

# Pebble Project

## Environmental Baseline Document

### Surface Water Hydrology

Agency Meetings, January 31 to February 3, 2012

Anchorage, Alaska

Jaime Cathcart, P.Eng., Ph.D.



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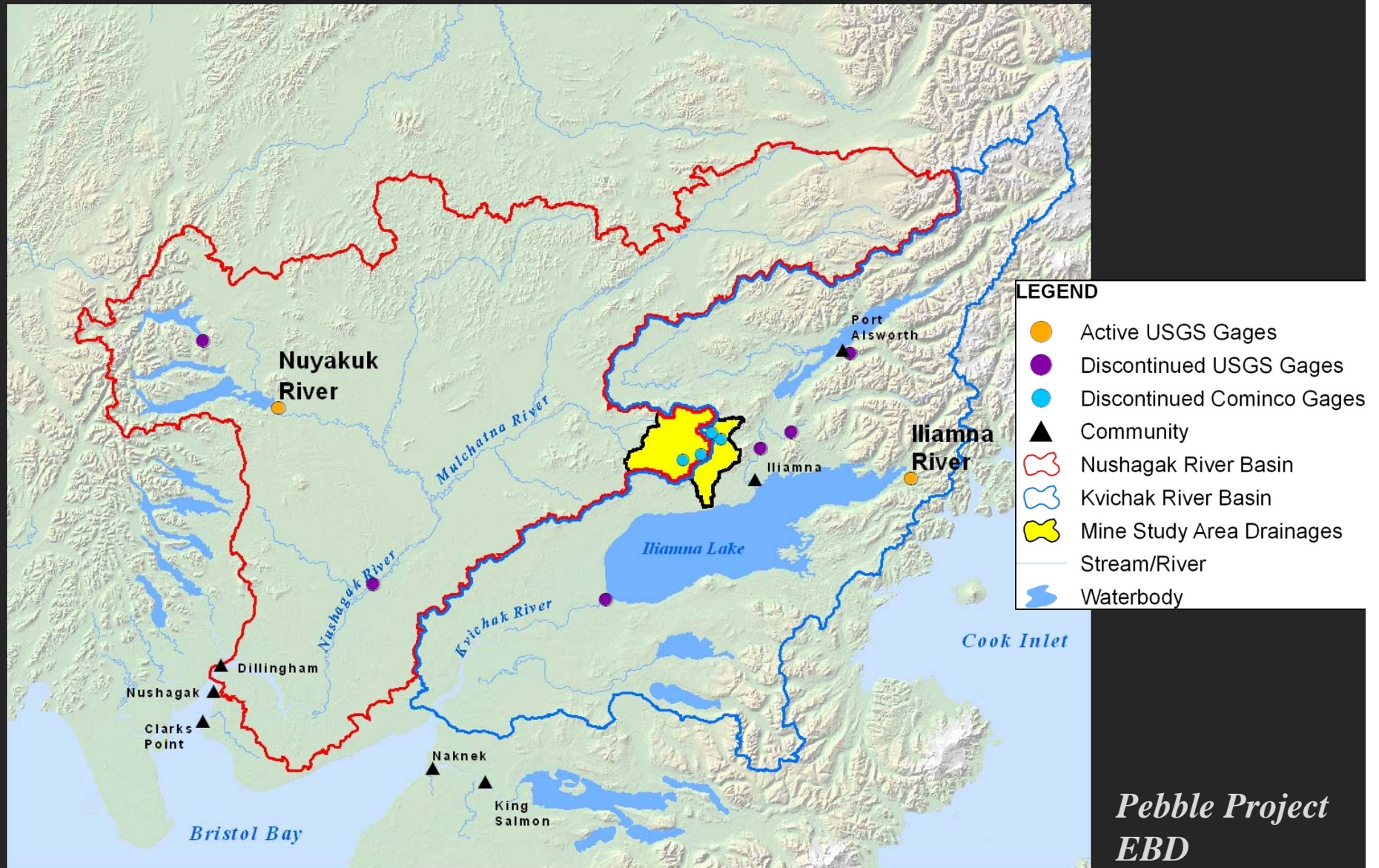
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# Outline

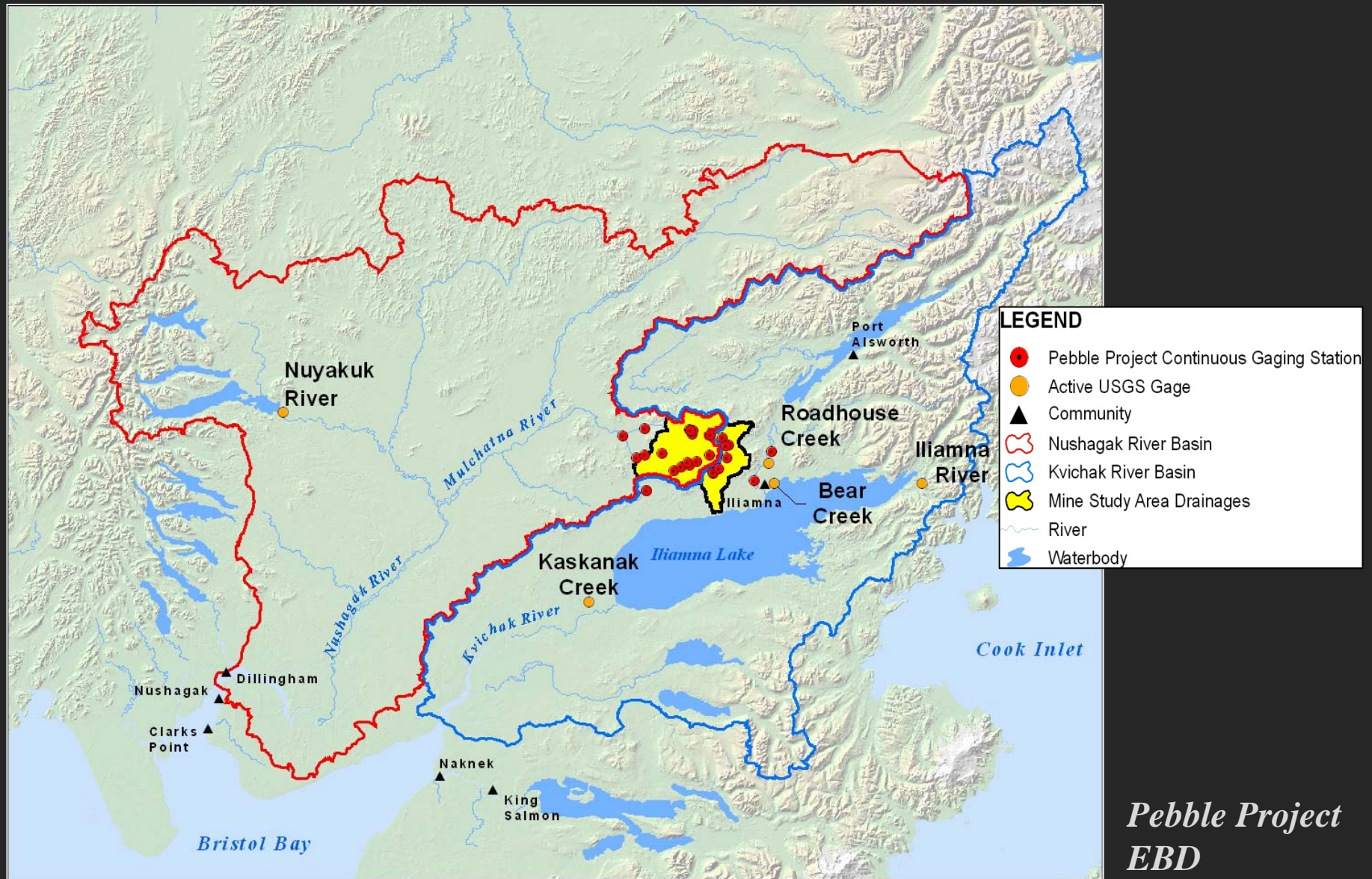
- Regional Overview
- Mine Study Area
  - Streamflow
  - Low Flow
  - Peak Flow
  - Snow
  - Small Pools
- Transportation Corridor Study Area
  - Streamflow
  - Low Flow
  - Peak Flow



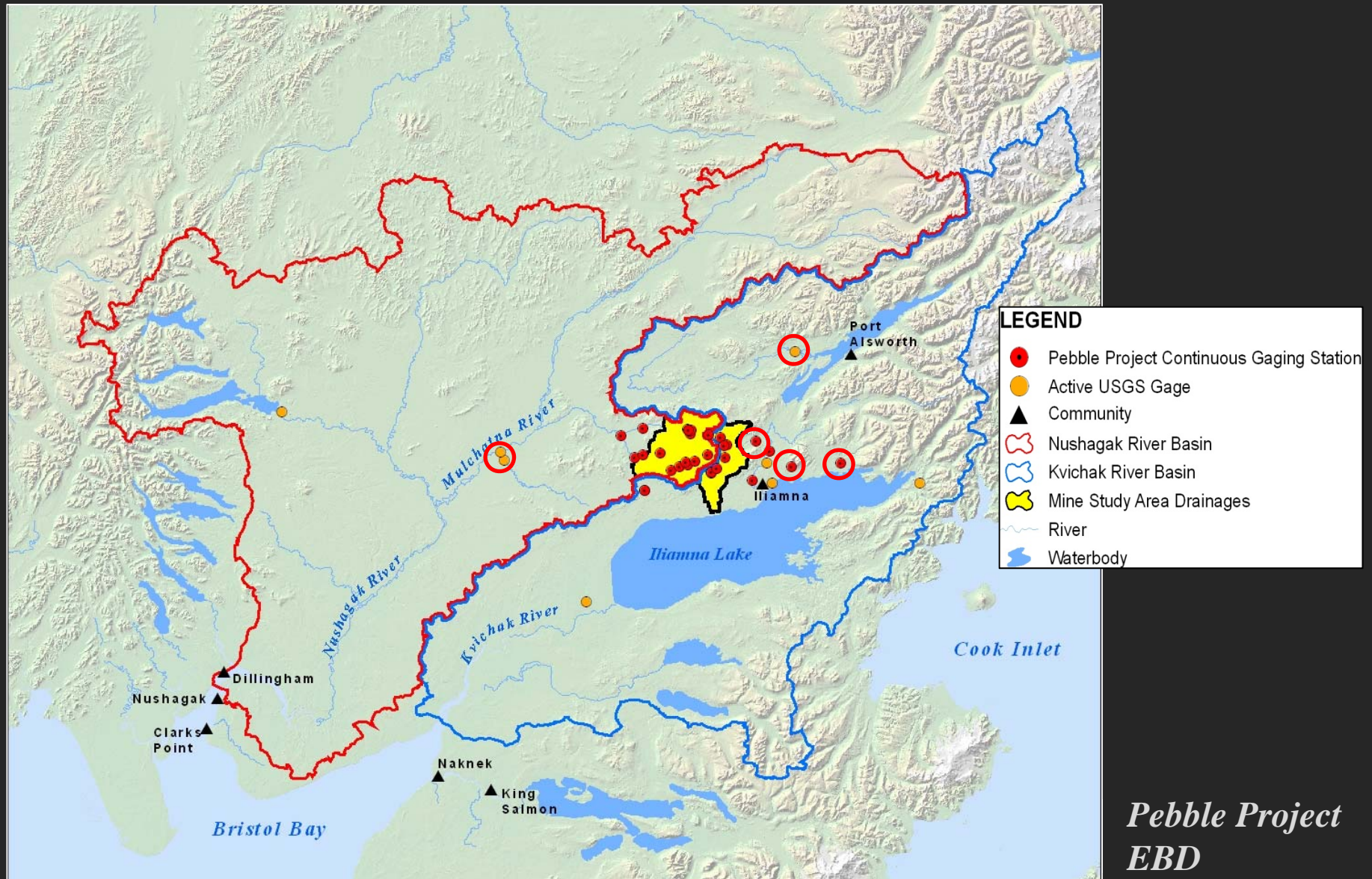
# Regional Overview: Prior to 2004



# Regional Overview: 2004-2008



# Regional Overview: 2009-2010



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# Regional Overview

## Prior to 2004

- USGS: 2 active, 6 discontinued
- Cominco: 4 intermittent/discontinued

## 2004-2008

- USGS: 6 new (including 3 for Pebble)
- Pebble: 26 new (Mine Study Area)

## 2009-2010

- USGS: 3 new
- Pebble: 3 new (Transportation Corridor)



# Regional Overview

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## Summary of Active Gaging Stations: 2004-2010

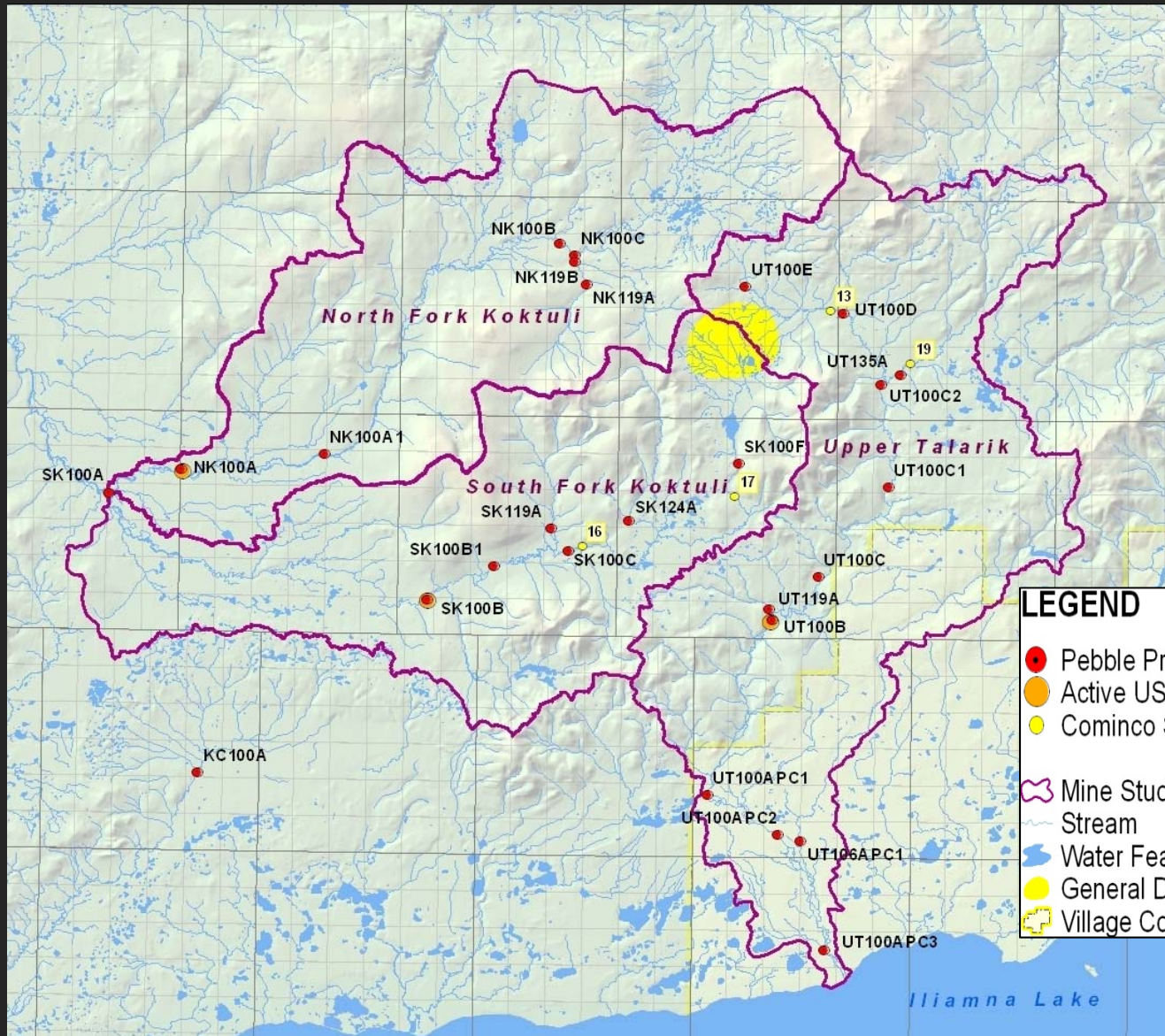
- USGS: **11 stations**  
drainage area = 20,700 sq. miles  
density = ~1 per 2000 sq. miles
- Pebble: **29 stations**  
drainage area = 350 sq. miles  
density = ~1 per 12 sq. miles

# Mine Study Area



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# Mine Study Area: 2008 (Continuous)



No changes  
for 2009/10

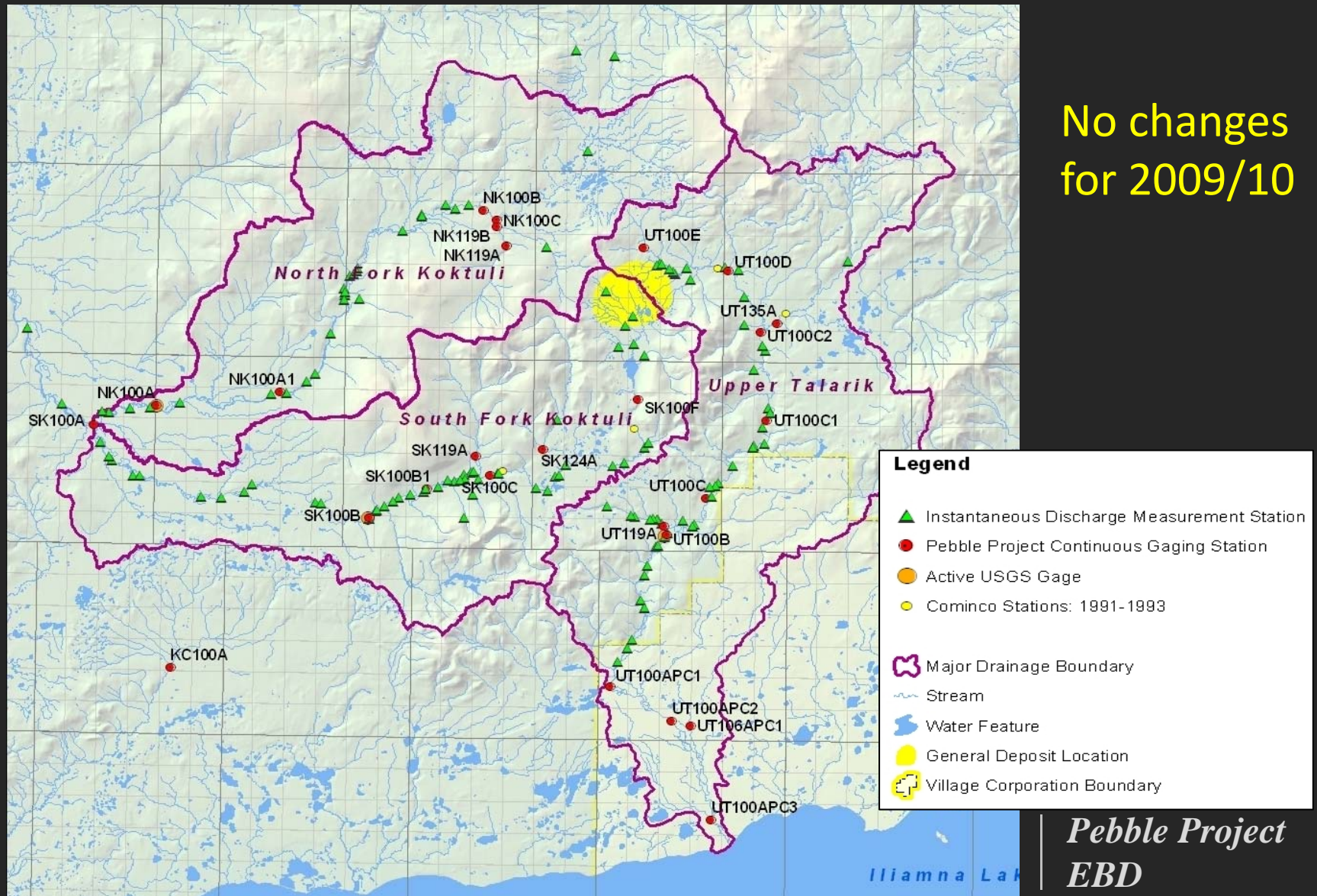
## LEGEND

- Pebble Project Continuous Gaging Station
- Active USGS Gage
- Cominco Stations: 1991-1993
- 🍷 Mine Study Area Drainages
- 🌊 Stream
- 💧 Water Feature
- 🟡 General Deposit Location
- 📏 Village Corporation Boundary

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# Mine Study Area: 2008 (All)

No changes  
for 2009/10



# Discharge Measurement Methods

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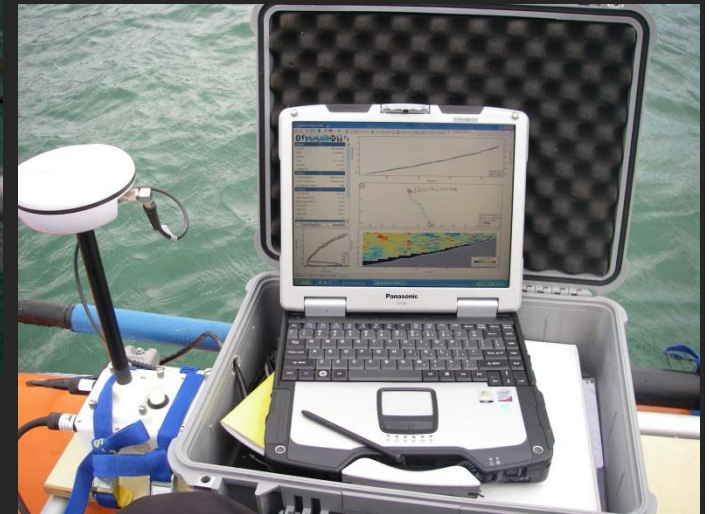
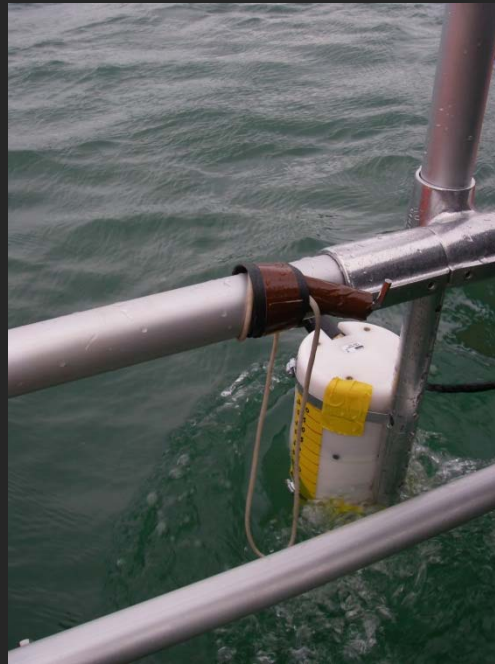


Velocity Meter



Salt Dilution

# Discharge Measurement Methods



Acoustic Doppler Current Profiler

# Discharge Measurement Methods

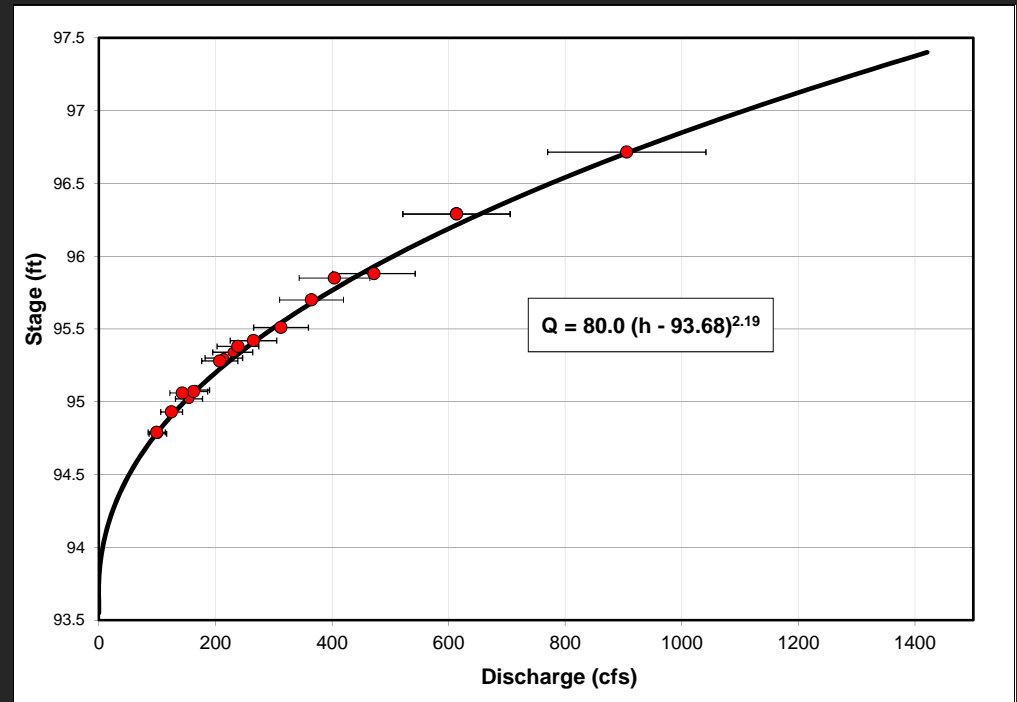


Velocity Meter

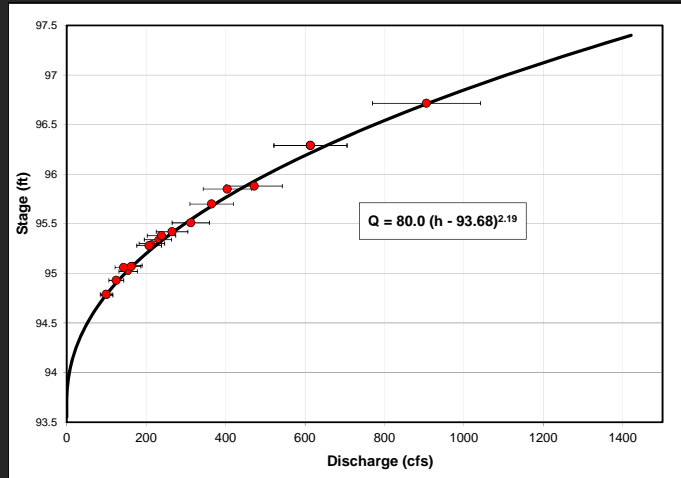


Salt Dilution

# Rating Curve Development



# Discharge Measurement Methods



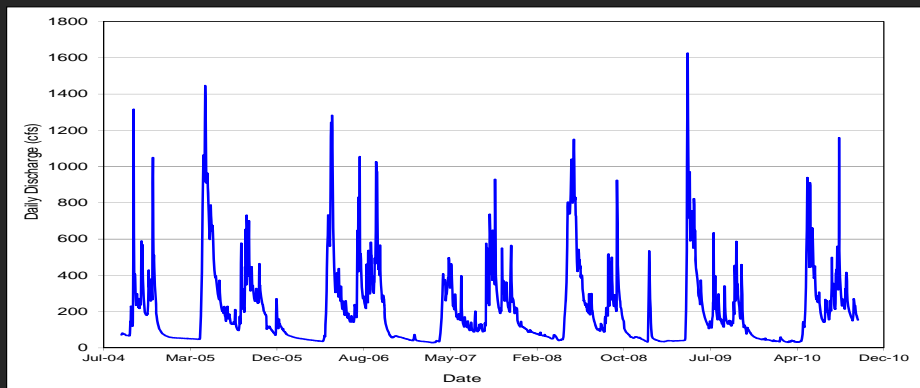
Rating curve

+



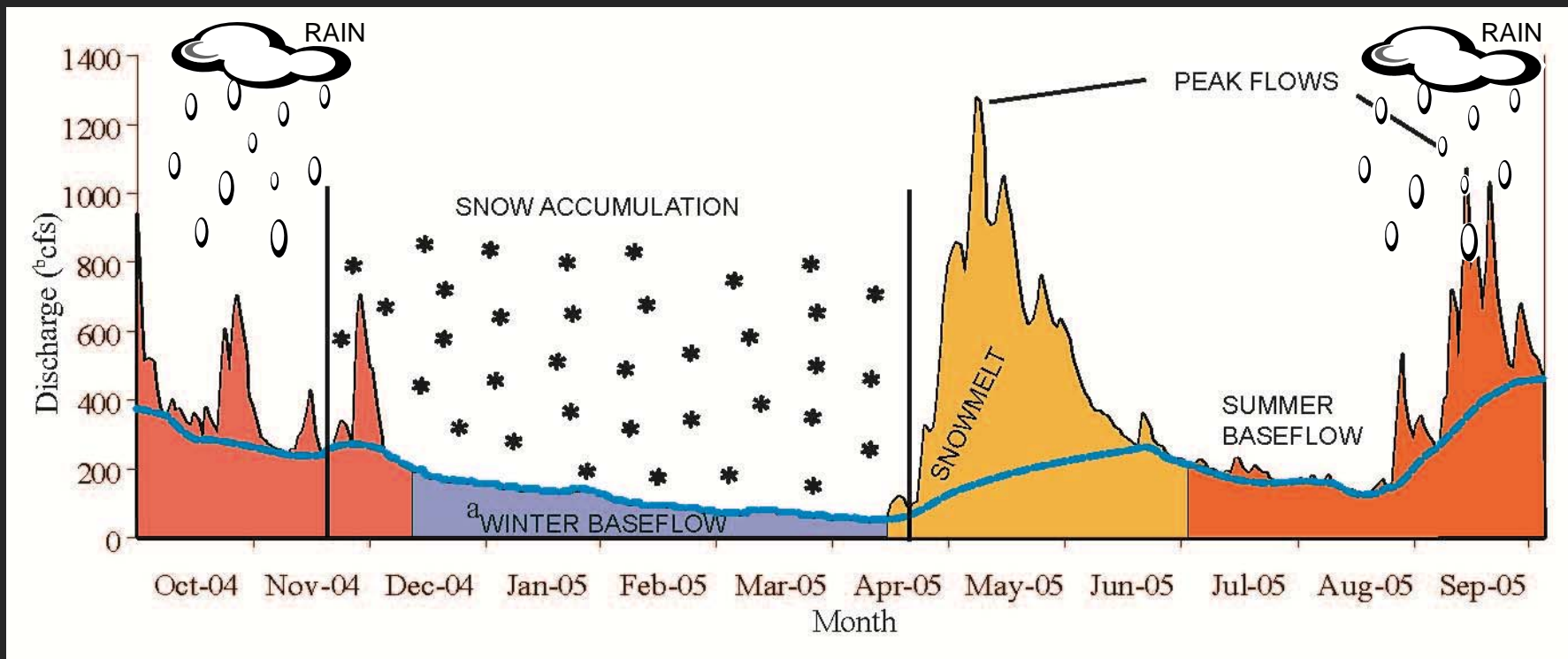
Pressure transducer  
(continuous stage record)

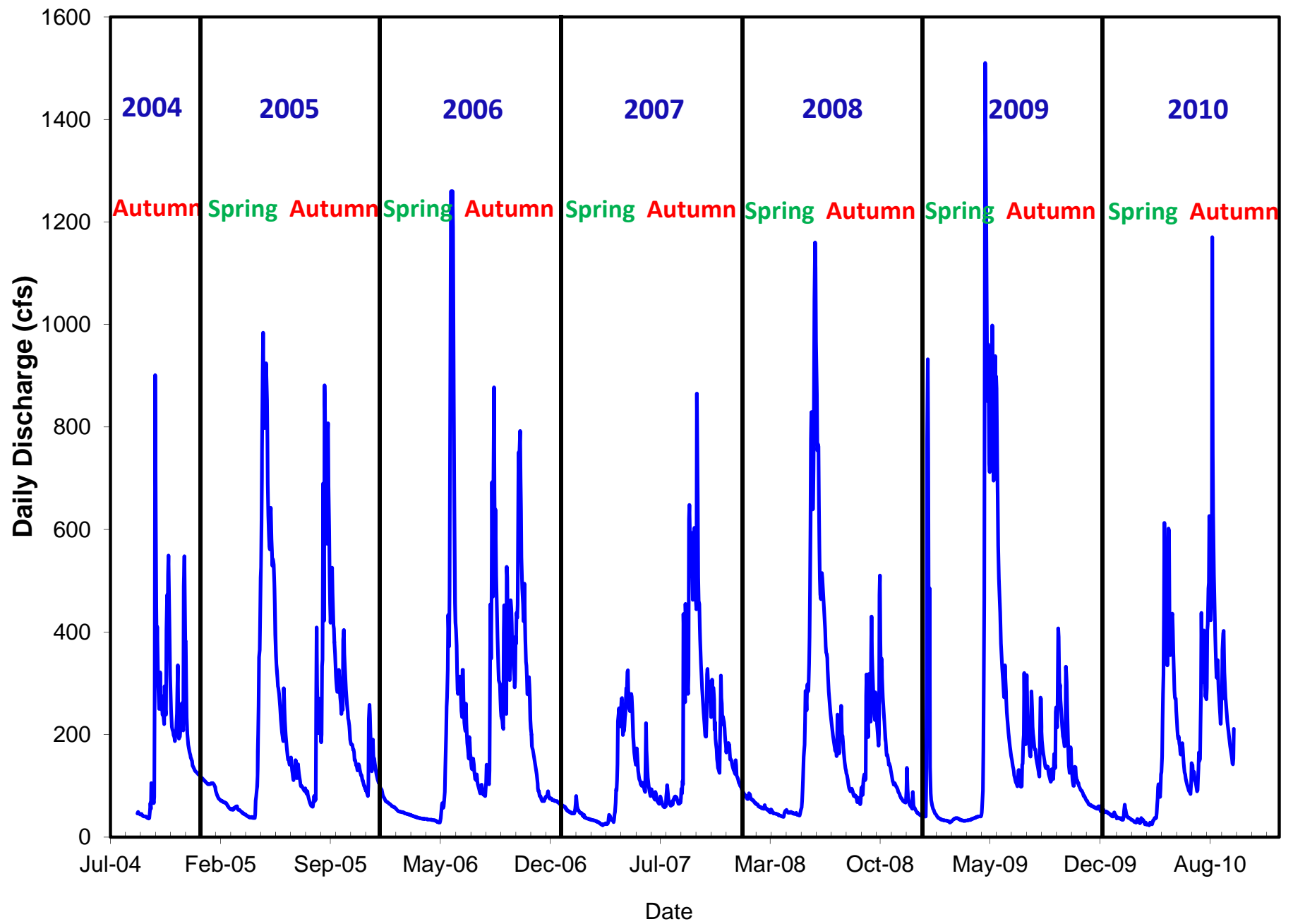
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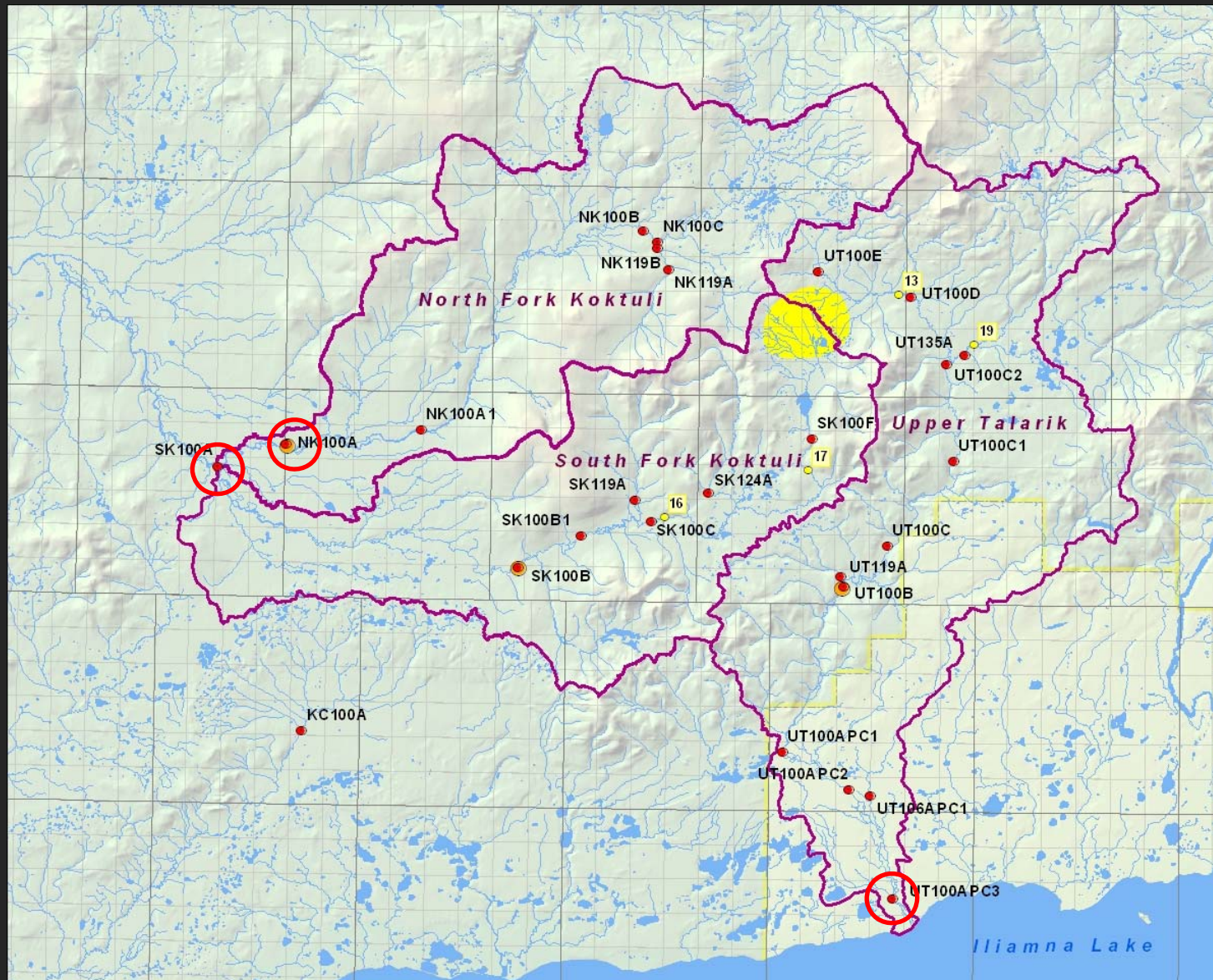
hydrograph

# Mine Study Area: Typical Hydrograph



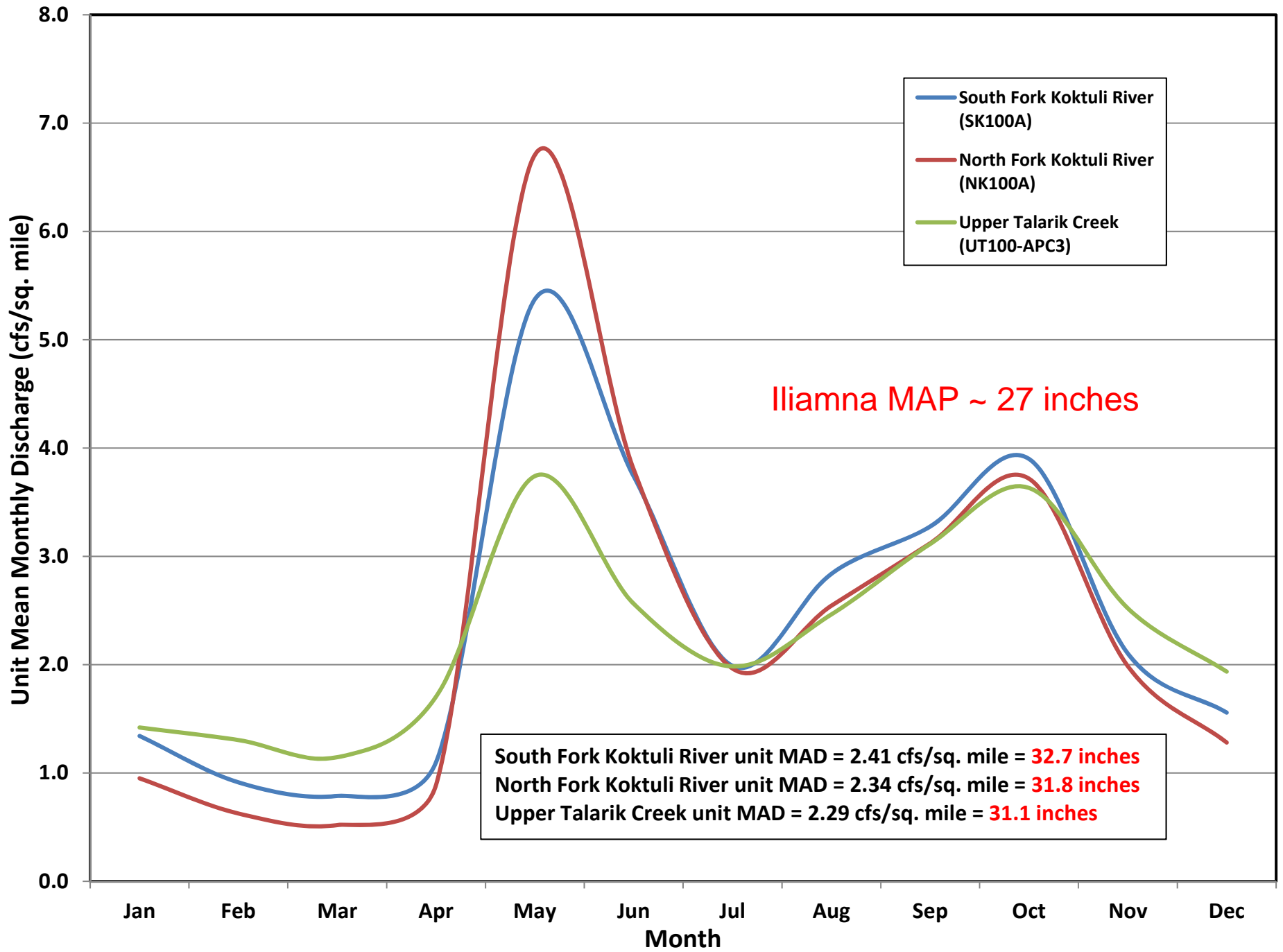


# Mine Study Area: Drainage Basins

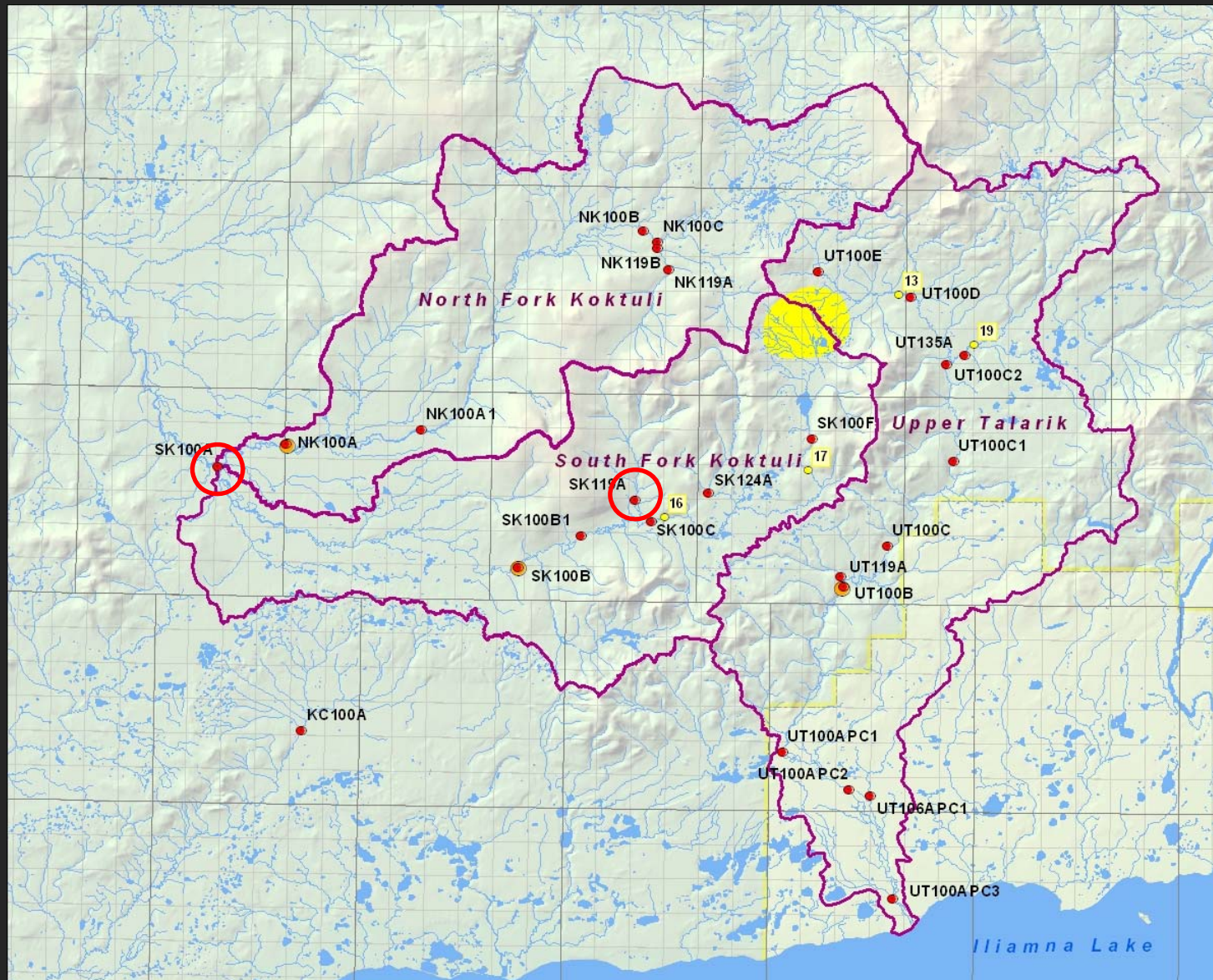


Mainstem  
flows

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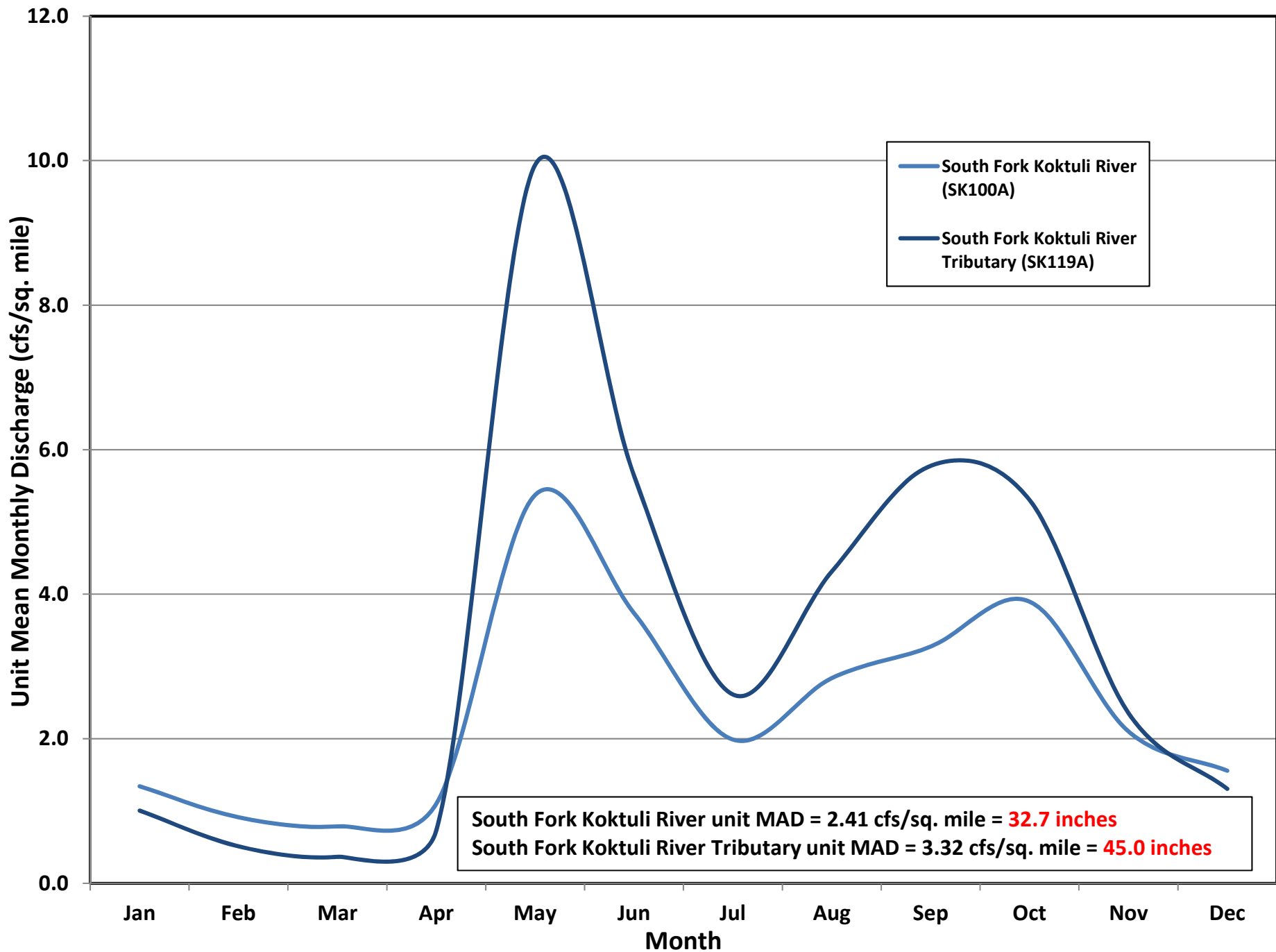


# Mine Study Area: Drainage Basins

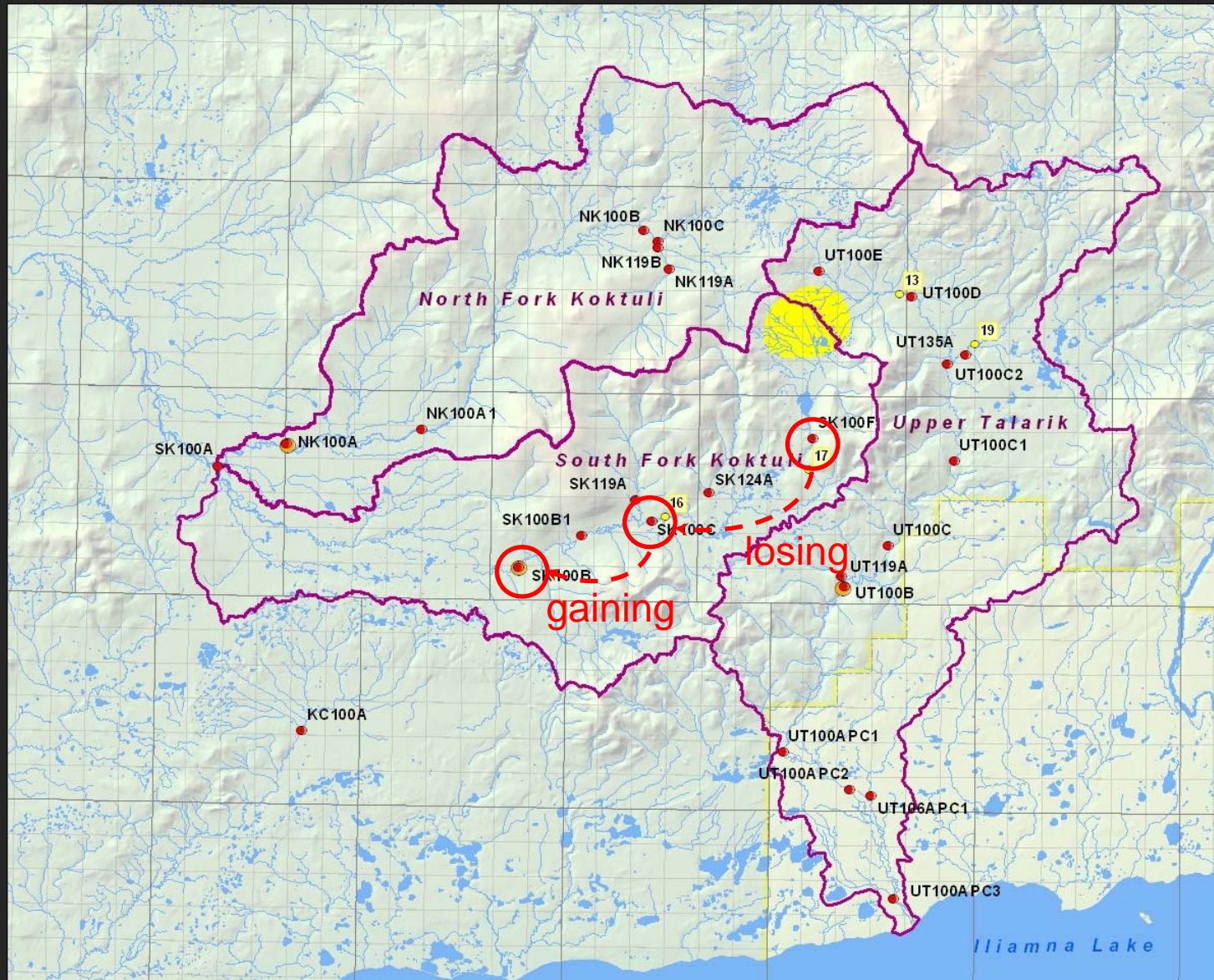


Mainstem  
and  
tributary  
flows

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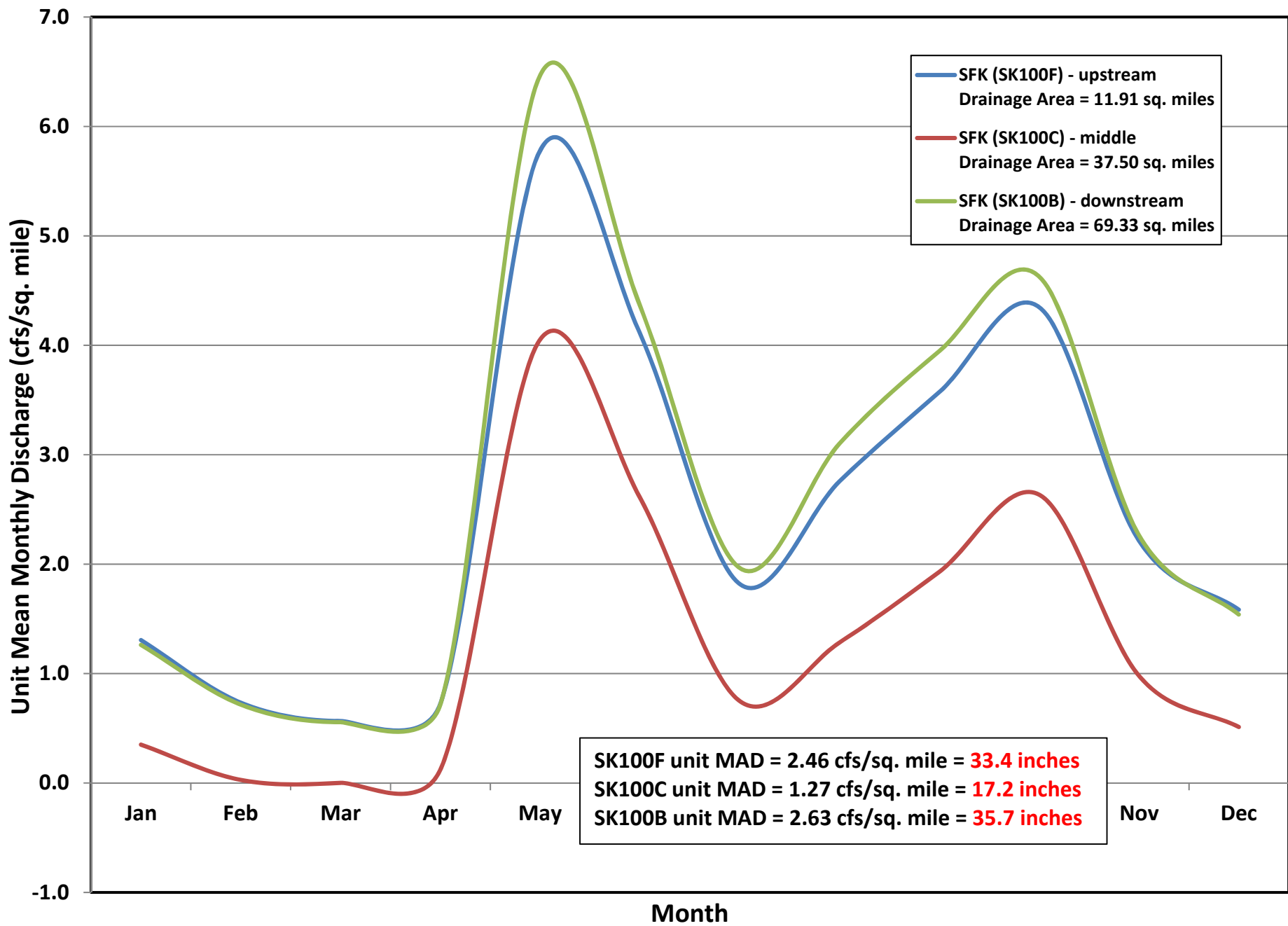


# Mine Study Area: Drainage Basins



Losing and  
gaining  
reaches

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# Mine Study Area: Inter-Basin Flow

SK100F (upstream)

SK100C

SK100B (downstream)

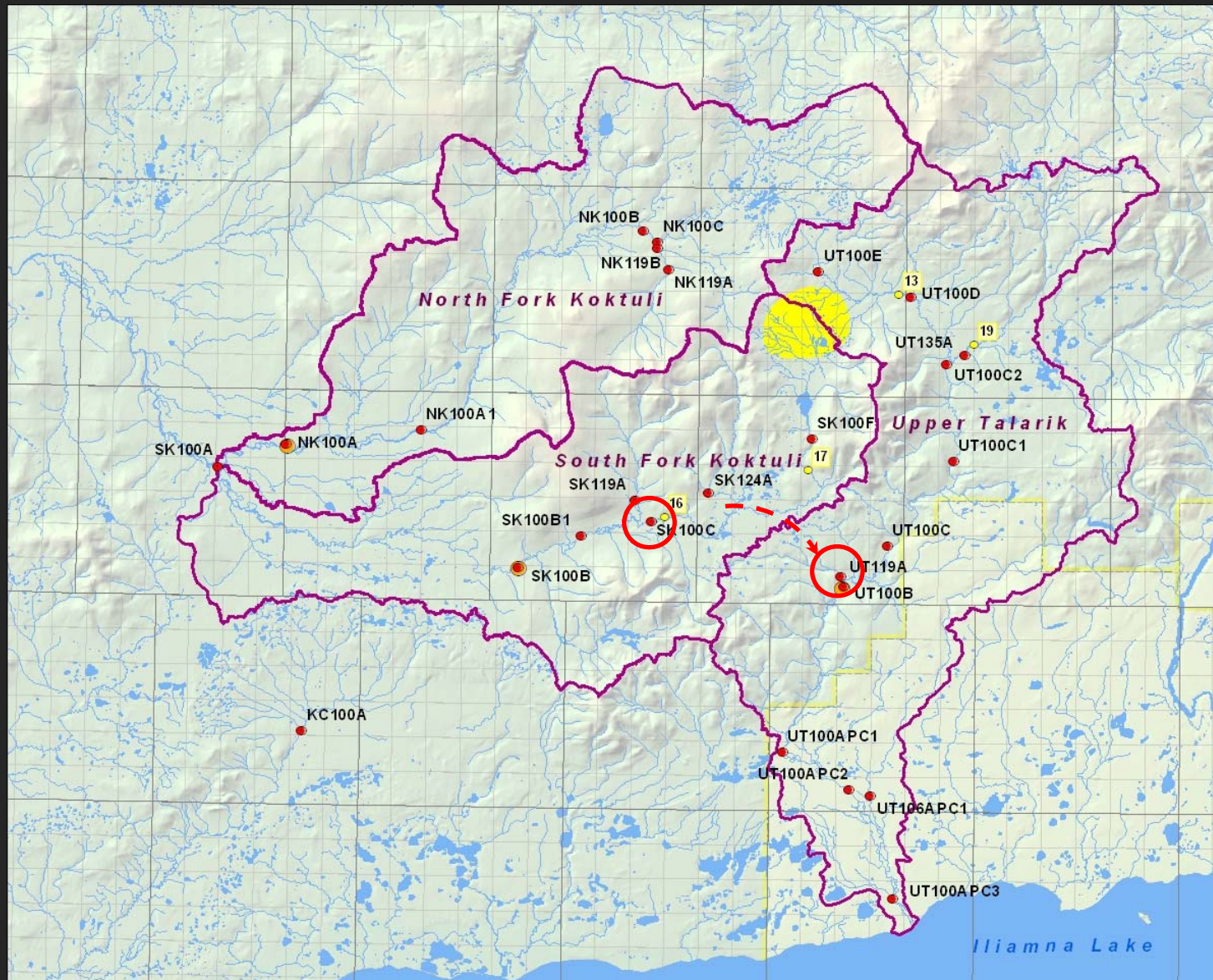
July 2005



August 2005

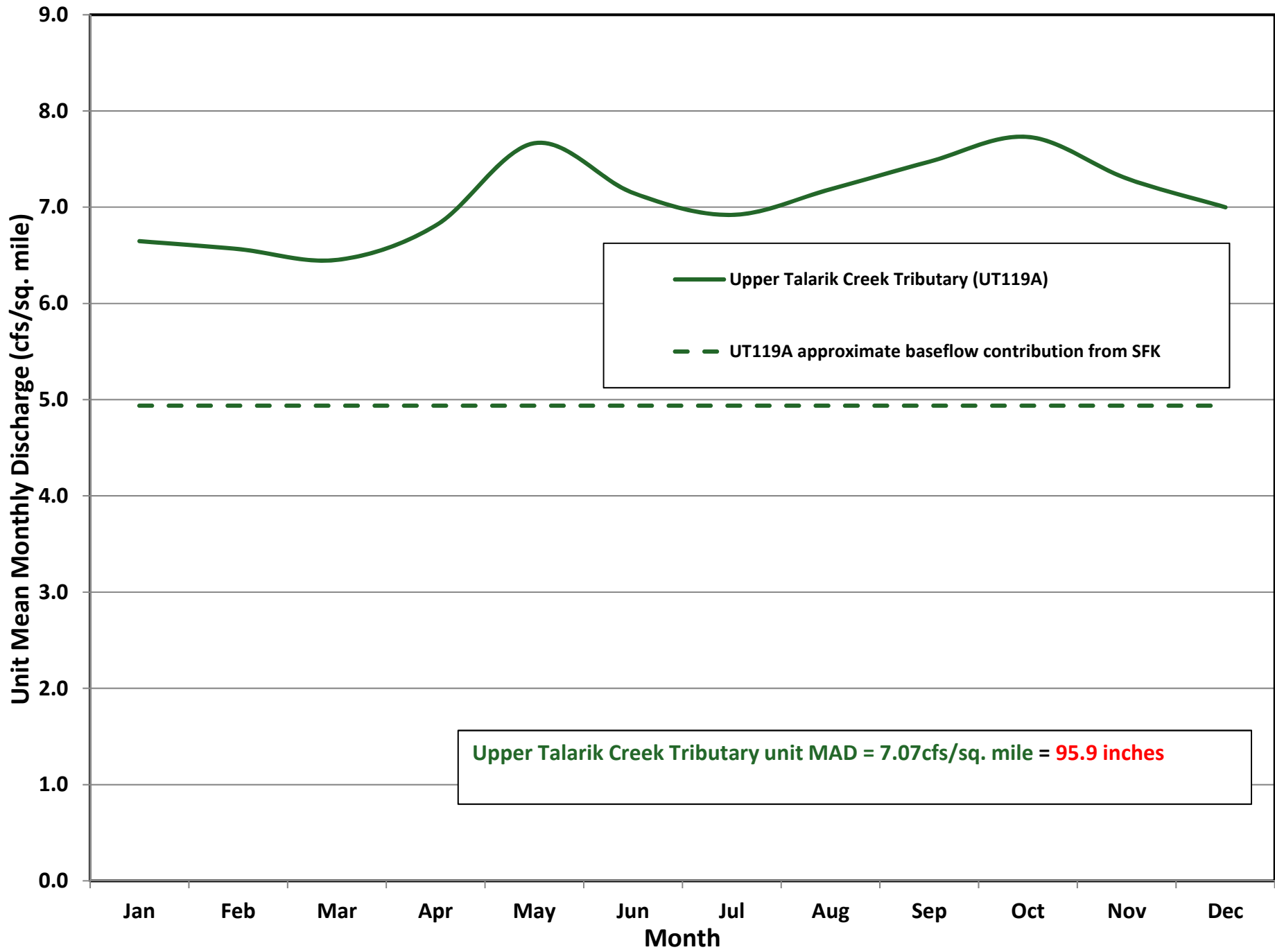


# Mine Study Area: Drainage Basins

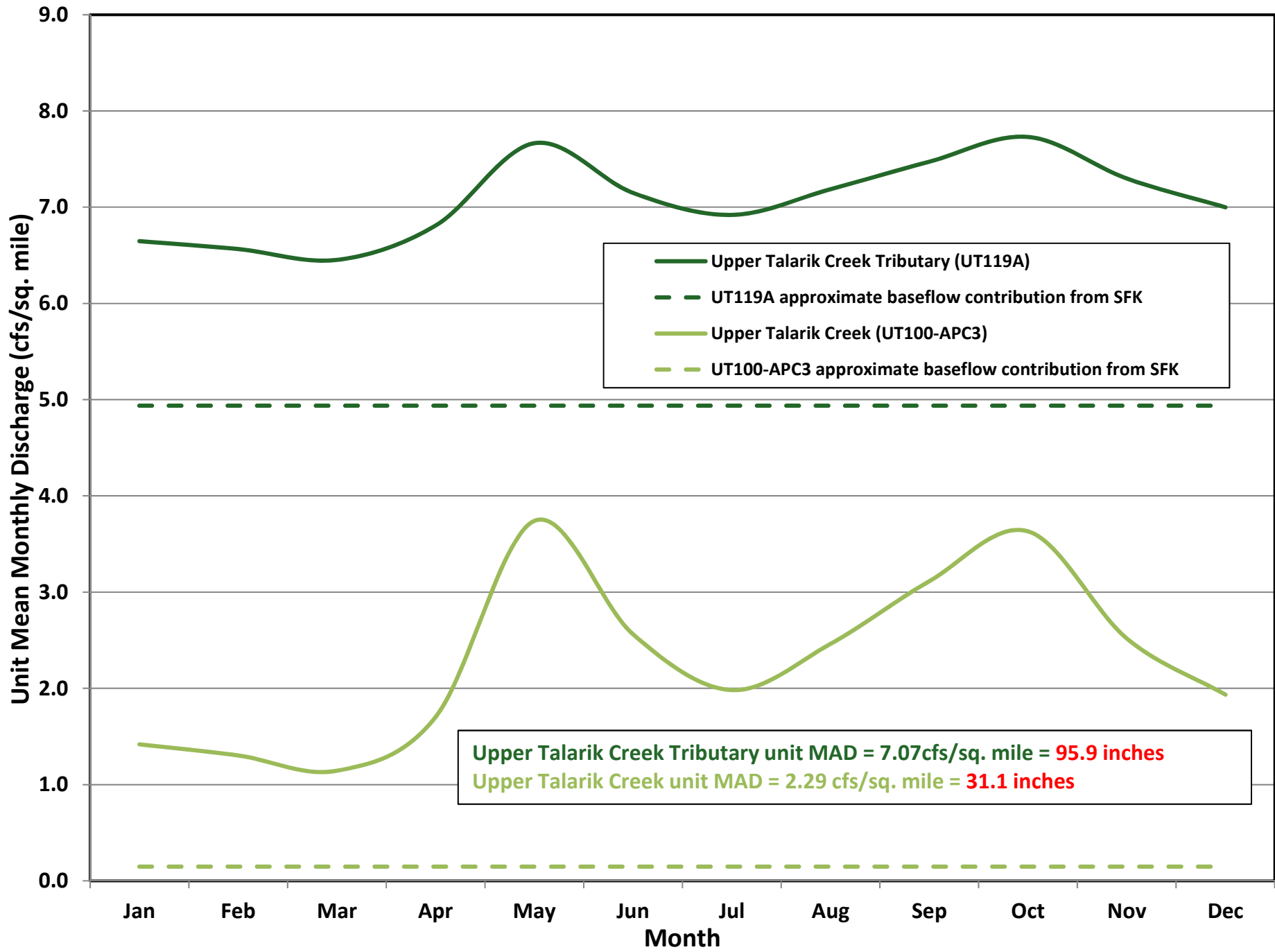


Effect of  
interbasin  
transfer

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Upper Talarik Creek Tributary unit MAD = 7.07cfs/sq. mile = 95.9 inches



Upper Talarik Creek Tributary unit MAD = 7.07cfs/sq. mile = 95.9 inches  
 Upper Talarik Creek unit MAD = 2.29 cfs/sq. mile = 31.1 inches

# Mine Study Area: Hydrographs



UT119A – May 2007 Q = 25 cfs.



UT119A - February 2007 Q = 25 cfs.

# Mine Study Area: Streamflow Summary

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- Similar Hydrograph Patterns
  - Bimodal spring and fall peaks
  - Late winter low flow period
- Unit runoff compared to Iliamna
- Orographic influences
- Surface/Groundwater Interactions

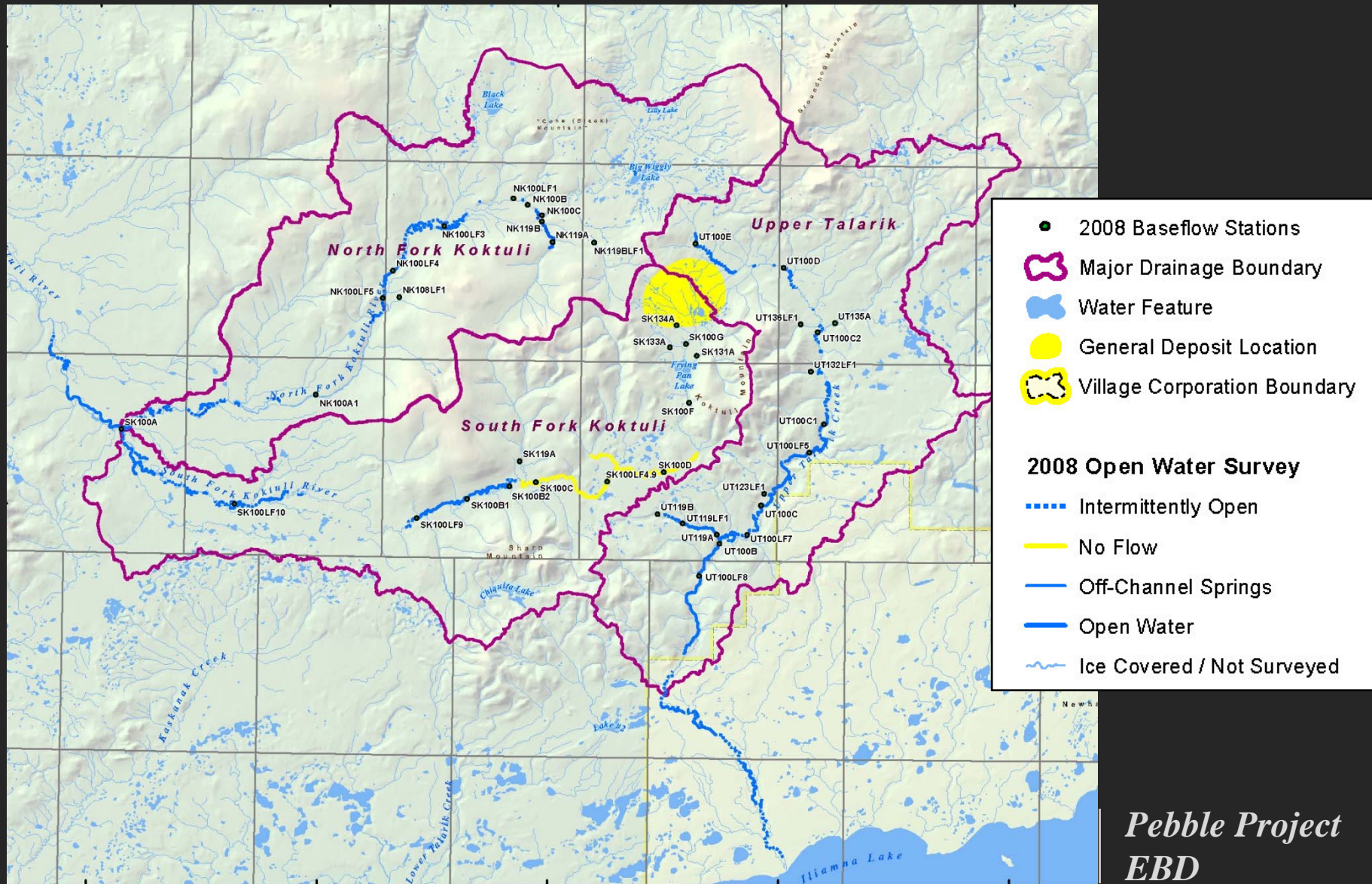
# Mine Study Area: Low Flow

Characterization of late winter low flow conditions (2004-2010)

- Winter measurements at gaging sites and **additional low flow sites in March (26)**
- Open water surveys



# Low Flow: Open Water





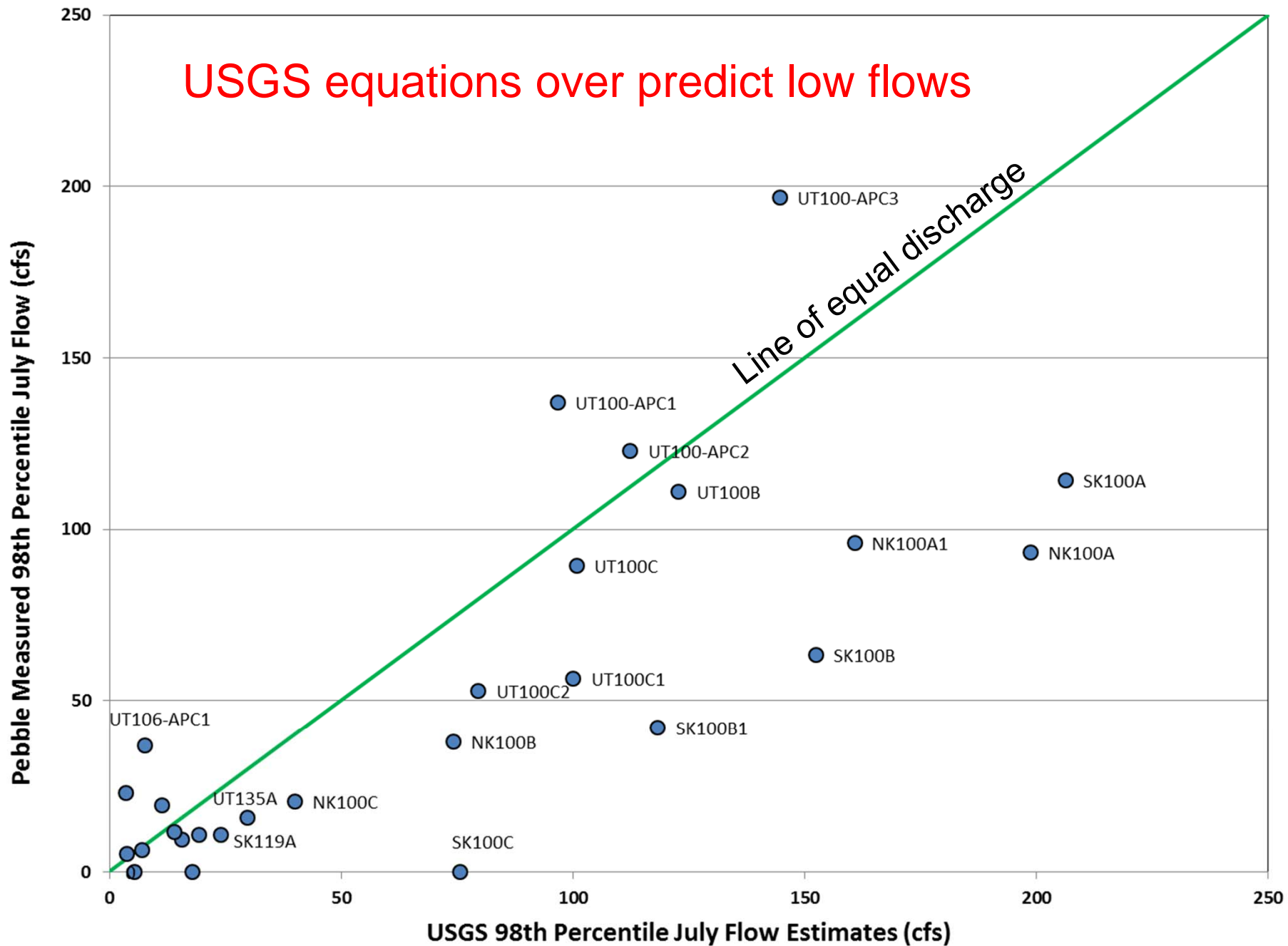
# Mine Study Area: Low Flow

## Assessment of low flow characteristics (2004-2008)

- Step: Compared regional and site specific low flow values
  - Used USGS regional regression equations to estimate low flow for study area gaging stations
  - Calculated low flow values from study area gage records
  - Compared values, which suggested that USGS equations over predict low flows



USGS equations over predict low flows

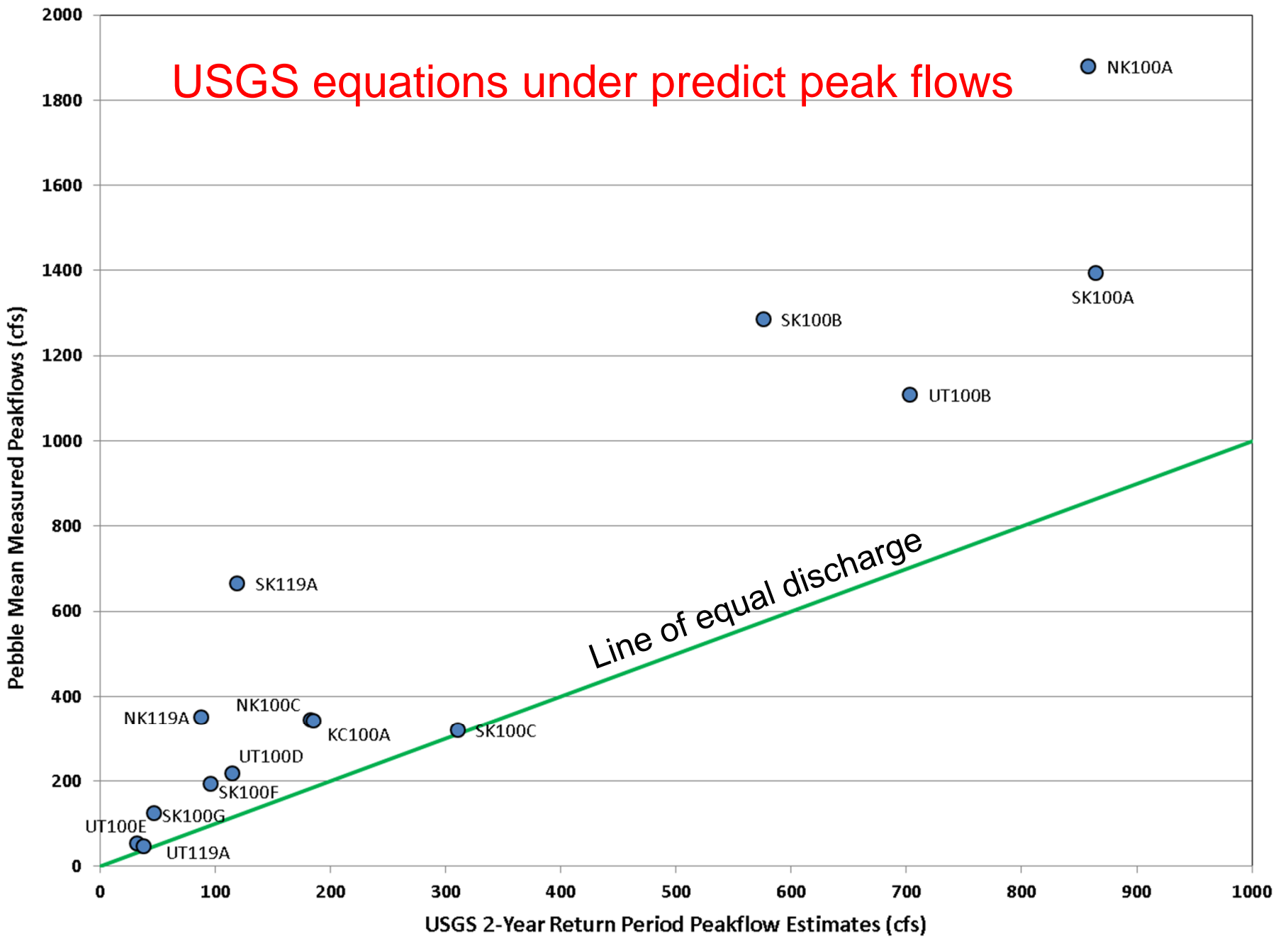


# Mine Study Area: Peak Flow

## Assessment of peak flow characteristics (2004-2008)

- Step 1: Compared regional and site specific flood values
  - Used USGS regional regression equations to estimate mean annual flood for study area gaging stations
  - Calculated mean annual flood from study area gage records
  - Compared values, which suggested that USGS equations under predict peak flows





USGS equations under predict peak flows

Line of equal discharge

# Mine Study Area: Peak Flow

## Assessment of peak flow characteristics

- Step 2: Developed a site specific estimation procedure
  - Determined the ratios of extreme floods to the mean annual flood using the USGS equations.
  - Applied these ratios to the mean annual floods from the study area gage records to estimate extreme floods for each gage site.



# Mine Study Area: Snow

Assessment of snow distribution and ablation patterns

Data collection (2004-2008)

- Snow surveys
- Satellite images during ablation season
- Lidar survey of snow surface

Snow Distribution Modeling

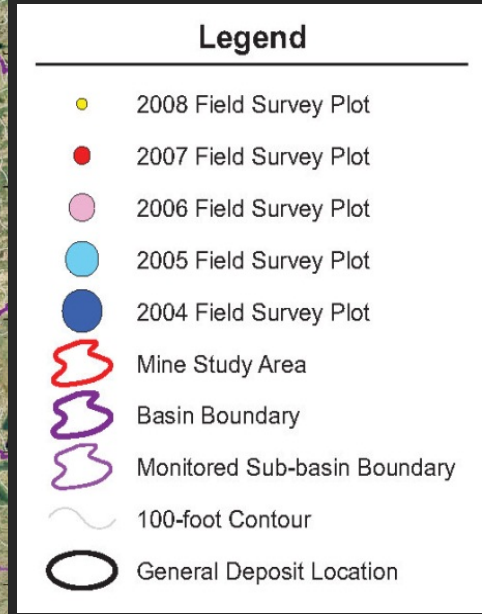
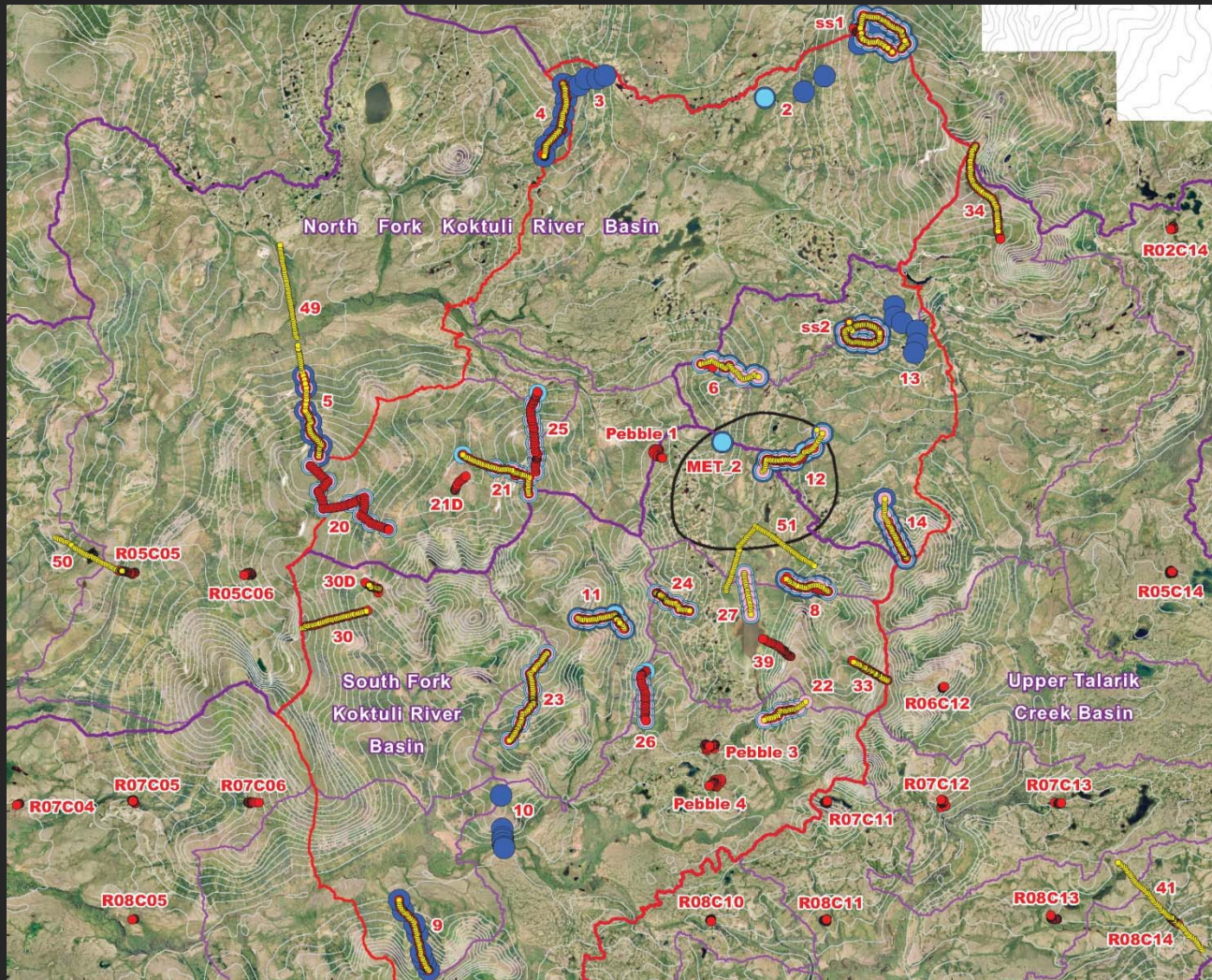
- Snow accumulation and water equivalent
- Snow distribution
- Snow ablation



# Mine Study Area: Snow Survey

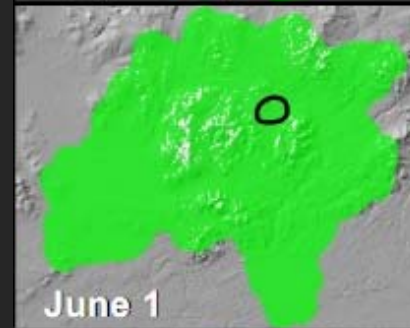
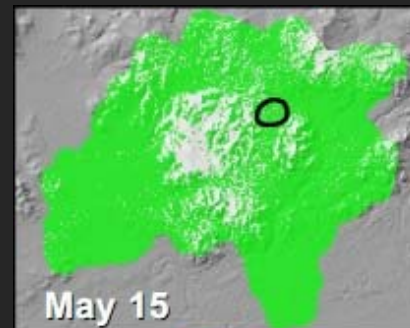
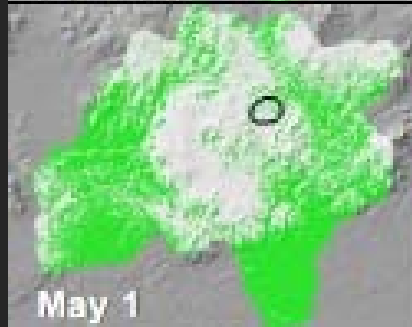


# Mine Study Area: Snow Survey



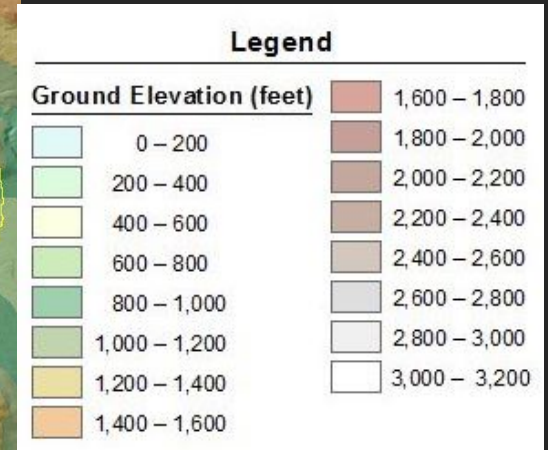
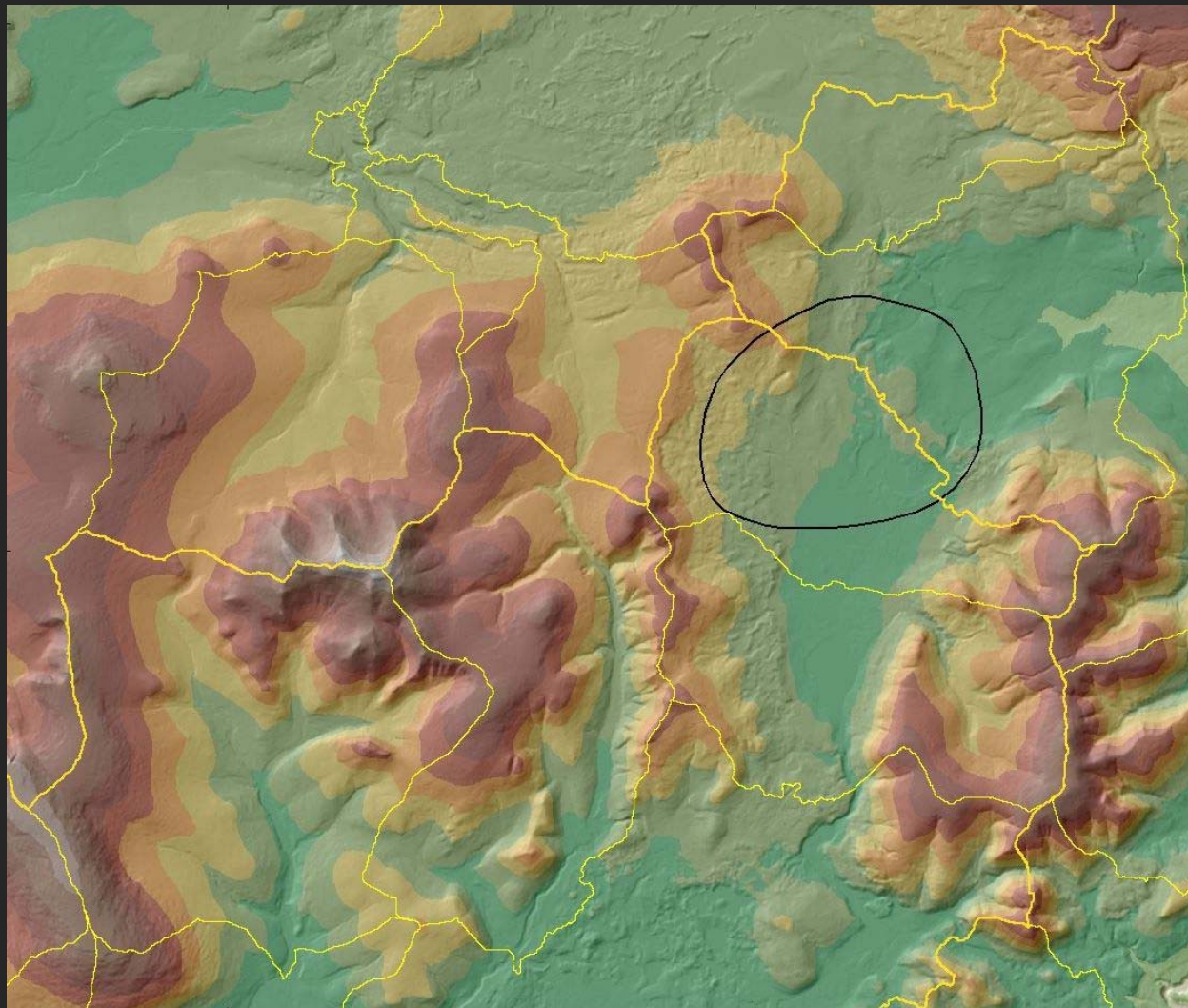
# Mine Study Area: Satellite Images

Full snow cover



No snow cover

# Mine Study Area: Lidar Images

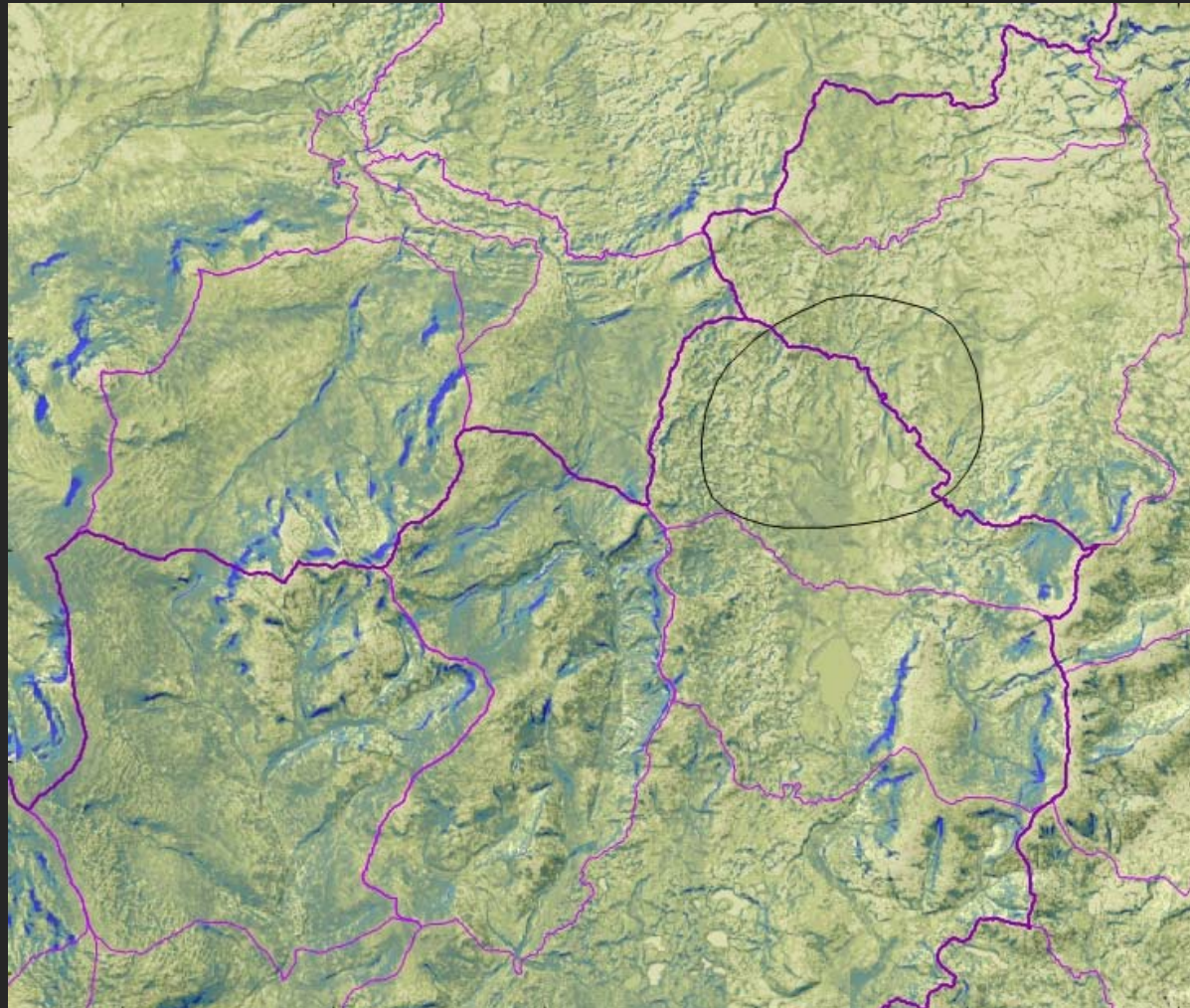


# Mine Study Area: SWE

Station	Basin Area (mi. sq.)	Modeled Mean Snow Water Equivalent for Basin (inches)		
		19-Apr-06	9-Apr-07	6-Apr-08
SK100A	106.92	19.5	4.5	19.3
NK100A	105.86	21.5	6.1	23.8
UT100-APC3	134.16	17.6	3.4	16.4

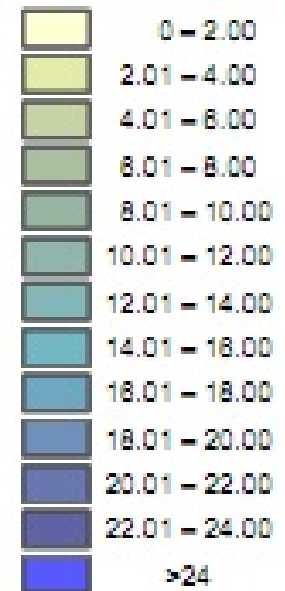
# Mine Study Area: Snow Depth

April 2008



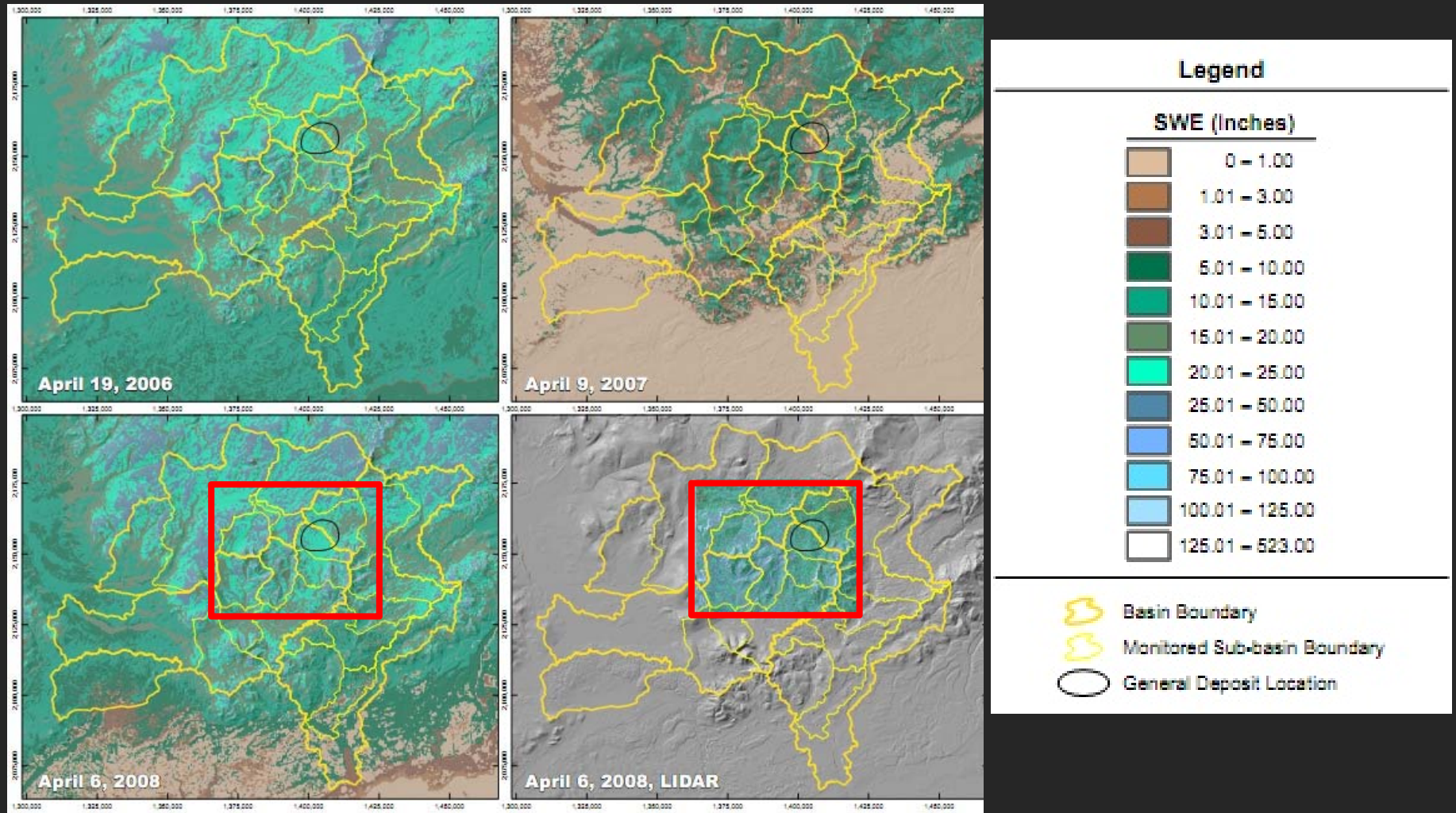
## Legend

### Snow Depth (Feet)

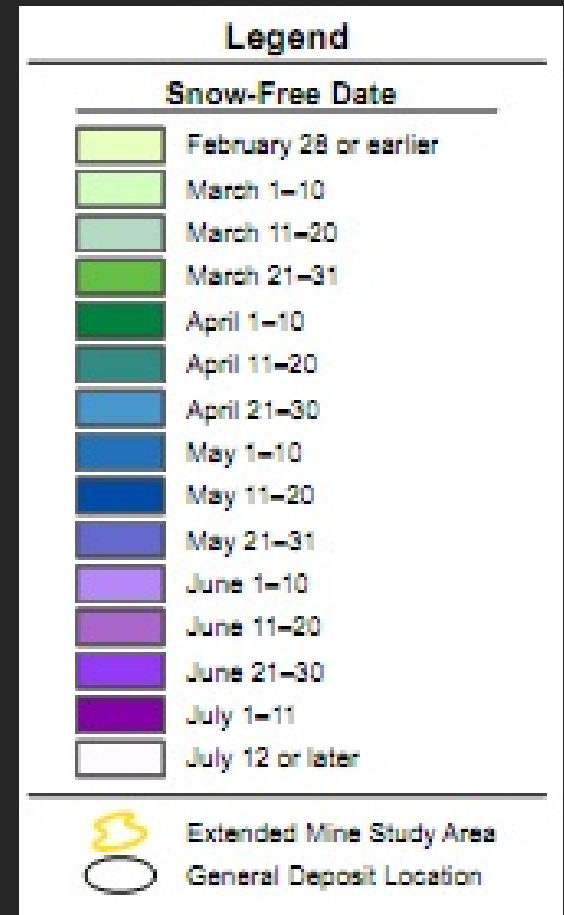
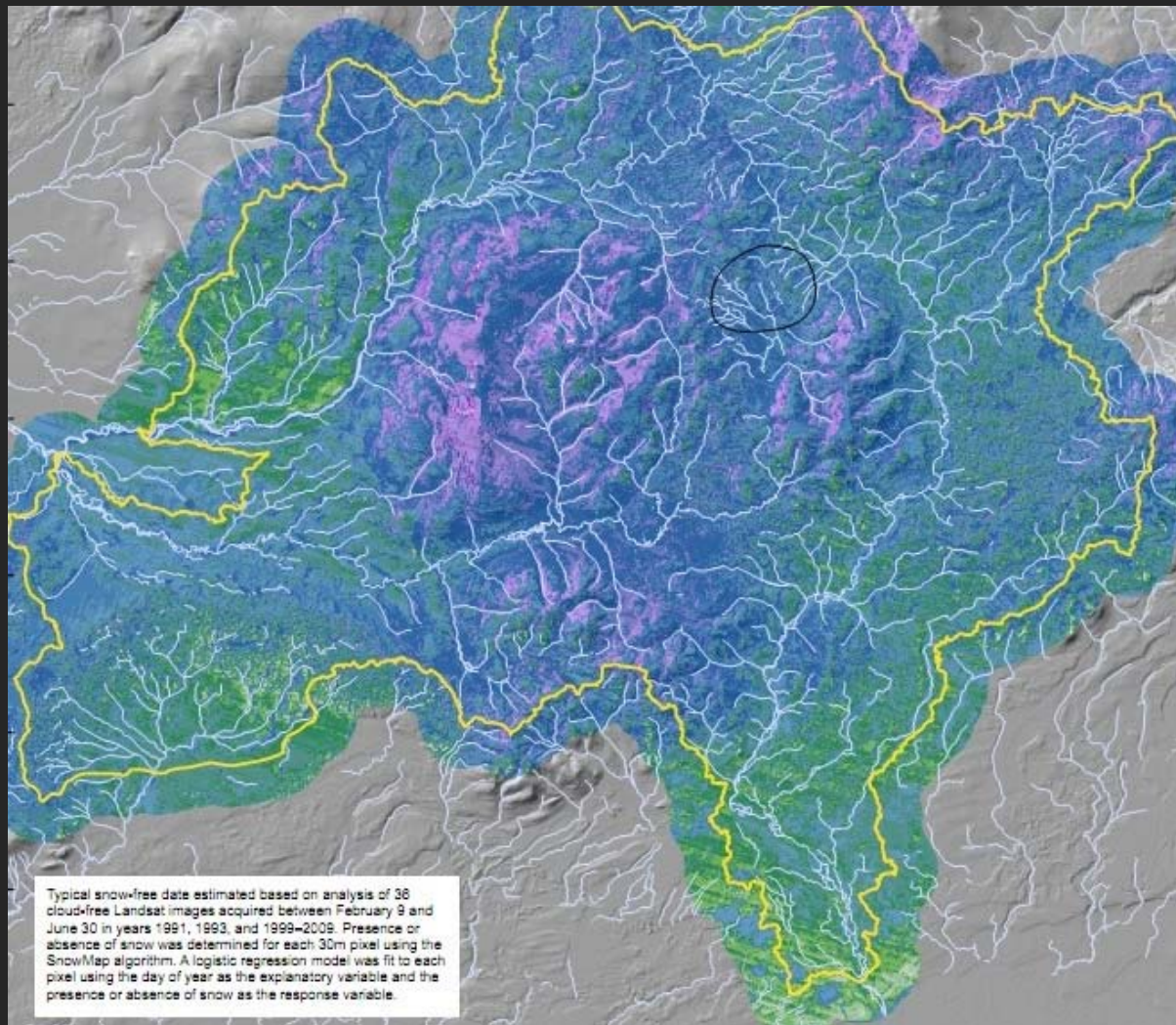


- Basin Boundary
- Monitored Sub-basin Boundary
- General Deposit Location

# Mine Study Area: Distribution



# Mine Study Area: Ablation



# Mine Study Area: Snow Summary

- Snow depth and snow water equivalent are highly variable throughout the site and from year to year, but typically is in the order of 20 inches for the basin average.
- Ablation typically begins in April and the timing is generally consistent with the topography.



# Mine Study Area: Pools

## Assessment of pool characteristics

### Data collection (2006-2007)

- 123 pools studied
- Surface water and groundwater levels and chemistry sampled

### Pool Assessment

- Two types of pools:
  - Perched-precipitation pools (“puddles”) - 45
  - Flow-through pools (interact with groundwater) - 78



# Mine Study Area: Pools



Perched pool



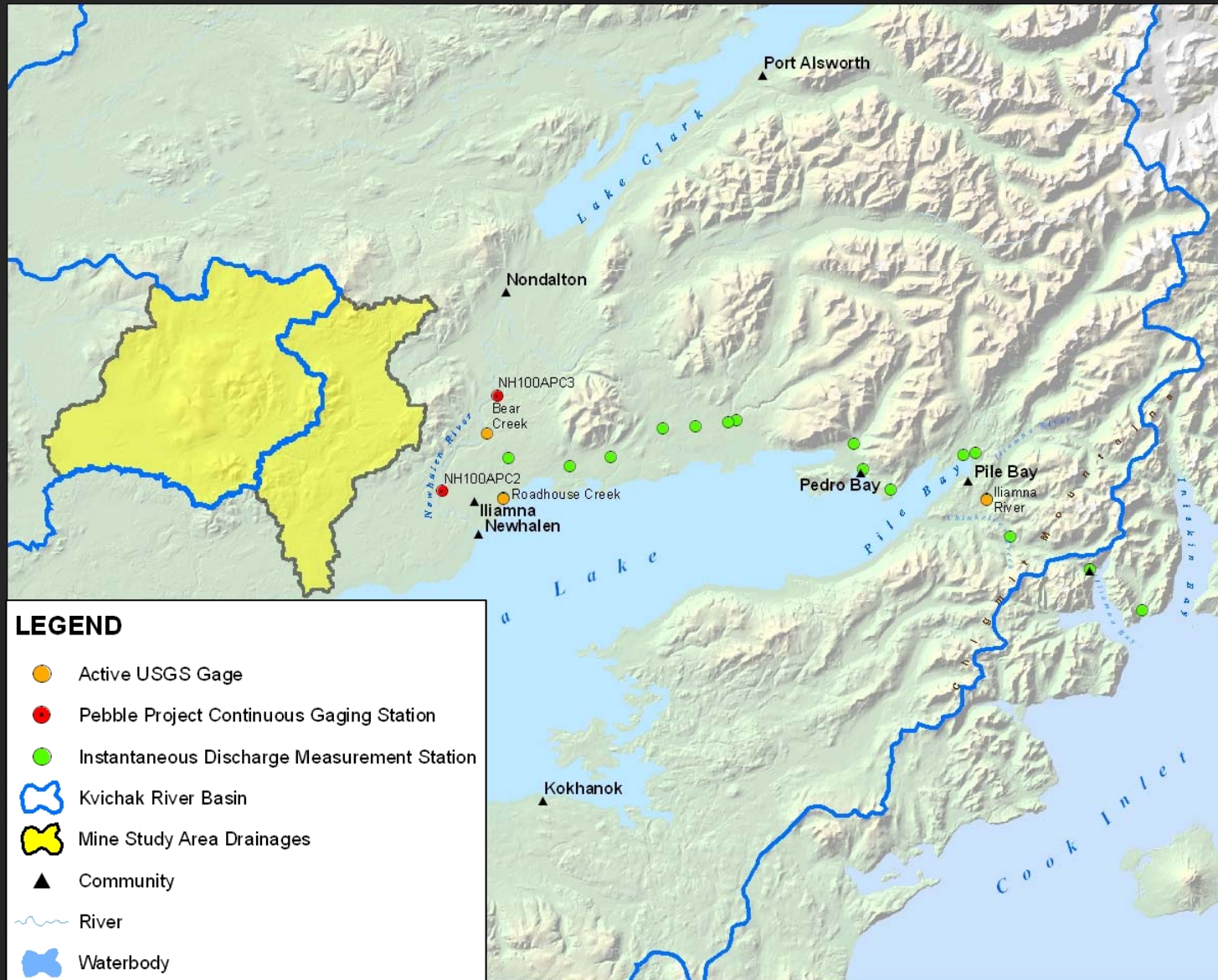
Flow-through pool

# Transportation Corridor

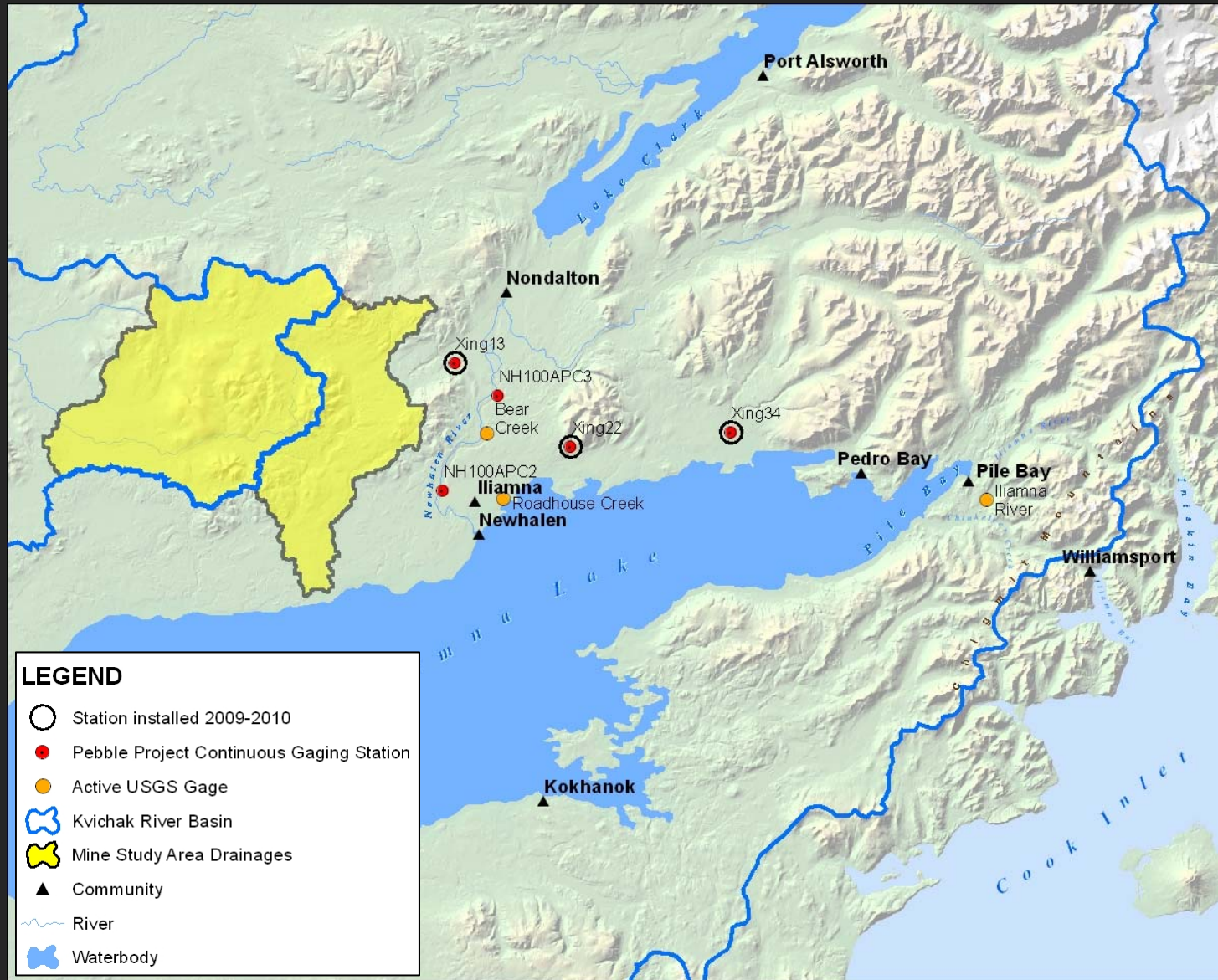


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# Transportation Corridor: 2008 Streamflow



# Transportation Corridor: 2010 Streamflow



# Transportation Corridor: Streamflow

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## Continuous Gages

### Prior to 2004

USGS: 1 active, 1 discontinued

### 2004-2008

USGS: 2 new

Pebble: 2 new (Newhalen River)

### 2009-2010

USGS: 0 new

Pebble: 3 new

# Transportation Corridor: Streamflow

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## Crest Gages

### Prior to 2004

USGS: 1 active, 1 discontinued

### 2004-2008

USGS: 0 new

Pebble: 13 new

### 2009-2010

USGS: 0 new

Pebble: 0 new



# Transportation Corridor: Streamflow

A regional assessment indicates a strong east/west runoff gradient and a change in annual hydrograph patterns, which is tied to the physiography.



Hills



Lowlands



Mountains



Ocean

Mine Study  
Area

Transportation Corridor

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# Transportation Corridor: Streamflow



Roadhouse Creek  
MAUR = 18 inches



South Fork Koktuli River  
MAUR = 33 inches



Iliamna River  
MAUR = 95 inches



Hills

Lowlands

Mountains

Ocean

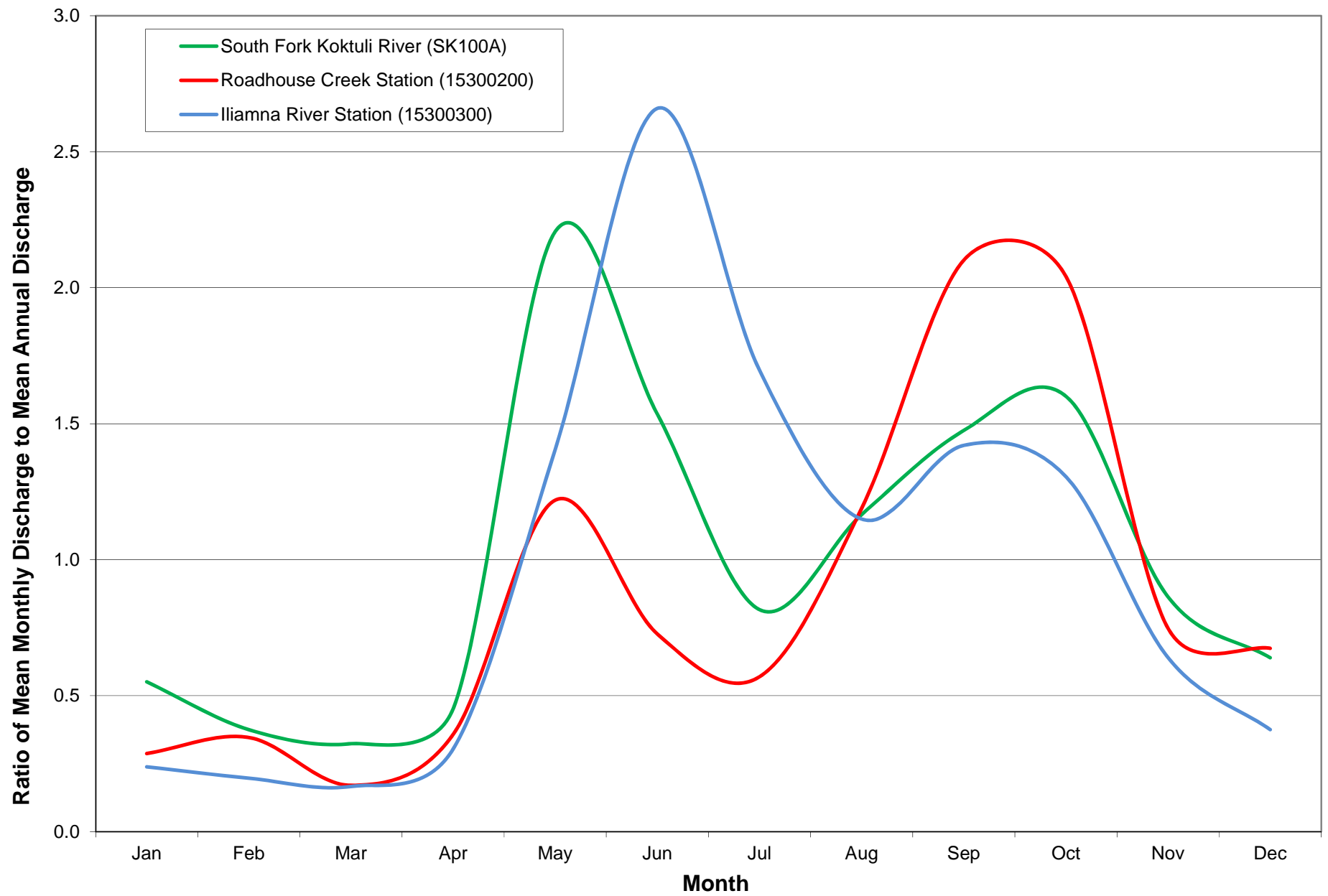
Mine Study  
Area

Transportation Corridor

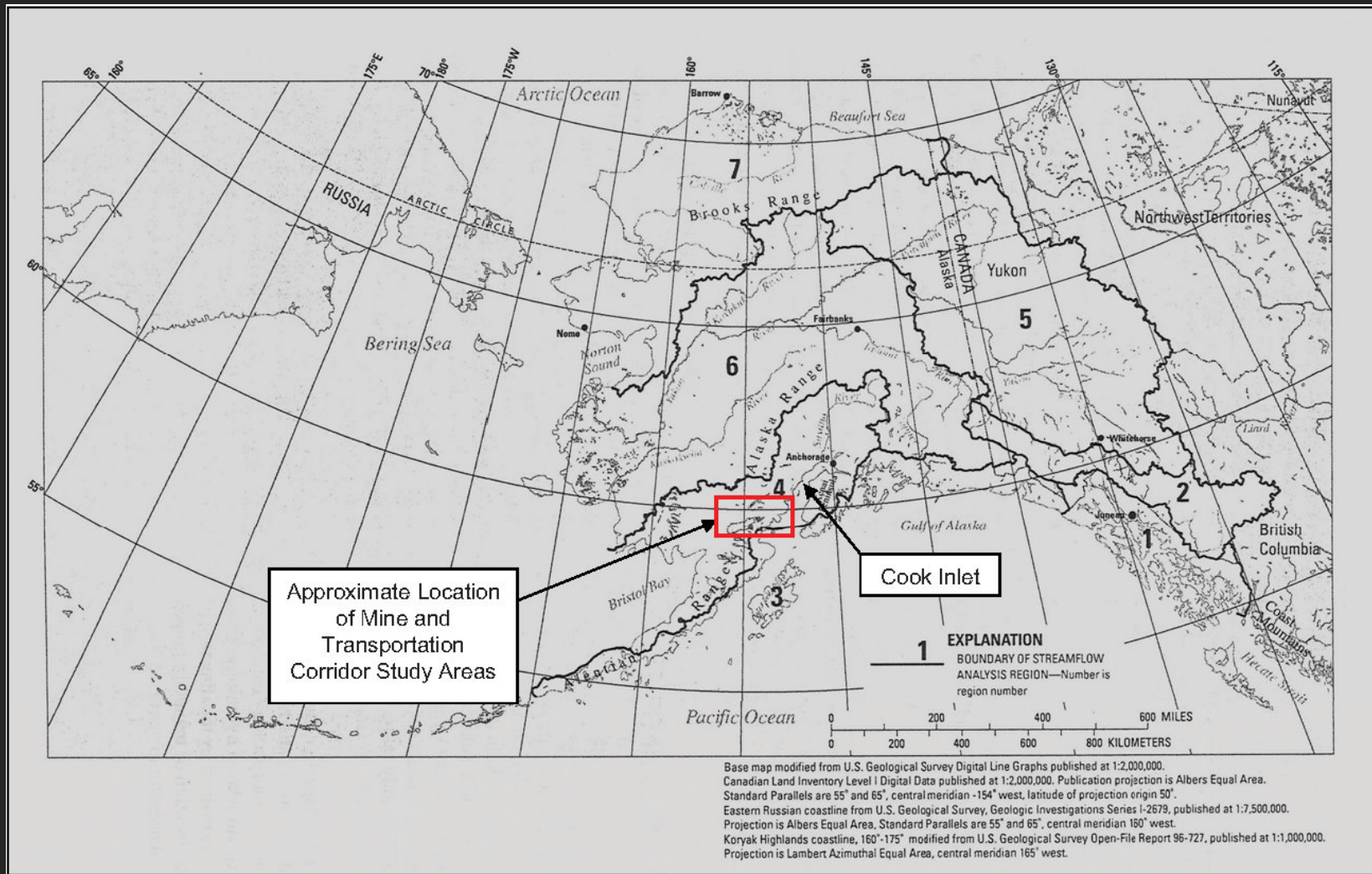
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# Transportation Corridor: USGS Regions



# Transportation Corridor: Peak/Low Flows

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- Currently, low flow and peak flow values are estimated from USGS equations.
- Region 4 equations are used for the west end of the corridor and Region 3 equations are used for the east end.
- The values and estimation procedures will be updated as more site specific data are collected.

# QUESTIONS?

