Wetland Loss Assessment by Wetland Type and Watershed in an Expanded Core Area of the Matanuska-Susitna Borough

Mike Gracz
Kenai Watershed Forum
360-820-2058
mike@kenaiwatershed.org

Prepared for:
US Fish and Wildlife Service &
The Matanuska-Susitna Fish Habitat Partnership
4700 BLM Road
Anchorage, AK 99507

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SUMMARY

Comparison of historic aerial imagery to 2017 high-resolution imagery, identified 642 separate wetland fills covering 1305 acres of the Expanded Core Area of the Matanuska-Susitna Borough since the era of modern settlement began. Although this acreage represents less than 2% of the overall area of wetlands within the Expanded Core Area, in some watersheds many wetland types have been filled at a disproportionately higher rate. More than 10% of the area of seven geomorphic types of wetlands within three watersheds have been filled. Moreover, more than 10% of the area of all wetlands in the Lucile Creek watershed have been filled. In the most extreme example, fifty-five percent of Discharge Slope wetlands within the Lucile Creek watershed have been filled (139 of the 253 acres of this type of wetland).

Substantial declines in water quality may be expected after more than five percent of wetlands in a boreal watershed have been filled. Ten percent of all of the wetlands in the Lucile Creek Watershed have been filled; and in three other watersheds more than ten percent of seven different types of wetlands have been filled. Five percent of the wetlands of a total of 13 types have been filled in four watersheds. These different types of wetlands perform different functions that are valued by society. Therefore, some values have likely been lost in at least four watersheds: Meadow Creek, Lucile Creek, Wasilla Creek, and Cottonwood Creek.

Because some values have likely been lost, either no additional filling should be permitted, or compensatory mitigation should be required in the types of wetlands within the watersheds listed below:

- Wasilla Creek Watershed
  - Depressions, Discharge Slopes, Kettles, Spring Fens, and Riverine wetlands
- Cottonwood Creek Watershed
  - Depressions, Discharge Slopes, Kettles, and Wetland/Upland complexes
- Lucile Creek Watershed
  - Depressions, Discharge Slopes, Kettles, and Spring Fens
- Meadow Creek Watershed
  - Drainageways

Green infrastructure is the patchwork of natural areas providing services to society such as flood protection, clean water and habitat. Without careful management this green infrasturcture will continue to deteriorate until expensive measures will be required to maintain the quality and quantity of surface and ground water in these watersheds.

INTRODUCTION

Wetlands are important components of green infrastructure: the valuable services that the natural environment provides to society. Federal law protects some of these services by requiring that a permit be obtained before a wetland can be filled. An assessment of valuable services, which include wildlife habitat, streamflow quantities, and clean water, may be required before the permit can be obtained. An assessment should evaluate cumulative impacts to wetland functions throughout the watershed. The Matanuska-Susitna Fish Habitat Partnership also recognizes that the cumulative impacts of filling wetlands can reduce their value to fish, which are an important resource to the citizens of the Matanuska-Susitna Borough. To protect the value of wetlands to fish, the Partnership has formulated Conservation Strategies which state that: "Wetland fill will be avoided, minimized or mitigated". If the wetland assessment identifies unavoidable impacts to functions, compensation to mitigate for the services lost due to the impacts may be required. The goal of compensatory mitigation is to maintain wetland functions, such as stream flow quantity and quality, which are important characteristics of fish habitat.

Different types of wetlands are often filled at different rates because development activity is concentrated in a subset of possible locations, such as along shorelines. These different types of wetlands in different locations function differently to provide differing degrees of services to society. Therefore, preventable losses of valuable services can occur even if less than two percent of wetlands are filled. Knowledge of cumulative impacts to different types of wetlands will inform managers when they are determining where and when compensation to mitigate for these preventable losses should be required. These types of determinations are currently being made in the absence of reliable estimates of wetland losses. Recently, for example, when compensation was proposed by the project proponent for unavoidable wetland losses along Wasilla Creek, an anadromous stream, it was determined to be unnecessary.

The amount of loss is an important component of a cumulative impacts analysis. Since July 1996, which was the baseline for the last assessment of wetland losses in the MSB, the population of the Matanuska-Susitna Borough has doubled from 50,367 to 104,166 (State of Alaska 2018). The assessment, published in 2001 but based on 1996 imagery, found that 200 acres of wetlands had been lost of the 59,994 acres of wetlands in the 274,276 acre area around Palmer, Wasilla, and Big Lake (Hall 2001). The 1996 assessment is clearly needs to be updated so that cumulative effects of issuing a permit to allow placement of fill without compensatory mitigation can be evaluated in the context of watershed-wide losses to wetland functions. If wetland losses due to filling have substantially increased, then compensation may need to be required more frequently so that wetland functions, including those related to fish habitat, may be adequately conserved.

Here I quantify the total acreage of wetland loss in an Expanded Core Area of the MSB, including losses by wetland type and watershed, since the era of modern settlement (figure 1). This Expanded Core Area is slightly smaller in size than the area studied by Hall using the 1996 imagery, but it avoids areas of change due to the natural migration of the Matanuska River channels, a major change in wetland area reported by Hall (2001).

The type of wetlands that have been filled were classified according the Cook Inlet Classification (Gracz & Glaser 2016), a system that classifies wetlands by geomorphic type and seasonal variation of water levels. The analysis was performed by using wetland mapping that was completed in 2009, along with comparing high-resolution imagery acquired in 2017 to the oldest imagery available for the area, which was acquired in either 1939, 1949, or 1950. This updated assessment of wetland loss will help inform a cumulative impacts analysis as part of permitting decisions, and, if considered, should help slow or halt the loss of important characteristics of wetland fish habitat in the Matanuska-Susitna Borough.

Figure 1. The Expanded Core Area (outlined in blue- 246,946 acres).

METHODS

We used wetland mapping data, LiDAR, and time-series comparisons of aerial imagery to guide the creation of polygons surrounding areas of wetland fill. Wetlands mapped with the Cook Inlet Classification (Gracz & Glaser 2016) were used to help guide the comparisons among imagery acquired in 2017, 1939, 1949, and 1950. Typically, the resolution of the 2017 imagery was sufficient on its own to guide the creation of the polygons around filled areas. Occasionally, imagery from 1939 revealed previous wetlands that had been completely filled and showed no trace on the modern imagery. The linework and marsh symbols that had been drawn in 1939 by the soils mappers was especially useful in these instances.

The objective of these methods was to produce the most reliable calculation of the area of wetland lost due to placement of fill by human activity during the era of modern settlement. The newest imagery for the project area was acquired in May of 2017 at resolutions of one-foot and one-half-foot. The imagery acquired at one-half-foot resolution covers nearly the entire area to be assessed. The 2017 and older imagery were used with a hillshade created from a 2-foot resolution digital elevation model obtained in 2011 using Light Detection and Ranging (LiDAR). The hillshade was overlain on the imagery and made partially transparent, in order to better visualize the hydro-geomorphic setting of wetlands on the landscape.

The oldest imagery that covers the entire project area was acquired in three different years. Scanned aerial photos that were acquired in September and October of 1939 for use in a soil survey were obtained from the Matanuska-Susitna Borough GIS department. These photos covered the area around Palmer, and extended westward in a narrow band to the easternmost portion of Big Lake. However, the area to be assessed for wetland loss includes all of Big Lake, and a larger region than was covered by the 1939 photography. (The first aerial photographs ever acquired were taken from balloons and kites in the middle of the nineteenth century. Aerial photography was used in both the American Civil War and WWI. By the mid-1930's, aerial photography had been in use for a long enough time so that stereo-photography was well-understood, as was the high altitude and fast speed necessary for minimization of distortion and parallax. Therefore, the 1939 photos are of high quality for cartography).

To cover the area outside of the extent of the 1939 photography, scans of aerial photographs acquired in 1949 and 1950 were downloaded from the US Geological Survey at https://earthexplorer.usgs.gov. The 1949 photos, which were acquired on 14 August 1949, were used wherever possible, as they cover most of the remaining project area and are the oldest available. However, some of the 1949 imagery was unsuitable due to cloud cover, damage to the original photographs, and lack of coverage of the project area. Therefore, scanned aerial photos acquired in 1950 were used when needed. The imagery from 1950 was acquired on three different dates: 15 July, and 7 and 8 August. Almost all of it was acquired on 8 August 1950; only two small areas were acquired on the different dates. Those areas are in the NE corner (7 August) and the SW corner (15 July) of the Expanded Core Area.

Geo-rectification of older imagery

The scanned photos were geo-rectified, or more accurately, rubber-sheeted, into real-world coordinates using the geo-rectification tool in ArcGIS 10.1. This tool requires the user to accurately locate matching control features on both old and new imagery. The new imagery employed for this purpose was the seamless 2004 FSA aerial imagery projected into State Plane Alaska Zone 4 coordinates using the NAD 83 datum. It was almost entirely flown 6 June 2004, with the exception of the NE corner of the project area, which was flown 9 August. The 2017 imagery was not available before the rubber sheeting was completed.

At least three matching control points are required to use a linear transformation to align the old, un-rectified photo with real-world coordinates. A linear transformation may be sufficient when the topography is almost completely flat, and when the altitude of acquisition is high, such as imagery acquired from satellites. However, where hills are present and altitudes are sub-orbital, a more complex method of transformation is needed to produce an accurate alignment over the entire photo. Therefore, a second-order transformation was used, which requires at least six matching control points. Even higher-order transformations are feasible, but they were avoided, because they required more matching control points. There are at least two dangers in using too many control points: 1) the difficulty in locating points that reliably align between the years, thus the potential for introducing increasing amounts of error in positional accuracy, and 2) bias, if the points that do align are located in unrepresentative areas of the photo. This bias will produce excessive distortion in regions of the photo that are under-represented.

For the reasons described above, between 6-9 control points were used with a second-order transformation to rectify all of the scanned photos. Points were as evenly distributed as possible across the scanned photo, and points near the extreme edges were avoided. Common types of features used to match the scanned aerial photography to the satellite images were points along the margins of lakes and peatlands where the transition was steep (minimizing differences due to differing water levels); small upland tree islands in larger peatlands; small open depressions in the forest; bridge crossings of the Alaska Railroad; and the projected centerlines of road intersections. On the 1939 photos, the soil mappers created control points, which show as pin-pricks. These control points were occasionally matched with the same control point on an adjacent 1939 photo that had already been rubber-sheeted, especially in areas of relatively featureless forest east of the Matanuska River. Use of this technique was minimized to avoid perpetuating rectification errors on the initial photograph into larger ones on adjacent photos. Landslide margins on the hillside north of the Little Susitna River matched in a few instances, and buildings near Palmer were used in a couple of other cases. Points along stream and river courses were avoided because, upon careful examination, they were almost always in different locations between images. Even with care, the aligning of control points was inexact, and precisely geo-rectified images were not obtained. However, the relatively small errors in geo-rectification should not be sufficient to substantially bias the calculation of the area of wetlands filled at the mapping scale of 1:18,000.

Each historic aerial photo was visually examined while control points were being selected so that distortion could be minimized before the transformation was committed to a geo-rectified file. Alignment was never perfect, and although points match very well over much of the area covered, errors of 10-20 meters in real-world units should be expected in some areas. After rectification, the 1949 and 1950 photos were clipped to discard edges and occasionally to the small area of the photo needed to fill a gap in coverage. Control points were distributed only around the area of the photo that was actually needed on these smaller images. The entire extent of each 1939 photo was retained, except for one photo near the Matanuska River. On that image, a small area that was just outside the extent of an adjacent photo was clipped to complete the coverage of the Expanded Core Area.

<u>Creation of wetland fill polygons</u>

Once the older imagery was rubber-sheeted, it was layered in ArcGIS 10.1 underneath the high-resolution imagery acquired in 2017, along with the hillshade of the 2011 LiDAR data, and the 2009 wetland mapping. The extent of the project area was systematically examined at a scale of 1:4000 or greater (i.e. higher zoom level) to identify fill that had been placed in wetlands. Typically, the high-resolution imagery was sufficient by itself to show areas that had been filled. Often, the LiDAR hillshade aided evaluation of wetland extent by revealing sharp breaks in slope. The areas of fill were primarily road crossings, airstrips, house pads, and parking areas that were located inside of mapped wetland boundaries.

Polygons surrounding the fill were created heads-up (clicking with a mouse while viewing a screen), typically at a scale of 1:2000 or greater (zoomed-in). Digitizing heads-up is more time-consuming than automated techniques using LiDAR and the color signatures on aerial imagery, but allows intervening human judgement. The boundaries of these fill polygons were digitized separately from the boundaries of the wetland polygons; i.e. the fill boundaries were not snapped to the boundaries of existing wetland polygons. Surface water surrounding the fill was usually visible, and its extent often exceeded the mapped wetland boundaries. In many instances, small areas of wetland fill lying completely outside of mapped wetland polygons could be observed on the high-resolution 2017 imagery. These areas were also digitized heads-up.

The wetland area that the fill covered was digitized regardless of the extent of the 2009 wetland mapping. Because the mapping of the fill extent was performed at a different scale (1:2000 or less), and with higher resolution digital imagery than the wetland mapping (which was completed at a scale of 1:18 000), a mismatch in boundary locations between the fill and the wetlands should be expected.

In other instances, the extent of the original wetland was difficult to determine because the boundary between wetland and upland was obscured by the fill material. In these instances, the display of the high-resolution 2017 imagery was turned off to reveal the underlying older imagery, which was used to guide the mapping of the boundary of the historic wetland. Moreover, to be certain that all filled wetlands were

Figure 2. A wetland (red outline) in 1939 (left-hand photo) is indicated by marsh symbols drawn as part of a soils map. The same wetland has been completely filled by gravel mining activity in 2017 (right-hand photo). The Old Glenn Highway south of Palmer is visible crossing the upper left-hand corner of both photos. The braidplain of the Matanuska River covers the lower right corner of both photos.

identified, the display of the 2017 imagery layer was also turned off to reveal the older imagery underneath for each extent at 1:4000. In a few cases, the underlying imagery revealed an historic wetland that had been completely obscured by fill. These historic wetlands were particularly apparent on the 1939 imagery where marsh symbols had been drawn to indicate wet soils (Figure 2). In other instances, the fill was sufficiently recent that the slightly older LiDAR hillshade helped guide the mapping of the boundary of the original wetland.

Analysis

An analysis of the acres of wetlands filled by the type of wetland was performed. A single fill polygon might cross several different geomorphic types of wetlands. Therefore, the wetland fill polygons were merged with the 2009 wetland mapping polygons that they intersected so that the fill polygons could be subdivided into wetlands of the same type (Figure 3). These smaller polygons were further clipped to the boundaries of the 12-digit HUCs for four watersheds: Big Lake, Cottonwood Creek, Wasilla Creek, Meadow Creek, and Lucile Creek. This merging and clipping guided an analysis of wetlands filled by type and by watershed. The wetland types used for the analysis were the geomorphic components of the Cook Inlet Classification; the classification system that was employed in the 2009 wetland mapping and which has been found to group wetlands more similarly than other widely used classification systems (Gracz & Glaser 2016). Areas outside of the wetland mapping were assigned to a geomorphic class based on adjacent polygons and/or by interpretation using the imagery and the LiDAR hillshade.

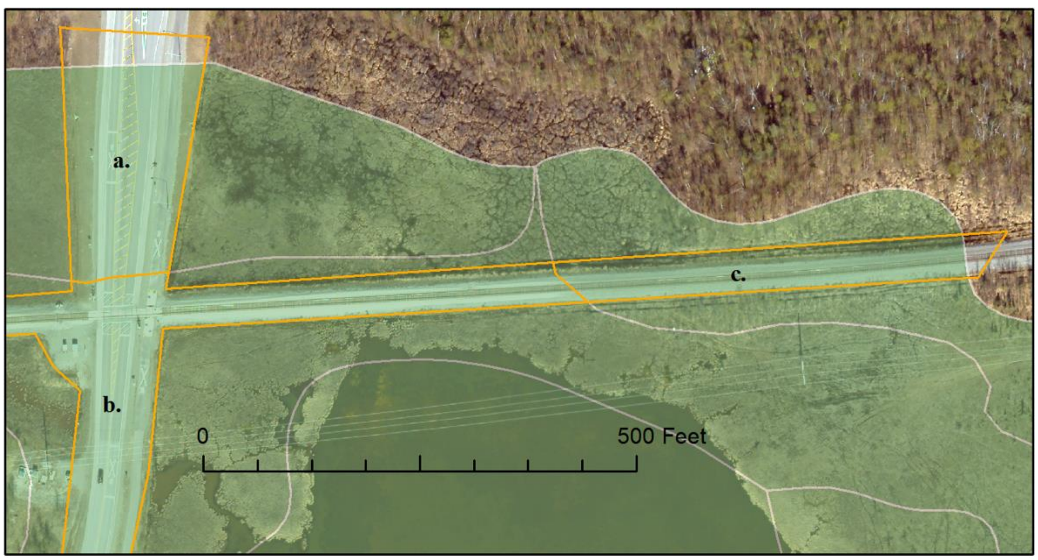

Figure 3. The single fill polygon (orange outline; near Big Lake) has been subdivided into three parts, labeled **a.** **b.** and **c.** based on geomorphic categories of the 2009 wetland mapping (transparent green with white outlines). The finer scale and higher resolution of the 2017 imagery show that portions of polygons **a.** and **c.** should extend beyond the 2009 mapping.

RESULTS

A total of 642 wetland fill polygons cover 1305 acres of the 69,054 acres of wetlands in the 246,946 acre Expanded Core Area (Figure 4). This acreage is a 6.5-fold increase

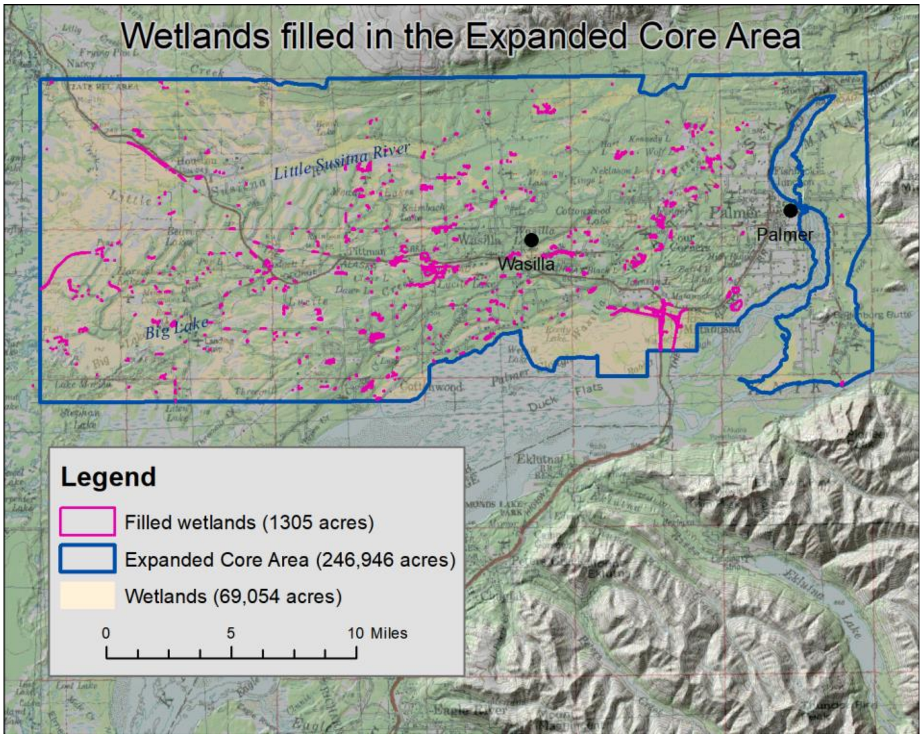

Figure 4. Wetland fill (pink) in the Expanded Core Area (blue). The wide pink borders of the filled wetland polygons exaggerate their area.

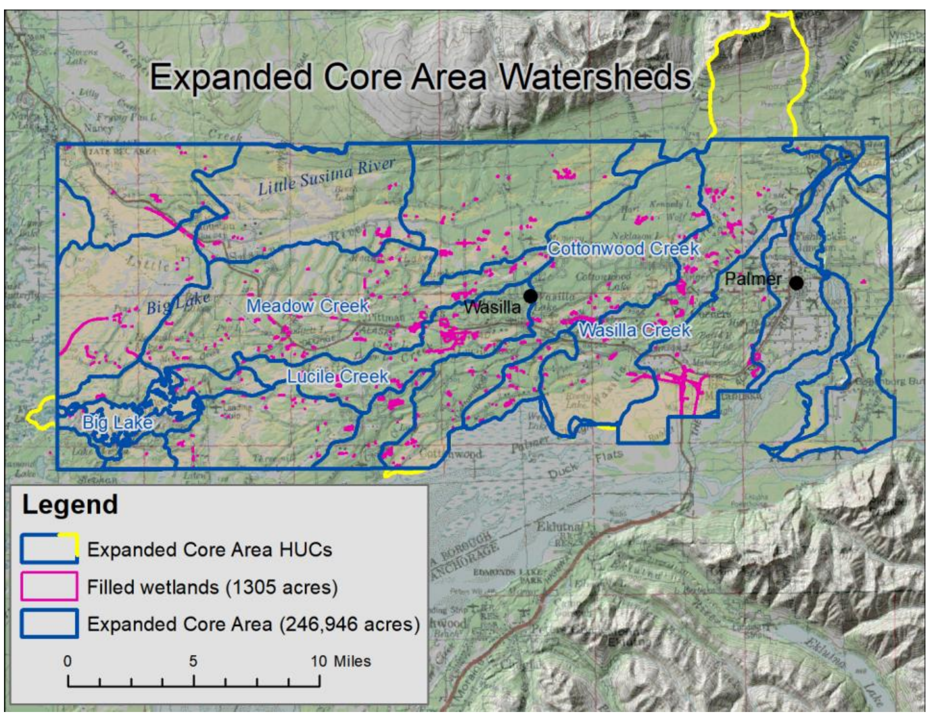

Figure 5. The location of the five 12-digit HUCs in the Expanded Core Area (ECA) that were used to analyze wetland fill by location (named in blue). Portions of the Wasilla Creek (29%), Big Lake (6%) and Cottonwood Creek (0.7%) HUCs lie outside of the ECA (yellow). The wide pink borders of the filled wetland polygons exaggerate their area.

from the area reported in 1996 over a similar area. The acreage of wetlands filled is two percent of all of the wetland acreage in the Expanded Core Area. Although only two percent of wetlands in the expanded core area have been filled, the wetlands that have been filled are not uniformly distributed by location or by geomorphic type. Some areas of the Expanded Core Area have had few wetlands filled, while some types of wetlands have been disproportionately filled within some watersheds. The geomorphic types described in the Cook Inlet Classification ([Gracz & Glaser 2016]) were used along with the watersheds delineated by 12-digit Hydrologic Units to analyze the variability of wetlands that have been filled by type and location (Figure 5).

The five 12-digit HUC watersheds with the most fill activity were analyzed. Within the five watersheds, or portions thereof that were examined (Figure 5), more than ten percent of the area of seven types of wetlands has been filled (Figure 6). More than

Figure 6 **a. - f**. Percentage of wetlands filled by type within each of the five watersheds examined (**a. - e.**), and the percent of all wetlands filled within each watershed (**f.**). The red horizontal line emphasizes wetland types filled at or above the 10% level. Wetland types with no fill were omitted from figures **a. - e.**.

25% of Depressions have been filled in the Wasilla Creek watershed (Figure 6a); greater than ten percent of Depression, Kettle and Wetland/Upland complex wetlands have been filled in the Cottonwood Creek watershed (Figure 6b); and more than ten percent of Depressions and Kettles, and nearly 55% of Discharge Slopes have been filled in the Lucile Creek watershed. (Figure 6c). In the Lucile Creek watershed, ten percent of all wetlands have been filled (Figure 6f). Within the Big Lake and Meadow Creek watersheds generally fewer than five percent of wetlands of any type have been filled (Figure 6d & e).

DISCUSSION

A comparison of early aerial imagery to 2017 high-resolution imagery identified 642 separate wetland fills covering 1305 acres of the Expanded Core Area of the Matanuska-Susitna Borough. Although this value represents less than two percent of the overall area of wetlands within the Expanded Core Area, some wetland types have been filled within some watersheds at a disproportionately higher rate. Ten percent of seven geomorphic types of wetlands have been filled in three different watersheds. In the Lucile Creek Watershed ten percent of all wetlands have been filled. In the most extreme example, 139 of the 253 acres of Discharge Slope wetlands within the Lucile Creek watershed have been filled (55%).

Estimating wetland loss by comparing modern and historical aerial imagery has limitations. Wetland filling has typically progressed greatly by the time of the earliest imagery, and the interpretation of wetlands on the historical imagery is impossible to ground-truth today. Even with modern, high-resolution imagery, interpretation of wetland extent without ground-truthing can lead to over- or under-mapping of wetland fill polygons. In the Expanded Core Area of the Matanuska-Susitna Borough that was examined here, those limitations are minimized because aerial imagery is available from a time when the footprint of wetland fill was almost completely absent. Moreover, some ground-truthing of wetland boundaries was performed for the 1939 aerial imagery as part of an early soil mapping survey. Marsh symbols were drawn in some of the polygons mapped using the 1939 imagery (Figure 2). Finally, the author has extensive experience mapping wetlands in the project area, including extensive ground-truthing, which minimizes errors of interpretation on the modern imagery. However, the boundaries of the fill polygons are inexact, and a fine-grained, site-specific analysis of any individual fill polygon would certainly lead to a different calculation of the total area filled. However, these limitations are expected to be minor for the purposes of a general assessment of watershed-wide cumulative impacts.

Reporting losses as percentages can be misleading when the absolute acreage is small (e.g. a loss of a half-an-acre of a wetland for a type that only covers a total of one acre is a 50% loss of wetlands over a small total area). However, in many of the watersheds the percentage losses were of types of wetlands covering relatively large areas. For example, Kettles in the watersheds of Cottonwood Creek and Lucile Creek, and Discharge Slopes in Lucile Creek Watershed all cover more than 250 acres. The summary data by percentage and by acres is tabulated in Appendix A.

Filling wetlands compromises their function, which decreases their value to society. The percentage of wetlands that can be filled before functions are substantially compromised is unknown. However, it has been widely reported that water quality decreases rapidly once impervious cover in a watershed reaches ten percent (Schueler 1994; Booth & Jackson 1997; Schueler et al. 2009; Loperfido et al. 2014). In Alaska, this decrease in water quality may be seen with impervious cover values as low as five percent (Ourso and Franzel 2000). It can be assumed that wetlands are covered by impervious surfaces (i.e. filled) at a lower rate than uplands because building is less desirable and more expensive on wetlands. Therefore, if more than ten percent of wetlands are filled, it may be reasonable to assume that an even larger percentage of the surrounding uplands are covered by impervious cover. If this assumption is true, and if water quality of streams is more sensitive to impervious cover in the boreal climate of Alaska, then filling of more than five percent of wetlands in a boreal watershed probably will cause substantial declines in at least some wetland functions. More work is required to test these two key assumptions.

A substantial portion of the Big Lake (6%) and Wasilla Creek (29%) HUCs lie outside of the Expanded Core Area, as does a minor portion of the Cottonwood creek HUC (0.7%) (yellow lines in Figure 5). This choice of scale of the twelve-digit HUC is somewhat arbitrary, and should not greatly change the interpretation in those watersheds. For example, a substantial amount of clean water is contributed to Wasilla Creek from the large, relatively undisturbed wetland area in the headwaters of the Wasilla Creek HUC that lies outside the Expanded Core Area. However, if smaller watershed areas around wells or groups of wells are considered, the amount of fill in the middle and lower portion of the HUC probably will affect wellhead water quality in those smaller areas.

Scale is important. Even as less than two percent of the area of wetlands in the Expanded Core Area are filled, some wetland function has already been lost. Four water bodies in the area, Cottonwood Creek, Fish Creek, Lake Lucile and Big Lake. are listed as Impaired Waters in the State of Alaska (http://dec.alaska.gov/water/water-quality/impaired-waters/). The rate of wetland fill over the entire Expanded Core Area appears to be irrelevant to the amount of function that wetlands have retained with the increasing urbanization of the Expanded Core Area. The finding here that more than ten percent of many types of wetlands in local HUCs have been filled, including in Cottonwood Creek and Lucile Creek (which flows into Big Lake), suggests that the relevant scale may be the types of wetlands that have been filled compared to their prevalence in local watersheds. Careful management will be required to prevent additional waters from being added to the impaired waters list and to allow those already on the list to recover.

Management Recommendations

Wetland losses of more than five percent by area in boreal watersheds may cause declines in water quality. Ten percent of the wetland area has been filled in the Lucile Creek Watershed, and more than ten percent of the area of many types of wetlands in other watersheds have been filled. These different types of wetlands have different functions that are valued by society. Some of these waters are listed on the State of

Alaska's Impaired Waterbody list demonstrating that valuable wetland functions have already been substantially compromised in the Expanded Core Area. Because wetland functions have been compromised, additional filling should either cease altogether or compensatory mitigation should be required to replace lost values if unavoidable impacts are to be permitted in any of the following types of wetlands in the following watersheds:

- Wasilla Creek Watershed
  - Depressions, Discharge Slopes, Kettles, Spring Fens, and Riverine wetlands
- Cottonwood Creek Watershed
  - Depressions, Discharge Slopes, Kettles, and Wetland/Upland complexes
- Lucile Creek Watershed
  - Depressions, Discharge slopes, Kettles, and Spring Fens
- Meadow Creek Watershed
  - Drainageways

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APPENDIX A

Wetland losses by type and watershed in units of acres and percentages.

Watershed	Wetland Type	Wetland acres	Filled acres	% Wetlands
Wasilla Creek	Depression	16.4	4.2	25.61%
	Drainageway	43.6	1.9	4.36%
	Discharge Slope	1298.7	106.2	8.18%
	Kettle	228.2	12.8	5.61%
	Spring Fen	370.2	19.9	5.38%
	D'way / Tidal	209.0	0.9	0.43%
	LAKE	101.9	0.003	0.00%
	Riverine	596.2	33.1	5.55%
	Wetland / Upland	4.4		0.00%
	Tidal	132.3		0.00%
	Tidal / Drainageway	2807.4		0.00%
	Total	5808.3	179.003	3.08%
Cottonwood Creek	Depression	52.1	7.7	14.78%
	Drainageway	102.8	0.7	0.68%
	Discharge Slope	447.8	26.3	5.87%
	Kettle	521.9	63.6	12.19%
	Spring Fen	403.0	6.5	1.61%
	LAKE	1489.7	1.6	0.11%
	Riverine	241.0	7.3	3.03%
	Wet/Up	165.8	17.1	10.31%
	Tidal	349.8		0.00%
	Tidal / Drainageway	397.3		0.00%
	Total	4171.2	130.8	3.14%
Lucile Creek	Depression	90.9	11.7	12.87%
	Drainageway	581.9	13.6	2.34%
	Discharge Slope	253.2	139.2	54.98%
	Kettle	330.7	35.2	10.64%
	Spring Fen	156.9	9.3	5.93%
	LAKE	427.4	0.03	0.01%
	Riverine	305.4	5.6	1.83%
	Total	2146.4	214.6	10.00%
Meadow Creek	Depression	106.1	4.3	4.05%
	Drainageway	609.4	38.2	6.27%
	Discharge Slope	1122.3	27.1	2.41%
	Kettle	1014.9	39.8	3.92%
	Spring Fen	604.0	10.1	1.67%
	LAKE	2205.1	1.6	0.07%
	Riverine	864.0	21.3	2.47%
	Lakebed	430.6	3.3	0.77%
	VLD Trough	2179.8	27	1.24%
	Floating Island	2.3		0.00%
	Wetland / Upland	5.4		0.00%
	Total	9136.2	172.7	1.89%
Big Lake	Depression	129.3	1.8	1.39%
	Drainageway	129.2	2.9	2.24%
	Discharge Slope	50.0	1.6	3.20%
	Kettle	291.1	6.6	2.27%
	Lakebed	1410.7	18.1	1.28%
	Spring Fen	1.8		0.00%
	LAKE	3359.2		0.00%
	Riverine	10.6		0.00%
	Total	5381.9	31.0	0.58%