFWS with conceptual restoration exhibits and associated construction cost estimates for each of the three analysis areas. While the below recommendation discussions are high level DU has developed approximately 137 possible improvements that span the study area. The exhibits are not provided in this document as they occur on private lands and have not been vetted by the corresponding landowners. DU is working with the USFWS to prioritize the list of potential improvements and present this possible improvement to landowners.

North Area

The northern region exhibits significant drainage limitations due to the plethora of water sources inundating the area. Floodwaters converge from various directions, ranging from the overtopping of tule canal banks on the east to inundation from Willow Creek on the west, and during higher flood flow levels from Wallace Weir and Fremont Weir. Ducks Unlimited recommends enhancing drainage capacity by augmenting ditch/canal capacity and enlarging water control structures. Many existing structures, while sufficient to convey water for managed seasonal wetlands in controlled water delivery systems, are undersized to convey flows during flood events. These structures prove inadequate in conveying flows as water levels approach the top of berms. If water levels on one side of the berm drain faster than opposing side a head differential occurs and produces increased velocities, typically resulting in scouring of material on the tops and side slopes of berms. Increasing drainage infrastructure will reduce this effect and ideally overall maintenance of infrastructure.

Recommendations are primarily focused on increasing drainage, with an increased emphasis on three main north-south running canals. An example of a substantial improvement is a recommendation to improve a crossing over Willow Creek on the westerly side of the bypass. This crossing consists of several large concrete pipes and the crossing is the main access point for northern area landowners. This area is plagued by debris accumulation further slowing flows and exacerbating overland flooding. The crossing is the lowest point and overtops before the adjacent sections of the road and constitutes an access restriction. DU recommends replacing this crossing with modular pre-cast concrete bridge structure(s) to elevate the crossing.

Center and South Area

While results indicate that impacts are typically higher in the northern area, the model is missing approximately 25,000 acre-feet of water. Due to this model condition, the duration and potential magnitude of impacts for areas further downstream are likely underestimated. Water fills wetland units and other lands to the north that would otherwise already contain water and flows would increase downstream sooner and with more volume than represented.

The center area region exhibits drainage limitations due to lower elevations and larger tidal influence. Flood waters in this area are typically more predictable and associated with a set water surface elevation at Lisbon Weir. Low level flood impacts are typically attributed to overbank flooding from the Toe Drain. Improvement recommendations to this area include establishing improved drainage, berm and road elevations improvements, improving road conditions, rehabilitating and installing pump stations. Many of these properties are reliant on others to flood and drain. DU recommends establishing greater independent flood and drainage for individual landowners to reduce conflict and allow property managers greater control over site specific habitat needs.

Monitoring and USFWS Reverification of Compatible Use

Per USFWS, compatible use determinations must be re-authorized every ten years. Due to the high level of uncertainty surrounding model simulations, continued changes to the watershed, as well as the incorporation of climate change in the operations of the Project, the effects of the Project should be monitored on an annual basis and reviewed at no later than this 10-year period. One potential way to monitor effects would be to develop a remote sensing monitoring program to better understand the realized impacts of the Project. Long-term remote-sensing could be utilized to collect data on water flows, water surface elevation, vegetation communities, as well as data that captures the impacts that landowners experienced. These long-term monitoring data would provide a basis to conduct an analysis to determine how operation of the Big Notch impacts vegetation communities. This could be feasible by monitoring vegetative communities within the study area for 10 years to ensure both drought and high rainfall years are captured. Recent work conducted using a remote sensing approach to evaluate changes in wetland plant communities and waterfowl food production in response to drought has demonstrated a framework that could be applied (Byrd et al. 2020).

Long Term Maintenance Fund

The proposed infrastructure improvements intended to mitigate the impact of the Project come with significant long-term management costs. DU suggests the establishment of a stewardship fund to generate annuity-like financing for future maintenance and replacement needs. By using a Property Analysis Record (PAR) or similar calculator to determine the capital needed to establish the stewardship fund, sustainability can be ensured beyond the completion of the implementation phase. DU conducted a preliminary estimate for a stewardship fund based on the cost of the proposed improvements, minus the existing facility's value. Establishing an endowment ultimately allows stakeholders to proactively address maintenance challenges, ensuring the project's viability and enhancing its long-term impact. While this approach requires further refinement, DU strongly recommends setting up an endowment for the future operation of the proposed improvements.

Water level data station

Wate level elevations for flood inundation events for the Center and South areas are determined by stage elevation at the Lisbon Weir. Many landowners in these areas utilize the Cdec river stage data to make determinations on when water levels will exceed berm and equipment elevations to make plans ahead of the flood event to remove critical equipment. However, the north area flooding is more variable than areas to the south due to a variety of inputs. No water level data station is available to gauge when roads and other equipment will be flooded out. DU recommends developing either a new Cdec station just north of the causeway or the installation of a smaller Onset Hobo Data station or similar that landowners have real-time data access to. Having access to this level of information could save landowners thousands of dollars in equipment loss and or damage repair. In addition to the water level data station, it is highly recommended that an automated communication system be set up for the public to be notified when BNP operations are anticipated and when BNP operations occur.

6 REFERENCES CITED

Kwasny et al., 2004. Central Valley Joint Venture, Technical Guide to Best Management Practices for Mosquito Control in Managed Wetlands, June.

Smith et al., 1995 A Guide to Wetland Habitat Management in the Central Valley, California Department of Fish and Game and California Waterfowl Association.

Albertus J. Smit, Eric C. J. Oliver, Robert W. Schlegel (2018). RmarineHeatWaves: Package for the calculation of marine heat waves. University of the Western Cape, Bellville, Cape Town, South Africa. R package version 0.17.0, https://github.com/ajsmit/RmarineHeatWaves.

Baldassarre, G.A. and Bolen, E.G. (2006). Waterfowl Ecology and Management. 2nd edition. Krieger Publishing Company, Malabar, FL, USA. 576 pp

Baschuk, M.S., Koper, N., Wrubleski, D.A., & Goldsborough, G. (2012). Effects of Water Depth, Cover and Food Resources on Habitat use of Marsh Birds and Waterfowl in Boreal Wetlands of Manitoba, Canada. Waterbirds, 35(1), 44–55. https://doi.org/10.1675/063.035.0105

Byrd, K. B., Flint, L. E., Alvarez, P., Casey, C. F., Sleeter, B. M., Soulard, C. E., Flint, A. L., & Sohl, T. L. (2020). Quantifying drought's influence on moist soil seed vegetation in California's Central Valley through remote sensing. *Ecological Applications, 30*(7), e02135. https://doi.org/10.1002/eap.2135

Taft, O.W., Colwell, M.A., Isola, C.R., Safran, R.J. (2002). Waterbird responses to experimental drawdown: implications for the multispecies management of wetland mosaics. In Journal of Applied Ecology (Vol. 39).

Sommer, T., Armor, C., Baxter, R., Breuer, R., Brown, L., Chotkowski, M., Culberson, S., Feyrer, F., Gingras, G., Herbold, B., Kimmerer, W., Mueller-Solger, A., Nobriga, M., Souza, K. (2007). The collapse of pelagic fishes in the upper San Francisco Estuary Fisheries. 32: 270–277.

Reid, F.A., and Heitmeyer, M.E. (1995). Waterfowl and rice in California's Central Valley. California Agriculture, 49, pgs. 62

Mount, J.F. (1995). California Rivers and Streams: The Conflict Between Fluvial Process and Land Use. Berkeley: University of California Press.

[CVJV] Central Valley Joint Venture. (2020). Central Valley Joint Venture 2020 implementation plan: Sacramento, California: U.S. Fish and Wildlife Service.

Mitsch, W.J. and Gosselink, J.G. (2007). Wetlands. Fourth Edition. John Wiley & Sons, Inc., Hoboken, New Jersey. 582 pgs.

Hanak, E., Lund, J., Dinar, A., Gray, B., Howitt, R., Mount, J., Moyle, P., and Thompson, B. (2011). Managing California's water: from conflict to reconciliation. Public Policy Institute of California.

Frayer, W. E., Peters, D. D., & Pywell, R. H. (1989). Wetlands of the California Central Valley: Status and Trends 1939 to mid 1980's. U.S. Fish and Wildlife Service.

Table 1. Four Most Impacted Years

The four years that produced the largest increase in impacts as a result of the big notch were identified for each impact class (hunt impact score, flood events, and flood duration) at each depth threshold (maximum berm, average blind, and six inch increase). By averaging these subset of peak impact years, we can better isolate the impacts attributable to the big notch from years that had major impacts resulting from atmospheric events.

Years Most Impacted under Baseline Conditions			Years Most Impacted by the Addition of the Big Notch		
Hunt Impact Score			***Hunt Impact Score***		
Berm	Blind	Six-inch	Berm	Blind	Six-inch
1996	1996	1996	2002	1998	1998
2005	2005	2005	2003	2002	2002
1997	1997	1997	2010	2010	2010
1999	2003	2002	2009	2003	2003
Flood Events			***Flood Events***		
Berm	Blind	Six-inch	Berm	Blind	Six-inch
2005	2005	2005	2004	1998	1998
1996	2002	2003	2009	2008	2008
1998	1996	2002	2003	2000	2004
2002	2003	1996	1998	2004	2006
Duration			***Duration***		
Berm	Blind	Six-inch	Berm	Blind	Six-inch
1997	1996	1996	2002	1998	1998
1996	1997	2005	2003	2002	2002

2005	2005	1997	2005	2010	2010
1999	2003	2003	2010	1996	2003

Table 2. Averaged Increase in Impacts by Region

The annual increase in impacts attributable to the big notch are presented by impact type (flood duration, flood events, hunt impact score) and depth threshold (maximum berm elevation, average blind elevation, and six inch increase), averaged across each of the three regions (North, Center, and South) within the project area.

Region	Number of Wetland Units Contained	Average additional days of annual flooding due to the Big Notch			Average additional annual flood events due to the Big Notch			Average increase in annual hunt impact score due to the Big Notch		
		Berm	Blind	Six Inch	Berm	Blind	Six Inch	Berm	Blind	Six Inch
North	23	2.2	7.1	10.9	0.1	0.3	0.3	9.4	26.7	39.5
Center	17	1.7	4.5	5.9	0.1	0.1	0.2	7.0	16.9	21.6
South	15	0.6	1.0	3.2	0.0	0.0	0.1	2.7	4.1	12.3

Table 3. Averaged Increase in Impacts by Region

The percentage increase in impacts attributable to the big notch during peak impact years are presented by impact type (flood duration, flood events, hunt impact score) and depth threshold (maximum berm elevation, average blind elevation, and six inch increase), averaged across each of the three regions (North, Center, and South) within the project area.

Region	Number of Wetland Units Contained	Percent increase in flood duration caused by Big Notch during peak impact years			Percent increase in flood events caused by Big Notch during peak impact years			Percent increase in hunt impact score caused by Big Notch during peak impact years		
		Berm	Blind	Six Inch	Berm	Blind	Six Inch	Berm	Blind	Six Inch
North	23	29.8	54.8	66.8	31.0	61.8	75.9	37.6	62.4	72.4
Center	17	21.5	38.4	46.7	21.0	56.1	67.8	25.6	46.0	53.3
South	15	10.1	9.8	29.4	12.0	5.6	30.9	11.9	15.1	37.1

FIGURES

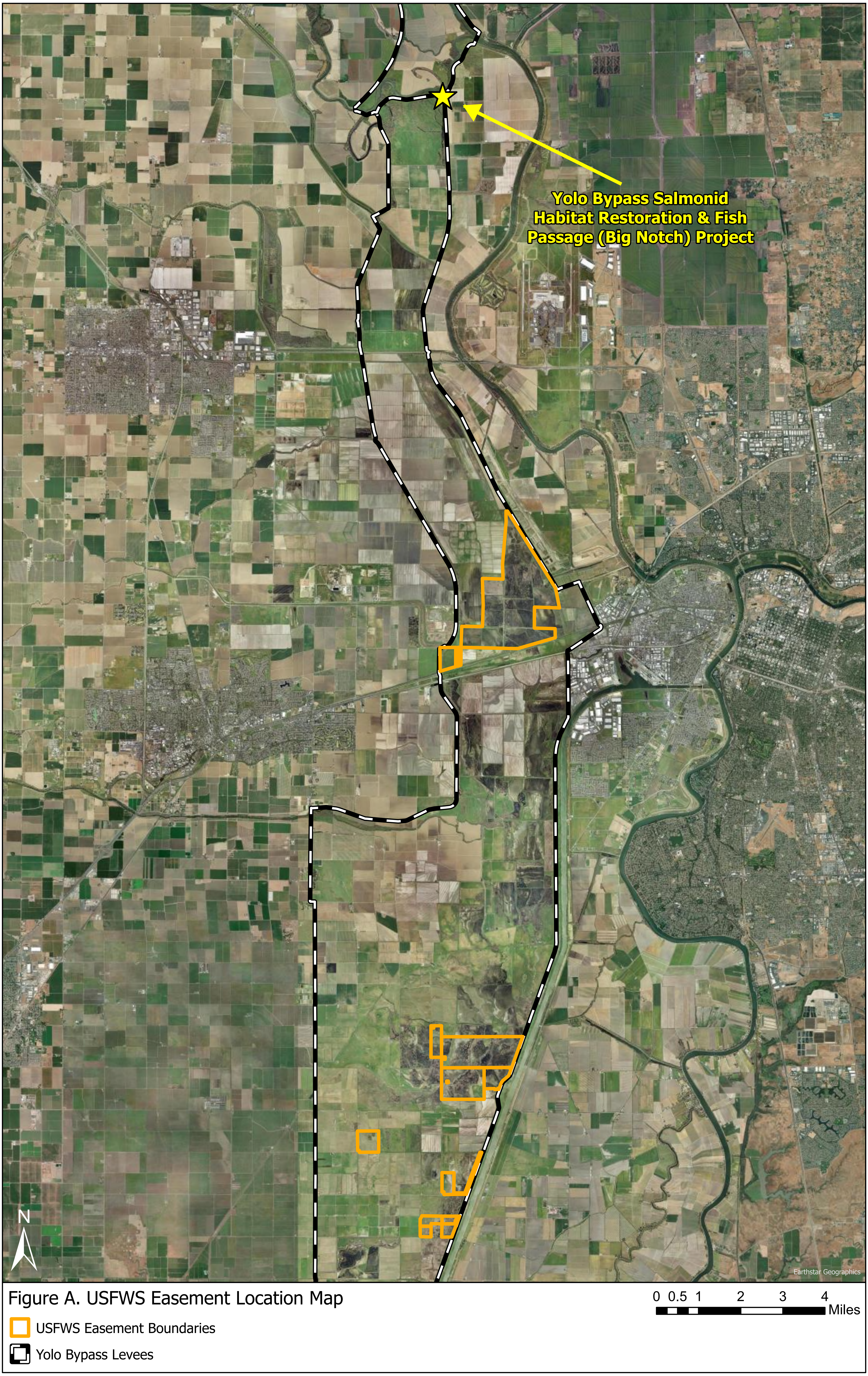

Figure A. USFWS Easement Location Map

Figure B. Depth Threshold

An illustration of the water depth thresholds considered in this analysis. Target Depth within each wetland unit was assumed to be approximately 12 inches deep, following the traditional guidelines of wetland management guides to provide wintering habitat for migratory waterfowl. The six inch increase threshold would correspond to an approximate depth of 18 inches, a depth that is beyond what most dabbling ducks forage within, resulting in a reduction in waterfowl use. The second depth threshold is the average elevation of hunting blinds within the managed wetland unit, water depths beyond this elevation would prevent proper use of these structures. The final depth threshold is the maximum berm elevation surrounding the wetland unit. Water would be moving over the top of the exterior berm once the threshold is surpassed, damaging the berm and preventing safe use of the wetland, and any type of management of the wetland unit.

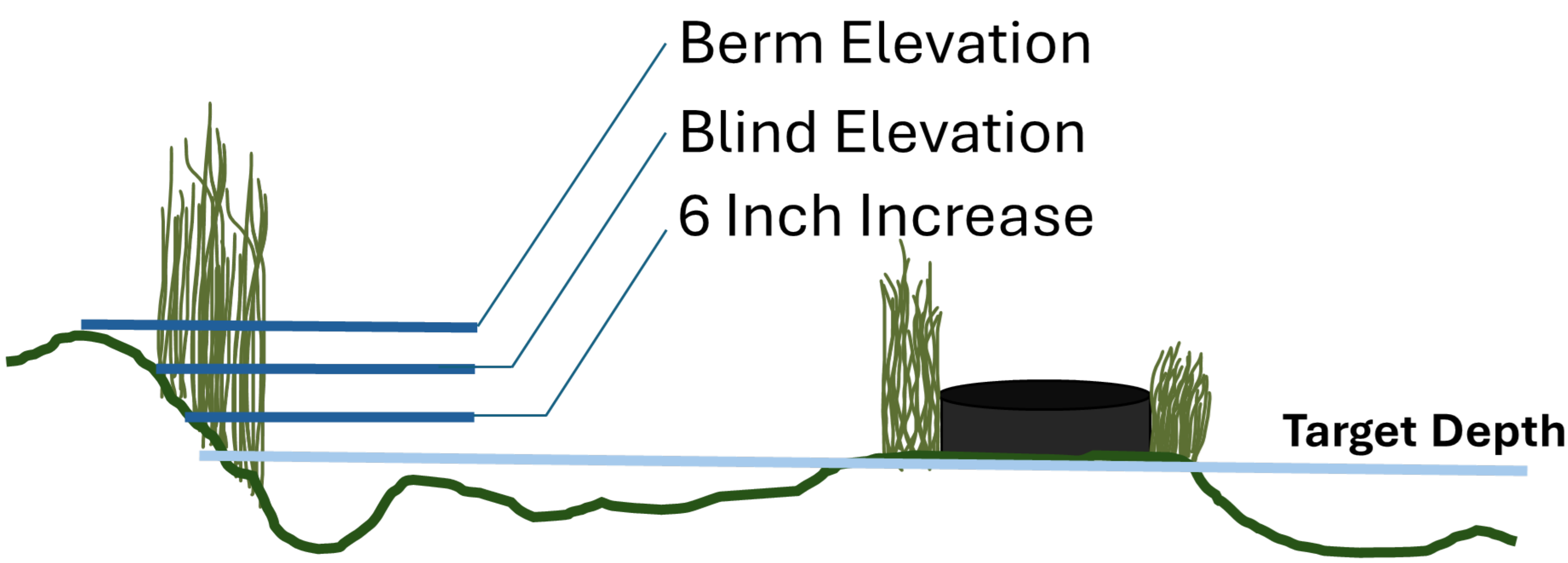

Figure DS: Each day between Oct. 2 – Mar. 15 was assigned a value ranging between one and five. The more valuable a day is, as perceived by landowners, the larger the value. Specific dates for the waterfowl hunting season, including opening day, closure of the season, junior hunt weekend, veterans hunt weekend, and late goose season, are based on the balance of state for the 2023-2024 season. These dates are subject to change due to the adaptive harvest management framework currently used by the U.S. Fish and Wildlife Service.

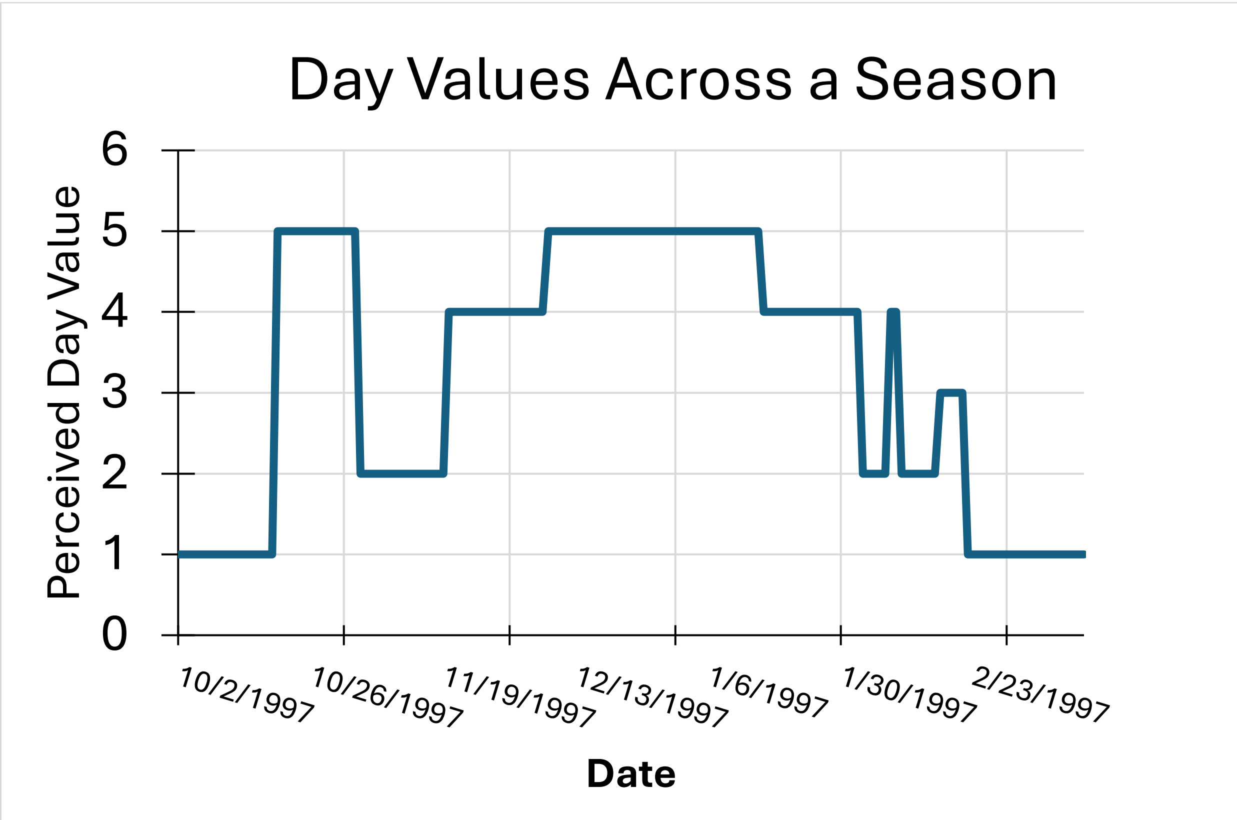

Figure 1: Averaged annual difference of flood duration between baseline and big notch scenarios, by depth threshold for wetland units in the North Area. Unit specific days are presented, followed by standard deviation values. Shading corresponds to values.

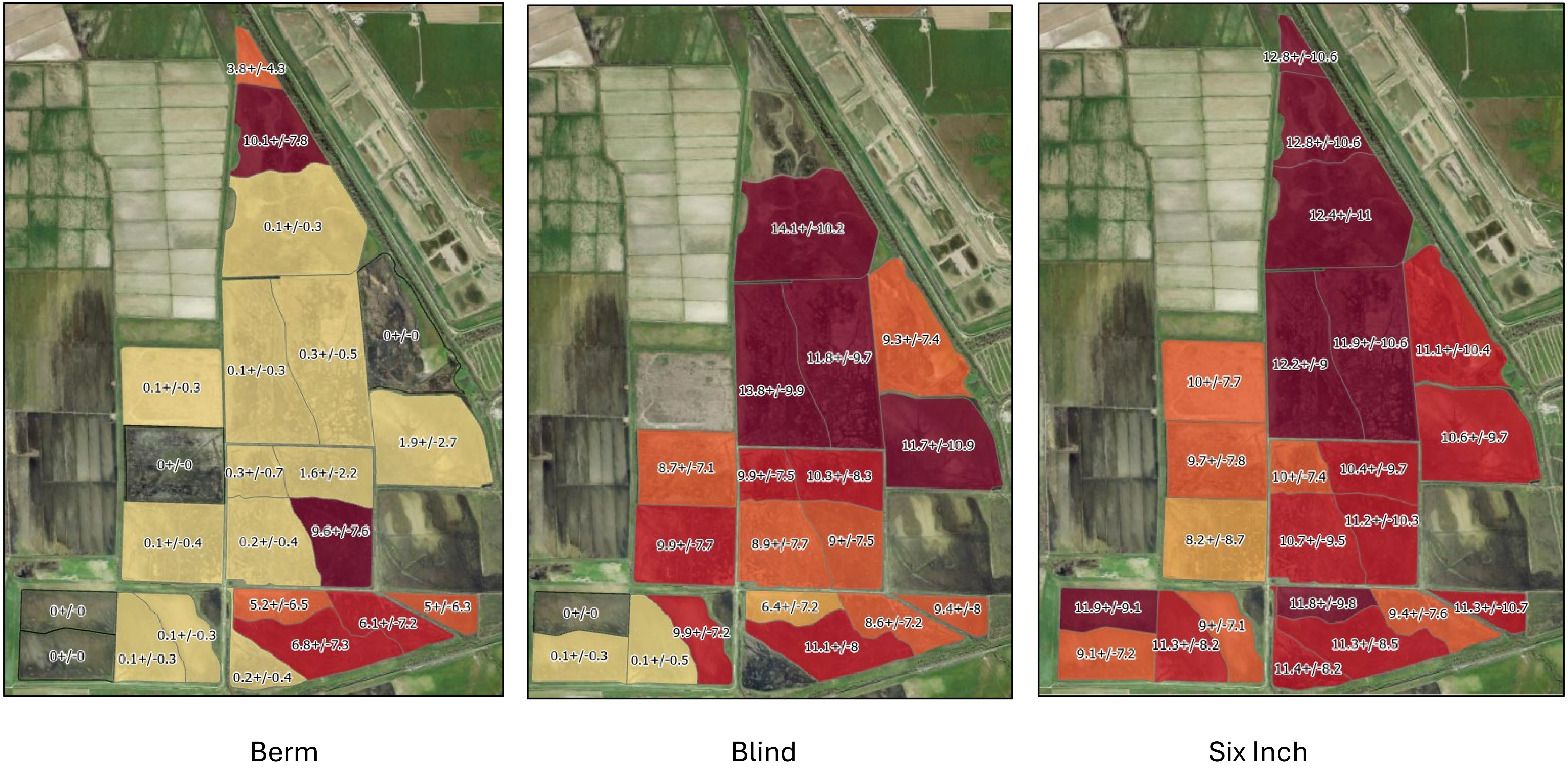

Figure 2: Averaged annual difference of hunt impact score between baseline and big notch scenarios, by depth threshold for wetland units in the North Area. Unit specific scores are presented, followed by standard deviation values. Shading corresponds to values.

Berm

Blind

Six Inch

Figure 3: Averaged annual difference of flood event count between baseline and big notch scenarios, by depth threshold for wetland units in the North Area. Unit specific values are presented, followed by standard deviation values. Shading corresponds to values.

Berm Blind Six Inch

Figure 4: Averaged annual difference of flood duration between baseline and big notch scenarios, by depth threshold for wetland units in the Center Area. Unit specific days are presented, followed by standard deviation values. Shading corresponds to values.

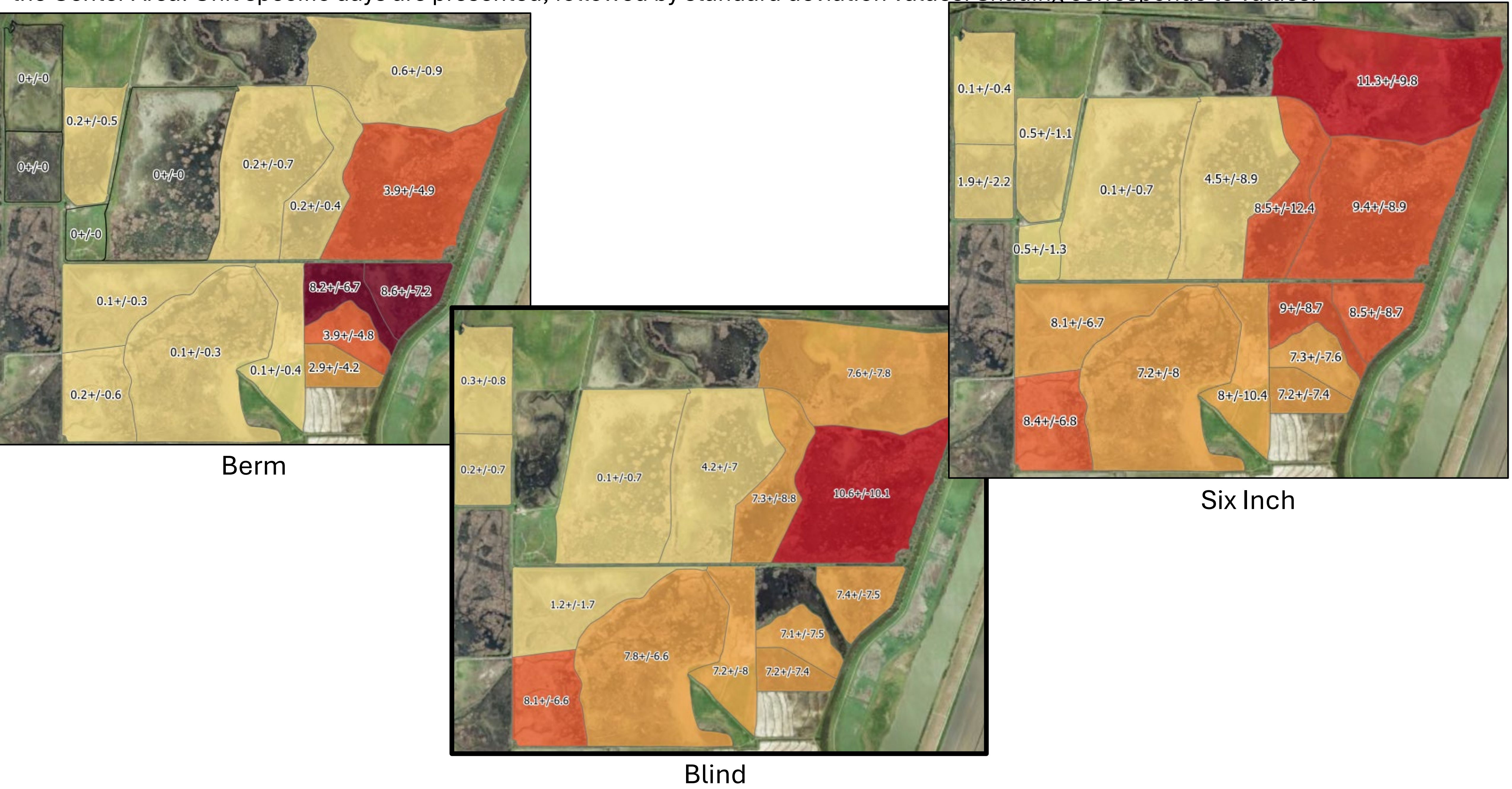

Figure 5: Averaged annual difference of hunt impact score between baseline and big notch scenarios, by depth threshold for wetland units in the Center Area. Unit specific scores are presented, followed by standard deviation values. Shading corresponds to values.

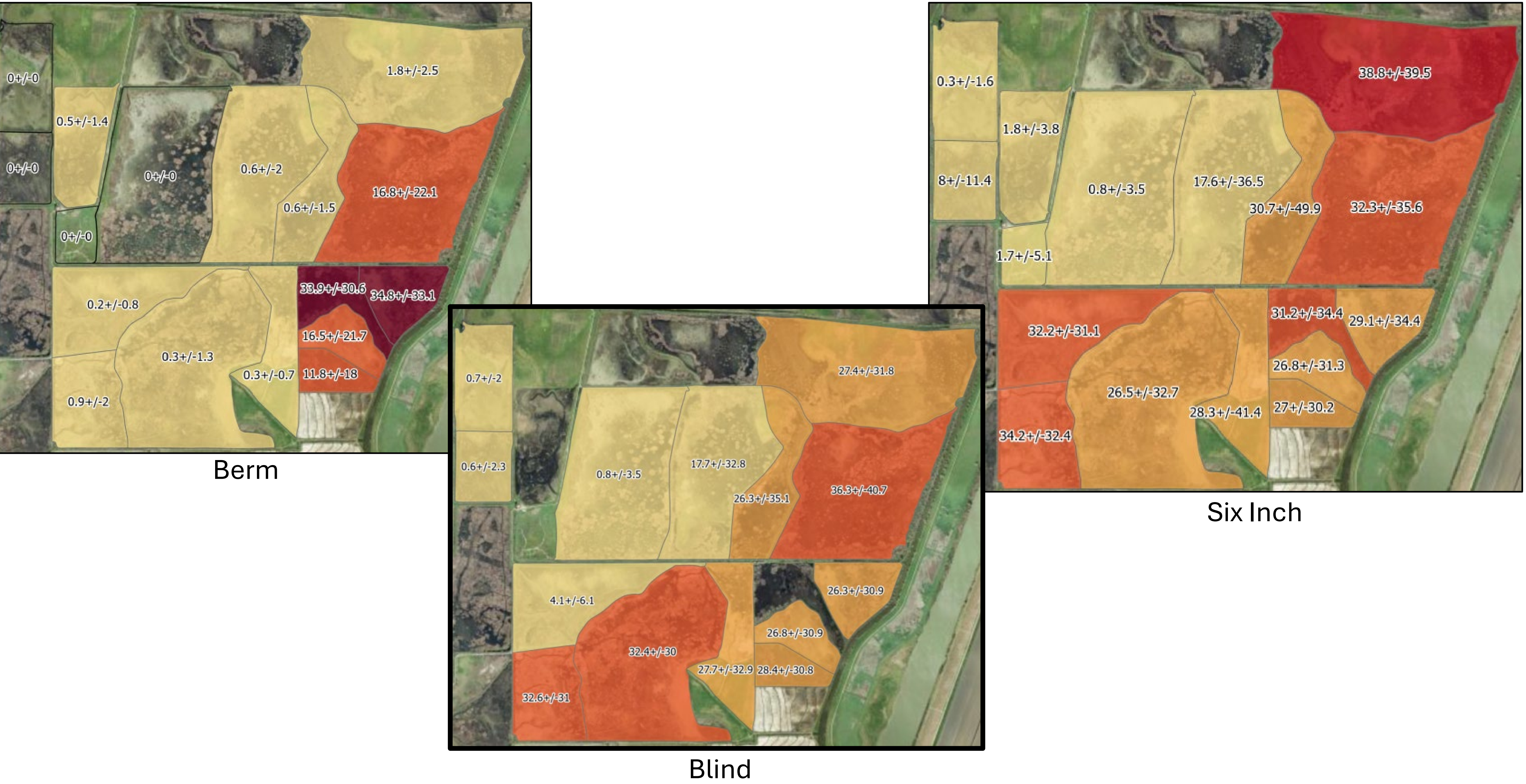

Figure 6: Averaged annual difference of flood event count between baseline and big notch scenarios, by depth threshold for wetland units in the Center Area. Unit specific values are presented, followed by standard deviation values. Shading corresponds to values.

Figure 7: Averaged annual difference of flood duration between baseline and big notch scenarios, by depth threshold for wetland units in the South Area. Unit specific days are presented, followed by standard deviation values. Shading corresponds to values.

Figure 8: Averaged annual difference of hunt impact score between baseline and big notch scenarios, by depth threshold for wetland units in the South Area. Unit specific scores are presented, followed by standard deviation values. Shading corresponds to values.

Figure 9: Averaged annual difference of flood event count between baseline and big notch scenarios, by depth threshold for wetland units in the South Area. Unit specific values are presented, followed by standard deviation values. Shading corresponds to values.

Figure 10: Proportional increase in flood duration over baseline conditions attributable to the big notch under maximum impact years. Maximum impact water years defined as the four years which had the largest cumulative difference in duration between baseline and big notch scenarios. Values are presented for each depth threshold by wetland unit in the North Area. Shading corresponds to values.

Berm Blind Six Inch

Figure 11: Proportional increase in hunt impact score over baseline conditions attributable to the big notch under maximum impact years. Maximum impact water years defined as the four years which had the largest cumulative difference in scores between baseline and big notch scenarios. Values are presented for each depth threshold by wetland unit in the North Area. Shading corresponds to values.

Figure 12: Proportional increase in flood event count over baseline conditions attributable to the big notch under maximum impact years. Maximum impact water years defined as the four years which had the largest cumulative difference in flood events between baseline and big notch scenarios. Values are presented for each depth threshold by wetland unit in the North Area. Shading corresponds to values.

Berm Blind Six Inch

Figure 13: Proportional increase in flood duration over baseline conditions attributable to the big notch under maximum impact years. Maximum impact water years defined as the four years which had the largest cumulative difference in duration between baseline and big notch scenarios. Values are presented for each depth threshold by wetland unit in the Center Area. Shading corresponds to values.

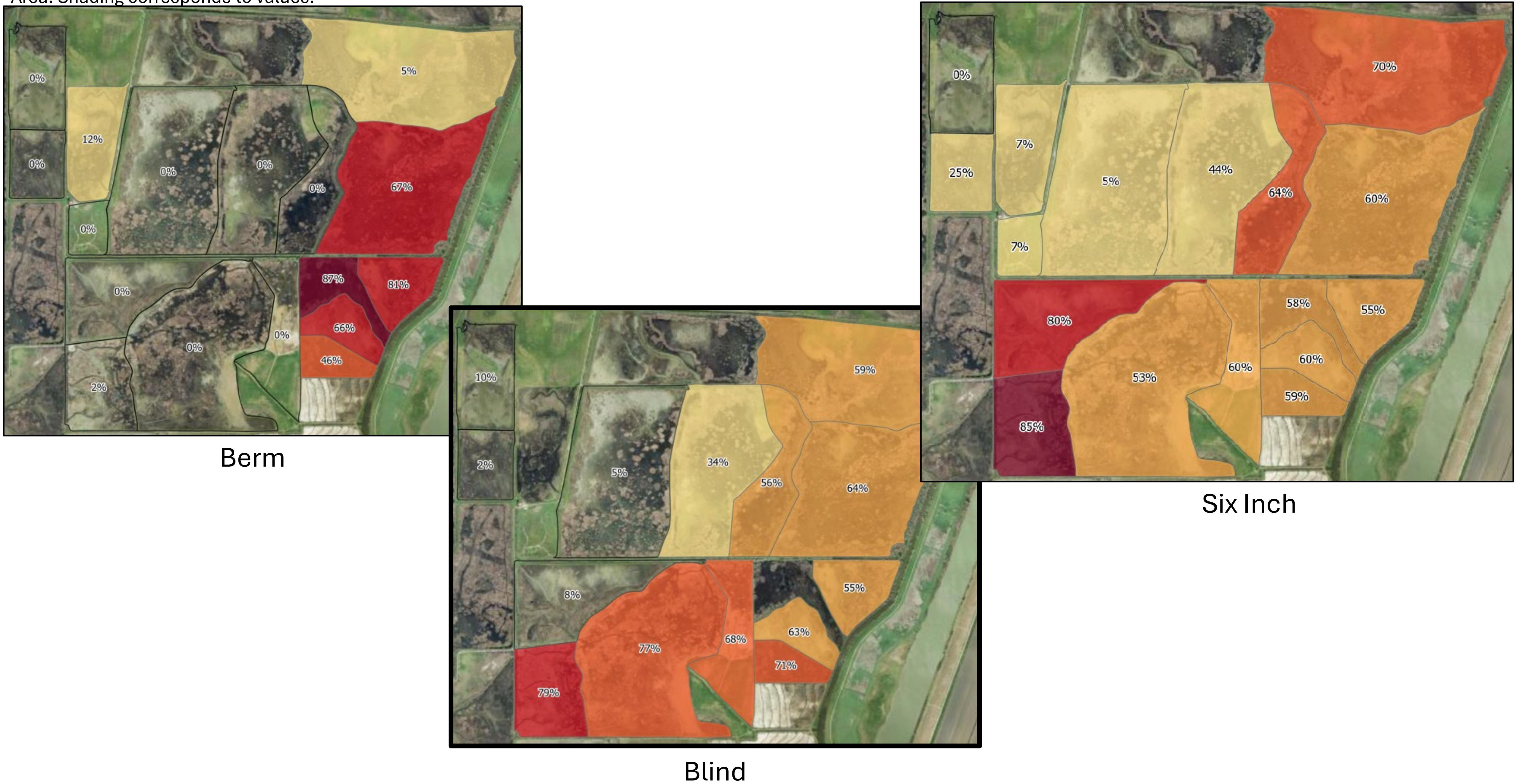

Figure 14: Proportional increase in hunt impact score over baseline conditions attributable to the big notch under maximum impact years. Maximum impact water years defined as the four years which had the largest cumulative difference in scores between baseline and big notch scenarios. Values are presented for each depth threshold by wetland unit in the Center Area. Shading corresponds to values.

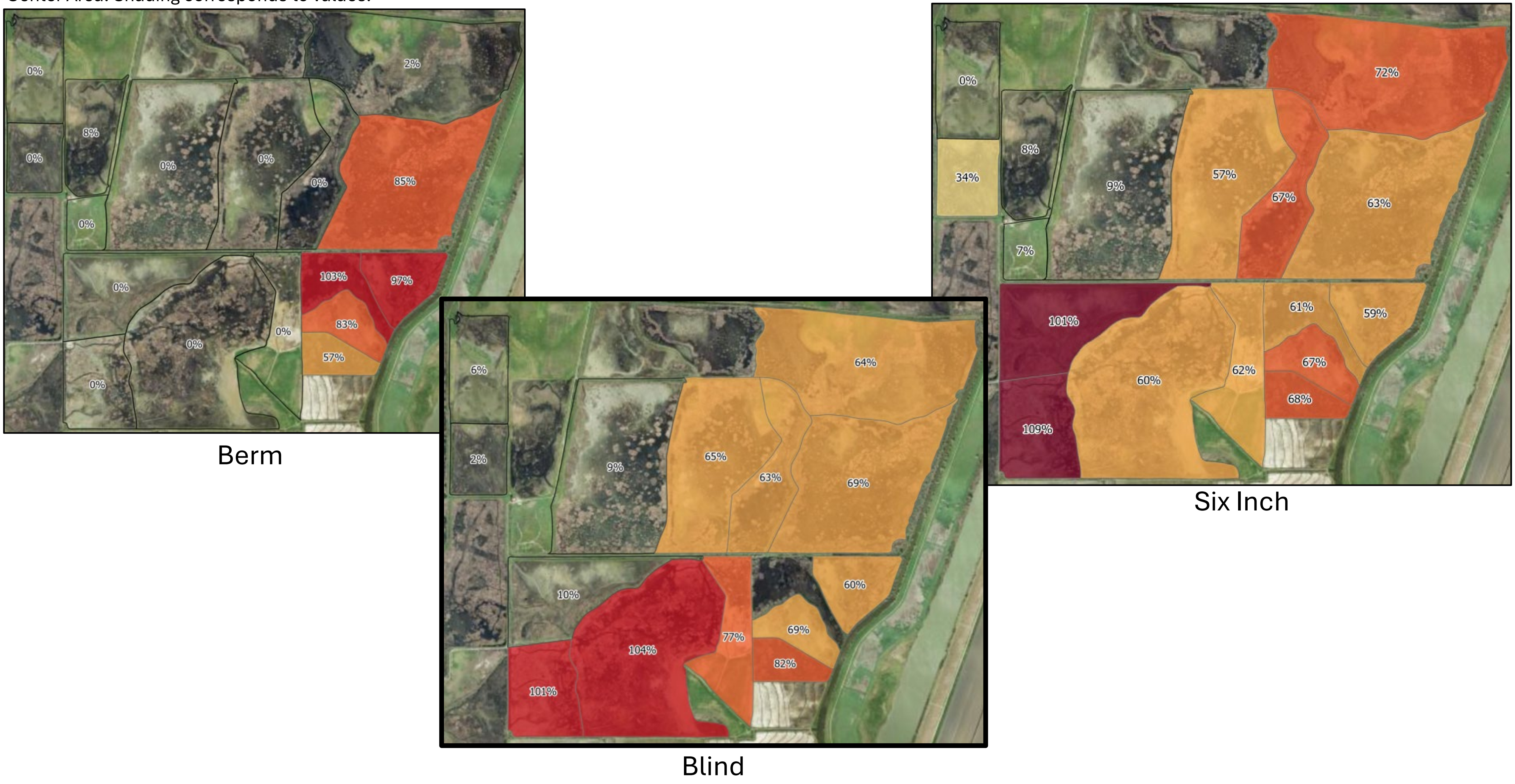

Figure 15: Proportional increase in flood event count over baseline conditions attributable to the big notch under maximum impact years. Maximum impact water years defined as the four years which had the largest cumulative difference in flood events between baseline and big notch scenarios. Values are presented for each depth threshold by wetland unit in the Center Area. Shading corresponds to values.

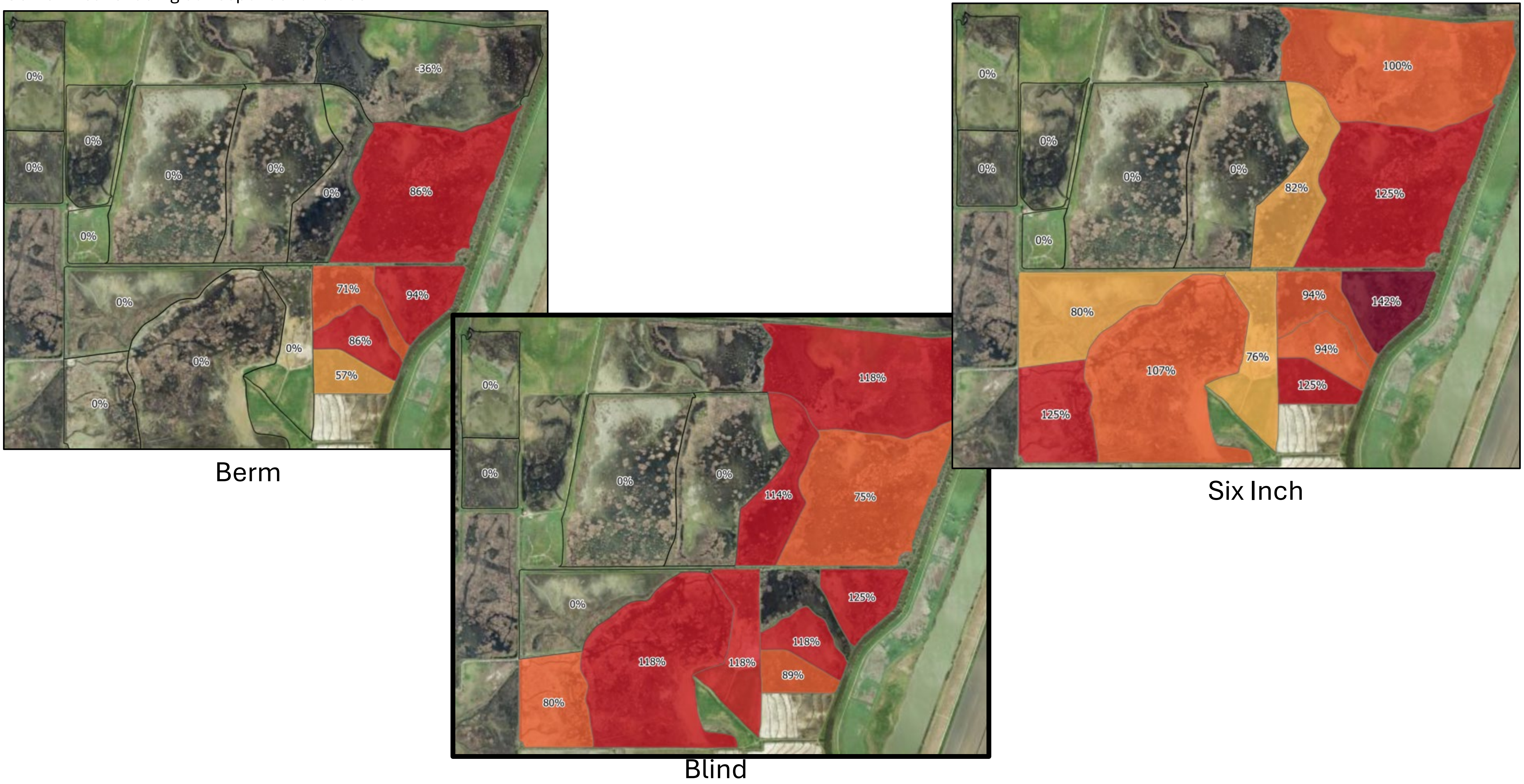

Figure 16: Proportional increase in flood duration over baseline conditions attributable to the big notch under maximum impact years. Maximum impact water years defined as the four years which had the largest cumulative difference in duration between baseline and big notch scenarios. Values are presented for each depth threshold by wetland unit in the South Area. Shading corresponds to values.

Berm Blind Six Inch

Figure 17: Proportional increase in hunt impact score over baseline conditions attributable to the big notch under maximum impact years. Maximum impact water years defined as the four years which had the largest cumulative difference in scores between baseline and big notch scenarios. Values are presented for each depth threshold by wetland unit in the South Area. Shading corresponds to values.

Figure 18: Proportional increase in flood event count over baseline conditions attributable to the big notch under maximum impact years. Maximum impact water years defined as the four years which had the largest cumulative difference in event count between baseline and big notch scenarios. Values are presented for each depth threshold by wetland unit in the South Area. Shading corresponds to values.