Tidal Wetlands and Waters

Target Description

Tidal wetlands occur in the eastern part of the Corridor, where the Blackbird Creek exchanges with the Delaware River. (Map R) There are approximately 6,000 acres of wetlands and open water in the Corridor; part of a much larger system of coastal wetlands that is one of the primary focuses of The Nature Conservancy's Delaware Bayshores program area.

These wetland areas are regularly flooded, with salinity ranging from salty to brackish (0.1 to 3.5 ppt) and highly influenced by tide stage. Tides are semi-diurnal, with 12.4 hours between consecutive high tides or two consecutive low tides and a mean tide range of about 5.65 feet (6.3 feet average high tide in spring.) It takes two to three hours (depending on the stage of the lunar cycle) for the tide to reach the head of tide at from the mouth of the Blackbird Creek.[1]

Tidal wetland vegetation is highly influenced by the frequency, height, and duration of tidal inundation (hydroperiod) and by salinity. The low marsh is the intertidal zone from mean tide level (the difference between high and low tide) to mean high water, and is completely inundated by the tide at least once per day. Low marsh vegetation is dominated by smooth cordgrass. The high marsh is the intertidal zone from mean high water to the highest extremes of spring tide mean high water and is inundated less than once per day, with the highest areas inundated once per month and upland marsh borders only flooded by storm tides. High marsh vegetation is more diverse, with more plant assemblages growing in more elevated areas, typically including saltmarsh hay, salt grass,, common reed, pickerelweed, arrow arum, yellow pondweed, sedges, rushes, sea lavendar and marshpepper smartweed, with swamp rose mallow and buttonbush in higher areas. Tidal swamp forests are typically of red maple, black gum, and green ash.

The Delaware National Estuarine Research Reserve noted four plant species of state special concern at its Upper Blackbird Creek sites: marsh marigold, rough avens, Canada lily, and nodding bur-marigold. Emergent wetland plant communities that are especially valuable for wildlife include cattails, salmarsh waterhemp, rice cutgrass, and American threesquare (for muskrat), smartweed, and wild rice stands (for birds).[2]

Tidal wetlands support a wide range of "wildlife", including the majority of those noted at the DNERR site in Figure 13 (next page.)

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[1] Delaware Department of Natural Resources and Environmental Control, Delaware National Estuarine Research Reserve (DNERR). 1999. *Delaware National Estuarine Research Reserve Estuarine Profiles*. Delaware Department of Natural Resources, Delaware National Estuarine Research Reserve, 818 Kitts Hummock Rd., Dover, DE: 8

[2] DNERR 1999: 11.

Figure 13

Type of Wildlife:	Including:
Mammals	muskrat, rice rats, beaver, river otter, mink, various shrews, voles, and mice, woodchuck, gray squirrel, opossum, raccoon, striped skunk, longtail weasel, cottontail rabbit, red and gray foxes, white-tailed deer, and various bats.
Wading birds	great blue heron, great egret, snowy egret, cattle egret, black-crowned night heron, green-backed heron, glossy ibis, little blue heron and tricolored heron
Ducks	American wigeon, northern shoveler, green-winged and blue-winged teals in open water and wood ducks in forested streamsides
Shorebirds	greater yellowlegs, killdeer, spotted sandpipers, clapper, king and Virginia rails, willet, laughing gulls, Forster's tern
Raptors/passerine birds	red-tailed hawks, sharp-shinned hawks, turkey vultures, northern harrier, short-eared horned owl, rough-legged hawk, bald eagles, and ospreys
Forest birds	barred owls, red-shouldered hawks, great horned and screech owls, northern parula warbler, prothonotary warbler, and swamp sparrow
Marsh birds	marsh wren, red-winged blackbird, boat-tailed grackle, common yellowthroat, seaside and sharp-tailed sparrows
Reptiles and amphibians	northern diamond back terrapin, snapping turtle, eastern mud turtle, red-bellied turtle, northern water snake, black rat snake, bullfrog, green frog, wood frog, southern leopard frog, northern spring peeper, red-backed salamander, and two-lined salamander
Finfishes	21 species, including (from most common to least): spot, Antlantic menhaden, white perch, mummichog, bullhead, silvery minnow, gizzard shad, yellow perch, black crappie, bluegill, pumpkinseed sunfish, hogchoker, weakfish, striped bass, American eel, black drum, and channel catfish
Other waterborne forms of life	microalgae, 42 taxa of Phytoplankton, 36 taxa of microzooplankton, and 21 taxa of benthic macroinvertibrates (including blue crabs and mud crabs)

Indicators of Healthy Tidal Wetlands and Waters

The five key attributes selected as those most important to sustained tidal wetlands and waters health are the ability to migrate (as indicated by unaltered topography), connectivity to upland habitats (as indicated by natural buffers), natural hydrologic regime (as indicated by the amount of impervious surfacing in the watershed and the extent of ditching and groundwater removal), natural hydroperiod (as indicated by unimpaired tidal exchange), and characteristic ecological community composition, distribution, and vegetation (as indicated by the absence of invasive *Phragmites*). The analysis surrounding each of these attributes and their indicators is presented below.

Unaltered Topography: An Indicator of Tidal Wetlands' Ability to Migrate

A key attribute identified by Corridor scientists for tidal wetland sustainability over time is the ability of the marsh to migrate as sea level rises. Tidal wetlands are creeping up into upland areas over time, as sea level is expected to rise as much as 60 centimeters in the next 100 years. Without low-lying areas to which these wetlands can migrate, many of these critical habitats will be lost to open water. The biggest barrier to migrating marshes is alterations to topography – development, berms, bulkheads -- within the area where marshes are likely to migrate. Sustaining tidal wetlands over time will require keeping topography unaltered within a migration zone that corresponds to a 60-centimeter sea level rise.

The Nature Conservancy has modeled a 60 centimeter sea level rise, based largely on elevation, has and mapped the resulting "migration zone". Corridor scientists developed indicator rating thresholds in Figure 14, and any existing alteration/development within the migration zone was identified. Using GIS, the marsh upland edge was measured and any areas where there is development between marsh upland edge and the 60cm sea level rise boundary were identified and measured. The results are show in Map R. There are 98,384 meters (322,783 feet) of upland edge to the marsh, 2,398 meters (7,867 feet) of which are altered by development within the migration zone, which means that 97.6% of the migration zone is undeveloped. This is not a reliable indicator of unaltered topography, since there are many berms along farm fields. However, even with such topographical alterations considered, the Corridor rests soundly within the "Very Good" category according to indicator ratings. The challenge will be to keep it that way over time.

Figure 14
Unaltered Topography Indicator Ratings:
Poor: topography unaltered within 100 year migration zone for 0 - 74% of marsh upland edge
Fair: topography unaltered within 100 year migration zone for 75 - 89% of marsh upland edge
Good: topography unaltered within 100 year migration zone for 90% of marsh upland edge
Very Good: topography unaltered within 100 year migration zone for 90 - 100% of marsh upland

Natural Wetland Buffers: An Indicator of Tidal Marsh Connectivity

Another key attribute of tidal wetlands identified by Corridor scientists is the connectivity between wetlands and the complementary habitats that support their functions and species. Many species rely on natural cover at wetland edges to survive – even the invasive *Phragmites* is beneficial to these species at the wetland edge if there is no other natural cover available. Natural cover at wetland edges also provides erosion control, helping to keep sediments out of the water. Therefore, the extent of connectivity between tidal wetlands can be largely measured by the extent of natural buffers to tidal wetlands and waters (beyond the sea level rise zone.) Based on these principals and the prevailing literature on the optimal extent of wetland buffers, Corridor scientists developed the thresholds in Figure 15 for 100-meter and 200-meter buffers (see sidebar).

To determine the amount of natural cover currently within wetland buffers of 100 and 200 meters (328 and 656 feet), GIS analysis was used to first combine wetlands and the anticipated sea level rise area, then generate buffers at the edge of them. Data for natural cover types[3] were merged with forest cover data to determine the area of wetland buffers with natural cover for the following results:

About Buffers…

Creating and maintaining forested buffers is important not just for tidal wetlands, but also for coastal plain ponds, and streams. Optimum buffers size(s) for each was determined by the Core Science team based on the literature, and built into indicator thresholds. However, Technical Teams and residents said, "Too Big and Complicated!" So, for the general purpose of communicating Corridor strategies with the public and landowners, scientists agreed that a standard 300 foot (almost 100 meters) buffer from the edge of streams and wetlands would be an appropriate compromise while still protecting water quality and maintaining habitat value. In reality, the appropriate buffer for any specific streamside or wetland-side area will be determined case-by-case, based on the property's features and the landowner's needs and goals, using the buffer sizes presented in this report as guides for adjusting the standard 300-foot buffer as needed for different features, and for monitoring viability increases/decreases.

[3] Beaches and River Banks, Inland Natural Sandy Areas, Natural Lakes and Ponds, and Shrub/Brush Rangeland from LULC data (in addition to forests.)

Figure 15
Wetland Buffer Indicator Ratings:
Poor: natural cover of <50% within 200m buffer or <75% within 100m buffer, whichever is less
Fair: natural cover of 50 - 80% marsh ecotone within 200m buffer or 75 - 90% within 100m buffer, whichever is less
Good: natural cover of 80+ - 90% within 200m buffer or 90+ - 95% within 100m buffer, whichever is less
Very Good: natural cover of >90% within 200m buffer or >95% within 100m buffer, whichever is less

Area of 100m buffer: 1,236 acres
Area of natural cover within 100m buffer: 453 acres
= **36.6% natural cover within 100m buffer**

Area of 200m buffer: 2,033 acres
Area of natural cover within 200m buffer: 683 acres
= **33.6 % natural cover within 200 meter buffer**

The result is a "Poor" rating (natural cover of <50% within 200m buffer or <75% within 100m buffer.) The results are shown graphically on Map R. Most of the natural cover within the buffer area has been converted to agricultural use.

Impervious Surfacing: An Indicator of Impaired Tidal Wetland Hydrologic Regime

The third key attribute identified for tidal wetlands and waters was hydrologic regime – the quantity, timing, location, and quality of available surface water, soil water, and groundwater that plays a role in determining how long and often wetland areas are inundated, and thereby dictating what species can persist there (as described in the Nested Targets/Species section above.) Hydrological regime refers to both single events (like floods) and long-term patterns. Changes in land use upstream that result in more impervious coverage have the tendency to increase the peak volume of water during a rain event -- which can cause local flooding and stream channel erosion -- and less base flow available during droughts. For this reason, impervious coverage was selected as a key indicator for hydrologic regime. The more rainwater runs off of hard surfaces directly into streams and wetlands, the less water is filtered through the ground and back into the streams and shallow aquifers, and the more pollutants end up in streams and wetlands. According to Corridor scientists, studies on coastal zones for the Mid-Atlantic show estuarine system impairment when 10% of the watershed has impervious coverage. A set of thresholds was developed for impervious coverage based on that information (Figure 16)

GIS analysis was used to determine the percentage of impervious coverage currently in the Blackbird Creek and Cypress Branch watersheds using land use cover data for each watershed and an Impervious Surfaces Calculations Worksheet from the Water Resources Agency. See Map S for a graphic representation of the distribution of impervious coverage in the Corridor. Results showed that the Blackbird Creek watershed is 6.65% impervious ("GOOD") and the Cypress Branch watershed is 3.86% impervious (VERY GOOD). Based on these results, the Corridor as a whole was rated "Good".

Figure 16
Impervious Coverage Indicator Ratings:
Poor: >15% impervious surfacing within watershed
Fair: 10-15% impervious surfacing within watershed
Good: 5-9% impervious surfacing within watershed, esp. gw recharge areas
Very Good: <5% impervious surfacing within watershed

Ditching and Groundwater Removal: Indicators of Impaired Hydrologic Regime

Another human impact on hydrologic regime is the extent of upland ditching in the watershed. Ditching has an effect on hydrologic regime similar to impervious coverage – more ditching allows more water to run off faster, disrupting the natural regime. In tidal marshes, ditching for mosquito control, for drying out salt hay to harvest, or to straighten out channels for navigation are the biggest concerns. While no hard data was available for analysis of ditching in the Corridor, examination of aerial photographs indicates minimal straightening or ditching in the eastern portion of the Corridor, where tidal wetlands are most directly impacted.

However, a preliminary look at ditch mapping under revision by the State of Delaware[4] indicates that ditching may be more extensive than originally thought; although many of those ditches may be older, not functioning, and or mostly impacting the western portion of the Corridor. In any case, obtaining ditch information from the State of Delaware once it is completed should help to more accurately determine the extent of ditching.

Another factor believed to impact the hydrologic regime for tidal marshes is the export of groundwater from the aquifers in the Corridor that recharge streams and wetlands. Little effort was made to analyze the current condition of this factor due to the paucity of data available on groundwater extraction and export from the Corridor.

So, there is currently not the necessary information or expertise available to establish a set of thresholds for the amount of ditching and/or groundwater extraction/loss from the watershed that would be considered "Poor", "Fair", "Good", and "Very Good". In the meantime, the impact of ditching and groundwater removal is estimated to be minimal, based on the minimal impact evident to scientists and practitioners familiar with the Corridor, and the relatively undeveloped nature of the Corridor at this point in time. However, this indicator should be revisited upon the receipt of information on ditching and/or groundwater removal, or if there is an evident change in ditching or groundwater extraction in the Corridor.

Impaired Tidal Exchange: An Indicator of Impaired Tidal Wetland Hydroperiod

Hydroperiod is the frequency, height, and duration of tidal inundation, and is a determining factor for the kind of vegetation that can survive and thrive in tidal wetlands. Tidal exchange is a critical driver of the hydroperiod for tidal wetlands. Obstructions or alterations in the landscape that prevent tides from flowing in and out of wetland areas – like undersized culverts – disrupt the natural hydroperiod

Figure 17
Impaired Tidal Exchange Indicator Ratings:
Poor: 25% or greater of marsh has impaired tidal exchange
Fair: 15-24% of marsh has impaired tidal exchange
Good: 15-1% of marsh has impaired tidal exchange
Very Good: 0% of marsh has impaired tidal exchange

[4] Per preliminary information (graphic only; no data) provided via email by John E. Inkster, Senior Application Support Specialist, Division of Soil & Water Conservation Drainage Section, DNREC, Georgetown, DE

and alter the ability of certain species to survive. Tidal exchange (measured by the lack of barriers to flow) was selected by Corridor scientists as an indicator because of its critical role in hydroperiod functions. Figure 17 shows the indicator ratings developed for impaired tidal exchange.

The process of determining a current rating for the Corridor for tidal exchange was a simple one. Based on the examination of aerials, there are only two major obstructions/alterations to tidal exchange: an improperly set roadway culvert and a dam across one tributary, together which impact less than 15% of the marsh (See Map R). This rates the Corridor as "Good" for tidal exchange.

Absence of Invasive *Phragmites*: An Indicator of Tidal Wetland Characteristic Ecological Community Composition, Distribution and Extent

A composition, distribution, and extent of native wetland vegetation that is appropriate to elevation and salinity is crucial to the survival of tidal wetland species. In recognition of this importance, Corridor scientists identified this as a key ecological attribute for tidal wetlands. The presence of indicator species for characteristic vegetation dominant within appropriate salinity and elevation zones was originally identified as the best indicator for this attribute. Indicator species would include cordgrass and spike hay for salt marsh, cordgrass, bulrush and native *Phragmites* for brackish marsh, and wild rice, arrow arum, and pickerelweed and mallow for freshwater. However, obtaining those data needed to measure this indicator has proven difficult -- no one was surveying and tracking those data comprehensively for the Corridor's tidal wetlands. Also, it was noted by the Science Team that indicator species for different elevations and salinities are moving targets because of increasing salinity in the Corridor's tidal marshes over time, and because of ongoing *Phragmites* control efforts by landowners and the State of Delaware.

In an effort to find a more easily measured indicator for characteristic vegetation in the Corridor, and in response to conversations with various Corridor scientists about the threat posed by invasive *Phragmites*, the presence or absence of non-native *Phragmites* was identified as a better indicator for this attribute. While the absence of *Phragmites* does not insure a healthy composition/distribution/extent of native vegetation, a substantial presence of *Phragmites* virtually assures the absence of healthy composition/distribution/extent of native species. Additionally, it is possible for a trained eye to identify *Phragmites* stands from an aerial photograph, in part because they are so homogenous and taller than native vegetation.

Various experts/agencies have mapped limited areas of *Phragmites* at different points in time, but none has completed comprehensive surveying or mapping. However, DNREC Coastal Management Programs is in the process of mapping *Phragmites*, the results of which can be used to establish a more confident baseline and current rating for the Corridor, from which future progress can be tracked. Furthermore, the State of Delaware's *Phragmites* spraying program (through partnership of the DNREC Division of Fish & Wildlife and the Natural Resources Conservation Service) provides information on which parcels (public and private) have been subject to *Phragmites* control efforts, which could also be useful for future monitoring.

Once *Phragmites* mapping efforts are complete, thresholds for *Phragmites* presence/absence will need to be developed. In the meantime, Corridor scientists suggest that 90% *Phragmites*-free would be the optimum "Very Good" condition (since some *Phragmites* at the marsh edge can be beneficial in the absence of a wooded buffer) and that the Corridor is presently in "Good-Fair" condition in regard to characteristic tidal wetlands vegetation.

Threats to Healthy Tidal Wetlands and Waters

Stresses to tidal wetlands and waters most impact characteristic ecological community composition, distribution, and/or extent. Both low marsh and high marsh community composition and the adjacent marsh forest ecotone and coastal forest that provides important upland habitat for migratory birds, raptors, and filtering/buffering services to marsh system.

There are eight primary sources of stress identified for Tidal Wetlands and Waters. Figure 18 presents a summary of evaluation results for these sources of stress.

Figure 18

Threats - Sources of Stress			Characteristic ecological community composition/distribution/extent	Hydrologic regime	Altered sediment regime	Hydroperiod	Connectivity Between Adjacent Ecological Systems	Threat to System Rank
Tidal Wetlands and Waters			*High*	*Medium*	*Low*	*Low*	*Medium*	
1	Loss of natural upland buffer	Contribution	Medium	High	Very High			Medium
		Irreversibility	High	High	Medium			
		Override						
		Source	Medium	High	High	-	-	
		Combined Rank	Medium	Medium	Low	-	-	
2	Climate change/increased rate of sea level rise / barriers to migration	Contribution	Medium	Low	Low	Low		High
		Irreversibility	Very High	Very High	Very High	Very High		
		Override						
		Source	High	Medium	Medium	Medium	-	
		Combined Rank	High	Low	Low	Low	-	
3	Invasive/alien species	Contribution	Very High	Medium	Medium	Medium		High
		Irreversibility	Medium	Medium	Medium	Medium		
		Override						
		Source	High	Medium	Medium	Medium	-	
		Combined Rank	High	Low	Low	Low	-	
4	Improperly set culverts	Contribution	Medium	Medium	Medium	Very High		Medium
		Irreversibility	High	High	High	High		
		Override						
		Source	Medium	Medium	Medium	Very High	-	

		Combined Rank	Medium	Low	Low	Low	-	
5	Construction of ditches, dikes, drainage or diversion systems	Contribution	Low	Low	Low	Low		Medium
		Irreversibility	High	High	High	High		
		Override						
		Source	Medium	Medium	Medium	Medium	-	
		Combined Rank	Medium	Low	Low	Low	-	
6	Shoreline stabilization/Armoring	Contribution	Low	Low	Low	Low	Low	Medium
		Irreversibility	Very High	Very High	Very High	Very High	Very High	
		Override						
		Source	Medium	Medium	Medium	Medium	Medium	
		Combined Rank	Medium	Low	Low	Low	Low	
7	Channelization of rivers or streams	Contribution	Medium	Low	Low	Low		Medium
		Irreversibility	High	High	High	High		
		Override						
		Source	Medium	Medium	Medium	Medium	-	
		Combined Rank	Medium	Low	Low	Low	-	
8	Incompatible agricultural practices	Contribution	Medium	Low	High		Low	Low
		Irreversibility	Low	Medium	Medium		Medium	
		Override						
		Source	Low	Low	Medium	-	Low	
		Combined Rank	Low	Low	Low	-	Low	

The top threats to tidal wetlands and waters are climate change resulting in increases in sea level rise, and invasive non-native species. Both have a profound affect on characteristic marsh communities. Increasing sea level rise pushes wetlands further upland, and results in losses of characteristic marsh vegetation where suitable migration areas don't exist. Non-native *Phragmites* is common and persistent in the Corridor and transforms diverse marsh plant communities to monocultures.

Two lesser sources of stress to tidal wetlands include loss of natural buffer and incompatible agricultural practices both of which can alter wetland plant communities and contribute to non-point source pollution. Improperly set culverts, construction of ditches, dikes, dams, shoreline stabilization, and channelization of rivers/streams also contribute to wetland stress by altering the flow of water and, subsequently, the hydrologic and sediment regimes and natural communities.