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Common Issues and FVMs (Frequent Vignette Mistakes):
Section E — Grading, Drainage & Stormwater Management

2011

Introduction

Section E of the LARE consists of four (4) Vignettes that will cover various aspects of the grading, drainage and storm water management. None of the practice vignettes available on line (this ASLA website, Google Groups), in the various publications, or those provided at review sessions will be exactly like the exam you will be taking. However, practicing with as many vignettes as possible will help to familiarize you with the format and technical challenges of the Section E exam.

The following comments and tips reflect the basic principles and concerns tested in Section E. The intent is to help you prepare for the performance vignettes. Highlighted are common errors that candidates make, as well as basic do's and don'ts that need to be addressed. Strategies for the process of solving specific probable situations are also discussed. The specific percentages, ranges, vegetation protection instructions, etc. given are generally accepted but are not guaranteed to be those on the actual exam—you must read and follow the vignette problem statement directions and *Reference Manual* for your exam!

Specific common errors on Section E include but are not limited to:

- DID NOT FOLLOW DIRECTIONS!!!!!
- Solutions were incomplete or the candidate ran out of time
- Did not adequately address program requirements
- Failed to provide important spot elevations
- Relied on "eyeballing" contours rather than accurately measuring/scaling (thus swales too shallow, slopes are flatter or steeper than allowed, inconsistent grades on sloping planes or embankments, reverse or missing curbs, reverse crowns on roads, etc.)
- Provided too little cover over pipes
- Did not respect minimums, maximums, etc. as stated in the *Reference Manual* or on the problem statement
- Did not consider implicit and unwritten expectations--the things a competent landscape architect does not need to be told to do (do not grade outside limits of work/property line,

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do not grade under drip-lines of trees to remain, etc.)

- Was unable to correctly visualize landforms and thus surface water flow
- Simple math errors or writing down the wrong number
- Spending too much time "perfecting" one solution at the expense of finishing other vignettes
- Over reliance on the calculator for simple computations

General Considerations

Follow the directions

The requirements for each vignette are given in either the problem statement or the *Reference Manual*. The requirements are very specific. Resist the temptation to alter them. You need to work to solve the problems using the criteria given for each vignette. A major beginning point for licensure testing is the ability to read, understand and follow directions

***The importance of the* Reference Manual**

Make sure you get the most recent edition of the *Reference Manual* from the CLARB web site! This resource is updated regularly and acts as the regulations and codes for *your* exam.

When the *Reference Manual* or problem statement gives minimum or maximum grades--do not violate them! In fact you may wish to back off slightly from the limits given to give yourself some breathing room in case of a slight miscalculation. However, allowing too much leeway may result in a solution that may not fit within the physical site constraints.

Provide the proper contour interval -- sometimes the interval may be greater than one foot.

Ensure solutions are complete

Complete all of the necessary contours and required spot elevations, which may include:

- Rim elevations for drainage structures
- Invert elevations of pipe systems
- Top/bottom of walls, stairs and ramps
- Structure or sports field/court corners
- High and low points
- Finish floor elevations of buildings or finish grades outside of doorways

Always check your final solution for completeness and accuracy. For example, proposed contours

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must be drawn from where they originate at the existing contour to where they tie back into that same existing contour. (Even though you know this basic grading rule, in a timed exam, you may make an error.) If a paved area pitches at a constant slope, it is critical that you show all proposed contours over that surface—merely providing spot elevations is not adequate.

You will only be graded on your work written on the sheet given to you in the exam! You may use tracing paper and non-photo blue pencil to work out solutions, if the information is not transferred to the vellum sheets provided, then it will not be graded. Taping trace to the vellum is like turning in nothing at all. Any marks in non-photo blue or any other colors will similarly be ignored by the graders.

Implicit expectations vs. explicit expectations

While you must address each vignette based on the clearly stated (explicit) expectations in the problem statement and *Reference Manual*, you should use common landscape architectural practices/knowledge to identify and address implicit, unstated expectations. For example, don't grade over a property line or limit of work, don't grade up onto a tree trunk and expect the tree to live. Competencies similar to these examples should not have to be brought to the attention of a competent landscape architect, and thus are not specifically detailed in writing.

As in real life, one is not guaranteed a totally satisfactory solution, and thus the competent landscape architect may have to make choices. For example, the Problem Statement directs you to minimize environmental impacts. The competent landscape architect would know that taking out small trees, scrubs, or a few trees is better than killing large or numerous trees—but only if necessary. Likewise, if a tree must be removed to accommodate required slopes from set beginning points or to site an element safely, human HSW takes precedence. However, if the Problem Statement explicitly says do not remove or adversely impact existing vegetation, follow those directions.

Failure to meet program requirement, codes, and zoning

In practice, different jurisdictions often have very different zoning and building code requirements, and the detail and scope of these codes and regulations can be enormous. Scope of professional practice may also vary between states and provinces.

CLARB has simplified and standardized the exam version of codes and regulations in the *L.A.R.E. Reference Manual*. This is what is required for the exam jurisdiction, and you must be familiar with it. [Note: CLARB periodically updates the *Reference Manual*, so be sure you have the most up-to-date version that will be used for your exam.] DO NOT AUTOMATICALLY DO WHAT YOU DO IN THE OFFICE!!! Use the *Reference Manual* in your practices so you become

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very familiar with it, but you do not have to memorize it. A clean copy will be given to you at the actual exam.

While the *L.A.R.E. Reference Manual* provides explicit codes and regulations for the jurisdiction in which your vignette is located, each vignette *problem statement* may provide additional information and requirements specific to that vignette. The problem statement may give a specific footprint for a building or specify required relationships between elements or activities. All program requirements must be incorporated into the solution at the size, shape and number specified and, if given, using the graphic conventions provided. You cannot alter footprints or other elements unless the problem statement explicitly allows the alteration
In the Exam Specifications, CLARB states what content and KSAs (Knowledge, Skills and Abilities) are on the exam. Make certain you know what you are expected to be able to do. For example, not all states and provinces allow landscape architects to sign and seal stormwater management plans or deal with storm drain piping, but the LARE has consistently expected its candidates to show competence in these areas. Review the Exam Specifications and be prepared to be tested on any or all of them.

Graphics and text
Use standard graphic conventions, such as:

- Symbols (such as swale flow line, direction of slope, proposed contours, top of wall etc.)
- Always place contour numbers in consistent locations relative to the contour lines
- % slope of a roadway or ramp should typically be shown along with a direction arrow pointing downhill

If you are provided with specific graphic symbols on a vignette legend, you are required to use them without exception.

This is not a graphic exercise, so make what you do legible. It does not need to be a work of art, but legibility is very important. Write large enough and clearly enough so that numbers and letters (HP, TW, etc.) can be easily read. Rendering is a waste of valuable time.

Slopes are correct
In the grading and drainage section, the problem statements for the vignettes typically indicate the minimum and maximum slopes allowed for the problem.

Where drainage is a primary concern, it is critical that you correctly draw contours to provide at least the minimum longitudinal slope from the high point of any swale all the way to the outlet point of the runoff. The outlet could be a drainage structure, an existing swale, or (if permitted)

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tie back to existing topography where the runoff can sheet flow off of the site.

Where berms or embankments are required on the vignette, the maximum slope requirements become more critical. These problem types test to see if you can solve the problem requirements of moving earth without exceeding the maximum allowable slope requirements. Gradient requirements may vary from vignette to vignette or differ for various elements.

Paved Surfaces are Graded Correctly

Grading paved surfaces requires more precision than grading unpaved areas and typically maintains a consistent slope across the paved area. Contours are drawn by calculating the longitudinal slope and cross slope on the paving to find where the contour crosses the edge of the pavement. Spot elevations required at the edge of a paved area are typically the elevation at the very edge of the paving. The plus sign graphically signifies the elevation at the edge of the pavement even though it must be drawn away from the edge for the sake of graphic clarity.

If the longitudinal slope on a paved surface changes, the contours should be drawn differently to properly show the pavement gradient. For example, on a road with a center crown and vertical curve, the contours on the vertical curve portion of the road would look different than the tangent (where the longitudinal slope is constant) portion of the road. In this scenario, the location where the contour crosses the edge of pavement must be calculated each time the longitudinal gradient of the road changes.

Surface water diversion

In order to effectively divert water away from an element, swales must be deep enough to catch and hold the water as it drains around the element. A general rule of thumb is that a minimum 6 inch deep swale is necessary for good drainage diversion. Some vignettes may specifically require deeper swales. Be accurate in your calculations and drawing and do not “eyeball”—just drawing a little “blip” in contour will not be sufficient to indicate an adequate swale. Water would simply run across the depression and would not be diverted around the element. (See Figure 1)

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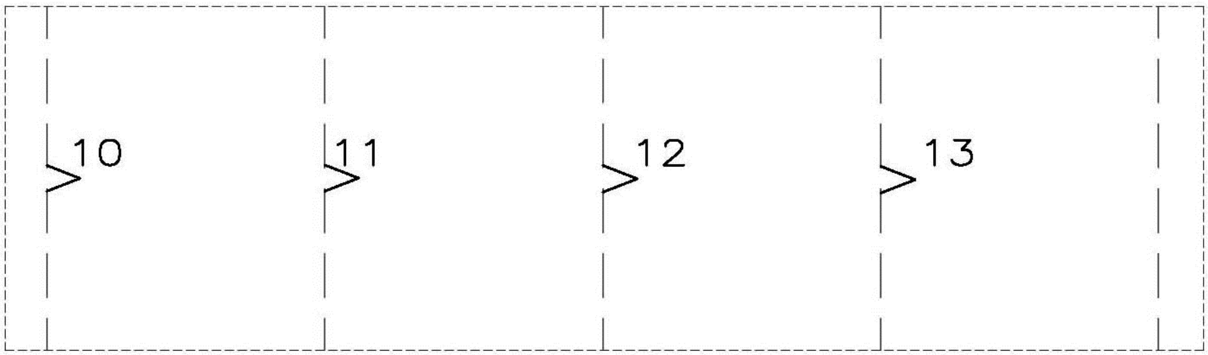

Figure 1. Blip Swale" (Bad)

Make sure you understand how to illustrate swales. Be familiar with the visual and mathematical difference in a 12" deep swale and a 6" swale. (See Figure 2) Include high points. And make sure you know which direction ridges and valleys go as expressed by contours.

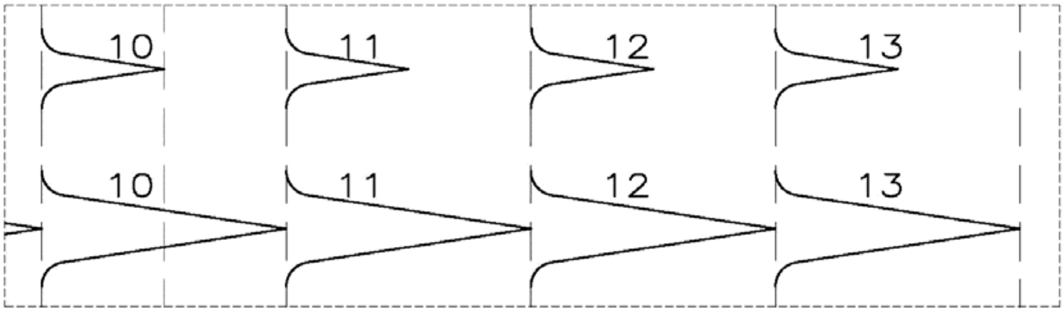

Figure 2. Six inch deep swale (top) Twelve inch deep swale (bottom)

Avoid drawing "test tube" swales. (See figure 3) These indicate variable side slopes and eat up a lot of space.

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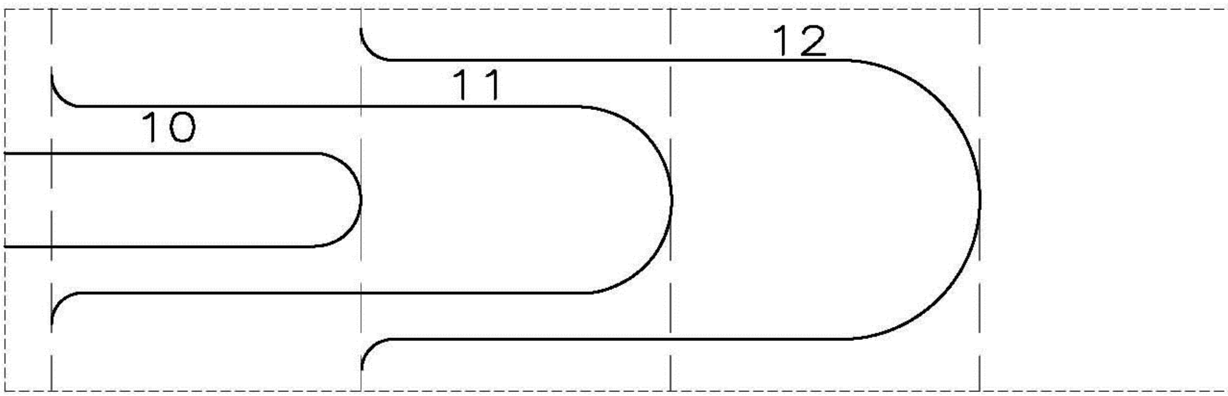

Figure 3. Test Tube Swales

To ensure that runoff is directed into your swales, it is critical that you indicate a high point and its elevation. This point is also known as a break or saddle point. The high point of swale must be lower than the elevation of the element protected so that the water will not run across the swale into or onto the element. If the problem statement directed you to make the swales a minimum of 6" deep, you should make the high point of swale at least 6" below the element to indicate that the start of the swales are at least 6" deep.

Storm drain pipes and structures

Even if your real world licensure/practice does not include piping, this is covered on the exam. The following are some general tips, but, depending upon licensure laws and your experience, you may need to do significantly more study on this aspect of Section E.

Two items are tested on Section E with regard to underground storm drain pipes.

- *Cover* on the exam is the vertical distance from finish grade to the top of an underground pipe. The purpose of cover is to protect pipes from structural damage due to dynamic loads being applied to the ground surface (e.g., a vehicle drives over the pipe).
- *Slope* is the length of pipe divided into the difference in elevation at each end of the pipe

Both cover and slope requirements are stated in the vignette's program requirements. These may vary from vignette to vignette, or if there are different types of utilities present (e.g., sanitary sewer, water pipes or drainage, etc.), as each type may have different cover requirements.

- Pipe sizes will be given on the vignette

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- Pipe inverts are the flow lines along the bottom center lines of storm drain pipes. If only a trickle of water was flowing through a pipe, the invert would be where the water would be located. Set inverts at both ends of each pipe.
- Rim elevations are the elevations of grates on drainage structures such as catch basins or drain inlets. These indicate finish grade at the structure.
- Surcharge is when a water surface elevation at the downstream end of a pipe is above the invert elevation. Surcharged pipes will not carry as much water as non-surcharged pipes of the same size and slope.
- As of 2006, the calculation of Q = C x I x A is no longer required in Section E. However, it is covered in Section D.

When pipes converge into a drainage structure such as a catch basin, there are typically requirements for offsetting the elevations of the pipe(s) coming into the structure and the pipe exiting the structure. There may be different requirements as to how the pipes should connect to a drainage structure. You may be required to set the outflow pipe a certain elevation below the incoming pipes. This could be a minimum required distance or a specific elevation which is to be maintained at all times.

Another method for this connection might require you to maintain the "crowns" (the top) of the pipes. If the crowns must be at the same elevation when connecting to a structure, the invert elevations will change based on the diameter of the pipes. A larger pipe will have a lower invert elevation than a smaller pipe. If there is no requirement for offsetting the invert elevations, the outgoing pipes invert should be at or below the incoming pipes so the runoff can flow down the system without depositing sediment in the drainage structure. This latter method is usually fine for the LARE and is the simplest system to employ on the exam.

When runoff exits the drainage system, you should set the invert elevation at the point of exit so that the pipe is not in a surcharge situation. This means that the pipe should not backup with water when it exits into a water body. To prevent surcharge, the invert elevation at this point should be at or above the highest water elevation of the downstream water body.

Watersheds

The L.A.R.E. tests your ability to recognize watershed areas and to indicate drainage divides or watershed boundaries within a site.

A watershed has a topographically determined boundary, consisting of ridges and saddle points that divide the land contributing runoff water to water features such as streams, ponds, and lakes. Understanding watershed boundaries is critical when designing systems to ensure the protection of

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natural site features and groundwater recharge areas.

When plotting the watershed boundary, the outlet is the most convenient starting point. Work uphill from the outlet, in both directions, at right angles to the contour. When the two lines join, the watershed boundary has been completely defined.

Existing vegetation

If you are not specifically directed to save existing vegetation you should remove only that necessary to solve the problem. Try to save as much existing vegetation as you can. An implicit expectation is that a competent landscape architect works *with* the given site to the best of their ability. On the other hand, if the problem statement tells you to save all trees, you must do exactly that. Rule of thumb for protecting trees is to avoid grading under the drip line. While in actual practice, one can argue where and how to grade under trees, for exam consistency and clarity, use this guide for all the vignettes unless directed otherwise

Accessibility standards

If walks and/or ramps are to be accessible, refer to the *Reference Manual* for the proper standards. These may vary somewhat from real world ADA guidelines.

General Vignette Solving Strategy

Candidates may say they have their own way of grading, graphics, etc, but this is a timed exam and it has specific issues that will be evaluated, so here are strategies and tips which should help.

Read through all of the requirements, check the legend, scale, contour interval, any sections given and look over the plan prior to setting pencil to paper. It is important to have a solid grasp of what you need to do to solve each vignette satisfactorily before you begin work.

Do not read anything into the problem statement that is not there. Neither should you ignore stated requirements. Understand that a true grading problem will have many possible solutions. You simply need to find one that works. Don't waste time looking for "the perfect answer".

Some requirements on vignettes are interdependent, so don't expect to be able to solve a grading vignette one Problem Statement bullet point at a time. Do, however, use the bullet point requirements as a checklist to verify that you have not missed something.

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Conceptualize your grading plan prior to starting any slope calculations. You wouldn't try to design a project by jumping right into preparing a detailed layout plan or construction details. Good grading and drainage involves using a design process. A conceptual grading plan starts with determining the location of ridges and valleys and noting with direction arrows how water will flow, or at least which direction is downhill.

Always begin the mathematical work of a vignette from a known (given) point, such as a spot elevation (+182.5), or a Finished Floor Elevation (FFE 76.5). Work from known elevations towards unknown elevations, especially when several fixed spot elevations or contours are given. Solve grades for given specific slopes before deciding on slopes where a range of possible slopes may be used.

DO NOT BEGIN WITH CONTOURS. Contours can only be constructed when they occur between known points, so set the important spot elevations prior to attempting contours. In fact, you should be confident that your solution will work prior to drawing any contours. Yes, everyone has their own personal method for grading, but if you are not proficient and do not do grading regularly, please consider the above advice carefully, as it is based on years of grading and teaching experience.

General Grading Standards

There are some standard conventions, but always check the *Reference Manual* and problem statement. Past exams suggest:

- Slope limitations will be given in a percentage (%) or a ratio (3:1), with 3 being the horizontal distance and 1 being the vertical rise. However, be able to convert slopes between all possible forms, including fractions and in feet per foot.
- Minimum overland drainage or swale slopes are rarely less than 2%
- Maximum slopes are generally 3:1 or 4:1
- Swales or ditches are generally 6-12 inches deep
- Roadway crowns usually range from 3"(0.25 ft) to 6"(0.5 ft) or cross slopes are often 2%
- Curb height is generally 6" or 0.5 ft. - but may vary
- Walkways adjacent to streets will likely pitch toward the road at around 2%
- Shoulders on rural roads should generally pitch away from the roadway at 5%.(However, this can vary)

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- There are likely to be curb inlets at the sides of the roads or parking lots, especially when there are curbs. There could be adjacent drain inlets that will need to be considered as well. Whenever drainage structures are shown on the base plan, you will be expected to direct runoff into them, unless specifically instructed otherwise.
- Headwalls are likely at the ends of pipes without drain inlets or catch basins. In addition to showing pipe inverts at these, you need to set top of wall elevations on headwalls.

Possible Vignette Problems

Since each vignette has been carefully constructed to test specific KSAs, it is useful to anticipate what you will be expected to do. The following are typical situations that you will likely be asked to address.

Flat and sloping planes

At least one vignette will contain a variety of slopes and one or more flat or gently sloping planes (sports fields, parking lots, building pads, etc.)

Flat planes may be building footprints, swimming pool copings, patios, courtyards or any area where there will be a sequence of like elevations. This plane will have the same elevation consistently all around it, and water must drain away from that edge. For a building it is a Finished Floor Elevation (FFE). Some key points:

- Water from outside the plane should not drain towards/onto the plane
- Place spot elevations at all outside corners. For many buildings a general rule of thumb is to make the ground surface outside the building 0.5 feet below the FFE.
- Place spot elevations at all doorways

You may need to work with steps and an accessible route and/or ramp in conjunction with the flat slopes. Be familiar with the criteria for each as given in the *Reference Manual*. Always give spot elevations at the top and bottom of stairs and ramps.

Sloping planes – sports fields such as tennis courts, baseball, and football fields, or open play fields that require consistent slopes are very common. Parking lots must be sloped as well.

- Begin at the high part of the site and establish a High Point of a Swale (HPS)
- Direct drainage around the entire plane area so that surface runoff from uphill is intercepted prior to reaching the field or court or other element to be kept dry.

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- You may be given the slope of the plane in percent (e.g., 2%) and direction arrows indicating flow direction. If slopes and slope direction are given on the plan, you must use them.
- Start your grading using any given spot elevations, or set a starting elevation that permits reasonable access, works well with existing contours, and/or allows you to address any surface drainage issues.
- If the plane is a parking lot, you will need to direct the water from the parking surface to a low point, generally a drain inlet or a series of inlets or openings in a curb along the low side(s) of the lot.

Swales

For swales or ditches, set a high point and then a low point, draw a flow arrow from high to low and figure the percent slope between the two. Measure to see if it meets the min/max slope requirements. Don't be afraid to adjust your swale flow line locations in order to fit within side slope requirements, to avoid crossing limit of work lines, or protect trees you are asked to preserve.

Using landform manipulation to solve visual problems

Screening, framing, and other functions are important uses of grading. To do so effectively you must be able to visualize!

Understand existing and/or proposed sight lines--both horizontal and vertical--before beginning the vignette.

To be able to screen an object from a specified point of view:

- Determine the spot elevation at the point of view/where the observer is located
- Set the eye height of viewer at this point. This information will be given in the problem statement, but generally 5'.
- Determine the spot elevation at the object to be screened
- Determine height of object to be screened (x feet above the object's ground elevation)
- Draw a line between the viewer and the object to be screened
- Determine the location and length of your screening landform (e.g.; an earthen berm)
- Set up a pair of complementary triangles in section. This does not need to be drawn to scale.

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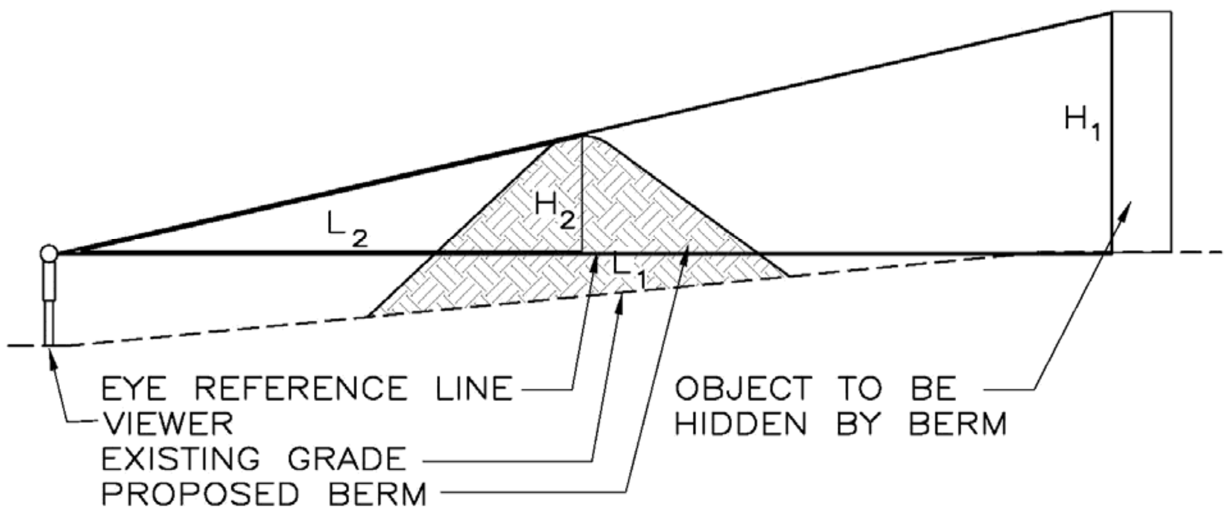

- Use the viewer's eye level as a reference elevation. The difference in elevation between the eye level and the top of the object to be screened is divided by the horizontal distance between the two in order to set up two sides of this triangle.
- Then set up a second triangle between the viewer and the blocking terrain feature
- Set up a ratio which expresses the vertical distances over the horizontal: $H_1/L_1 = H_2/L_2$
- Solve for the vertical distance (H_2) of the berm to be constructed. This will usually be above the eye reference line. Add this distance (H_2) to the eye reference elevation. This gives the elevation of the top of the berm necessary to screen the object from view.
- Grade out the berm to tie back into the existing contours. You will likely need to re-direct surface runoff around the berm you have created.
- Some vignettes may require you to do the *opposite* – *c*ut down a landform in order to open a view to an object. The same techniques apply, but may need to be adjusted to achieve the stated requirements.

Roads and streets

Critical factors in roadway grading include understanding and using conventions and accurate visualization for satisfactory completion within time constraints. Some key points, issues to expect, and general guides include

- Roadway crowns range from 3"(0.25 ft) to 6"(0.5 ft) higher than road edge
- Roadway Longitudinal Slope in percent, with a corresponding high point or low point.
- Curb heights may vary but 6" (0.5 ft) is commonly used
- Adjacent sidewalks almost always slope with the longitudinal slope of the road and cross slope towards curbs

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- Shoulders almost always slope away from the roadway
- Swales should be provided along the uphill side of rural roads to divert water away from the pavement structure
- You will probably be given at least one spot elevation - probably at a point on the centerline of the road or the center of an intersection. This could be a High Point (HP) or Low Point (LP), but may not be
- You will be given a longitudinal slope to follow in percent (e.g., 3%)
- You will likely be given a cross slope on the plan, in a separate section, or in the problem requirements
- Crown contours on roads always point down slope
- Contours on swales or ditches always point uphill

Watershed and ecosystem vignettes

Section E will look at landform issues at a scale larger than site grading. Typical vignettes have used conceptual planning as it reflects an understanding of topography. Also of concern are the ramifications of siting land uses and/or structures (buildings, roads, etc.) on adjacent ecosystems, watersheds, land uses, etc. Watershed problems are generally at 1 inch equals 100 feet or larger scales.

Again, both visualization and understanding of key concepts are important. Some key considerations include:

- Delineate watershed divides. Be able to follow ridge lines to identify a drainage area or watershed
- Contours on ridge lines point downhill and swale or valley contours point uphill
- Watersheds are defined by the location of their outlet points. In natural watersheds, this may be at the confluence of two streams. In urban watersheds, the outlet may be a catch basin or other structure.
- Water flows perpendicular to contours in a downhill direction and you must be able to graphically indicate water flow direction
- Avoid siting new development within any watershed where endangered species, sensitive or protected environments are located, or within designated development setbacks, etc.

  Locate roadways or other constructed facilities so as to minimally impact the ecology or important features a site
- If required, locate stormwater management impoundments so as to prevent downstream flooding, to prevent offsite runoff, or to protect sensitive ecological areas.
- Be able to determine the steepness of existing slopes based on contour interval and map scale. Facility siting on watershed planning vignettes often depends on avoiding

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steep or taking advantage of gentle slopes (such as siting sports fields or parking where relatively minimal grading is required).

Ponds and dams

You may be required to site ponds in suitable locations to intercept runoff from proposed features prior to the runoff entering a natural water feature. This pond will need to be downhill from the “developed” area. If the pond has a dam, it must be on the downhill side of the pond or impoundment.

Ponds may be created by excavation, by constructing an earth fill dam across an existing ravine, or by a combination of excavation and filling.

Problem statement requirements may include constructing a pond with a given water surface area, a given depth, using a given footprint for the bottom of the pond, or sizing the pond to provide a minimum storage volume for water.

You may be given verbal descriptions of the dam or cross sections or elevations to use in your design.

Freeboard may be required. Freeboard in Section E is generally defined as the difference in elevation between the designed water surface elevation and the elevation of the top of the dam.

A good rule of thumb is that dams should be shown with a minimum top width of ten feet unless other specific instructions apply. Spot elevations to show the top of dam elevations are necessary. You may also need to provide spot elevations at the bottom of the pond to prove that you have provided sufficient depth or volume.

If a spillway is required, a spot elevation in the bottom “throat” of the spillway will be needed. If a pipe outlet is required, remember that you need to meet slope requirements and set inverts on both ends.

If a vertical riser pipe is called for, you will need to set a top elevation for it. This elevation will usually correspond to the designed water surface elevation of the pond.

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Recommended Reference Books

In addition to the current list of reference books for this section of the exam that are currently recommended by CLARB, the following books may also prove useful, especially if they are readily available in your office library.

Landphair, Harlow and Klatt, Fred. *Landscape Architecture Construction*
Nelischer, Maurice, editor, *The Handbook of Landscape Architecture Construction: Volume 1.* Chapters 2 and 7, ASLA.
Untermann, Richard, *Grade Easy*
Aymer, Valerie, *Landscape Grading: A Study Guide for the LARE Grading Examination*
(This is an introductory level book for Section E material. It could be valuable if you need a refresher on basic grading and drainage principles and techniques)