Review Session | GEOG201

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1. Maps and Mapping

1. Map Scales

- **Types of Map Scales**: Maps scale down real-world distances to make large areas viewable on a page. The three types of map scales are:
    - **Graphical Scale**: Presented as a bar or line. This is easy to use for measuring real distances directly, even if the map's size changes.
    - **Verbal Scale**: Describes scale in a simple statement (e.g., "one inch to the mile"). Although historically important, it's not common on modern maps.
    - **Ratio Scale**: Shows scale as a fraction or ratio (e.g., 1:50,000), meaning 1 unit on the map equals 50,000 units on the ground. This type of scale helps calculate distances accurately.
- **Small vs. Large Scale Maps**:
    - **Small-Scale Maps**: Cover large areas with less detail (e.g., world maps).
    - **Large-Scale Maps**: Show smaller areas with more detail (e.g., city maps). This is useful to remember because small and large scale can be confusing terms.
- **Using Ratio Scales for Distance Calculation**: The ratio scale allows you to calculate ground distances by multiplying the map measurement by the scale factor. For example, a 1:5,000 map would mean 1 cm on the map equals 5,000 cm (50 m) in reality.

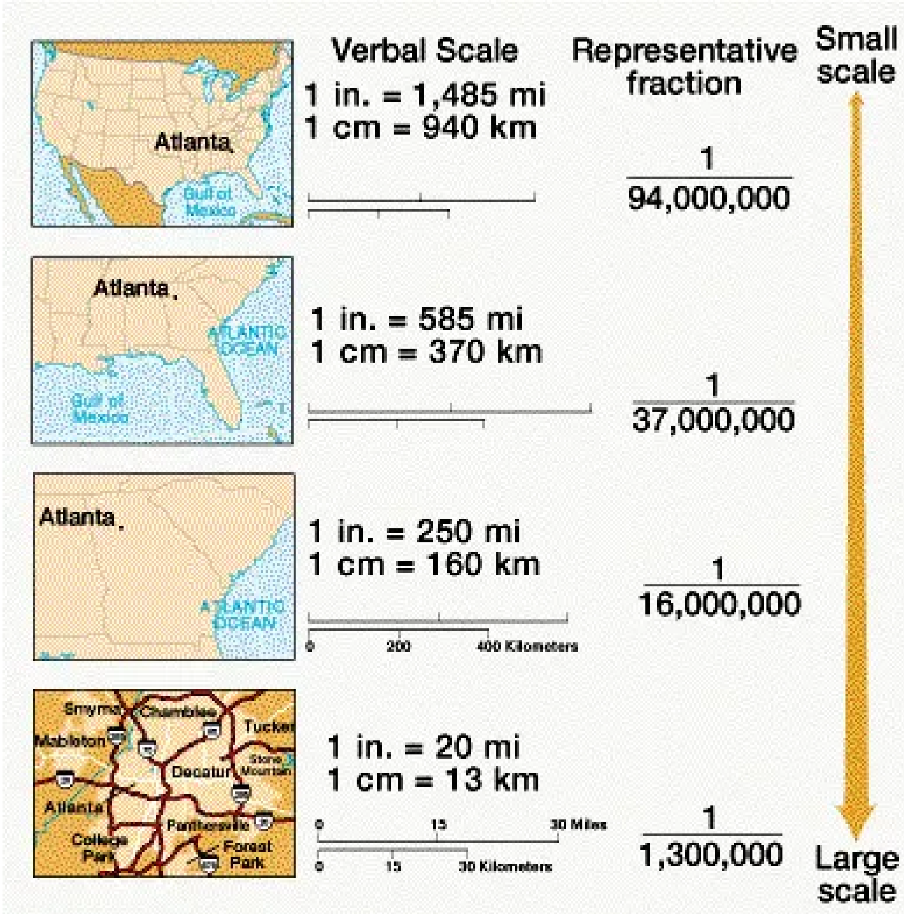

Fig 1. Scales and Maps

https://www.surveyinggroup.com/map-scale/

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2. Grid Systems

- **Geographic Coordinates**: Earth's surface is divided into a coordinate grid using latitude and longitude:
    - **Latitude**: Measures north-south position, with values ranging from 0° at the Equator to 90° at the poles. Lines of latitude run east-west.
    - **Longitude**: Measures east-west position, starting from the Prime Meridian in Greenwich, England, and extending 180° east and west to form the International Date Line. Lines of longitude converge at the poles.

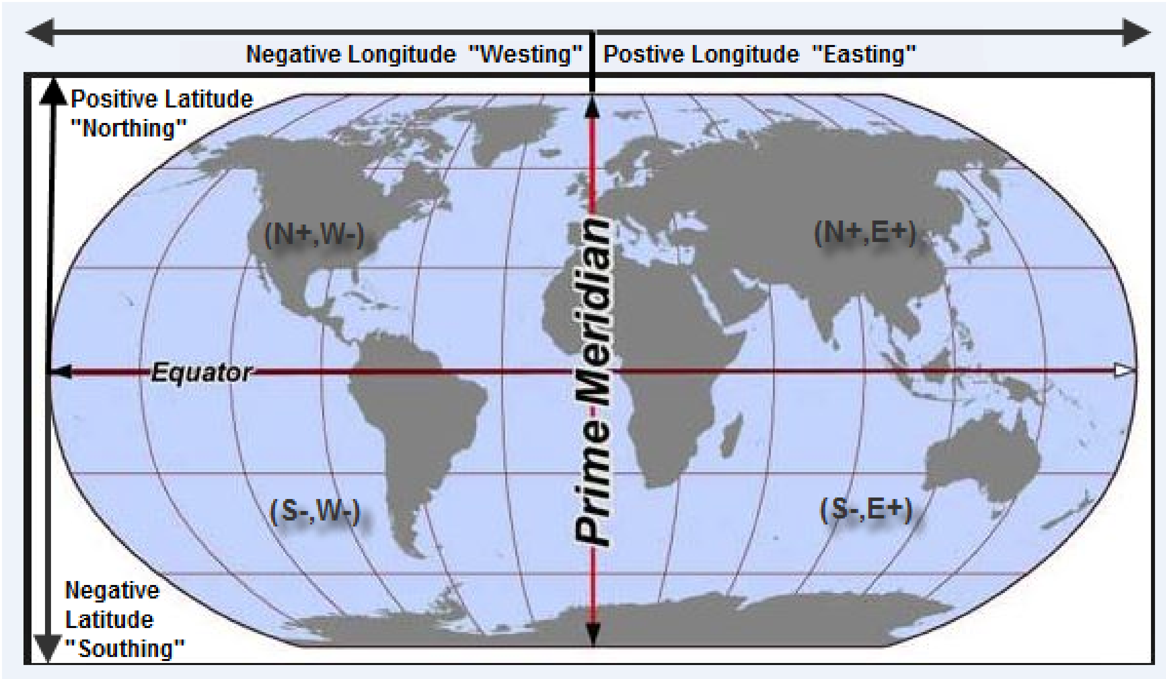

Fig 2. Geographic Coordinates

- **Universal Transverse Mercator (UTM)**: A more modern grid system that uses metric distances (in meters) instead of degrees, which simplifies calculations.
  - **UTM Zones**: The Earth is split into 60 zones, each covering 6° of longitude.
  - **Easting and Northing**:
    - **Easting** measures how far east or west a location is within a UTM zone.
    - **Northing** measures distance from the equator northward (for the northern hemisphere) or from the southern limit of the zone for the southern hemisphere.

Video: Introduction to UTM, Universal Transverse Mercator:
https://www.youtube.com/watch?v=LcVlx4Gur7I

Q1: How far is a UTM northing of 4,000,000m from the equator?

The UTM northing value measures the distance in meters north (or south in the southern hemisphere) from the equator. Since the northing is 4,000,000 meters, so the answer is 4,000,000 meters.

Q2: In the UTM system, if a location has an easting of 600,000m, is it EAST or WEST of the central meridian?

The UTM system defines the central meridian of each zone as having an easting of 500,000 meters (referred to as the false easting). An easting value greater than 500,000 meters indicates that the location is EAST of the central meridian, while an easting less than 500,000 meters would indicate it is WEST.

Since 600,000m is greater than 500,000m:

Answer: EAST.

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3. Topographic Maps

- **Contour Lines and Elevation**:
  - **Contour Lines**: Represent lines of equal elevation on a map. All points on a line share the same height above sea level.
  - **Contour Interval**: The difference in elevation between two adjacent contour lines, which shows the steepness of the terrain. A smaller interval indicates more detailed elevation changes.
  - **Index Contours**: Thicker lines that appear every fifth contour line, making it easier to read changes in elevation quickly.
- **Topographic Features**:
  - Hills, valleys, and slopes can be identified by the shapes and spacing of contour lines.
  - **Closed Circles**: Usually represent the tops of hills or depressions. If the lines are "hachured" (with small tick marks), they indicate a depression.
  - **Stream Channels**: Appear as blue lines on most maps, which are the low-lying areas where water flows.

4. Slope Calculation

- **Gradient and Percent Slope**:
  - **Gradient**: Calculated as "rise over run" (vertical change divided by horizontal distance).
  - **Percent Slope**: Calculated by multiplying the gradient by 100, which gives a percentage that shows how steep the slope is. For example, if a slope rises 10 meters over a horizontal distance of 100 meters, the slope is 10%.

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2. Minerals and Rocks

1. Minerals Overview

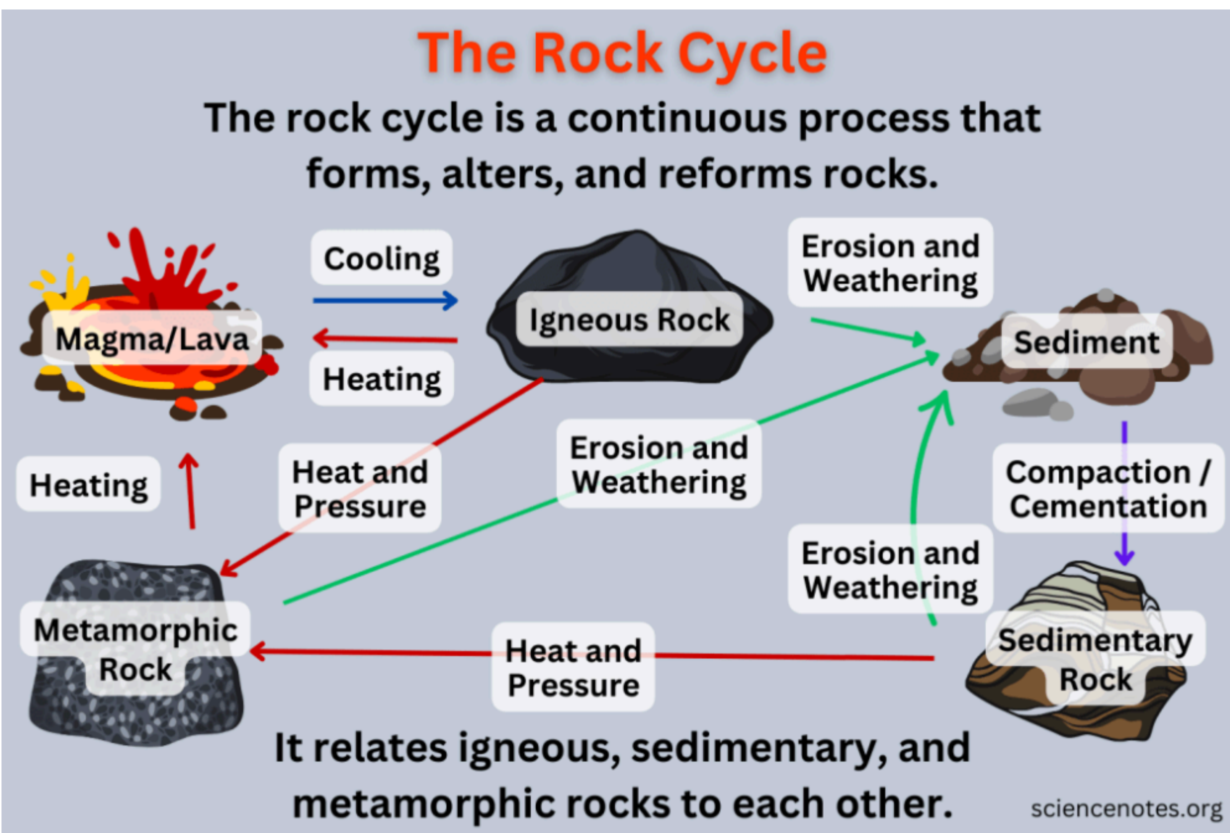
- **Definition**: Minerals are naturally occurring, inorganic substances with a specific chemical structure and repeating atomic pattern, giving each mineral unique physical properties.

- **Mineralogy**: The science of studying minerals, focusing on their properties, chemical composition, and atomic structure.

2. Mineral Properties for Identification

- **Color**: Though useful, color can vary due to impurities, so it's best to consider it along with other properties.
- **Streak**: The color of the powdered mineral, often more reliable than surface color. For instance, hematite appears black but leaves a red streak.
- **Luster**: The way a mineral reflects light; categories include metallic, vitreous (glassy), and pearly, among others.
- **Crystal Form**: Determined by atomic arrangement, with forms like cubic (e.g., halite), hexagonal, and prismatic being common.
- **Cleavage and Fracture**: Minerals break along planes of weakness (cleavage) or irregularly (fracture). For example, quartz fractures conchoidally (curved surface).
- **Specific Gravity**: Ratio of a mineral's weight to water, estimating density by hand. Higher specific gravity indicates a denser mineral.
- **Hardness**: Mohs scale (1-10) measures scratch resistance, with talc being the softest (1) and diamond the hardest (10).
- **Magnetism**: Some minerals (e.g., magnetite) are magnetic, aiding identification.

3. Types of Rocks



- **Igneous Rocks**:
    - **Formation**: Created from cooled magma or lava. Intrusive igneous rocks cool slowly beneath the surface (coarse-grained), while extrusive rocks cool quickly on the surface (fine-grained).
    - **Classification**: Based on grain size and composition. Examples include:
        - **Intrusive**: Granite (felsic, coarse-grained), Diorite (intermediate).
        - **Extrusive**: Basalt (mafic, fine-grained), Obsidian (volcanic glass with no crystals).
- **Sedimentary Rocks**:
    - **Formation**: Result from deposition and lithification of sediments, often showing visible layers or beds.
    - **Categories**:
        - **Clastic**: Classified by grain size, including shale (fine), sandstone (medium), and conglomerate (coarse, rounded grains).
        - **Chemical**: Formed by precipitation of minerals; limestone is a common example, often derived from calcium carbonate.
- **Metamorphic Rocks**:
    - **Formation**: Altered by heat, pressure, or chemical processes. Foliation (alignment of mineral grains) is common in some metamorphic rocks.
    - **Examples**:
        - **Slate**: Derived from shale, shows foliation.
        - **Marble**: Formed from limestone, valued for its appearance and softness.
        - **Quartzite**: Hard and durable, formed from sandstone.

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3. Soils and Soil Mapping

1. Overview of Soil Composition and Soil Science

- **Soil Components**: Soils consist of minerals, organic matter, water, and air. They're vital for supporting plant growth and are influenced by climate, organisms, and geological factors.
- **Soil Science**: Focuses on soil formation, classification, mapping, and studying soil properties (physical, chemical, biological) for land use and management.

2. Basic Soil Properties

- **Soil Texture**:
    - Refers to the size distribution of soil particles (sand, silt, clay).
    - Most soils are a mix, classified using the soil texture triangle, which shows proportions of sand, silt, and clay.
    - Particle size impacts water retention, drainage, and suitability for agricultural use.
- **Soil Structure**:

    - Soil particles cluster into “peds” (aggregates) with various shapes and sizes, impacting soil aeration, water movement, and plant growth.
    - Types include blocky, platy, and granular structures, influencing soil workability and drainage.

3. Importance of Soil Texture and Structure

- **Infiltration and Permeability**:
    - Infiltration is the rate at which water enters soil, while permeability indicates how water moves through soil layers.
    - Soils with larger particles (like sand) typically have higher permeability and quicker drainage than fine-textured soils (like clay).
- **Water-Holding Capacity and Porosity**:
    - Porosity measures the volume of pore spaces, crucial for retaining moisture.
    - Soils with high porosity (e.g., clay) hold water longer but have slower permeability, making them prone to waterlogging.
- **Practical Applications**:
    - Farmers and builders assess soil permeability and porosity for crop growth and construction planning. High-clay soils retain water but may lead to surface runoff.

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4. Mass Wasting

1. Introduction to Mass Wasting

- **Definition**: Mass wasting is the downslope movement of soil and rock under gravity's influence. This process varies widely in speed, from rapid landslides to slow soil creep.
- **Angle of Repose**: The maximum slope angle at which unconsolidated materials remain stable. It typically ranges between 25-40° depending on material type and cohesion.
- **Triggering Events**: Mass wasting can be triggered by external factors like heavy rainfall or earthquakes, especially when slopes exceed the angle of repose.

2. Types of Mass Wasting Events

- **Classifications by Speed and Moisture**:
    - **Fast Events**: Landslides (quick, with defined movement along a surface) and mudflows (rapid, high-water content).
    - **Slow Events**: Soil creep (very gradual movement often seen in dry conditions).
- **Impact of Vegetation**: Plant roots can stabilize slopes by binding soil particles, reducing the risk of mass wasting until triggering events occur.

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5. Surface Hydrology and Watershed Processes

Introduction to Surface Hydrology

- **Definition**:
  - Hydrology examines water movement on and near the Earth's surface, including processes like runoff, infiltration, and stream discharge.
- **Runoff and Infiltration**:
  - Runoff occurs when precipitation exceeds the soil's capacity to absorb water.
  - Human activities, such as urbanization, reduce infiltration, increase runoff, and exacerbate flooding and erosion risks.
- **Hydrologic Systems**:
  - Water pathways after precipitation include interception (evaporation before reaching the ground), infiltration, and runoff.

Runoff and Human Impact

- **Key Factors Influencing Runoff**:
  - **Soil Texture**:
    - Sandy soils absorb more water (higher infiltration, less runoff).
    - Clay-rich soils retain water at the surface, increasing runoff.
  - **Vegetation**:
    - Reduces runoff by intercepting rain and enhancing infiltration.
    - Forest clearing increases runoff and flood risk.
- **Urbanization Impacts**:
  - Impervious surfaces (e.g., roads, buildings) amplify runoff and reduce groundwater recharge, causing flash floods and lower water tables.

Drainage Basins and River Discharge

- **Drainage Basin**:
  - An area where all runoff flows to a single outlet.
  - Boundaries are defined by drainage divides (topographic highs).
- **River Discharge (Q)**:
  - Volume of water flowing through a channel, calculated as: $Q = A \times V$

Where A is the cross-sectional area (W×D), and V is the mean velocity.

  - Used to assess flood size, water yield, and low-flow conditions.
- **Measuring Discharge**:
  - Divide the river channel into segments, calculate area and velocity for each, then sum up the discharges of all segments.

Key Calculations

- **Discharge**:
  - $Q=A\times V$ for each segment; total discharge is the sum of all segments.
- **Mean Depth**:
  - $\text{Mean Depth}=\text{Total Area}/\text{Total Width}.$
- **Mean Velocity**:
  - $\text{Mean Velocity}=\text{Total Discharge}/\text{Total Area}.$

Q1: A storm drops 4" of rainfall on the USC campus, of which 0.5" is intercepted by vegetation and evaporates before ever reaching the ground. Of the remaining water, 0.5" infiltrates into the soil. What is the total depth of surface runoff that you would expect?

1. **Total rainfall**:
   4 inches.
2. **Interception by vegetation**:
   0.5 inches of rainfall is intercepted and evaporates, so the remaining water:
   $4-0.5=3.5$inches.
3. **Infiltration into the soil**:
   Of the remaining 3.5 inches, 0.5 inches infiltrates into the soil, leaving:
   $3.5-0.5=3.0$inches.

Thus, the **total surface runoff** expected is 3.0 Inches.

Answer: 3.0 inches.

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6. Fluvial Processes and Landforms

Introduction to Fluvial Processes

- **Definition**: Fluvial processes involve the movement of water and sediment within drainage basins, shaping landforms through erosion, transportation, and deposition.
- **Variation Across Environments**: Fluvial processes and resulting landforms differ significantly between arid/humid and tropical/polar regions, influenced by climate, geology, and surface materials.

Drainage Networks and Watershed Characteristics

- **Drainage Density (Dd)**:
  - Measures how well a watershed is drained.
  - Formula: $Dd = Total\ Channel\ Length/Drainage\ Area$.
  - High drainage density correlates with rapid water delivery and higher erosion risks.

- **Drainage Patterns**:
    - Geometric arrangements of streams, such as dendritic, radial, or rectangular, reflect geological conditions.
- **Stream Order**:
    - Classification of streams based on the Strahler system. Headwater streams are first-order; higher orders result from confluences of streams of the same order.
    - Example: The Mississippi River is a tenth-order stream.
- **Impact of Land Use**:
    - Urbanization and deforestation increase runoff, peak discharges, and flood risks, while natural forests reduce flooding by enhancing infiltration.

Fluvial Landforms

- **Channel Types**:
    - **Braided Channels**: Multiple rejoining channels with high sediment loads and unstable banks.
    - **Meandering Channels**: Single sinuous channels balancing erosion and deposition, creating dynamic equilibrium.
    - **Straight Channels**: Often human-made for flood control or navigation.
- **Floodplain Features** (Table 1):
    - **Floodplain**: Low-lying area adjacent to rivers prone to flooding.
    - **Cutbank**: Erosional outer bend of a meander.
    - **Point Bar**: Depositional inner bend of a meander.
    - **Oxbow Lake**: Former meander cut off from the river.
    - **Scroll Bars & Levees**: Formed by deposition along meander bends or channel edges.
    - **Yazoo River**: Tributary running parallel to the main channel, blocked by natural levees.

Dynamic River Features

- **Lateral Migration**:
    - Meandering streams shift side-to-side, eroding cutbanks and depositing point bars, maintaining a balance of forces over time.
- **Floodplain Evolution**:
    - Features such as oxbow lakes and meander scars record a river's historical paths, which can be studied to understand geomorphic processes.

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7. Coastal Landforms and Processes

Introduction to Coastal Processes

- **Role of Waves**:
  - Waves are powerful agents of coastal change, capable of eroding landforms (e.g., sea cliffs) and building features like beaches.
- **Wave Behavior**:
  - Waves slow down as they approach shallow water, increasing height and decreasing wavelength due to interaction with the ocean floor (bathymetry).
  - Classification:
    - **Deep Water Waves**: $h>L/2$ (water depth greater than half the wavelength).
    - **Shallow Water Waves**: $h<L/20$ (water depth less than one-twentieth of the wavelength).
- **Wave Energy Calculation**:
  - Formula: $E = \frac{1}{8}\rho g H^2$
    - ρ: density of seawater (1029 kg/m³).
    - g: gravity (9.78 m/s²).
    - H: wave height.
  - Wave energy increases significantly with wave height, explaining the destructive power of storm waves.

Longshore Currents and Sediment Transport

- **Mechanism**:
  - Waves striking the coast at an angle generate longshore currents that transport sediment parallel to the shore.
  - These currents shape depositional landforms like barrier islands, spits, and beaches.
- **Human Structures**:
  - **Groins and Jetties**:
    - Built perpendicular to the shore, these structures trap sand on the updrift side, causing erosion on the downdrift side.
- **Dominant Current Direction**:
  - Observed by identifying sand accumulation on the updrift side of structures or growth direction of natural features like spits.

Barrier Islands

- **Definition**:
  - Narrow, low-lying landforms parallel to the coast, separated by a lagoon or bay. Barrier islands are dynamic, reshaped by storms, sea-level changes, and wave action.
- **Components**:
  - **Intertidal Beach**: Always wet; lies between high and low tide marks.
  - **Berm Crest**: Boundary between upper beach and intertidal zone, often marking high tide limits.

    - **Upper Beach**: Largest beach area, containing vegetation and debris lines.
    - **Foredune**: Vegetated primary dune forming the landward boundary of the beach.
    - **Swale**: Low-lying area between dunes.
    - **Washover**: Sediment deposition landward of dunes during storms.
- **Beach Profiles**:
    - Surveys provide elevation and distance data to identify and label features like dunes and washovers.