Levees

Part 1: Reading Questions

1) What causes rivers to flood? ____________________________________________

2) Does flooding affect people?    Yes         No

3) What can engineers do to protect people from flooding? ________________________

4) Draw the following pictures

<table>
<thead>
<tr>
<th>Land Before Levee was Built</th>
<th>Land After Levee was Built</th>
</tr>
</thead>
</table>

5) ____________________________________________ allow the levees to hold back water.

<table>
<thead>
<tr>
<th>Structure of the Levee</th>
<th>Function</th>
</tr>
</thead>
</table>

6) Rocks along the side of the levee allow the levee to ____________________________

<table>
<thead>
<tr>
<th>Structure of the Levee</th>
<th>Function</th>
</tr>
</thead>
</table>

7) What factors do people need to think about when designing a levee? ______________
   ______________

8) Do all people agree that all factors are equally important?    Yes         No

9) How do levees fail? ____________________________________________

__________________________________________
**Part 2: Material Exploration**

**Engineering Problem**

The city of Lowlandia has contacted several engineering firms and requested that each firm put together a bid and a scale model of a levee that they could construct for the town. The firm with the “best” levee will be hired to build the town’s new levee.

**Earth Materials**

Lowlandia has the following materials that can be used to build the levee:

- Rocks
- Gravel
- Sand
- Clay
- Grass

**Testing Earth Materials**

For each of the materials above, construct a levee solely out of that material. Test how well the levee holds back flood waters by pouring 50 mL of water behind the levee and letting it sit for 30 s. Then test how well the levee withstands erosion from rain by filling the rain cup 1/4 of the way full of water and letting it rain on the levee for 10 seconds.

10) Rocks (Cost: $20 per cup)

Drawing of Material

<table>
<thead>
<tr>
<th>The material held back floodwater (water behind levee).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree 1 2 3 4 5 Disagree</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The material eroded with rain (water on top of levee).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree 1 2 3 4 5 Disagree</td>
</tr>
</tbody>
</table>

What function could rocks serve in the levee? 

_______________________________________________________

_______________________________________________________

_______________________________________________________

_______________________________________________________

_______________________________________________________
11) Gravel (Cost: $20 per cup)

The material held back floodwater (water behind levee).
Agree 1 2 3 4 5 Disagree

The material eroded with rain (water on top of levee).
Agree 1 2 3 4 5 Disagree

What function could gravel serve in the levee?

12) Sand (Cost: $20 per cup)

The material held back floodwater (water behind levee).
Agree 1 2 3 4 5 Disagree

The material eroded with rain (water on top of levee).
Agree 1 2 3 4 5 Disagree

What function could sand serve in the levee?

13) Clay (Cost: $100 per cup)

The material held back floodwater (water behind levee).
Agree 1 2 3 4 5 Disagree

The material eroded with rain (water on top of levee).
Agree 1 2 3 4 5 Disagree

What function could clay serve in the levee?
14) Grass (Cost: $10 per 5 cm x 5 cm square (size of drawing box below))

Drawing of Material

The material held back floodwater (water behind levee).

Agree 1 2 3 4 5 Disagree

The material eroded with rain (water on top of levee).

Agree 1 2 3 4 5 Disagree

What function could grass serve in the levee?_____________________

_________________________________________________________

Part 2: Designing Levees

Levee Testing

To see how the levees perform, the following tests will be done:

Test 1: 100 mL of rain will fall on the levee.

Test 2: The floodwaters will rise to half the maximum predicted flood height and will sit for 30 seconds.

Test 3: The floodwaters will rise to the maximum predicted flood height and will sit for 30 seconds.

Levees will be evaluated on how well they perform and their cost.

Preliminary Levee Design

As a group, use your findings about how the Earth materials interact with water to help you design the best levee for Lowlandia. Lowlandia has set your budget to be $400. City planners think you will need ~12 cups of material in your final levee construction. Use the terms in the picture below when deciding where to use materials. In the city yard are the following tools that you can use: a water truck (squirt bottle), a backhoe (spoon), and a dump truck (bowl).

<table>
<thead>
<tr>
<th>Levee Material</th>
<th>Price per Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocks</td>
<td>$20 per cup</td>
</tr>
<tr>
<td>Gravel</td>
<td>$20 per cup</td>
</tr>
<tr>
<td>Sand</td>
<td>$20 per cup</td>
</tr>
<tr>
<td>Clay</td>
<td>$100 per cup</td>
</tr>
<tr>
<td>Grass</td>
<td>$10 per square (5 cm x 5 cm)</td>
</tr>
</tbody>
</table>
15) We will use **rocks** in our levee: yes no (if no, skip to **gravel**)

Rocks will be used in the following locations: (circle all that apply)

- Upper Surface
- Lower Surface
- Upper Inside
- Lower Inside

We are putting rocks here because:

- It is resistant to rain or normal erosion
- It helps hold water back
- It is cheap
- It is expensive
- Other: _______________________________________________________

16) We will use **gravel** in our levee: yes no (if no, skip to **sand**)

Gravel will be used in the following locations: (circle all that apply)

- Upper Surface
- Lower Surface
- Upper Inside
- Lower Inside

We are putting gravel here because:

- It is resistant to rain or normal erosion
- It helps hold water back
- It is cheap
- It is expensive
- Other: _______________________________________________________

17) We will use **sand** in our levee: yes no (if no, skip to **clay**)

Sand will be used in the following locations: (circle all that apply)

- Upper Surface
- Lower Surface
- Upper Inside
- Lower Inside

We are putting sand here because:

- It is resistant to rain or normal erosion
- It helps hold water back
- It is cheap
- It is expensive
- Other: _______________________________________________________
18) We will use **clay** in our levee: yes no (if no, skip to grass)

Clay will be used in the following locations: (circle all that apply)

- Upper Surface
- Lower Surface
- Upper Inside
- Lower Inside

We are putting clay here because:

- ☐ It is resistant to rain or normal erosion
- ☐ It helps hold water back
- ☐ It is cheap
- ☐ It is expensive
- ☐ Other: ____________________________________________________

19) We will use **grass** in our levee: yes no

Grass will be used in the following locations: (circle all that apply)

- Upper Surface
- Lower Surface
- Upper Inside
- Lower Inside

We are putting grass here because:

- ☐ It is resistant to rain or normal erosion
- ☐ It helps hold water back
- ☐ It is cheap
- ☐ It is expensive
- ☐ Other: ____________________________________________________

20) Use the checklist below to verify your group has materials for each section of the levee. If not, go back and modify questions 15-19.

**Inside Levee**

The **Upper Inside** of the levee will be made from (check all that apply):

- ☐ rocks
- ☐ gravel
- ☐ sand
- ☐ clay
- ☐ grass

The **Lower Inside** of the levee will be made from (check all that apply):

- ☐ rocks
- ☐ gravel
- ☐ sand
- ☐ clay
- ☐ grass

**Outside Levee**

The **Upper Outside** of the levee will be made from (check all that apply):

- ☐ rocks
- ☐ gravel
- ☐ sand
- ☐ clay
- ☐ grass

The **Lower Outside** of the levee will be made from (check all that apply):

- ☐ rocks
- ☐ gravel
- ☐ sand
- ☐ clay
- ☐ grass
21) Draw a picture of your levee using the following symbols

- Rock
- Gravel
- Sand
- Clay
- Grass

Max Predicted Flood Level

Upper Surface (~2 cups)

Upper Inside (~3 cups)

Lower Inside (~4 cups)

Lower Surface (~3 cups)

Sand/Gravel Base

1/2 Flood Level

Land Here

Water Here

22) Will you be able to afford your levee? Keep in mind that you only have $400.  Yes  NO*

*If you answered no go back and modify questions 15-20.

Part 3: Building Levees

Levee Evaluation

As a class, fill out the levee evaluation tool, so that all levees will be evaluated the same after they are constructed.

Building Your Levee

As a group, construct your levee. You must follow the union rules below during construction.

1) Workers (you) cannot touch the soil with their hands.
2) Workers can only use one tool at a time.

Any time that your firm does not obey the rules you will be fined $10, which will come out of your $400 levee budget.

Buying Materials

To get materials you will need to give the store the correct amount of money.

You can buy full cups or half cups of materials. Grass must be bought in 5 cm x 5 cm pieces. Unused, unmixed materials can be returned to the store for credits, if needed.
## Levee Statistics

<table>
<thead>
<tr>
<th>Levee Material</th>
<th>Price per Unit</th>
<th>Amount Used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Full Cups</td>
</tr>
<tr>
<td>Rocks:</td>
<td>$20 per cup</td>
<td></td>
</tr>
<tr>
<td>Gravel:</td>
<td>$20 per cup</td>
<td></td>
</tr>
<tr>
<td>Sand:</td>
<td>$20 per cup</td>
<td></td>
</tr>
<tr>
<td>Clay:</td>
<td>$100 per cup</td>
<td></td>
</tr>
</tbody>
</table>

Number of Squares

<table>
<thead>
<tr>
<th>Levee Material</th>
<th>Price per Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass:</td>
<td>$10 per square</td>
</tr>
</tbody>
</table>

Total Cost: $400 - $__________ = $__________

Money Left

---

### Part 4: Levee Testing and Evaluation

#### Levee Ratings

Fill out the form below as you test your levee and 2 others levees. Make sure that you use the evaluation tool to give a score (1-4) for the cost and the performance.

<table>
<thead>
<tr>
<th></th>
<th>Firm 1</th>
<th>Firm 2</th>
<th>Firm 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levee Cost:</td>
<td>$____________</td>
<td>$____________</td>
<td>$____________</td>
</tr>
<tr>
<td>Cost Score:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Check box if test is passed)</td>
<td>☐ Rain</td>
<td>☐ Rain</td>
<td>☐ Rain</td>
</tr>
<tr>
<td>☐ ½ Flood</td>
<td>☐ ½ Flood</td>
<td>☐ ½ Flood</td>
<td></td>
</tr>
<tr>
<td>☐ Flood</td>
<td>☐ Flood</td>
<td>☐ Flood</td>
<td></td>
</tr>
<tr>
<td>Performance Score:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Score:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Part 4: Discussion Questions

- Think about how your levee performed in Test 1 (rain).
- Discuss with your firm how your levee held up to rain and normal erosion.

23) How could you change your levee to better withstand rain and erosion?__________________
______________________________________________________________________________
______________________________________________________________________________

- Think about how your levee performed in Test 2 (half flood) and Test 3 (full flood).
- Discuss with your firm how your levee held up to flooding.

24) How could you change your levee to better withstand flooding?____________________
______________________________________________________________________________
______________________________________________________________________________

25) Are levee cost and levee performance equally important why or why not?__________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

26) Do you think that all people will agree with this (circle one)? Yes No

27) I think firm (1  2  3) deserves the contract because_______________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Circle One
28) The structural difference between levee A and levee B is ___________________________

29) The function of this feature is ___________________________________________________

30) Levee ____ is the better design because ___________________________________________

______________________________________________________________________________

31) The structural difference between levee C and levee D is ___________________________

32) The function of this structure is _________________________________________________

33) Levee ____ is the better design because ___________________________________________

______________________________________________________________________________

34) The structural difference between levee E and levee F is ___________________________

35) The function of this structure is _________________________________________________

36) Levee ____ is the better design because ___________________________________________

______________________________________________________________________________

37) What is the purpose of a levee?_______________________________________________

______________________________________________________________________________

Before answering the next question watch the levee video.

38) Are there any negative impacts to building levees, if so what are they?______________

______________________________________________________________________________