Arctic LCC Project Summary

1. PROJECT INFORMATION

Title:	Linking North Slope Climate, Hydrology, and Fish Migration
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Author of report	Erica Betts
Key words	Arctic hydrology, hyporheic flow, Arctic grayling, hydrologic connectivity, fish migration

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2. PROJECT OVERVIEW

a. Briefly (4-5 sentences) describe both the research purpose and the underlying need for this research.

The purpose of this research is to assess whether a changing hydrologic regime on the North Slope of Alaska may impact fish migration. Figure 1 below highlights the relationship between Arctic grayling migration and the typical hydrologic regime found in the Kuparuk River basin.

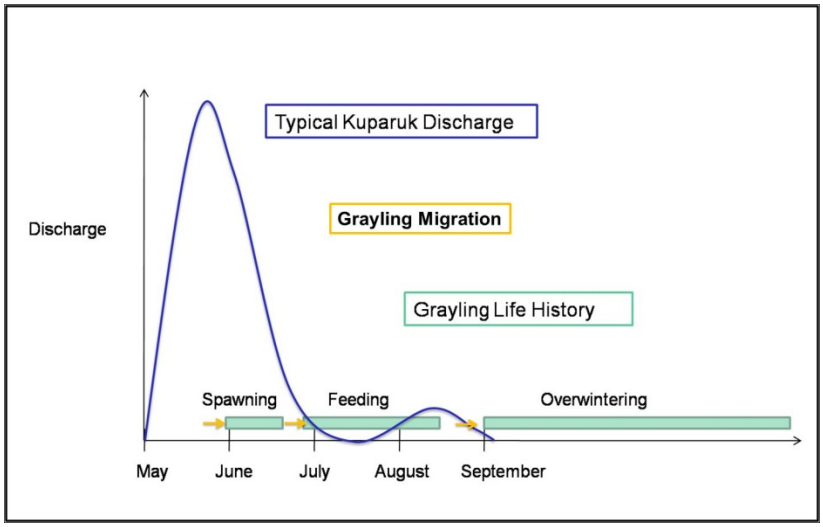


Figure 1. Relationship between timing of grayling migrations and typical hydrologic flow regime in non-glacial fed arctic rivers.

This hydrograph is typical of non-glacial fed arctic streams in that the highest flows occur during spring melt. Grayling migrate to spawning grounds during these high flows. High spring flows can quickly dissipate as low precipitation rates and high evapotranspiration rates occur in early summer. This drying of the landscape can lead to a fragmented hydrologic landscape for fish as lakes and ponds become disconnected from rivers and rivers themselves become fragmented by low water levels. Grayling must migrate back to safe overwintering sites before freeze-up occurs. Changing precipitation patterns, higher temperatures and longer open water seasons may result in magnified drying across the Arctic landscape. The purpose of this research is to assess the possibility of increased hydrologic fragmentation along the Kuparuk River in response to climate change and its impact on Arctic grayling.

b. List the objective(s) of the project, exactly as described in your Statement of Work.

Specific project goals are to:

1) Identify "critical" river reaches based on previous occurrence of minimal flow depth along known conveyances between seasonal fish habitats;

2) Establish the relationship between measured stream flow and depth of surface flow (as opposed to subsurface flow beneath the river bed) within the critical reaches;

3) Quantify the frequency, timing, duration, and magnitude of low flow periods over the historical record.

3. PROJECT SUMMARY

Figure 2 below shows the project location as well as the location of equipment installed.

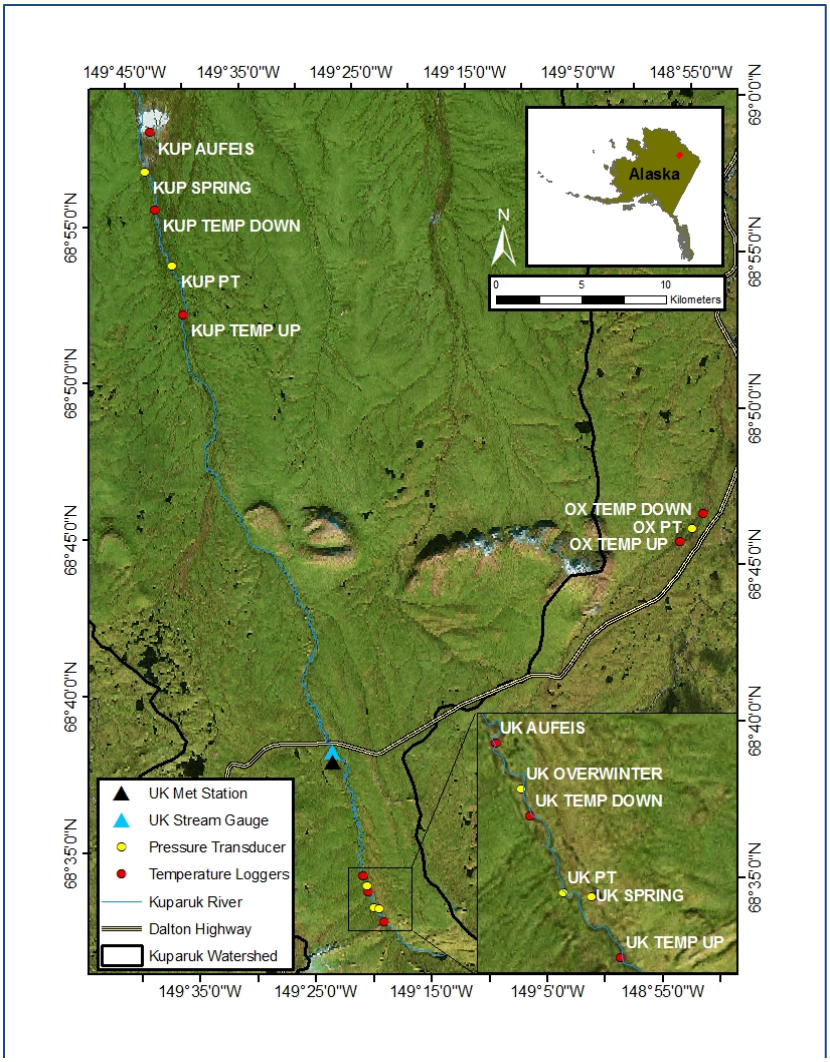


Figure 2. Research location: Kuparuk watershed, North Slope of Alaska. Image shows location of pressure transducers, temperature loggers, and meteorological stations. Research was conducted at three sites: Upper Kuparuk (UK), Lower Kuparuk, (KUP) and Oksrukuyik Creek (OX).

Stage data collected at the Upper and Lower Kuparuk sites was compared with data from the Upper Kuparuk Stream Gauge. Data from 2010 - 2012 was used to establish a statistical relationship between the sites. Based on this relationship, a historical data set was created for the Upper and Lower Kuparuk sites. This dataset provided information regarding the timing and frequency of dry periods over the past 15 years. Field notes of observations from researchers working in this area of Alaska were used to confirm as many dates as possible. Figures 3-5 highlight some of the findings from this dataset.

Figure 3 displays the timing of “no flow” events at the Upper Kuparuk site as identified by the recreated dataset. The shaded area indicates the critical migration period for Arctic grayling. Dry spells occurring during this period would impede fish from migrating to their overwintering site.

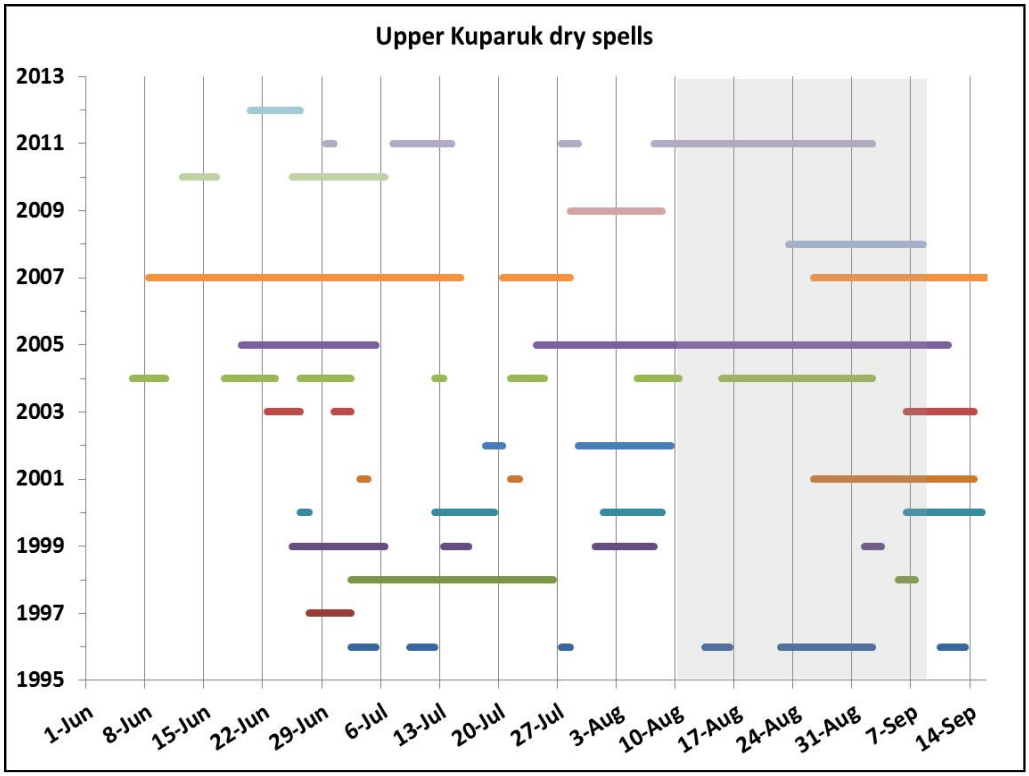


Figure 3. The recreated dataset showing dry spells (horizontal bars) per year. The shaded region indicates the time period during which Arctic grayling migrate to their overwintering site.

Figure 4 shows the data in terms of total number of days with no flow. This gives a picture of how often such events occur on average in any given year. Notice the particularly high number of days in 2004, 2005 and 2007. The green triangles represent the actual measured values in the Upper Kuparuk while the blue diamonds represent the estimated values. The discrepancy between observed versus estimated values for 2011 and 2012 occurs because the historical relationship is based on two years of data. If the model is run on 2011 data only, the predicted and observed values for that year are much closer. The same is true for 2012 if only the data from that year is used.

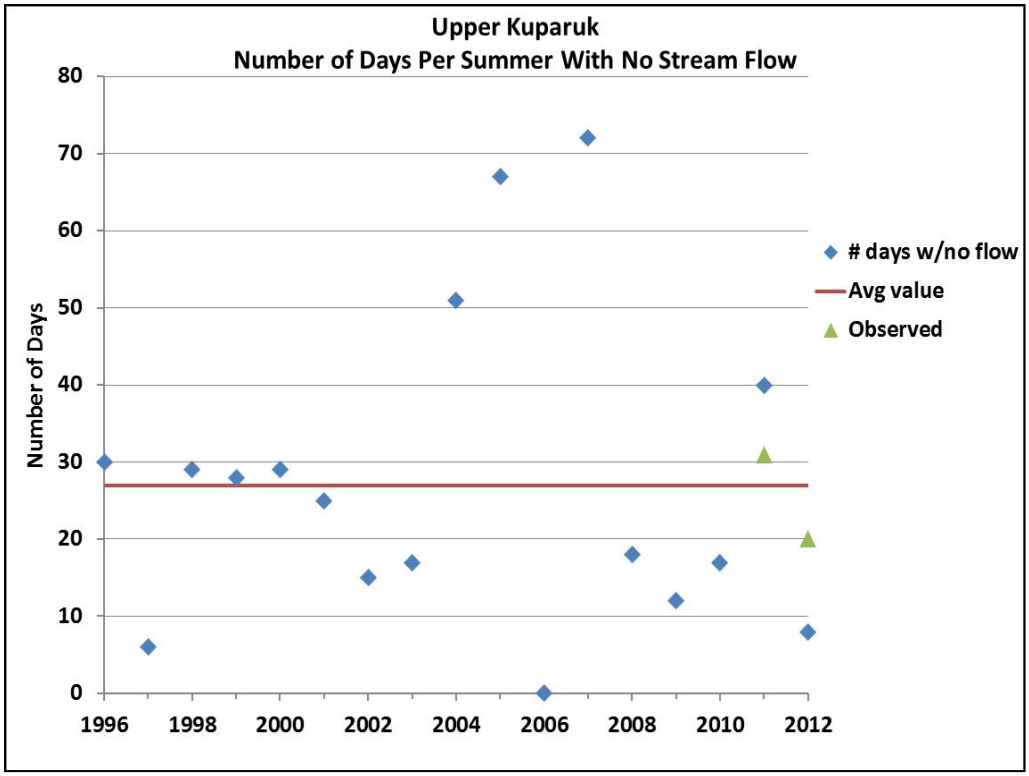


Figure 4. Estimated number of days per summer with no above surface stream flow based on 15 years of data. Observed values for 2011 and 2012 are also shown.

Figure 5 shows the timing of dry events as a monthly average. It is interesting to note that there is no statistically significant difference in the likelihood of a dry event occurring in any given month during the summer.

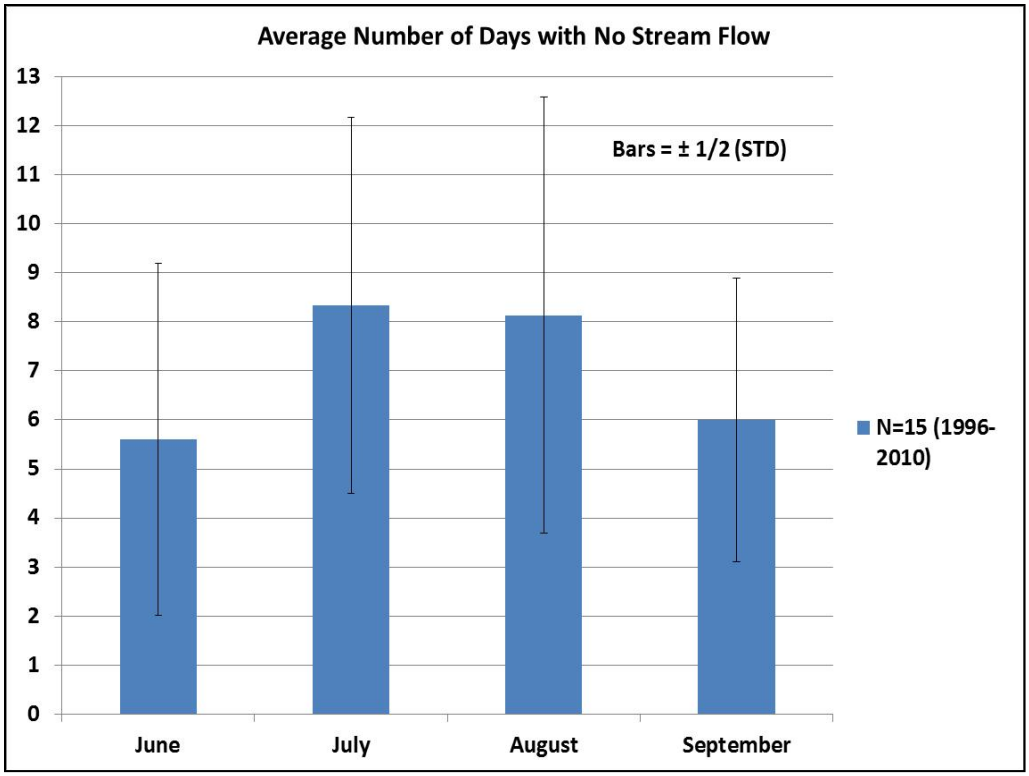


Figure 5. Average number of days per month with no flow at Kuparuk dry site.

The long term summer surface water balance (P-ET) is estimated based on measurements made in Imnavait Creek from 1996-2008.Imnavait Creek basin is adjacent to the Upper Kuparuk. Data shows a strong seasonal trend with a surface water deficit occurring until August (Figure 6).

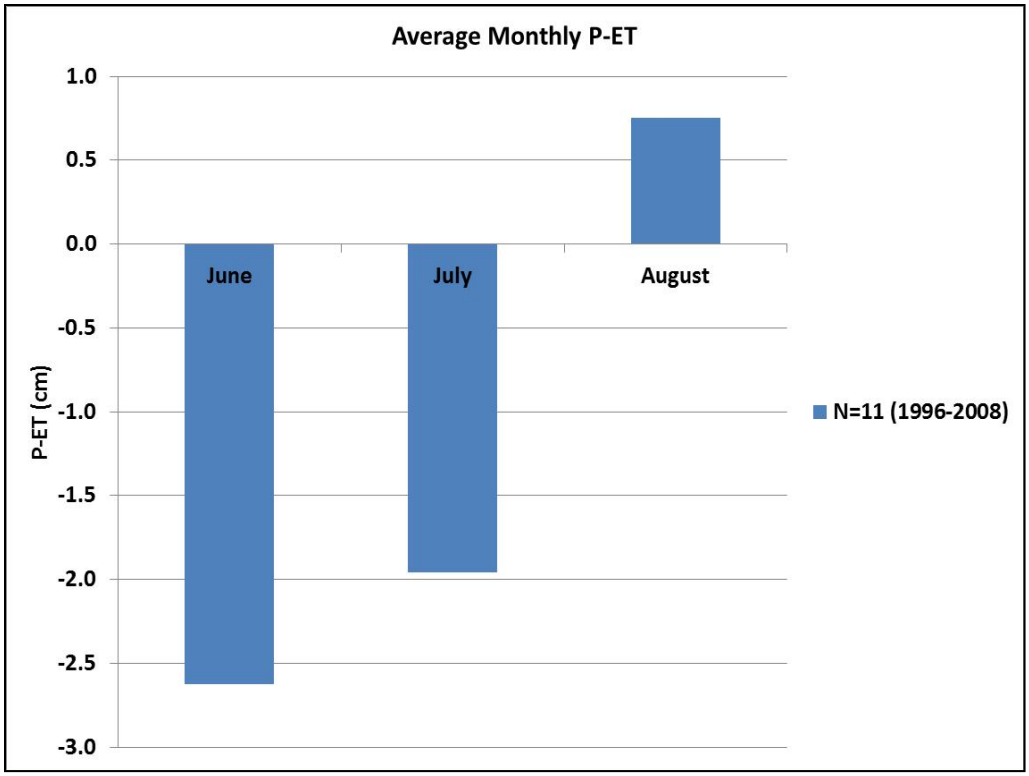


Figure 6. Monthly averaged values of surface water balance based on 11 years of data. Negative values indicate a water deficit, or drying conditions.

Figure 7 shows data collected by George Kling and represents thaw depths collected over a 7 year period at the Arctic LTER site located near the Upper Kuparuk research site. This data shows a strong seasonal trend as well with increased thawing of up to 30 cm over the course of the summer.

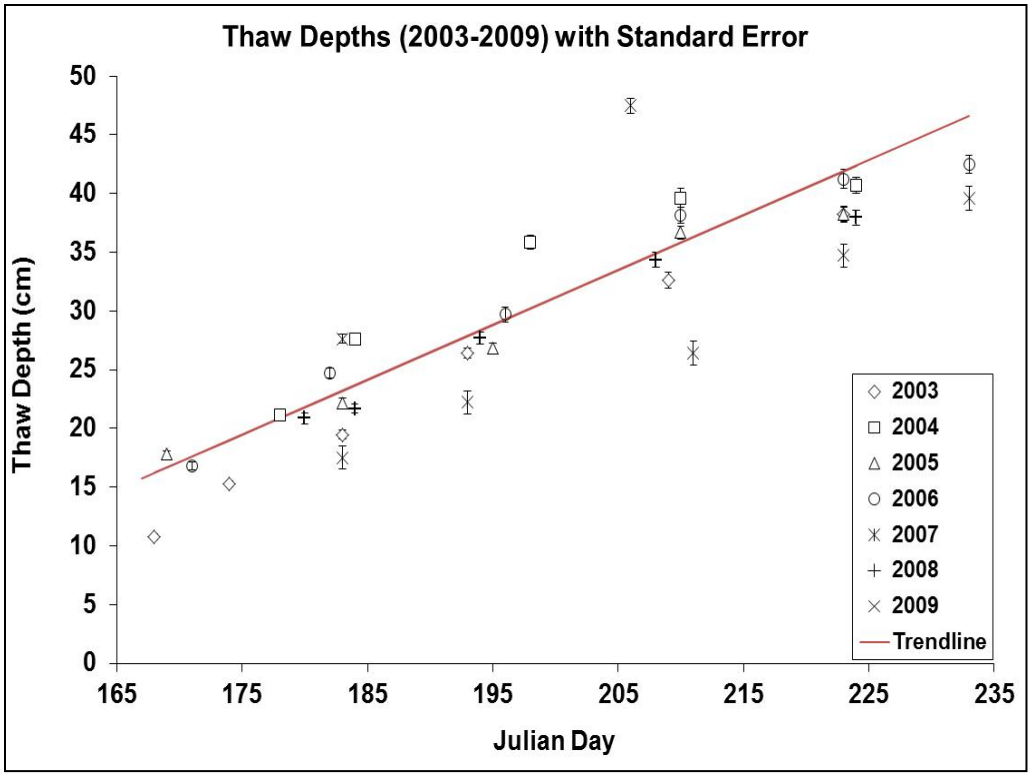
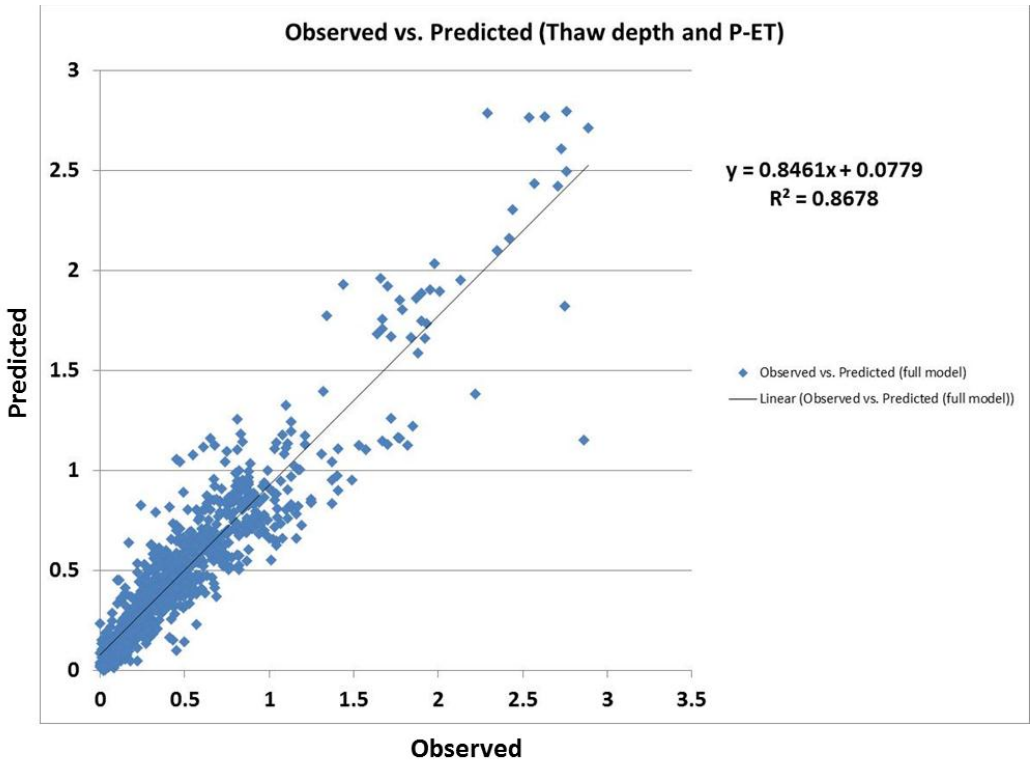


Figure 7. Summer thaw depths collected over a 7 year period show an average increase in thaw depth of 30 cm from June 14 (Julian Day 165) through August 23 (Julian Day 235). *Data source: George Kling, Arctic LTER database*.

Figures 6 and 7 represent surface and subsurface controls on the hydrology of the critical reaches studied in this project. Figure 6 represents the surface controls of precipitation and evaporation. Figure 7 represents the subsurface controls of active layer depth. There is a strong seasonal trend to both of these drivers. Figure 5 showed that there was not a seasonal trend to the occurrence of "dry" events. The lack of any significant seasonal trend here indicates that surface and sub-surface controls may both be drivers of these dry spells. More dry spells early in the summer would indicate that surface drivers were the control because of low rainfall rates and high ET. More dry spells later in the summer would indicate a greater subsurface control as a result of greater thaw depths allowing for greater subsurface/hyporheic flow. Recent work has focused on determining the drivers of these dry spells. A multiple regression analysis using air temperature, soil temperature, thaw depth, precipitation, evapotranspiration, and P-ET found that P-ET and thaw depth alone each accounted for most of the variability in the stage data with R^2 values of .67 and .70 respectively. Combined these two variables achieve an R^2 value of .87. Figure 8 below shows the results of this analysis where predicted and observed values represent stage data and predicted values are derived from the input variables of thaw depth and P-ET.



These values represent 10 years of data (1996-2005). If the same analysis is performed on each year individually, annual R^2 values range from .7 to .94. The next step in this research was to use a parameter estimation model to determine the relative importance of these two variables in explaining overall variability in stage. The results of this analysis have been less consistent year to year. One possible reason for this is the thaw depth data set used. This data set is a derived from three annual measurements. Substitution of a finer resolution dataset may provide better results but such data is not available for all years. The final stage of this project involves fine tuning this last round of analysis.

4. PRODUCTS

a. Publications, conference papers, and presentations.

Presentation at the 19th Northern Research Basins Symposium and Workshop, Southcentral Alaska, August 11-17, 2013

Presentation at the American Fisheries Society – Alaska Chapter 40th Annual Meeting, Fairbanks, Alaska, October 8-11, 2013

Presentation at the University of Alaska Fair banks, Water and Environmental Research Center's Seminar Series, Fairbanks, Alaska, November 22, 2013

Betts, E. D. and Kane, D.L. (2014) *Linking North Slope Climate, Hydrology, and Fish Migration.* In press, Hydrology Research.

b. Education and outreach.
Nothing to Report

c. Other products resulting from the project.
Aerial imagery was collected along a 30 mile section of the Kuparuk River as well as a 20 mile section of Oksrukuyik (Ox) Creek. This imagery was collected during a “dry” spell and several reaches that ran dry were identified.