

Appendix E
Ice Evaluation Report
Great Lakes Legacy Act Project – Spirit Lake Sediment Site
Former U.S. Steel Duluth Works
Saint Louis River, Duluth, Minnesota

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1.0 Introduction

Sheet ice that forms during winter months can affect sediment at shallow depths and at shorelines through transport of entrained material. Ice conditions were observed and ice thicknesses measured during the winter of 2010/2011 along the shorelines of the Spirit Lake Sediment site (Site), located on the St. Louis River near the Morgan Park neighborhood of Duluth, Minnesota (Figure E-1). The purpose of the ice observation and measurement was to evaluate the effect of ice on nearshore sediments at the Site. Ice evaluation data was collected for use in hydrodynamic modeling for the Site and for evaluation of remedial design alternatives.

As discussed in the Sediment Investigation Work Plan (Barr, 2011), ice conditions were evaluated to discern how ice may or may not affect sediments at the Site. Observations were performed periodically during the late winter and during spring melt-out to evaluate whether ice movement has an effect on nearshore sediment.

An extensive study of ice behavior in the St. Louis River was performed in 2000 to 2002 (SERVICE, 2002) at the nearby (approximately four miles downstream) St. Louis River Interlake/Duluth Tar (SLRIDT) site to evaluate the same processes and potential effects of ice movement on shallow sediments. Since the SLRIDT site is nearby, that study is referenced for historic data and the properties of the St. Louis River environment as related to ice formation, movement and melting.

Ice observation work was also performed in the late winter and early spring of 2012 and is continuing in the spring of 2013. The additional observations will be summarized in a technical memo and included in the planned FS report.

2.0 Background

2.1 Setting

The Site is located in an open reach of the St. Louis River estuary referred to as Spirit Lake, near the Morgan Park neighborhood of Duluth, Minnesota. Spirit Lake is approximately one square mile in size with typical water depths ranging from 2 to 10 feet (Figure E-2). The adjacent river channel averages 15 to 25 feet of water depth, and several islands and emergent wetland areas are present at the edges of, and within Spirit Lake. Adjacent upland uses include the former U. S. Steel Duluth Works steel operations and the community of Morgan Park. Features in Spirit Lake include a man-made spit of land between the Unnamed Creek and Wire Mill deltas, a dredged channel at the outer edge of the Unnamed Creek delta, and a deep-water area in the northwest corner of the Wire Mill delta. Figure E-2 depicts these features and their locations.

The shorelines of the Site tend to be comprised of sand, gravel, and larger sized aggregates, except near the mouth of Unnamed Creek where fine-grained sediments are present, and at the southern edge of the Wire Mill Delta where thick, emergent vegetation is present. The RI report discusses the current Conceptual Site Model including a summary of site meteorological observations and data with respect to climate and wind waves in detail.

2.2 Environmental Factors

Several local factors can affect ice formation and behavior. Ice action, including ice heaving and or frozen bed attachment processes are potential physical mechanisms for sediment transport or reworking. Temperature, precipitation, current, wind, and changing water levels all contribute to ice properties and/or movement, and these factors were considered during this study.

Based on historic temperature and snow cover data, it has been determined that in a normal year in the Duluth area, maximum ice thickness ranges from 21 to 34 inches (SERVICE, 2002).

High current areas have the potential to transport ice as it breaks up during spring melt, and can cause ice to transport shallow sediments in these areas, if the current moves ice from shore-attached areas. Based on the 2011 bathymetry of Spirit Lake, there are no apparent areas of high current adjacent to the shallow sediments of the Site. The Site project area is focused on the western side of Spirit Lake, while the main channel of the St. Louis River defines the eastern edge of Spirit Lake.

Currents also can be caused by seiche flow -- moving free ice as water levels rise and fall in Spirit Lake. Seiche-induced ice movement can occur as ice is forming and breaking apart, but is not considered to be a significant transport factor as ice strength is low at these times (SERVICE, 2002).

Wind can move ice as it breaks up during spring thaw into sheets that are not frozen to the sediment bed. These sheets of ice can be driven by wind into shorelines and, if the ice competency is sufficient, create ridges of sediment at the shoreline.

Surface water elevations can affect ice during spring melt. Typically, water elevations drop over the winter months leaving ice frozen at the shoreline at a higher elevation than ice with water beneath it. As the spring melt progresses this shoreline ice melts in place, protecting the shallow sediments from transport by free-floating ice. St. Louis River water levels are recorded at the US Army Corps of Engineers' (USACE) Vessel Yard at 901 Minnesota Avenue, Duluth, Minnesota. Data from the USACE monitoring station is available on the National Oceanic and Atmospheric Administration website (<http://tidesandcurrents.noaa.gov>), and can be used to approximate surface water level conditions at the Spirit Lake Sediment site.

3.0 Field Activities

3.1 Overview

Ice observation was conducted during March and April of 2011, spanning the period of transition from solid ice cover to open water. Ice observation stations were chosen to capture the conditions of the shorelines of the Site where ice formation and movement would most likely affect shallow sediments. The locations of the ten observation stations are depicted on Figure E-3, with arrows indicating the directions of observation at each station. A photographic log of ice conditions over time at each station, in each direction, is included as an appendix to this report (Appendix E-A).

Ice thicknesses (above water) were measured in March 2011 during remedial investigation activities as part of the ice safety program for work at the Site. An ice auger was used to bore a hole through the ice and a tape measure was used to measure the ice thickness. Ice thickness was measured at over 600 locations and ranged from 10 to 34 inches with an average thickness of 23 inches.

The measured ice thicknesses were consistent with the expected maximum ice thicknesses for the Duluth area. Areas of the Site with a sediment bed elevation of greater than approximately 599 feet above sea level typically had ice frozen to ground, with frozen sediments beneath. The long-term average surface water elevation at the Site is approximately 601 feet above sea level. The monthly surface water elevation averages at the USACE monitoring station during the winter of 2010/2011 are detailed in Table E-1 of this report, and show a decrease in elevation as the winter progressed.

Table E-1 Average Surface Water Elevations for St. Louis River (NOAA Great Lakes Water Level Report for Station 9099064)

Month/Year	Average Surface Water Elevation (ft above sea level)
November 2010	601.02
December 2010	600.74
January 2011	600.54
February 2011	600.27
March 2011	600.23
April 2011	600.35

3.2 Unnamed Creek Delta

The Unnamed Creek Delta is a broad, flat, shallow delta adjacent to the shoreline. Ice at the mouth of Unnamed Creek and near the shoreline in this delta was frozen to ground and melted in-place. Evidence of transport or ridging of sediment by ice along the shorelines of the Unnamed Creek Delta was not observed. Also of note is that, with the low water levels in April of 2011, much of this area was exposed above the surface water elevation of the river.

3.3 Man-Made Spit of Land

Each side of the man-made spit of land that separates the Unnamed Creek and Wire Mill deltas has shallow water close to shore. Only at the tip of the spit is there a relatively steep drop of approximately 8 feet to deeper water.

The northern shoreline of the spit defines the southern edge of the Unnamed Creek Delta, and the ice there was frozen to ground and melted in-place without evidence of sediment transport or ridging.

The southern shoreline of the spit (northern edge of Wire Mill Delta) also had ice frozen to the bed, where it melted in-place. The area southeast of the spit (near observation Stations 4 and 5) is shallow with a significant amount of emergent vegetation that prevents thick ice from forming. Some small, localized sediment ridging was observed near Station 5, possibly due to early-winter wind driving ice into the shoreline. This ridging was not consistent or predominant along the southern shoreline of the spit. Also of note in this area is the tilting of the ice due to water level drop over the winter, with subsequent cracks running parallel to shore.

During the winter of 2010/2011 an ice ridge formed at the northeastern tip of the spit. This ice ridge extended for a short distance (over water) from the end of the spit to the northeast. Based on the thickness of the ridge ice, the ridge was formed early in the winter and was likely created by ice pushed to the north by wind.

3.4 Wire Mill Delta

With the exception of a deep hole in the northwest corner, the nearshore bathymetry (2011) in the Wire Mill Delta has generally shallow depths transitioning to water depths of four to ten feet to the northeast. Ice was observed to be frozen to ground, and to melt in-place. Evidence of sediment transport or ridging along the western and southern shorelines of the Wire Mill Delta was not present during this study.

4.0 Conclusions

Ice thicknesses measured at the Site during the winter of 2010/2011 fall within the range of expected ice thicknesses for a normal winter in Duluth, Minnesota. Ice conditions were observed along the shorelines of the Site in March and April of 2011 during the transition from solid ice to open water.

The Unnamed Creek and Wire Mill deltas are generally shallow areas located on the inside curve of a river meander, and apparently are not affected by ice moved by the river channel's current.

Most of the shorelines at the Site are adjacent to very shallow water where ice freezes to the sediments during normal conditions. As ice melts in the spring, these areas frozen to ground are anchored in-place, and are not moved by wind or currents. Small, localized ridges of sediment on the southern shoreline of the spit and an ice ridge just off-shore of the tip of the spit indicate early-ice movement due to wind.

Additional observations and analysis will be summarized in a technical memo and included in the planned FS report.

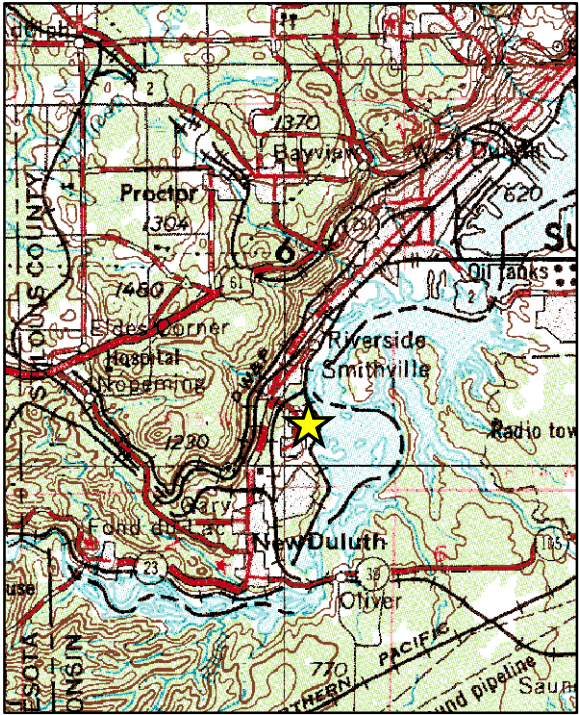
5.0 References

Barr Engineering Company, 2011. *Sediment Investigation Work Plan*, Former U.S. Steel Duluth Works Site, St. Louis River, Duluth, MN. Prepared for U.S. Steel.

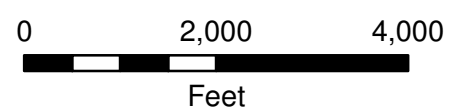
SERVICE Engineering Group, 2002. *Data Gap Report, Appendix GT6, Ice Analysis*. St. Louis River/Interlake/Duluth Tar Site, Duluth Minnesota. Available at:
<https://www.barr.com/slridt/documents.htm>

National Oceanic and Atmospheric Administration. <http://www.tidesandcurrents.noaa.gov>

Figures



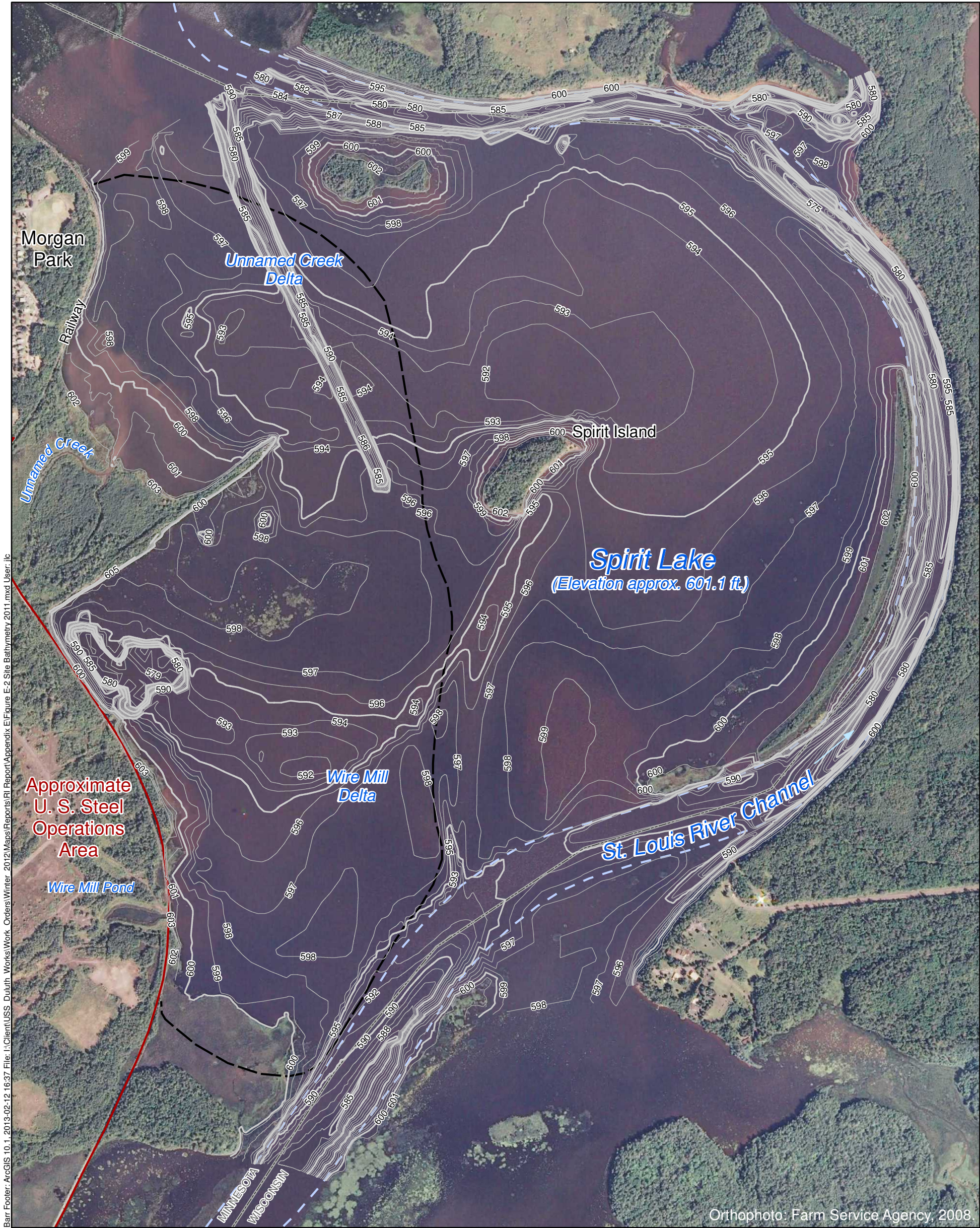
- Approximate U. S. Steel Operations Area (URS, 2008)
- State Boundary



1 Inch = 2,000 Feet

Figure E-1

SITE LOCATION
Spirit Lake Sediment Site -
Former U. S. Steel Duluth Works
Saint Louis River
Duluth, Minnesota



- Bathymetry Contour (5-Foot)
- Bathymetry Contour (1-Foot)
- Approximate Outer Study Area Limit
- Approximate Location of St. Louis River Channel, Based on Orthophoto Interpretation
- Approximate U. S. Steel Operations Area (URS, 2008)
- State Boundary

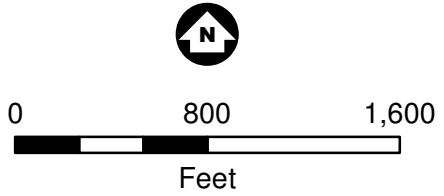
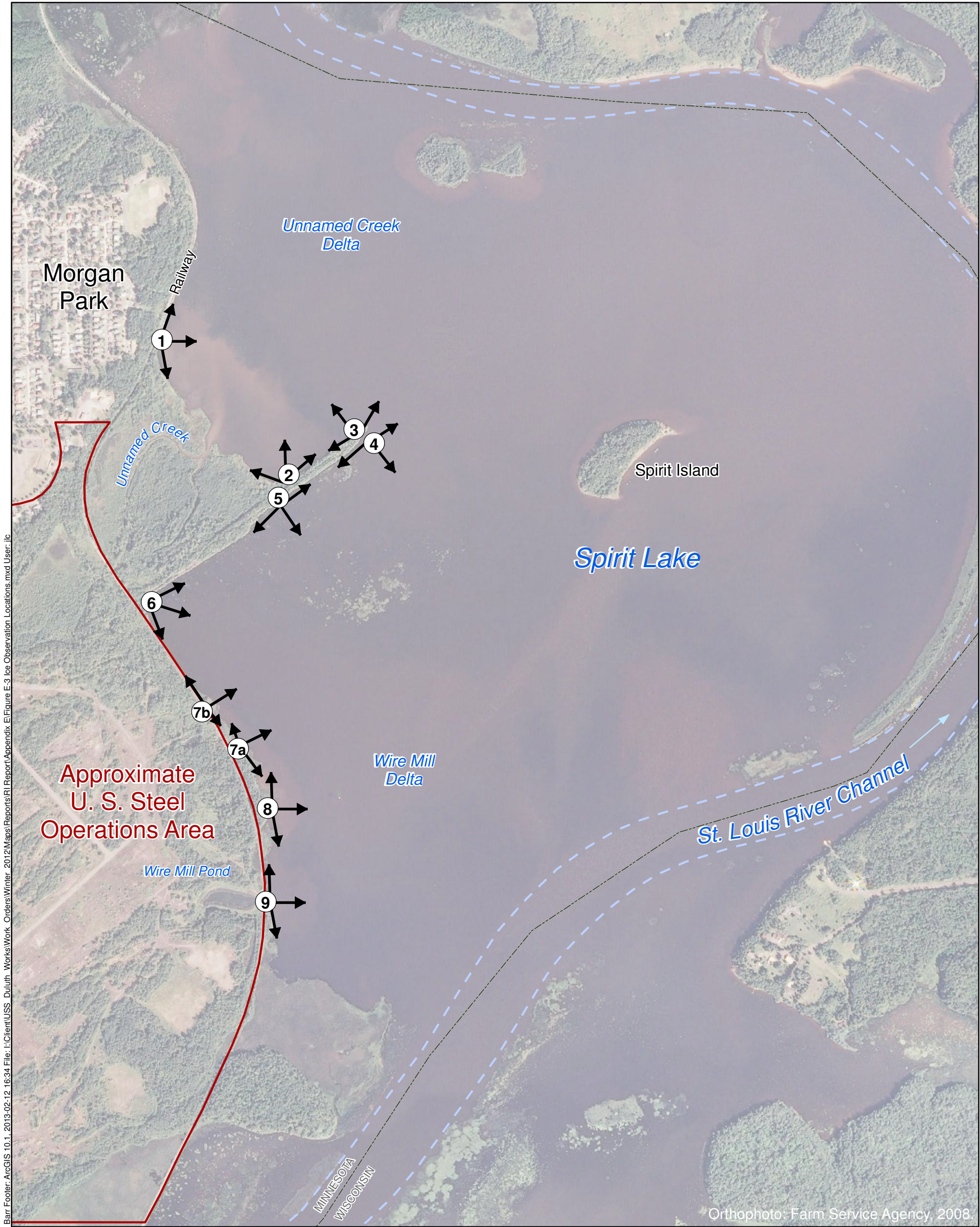


Figure E-2

SITE BATHYMETRY 2011
Spirit Lake Sediment Site -
Former U. S. Steel Duluth Works
Saint Louis River
Duluth, Minnesota



- Approximate Location of St. Louis River Channel, Based on Orthophoto Interpretation
- Approximate U. S. Steel Operations Area (URS, 2008)
- State Boundary

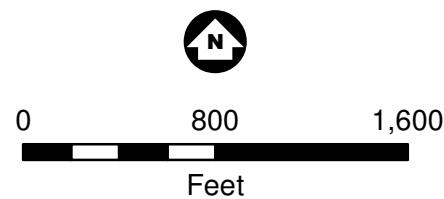



Figure E-3

**LOCATIONS OF
ICE OBSERVATION STATIONS
WINTER 2010/2011**
Spirit Lake Sediment Site -
Former U. S. Steel Duluth Works
Saint Louis River
Duluth, Minnesota





Attachment A

Ice Photographs, March 2011 and April 2011







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #1, Looking NE 3/4/2011, 13:36</p> 	<p>Station #1, Looking NE 3/11/2011, 15:13</p> 	<p>Station #1, Looking NE 3/17/2011, 12:18</p> 
<p>Station #1, Looking NE 3/18/2011, 11:14</p> 	<p>Station #1, Looking NE 3/21/2011, 10:19</p> 	<p>Station #1, Looking NE 3/28/2011, 15:38</p> 





Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #1, Looking NE 4/4/2011, 10:59</div> <div></div>	<div>Station #1, Looking NE 4/6/2011, 12:34</div> <div></div>	<div>Station #1, Looking NE 4/8/2011, 12:51</div> <div></div>
<div>Station #1, Looking NE 4/14/2011, 13:50</div> <div></div>		







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #1, Looking E 3/4/2011, 13:37</p>  A photograph of a frozen lake with a snow-covered surface. A line of bare trees is visible in the background under a grey sky. In the bottom right corner, there is orange text: "100 2: 500016.7 8-6171853.3".	<p>Station #1, Looking E 3/11/2011, 15:14</p>  A photograph of a frozen lake with snow and some dry grass in the foreground. A date stamp "2011-3-11" is visible in the bottom right.	<p>Station #1, Looking E 3/17/2011, 12:18</p>  A photograph of a frozen lake with snow and some dry grass in the foreground. A line of trees is visible in the background.
<p>Station #1, Looking E 3/18/2011, 11:13</p>  A photograph of a frozen lake with a snow-covered surface. A dark, winding line, possibly a road or path, is visible in the middle ground. Some dry grass is in the foreground.	<p>Station #1, Looking E 3/21/2011, 10:19</p>  A photograph of a frozen lake with a snow-covered surface. A dark, winding line is visible in the middle ground. Some dry grass is in the foreground.	<p>Station #1, Looking E 3/28/2011, 15:38</p>  A photograph of a frozen lake with a snow-covered surface. A dark, winding line is visible in the middle ground. Some dry grass is in the foreground.





Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #1, Looking E 4/4/2011, 10:59</div> <div></div>	<div>Station #1, Looking E 4/6/2011, 12:34</div> <div></div>	<div>Station #1, Looking E 4/8/2011, 12:51</div> <div></div>
<div>Station #1, Looking E 4/14/2011, 13:50</div> <div></div>		







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #1, Looking SE, 3/4/2011, 13:37	Station #1, Looking SE 3/11/2011, 15:14	Station #1, Looking SE 3/17/2011, 12:19
		
Station #1, Looking SE, 3/18/2011, 11:13	Station #1, Looking SE 3/21/2011, 10:19	Station #1, Looking SE 3/28/2011, 15:38
		





Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #1, Looking SE 4/4/2011, 10:58</div> <div></div>	<div>Station #1, Looking SE 4/6/2011, 12:34</div> <div></div>	<div>Station #1, Looking SE 4/8/2011, 12:51</div> <div></div>
<div>Station #1, Looking SE 4/14/2011, 13:50</div> <div></div>		







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #2, Looking NW 3/4/2011, 12:14</p>	<p>Station #2, Looking NW 3/11/2011, 15:31</p>	<p>Station #2, Looking NW 3/17/2011, 12:28</p>
		
<p>Station #2, Looking NW 3/18/2011, 11:05</p>	<p>Station #2, Looking NW 3/21/2011, 10:08</p>	<p>Station #2, Looking NW 3/28/2011, 15:22</p>
		



Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #2, Looking NW 4/4/2011, 10:04</div> <div></div>	<div>Station #2, Looking NW 4/6/2011, 12:19</div> <div></div>	<div>Station #2, Looking NW 4/8/2011, 12:35</div> <div></div>
<div>Station #2, Looking NW 4/14/2011, 13:23</div> <div></div>		







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #2, Looking N 3/17/2011, 12:28</p> 	<p>Station #2, Looking N 3/18/2011, 11:05</p> 	<p>Station #2, Looking N 3/21/2011, 10:08</p> 
<p>Station #2, Looking N 3/28/2011, 15:22</p> 	<p>Station #2, Looking N 4/4/2011, 10:04</p> 	<p>Station #2, Looking N 4/6/2011, 12:19</p> 





Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #2, Looking N 4/8/2011, 12:35	Station #2, Looking N 4/14/2011, 13:23
	







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #3, Looking NW 3/4/2011, 12:26</p> 	<p>Station #3, Looking NW 3/11/2011, 15:38</p> 	<p>Station #3, Looking NW 3/17/2011, 12:30</p> 
<p>Station #3, Looking NW 3/18/2011, 11:03</p> 	<p>Station #3, Looking NW 3/21/2011, 10:03</p> 	<p>Station #3, Looking NW 3/28/2011, 15:17</p> 

Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #3, Looking NW 4/4/2011, 10:09</div> <div>A photograph showing a wide expanse of a frozen lake. The foreground is covered in a thick layer of white snow. In the middle ground, there is a dark, narrow strip of water or a different ice formation. The background shows distant, hazy hills under a grey sky.</div>	<div>Station #3, Looking NW 4/6/2011, 12:13</div> <div>A photograph of a frozen lake with a large, irregular patch of white snow in the foreground. The snow reflects the light, making it appear very bright. The water beyond the snow is dark and still. Hills are visible in the distance.</div>	<div>Station #3, Looking NW 4/8/2011, 12:26</div> <div>A photograph showing a frozen lake with a large, irregular patch of white snow in the foreground. The snow reflects the light, making it appear very bright. The water beyond the snow is dark and still. Hills are visible in the distance.</div>
<div>Station #3, Looking NW 4/14/2011, 13:19</div> <div>A photograph showing a body of water with a small, turbulent flow or waterfall cascading over a rocky ledge in the foreground. The water is brown and turbulent. The background shows a shoreline with trees and hills.</div>		







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #3, Looking NE 3/4/2011, 12:26	Station #3, Looking NE 3/11/2011, 15:38	Station #3, Looking NE 3/17/2011, 12:30
		
Station #3, Looking NE 3/18/2011, 11:03	Station #3, Looking NE 3/21/2011, 10:03	Station #3, Looking NE 3/28/2011, 15:17
		

Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #3, Looking NE 4/4/2011, 10:09	Station #3, Looking NE 4/6/2011, 12:13	Station #3, Looking NE 4/14/2011, 13:19
		







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #4, Looking NE 3/4/2011, 12:25</p> 	<p>Station #4, Looking NE 3/11/2011, 15:39</p> 	<p>Station #4, Looking NE 3/17/2011, 12:30</p> 
<p>Station #4, Looking NE 3/18/2011, 11:02</p> 	<p>Station #4, Looking NE 3/21/2011, 10:03</p> 	<p>Station #4, Looking NE 3/28/2011, 15:16</p> 



Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #4, Looking NE 4/4/2011, 10:10	Station #4, Looking NE 4/6/2011, 12:13	Station #4, Looking NE 4/14/2011, 13:19
		

Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #4, Looking SE 3/11/2011, 15:39</p> 	<p>Station #4, Looking SE 3/17/2011, 12:30</p> 	<p>Station #4, Looking SE 3/18/2011, 11:02</p> 
<p>Station #4, Looking SE 3/21/2011, 10:03</p> 	<p>Station #4, Looking SE 3/28/2011, 15:16</p> 	<p>Station #4, Looking SE 4/4/2011, 10:10</p> 

Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #4, Looking SE 4/6/2011, 12:13	Station #4, Looking SE 4/14/2011, 13:18
	







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #4, Looking SW 3/4/2011, 12:25	Station #4, Looking SW 3/11/2011, 15:39	Station #4, Looking SW 3/17/2011, 12:30
		
Station #4, Looking SW 3/18/2011, 11:02	Station #4, Looking SW 3/21/2011, 10:03	Station #4, Looking SW 3/28/2011, 15:16
		

Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #4, Looking SW 4/4/2011, 10:10	Station #4, Looking SW 4/6/2011, 12:13	Station #4, Looking SW 4/14/2011, 13:19
		

Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #5, Looking NE 3/4/2011, 12:17</p>	<p>Station #5, Looking NE 3/11/2011, 15:47</p>	<p>Station #5, Looking NE 3/17/2011, 12:27</p>
		
<p>Station #5, Looking NE 3/18/2011, 11:00</p>	<p>Station #5, Looking NE 3/21/2011, 9:57</p>	<p>Station #5, Looking NE 3/28/2011, 15:12</p>
		
<p>Station #5, Looking NE 4/4/2011, 10:15</p>	<p>Station #5, Looking NE 4/6/2011, 12:07</p>	<p>Station #5, Looking NE 4/8/2011, 12:21</p>







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011



**Station #5, Looking NE
4/14/2011, 13:13**



Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #5, Looking SE 3/4/2011, 12:16</p>	<p>Station #5, Looking SE 3/11/2011, 15:47</p>	<p>Station #5, Looking SE 3/17/2011, 12:27</p>
		
<p>Station #5, Looking SE 3/18/2011, 11:00</p>	<p>Station #5, Looking SE 3/21/2011, 9:57</p>	<p>Station #5, Looking SE 3/28/2011, 15:12</p>
		
<p>Station #5, Looking SE 4/4/2011, 10:15</p>	<p>Station #5, Looking SE 4/6/2011, 12:07</p>	<p>Station #5, Looking SE 4/8/2011, 12:21</p>







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011



**Station #5, Looking SE
4/14/2011, 13:13**



Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #5, Looking SW 3/4/2011, 12:16</p>	<p>Station #5, Looking SW 3/11/2011, 15:47</p>	<p>Station #5, Looking SW 3/17/2011, 12:27</p>
		
<p>Station #5, Looking SW 3/18/2011, 11:00</p>	<p>Station #5, Looking SW 3/21/2011, 9:57</p>	<p>Station #5, Looking SW 3/28/2011, 15:12</p>
		
<p>Station #5, Looking SW 4/4/2011, 10:15</p>	<p>Station #5, Looking SW 4/6/2011, 12:07</p>	<p>Station #5, Looking SW 4/8/2011, 12:21</p>

Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011



**Station #5, Looking SW
4/14/2011, 13:13**



Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #6, Looking NE 3/4/2011, 12:36</p> 	<p>Station #6, Looking NE 3/11/2011, 15:52</p> 	<p>Station #6, Looking NE 3/17/2011, 12:25</p> 
<p>Station #6, Looking NE 3/18/2011, 10:57</p> 	<p>Station #6, Looking NE 3/21/2011, 9:57</p> 	<p>Station #6, Looking NE 3/28/2011, 15:09</p> 
<p>Station #6, Looking NE 4/4/2011, 10:21</p> 	<p>Station #6, Looking NE 4/6/2011, 12:04</p> 	<p>Station #6, Looking NE 4/8/2011, 12:14</p> 






Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011







**Station #6, Looking NE
4/14/2011, 13:10**








Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #6, Looking SE 3/4/2011, 12:36	Station #6, Looking SE 3/11/2011, 15:52	Station #6, Looking SE 3/17/2011, 12:25
No photograph		
Station #6, Looking SE 3/18/2011, 10:57	Station #6, Looking SE 3/21/2011, 9:54	Station #6, Looking SE 3/28/2011, 15:09
		





Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #6, Looking SE 4/4/2011, 10:21</div> <div></div>	<div>Station #6, Looking SE 4/6/2011, 12:04</div> <div></div>	<div>Station #6, Looking SE 4/8/2011, 12:14</div> <div></div>
<div>Station #6, Looking SE 4/14/2011, 13:10</div> <div></div>		






Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #6, Looking SW 3/4/2011, 12:36</p>	<p>Station #6, Looking SW 3/11/2011, 15:53</p>	<p>Station #6, Looking SW 3/17/2011, 12:25</p>
		
<p>Station #6, Looking SW 3/18/2011, 10:57</p>	<p>Station #6, Looking SW 3/21/2011, 9:54</p>	<p>Station #6, Looking SW 3/28/2011, 15:09</p>
	<p>No photograph</p>	


Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #6, Looking SW 4/4/2011, 10:21</div> <div></div>	<div>Station #6, Looking SW 4/6/2011, 12:04</div> <div></div>	<div>Station #6, Looking SW 4/8/2011, 12:14</div> <div></div>
<div>Station #6, Looking SW 4/14/2011, 13:10</div> <div></div>		







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #7a, Looking NW 3/4/2011, 12:59</p>	<p>Station #7a , Looking NW 3/11/2011, 15:53</p>	<p>Station #7a , Looking NW 3/17/2011, 12:09</p>
	<p>No photograph</p>	
<p>Station #7a , Looking NW 3/18/2011, 10:53</p>	<p>Station #7a , Looking NW 3/21/2011, 9:49</p>	<p>Station #7a , Looking NW 3/28/2011, 2:59</p>
		





Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #7a , Looking NW 4/4/2011, 10:32</div> <div></div>	<div>Station #7a , Looking NW 4/6/2011, 11:55</div> <div></div>	<div>Station #7a , Looking NW 4/8/2011, 11:58</div> <div></div>
<div>Station #7a , Looking NW 4/14/2011, 13:01</div> <div></div>		






Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #7a, Looking NE 3/4/2011, 13:00</p> 	<p>Station #7a , Looking NE 3/11/2011, 16:06</p> 	<p>Station #7a , Looking NE 3/17/2011, 12:09</p> 
<p>Station #7a , Looking NE 3/18/2011, 10:53</p> 	<p>Station #7a , Looking NE 3/21/2011, 9:49</p> 	<p>Station #7a , Looking NE 3/28/2011, 2:59</p> 





Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #7a , Looking NE 4/4/2011, 10:32</div> <div></div>	<div>Station #7a , Looking NE 4/6/2011, 11:55</div> <div></div>	<div>Station #7a , Looking NE 4/8/2011, 11:58</div> <div></div>
<div>Station #7a , Looking NE 4/14/2011, 13:01</div> <div></div>		






Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #7a, Looking SE 3/4/2011, 13:00</p>	<p>Station #7a , Looking SE 3/11/2011, 16:06</p>	<p>Station #7a , Looking SE 3/17/2011, 12:09</p>
	<p>No photograph</p>	
<p>Station #7a , Looking SE 3/18/2011, 10:53</p>	<p>Station #7a , Looking SE 3/21/2011, 9:49</p>	<p>Station #7a , Looking SE 3/28/2011, 2:59</p>
		

Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #7a , Looking SE 4/4/2011, 10:32</div> <div></div>	<div>Station #7a , Looking SE 4/6/2011, 11:55</div> <div></div>	<div>Station #7a , Looking SE 4/8/2011, 11:58</div> <div></div>
<div>Station #7a , Looking SE 4/14/2011, 13:01</div> <div></div>		






Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #7b, Looking NW 3/4/2011, 13:00	Station #7b , Looking NW 3/11/2011, 14:01	Station #7b , Looking NW 3/17/2011, 12:11
No photograph		
Station #7b , Looking NW 3/18/2011, 10:55	Station #7b , Looking NW 3/21/2011, 9:51	Station #7b , Looking NW 3/28/2011, 3:01
		





Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #7b , Looking NW 4/4/2011, 10:32</div> <div></div>	<div>Station #7b , Looking NW 4/6/2011, 11:57</div> <div></div>	<div>Station #7b , Looking NW 4/8/2011, 12:03</div> <div></div>
<div>Station #7b , Looking NW 4/14/2011, 13:04</div> <div></div>		






Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #7b, Looking NE 3/4/2011, 13:00	Station #7b , Looking NE 3/11/2011, 14:01	Station #7b , Looking NE 3/17/2011, 12:11
<p>No photograph</p>		
Station #7b , Looking NE 3/18/2011, 10:55	Station #7b , Looking NE 3/21/2011, 9:51	Station #7b , Looking NE 3/28/2011, 3:01
		





Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #7b , Looking NE 4/4/2011, 10:27</div> <div></div>	<div>Station #7b , Looking NE 4/6/2011, 11:57</div> <div></div>	<div>Station #7b , Looking NE 4/8/2011, 12:03</div> <div></div>
<div>Station #7b , Looking NE 4/14/2011, 13:04</div> <div></div>		

Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #7b, Looking SE 3/4/2011, 13:00	Station #7b , Looking SE 3/11/2011, 14:01	Station #7b , Looking SE 3/17/2011, 12:11
<p>No photograph</p>		
Station #7b , Looking SE 3/18/2011, 10:55	Station #7b , Looking SE 3/21/2011, 9:51	Station #7b , Looking SE 3/28/2011, 3:01
		




Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #7b , Looking SE 4/4/2011, 10:32</div> <div></div>	<div>Station #7b , Looking SE 4/6/2011, 11:57</div> <div></div>	<div>Station #7b , Looking SE 4/8/2011, 12:03</div> <div></div>
<div>Station #7b , Looking SE 4/14/2011, 13:04</div> <div></div>		







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #8, Looking N 3/4/2011, 12:53</p> 	<p>Station #8 , Looking N 3/11/2011, 16:13</p> 	<p>Station #8 , Looking N 3/17/2011, 12:09</p> 
<p>Station #8 , Looking N 3/18/2011, 10:53</p> 	<p>Station #8 , Looking N 3/21/2011, 9:49</p> 	<p>Station #8 , Looking N 3/28/2011, 2:54</p> 





Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #8 , Looking N 4/4/2011, 10:40</div> <div>A photograph showing a rocky shoreline with a large, flat, white ice sheet extending from the water onto the beach. The sky is overcast.</div>	<div>Station #8 , Looking N 4/6/2011, 11:55</div> <div>A photograph showing a rocky shoreline with a narrow channel of water between the beach and a large ice sheet. The sky is overcast.</div>	<div>Station #8 , Looking N 4/8/2011, 11:58</div> <div>A photograph showing a rocky shoreline with a narrow channel of water between the beach and a large ice sheet. The sky is clear and blue.</div>
<div>Station #8 , Looking N 4/14/2011, 12:53</div> <div>A photograph showing a rocky shoreline with a narrow channel of water between the beach and a large ice sheet. The sky is clear and blue.</div>		







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #8, Looking E 3/4/2011, 12:53	Station #8 , Looking E 3/11/2011, 16:13	Station #8 , Looking E 3/17/2011, 12:07
		
Station #8 , Looking E 3/18/2011, 10:50	Station #8 , Looking E 3/21/2011, 9:47	Station #8 , Looking E 3/28/2011, 2:54
		




Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #8 , Looking E 4/4/2011, 10:40</div> <div></div>	<div>Station #8 , Looking E 4/6/2011, 11:48</div> <div></div>	<div>Station #8 , Looking E 4/8/2011, 11:36</div> <div></div>
<div>Station #8 , Looking E 4/14/2011, 12:53</div> <div></div>		







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #8, Looking S 3/4/2011, 12:55	Station #8 , Looking S 3/11/2011, 16:13	Station #8 , Looking S 3/17/2011, 12:07
		
Station #8 , Looking S 3/18/2011, 10:50	Station #8 , Looking S 3/21/2011, 9:47	Station #8 , Looking S 3/28/2011, 2:54
		




Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #8 , Looking S 4/4/2011, 10:40</div> <div></div>	<div>Station #8 , Looking S 4/6/2011, 11:48</div> <div></div>	<div>Station #8 , Looking S 4/8/2011, 11:36</div> <div>No photograph</div>
<div>Station #8 , Looking S 4/14/2011, 12:53</div> <div></div>		







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #9, Looking N 3/4/2011, 12:48	Station #9 , Looking N 3/11/2011, 16:17	Station #9 , Looking N 3/17/2011, 12:05
		
Station #9 , Looking N 3/18/2011, 10:48	Station #9 , Looking N 3/21/2011, 9:44	Station #9 , Looking N 3/28/2011, 2:51
		





Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #9 , Looking N 4/4/2011, 10:46	Station #9 , Looking N 4/6/2011, 11:44	Station #9 , Looking N 4/8/2011, 11:50
		No photograph
Station #9 , Looking N 4/14/2011, 13:01		
		







Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<p>Station #9, Looking E 3/4/2011, 12:46</p> 	<p>Station #9 , Looking E 3/11/2011, 16:18</p> 	<p>Station #9 , Looking E 3/17/2011, 12:05</p> 
<p>Station #9 , Looking E 3/18/2011, 10:48</p> 	<p>Station #9 , Looking E 3/21/2011, 9:44</p> 	<p>Station #9 , Looking E 3/28/2011, 2:51</p> 





Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #9 , Looking E 4/4/2011, 10:46</div> <div></div>	<div>Station #9 , Looking E 4/6/2011, 11:44</div> <div></div>	<div>Station #9 , Looking E 4/8/2011, 11:30</div> <div></div>
<div>Station #9 , Looking E 4/14/2011, 12:50</div> <div></div>		

Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

Station #9, Looking S 3/4/2011, 12:46	Station #9 , Looking S 3/11/2011, 16:18	Station #9 , Looking S 3/17/2011, 12:04
		
Station #9 , Looking S 3/18/2011, 10:48	Station #9 , Looking S 3/21/2011, 9:44	Station #9 , Looking S 3/28/2011, 2:51
		

Appendix E-A: Ice Photograph Index, Spirit Lake Sediment Site, March 2011 and April 2011

<div>Station #9 , Looking S 4/4/2011, 10:46</div> <div></div>	<div>Station #9 , Looking S 4/6/2011, 11:44</div> <div></div>	<div>Station #9 , Looking S 4/8/2011, 11:30</div> <div></div>
<div>Station #9 , Looking S 4/14/2011, 12:50</div> <div></div>		