Prepared for the Alaska Department of Environmental Conservation

Evaluate Fecal Coliform Bacteria for Two Anchorage Watersheds

Alaska Clean Water Actions Grant # 18-07– Task 8

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Introduction

This report summarizes the findings from ACWA grant 18-07 for task 8 on Chester Creek and Little Campbell Creek within the Municipality of Anchorage (MOA). Anchorage Waterways Council's (AWC) water quality monitoring program is described as well as how the fecal coliform bacteria (FC) monitoring data between 2010 and 2017 was vetted through Quality Assurance and Quality Control procedures (QA/QC). A discussion follows regarding the use of the FC data for screening or analytical purposes. Included in the report are four GIS maps depicting monitoring sites and potential sources of fecal coliform from different factors. The conclusion covers areas where additional monitoring would be useful.

Anchorage Waterways Council's Monitoring Program

AWC began its volunteer water quality monitoring program in 1998 when Robert Shipley, a board member and biologist, took the first samples. Known as CEMP, citizens' environmental monitoring program, to date it has trained over 300 volunteer monitors to collect baseline water quality data which is used to identify trends and detect pollution. About half of Anchorage's 26 watersheds have had some monitoring, and several creeks have had multiple sites monitored. Baseline goals for individual sites are to achieve 5 years of monitoring with a total of 20 monthly site visits during winter months (monitoring cannot be achieved when the site is frozen, but we still require visits) and a total of 40 monthly site visits during summer over the 5 year period.

AWC's monitoring protocols have changed over the years as has the equipment. Initially, Hanna meters were used which necessitated 3-day trainings and frequent recertifications. In 2016, the lack of adequate funding for the program, the expense of replacing Hanna meters every 18 months, and the cost for shipping hazardous chemicals by 2nd day air made the existing program nonviable. In order to keep our monitoring program going, some changes had to be made. As an example, pH testing had been done by a colorimetric system as well as by a Hanna meter which needed 3 chemicals just for calibrating. pH testing is now done solely by using test strips, and they seem to be fairly comparable to colorimetric tests.

Dissolved oxygen (DO), previously done through titration (which uses sulfuric acid), was changed to a comparator system. Ampoules that have been vacuum-sealed with a chemical reagent are inserted into a vial containing the sample. The tip of the ampoule is broken off and within seconds the ampoule sucks in the water and changes to a shade of blue which is then matched to a color/reading in the comparator. It's usually not crucial to worry about the difference between a 7 or 8. What is important is to make sure the DO is not 6 or less. And that is easily discernable.

There have been no changes in the fecal coliform (FC) testing which uses Micrology's Coliscan® or measuring turbidity with LaMotte's Standard Turbidity Reagent. These remain according to the original Quality Assurance Project Plan (QAPP) approved by the Alaska Department of Environmental Conservation (DEC) in 2008. It must be remembered that these tests are used as water quality screening and a means of alerting AWC to potential problems, and, if necessary, the need for more extensive testing. It would require a much greater cost per sampling to have laboratory analytical results all the time.

In reviewing the differences between AWC's previous testing and that which began in 2016— we have reduced the need for chemical reagents from ten to one (turbidity) which has given our program the ability to continue. And we are satisfied with the quality of the results[1] for screening purposes.

[1] Calibrating Hanna meters and performing DO titration require careful attention and skill by the monitor. This probably was the case with about half the monitors, the other half had difficulty performing the calibrations and test, which resulted in data that was not always the best.

The monitoring forms used for both protocols are included in Figures 1-4.

Anchorage Waterways Council CEMP
Water Quality Data Sheet
Revised April 1, 2011

Office Use Only		Page 1 of 2
Entry Date	Edit	Comments

Sample Information

Date		Site ID		Collection Time	
Monitoring Kit Number			Kit Condition		

Volunteer Information

	Print Name	Signature	Mileage	Hours
Volunteer 1				
Volunteer 2				

Exp. Dates											
		pH 4		Mang. Sulf.		Starch Ind.			
		pH 7		Alk. Pot.		Thiosulf.			
WR Ind.		Cond.		Sulf. Acid		Turb. Rgt.			

Hanna Meter Calibration

Meter #		Date	
pH 7 (Initial)	Temp	pH 4 (Cal)	Temp
Cond. (initial)	Temp	Cond. (Cal)	Temp

Weather

Clear

Partly Cloudy

Cloudy

Precipitation

Fog or Haze

# of Days Similar	
Temp. °F	

Wind

Mph	**Direction**
<1	N
1-3	NE
4-7	E
8-12	SE
13-18	S
19-24	SW
25-31	W
32-38	NW
39-46	
47-54	**Character**
55-63	Calm
64-72	Steady
73 or greater	Variable

Sample Location

Depth	**Bottom**
0-6"	Silty
6-12"	Sandy
12-36"	Gravel
	Cobble

Description

Pool	Riffle
Other:	

Precipitation

Type (circle one)			
Last 24 hr.	Yes	Rain	Hail
	No	Snow	Sleet

Comments

Sketch

Photos

Photo #	Photo Description	Camera #	
#			
#		Additional Photos	
#			

Figure 1. Page 1 of data sheet used until 2016

Please Return ASAP to:
Anchorage Waterways Council
P.O. Box 241774
Anchorage, Alaska 99524-1774

Date		Page 2 of 2
Site ID		

Water Temperature Repeat if not within 2.0 ºC

	Replicate 1	Replicate 2	Location (circle one)
Temp ºC			Stream
Time			Bucket

Two replicates should be taken 5 minutes apart

Color

	2.5 Gallon	50 ml
Apparent Color		

Turbidity

Sample Size (circle one)

25 ml 50 ml

	Replicate 1	Replicate 2
# of Additions		
Water Temp ºC		

Repeat if replicates are not within 1 addition of each other

Colorimetric pH

Replicate 1	Replicate 2

Record to nearest 0.25 pH units
Repeat if replicates not within 0.25 units

Hanna Meter

Meter #

Wait for Hanna meter to stablize before recording measurement. Record time when Hanna meter is placed in bucket/stream. Allow 15 seconds to stabilize between 3 replicate readings. Minimum of 2 replicates must be in the following ranges of each other, repeat outlier: pH 0.05 units, Conductivity 4µs, TDS 4 ppm.

	start	stop
Temp ºC		
Time		

	Rep. 1a	Rep. 2a	Rep. 3a	Rep. 1b	Rep. 2b	Rep. 3b
pH						
Cond						
TDS						

Comments:

Dissolved Oxygen Minimum of 2 replicates must be within 0.6 mg/L of each other, repeat outlier.

Fix Time		Replicate 1a		Replicate 1b	
Fix Temperature ºC		Replicate 2a		Replicate 2b	
Titration Date		Replicate 3a		Replicate 3b	
Titration Time					

Comments:

Coliform Bacteria

					1 ml	5 ml	
Time mixed		Date counted		Total E. coli Colonies			(blue/purple)
Time plated		Time counted		Total pink/red colonies			
Easygel Exp.		Plate Exp.		Total teal Colonies			

Figure 2. Page 2 of data sheet used until 2016

Anchorage Waterways Council CEMP Water Quality Data Sheet Revised April 1, 2016	Office Use Only		Page 1 of 2
	Entry Date	Edit	Comments

Sample Information

Date		Site ID	Ma	Collection Time	
Monitoring Kit Number		Kit Condition			

Volunteer Information	Print Name	Signature	Mileage	Hours
Volunteer 1				
Volunteer 2				

Weather	Precipitation		Type	# of days similar
Clear	Last 24 hr.	Yes	Rain	
Partly Cloudy		No	Snow	
Cloudy			Hail	
Precipitation			Sleet	
Fog or Haze	Air Temp ºC			

Sample Location	Comments
Depth	
0-6"	
6-12"	
12-36"	
Bottom	
Silty	
Sandy	
Gravel	
Cobble	
Description	
Pool	
Riffle	

Photos	Photo #	Photo Description
	#	
	#	
	#	
	#	

Figure 3. Page 1 of data sheet used in 2016

Please Return ASAP to:
Anchorage Waterways Council
P.O. Box 241774
Anchorage, Alaska 99524-1774

Date		Page 2 of 2
Site ID	Ma	

Water Temperature

		Location (circle one)
Temp ºC		Stream
Time		Bucket

Color

Apparent Color	2.5 Gallon	50 ml

Turbidity

Sample Size (circle one)	Reagent exp		Replicate 1	Replicate 2	Replicate 3
25 ml / 50 ml	# of Additions				

Remember to SHAKE the turbidity reagent well beforehand.

Repeat if first 2 replicates are not within 1 addition of each other

pH Strips

Replicate 1	Replicate 2	Replicate 3

Do 2 readings, and record to nearest 0.5 pH units. Do a 3rd replicate if values are not within 0.5 units

Dissolved Oxygen

DO # (PPM, mg/L)	
Bucket Temperature ºC	

Coliform Bacteria

5 ml sample

Time mixed		Date counted		Total E. coli Colonies		(blue/purple)
Time plated		Time counted		Total pink/red colonies		
Easygel Exp.		Plate Exp.		Total teal Colonies		

Site Sketch

Figure 4. Page 2 of data sheet used in 2016

QA/QC of Monitoring Data Entry

AWC has close to 20 years of water monitoring data for the Chester and Little Campbell Creek watersheds, however the only records that were used for this ACWA grant were those from 2010 to 2017. The reason is that the original Access database that had monitoring data entered between 1999 and 2009 was found to be extremely cumbersome with too much information entered, much of it unnecessary, and a considerable amount of what had been entered was fraught with errors.

In 2010 when Dr. Cherie Northon became the Executive Director and Dr. Thom Eley became the monitoring coordinator, a new data entry system was created using Google Docs. It was much less complicated yet covered all the parameters needed. Interns entering the data were given training and clear instructions on how to do so.

Even so, errors were still introduced. AWC's UAA intern, Veronica Campbell, was with us for 3 semesters and she was tasked with reviewing all the hard copy data sheets from 2010 to 2017 to the new database. After she completed checking the records, Dr. Northon reviewed all of her comments for sites in Little Campbell Creek and Chester Creek—and then made the corrections in the database herself. Our confidence level in the data accuracy is quite high for these two watersheds.

Screening or Analytical Water Quality Data

As discussed above, AWC is confident that the water quality data collected from 2010-2017 is useful for screening potential water quality problem areas. There is no doubt that using a handheld meter for pH is more accurate than test strips, but a sampling result of concern that did not meet Alaska Water Quality Standards (WQS) would most likely be identified and followed up on by additional more advanced water testing techniques. As mentioned, the DO testing would also capture any outliers (<6.5 or >8.5) that are detrimental to the Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife from the WQS.

One of the most important correlations is that of FC testing. SGS Laboratories in Anchorage has provided AWC with some lab-quality FC testing at no cost for some situations. We have done some side-by- side testing with SGS and Micrology's Coliscan® and found them to be highly comparable. Again, if there was a concern about a high FC result using the Coliscan screening methodology, there is always an opportunity to have follow up samples analyzed at a laboratory provided there is funding.

GIS Maps

Tasks 4 and 5 of ACWA 18-07 required a GIS base map with hydrology, AWC monitoring sites for Chester Creek and Little Campbell Creek, as well land use, pet waste stations (previous ACWA grant), and animal facilities and events created for the MOA's Watershed Management Service's APDES permit AKS-052558. AWC is providing the following shapefiles that we have created:

1. AWC-2018-DogParks.shp
2. AWC-MonitoringSites.shp
3. AWC-PetWasteStations.shp
4. AWC_Stables – Zoo.shp
5. AWC-AnimalFacilities.shp

Additionally, there are shapefiles from MOA WMS that have been altered to include only things that we need. An example would be MOA-ChesterCreekWatershed. It was originally a shapefile with all of Anchorage's watersheds. These will all be provided to DEC.

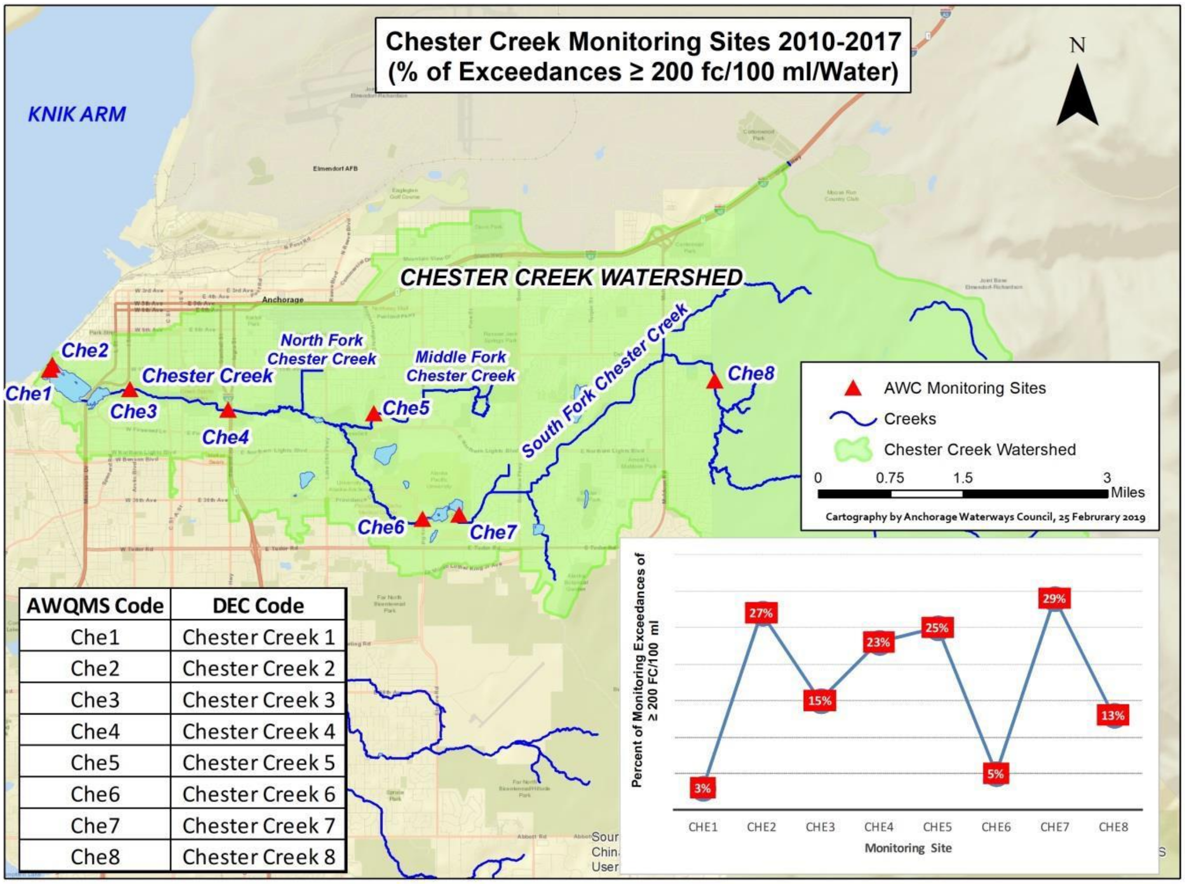
The following GIS maps are in the Appendix.

1. Commercial Stables, the Alaska Zoo, Trails and LCC Monitoring Sites (This map is specific to Little Campbell Creek because there are no commercial stables in the Chester Creek watershed.)
2. Indoor Animal Facilities, Pet Stores, Kennels and Monitoring Sites
3. Dog Parks, Pet Waste Stations, and Monitoring Sites
4. Landuse and Monitoring Sites in the Chester Creek and Little Campbell Creek Watersheds

Discussion

Chester Creek

Fecal Coliform (FC) bacteria data from 2010 to 2017 using the Coliscan method for Chester Creek watershed covers eight monitoring sites. These sites are shown in Map 1 along with a graph of the percentage of times that the FC sample was equal to or greater than WQS's 200 FC/100 ml/water for secondary recreation and not more than 10% of the total samples may exceed 400 fecal coliform/100 ml. Because the number of monitoring events varies by site, a percentage puts them on a more even basis (Table 1).



Map 1. Chester Creek Monitoring Sites 2010-2017 (% of Exceedances ≥ 200 fc/100 ml/Water)

Table 1. Chester Creek Monitoring Sites 2010-2017 (% of Exceedances ≥ 200 fc/100 ml/water)

Monitoring Site	Total # Monitoring Events	Exceedances ≥ 200 FC/100 ml	% Exceeding
Che1	39	1	3%
Che2	11	3	27%
Che3	26	4	15%
Che4	22	5	23%
Che5	4	1	25%
Che6	58	4	7%
Che7	14	4	29%
Che8	24	3	13%

This is an interesting exercise when these values are placed in their creek locations. The two lowest exceedances are at the outfall of Westchester Lagoon and University Lake. Site Che3 is at Arctic and 17th just below Valley of the Moon Park. It typically has relatively high FC numbers, yet when the water exits the lagoon at Che1—the numbers have dropped dramatically. The same is true for Che5 which is the inflow into University Lake and Che6 which is the outflow from the lake at Elmore. This is even more remarkable because the lake is surrounded by a popular dog park and waterfowl are present.

When looking at the data for the highest readings by site, one of the most striking anomalies is the reading for Che8 at 2,000 FC in August 2010. This is the highest reading of all monitoring events that have been taken by AWC on Chester Creek in that time frame, and it is just downstream of military land which has no housing or other forms of development except for a few roads, trails, and buildings.

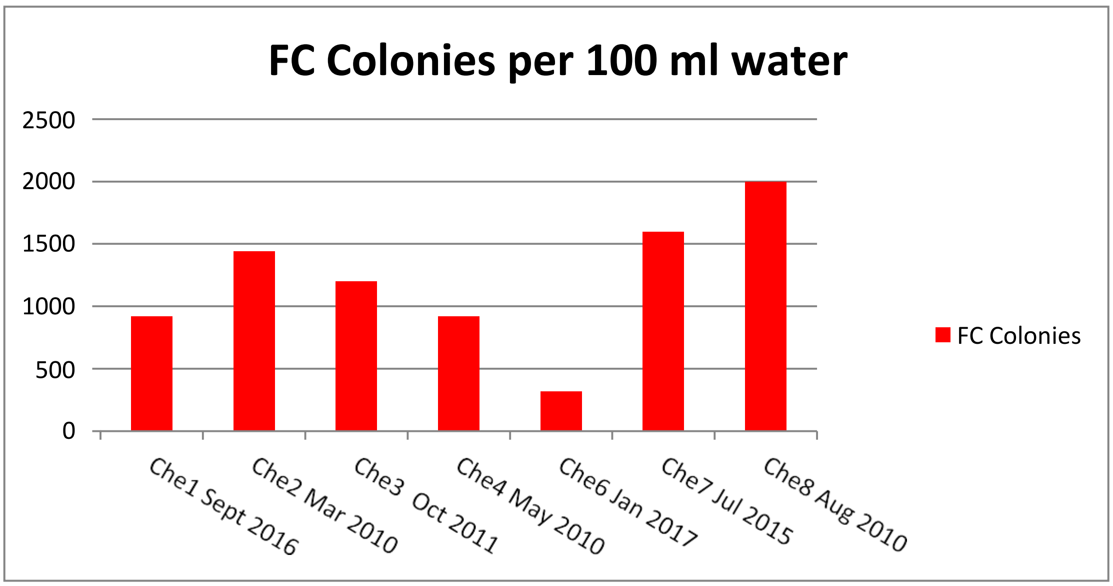
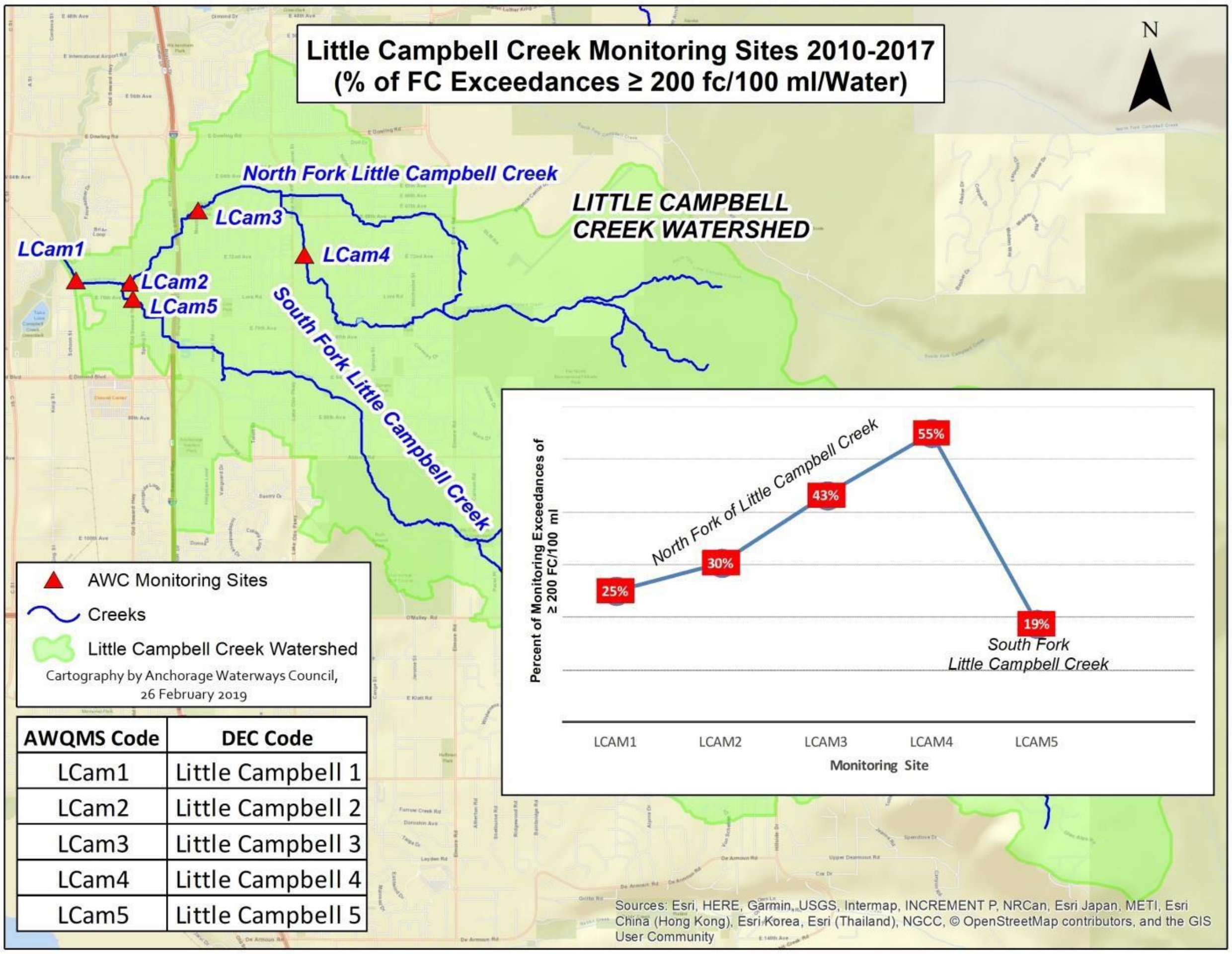


Figure 5. Highest recorded site readings by date for FC monitoring from 2010 to 2017 – Chester Creek

Little Campbell Creek

Fecal coliform bacteria data from 2010 to 2017 for Little Campbell Creek watershed covers five monitoring sites. These sites are shown in Map 2 along with a graph of the percentage of times that the FC sample was equal to or greater than WQS's 200 FC/100 ml/water for secondary recreation and not more than 10% of the total samples may exceed 400 fecal coliform/100 ml. Because the number of monitoring events varies by site, a percentage (Table 2) puts them on a more even basis.



Map 2. Little Campbell Creek Sites 2010-2017 (% of Exceedances ≥ 200 fc/100 ml/water)

Table 2. Little Campbell Creek Monitoring Sites 2010-2017 (% of Exceedances ≥ 200 fc/100 ml/water)

Monitoring Site	Total # Monitoring Events	Exceedances ≥ 200 FC/100 ml	% Exceeding
LCam1	16	4	25%
LCam2	33	10	30%
LCam3	37	16	43%
LCam4	29	16	55%
LCam5	16	3	19%

Figure 6 is also an interesting graph. When highest recorded values are placed in their creek locations, rather than showing an increase as the North Fork Little Campbell Creek runs downstream to Campbell Creek, the number of FC colonies actually decreases. The highest exceedance is on the South Branch of the North Fork which is about 1.4 miles from Elmore Road an area bounded by BLM at Campbell Creek, Abbott Loop Community Park, and Far North Bicentennial Park. Once the creek enters at Elmore Road, it runs primarily through a residential area except for a 10 acre parcel known as the F Bar J Ranch which boards horses (Figure 7). A report by Davis and Davis for DEC suggests that this stable could be contributing bacteria to the North Fork Little Campbell Creek (2010:21).

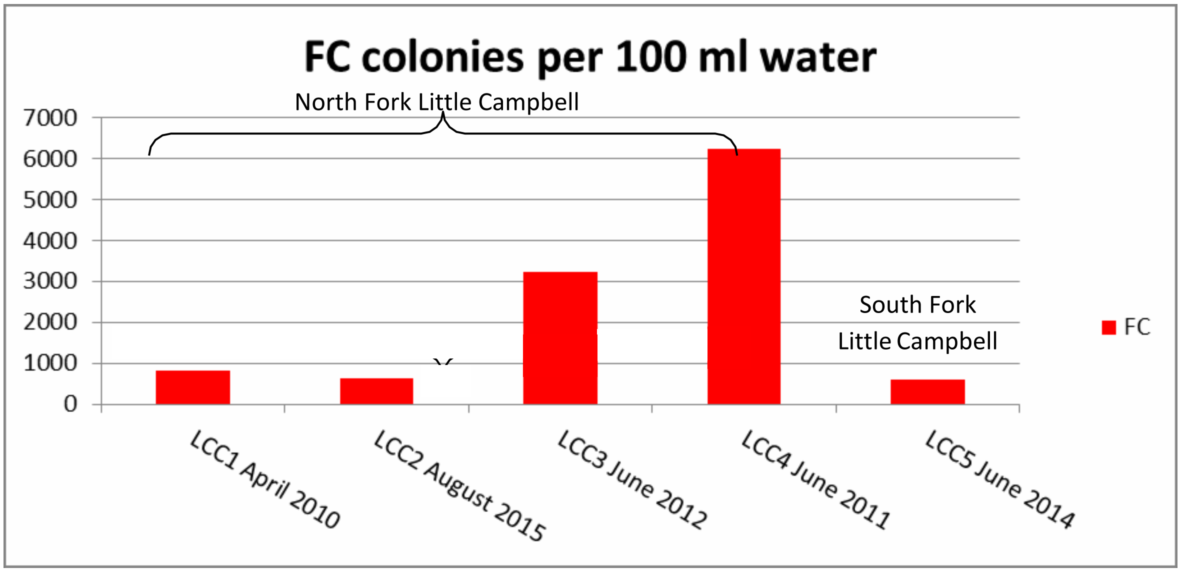


Figure 6. Highest recorded site readings by date for FC monitoring from 2010 to 2017 – Little Campbell Creek

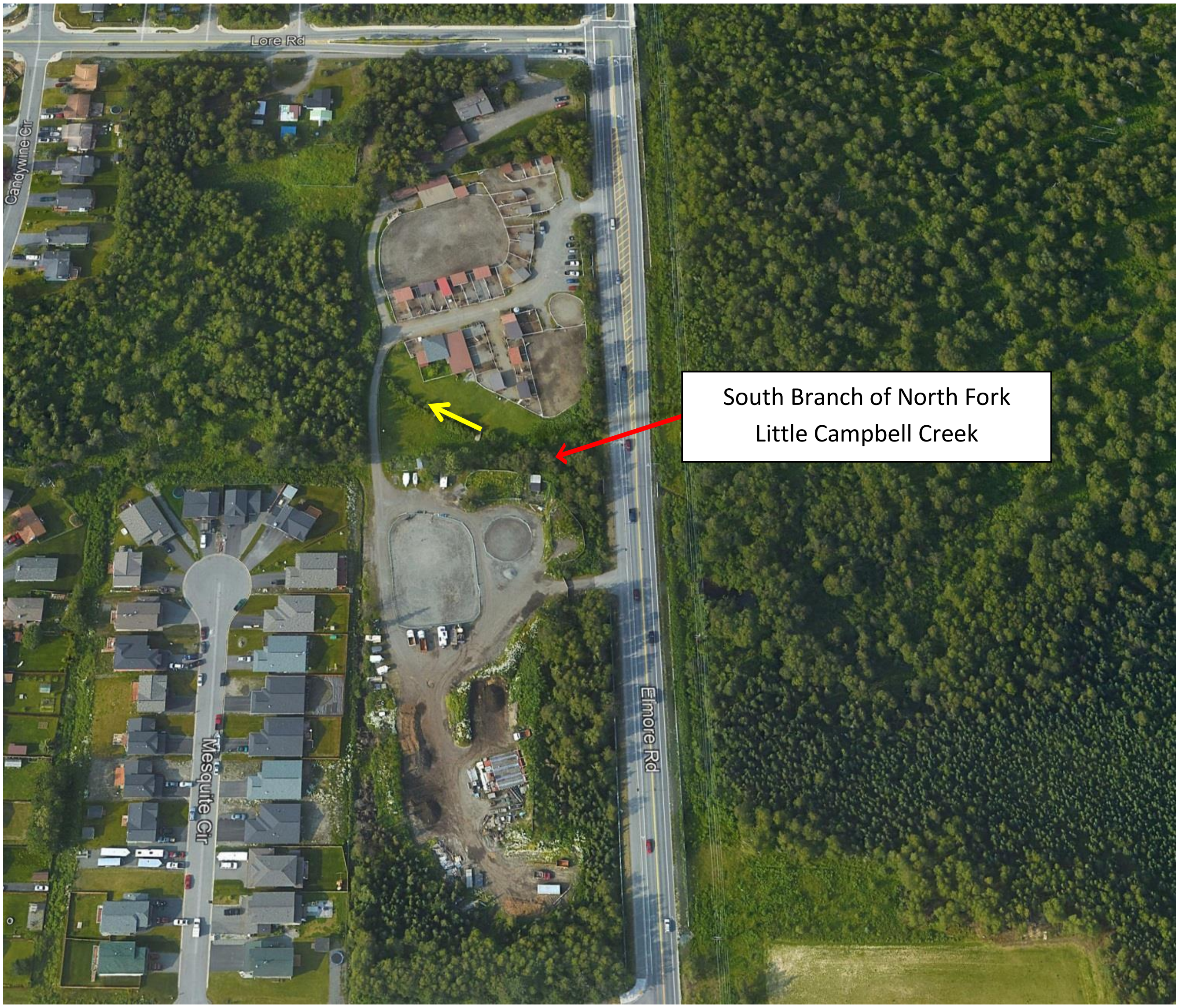


Figure 7. F Bar J Ranch with the South Branch of the North Fork Little Campbell Creek. The yellow arrow shows the direction of creek flow. Monitoring station LCam4 is 1.4 miles downstream.

Analysis

Chester Creek

Trying to account for the FC readings that don't seem to "fit" logically is difficult. The exceedances were checked against precipitation. In about half the cases there was no precipitation on the monitoring day or the previous 3 days for high FC readings, and the rest of them there was. A quick literature review did show that precipitation is not always a factor for high fecal counts.

Another way to look at the area involves the stormwater drainage maps by the Municipality from their Municipal Drainage Viewer. This is an online GIS that the Municipality uses to show stormwater drainage areas. It can be found at anchoragestormwater.com/maps.html>Municipal Drainage Viewer. One feature that it can portray is the polygon boundary of a drainage area into an outlet. The following maps were created with this program.

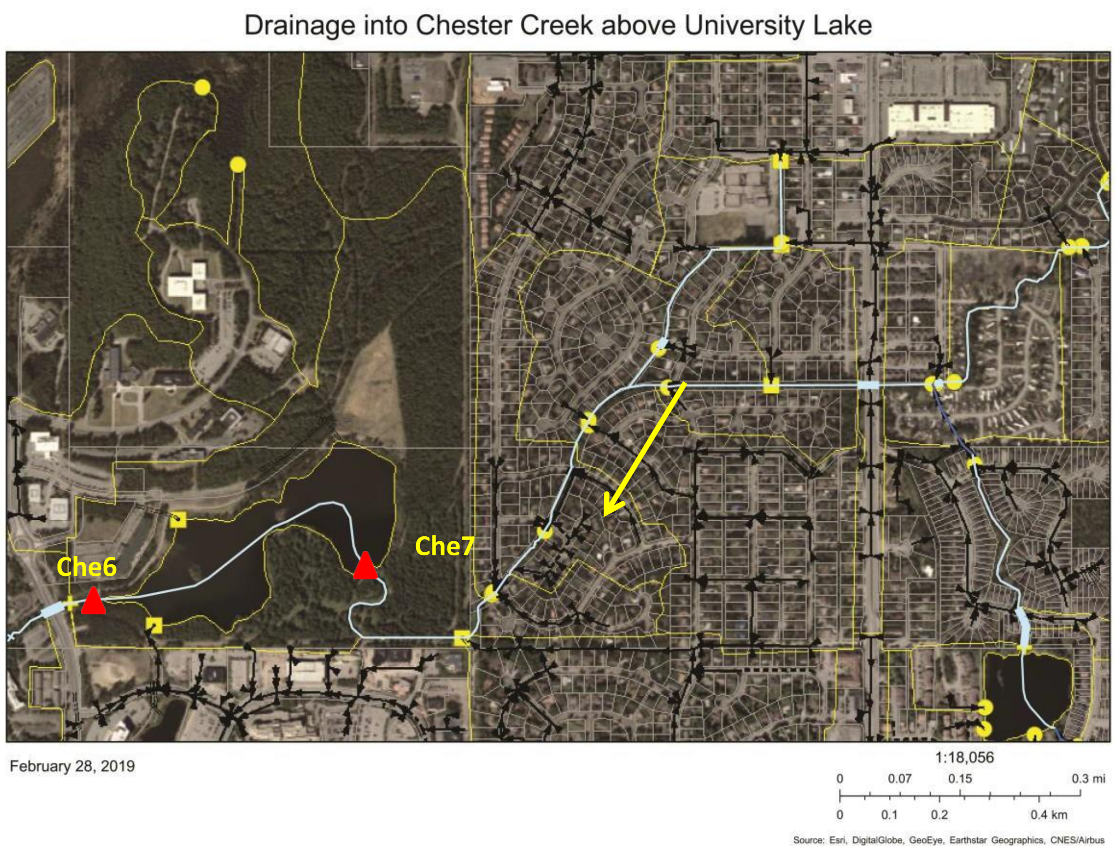


Figure 8. Monitoring sites above and below University Lake in the lower left of this image (MOA Drainage Viewer). The yellow arrow shows the direction of stream flow.

Figure 8 shows monitoring sites Che6 and Che7 in relation to University Lake. The FC readings in Che7 (upstream) have always been considerably higher than those at Che6—below the University Lake Dog Park. It is important to see what might be contributing to the high FC readings at this location. Land use shows primarily residential as well as the Alaska Native Medical Center campus. South Fork Chester Creek leaves military lands and enters the residential area of Anchorage at Early View Dr. above Windsong Park by site Che8. It then runs about 3.5 miles until the Che7 monitoring site where it enters University Lake on the east. The surrounding area that it runs through is primarily residential including Riviera Terrace Trailer Park and Begich Middle School, both of which appear to be on AWWU sewers.

There is one tributary, the North Branch of the South Fork Chester Creek that joins the South Fork Chester Creek just south of Debarr Road and Muldoon Road. It runs along half of the eastern boundary and all of the southern boundary of the Rangeview Mobile Home Park—which is entirely on septic according to Anchorage Water and Wastewater Utility's (AWWU) GIS data set "Parcels_No_AWWU_Sewer". From a literature search it appears that the trailer park was in use at least as early as 1966. Recommendation one: test for FC above and below Rangeview Mobile Home Park.

Another tributary, North Fork Chester Creek, flows south under Merrill Field in a culvert, exits at 15th and Lake Otis, and runs in a ditch due west to Sitka St. and then due south until it joins Chester Creek. The former Merrill Field landfill is located just north of 15th Ave., and it was used from the 1940s until 1987 when it was closed. It covers about 200 acres with a depth of 30'. According to a 1990 USGS report by Brunett, there has been concern about leachate which was tested for in 1989. That report concludes that while there are minor amounts of contaminants reaching much of the wetlands between 15th and Chester Creek, their concentration in the groundwater is generally less than U.S. EPA standards for drinking water (1990:1). Today this area holds Sitka Street Park which is classified as Class A wetlands and a municipal snow dump.

Although there would be no FC issues from the leachate, the snow dump and park area could be contributing FC to the North Fork Chester Creek before it converges with Chester Creek. Recommendation two: the areas above the snow dump and sites below it should be tested for FC.

Map 3. Chester Creek by Merrill Field and Former Landfill

The other anomaly on Chester Creek at Che8, which is at the boundary of military land and a residential area, remains unidentified as to the source of two high readings: 2000 FC on August 29, 2010 and 1200 FC on September 26, 2010. There are no houses, parks, stables, or anything that might cause readings this high. The only activity is on the military land which mostly has wildlife on it, although some civilians do access it for recreation. Just below the monitoring site at Windsong Park and by its outlet in South Fork Chester Creek there have been some large beaver colonies beginning around 2000 and which are no longer there. Figure 9 shows a lodge in the pond in June 2006, and Fig. 10 shows the location of the monitoring site and a beaver lodge. Perhaps there is/was a beaver lodge upstream, but this is not an area that is open to civilians for exploration. Even so, it is obvious that this area is used by kids playing, bicyclists, hikers, and others.

Figure 9. Beaver lodge in the Windsong sedimentation basin June 6, 2006 (Photo by C. Northon)

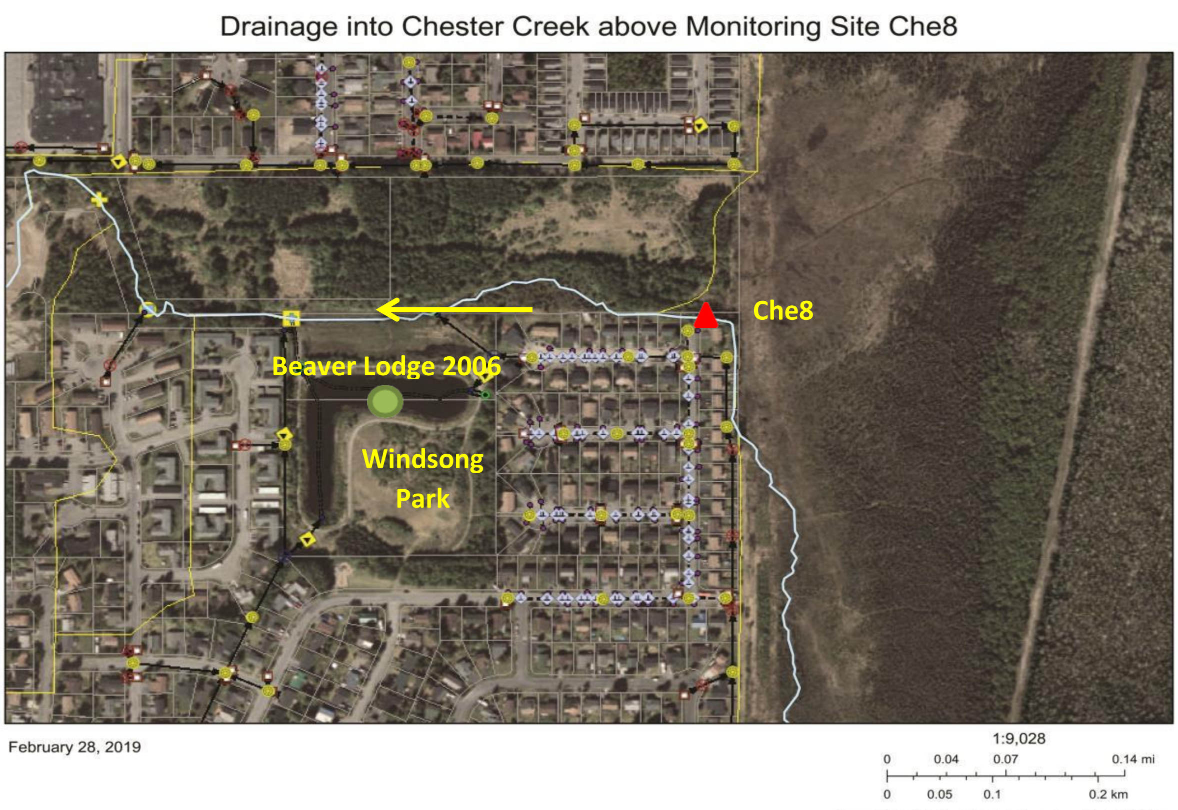


Figure 10. Drainage into Chester Creek above AWC monitoring site Che8 (MOA Drainage Viewer). The yellow arrow shows the direction of stream flow.

Little Campbell Creek

Little Campbell Creek also has a data anomaly not easily explained by weather. In Fig. 11, LCam 4 is the farthest east monitoring site on the North Fork Little Campbell Creek. It's actually on the South Branch North Fork, and is about 1.4 miles below Elmore Road which is bounded by BLM at Campbell Creek, Abbott Loop Community Park, and Far North Bicentennial Park. As noted above, the creek then runs through the F Bar J Ranch. Other than the park areas east of Elmore Road—there isn't much that could explain the high FC counts.

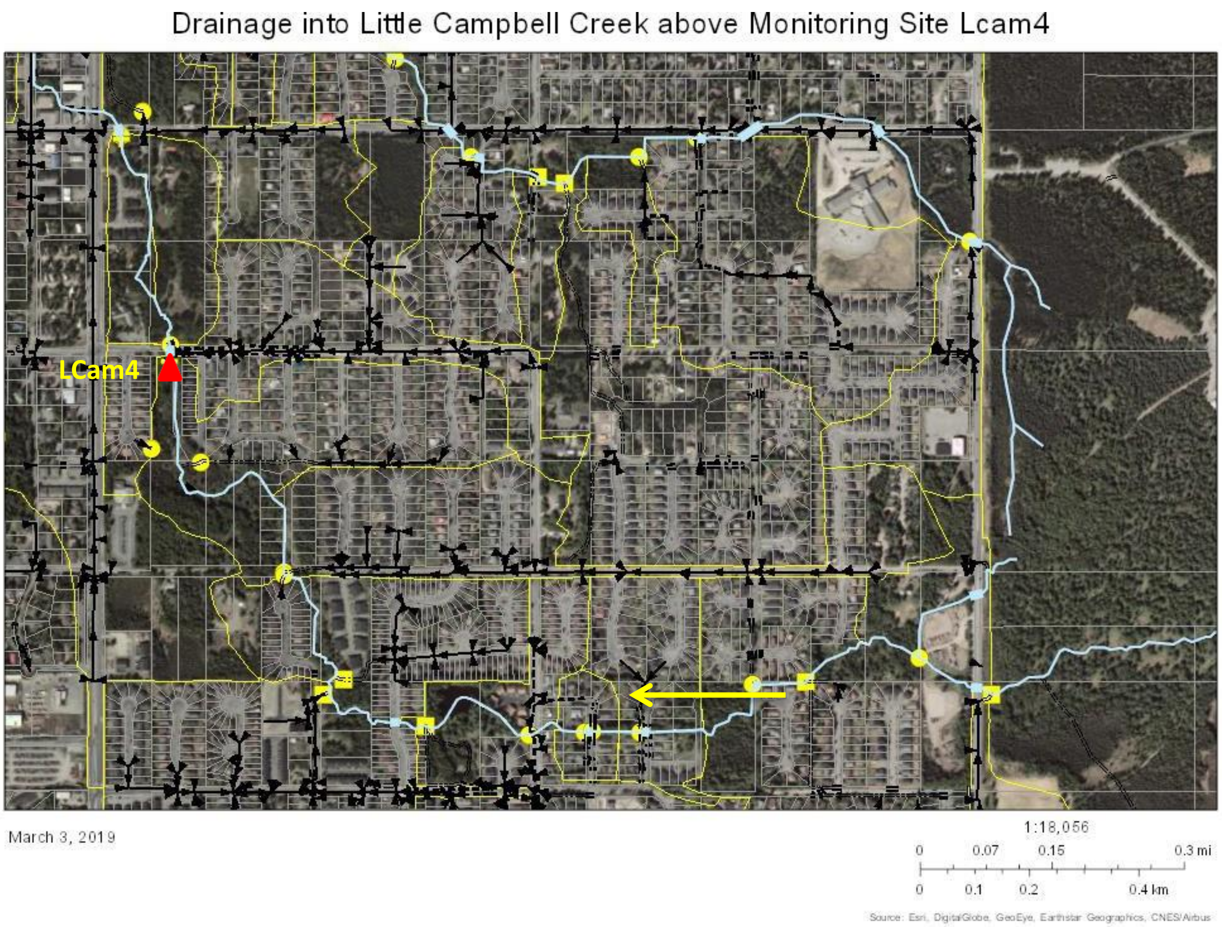


Figure 11. Drainage into Little Campbell Creek above monitoring site LCam4 (MOA Drainage Viewer). The yellow arrow shows the direction of flow.

Conclusions and Recommendations

One conclusion that can be drawn from this study is that what seems to be the obvious—is not always the case. High FC counts aren't necessarily found downstream of dog parks, and yet they can be found downstream of unoccupied land, and FC counts can be high during precipitation and as well as non- precipitation events. This suggests that other possible bacteria sources should be considered.

Accordingly, such things as storm drains, septic sewer systems, wildlife, and land use are beneficial for postulating the reason for high FC counts. Based on this study, AWC believes that there are many factors contributing to sporadic high FC counts. In the Chester and Little Campbell Creek watersheds, it would be useful to test above and below: stables, those animal facilities (Map 2 in Appendix) that are adjacent to or near streams, mobile home communities using onsite septic systems, the Alaska Zoo, snow dumps, and single family residential areas with extensive septic systems. To make these tests even more useful, tests using Microbial Source Tracking (MST) in some cases, e.g. stables and areas with extensive and older septic systems, could be performed.

AWC was tentatively awarded an ACWA grant for FY19-21, "Increase Knowledge on Anchorage Bowl Watersheds", to collect additional bacteria information to answer some of the questions posed in this data analysis report. Funding for this proposed work is currently on hold due to state budget cuts.

AWC is putting forward the following specific recommendations:

1. Test for FC above and below Rangeview Mobile Home Park along Chester Creek.
2. The areas above the snow dump and sites below it on Middle Fork Chester Creek should be tested for FC.
3. The area below Che8 should be tested using MST.
4. On Little Campbell Creek, the area above and below the F Bar J Ranch on Elmore Road should be tested for FC, and if it is higher at the downstream side—then test for MST to confirm if it is because of the stable.
5. Test for FC above and below the Alaska Zoo[1] on the South Fork Little Campbell Creek.

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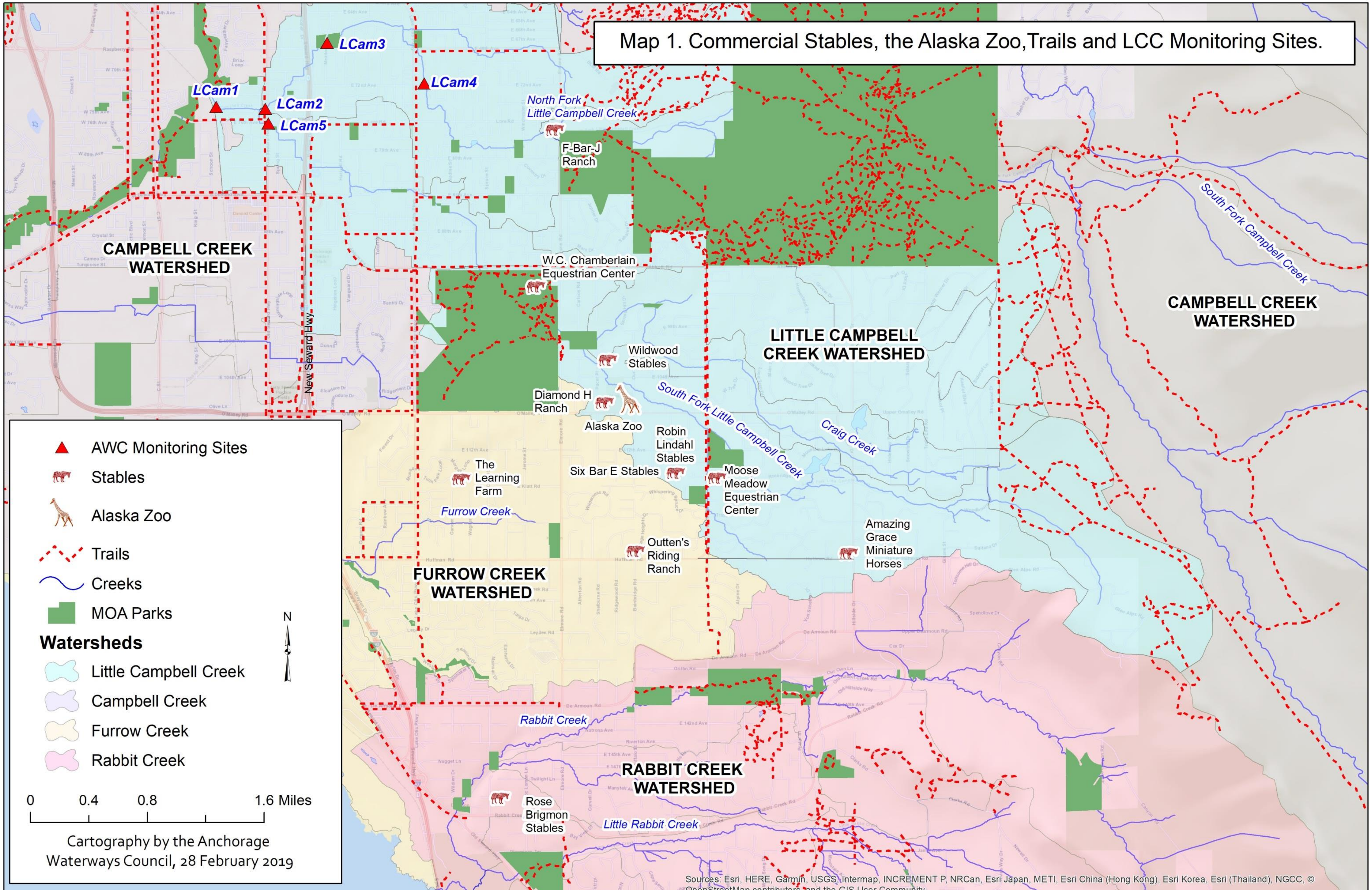
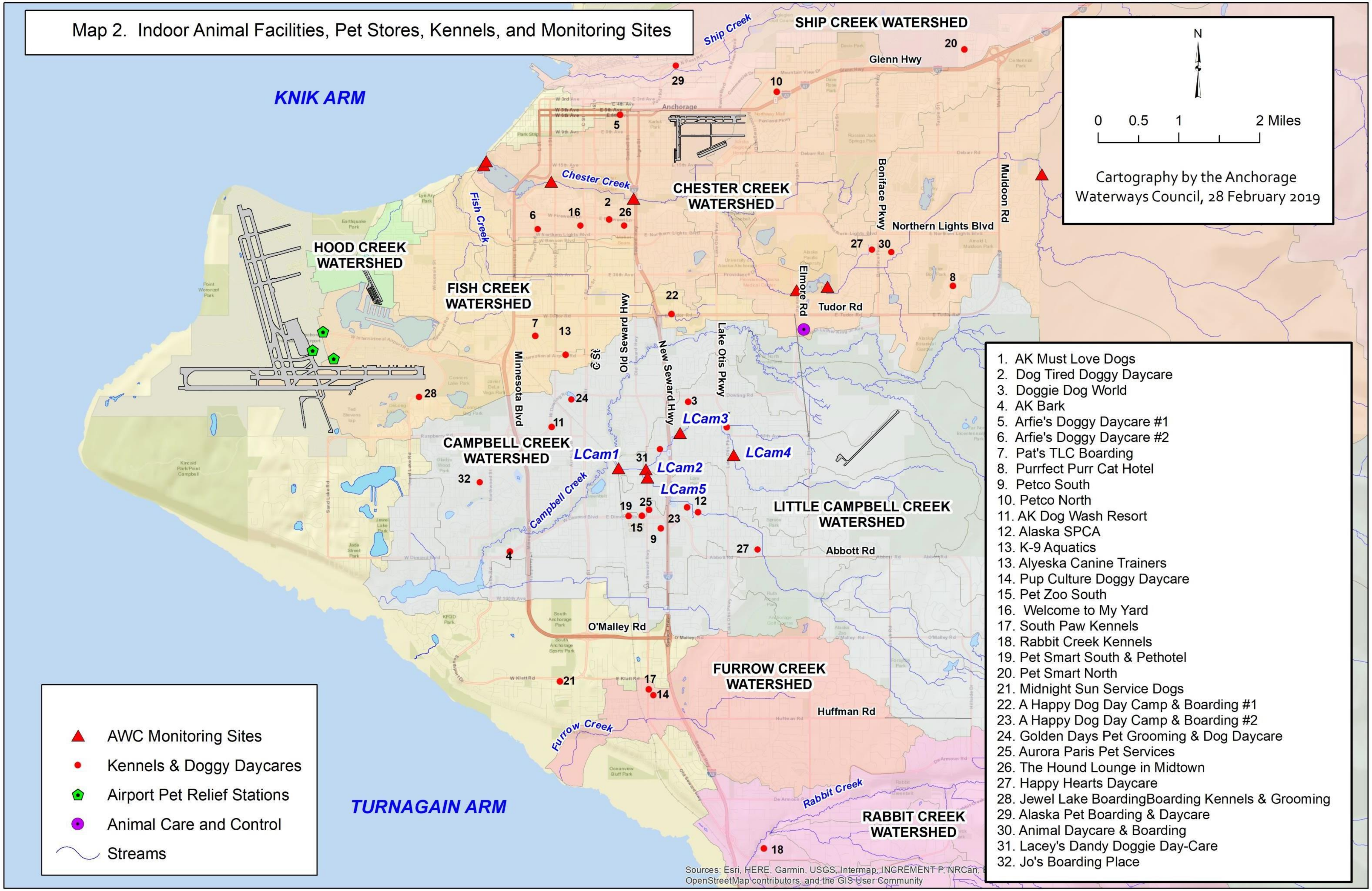
[1] Sites above and below the Alaska Zoo were monitored for FC on the South Fork Little Campbell Creek by AWC in 2017 after noticing that during heavy precipitation the creek was running through a portion of the brown bear pen. In addition, several of the surrounding large animal exhibits sit above the creek. It was monitored 5 times between May 30 and September 11 and analyzed by SGS Labs. Three of the five monitoring events had higher FC counts below the zoo, and two here higher above the zoo. Again, an

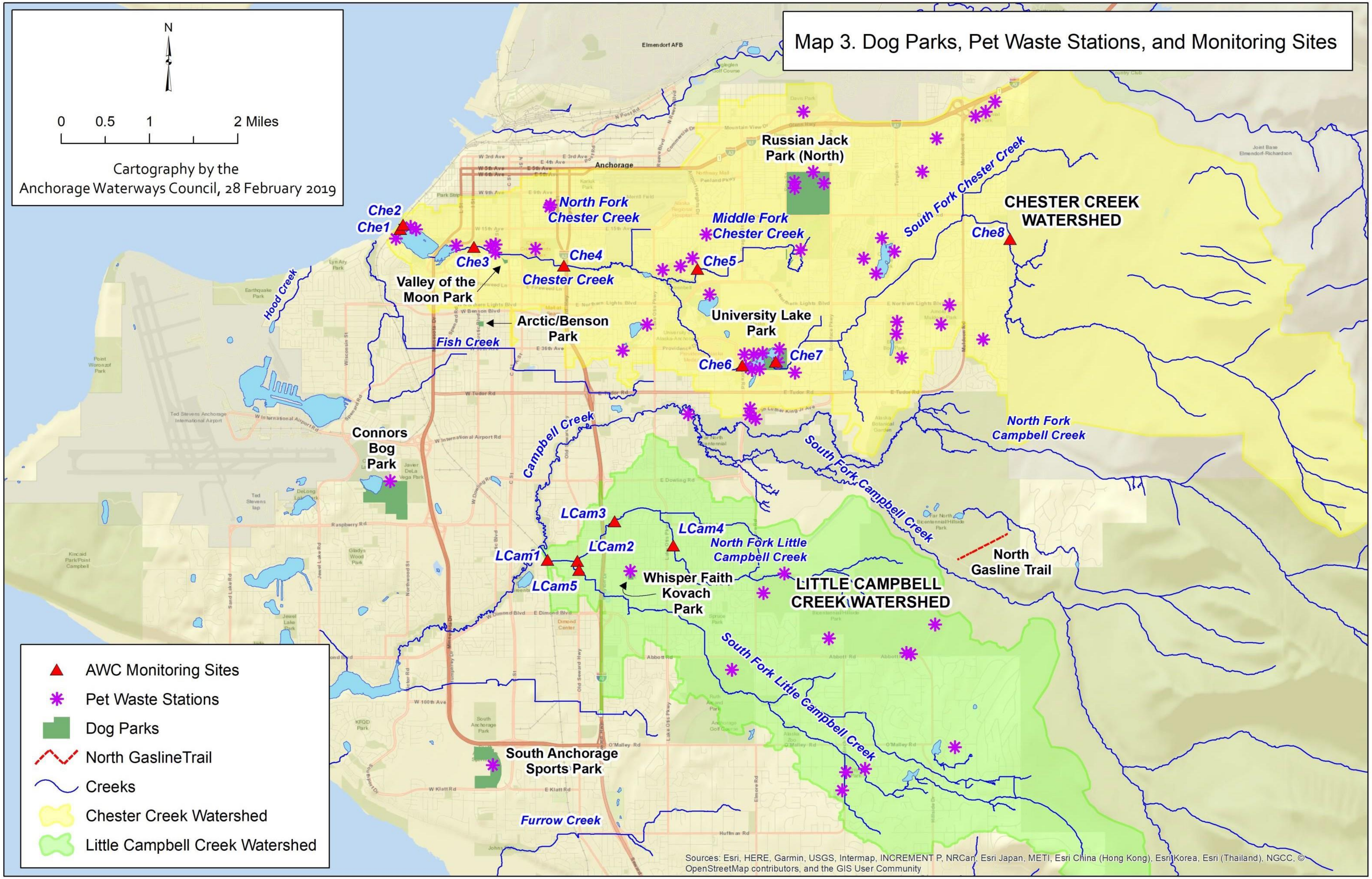
anomaly except when you take into account that this area of Anchorage is high density septic.

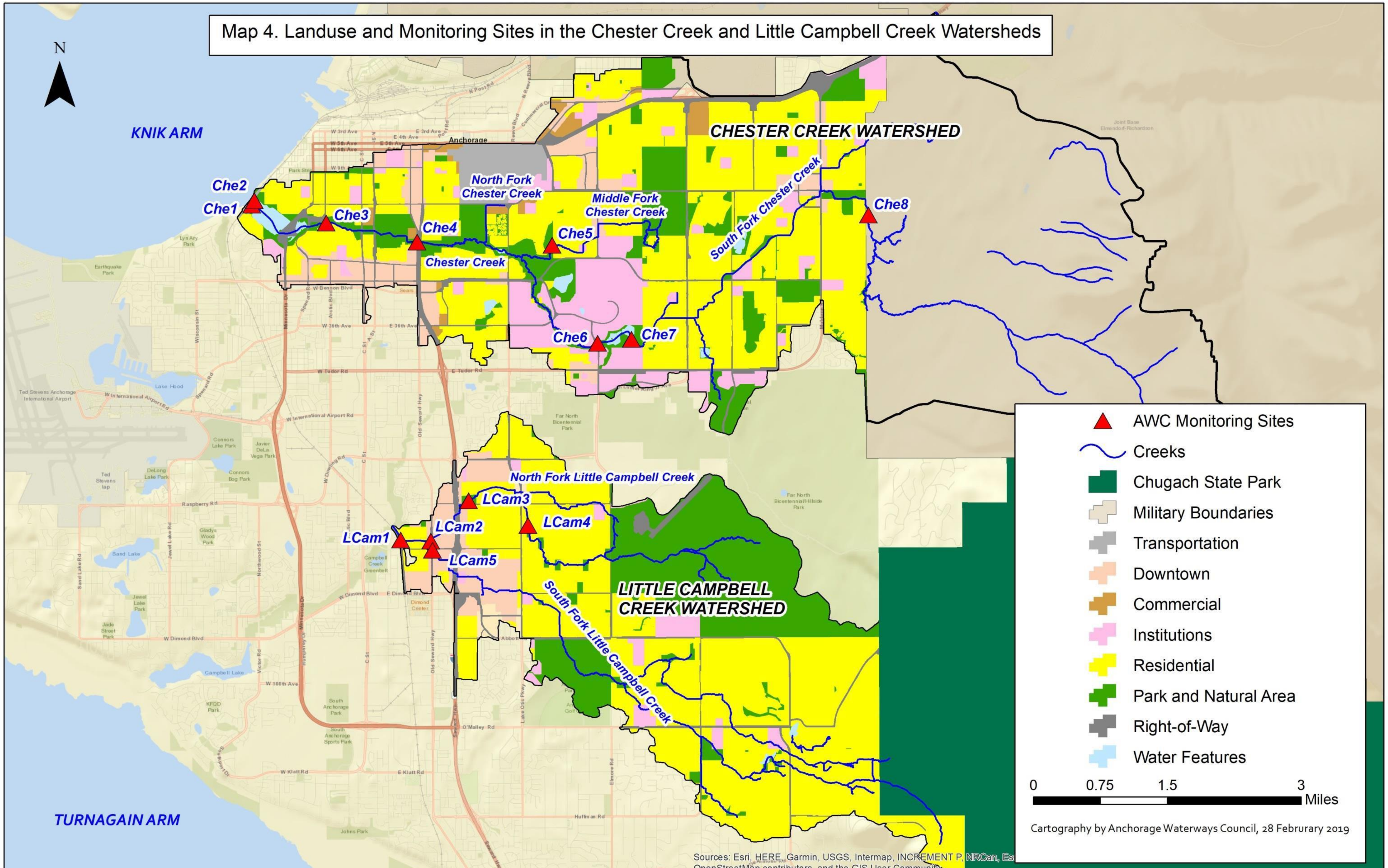
Davis and Davis again suggest that the Alaska Zoo could be a source of microbial contamination as well as the human markers above the zoo (2010:30).

APPENDIX


Map 1. Commercial Stables, the Alaska Zoo,Trails and LCC Monitoring Sites.
LCam1
LCam2
LCam3
LCam4
LCam5
North Fork Little Campbell Creek
F-Bar-J Ranch
CAMPBELL CREEK WATERSHED
W.C. Chamberlain Equestrian Center
LITTLE CAMPBELL CREEK WATERSHED
CAMPBELL CREEK WATERSHED
South Fork Campbell Creek
Wildwood Stables
Diamond H Ranch
Alaska Zoo
South Fork Little Campbell Creek
Craig Creek
Robin Lindahl Stables
Six Bar E Stables
Moose Meadow Equestrian Center
The Learning Farm
Furrow Creek
Outten's Riding Ranch
Amazing Grace Miniature Horses
FURROW CREEK WATERSHED
Rabbit Creek
RABBIT CREEK WATERSHED
Rose Brigmon Stables
Little Rabbit Creek
New Seward Hwy
AWC Monitoring Sites
Stables
Alaska Zoo
Trails
Creeks
MOA Parks
Watersheds
Little Campbell Creek
Campbell Creek
Furrow Creek
Rabbit Creek
N
0 0.4 0.8 1.6 Miles
Cartography by the Anchorage Waterways Council, 28 February 2019
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community


Map 2. Indoor Animal Facilities, Pet Stores, Kennels, and Monitoring Sites
KNIK ARM
TURNAGAIN ARM
SHIP CREEK WATERSHED
CHESTER CREEK WATERSHED
HOOD CREEK WATERSHED
FISH CREEK WATERSHED
CAMPBELL CREEK WATERSHED
LITTLE CAMPBELL CREEK WATERSHED
FURROW CREEK WATERSHED
RABBIT CREEK WATERSHED
Ship Creek
Chester Creek
Fish Creek
Campbell Creek
Furrow Creek
Rabbit Creek
Glenn Hwy
Northern Lights Blvd
Tudor Rd
Abbott Rd
O'Malley Rd
Huffman Rd
Minnesota Blvd
Old Seward Hwy
New Seward Hwy
Lake Otis Pkwy
Elmore Rd
Boniface Pkwy
Muldoon Rd
LCam1
LCam2
LCam3
LCam4
LCam5
N
0 0.5 1 2 Miles
Cartography by the Anchorage Waterways Council, 28 February 2019
AWC Monitoring Sites
Kennels & Doggy Daycares
Airport Pet Relief Stations
Animal Care and Control
Streams
1. AK Must Love Dogs
2. Dog Tired Doggy Daycare
3. Doggie Dog World
4. AK Bark
5. Arfie's Doggy Daycare #1
6. Arfie's Doggy Daycare #2
7. Pat's TLC Boarding
8. Purrfect Purr Cat Hotel
9. Petco South
10. Petco North
11. AK Dog Wash Resort
12. Alaska SPCA
13. K-9 Aquatics
13. Alyeska Canine Trainers
14. Pup Culture Doggy Daycare
15. Pet Zoo South
16. Welcome to My Yard
17. South Paw Kennels
18. Rabbit Creek Kennels
19. Pet Smart South & Pethotel
20. Pet Smart North
21. Midnight Sun Service Dogs
22. A Happy Dog Day Camp & Boarding #1
23. A Happy Dog Day Camp & Boarding #2
24. Golden Days Pet Grooming & Dog Daycare
25. Aurora Paris Pet Services
26. The Hound Lounge in Midtown
27. Happy Hearts Daycare
28. Jewel Lake BoardingBoarding Kennels & Grooming
29. Alaska Pet Boarding & Daycare
30. Animal Daycare & Boarding
31. Lacey's Dandy Doggie Day-Care
32. Jo's Boarding Place
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan,
OpenStreetMap contributors, and the GIS User Community


Map 3. Dog Parks, Pet Waste Stations, and Monitoring Sites
N
0 0.5 1 2 Miles
Cartography by the
Anchorage Waterways Council, 28 February 2019
CHESTER CREEK WATERSHED
LITTLE CAMPBELL CREEK WATERSHED
Russian Jack Park (North)
North Fork Chester Creek
Middle Fork Chester Creek
South Fork Chester Creek
Chester Creek
Che1
Che2
Che3
Che4
Che5
Che6
Che7
Che8
Valley of the Moon Park
Arctic/Benson Park
University Lake Park
Hood Creek
Fish Creek
Campbell Creek
Connors Bog Park
North Fork Campbell Creek
South Fork Campbell Creek
North Gasline Trail
LCam1
LCam2
LCam3
LCam4
LCam5
North Fork Little Campbell Creek
Whisper Faith Kovach Park
South Fork Little Campbell Creek
South Anchorage Sports Park
Furrow Creek
AWC Monitoring Sites
Pet Waste Stations
Dog Parks
North GaslineTrail
Creeks
Chester Creek Watershed
Little Campbell Creek Watershed
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community


Map 4. Landuse and Monitoring Sites in the Chester Creek and Little Campbell Creek Watersheds
N
KNIK ARM
CHESTER CREEK WATERSHED
North Fork Chester Creek
Middle Fork Chester Creek
South Fork Chester Creek
Chester Creek
Che1
Che2
Che3
Che4
Che5
Che6
Che7
Che8
North Fork Little Campbell Creek
South Fork Little Campbell Creek
LITTLE CAMPBELL CREEK WATERSHED
LCam1
LCam2
LCam3
LCam4
LCam5
TURNAGAIN ARM
AWC Monitoring Sites
Creeks
Chugach State Park
Military Boundaries
Transportation
Downtown
Commercial
Institutions
Residential
Park and Natural Area
Right-of-Way
Water Features
0 0.75 1.5 3 Miles
Cartography by Anchorage Waterways Council, 28 Februrary 2019
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri
OpenStreetMap contributors, and the GIS User Community

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