

## Lesson Title: The Erratic Walk

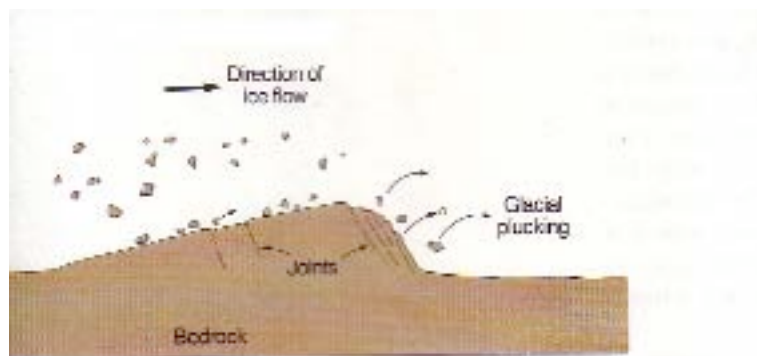
**Overview:** Students will be able to recognize glacial erratics and to understand the processes responsible for their development.

**Key goals and objectives:** A glacial erratic is a rock that was brought from another location by glacial movement, and left in a random location. In this lesson SWBAT learn how we know this, and to recognize certain rocks as an erratic. SWBAT identify rocks around the IW core campus area (and along the trails) that may or may not be glacial erratics.

**Introduction and Activity:** The last ice age created most of the surface features in the Puget Sound Lowland Basin, and also brought many rocks from Canada that were not here originally. How do we know this? What kind of rock is at our feet (granite, metamorphic, or sedimentary)?

**The core lesson:** When a glacier covers the ground it scrapes and scours the earth, picking up things — trees, plants, and rocks. The pressure of the ice freezes the ground underneath, and ice wedges between hairline cracks in the rocks. After some time, the pressure increases and the ice expands, and the rock may crack and break further. This is called ice wedging, and it does not have to happen only with glaciers, but can happen anywhere that there are repeated frosts in the winter.

When the glacier passes over some of these rocks that have been loosened by ice wedging, the glacier plucks the rocks apart and carries them downstream. This is called glacial plucking.



(Hamblin and Christiansen 1995:368)

**Theme:** glacial erratics

**Concepts:** relative time, quantification, order, and scale

**Skills:** observation, communication, infer, mapping

**Age group:** 12- 97

**Venue/s:** *Part 1:* IW core campus at one of the glacial erratics (see attached map).  
*Part 2:* at any computer with access to [learn.islandwood.org](http://learn.islandwood.org)

**Materials:** 3-4 blank laminated core campus map; Erratics.pdf

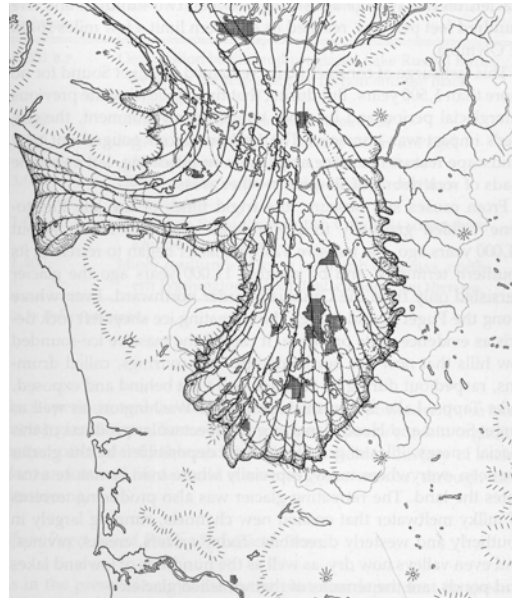
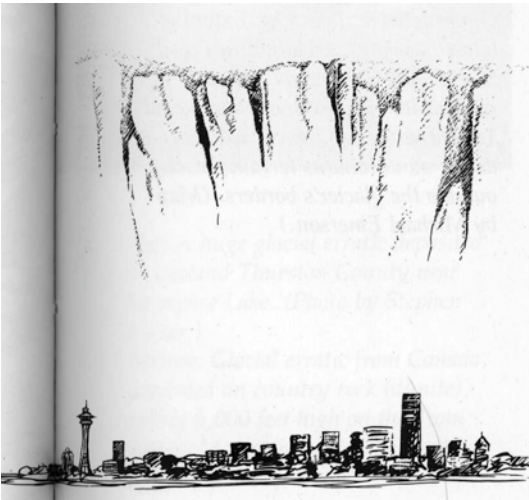
**Time:** 45 minutes to complete both parts in either order

**Set up:** none

The rocks vary in sizes, from small hand-held boulders to the size of small cars and refrigerators.

When the glacier recedes, the rocks suspended in the ice are left behind. The rocks that you see around this campus are examples of such movements, and some may have already been visible, while others were discovered and excavated in the building process.

At the peak of the glacier advance Seattle would have been under three miles of ice.



*An artist rendition of the height of the glacier over Seattle (left), and the extent of the Puget Sound Lobe (right) Kruckenberg (date: 19), adapted from (date: 21)*

*Part 1:* We are going to map the glacial erratics on the IslandWood Core Campus, so grab a marker, map, and sharp observation skills, and keep your eyes open for random rocks. First find where you are on the map. How many rocks do you think are erratics between here and the Learning Studios? Write down how many you expect to find. Mark their approximate location on your map.

[Distribute laminated maps, markers, and use attached Map as a guide. Give student groups 15 minutes to get as many as possible on the page, or until arrival at destination whichever comes first. This may be done on the way to venue of Part 2; for example, from the garden or lodge to the LS.]

*Part 2:* Before the glaciers came, the rivers of Cascades and Olympics flowed into the lowland area; those sedimentary rocks comprise the bedrock. This layer appears to be sorted (a good example in on the lower loop trail, between the spine trail and the lower dam, just before the bridge). We are going to watch a video about the glaciations of the Puget Sound Lowland, which left behind newer sediments— erratics, till (fine clay), and unsorted moraines [vashon6.mov].

How fast does the glacier advance and retreat? Watch carefully how quickly the fresh water changes to salt water; how would that affect the ecosystem? What would happen to those animals? How would that affect any people living in the area? How many times does it change? [3: fresh to salt with the advance, salt to fresh with the advance; and fresh to salt with the retreat].

[This can be done before mapping the erratics, or as follow-up activity. This video is currently available on [learn.IslandWood.org](http://learn.IslandWood.org)]

### **Conclusion:**

*Part 1:* How many rocks did you find? Do any of them look the same? What does that tell you about where they came from? Did you find all of them? Did you find any that are not marked in the master? What kinds of patterns do you notice about the placement of the rocks? [On the side of the trails]

How would these random rocks help you if chose to live here (i.e. what are they, can they be used to make tools, etc.?)?

[Compare to attached map, with erratics marked.] Did you find all of them? Did you find any that are not marked on the master?

*Part 2:* What would the landscape look like, before, during, and after the glacial advance? How would these random rocks help you if you chose to live here (i.e. what are they, can they be used to make tools, etc.?)? How many years would it be, do you think, after the glacier retreated before the forests returned?

**Assessment:** Built-in to the experience or based on a follow-up. Every once and a while stop at one of the other rocks in the central campus, and ask, "What is this? How do we know that it got here? Where did it come from? What kind of rock is it? Etc."

*Extension:* Students should write an "I am like..." poem to tell the story of a rock, glacier, and geologic features. They should include vocabulary herein — glacier, erratic, glacial plucking, ice wedging, moraines, etc.

**Safety Considerations:** No immediate safety considerations, except to send kids off in too many disparate directions in search of erratics on their own.

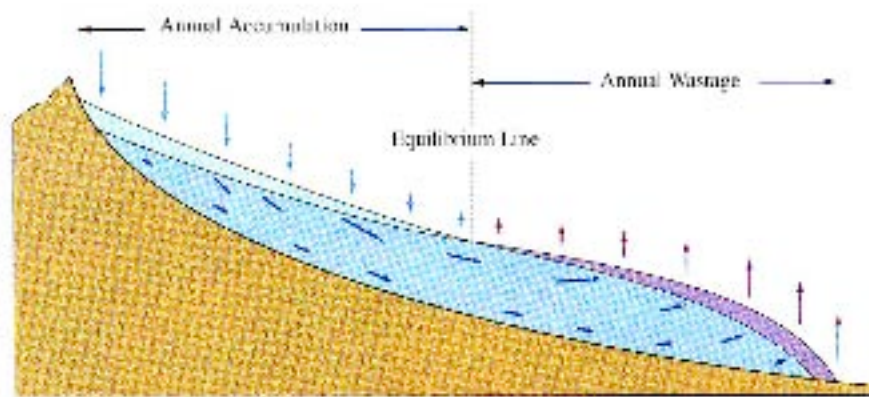
**Background information:** Glaciers are an open system of flowing ice. There are two types of glaciers: *valley glaciers* and *continental glaciers*.

A valley or alpine glacier flows down preexisting stream valleys. As the ice moves, it erodes the landscape, creating deep U-shaped valleys, sharp ridge divides, cirques, horns, and hanging valleys. Sediment deposited near the end of the glacier typically forms terminal moraines, part of which is reworked by meltwater and deposited as outwash.

A continental glacier flows up to 2 miles thick, and covers large parts of a continent. As the ice within the glacier moves, it erodes the soil and the bedrock and transports the erosional debris towards the margins of the ice, where the debris is deposited in a variety of landforms: drumlins, eskers, and ground moraines form beneath the ice. Meltwater from the glacier may rework large amounts of glacial debris and deposit it in an outwash plain in front of the ice sheet.

Water enters the system as snow, which is transformed into ice by compression and recrystallization. The ice then flows through the system under the pressure of its own weight and leaves the system by evaporation and melting. The balance between the rate of accumulation and the rate of melting determines the size of the glacial system (the body of ice).

The essential parts of a glacial system are (1) the *zone of accumulation*, where there is a net gain of ice, and (2) the *zone of ablation*, where ice leaves the system by melting, calving, and evaporating. In the zone of accumulation, the direction of movement is inclined downward with respect to the surface of the glacier. The degree of downward inclination decreases from the head of the glacier to the snow line. At the snow line, the direction of movement is upward toward the surface of the glacier. In the zone of ablation, the movement is upwards toward the surface, with upward inclination increasing from the snow line to the snout.

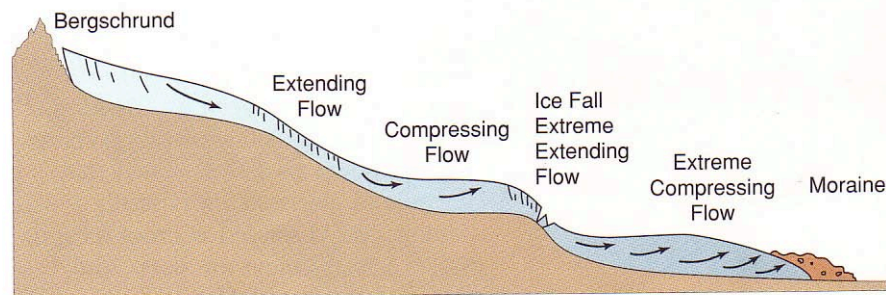


**Movement of ice through a glacier is shown in this longitudinal cross section. In the zone of accumulation, a wedge of snow is added each year. It is thickest at the head and thins to a feather edge at the snow line. A similar wedge that is thin at the snow line and thickest at the end of the glacier is removed by melting. The internal flow of the glacial ice resulting from this accumulation and wastage is shown by vector arrows. In the zone of accumulation, the ice moves downward. Near the snow line movement is horizontal; the movement is upward near the lower end.**

(Hamblin and Christensen 1995:364)

The movement of glacial ice is not uniform. The velocities of ice flow in the zone of accumulation increase progressively from the head to the snow line. Here, the ice is under tension and is constantly pulling from up-valley ice. This is the condition of

*extending flow*. Below the snow line, velocities progressively decrease, so up-valley ice is continually pushing against down-valley ice. This is a condition of *compressing flow*. Where bedrock slopes steepen, glacier velocities increase, and extending flow prevails; where the bedrock flows are gentle, velocities decrease and compressing flow occurs. Where glaciers descend over extremely steep slopes, the ice descends with high velocities, creating a veritable icefall. These are zones of extreme extending flow, and the ice is greatly thinned and completely crevassed. The flow velocity in an icefall can exceed ten times that of the glacier elsewhere along its course. At the base of an icefall, conditions are reversed; flow decreases rapidly, the compressing flow dominates and the glacier thickens.



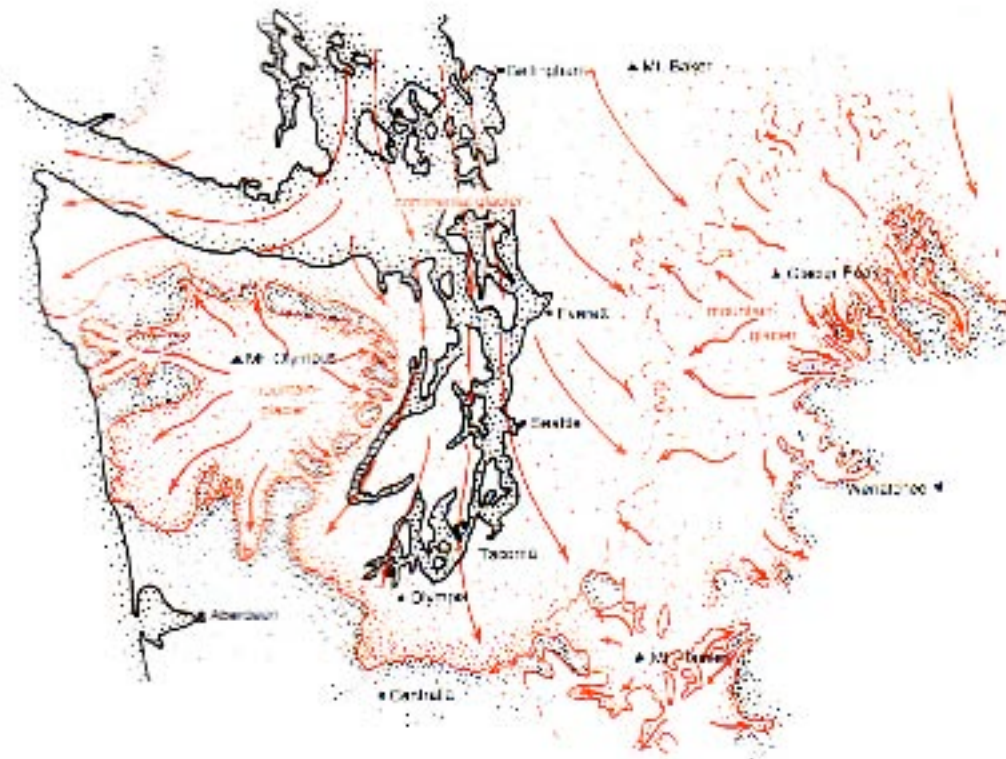
### Extended and Compressing Flow

(Hamblin and Christensen 1995:364)

Key terms: *drumlins, eskers, kettles, cirques, horn, hanging valley, lateral moraines, medial moraines, arêtes, terminal moraine, recessional moraine, and outwash plain.*

#### *Puget Sound Lowland Glaciations;*

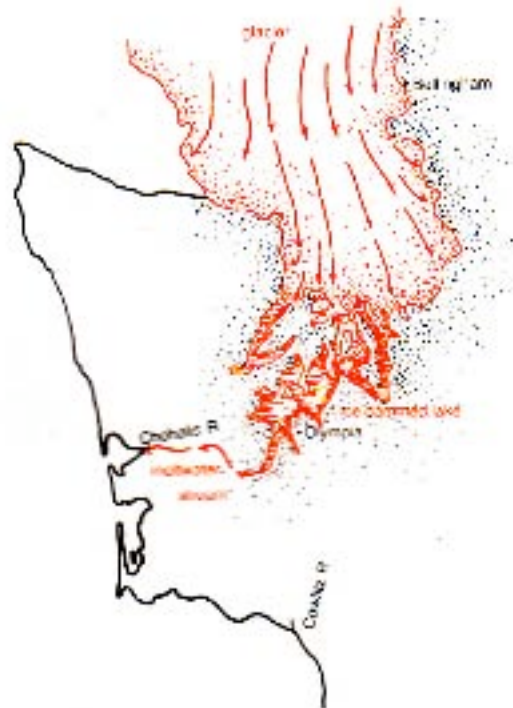
Sometime around 20,000 calendar years before present (ybp), ice from the Coast Mountains of British Columbia began filling the Fraser Lowland. The *Puget Lobe* of the ice sheet reached the US border after 19,000 ybp, Seattle about 17,600 ybp, and its farthest south extent (just south of Olympia) at about 16,900 ybp. The ice front then retreated even more rapidly than it advanced, and Seattle was ice-free by about 16,400 ybp. By about 15,000 ybp the ice front was again, back at the border (Haugerud, and Greenberg 2000).



*Approximate maximum extent of glacialiation in the Olympic Peninsula and Puget Sound lowland.*

(Alt and Hyndman 1984:252)

Before the advance of the glacier, the proto-Puget Sound almost certainly did not have the same shape as now. The bedrock comes from sedimentary deposition of the extensive cascade and Olympic rivers systems, and flowed in various directions including the Chehalis river in the south (see figure below). Some north-south troughs may not have existed and there may have been troughs where now there is upland. The pre-existing sounds, lakes, and valleys of the Lowland were filled in by advance outwash deposits; the present topography of the lowland was almost entirely eroded by Vashon-age subglacial meltwater (Booth 1994, Haugerud, and Greenberg 2000).



*Glacial meltwater drainage during the last ice age.*

(Alt and Hyndman (1984:242)

### References:

Alt, David D. and Hyndman, Donald W.  
(1984). *Roadside Geology of Washington*. Missoula, MT: Mountain Press Publishing Company.

Booth, D.B.,  
(1994). "Glaciofluvial infilling and scour of the Puget Lowland, Washington, during ice-sheet glaciation." *Geology*, v. 22, p. 695-698.

Booth, Derek B., Haugerud, Ralph A., and Troost Kathy Goetz  
(2003). "The Geology of Puget Lowland Rivers." In *Restoration of Puget Sound Rivers* (Montgomery, Bolton, Booth and Wall, eds.) Seattle: University of Washington Press.

Haugerud, Ralph, and Greenberg, Harvey  
(2000). Reconstructing the last (Vashon) continental glaciation of the Puget Lowland: The movie. *Geological Society of America Abstracts with Programs*, v. 32,

n. 6, p. A. [http://www.prism.washington.edu/vps/intrface/multigal/graphics\\_animations/animations/ps\\_glaciation2.html](http://www.prism.washington.edu/vps/intrface/multigal/graphics_animations/animations/ps_glaciation2.html). Visited November 23, 2003.

(2002). Reconstructing the last (Vashon) continental glaciation of the Puget Lowland: The movie: Vashon6.mov.

Hamblin, W. Kenneth and Christiansen, Eric H.  
(1995). *The Earth's Dynamic Systems: A Textbook in Physical Geology*. Englewood Cliffs, NJ: Prentice Hall, Inc. Ch. 15: Glacial Systems, pp.359-403.

Hamblin, W. Kenneth and Howard, James D.  
(1995). *Exercises in Physical Geology*. Englewood Cliffs, NJ: Prentice Hall, Inc. Ex. 13: Continental Glaciation, pp.133-139.

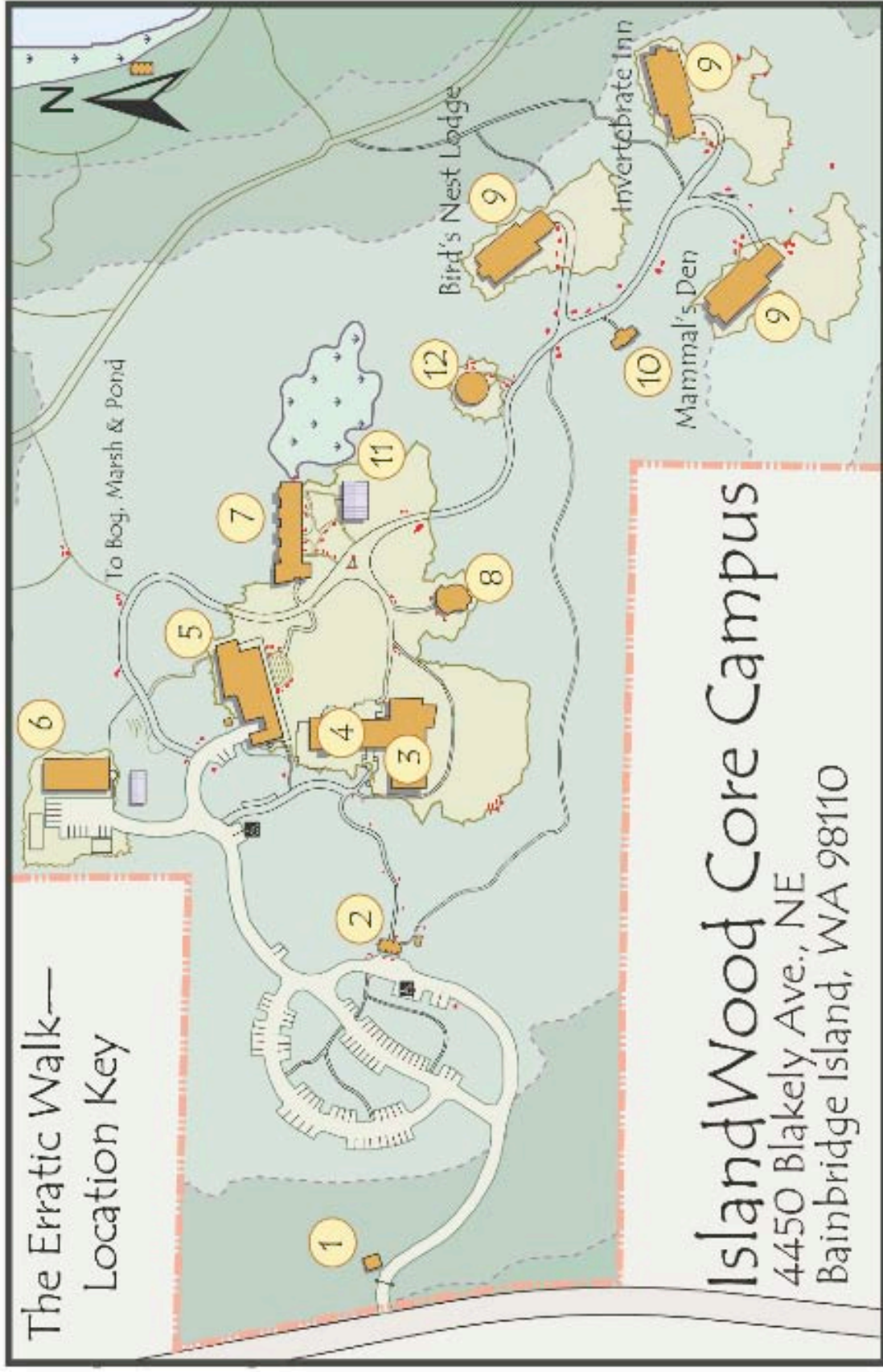
Kruckenber, Arthur R.  
(1991). *Natural History of Puget Sound Country*. Seattle: University of Washington Press.

Pacific Northwest geologic mapping and urban hazards  
(2003). Lowland Surface Processes and History. Updated May 7, 2003.  
<http://geology.wr.usgs.gov/wgmt/pacnw/reslow.html>. Visited November 23, 2003.

Pacific Northwest geologic mapping and urban hazards  
(2002). Geomorphology and surface processes. Updated April 25, 2002.  
<http://geology.wr.usgs.gov/wgmt/pacnw/reslowsm.html>. Visited November 23, 2003.

Wells, Ray, Booth, Derek, Walsh, Tim, Haugerud, Ralph, Troost, Kathy, and Logan, Josh  
(2000). The Consortium for Geologic and Hazard Mapping in Puget Sound (CHAMPS): Rationale, Strategy, and Plans for Large-Scale Digital Geologic Maps in the Central and Southern Puget Lowland. Administrative Report to USGS National Earthquake Hazards Reduction Program March 1, 2000. Updated May 7, 2003.  
<http://geology.wr.usgs.gov/wgmt/pacnw/pdf/champs6.1.pdf>. Visited November 23, 2003.

*Created by Matthew John Brewer on November 23, 2003, modified on March 8, 2004.*



# Key

- 1. Gatehouse
- 2. Welcome Shelter
- 3. Administrative Offices
- 4. Main Center / Great Hall
- Locations of Glacial Erratics (not to scale)
- 5. Dining Hall
- 6. Maintenance / Greenhouse
- 7. Learning Studios
- 8. Art Studio
- 9. Lodges
- 10. Guest Cottage
- 11. Living Machine
- 12. Friendship Circle