QUANTIFICATION OF HABITAT ALTERATIONS AND BIRD USE OF IMPOUNDMENTS IN THE PRUDHOE BAY OIL FIELD, ALASKA, 1994

Final Report

Prepared by

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for

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29 March 1996

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EXECUTIVE SUMMARY

Impoundments are water bodies created by changes to natural drainage patterns. Gravel roads and pads supporting oil field operations can cause impoundments by acting as dams. Impoundments alter bird habitats, and this study evaluates the types and amounts of natural habitats that have been altered due to impoundments. The objectives of this study were to: 1) determine the area covered by impoundments within the entire Prudhoe Bay oil field (PBOF); 2) determine the habitat types altered by impoundments; 3) estimate the numbers of birds which historically used habitats that have been altered by impoundments; 4) survey a subsample of impoundments for bird use; and 5) compare estimated historical use and current bird use of impoundment areas.

Current impoundment flood areas were mapped from July 1993 natural color aerial photographs, and historic habitats were mapped from July 1955 black and white aerial photographs. A Geographic Information System (GIS) was used to calculate the area by habitat type within current impoundment flood areas. One hundred forty-four impoundments were identified and mapped. The area within the PBOF temporarily and permanently flooded by impoundments in mid- to late July 1993 was 11.3 km^2. Of this total, 5.3 km^2 was open water, and 6.0 km^2 was temporarily flooded tundra during July 1993. Of the 5.3 km^2 open water in July 1993, 3.3 km^2 was open water prior to oil field development, based on 1955 aerial photography. Therefore, a total of 8.0 km^2 of tundra was permanently or temporarily flooded by impoundment in 1993 (11.3 km^2 maximum flood minus 3.3 km^2 pre-development water equals 8.0 km^2 flooded tundra). This area represents 0.8% of the entire PBOF unit area (968 km^2).

Fifty-one impoundments covering 7.1 km^2 were censused for bird use in summer 1994. Open water during July 1993 within the 7.1 km^2 flood area was 3.8 km^2. Prior to any oil field development, open water within this flood area was 2.6 km^2. Therefore, a total of 4.5 km^2 of tundra was temporarily or permanently flooded for these 51 sites. Pre-development tundra habitats affected by flooding for the 4.5 km^2 area of flooded tundra were aquatic tundra 59%, wet tundra 37%, and moist tundra 4%. Extrapolating these percentages to the 8.0 km^2 tundra area altered by all 144 mapped impoundments suggests 4.7 km^2 aquatic tundra , 3.0 km^2 wet tundra, and 0.3 km^2 moist tundra were affected by impoundments. Most impoundments generally occur in areas with natural lakes and ponds, specifically drained lake basins, and their effect is to cause a retention of additional melt water.

A total of 2477 sightings of 5135 birds was recorded during four census periods on the 51 impoundments censused for bird use. Thirty-seven species were recorded at impoundments and

17 species nested at impoundments. Shorebird density (135 birds per km^2) was the highest, comprising 59% of all birds combined. Waterfowl density was the next highest with 53 birds per km^2 and 23% of all birds combined. Ducks comprised the majority of waterfowl, with 34.89 birds per km^2 or 15% of the total bird density. Mean densities in impoundment areas for 14 of the most common species were compared to estimated pre-development mean densities. Pre-development mean densities were empirically determined by mapping pre-development bird habitats and then extrapolating bird density-habitat relationships.

Using Mann-Whitney U and Wilcoxon signed rank tests, we made statistical comparisons of pre-development expected bird densities versus 1994 observed bird densities in the 51 impoundments. Impoundments generally supported higher waterfowl and lower shorebird densities than pre-development habitats, but bird habitat density relationships are highly variable and these trends were not statistically significant. Although the eight-fold difference in Red-necked Phalarope density was probably biologically significant, the statistical tests indicated that differences in pre- and post-development bird densities were not statistically significant. The most substantial change from pre-development conditions was the eight-fold increase in Red-necked Phalaropes in impounded areas.

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INTRODUCTION

Impoundments are water bodies created by changes to natural drainage patterns. Elevated gravel roads and pads supporting oil field operations can cause temporary and permanent flooding by acting as dams when they intersect natural drainage patterns. In many cases, culverts within the roadbed at the tundra surface can prevent permanent ponding. However, culverts are ineffective when clogged by gravel, deformed within the roadbed, or blocked by snow or ice. Improvements in culvert design, placement, and maintenance have reduced flooding and eliminated some impounded areas (Klinger et al. 1983; Walker et al. 1986). Impoundments in the Prudhoe Bay oil field (PBOF) are principally caused by roads crossing drained thaw-lake basins (Walker et al. 1987). In many instances, the flooded areas drain before mid-summer and the temporary increase in moisture produces a noticeable greening of the graminoid vegetation within the impoundment area. Areas of permanent impoundments retain water throughout the year.

Within oil fields in arctic Alaska, water impounded beside gravel roads and pads has been cited as one of the major indirect, human–induced landscape disturbances in terms of area affected (Walker et al. 1987). In 1983, in an intensively developed portion of the PBOF, impoundments were found to cover approximately 22% of the landscape, compared with 11% covered by gravel roads and pads. These estimates were based on 1:6000 scale mapping from 4 July 1983 natural color 1:18000 scale aerial photography (Walker et al. 1986). From 1:24000 scale mapping based on the 4 July 1983 aerial photography, Walker et al. (1987) estimated that 2.8% (14 km^2 of 500 km^2) of the entire PBOF was covered by impoundments. The actual area covered by impoundments within the PBOF will vary in extent and duration of flooding due to variations in snow pack and precipitation levels in combination with temperature the regime during spring thaw.

Concerns have been expressed by the U.S. Fish and Wildlife Service (USFWS) about the potential loss of bird habitat due to indirect habitat alteration by impoundments, and the resulting effects on bird populations. It has also been suggested (NRDC 1991) that, because of the loss of habitat due to direct and indirect impacts, approximately 15,300 birds have been displaced from the PBOF, based on nesting densities reported in Meehan (1986). Indirect impacts (primarily impoundments) have been implicated as the primary cause for displacement of nesting birds because, in flat thaw-lake plains, indirect impacts can represent over twice the area covered by gravel fill (Walker et al. 1987).

Because of these concerns, BP Exploration (Alaska) Inc. (BPXA) and LGL Alaska Research Associates, Inc. (LGL) conducted a three–year study to determine productivity and waterbird use of impoundments by comparing impoundments and natural ponds in the PBOF

(Kertell and Howard 1992; Kertell 1993; Kertell 1994). Study objectives were guided by the need to maintain "wildlife habitat productivity," a major goal of the USFWS (USFWS 1989), and because waterbirds are of special interest to state and federal regulatory agencies. Both waterfowl and their macroinvertebrate food source (plecopterans, trichopterans, and gastropods) were generally more abundant on impoundments than on natural ponds, but high variability in bird and invertebrate abundance data resulted in few statistically significant differences between natural ponds and impoundments (Kertell and Howard 1992; Kertell 1993; Kertell 1994). The results of these studies indicate that impoundments do not represent a total loss of habitat for birds but may in fact be equivalent to natural tundra ponds in terms of value to waterfowl. This study is an evaluation of the types and amounts of bird habitats that have been altered due to the presence of impoundments.

OBJECTIVES

The objectives of this study were to:

- determine the area covered by impoundments within the entire PBOF;
- determine the historical habitat types altered by impoundments for a subsample of impoundments, and estimate the area by habitat type covered by all impoundments in the oil field;
- estimate the numbers of birds which used historical habitats that have been altered by impoundments by using values of bird densities based upon empirical bird/habitat relationships;
- survey a representative subsample of impoundments for current bird use; and
- compare historical and current bird use of impoundment areas.

METHODS

Impoundment Identification and Mapping

All 1:6000 scale map sheets covering the entire unit boundary of the PBOF (968 km^2) were reviewed to identify water bodies greater than 0.0002 km^2 next to roads and gravel pads. Areas with potential impoundments were compared to impoundments identified on the "Cumulative Development of the Prudhoe Bay Field" map prepared by Lederer et al. (1984) and "Eileen West

End-Hydrology" maps prepared by Moses (1983). Topographic information from 1:6000 scale basemaps was used to evaluate drainage patterns. Areas with possible impounding were then delineated on the 1:6000 scale base maps and labeled with the map identification (township, range, and upper right-hand section number, e.g., 111329) and a letter, such that each impoundment was assigned a unique identifier (e.g., 101401A, 101403D, etc.). A database of impoundments was compiled with impoundment numbers, general location description, cross reference data, the 3 and 12 July 1993 natural color 1:18000 scale photo number, and the 24 July 1955 black and white 1:18000 scale photo number. Aerial photography was not orthorectified. Acetate overlays of impoundment locations were prepared for the 26x26 inch 1955 photos to facilitate relocation of impoundment areas for mapping.

Focusing on impoundments with more than 0.0002 km^2 of open water allowed inclusion of all major permanent additions of open water, but omitted many small impoundment areas between roadways and intersections. The July photography also does not include many temporary impoundments that drain completely by early to mid-July. Two areas with impounded water were omitted from this study due to the nature of their occurrence. Pump Station One is located in a lake basin which was drained prior to construction. This lake basin is beginning to refill with water. Because this area was originally covered by open water, refilling of the lake basin may not be caused by alterations of the natural drainage patterns, so this area was not mapped as an impoundment. In addition, the area impounded behind the flood-prevention dike near Kuparuk Reservoirs 5 and 6 was not mapped as an impoundment. This area was similarly not included in the previous impoundment mapping (Lederer et al. 1984).

After all areas of possible development-related impounding were identified, an estimated flood area was delineated and areas of open water within the estimated flood area were calculated using 1:6000 scale digital base maps updated with 1991 and 1992 aerial photography. These areas of open water within the estimated maximum flood areas were then used to stratify sampling for bird use study sites. As flooding progressed, several impoundments identified during map review were evaluated and removed from consideration as it became apparent that there was no addition of flood water. Although all impoundments were not specifically visited, most questionable areas were visited during selection of bird use sites and throughout the census periods.

Once impoundments were identified, 1:6000 scale base maps were prepared to scale projections of the 1:18000 scale 1955 pre-development and 1993 post-development photographs. Acetate overlays delimiting open water, general wetness categories, flood area as determined by the extent of lush vegetation, and field survey flood areas were prepared from projected images of the aerial photography and field prepared flood maps. For each impoundment, one pre-development habitat overlay and one post-development impoundment overlay were prepared. If post-development water areas were the same on 1993 aerial photography and 1:6000 scale base maps, which were based on 1991 and 1992 aerial photography, the base map water polygons were used. Acetate overlays were digitized by Aeromap U.S., Inc. Polygons were completed for flood areas and most water bodies, and then converted to MapInfo® files. These files were then used to construct a Geographic Information System (GIS) database of impoundments, which includes impoundment polygons as defined by flood areas, and the following information fields: 1) ID–bird use study site number; 2) ImpNo–impoundment number; 3) prewater–area in km^2 of open water prior to construction; 4) postwater–area in km^2 of open water after construction; 5) area–flood polygon area in km^2; 6) source–data used for maximum flood polygon (p=photo interpretation, f=field observations, w=post-development water area, s=area sampled for bird use); 7) impact–calculated field in km^2 (impact=area-prewater).

Pre-development habitat types were assessed from 1955 aerial photographs and classified using the habitats defined in Troy (1988), for the 51 impoundments sampled for bird use (Fig. 1). Pre-development vegetation line work and water polygons were used in combination with flood area polygons to create pre-development habitat maps for each study site. To calculate areas for habitat types, vegetation line work and water polygons were used to construct polygons within the impoundment flood area. Either field identified flood areas or photo-interpreted flood areas were used as the habitat map boundary. The pre-development habitat polygons were constructed in a GIS database with fields for 1) ID-bird use study site number, 2) Veg-habitat type number (Fig. 1), and 3) Area-area in km^2 for each habitat polygon.

Post-development impoundment area was evaluated for the 51 bird study sites using the same flood area polygons used for pre-development habitat mapping. Lakes and ponds within the flood boundary were summed to give the area of current open water within each flood polygon. Tundra area was calculated by subtracting the open water area from the flood polygon area. To indicate habitat complexity within the flood area, water edge was calculated as the sum of the perimeter of all water bodies and islands within the flood area.

Pre-development habitat type maps, color coded by thematic mapping (Fig. 1), were prepared for the 51 sites censused for bird use. Visual comparison of the pre-development habitat maps overlain by post-development water illustrates the changes in water boundaries. Area summaries by habitat type for each study site were computed.

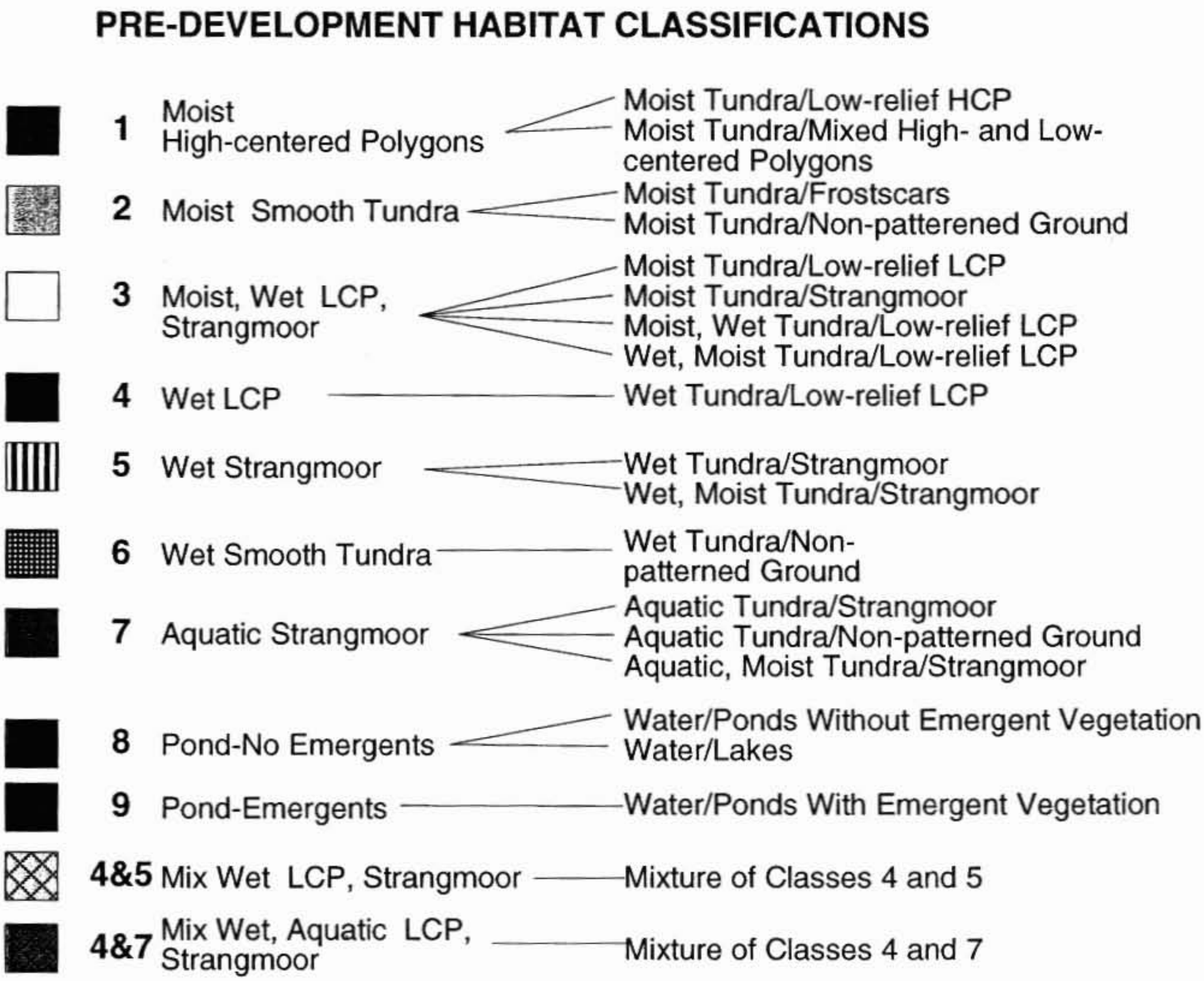

Figure 1. Classifications used for pre-development habitat mapping at 51 impoundment sites sampled for bird use in the Prudhoe Bay oil field during 1994 (Troy 1988). Pre-development habitats were mapped from 1:6000 scale projections of 1:18000 scale, 24 July 1955 black and white aerial photographs.

Current Bird Use of Impoundments

From the complete set of possible impoundments, a sample of 51 sites was randomly selected for bird use censuses during the 1994 nesting season. Sampling was stratified by five size categories with at least 10 impoundments in each category. Size categories were determined as the area of open water on 1:6000 scale base maps. The size categories were: 0.20-0.49, 0.50-1.49, 1.5-4.99, 5.00-9.99 and >10.00 hectares. This stratification resulted in the inclusion of nearly all large impoundments. Stratified random selection based on these size categories of impoundments ensured that 1) a large proportion of the areas previously designated as impounded were sampled, and 2) extrapolated results are unbiased.

Selected impoundments were censused during four nesting season sampling periods: Period 1—29 May to 3 June, Period 2—12 to 18 June, Period 3—27 June to 4 July, and Period 4—14 to 21 July. These sampling periods occur during the primary nesting season and coincide with Troy's (1988) censuses, which were the basis for historical bird use estimates. For analysis of bird use in 1994, periods 2, 3 and 4 were used because 1) most impoundments were completely frozen during period 1, and 2) estimates of historical bird use do not include late May/early June data. We censused each impoundment in the same order during each sampling period. Impoundments near Deadhorse became ice-free first and were sampled first, while impoundments west of the Kuparuk River remained frozen longer and were sampled last.

At peak flooding during Period 2, the maximum extent of melt water for each impoundment was marked on site maps. The perimeter of the maximum flood zones defined the outer edge of bird use census zones, regardless of flood duration. All bird observations within these maximum flood zones were recorded during each census period. Bird census data included areas which were both permanently and temporarily flooded.

All bird observations within the impounded areas were recorded. Data recorded for each observation included species, number of individuals, activity and habitat. Shorebird and passerine nests were recorded opportunistically, but we attempted to locate all waterfowl, gull, and loon nests. Large impoundments were censused by two observers and small impoundments were censused by a single observer. Shorelines of all water bodies and tundra segments in pond complexes were walked and scanned to locate birds. Islands were scanned with binoculars from both sides when high water prevented wading out to them. Some islands were visited in the later periods when water levels had dropped and they could be reached on foot. In areas of emergent vegetation with shallow water and in open tundra areas between water bodies, a zig-zag pattern was followed by the observer(s) in an attempt to locate cryptic species. Birds flying over the sampling area were recorded but were not included in our analyses. Likewise, birds drawn from surrounding areas by the observer's presence (mobbing) were not counted. Down and contour feather samples were collected from all depredated waterfowl nests.

We computed average bird density (birds per km^2) for each impoundment by totaling the number of birds by species recorded during sampling periods 2, 3 and 4, and dividing by three (3) times (3x) the area (km^2) of maximum flood for each impoundment. This computation gives the mean number of birds sited during the three sampling periods divided by the area of the impoundment resulting in the density (number of birds per km^2) of birds for the impoundment. We then calculated both a true mean density and standard error by averaging the densities for the 51 impoundments; and a weighted average density for each species in all impoundments combined. The weighted average was weighted by the area of each impoundment and therefore gives greater weight to larger impoundments.

Nest locations for waterfowl, loons and gulls, were digitized and entered in a GIS database with fields for species identification abbreviations as recorded in field records, site number, and notes including dates and depredation observations. Field mapped nest locations and recorded nest observation records were compared to account for each nest. The number of nests for each species was then divided by the total flood area to calculate density (nests per km^2).

Comparison of Current and Pre-Development Bird Use of Impoundments

To quantify changes in bird habitats resulting from impounding in the PBOF, bird densities observed during the summer 1994 were compared to pre-development bird densities for a set of 14 common nesting species: Pacific Loon (*Gavia pacifica*), Red-throated Loon (*Gavia stellata*), King Eider (*Somateria spectabilis*), Greater White-fronted Goose (*Anser albifrons*), Oldsquaw (*Clangula hyemalis*), Red-necked Phalarope (*Phalaropus lobatus*), Red Phalarope (*Phalaropus fulicaria*), Pectoral Sandpiper (*Calidris melanotos*), Semipalmated Sandpiper (*Calidrus pusilla*), Dunlin (*Calidris alpina*), Stilt Sandpiper (*Calidris himantopus*), Lapland Longspur (*Calcarius lapponicus*), Lesser Golden Plover (*Pluvialis dominica*), and Buff-breasted Sandpiper (*Tryngites subruficollis*). Pre-development or historical bird densities were calculated using historical habitat types from mapping and species-habitat relationships documented for the North Slope of Alaska in Troy (1988) and Troy (pers. comm.). Troy's data are from study plots located > 100 m from any roads or oil field facilities and are thought to represent bird densities relatively unaffected by development in the PBOF (TERA 1993). These data include bird study plots in the Eileen West End area (one year study, Troy et al. 1983), in the PBOF (one year study, Troy 1988), and study plots in the more coastally located Point McIntyre area (3-4 years study, Troy 1988; Troy pers. comm.).

These natural bird densities, therefore, are biased towards more coastally-influenced areas. In our discussion, we evaluate the possible effects of this bias, and the more serious bias associated with extreme year-to-year variations in bird densities (TERA 1993).

Natural bird densities in each of the nine habitat types (Fig. 1) were multiplied by the total aerial coverage of each pre-development habitat type to calculate the number of birds expected in each habitat prior to impoundment. Combined categories 4&5 and 4&7 (Fig. 1) were considered to represent equal parts of the individual habitat types for calculating expected bird numbers. Pre-development bird densities were computed by summing all the expected bird numbers for each pre-development habitat type and then dividing by the total impoundment flood area, resulting in an expected pre-development density for each of the 14 common species. Weighted mean densities for each bird species were computed for pre- and post-development, and only these overall mean densities were used in our analyses. Analyses were not based on individual impoundments because of the well-documented high spatial variability in bird densities, even within similar habitat types (TERA 1993b, Declan Troy, pers. comm.). Regression analysis and nonparametric paired-sample tests were used to compare pre- and post-development bird densities.

The bird data were analyzed in two ways: 1994 data corrected for inter-year variation, and 1994 data not-corrected. To correct for inter-year variation, the 1994 data for each of the 14 species were adjusted to reflect the proportional change from the multi-year averages for the same 14 species on the Point McIntyre study plots (TERA 1992) in 1994. These reference data were supplied by Declan Troy (pers. comm.).

RESULTS

Impoundment Area Calculations

One hundred forty-four impoundments were identified and flood lines were mapped. A large format map of all 144 impoundments identified in this study with bird use study sites labeled is included in a pocket at the end of this report (Fig. 2). The area impacted by impoundments with more than 0.0002 km^2 of open water in July within the Prudhoe Bay oil field is presented in Appendix A. A total of 11.3 km^2 was covered by flooding. Of this maximum flood area, 5.3 km^2 was open water in July, and 6.0 km^2 was tundra that had been temporarily flooded in June. Of the 5.3 km^2 of open water in July, 3.3 km^2 consisted of open water prior to any construction, based on 1955 pre-development aerial photography. Impoundments have resulted in the addition of 2.0 km^2 of open water in July (Appendix A). Therefore, a total of 8.0 km^2 of tundra was permanently (open water in July) or temporarily flooded by impoundments in 1993 (11.3 km^2 maximum flood minus 3.3 km^2 pre-development water equals 8.0 km^2 flooded tundra, Appendix A).

For the 51 impoundments censused for bird use, the total area covered by flooding was 7.1 km^2 (Table 1). Maps of pre-development habitat types were constructed for the 51 impoundment sites censused for bird use. Open water in July within the maximum flood areas was 3.8 km^2 (Table 1). Prior to any construction, open water within the maximum flood areas was 2.6 km^2 (Table 2), based on July 1955 aerial photography. For these sites, the total maximum flood area of 7.1 km^2 consisted of 2.6 km^2 pre-existing open water, 1.2 km^2 permanently flooded tundra and 3.3 km^2 of temporarily flooded tundra (Tables 1 and 2)

The predominant pre-development habitats (defined in Fig. 1) covered by the maximum flood area for the 51 bird use study sites were 7-Aquatic Strangmoor (2.6 km^2, 37%), 9-Pond-Emergents (1.6 km^2, 22%), and 8-Pond-No Emergents (1.0 km^2, 14%) (Table 3, Fig. 3). Using these proportions to calculate the habitat areas covered by the total 11.3 km^2 maximum flood area for all 144 mapped impoundments results in affected pre-development habitat areas of 7-Aquatic Strangmoor 4.2 km^2, 9-Pond-Emergents 2.5 km^2, and 8-Pond-No Emergents 1.6 km^2 (Table 3). This extrapolation calculates the pre-development open water area as 4.2 km^2. However, mapping from 1955 aerial photography for open water within the 144 impoundments resulted in a total of 3.3 km^2 pre-development open water. Therefore, the extrapolation over estimates the amount of pre-development open water. To account for this discrepancy and accurately characterize the total 8.0 km^2 area of pre-development tundra habitat affected by flooding, the proportional area of tundra covered by habitat type was calculated (Table 3). Of the 4.5 km^2 area of tundra flooded in the 51 bird use study sites 59 % was aquatic tundra, 37% was wet tundra and 4% was moist tundra. Extrapolating these proportions to the 8.0 km^2 of tundra flooded by all 144 impoundments results in areas of 4.7 km^2 aquatic tundra, 3.0 km^2 wet tundra, and 0.3 km^2 moist tundra (Table 3).

Bird Abundance On Impoundments

A total of 2477 sightings of 5135 birds were recorded during the four sampling periods in 1994 (Table 4 and Appendix B, Table B-1). Of this total, 97% (2395) of sightings and 95% (4870) of birds were recorded during sampling periods 2, 3 and 4 (Table 4). Consequently, results presented hereafter are based only on sampling periods 2, 3 and 4, the periods when most impoundments and adjacent tundra habitats were relatively free of ice and snow.

Table 1. Physical characteristics of impoundments sampled for bird use in the Prudhoe Bay oil field, Alaska, summer 1994.

Site Number	Impound. Number	Impound. Area (ha)	Impound. Area (sq km)	Area of Open Water (ha)	Area of Open Water (sq km)	Area of Tundra (ha)	Area of Tundra (sq km)	Perimeter of Waterbodies (m)
2	111205A	0.855	0.009	0.512	0.005	0.342	0.003	393.7
3	111215G	61.520	0.615	41.149	0.411	20.371	0.204	26727.4
6	111203E	1.038	0.010	0.201	0.002	0.837	0.008	370.1
7	121225B	0.558	0.006	0.359	0.004	0.199	0.002	440.6
8	121225C	4.957	0.050	3.004	0.030	1.953	0.020	2947
9	111315F	6.081	0.061	3.287	0.033	2.793	0.028	2779.7
10	111315C	11.639	0.116	9.987	0.100	1.653	0.017	2339.4
11	111315A	3.732	0.037	1.637	0.016	2.095	0.021	1518.2
12	111303C	46.210	0.462	25.621	0.256	20.589	0.206	7338.7
13	111301C	19.910	0.199	9.592	0.096	10.318	0.103	4029.1
14	111301A	37.010	0.370	17.940	0.179	19.071	0.191	6731.9
17	111313I	4.084	0.041	2.655	0.027	1.429	0.014	2239.4
18	111313A	88.356	0.884	7.212	0.072	81.423	0.814	2575.5
19	111301F	2.458	0.025	1.467	0.015	0.991	0.010	1076.7
20	111405B	3.895	0.039	0.564	0.006	3.331	0.033	1202.6
21	121427D	1.756	0.018	0.384	0.004	1.372	0.014	872
22	121427A	0.951	0.010	0.897	0.009	0.055	0.001	482.3
23	121425A	9.763	0.098	5.235	0.052	4.528	0.045	2595.1
24	111401A	1.404	0.014	0.284	0.003	1.120	0.011	719
25	111401D	4.403	0.044	3.940	0.039	0.463	0.005	1505.9
27	111417C	47.780	0.478	41.580	0.416	6.200	0.062	4837.5
28	111417B	47.230	0.472	19.500	0.195	27.731	0.277	8909.4
29	111417F	8.874	0.089	5.574	0.056	3.134	0.031	3936.5
30	101405A	10.370	0.104	7.120	0.071	3.250	0.033	1673.4
31	111427D	3.758	0.038	3.533	0.035	0.225	0.002	1530.7
32	111427B	4.240	0.042	1.301	0.013	2.939	0.029	1554.2
33	111427A	24.310	0.243	21.210	0.212	3.100	0.031	3186
34	111425D	0.841	0.008	0.512	0.005	0.329	0.003	794.6
35	101505E	23.480	0.235	16.061	0.161	7.419	0.074	9062.4
36	101505A	2.952	0.030	0.904	0.009	2.048	0.020	746.3
37	101503G	5.885	0.059	2.344	0.023	3.544	0.035	1787.6
38	111527D	14.860	0.149	4.678	0.047	10.182	0.102	9343.7
40	111525D	10.010	0.100	9.164	0.092	0.846	0.008	2404.9
41	111525A	13.370	0.134	8.514	0.085	4.856	0.049	5290.5
42	111513A	0.756	0.008	0.237	0.002	0.519	0.005	393.9
43	101503C	1.372	0.014	0.644	0.006	0.728	0.007	1284.9
44	101501A	5.944	0.059	4.838	0.048	1.106	0.011	1626.1
45	101515G	4.805	0.048	3.721	0.037	1.084	0.011	3522.3
46	101515C	1.701	0.017	1.079	0.011	0.622	0.006	562.9
47	101515D	3.122	0.031	2.972	0.030	0.150	0.002	3775.8
48	101515E	4.457	0.045	2.898	0.029	1.559	0.016	4101.4
49	101501B	0.814	0.008	0.605	0.006	0.209	0.002	490.5
50	101517C	13.400	0.134	8.549	0.085	4.851	0.049	3078.3
51	101517B	42.640	0.426	35.217	0.352	7.423	0.074	3385.5
52	101517A	58.590	0.586	17.462	0.175	41.128	0.411	6109.9
53	101413E	6.125	0.061	5.409	0.054	0.716	0.007	1380.9
54	101413A	27.050	0.271	19.054	0.191	7.996	0.080	5654.3
55	101413D	0.986	0.010	0.879	0.009	0.107	0.001	404.3
56	101401B	0.705	0.007	0.238	0.002	0.467	0.005	470.5
57	101505G	1.751	0.018	0.000	0.000	1.751	0.018	0
59	111401B	3.222	0.032	0.510	0.005	2.712	0.027	723
Total Area		705.980	7.060	382.234	3.822	323.864	3.239	160906.5

Table 2. Pre-development habitat type calculations (square kilometers) for 51 bird use study sites at areas affected by impoundments, Prudhoe Bay oil field, Alaska, 1994. Predevelopment habitats after Troy (1988) were evaluated and mapped from 24 July 1955 black and white 1:18000 scale aerial photographs, projected and scaled to 1:6,000 basemaps (Fig. 1).

Site Number	Habitat Type											Open Water (Type 8+9)	Total Area
	1	2	3	4	5	6	7	8	9	4&5	4&7		
2				0.004				0.005				0.005	0.009
3	0.001					0.067	0.289	0.107	0.052	0.098		0.160	0.615
6							0.0104					0.000	0.010
7		0.0056										0.000	0.006
8			0.026					0.012	0.012			0.024	0.050
9		0.008					0.027	0.011	0.015			0.026	0.061
10	0.002		0.009		0.008		0.014	0.083				0.083	0.116
11				0.003			0.023	0.012				0.012	0.037
12	0.004		0.008	0.004			0.181	0.029	0.236			0.266	0.462
13			0.008				0.142		0.049			0.049	0.199
14			0.003				0.217		0.149			0.149	0.370
17						0.005	0.030	0.006				0.006	0.041
18						0.052	0.751	0.081				0.081	0.884
19			0.001	0.007			0.008		0.009			0.009	0.025
20		0.009					0.029		0.001			0.001	0.039
21	0.003				0.006		0.008	0.001				0.001	0.018
22	0.007		0.002					0.001				0.001	0.010
23									0.019	0.078		0.019	0.098
24		0.002			0.011			0.000				0.000	0.014
25						0.025	0.019					0.000	0.044
27							0.045	0.415		0.017		0.415	0.478
28							0.194	0.200		0.078		0.200	0.472
29							0.056			0.033		0.000	0.089
30				0.042			0.061	0.000				0.000	0.104
31			0.001					0.001		0.036		0.001	0.038
32			0.014				0.016			0.013		0.000	0.042
33			0.013		0.042		0.041			0.147		0.000	0.243
34			0.002				0.004		0.002			0.002	0.008
35			0.006	0.015					0.155		0.059	0.155	0.235
36			0.004	0.018					0.007			0.007	0.030
37				0.035					0.024			0.024	0.059
38									0.038		0.111	0.038	0.149
40				0.066			0.022		0.012			0.012	0.100
41									0.057	0.077		0.057	0.134
42								0.001		0.002	0.004	0.001	0.008
43								0.001			0.012	0.001	0.014
44			0.010			0.049						0.000	0.059
45								0.019			0.029	0.019	0.048
46			0.001			0.015	0.001					0.000	0.017
47				0.008				0.013			0.010	0.013	0.031
48								0.009			0.042	0.009	0.051
49						0.004	0.004					0.000	0.008
50			0.008	0.033			0.007		0.086			0.086	0.134
51			0.009	0.063			0.010		0.345			0.345	0.427
52			0.001	0.075			0.328		0.182			0.182	0.586
53			0.004			0.041	0.017					0.000	0.061
54			0.003	0.067			0.069		0.132			0.132	0.271
55	0.000						0.000	0.010				0.010	0.010
56				0.003			0.003	0.001				0.001	0.007
57			0.018									0.000	0.018
59					0.032							0.000	0.032
Total Area*	0.017	0.024	0.150	0.442	0.100	0.260	2.626	1.019	1.583	0.579	0.268	2.602	7.067

* Difference in total area of 7.060 in Table 1 is due to map corrections, rounding and map calculation errors.

Table 3. Summary of pre-development habitat types following Troy (1988) classifications, for 51 impoundments censused for bird use during 1994, and extrapolated to the total area affected by all 144 impoundments mapped, Prudhoe Bay oil field, Alaska. Pre-development habitat types were evaluated and mapped from 1:18000 scale black and white 24 July 1955 aerial photographs projected and scaled to 1:6000 scale basemaps.

		Bird Use Sites (n=51)				All Impoundments (n=144)	
Habitat Type		Total Area (sq km)	Percent of Total Area	Total Tundra Area (sq km)	Percent of Tundra Area	Total Area (sq km)	Total Tundra Area (sq km)
1	Moist High-centered Polygons	0.017	0.2	0.017	0.4	0.03	0.03
2	Moist Smooth Tundra	0.024	0.3	0.024	0.5	0.03	0.04
3	Moist, Wet Low-centered Polygons, Strangmoor	0.150	2.1	0.150	3.4	0.24	0.27
4	Wet Low-centered Polygons	0.442	6.3	0.442	9.9	0.71	0.79
5	Wet Strangmoor	0.100	1.4	0.100	2.2	0.16	0.18
6	Wet Smooth Tundra	0.260	3.7	0.260	5.8	0.42	0.47
7	Aquatic Strangmoor	2.626	37.1	2.626	58.8	4.19	4.70
8	Pond-No Emergents	1.019	14.4			1.63	
9	Pond-Emergents	1.583	22.4			2.54	
4&5	Mix Wet Low-centered Polygons, Strangmoor	0.579	8.2	0.579	13.0	0.93	1.04
4&7	Mix Wet, Aquatic Low-centered Polygons, Strangmoor	0.268	3.8	0.268	6.0	0.43	0.48
8+9	Open Water	2.602	36.9			4.17	
Total Area*		7.067		4.465		11.3	8.0

* Difference from Table 1 total is due to map corrections, rounding and map calculation errors.