TECHNICAL MEMORANDUM

Date:	October 12, 2022
To:	Floodplains Reimagined Program Team
From:	cbec Technical Team
Project:	Floodplains Reimagined Program Phase I: The Landscape Scale Multi-Benefit Floodplain Feasibility Study Project
Subject:	Modeling Framework for Managed Wetlands in the Butte and Colusa Basins

INTRODUCTION

This Technical Memorandum describes the modeling framework developed by cbec for winter-managed flooding of wetlands and rice fields in the Butte and Colusa basins. This framework is being implemented in hydrodynamic models of the Butte and Colusa basins to support Floodplains Reimagined habitat assessments. The hydrodynamic models route water through the two basins primarily based on topographic relief and water control structures. However, water routing is also strongly dependent on water management schedules for rice fields and wetlands. Rice fields are flooded for decomposition as well as waterfowl habitat, and wetlands throughout the basins are flooded to provide a variety of habitat types.

The main objective of the modeling framework described herein is to specify generalized flood-up and drawdown schedules, as well as target depths or water levels, for the various types of rice fields and wetlands in the basins. For the purposes of this framework, three types of managed wetlands were delineated: 1) managed rice fields; 2) private wetlands (i.e., Butte Sink duck clubs, Wetland Reserve Program easements, US Fish and Wildlife Service easements, mitigation banks); and 3) public wetlands (i.e., State and Federal wildlife areas). Figure 1 shows a map of the different types of managed wetlands in the basins.

A second objective of the framework is to specify a method for adjusting ground elevations in areas that were inundated during LiDAR data collections. LiDAR data in these inundated areas do not reflect actual ground elevations because LiDAR does not penetrate water. Thus, the elevations in these areas must be adjusted to better reflect water storage capacity.

Several simplifying assumptions were made to specify generalized flooding schedules. First, it is important to note that the hydrodynamic models do not capture all details of the water distribution systems in the basins. That is, the models route water through the major channels and canals but do not include many of the smaller canals that deliver water to individual fields. Rather, it is assumed that water is delivered and is readily available for rice fields and wetland flooding during winter months. This assumption is necessary due to the large sizes of the basins and complexity of the water delivery systems. In addition, it is assumed that flooding schedules do not vary year-to-year based on water availability. While it is known that some variability in schedules does occur, the necessary information to incorporate this variability is not readily available. Specifying a common flooding schedule for all years allows for establishing a common baseline condition for comparison of proposed scenarios.

The generalized schedules were developed from a variety of data sources, including available reports such as the 2001 Butte Sink Cooperative Management Plan and 2021 Feather River Regional Agricultural Water Management Plan. The primary source of information, though, was conversations with interested parties with knowledge of flooding schedules in the basins, including Ducks Unlimited, Point Blue, Butte Sink duck club operators, various irrigation and water district personnel, USDA-NRCS personnel, and other entities involved in the Floodplains Reimagined effort. A full list of contacts is provided in the Acknowledgements section.

The generalized flooding schedules for each wetland type and the LiDAR adjustments are described in detail in the following sections.

MANAGED RICE FIELDS

Winter Water Management

As previously mentioned, many rice fields are flooded in the winter for decomposition and to provide waterfowl habitat. The fields shown in Figure 1 as managed rice fields were identified through analysis of multiple years of inundation mapping from remote sensing data sources conducted by Point Blue (https://data.pointblue.org/apps/autowater/) and are assumed to be managed every year. Figure 2 shows the locations of all rice fields in the basins, the subset that were identified for winter management, and other types of agricultural fields.

The generalized flooding schedule for rice fields is shown in Figure 3. The schedule has the following primary components: 1) flood-up beginning on November 1 with a 2-week duration; 2) flooding to a depth of 10 inches; and 3) drawdown beginning February 1 with a 1-week duration. The target flooding depth of 10 inches represents a typical value with the recognition that variability exists based on personal preferences of landowners. Cited values ranged from as shallow as 6 inches to as deep as 12-14 inches. The choice of 10 inches represents a compromise that allows for winter-managed rice fields to have depths that provide suitable waterbird habitat.

LiDAR Adjustments

Many of the winter-managed rice fields were inundated when LiDAR acquisitions occurred in the winter of 2008 and 2018/2019; thus, the field elevations must be adjusted to account for this inundation. Figure 4 illustrates these adjustments schematically. The flat surfaces in the LiDAR terrain in Figure 4 indicate that the field was inundated during acquisition. Another feature apparent in the LiDAR terrain are the internal berms (rice checks); these features cannot be resolved in the hydrodynamic models because 1) they are not resolved very well in the LiDAR, and 2) the area between rice checks is often smaller than the model grid cells. Thus, a method was devised to account for the effect of the rice checks without including them explicitly in the models. To accomplish this, it was assumed that the rice checks are used to manage to comparable depths (10”) within the individual units between checks. With this assumption, the entire field can be managed to a consistent depth and modeled without the need for rice checks.

To estimate the appropriate ground elevation without the rice checks, the lowest point on the exterior berms surrounding a given rice field was extracted (the exterior berms are well-resolved in the LiDAR). The lowest point in the exterior berms was then used as a reference for estimating the water surface and ground elevations in the field, by first subtracting the typical freeboard to get the water surface elevation, then subtracting the target depth to get the ground elevation (Figure 5). Typical freeboard was assumed to be 4 inches and the target depth was assumed to be 10 inches. The LiDAR terrain was then adjusted to the computed ground elevation throughout each field. Sensitivity tests were conducted on the freeboard depth for several fields, and it was determined that 4 inches provided the best representation of the total volume of water storage capacity in the fields.

PRIVATE WETLANDS

Winter Water Management

The primary area of private wetlands with managed flooding within the hydrodynamic model footprints is the Butte Sink, which contains many properties that are managed for waterfowl hunting (Figure 1). Another area of private wetlands with managed flooding is along the Colusa Drain, which contains private lands in conservation easements for a variety of purposes. The vast majority of private wetlands outside of Butte Sink participate in the USDA Wetlands Reserve Program (WRP) and are managed for waterfowl habitat in the winter. Because the Butte Sink and WRP wetlands are both managed for waterfowl habitat, similar schedules are specified for both as described below.

The generalized flooding schedules for private wetlands in the Butte Sink and WRP are shown in Figure 5. The managed water depth, 10 inches, is the same as for the managed rice fields. In Butte Sink flood-up typically begins in the late summer, utilizing agricultural drain water, and is assumed to be completed by October 1 in typical years (note: the hydrodynamic model simulations begin on October 1). WRP wetlands are assumed to flood-up during October. Drawdown in Butte Sink is assumed to begin on March 1 and continues for 6 weeks; WRP wetlands are assumed to start drawdown mid-March and continue through mid-April. It is recognized that the flood-up and drawdown rates are variable depending on the size and location of the property; the schedules in Figure 5 are meant to represent typical or average conditions.

LiDAR Adjustments

As with the managed rice fields, most of the private wetlands were inundated during LiDAR acquisition and thus require adjustments to ground elevations. A similar approach to rice field adjustments was used as shown in Figure 6, where the flattened terrain due to inundation is apparent. The main difference between the rice fields and private wetlands is that berms in the private wetlands cannot be used as the reference elevations because the berms are not well-resolved in the LiDAR due to vegetation effects.

Instead, the “hydro-flattened” elevations were used as the reference. Hydro-flattening refers to the process used in LiDAR processing of inundated areas, whereby inundated areas are assigned a common elevation. Field surveys of target water levels (i.e., shooting levels) conducted throughout Butte Sink and other wetlands indicated that the hydro-flattened elevations generally coincided with the target water levels (see Verification section below), which suggests they represent water levels during the time of the LiDAR acquisition. Thus, to estimate the adjusted ground elevations, the target depth (10 inches) was simply subtracted from the hydro-flattened elevations as shown in Figure 6. The exterior field berms in this area were also poorly resolved, therefore exterior berm elevations were corrected by adding an estimated freeboard height of 12 inches to the hydro-flattened elevation.

PUBLIC WETLANDS – STATE

Winter Water Management

Two large State of California managed wildlife areas that contain managed wetlands are located in the Butte Basin: the Upper Butte Basin Wildlife Area (UBBWA) and the Gray Lodge Wildlife Area (Figure 1). The UBBWA contains three separate units: Little Dry Creek Unit, Howard Slough Unit, and Llano Seco Unit.

Flood-up on the State wetlands generally occurs over the same time frame as rice fields and private wetlands (i.e., July/August through December). However, the timing of the flood-up tends to be staggered in time, as water is distributed through the wildlife areas from the various water sources. Figure 7 shows a generalized schedule for managed wetland flooding in the State-managed public wetlands. The staggered flood-up schedule is represented by dashed lines but is not meant to represent the exact schedules. Specific schedules have been developed for each wildlife area based on conversations with and information provided by CDFW staff. As with rice fields and private wetlands, target water depths are assumed to be 10 inches to support waterfowl habitat. Drawdown is assumed to begin on March 1 with a 4-week duration.

LiDAR Adjustments

The State wildlife areas were also largely inundated during the LiDAR acquisitions and thus require ground elevation adjustments. The same methodology was used as described in the previous section for private wetlands. The hydro-flattened elevations from the LiDAR were assumed to represent the target managed water levels (and confirmed with field data), and ground elevations were computed by subtracting the target water depth (10 inches) from the managed water levels.

PUBLIC WETLANDS – FEDERAL

Winter Water Management

There are several Federal National Wildlife Refuges (NWR) and Wildlife Management Areas (WMA) within the Butte and Colusa basin hydrodynamic model footprints: Delevan NWR, Colusa NWR, the Llano Seco Unit of the Steve Thompson North Central Valley WMA, and the Butte Sink WMA (Figure 1). For the NWRs and WMAs, the USFWS documents flood-up and drawdown schedules for individual wetland units in annual Habitat Management Plans (HMP). The HMPs indicate that the flood-up and drawdown schedules are variable in timing and duration, as illustrated schematically in Figure 8. Flood-up generally occurs during the period of August – December, and the duration varies from only a few days to about one month. Similarly, drawdown schedules vary in timing and duration, generally occurring March – May with durations ranging from only a few days to as long as a month and a half. In addition to variable flood-up and drawdown, the target water depths also vary for the individual wetlands depending on the desired species habitat type. For wetlands managed for waterfowl, which is the vast majority of wetland areas within the NWRs and WMAs, the target depth was assumed to be 10 inches (same as for rice and private wetlands). For areas managed for other species, target depths were specified based on information provided by USFWS.

LiDAR Adjustments

As with the other wetland types, the Federal NWRs and WMAs were mostly inundated during the LiDAR acquisitions. The ground elevations were adjusted using the same procedure as the private wetlands and State-managed wetlands, as described in previous sections.

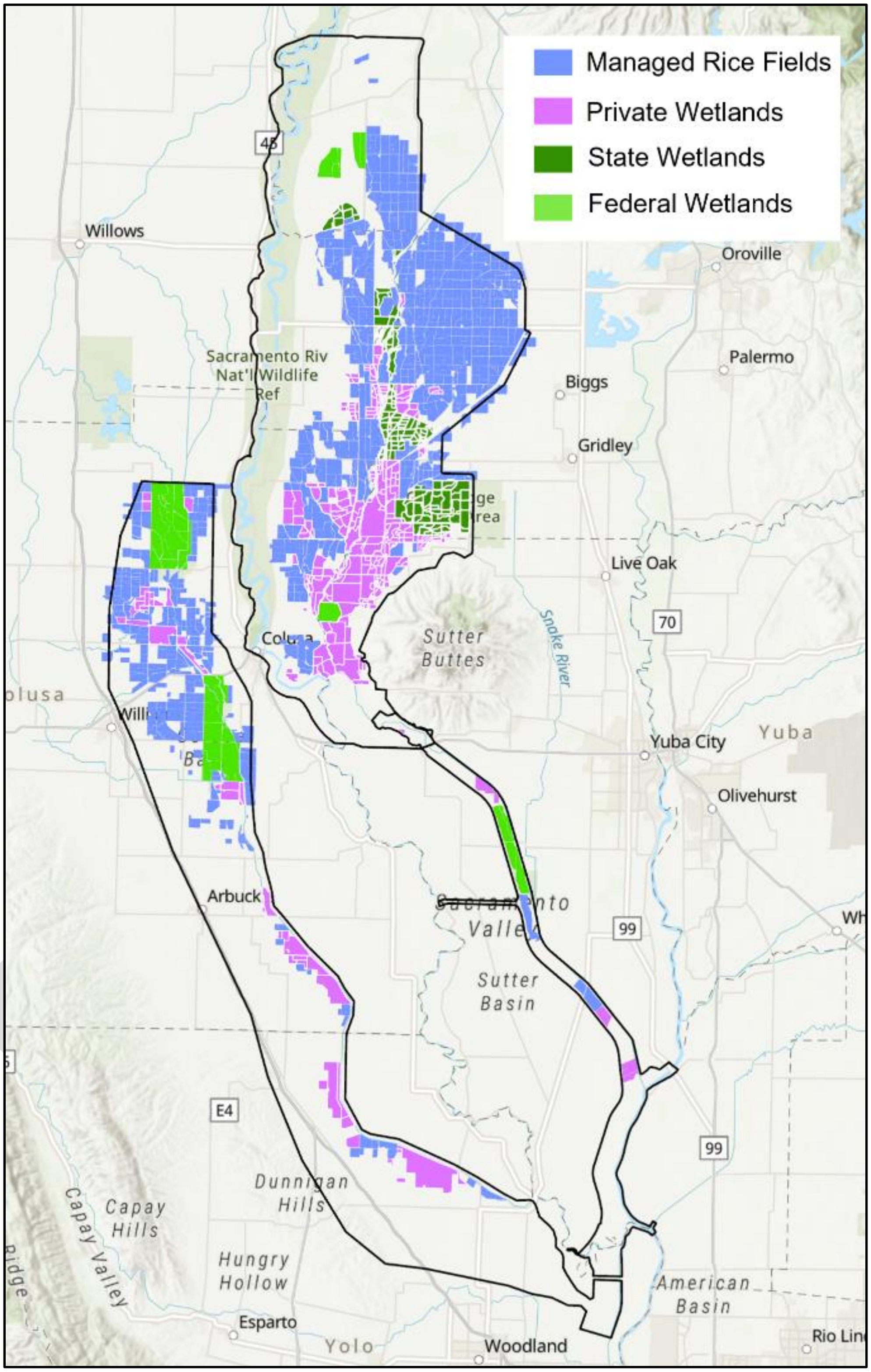
ACKNOWLEDGEMENTS

Outreach was conducted by cbec to obtain information on winter management schedules and target depths. We would like to acknowledge the following people, in no particular order, for their contributions to this effort: Roger Swanson and JP Stover (Wild Goose Club), Joe Gibson (Field and Tule Club), Bob Duffey (Live Oak Gun Club), Jordon (North Butte Inc), Dirk (El Anzar), Dan Gibson (Sacramento Outing), Eric Gibson (Swanston and Stack Farms), Chuck Nuchols (RD 833), Braly Zumwalt (Colusa Shooting Club), Andy Duffey (RD 1660), Matt Menzel and Chris Tocatlian (White Mallard), Jered Shipley and Zachary Dickens (GCID), Ted Trimble (Western Canal), Virginia Getz, Brian Heidman, and Dan Fehringer (Ducks Unlimited), James Allen and Tim Hermanson (CDFW, Gray Lodge), Dave van Buren (CDFW, Upper Butte Basin), Jacob Byers, Craig Isola, Michael D'Errico, Curt McCasland and Brendan Leigh (USFWS), Kristy Dybala, Kristin Sesser and Corey Shake (Point Blue), Terry Bressler (RD 1004), Nathan Key (USDA NRCS).

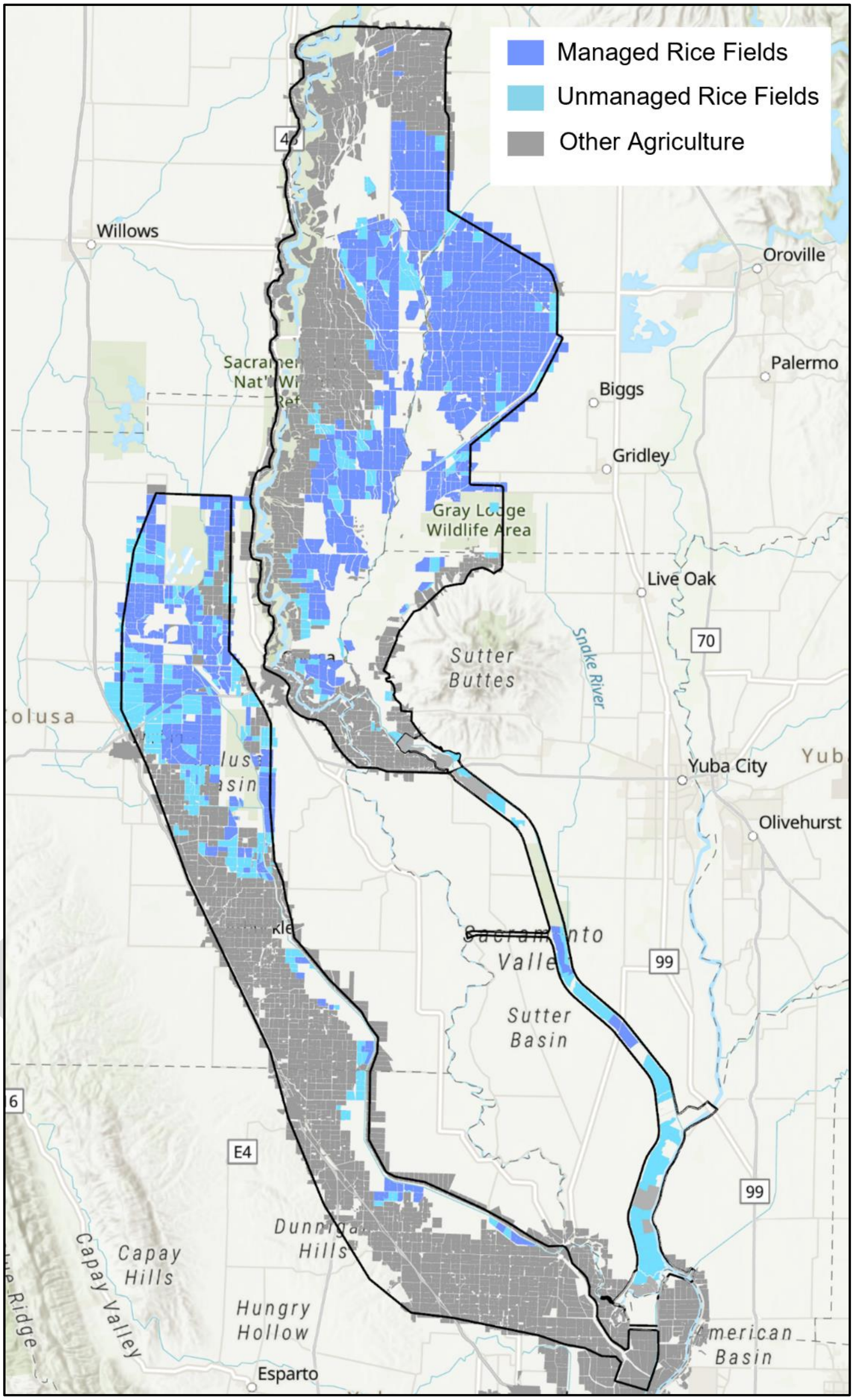
LIDAR-DERIVED WATER MANAGEMENT LEVEL VERIFICATION

As described in previous sections, hydro-flattened areas in the LiDAR data were assumed to represent water levels at the time of acquisition, which in turn were assumed to represent management levels within the wetland areas. To test and verify this assumption, cbec collected target water levels throughout the Butte Sink and public wetlands. Locations to survey elevations were determined through conversations with duck club operators and by identifying high-water marks (i.e., bathtub rings) on structures within the wetlands. All surveying was carried out using RTK-GPS with additional corrections from surveying established benchmarks in the area.

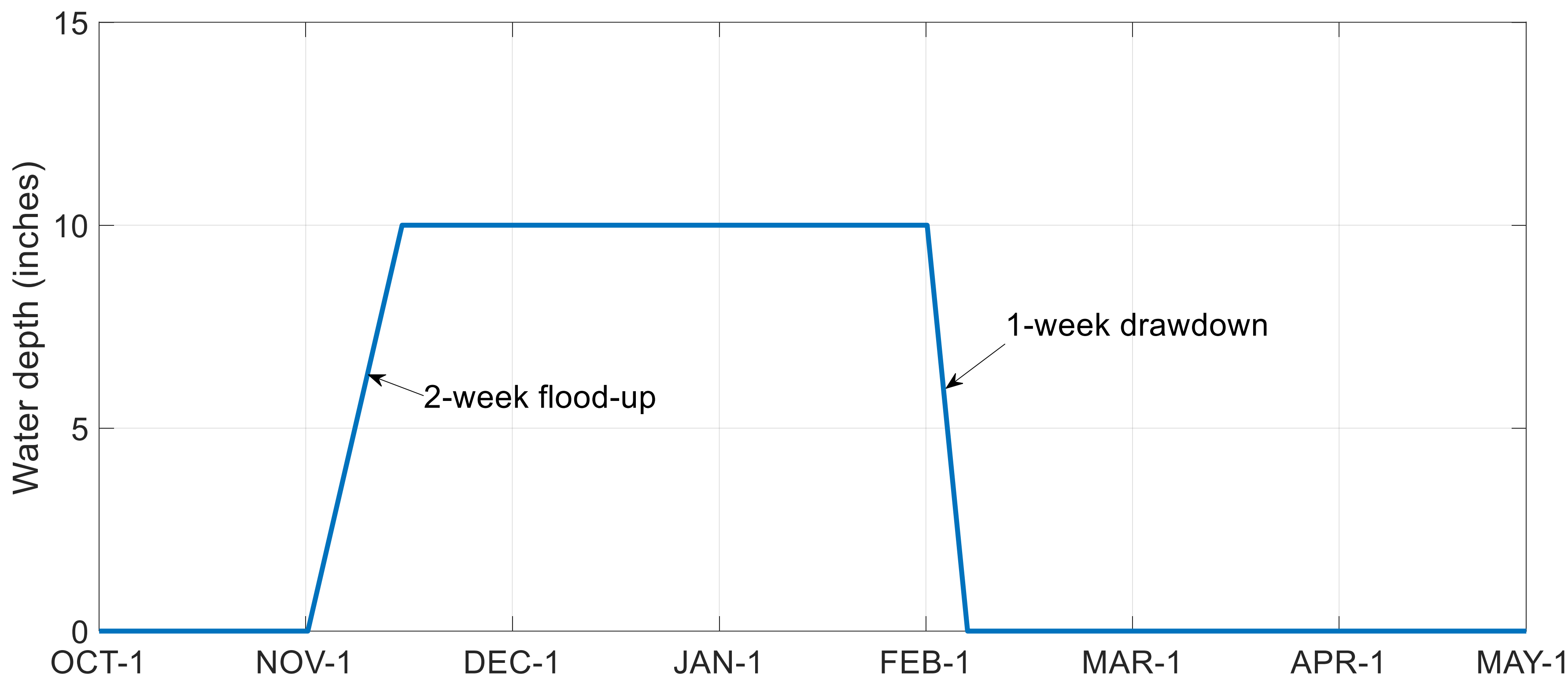
Figure 9 shows the correlation between the LiDAR hydro-flattened elevations and the field-measured elevations, indicating good agreement in general. The mean difference between the LiDAR and field elevations was 0.31 feet, ranging from -1.14 to 1.73 feet. Because the mean averages out negative and positive differences, a better measure of correlation is obtained by taking the absolute value of the differences, then computing the mean. Using this method results in a mean difference of 0.59 feet. These results confirm the appropriateness of the assumption, with reasonably small error that can be attributed to several sources including GPS survey error, LiDAR survey error, high-water marks, and the possibility that water levels at the time of the LiDAR acquisition were different from typical managed water levels.



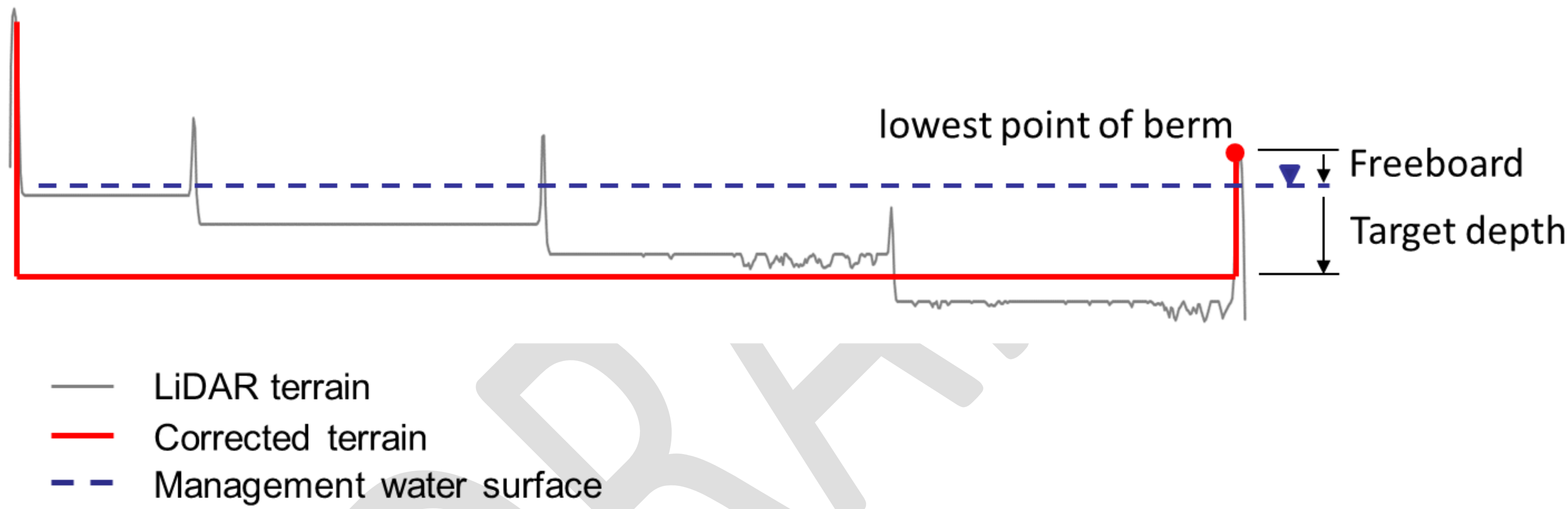
Notes:	cbec eco engineering	*Floodplains Reimagined* **Managed Wetland Types in the Project Footprint**		
		Project No. 21-1028	Created By: Jenna Duffin	**Figure 1**



Notes:	cbec eco engineering	*Floodplains Reimagined* **Managed Rice Fields in the Project Footprint**		
		Project No. 21-1028	Created By: Jenna Duffin	**Figure 2**



Notes:	cbec eco engineering	*Floodplains Reimagined* **Flooding Schedule for Managed Rice Fields**		
		Project No. 21-1028	Created By: Scott Wright	**Figure 3**



Notes: Conceptual representation. Not to scale.

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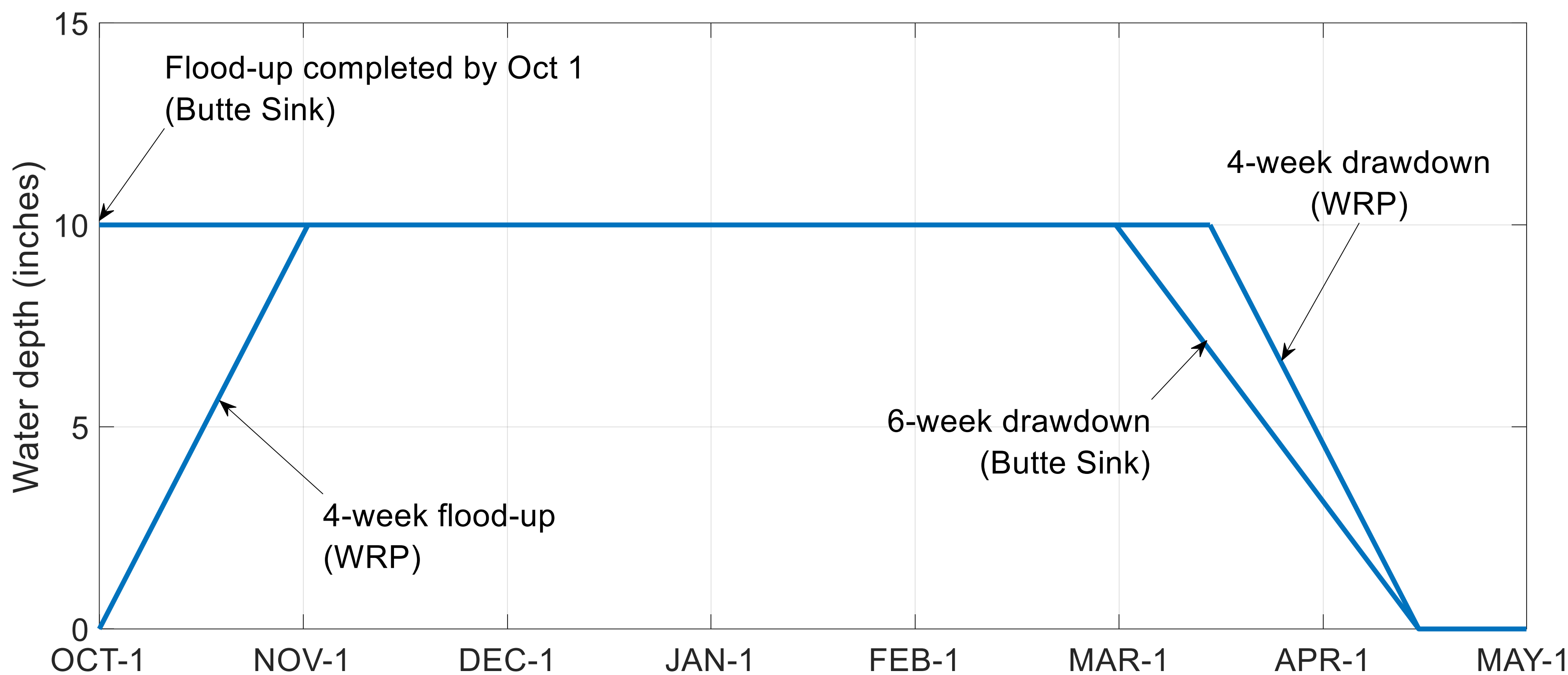
LiDAR Terrain Adjustments for Rice Fields

Project No. 21-1028 | Created By: Jenna Duffin | **Figure 4**



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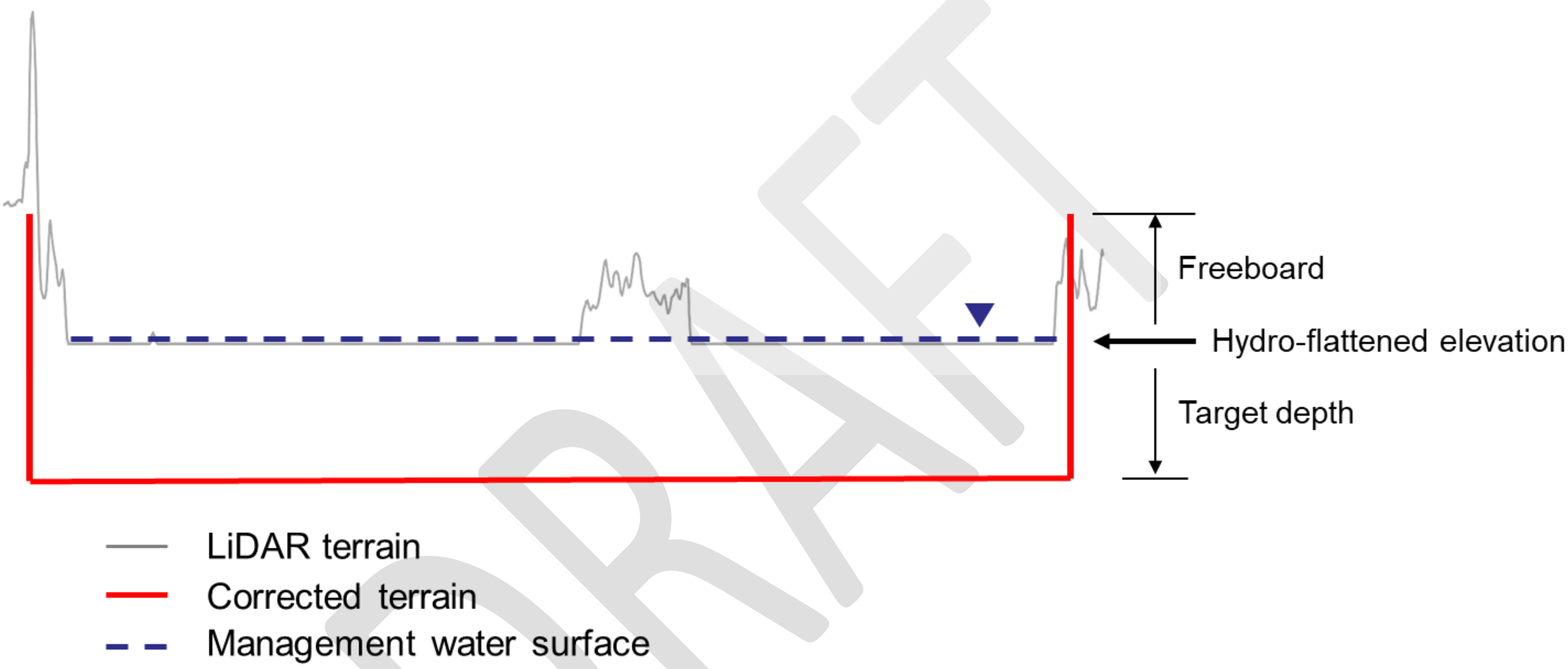
Flooding Schedules for Private Wetlands

Project No. 21-1028 | Created By: Scott Wright | **Figure 5**



Notes: Conceptual representation. Not to scale.

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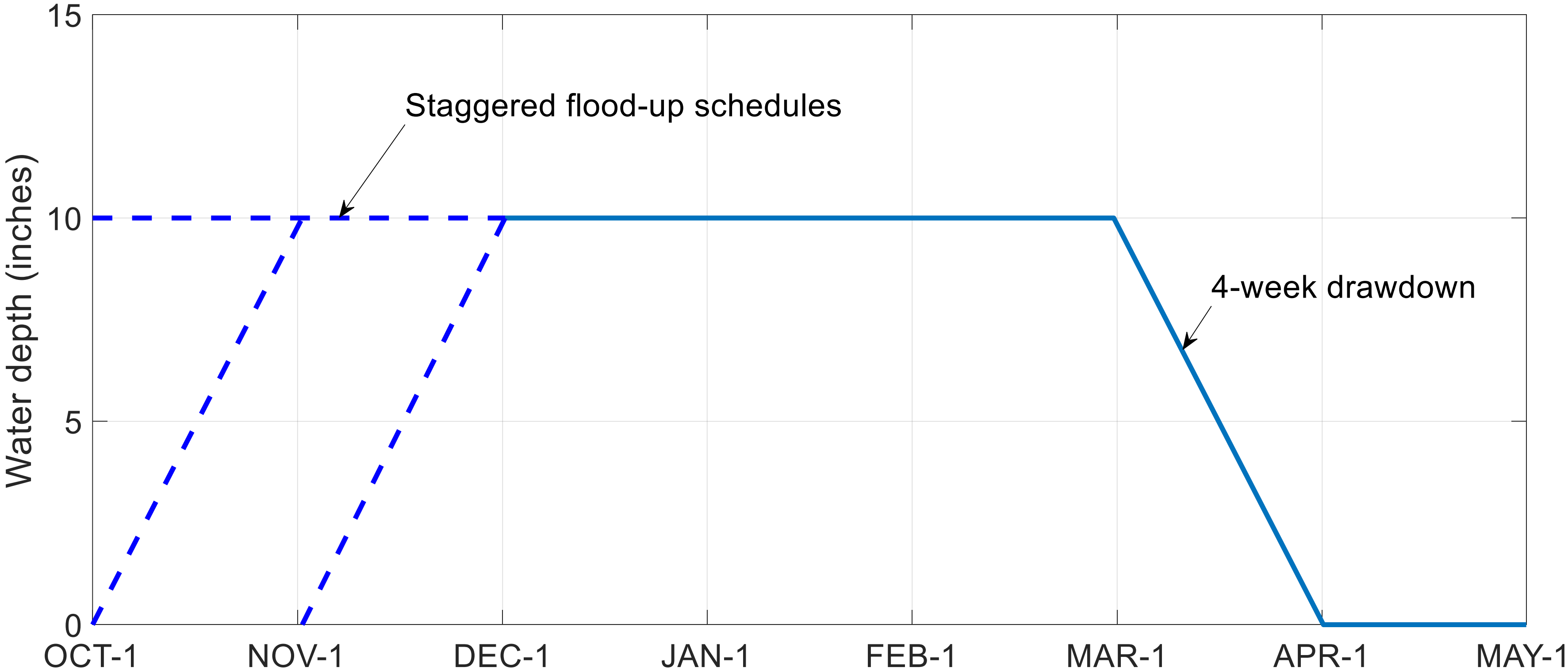
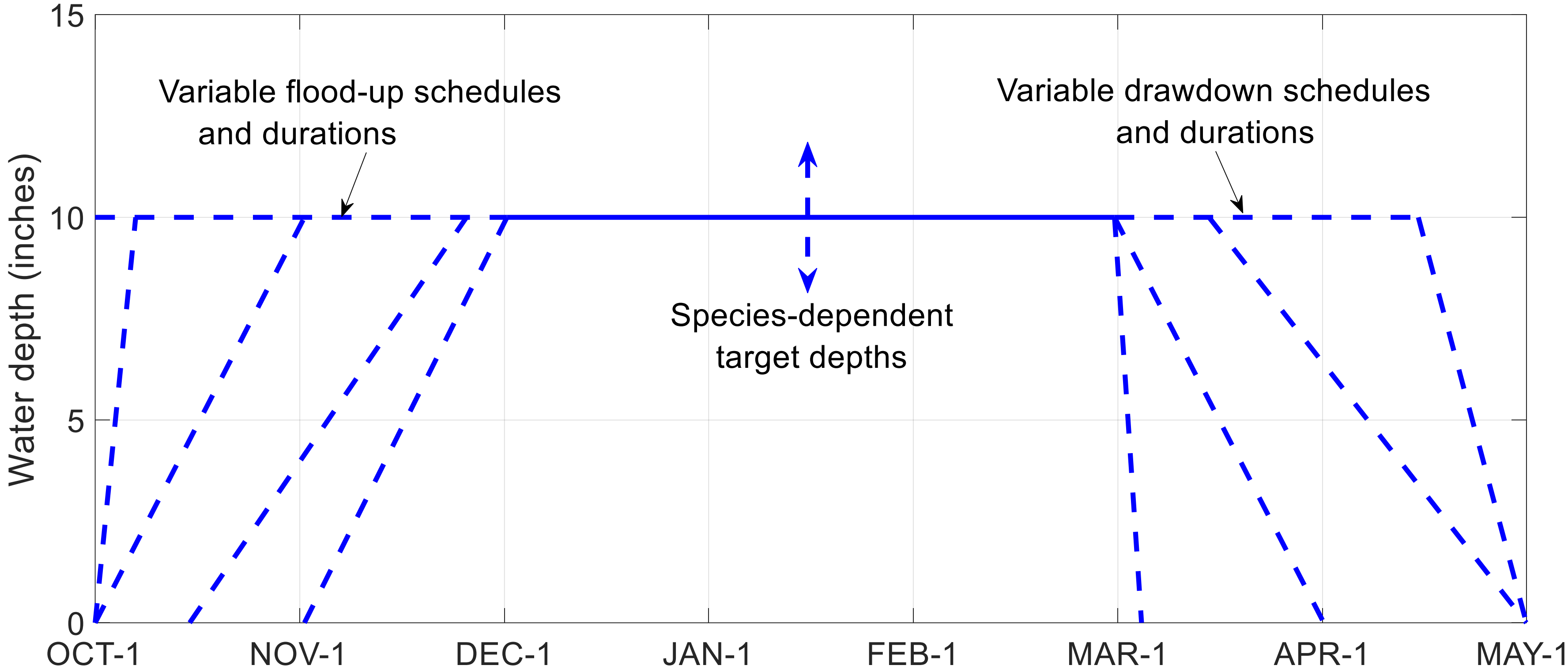
LiDAR Terrain Adjustments for Private Wetlands

Project No. 21-1028 | Created By: Jenna Duffin | **Figure 6**



Notes: Dashed lines are not exact schedules but rather represent the fact that schedules are variable in terms of flood-up start, end, and duration.	cbec eco engineering	*Floodplains Reimagined* **Flooding Schedules for State Wetlands**
		Project No. 21-1028 | Created By: Scott Wright | **Figure 7**



Notes: Dashed lines are not exact schedules but rather represent the fact that schedules are variable in terms of flood-up start, end, and duration.

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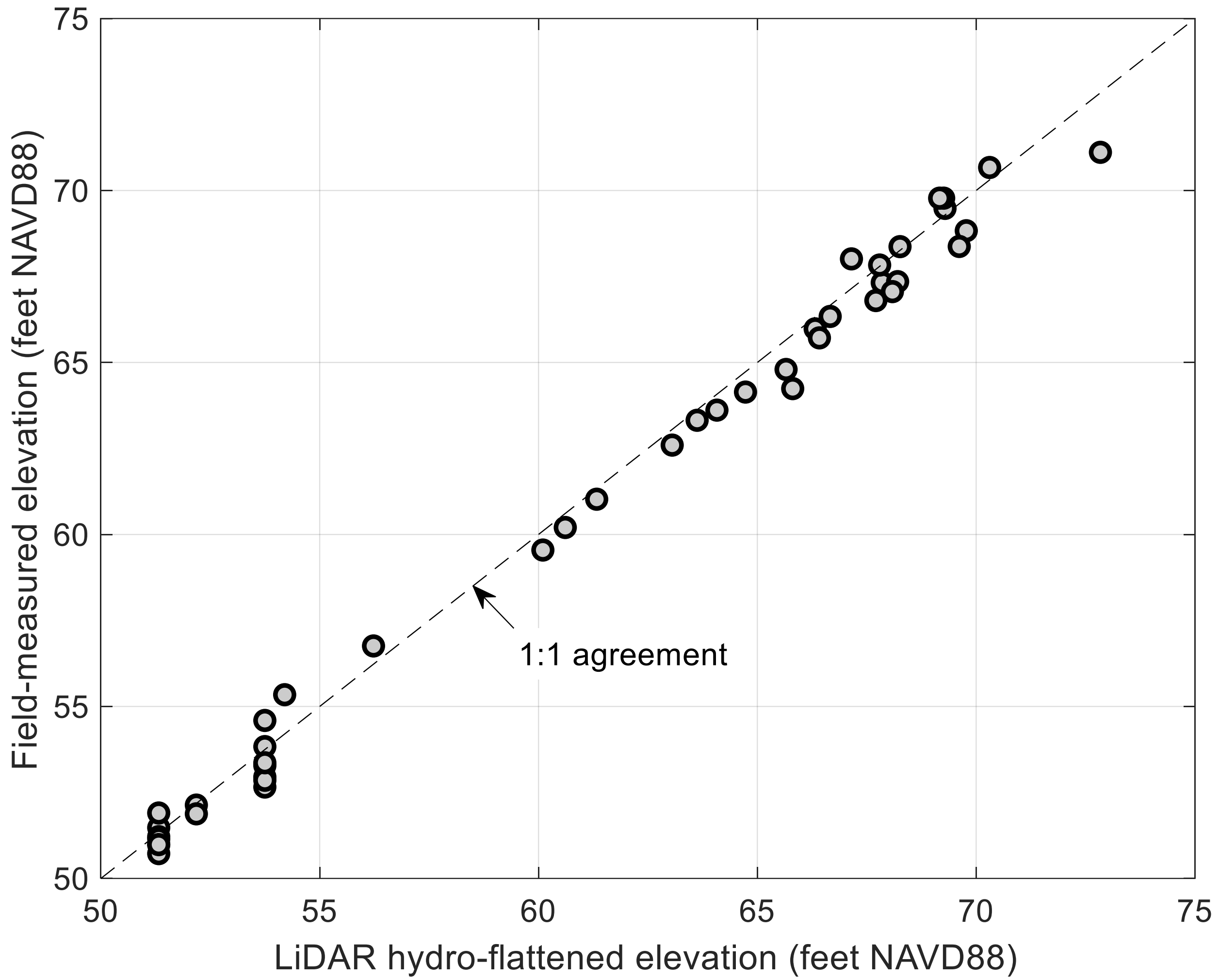
Flooding Schedules for Federal Wetlands

Project No. 21-1028 | Created By: Scott Wright | **Figure 8**



Notes:

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Field Verification of LiDAR-Derived Water Levels

Project No. 21-1028 | Created By: Scott Wright | **Figure 9**