CONSIDERATIONS AND PRESCRIPTIONS FOR THE DESIGN, CONSTRUCTION, AND MANAGEMENT OF SHALLOW WATER WETLANDS FOR SPRING THROUGH FALL USE BY TRUMPETER SWANS *(Cygnus buccinator)* IN WESTERN WYOMING

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INTRODUCTION

Trumpeter Swans require shallow-water wetlands that produce extensive, luxuriant, and diverse stands of submerged aquatic vegetation. These kinds of wetlands, with some recognized physical and biological characteristics, fulfill functions important for swans of all age classes. The following information was developed based on data and publications from past investigations and the collective knowledge of three biologists (Dave Lockman, Dan Stevenson, and Susan Patla) who have intensively studied swans and their habitats for the Wyoming Game & Fish Department in Wyoming from 1981-2004. We have compiled this information for use by private landowners, wetland construction contractors, biologists, land trusts, and land managers for the planning, construction, improvement, and management of wetlands for spring through fall use by Trumpeter Swans. If these considerations and prescriptions are utilized in the design and construction of shallow-water wetlands, we anticipate a high probability of use either by adult swans for nesting and production, by molting sub-adults during mid-summer, by paired adults prior to the nesting period, or by migrating swans in the spring or fall seasons. Shallow water wetlands are crucial for sustaining the local resident flock between ice-off and ice-on (late March-late November). Because of the unique security and aquatic food needs of adult and young swans, summer flock size may be currently limited by lack of habitat with the physical and biological characteristics capable of sustaining nesting adults and producing cygnets to flight. We predict that the resident flock size will increase slowly if productive, suitable habitat increases in availability and dispersion; and local swan production and recruitment increases. Wetland habitats designed with trumpeter swans in mind will accommodate many other waterfowl, water birds, and numerous other wildlife species associated with aquatic and riparian habitats in the state.

WETLAND DESIGN AND MANAGEMENT PRESCRIPTIONS FOR TRUMPETER SWAN HABITAT IN THE NESTING SEASON

Background Biological Considerations

Security and availability of food are the two most important factors that determine the suitability of a wetland site for nesting, and subsequent adult and young survival. An adult pair must feel secure during the nest building, egg laying, incubation, and brood rearing periods. If a pair does not have sufficient open water space, cover, and food; or is disturbed frequently, they probably will not lay eggs, or if they do, may not incubate the clutch to hatch. If a sense of security is not maintained or if adequate forage is not available after young hatch, the adults may try to move cygnets across land to another more suitable location, which can result in loss of young and subsequent abandonment of the nest site by the adult pair. In addition, all sub-adult and adult swans go through a 3-4 week molting period in July during which they are flightless and quite vulnerable, so non-nesting pairs and groups of sub-adults also require adequate open water space, food and cover to feel secure on a wetland from intruders and predators.

Wetland Size, Spatial Considerations and Swan Security

To maintain their sense of security, swans depend on open water space and their ability to see or conceal themselves from approaching intruders. Emergent vegetation such as willows, bulrushes, and cattails; irregular-shaped shorelines; and topographical relief can provide concealment cover and escape from human activities in line-of-sight. Swans do not generally select sites that are surrounded by dense tree or tall shrub cover or that offer very low visibility. Open water distances of at least 300 feet (91 m) in length without obstructions of trees, shrub and aquatic emergent vegetation cover are also important for take-off and landing. An adult Trumpeter requires approximately 110 feet (34 m) without a head wind to take off and gain six feet elevation. For loafing, swans prefer some shoreline or island sites with low forms of vegetation cover or gravel/mud flats. Stands of tall emergents or shrub cover located centrally in open water areas can also provide concealment cover and improve security for nesting, brood concealment, and molting. As a general rule, no more than 40% of the surface water area or shoreline length should contain tall emergent vegetation cover, such as cattails or bulrushes, or dense shrub cover. Shoreline configurations designed with irregularity, such as bays and peninsulas, can also provide concealment cover. These types of concealment cover may not be as essential in more secluded sites with fewer human intrusions.

When a new pair occupies a territory for the first year, they need to feel secure enough to go through their first flightless molt, and remain on the pond for some time after the molt. If a molting pair does not feel secure, they may try to move across country on foot, or leave immediately after the molt never to return. Once a pair has gotten through the first molt on a new territory, they have a strong fidelity to that territory and will generally return in subsequent years. Generally, first nest attempts and brood rearing occur after the first year on territory. Some pairs attempt to nest for 2-3 years before they successfully raise young. Once a pair becomes established, they may return to a territory for over a decade. If a pair is lost, other sub-adults will often reoccupy a site. Young swans raised on a site will generally return to the same area or region in subsequent years, and one of the siblings will often reoccupy a site vacated by the parents or will occupy available sites nearby.

Wetland size, and segregation from fishing and canoeing activity, is important for providing an adequate sense of security. A large open water area also protects swans from potential mammalian and avian predators. Over time, swans can habituate to some human activity and vehicle use on the surrounding land if such activities are low frequency, predictable, and not directed towards swans or do not intrude on their open water space. Like many other species of wildlife, swans can adjust to events they see coming more readily than to surprises. If a swan on a nest vacates the nest every time someone approaches the shoreline, this indicates she feels insecure and such disturbances will likely affect her ability to lay or incubate successfully. On private lands, managers or landowners can manage wetland access and instruct people on how to behave when swans are present.

Nesting and Aquatic Vegetation Production Considerations

A pair of breeding trumpeters will arrive on a territory soon after ice-off in the spring and remain on the pond for a period of 157-200 days. This includes a pre-nesting period (8-15 days) for nest building and feeding prior to egg laying, clutch production (6-12 days), incubation (36 days), brood rearing to flight (100-120 days), and a period for the young to exercise their wings prior to dispersion to a wintering area (7-21 days). During this time, each adult will have consumed about 10 pounds (4.5 kg) wet weight and 2 pounds (0.90 kg) dry weight of aquatic vegetation per day. With 3-6 cygnets and two adults over the spring and summer, they will have consumed 3-5 tons of wet aquatic vegetation. If a wetland does not produce adequate food resources, young will develop very slowly and be vulnerable to predators, may die within the first four weeks due to malnourishment, or may not be strong enough to fly prior to freeze-up and be abandoned by adults. Inadequate food resources near the nest site also can cause the incubating female to spend excessive time off the nest, resulting in heat or cold stress to the eggs and developing embryos, affecting hatchability. An abundant source of aquatic insects and crustaceans, harbored by aquatic vegetation, is also important for the reproductive female, and her rapidly growing brood. These invertebrates are attached to aquatic plants, and consumed incidental to their use. The diversity, abundance and succession of aquatic vegetation will depend upon many factors including size and depth of the wetland, water level management, substrates, and time of ice-off. Monitoring of vegetation diversity and abundance is essential for understanding how to manage particular sites for optimal productivity.

The following management prescriptions were designed primarily for private lands. Wetland size requirements may be greater for sites on public land where human intrusion is often less predictable and less manageable. If the wetland being developed or improved for swans will also provide habitat for fish and fishing activity, special considerations must be made when the site is being designed. On more extensive marsh complexes managed primarily for waterfowl, such as on waterfowl refuges, these cover and spatial requirements may not be applicable.

PRESCRIPTIONS

I. Standards for Wetland Size and Water Depths

Optimum Conditions: 8-15 acres of open water with at least 5 acres of shallow water, 6-42 inches variable depth. If in an interconnected wetland complex, at least one of the ponds should be designed with 5 surface acres of shallow, open water.

Minimum Conditions: Provide at least 3-5 acres of shallow water wetland on one site, with one or more additional shallow water wetlands in close proximity that provide adequate submerged vegetation for foraging. If deep water habitat for fish and fishing is being designed into the project, provide at least 3 acres of shallow wetland in conjunction with the fish pond and an adjacent shallow wetland of at least 3-5 acres for nesting and brood production.

RATIONALE: The larger the wetland area, the higher probability of use by swans. Water depths should be variable and bottom/shoreline contours gradual. Shallow water areas of less than 12-inch depth along the shoreline are generally affected by seasonal water fluctuations, which are conducive to the growth of taller emergents such as cattails and bulrushes. Tall emergents also provide concealment cover around islands and shorelines. Submerged aquatic vegetation produced in areas less than 12 inches in depth insure availability of food for cygnets in the first three weeks after hatch when their feeding activity is primarily restricted to the surface and shallow water zones. The design should insure that there are open water areas of at least 300 feet in length with shorelines unobstructed by trees and tall shrub vegetation for take-off and landing by swans.

Eight (8) plus acres with at least five (5) acres of shallow-water wetland provide enough open water for security between the swans and occasional shoreline intruders. Linear shapes require more surface area because distances of open water to shore are less. If the nesting pond is 5 acres or less, there should be at least another 3 acres of shallow wetland adjacent or in close proximity. These requirements minimize overland travel to feeding sites by adults with a flightless brood, or adults during molting. If shoreline or fisherman intrusion may be a problem, the minimum size should be increased, and fisherman use be managed to prevent disruption of nesting, molting, or brood-rearing activities.

II. Standards for Shoreline Configuration and Characteristics:

Optimum Conditions: The shoreline should be configured and island sites located to provide for concealment or escape from shoreline disturbance. The larger the open water wetland area, the more irregularity can be designed into the shoreline. Bays and peninsulas are desirable. Shorelines and island sites should have gradual slopes, at least 5:1, so 1) they can be easily traversable by adults and young leaving the water to loaf and preen, and 2) allow adults on the water to be able to see approaching predators and intruders. Shallow sloping shorelines are also conducive to emergent vegetation and tall shrub growth. In linear-shaped wetlands, such as oxbows, varying channel widths of no less than 70-150 feet should be available.

RATIONALE: Security from intrusions and good visibility are primary requirements to establish swan nesting pairs or consistent seasonal use by swans of wetland sites. If shoreline or fisherman intrusion will likely occur, shoreline activity should be limited to one specific area and emergent cover such as cattails and/or shoreline irregularity enhanced to provide a visual screen from the nesting female, molting adults, or adults with a brood. Wetland size (open water area) and shoreline irregularity should be designed according to the anticipated intensity and frequency of shoreline disturbance. Bays, peninsulas and islands can create visual barriers as can shrub and cattail/rush vegetation on shorelines and islands. However, when in excess, tall shoreline vegetation and steep topography can create a situation where the swans' comfort level may be compromised.

III. Standards for Desired Substrates (Bottom Soils) and Associated Submerged Aquatic Plants

Optimum Conditions: The bottom, water-covered soils should be of silts, organics, sandy-loams, or clays at least six inches in depth when overlaying cobble or gravels. Bare ground or disturbed soils, when inundated, provide a better substrate for submergent vegetation establishment and growth than do sod bound soils or soils with high amounts of accumulated vegetation litter.

RATIONALE: Submerged aquatic vegetation rooted to the pond bottom, and associated invertebrates are the crucial food sources for adult and young trumpeters. The seeds of plants, like sago pondweed (*Potamogeton pectinatus*), Elodea (*Elodea canadensis*), milfoil (*Myriophyllum exalbescens*), and the algae spores of muskgrass (*Chara* spp.) are airborne and generally dormant in bottom soils or are brought in by birds, and rarely require artificial planting in a new wetland environment. Submerged, rooted aquatic vegetation becomes established naturally in most sites from seed and rootstocks within three years after covering a disturbed site and maintaining year-long water covering. These plants grow best in shallow depth and specified substrate conditions, and are affected by water warming, fluctuations, movement, and chemistry. The pond substrate should be a soft bottom of at least 6 inches. Gravels are not conducive to the luxuriant growth of submerged, rooted aquatic plants required by swans. When new soils are inundated, if there is much vegetation litter or the soils are sod-bound, it will take longer for decomposition and the subsequent development of aquatic vegetation.

IV. Standards for Water Level Management during the nesting season

Optimum Conditions: Wetlands should have sufficient water flowage between ice-off and early October to maintain a reasonably static water level during that period and to prevent a build-up in total dissolved solid loads. A rule of thumb in the arid western shrub zone is: a summer-long flow of one cfs (cubic feet per second) of water through a wetland with no water loss due to bottom or dike leakage will maintain a static water level and tds (total dissolved solid) level, accounting for evaporation and plant transpiration, on at least 50 surface acres of wetland water area. Partial draw-downs in late fall/winter often occur naturally and can stimulate aquatic vegetation growth and diversity. In wetlands where water levels tend to be stable year-round, partial or complete draw-downs may need to be scheduled (see next section).

RATIONALE: Flow through systems with good water interchange help prevent excessive water warming, nutrient build-ups conducive to stagnation and algal scums, build-up of decaying aquatic vegetation along shorelines , and insure aquatic plant production in all open water areas throughout the summer. Induced water fluctuations and draw-downs should only be practiced with the advice and direction of someone experienced in marsh water level management. Fluctuations of water levels in spring and early summer, especially in high run-off years, may cause flooding of potential nest areas and result in loss of eggs and abandonment of sites by nesting pairs. High water levels during mid-summer may prevent cygnets from obtaining adequate forage. Generally, partial draw-downs (of a few inches to expose shoreline soils) that imitate naturally occurring fluctuations in the hydroperiod in late fall and winter help stimulate nutrient recycling and maintain aquatic plant and invertebrate diversity and abundance.

V. Standards for Wetland Vegetation Management

Optimum Conditions: Shallow-water wetlands used by swans need to have luxuriant and diverse stands of submergent aquatic vegetation including such species as sago pondweed, Elodea, and Chara. Well-developed stands of tall emergent vegetation for cover and security should not occupy more than 40% of the shoreline or open water area. Wetlands that tend to stay open and ice-free the longest period of time and warm up quickly in the spring provide the most productive sites for nesting pairs. Naturally occurring draw-downs in late fall and winter (or water fluctuations managed to simulate natural conditions) are important for nutrient recycling and vegetation management.

RATIONALE:

A. *Submerged aquatic vegetation*

Sago pondweed, Elodea, and Chara are the most preferred and important aquatic submergent plants for Trumpeter Swans, and are also common in most shallow water environments in the area. Submergent aquatic vegetation is also important to a system, because it helps metabolize excess nutrients, such as nitrates. In many communities submergent aquatics in a shallow wetland system are used as a secondary or tertiary treatment of sewage water.

Submerged aquatic vegetation growth responds to substrate conditions, water warming, depths, fluctuation, and light penetration. In the cool air and water environments of higher elevation areas, leaf growth of submerged aquatic plants will be limited until shallow water temperatures have reached at least 60 degrees F. In the early spring, when the ice is melting off, swans feed on the tubers of sago pondweed, and the remaining leaf mass of Elodea and other plants. Availability of adequate vegetation for foraging in the early spring pre-nesting period is likely a critical factor limiting swan productivity in western Wyoming. If female adults fail to obtain adequate nutrition in the pre-nesting period, they may not initiate incubation, lay few eggs, or fail to hatch clutches. Spring-fed ponds, ponds with good water inflow, and ponds fed by warm water sources open earlier than other sites.

Partial or complete over-winter draw-downs stimulate decomposition of bottom plant material, and subsequent nutrient releases enhance aquatic plant and invertebrate production. Sago pondweed, the plant most preferred by Trumpeters, often responds vigorously to partial or complete over-winter draw-downs. Sago tubers remaining in the bare, frozen substrate over-winter will respond immediately to early spring water covering by producing early plant growth.

Winter draw-downs can be used by managers also to stimulate aquatic plant diversity in systems that have become dominated by species like water milfoil, muskgrass, or water lily (*Nuphur* spp.).

In newly developed sites, submerged aquatic vegetation will begin to occupy the substrates naturally by the end of the first full summer season of open water covering. By the third or fourth summer season, most of the shallow water substrates should be occupied by submergent growth. In colder water environments it will generally take longer for submergents to occupy new substrates. If submergent vegetation occupied a portion of the site or adjacent sites prior to inundation, aquatic vegetation invasion can be expected much sooner on bare soil sites. New sites should be monitored and, by the third season, if only limited growth of submergent plants has occurred, a biologist familiar with wetland ecology should be consulted. Transplanting of sago pondweed rootstocks and other vegetation from nearby sites may need to be considered. Transplants should be placed into the pond bottom at depths not affected by over-winter draw-downs. Once submergents are established in a new impoundment, and after four years or more of stable water level management throughout the ice free period, if a monotypic community has become established such as water milfoil or coon tail (*Ceratophyllum demersum*), a partial over-winter drawdown to expose shoreline shallow soils and enhance decomposition rates may be needed to encourage re-establishment of more desirable species. It is recommended that a wetland biologist be consulted to develop a site-specific water management prescription for your particular situation.

B. *Emergent Aquatic Vegetation*
Taller growth forms of emergents, like cattail (*Typha latifolia*) and bulrush (*Scirpus acutus*), generally respond to yearlong saturated or water covered soil conditions, while most of the shorter growth forms, like many sedges and rushes, respond to seasonal or periodic water covered soil or saturated soil conditions. Water sedge (*Carex aquatilis*), however, is a low emergent that occupies permanently water-covered soils to depths of about 12". Emergents present on or near a new wetland site will generally invade the site on exposed soils with moisture regimes most conducive to each respective species' growth. Before one introduces any emergents to a new site through plantings, it would be wise to consult a wetland biologist, so they can prescribe a water management regime after planting that will discourage invasion of all open water areas by cattail or bulrush.

VI. Standards for Nesting and Loafing Islands

Optimum Conditions: Design and construct at least two low profile island sites with gradual contours of at least a 5:1 slope and a 100 square foot surface two feet above the highest water line anticipated. Each island should be located on the pond no less than 50 feet away from the shoreline. If erosion due to wave action from wind or ice is anticipated to be a problem on islands or dikes the face (sides) may require measures such as preplanted vegetation mats, rip rap, modifications in island location or configuration relative to prevailing wind direction, use of deep-rooted sod from nearby sources, and/or breaking up wave action with emergents transplanting near the water line.

RATIONALE: Islands are preferred because they provide security from shoreline intrusion, and an easy escape for swans to open water. One island will serve as a nesting island and the other as a loafing and preening site for the territorial male. Adults with a brood will also use these islands for loafing and preening. Islands will also enhance shoreline irregularity, and provide concealment cover.

VI. Standards for Flight Corridor Safety

A. Fences and Powerlines

Optimum Conditions: Swan flight paths to and from a wetland site should be free of obstructions such as fences and power lines to prevent collisions. It is not desirable to locate new wetlands where fences or power lines cross flight corridors where swans would routinely land or take off in low level flight. In some cases islands or dikes can be used to direct flight to avoid fences fences.

RATIONALE: Collisions with lines and fences result in a large number of swan mortalities every year. If swans are disturbed and fly suddenly from a pond, especially in low-light or foggy conditions, they can hit wires even at sites they have used for years. Young birds or new birds unfamiliar with the area are most vulnerable to collisions. If fences are in close proximity to the pond (wetland) shoreline and cannot be relocated, a pole top fence can be used to insure greater visibility as well as long pieces of flagging tied to fence wires. If existing powerlines cannot be buried or moved, they should be well marked with orange balls or moveable new style "bird diverters".   Good information can often be obtained from local power companies or on the Internet on such devices. In some cases, wetlands can be designed and configured to help direct flight over fences and away from power lines.

SUMMARY

These are some of the most important parameters and standards to consider for use in layout and design of wetlands with physical and biological characteristics with the greatest potential to attract a trumpeter swan breeding pair and of producing young to flight. If not used by producing adults throughout the nesting period, a site designed with these standards in mind could achieve use by adult swans in spring or fall, or sub-adult birds summer long. In addition to potential use by swans, these types of shallow-water wetlands will be utilized by many other species of birds, waterfowl, mammals, and amphibians throughout the year for breeding, resting, feeding and hibernation. Such wetlands greatly add to the biodiversity of the arid shrub lands of western Wyoming.

SUMMARY OF KEY HABITAT DESIGN STANDARDS FOR THE CONSTRUCTION AND IMPROVEMENT OF WETLANDS WITH CAPABILITIES FOR TRUMPETER SWAN PRODUCTION

- **WETLAND SIZE AND WATER DEPTHS**
  Provide at least 5 acres of shallow wetland water with depth ranges of 6-42 inches. Open water areas of 8-15 surface acres in size as one water body or in an inter-connected complex are preferred.
- **SHORELINE CONFIGURATION AND CHARACTERISTICS**
  Provide irregular shaped shorelines with peninsulas and bays. The larger the open water wetland area, the more irregularity can be designed into the shoreline. All slopes should be designed and constructed with gradual slopes of at least 5:1. Islands and impoundment structures that may be influenced by wave action and erosion should be protected by cobble rock riprap or sod removed during excavation.
- **DESIRED SUBSTRATES (BOTTOM SOILS) AND ASSOCIATED SUBMERGENT AQUATIC PLANTS**
  Soft substrates with 6 inches or greater depth are preferred. Cobble or gravel bottoms are not conducive to aquatic plant growth, and if present should be covered with at least 6 inches of soil. Before inundation disturb sod-bound soils and soils with excessive litter accumulation by disking or rototilling to provide a bare soil site more conducive for occupancy by rooted, submerged aquatic vegetation. In colder water environments with an over water covering, it takes a considerably long time for sods and coarse plant materials to decompose and provide a substrate conducive to submerged aquatic plant growth. Sago pondweed, muskgrass, and Elodea are preferred submerged aquatic food species for trumpeter swans and also found throughout Wyoming.
- **WATER LEVEL MANAGEMENT AND WETLAND VEGETATION**
  Flow-through systems with some degree of water level control are preferred. Sufficient water should be available throughout the ice-free period to maintain relatively stable water levels and prevent summer stagnation. Natural over winter partial draw-downs in water level of a foot or less are acceptable, and in some cases complete over-winter draw-downs may be necessary.
- **NESTING AND LOAFING ISLANDS**
  Construct at least two low profile island sites with gradual contours of at least 5:1 slope, and a 100 square foot surface area two feet above the highest water line. Each island should be located no less than 50 feet from any land mass.
- **FLIGHT CORRIDOR SAFETY**
  Do not locate wetlands for swans and other water birds beneath overhead power lines or in wetlands crossed by fence lines. Power lines and fence lines located in or adjacent to probable flight corridors should be relocated if possible or made visible with markers.