



USING NEAR INFRARED SATELLITE IMAGERY TO DETERMINE AQUATIC CONDITIONS

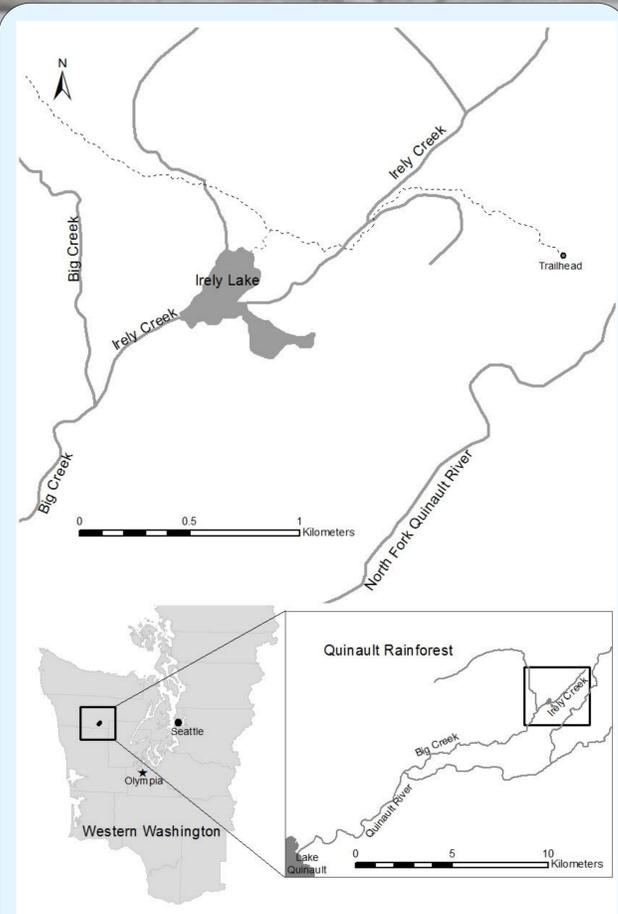
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Introduction

Irely Lake is a geologically recent addition to the landscape of the Olympic Mountain Range in the Quinault watershed. The lake was calculated to be a shallow 4 acre marshy area varying to about 20 acres and 10 feet deep (Wolcott, 1973).

Irely lake forms at the mouth of Irely Creek and drains via a short spur into Big Creek, a Quinault River tributary upstream of Lake Quinault. Washington Department of Fish and Wildlife (WDFW) staff have been involved in annual fish and habitat assessments in Irely Creek and noted semi-regular occurrences of Irely Lake drying out during the summer months.

Using satellite imagery and aerial photos in ArcGIS, plus direct observations during site visits, a record of past summer lake conditions can be established.



Irely Creek in Olympic National Park, Washington State

Background

Our more recent work in the watershed indicated that Irely Lake dries out about 5 years out of 10. Questions have been raised about the lake dry out periods and whether conditions have changed recently that may be increasing the frequency or duration of lake dry out.

Two stocks of migratory fish, coho salmon and cutthroat trout, reside in or pass through Irely Lake. The lake is a crucial pathway to upstream spawning grounds and provides important rearing habitat. Evidence supports a correlation between lake dry out events and the number of spawning trout upstream in Irely Creek the following year.

Without regular visits late in the summer, it is very difficult to monitor Irely Lake conditions. Without reliable historical observations, we could not know when Irely Lake dried out.



Direct observation of the lake offers the most reliable method for determining conditions. However, access is time consuming and has a high cost for the data collected.

Landsat satellite images were available from 1984 to present. In order for the images to be useful to us in this study, two conditions were required:

1. Satellite passes had to be available in August and September when likelihood of lake drying was greatest.
2. The weather had to be clear enough that cloud cover did not block the view of the lake. Satellite images were filtered to view in the near infrared spectrum.

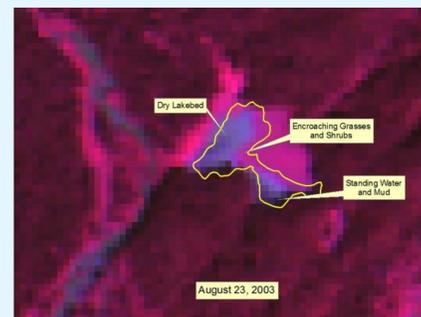
In 20 out of 28 years (1984-2011) satellite coverage was sufficient to determine late summer lake conditions. More recent years (2001-2011) have fairly consistent visual observations, and three NAIP orthophotos (2006, 2009 & 2011) provide a very clear aerial view of the Lake.

Using Multiple Methods

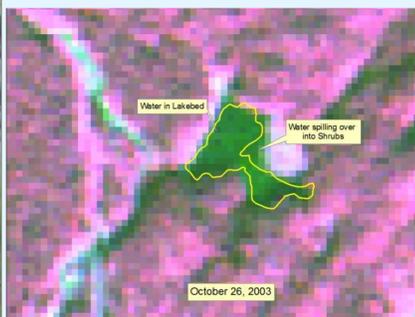
Irely Lake photo taken August 19, 2003



Satellite Image from August 23, 2003



Irely Lake photo taken October 27, 2003



Satellite Image from October 26, 2003

When viewing satellite images in ESRI ArcMAP, I set the color settings as follows: Red-4, Blue-3, Green-5, Alpha-off.

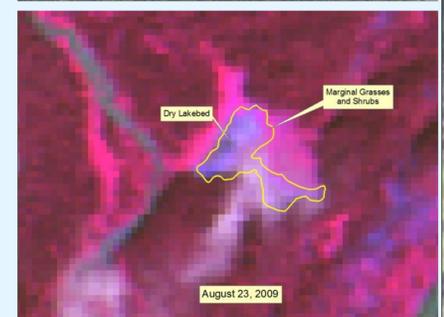
At these settings actively photosynthesizing plants show up in shades of red and pink. Dirt, mud and rocks show up in grays and blues. Water is dark green to black.

On site observations and NAIP orthophotos allowed us to compare the near infrared satellite images with known conditions in order to validate and fine tune our assessment of the older satellite images without direct observations.

Irely Lake aerial photo taken August 27, 2009



Satellite Image from August 23, 2009



Results

| Date | Year | Satellite | Visual | Date | Year | Satellite | Visual | Photo |
|--------|------|-----------|--------|--------|------|-----------|--------|----------|
| 26-Jul | 1984 | F | N/A | 22-Jul | 2003 | <F | N/A | |
| 13-Jul | 1985 | F | N/A | 19-Aug | 2003 | N/A | D | Photo |
| 14-Aug | 1985 | >D | N/A | 23-Aug | 2003 | >D | N/A | |
| 29-May | 1986 | F | N/A | 1-Sep | 2003 | D | N/A | |
| 30-Jun | 1986 | F | N/A | 8-Sep | 2003 | N/A | >D | |
| 7-May | 1987 | F | N/A | 26-Oct | 2003 | F | N/A | |
| 17-Jun | 1987 | F | N/A | 27-Oct | 2003 | N/A | F | Photo |
| 27-Aug | 1987 | >D | N/A | 14-May | 2004 | F | N/A | |
| 21-Sep | 1987 | D | N/A | 15-Jun | 2004 | F | N/A | |
| 28-Sep | 1987 | D | N/A | 17-Jul | 2004 | F | N/A | |
| 19-Jun | 1988 | F | N/A | 24-Jul | 2004 | <F | N/A | |
| 22-Jul | 1988 | F | N/A | 8-Aug | 2004 | <F | N/A | |
| 30-Sep | 1988 | F | N/A | 18-Aug | 2004 | <F | N/A | |
| 9-Oct | 1988 | F | N/A | 3-Sep | 2004 | F | N/A | |
| 24-Jul | 1989 | F | N/A | 26-Sep | 2004 | F | N/A | |
| 10-Sep | 1989 | <F | N/A | 1-May | 2005 | F | N/A | |
| 8-May | 1990 | F | N/A | 29-Jul | 2005 | F | N/A | |
| 12-Aug | 1990 | F | N/A | 27-Jul | 2005 | F | N/A | |
| 13-Sep | 1990 | F | N/A | 5-Aug | 2005 | F | N/A | |
| 20-Sep | 1990 | <F | N/A | 23-Aug | 2005 | N/A | <F | Photo |
| 2-May | 1991 | F | N/A | 6-Sep | 2005 | >D | N/A | |
| 5-Jul | 1991 | F | N/A | 13-Sep | 2005 | >D | N/A | |
| 15-Aug | 1991 | <F | N/A | 13-Oct | 2005 | N/A | F | |
| 23-Sep | 1991 | F | N/A | 4-May | 2006 | F | N/A | |
| 9-Oct | 1991 | <F | N/A | 25-Jun | 2006 | N/A | N/A | F-Ortho |
| 18-Sep | 1992 | D | N/A | 28-Jun | 2006 | F | N/A | |
| 11-Oct | 1992 | <F | N/A | 23-Jul | 2006 | <F | N/A | |
| 16-May | 1993 | F | N/A | 22-Aug | 2006 | N/A | >D | Photo |
| 4-Aug | 1993 | F | N/A | 31-Aug | 2006 | >D | N/A | |
| 21-Sep | 1993 | >D | N/A | 25-Sep | 2006 | >D | N/A | |
| 22-Jul | 1994 | F | N/A | 2-Oct | 2006 | >D | N/A | |
| 22-May | 1995 | F | N/A | 11-Oct | 2006 | >D | N/A | |
| 23-Jun | 1995 | F | N/A | 18-Oct | 2006 | N/A | >D | Photo |
| 29-Oct | 1995 | F | N/A | 7-May | 2007 | F | N/A | |
| 24-May | 1996 | F | N/A | 19-Jul | 2007 | F | N/A | |
| 27-Jul | 1996 | <F | N/A | 22-Aug | 2007 | N/A | <F | Photo |
| 12-Aug | 1996 | >D | N/A | 27-Aug | 2007 | <F | N/A | |
| 11-May | 1997 | F | N/A | 19-Sep | 2007 | <F | N/A | |
| 31-Aug | 1997 | <F | N/A | 13-Oct | 2007 | N/A | F | |
| 2-Aug | 1998 | <F | N/A | 12-Jul | 2008 | F | N/A | |
| 3-Sep | 1998 | D | N/A | 4-Aug | 2008 | F | N/A | |
| 23-Oct | 1998 | F | N/A | 13-Aug | 2008 | F | N/A | |
| 22-Sep | 1999 | <F | N/A | 14-Sep | 2008 | <F | N/A | |
| 20-Jun | 2000 | F | N/A | 21-Oct | 2008 | N/A | F | Photo |
| 24-Sep | 2000 | >D | N/A | 28-May | 2009 | F | N/A | |
| 8-Apr | 2001 | N/A | F | 4-Jun | 2009 | F | N/A | |
| 16-May | 2001 | N/A | F | 29-Jun | 2009 | F | N/A | |
| 22-May | 2001 | F | N/A | 15-Jul | 2009 | <F | N/A | |
| 7-Jun | 2001 | F | N/A | 16-Aug | 2009 | >D | N/A | |
| 9-Jul | 2001 | <F | N/A | 23-Aug | 2009 | D | N/A | |
| 10-Aug | 2001 | F | N/A | 27-Aug | 2009 | N/A | N/A | >D-Ortho |
| 26-Aug | 2001 | <F | N/A | 2-Sep | 2009 | >D | N/A | Photo |
| 4-Oct | 2001 | <F | N/A | 17-Sep | 2009 | <F | N/A | |
| 12-Jul | 2002 | F | N/A | 28-Oct | 2009 | N/A | F | Photo |
| 13-Aug | 2002 | <F | N/A | 15-May | 2010 | F | N/A | |
| 21-Sep | 2002 | >D | N/A | 9-Jul | 2010 | F | N/A | |
| 14-Oct | 2002 | N/A | >D | 25-Jul | 2010 | F | N/A | |
| 16-Oct | 2002 | >D | N/A | 31-Aug | 2010 | N/A | >D | Photo |
| 23-Oct | 2002 | >D | N/A | 28-Oct | 2010 | N/A | F | Photo |
| 25-Oct | 2002 | N/A | D | 26-Aug | 2011 | N/A | F | Photo |
| 15-Nov | 2002 | N/A | F | 7-Sep | 2011 | N/A | <F | Ortho |

| Dry or Near-Dry Percentages | | |
|-----------------------------|-----------|---------|
| Years | 1984-2011 | |
| | Total | Percent |
| 28 | | |
| 13 | Dry | 54.2% |
| 11 | Full | 45.8% |
| 4 | N/A | |
| Years | 1984-2000 | |
| | Total | Percent |
| 17 | | |
| 7 | Dry | 53.8% |
| 6 | Full | 46.2% |
| 4 | N/A | |
| Years | 2001-2011 | |
| | Total | Percent |
| 11 | | |
| 6 | Dry | 54.5% |
| 5 | Full | 45.5% |
| 0 | N/A | |

Legend:
 F = Lake full
 <F = Shallow water and mud throughout lake bed
 >D = Lake bed dry except for ponded water in SE end of lake
 D = Lake bed dry
 N/A = Data not collected on that date
 Satellite = Satellite image layers viewed in ArcMAP®
 Visual = Observations made by WDFW personnel
 Photo = Photo documentation available
 Ortho = Aerial photography available