Ethics and Floodwater Engineering – 3

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Couse Description

This course is the 3rd hour of a 4-hour course on engineering ethics and floodwater engineering.

This course satisfies 1-hour of engineering ethics continuing education requirement for Professional Engineer license renewal.

The course in engineering ethics and floodwater engineering is intended to encourage the engineer to consider the big-picture result of decisions using real-world examples from a licensed Professional Engineer with extensive experience in Floodwater Engineering.

The engineer's duty is to make things work. Following instructions, complying with the law, and using current best practices are usually good enough for the present. But the engineer's task to make things work in the future. This requires making projections about future conditions and use. While engineers prefer hard facts, we are sometimes forced to work with "soft data" that require evaluating many possible options. During this evaluation, we use legal requirements and best technology as tools. Ethics can be used as a third tool to make decisions. "Ethics and Flood Water Engineering" contains many examples of using ethics in real-world situations to make engineering decisions.

Objectives

At the conclusion of this course, the student will have read and evaluated:

- Considerations for the long-term implications of design decisions beyond code requirements
- Considerations and implications when forced to work with "soft data" that require evaluating many possible options
- Use of legal requirements and best technology as tools
- Consideration of the use of ethics as a third decision making tool
- Review many examples of using engineering ethics in real-world situations to make engineering decisions

How to Read this Course

The student is required to thoroughly read and comprehend the course material and examples

In order to complete the course, the student must pass the quiz in the final chapter of the course. It is recommended that the student keep these questions in mind as the course is read.

Topics Covered

Introduction, Engineering Ethics, Floodwater Engineering, Real-World Examples of Engineering Ethics in Floodwater Engineering Applications.

Grading

Students must achieve a minimum score of 70% on the online quiz to pass this course.

The quiz may be taken three times.

The student will be asked at the end of the quiz to attest that he or she has personally and successfully completed all chapters of instruction.

The quiz may be viewed in the final chapter of this course.

Couse Inquiry

This course is designed to be interactive. The student is encouraged to contact us to discuss any questions that arise while taking this course. All inquiries will be answered within two days or less. The reader can contact PDH*Now* as follows:

By Email: info@pdhnow.com

By Phone: 1-833-PDHNOW9

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Ethics and Floodwater Engineering – 3rd Hour

In the third hour we will examine actual examples of ethics applied to planning floodwater projects.

Floodwater engineering is less well defined that most other engineering disciplines. Think of how many times the TV weather man misses a 24-hour forecast. Estimating the magnitude of an event that occurs once every century is even harder. The standard for many designs and for flood insurance is the 100-year flood. The 100-year rainfall may produce the 100-year flood. Estimating the 100-year rainfall and 100-year flood flow yields statistical confidence limits of considerable variation.

Rainfall amounts found in nature may not correlate with computed patterns. For example, the house where my wife and I lived for 30 years had a 100-year, 6-hour rainfall of 3.8 inches. Yet in the late 1980's we were at the center of thunderstorm that dumped 6 inches of rain on our property in much less than 6 hours. The runoff caused about a dozen homes to be flooded and killed one driver whose car was swept off a low water crossing.

Flooding can come from both hurricanes and thunderstorms. Hurricanes don't always keep moving. During the 1950's a hurricane stalled over the Pecos River south of New Mexico and dumped 30 inches of rain in about 3 days. This resulted in a flow estimated to be about a million cubic feet per second entering a downstream reservoir.

What is the floodwater engineer to do? The local design code may specify a 100-year design, but Mother Nature may have other plans.

Ethical concept: Mother Nature's plans may differ from design code.

The 100-year design has generally been accepted as a reasonable compromise between construction cost and public safety. I believe that 100-year is in the "good enough" category. While major roads have 100-year design, some minor roads could not be constructed at such a high level. So, some designs specify 50-year or less floodwater design criteria.

Ethical concept: Design and construct following code requirements but install overflow zones. For example, install a concrete channel to convey 10- to 100-year flows and then zone dirt areas adjacent to the channel to carry the 500- to 2000-year flows.

One problem with flood criteria being determined by population of users is that populations change. One of the scariest moments of my career occurred when I was on a field trip looking at a watershed I was about to code into a hydrologic model. As a youngster I had seen this area when it was low density farmland. Now I was looking at high density housing area. I walked

the top of the dam above the houses. Suddenly I realized something was missing. The dam did *not* have an emergency spillway.

Dams need to have an emergency spillway to pass flows greater than the reservoirs holding capacity. If water flows over an earth embankment, it can erode the top of the dam and cause a catastrophic dam failure. Spillways are expensive, so in very low-density areas some agencies put earth-fill dams without spillways.

The Corps in cooperation with the city under the Corps Local Protection Authorities constructed a larger dam with an emergency spillway.

Ethical concept: Existing flood control structures need to be reviewed by local authorities at least once every decade to ensure changed urban conditions haven't rendered a floodwater project non-functional or even dangerous.

Please note that I refer to "local" authorities, because state authorities are frequently underfunded and may be more focused on private dams than those now located in newly created city limits.

The key ethical concept in floodwater management is to not increase existing runoff. It's that simple. If you increase floodwater runoff because you add impervious area by constructing buildings, sidewalks, or parking lots you have an obligation not to dump that on your neighbors.

If you increase impervious area then you need to add floodwater storage to offset your increase. Code usually requires using the 100-year frequency rainfall. Excess runoff is computed by subtracting pre-project runoff from post project runoff. Using the 100-year storm is an economical compromise between construction cost and downstream flooding from rare events that exceed the 100-year storm.

There is one other way to negatively affect your neighbors and that is by re-grading your yard so that the drainage is leaving your yard in a different direction, different location, or different elevation. How do you tell if it is significant? If your neighbor complains it is significant. If your neighbor even questions it, it is probably significant. I remember seeing a home remodeling show where the super-competent cast attempted to dump excess drainage in a new location that affected an adjacent neighbor. The whole scheme was so sleazy and totally beneath the outstanding craftsmanship they normally practiced. The neighbor complained and they had to do the job over instead of doing it right in the first place (like they almost always do).

At the 100 home construction site I mentioned in the first hour we had a downpour. The drainage from one back yard started spilling sideways into another backyard and they both spilled sideways into a third back yard which then spilled into a forth back yard. The owner of the fourth yard complained to me. The subs involved agreed it wasn't right. We got a small

dozer and re-graded all four lots to drain into the street. No money exchanged hands. No plans were consulted. No reports filed.

Ethical construction = Problem Solved

Ethical concept: Do not increase the floodwater exiting your property.

Letter Vs. Intent:

One challenge engineer sometimes have is to decide between the letter of the law and the spirit of it. By "spirit" I mean "intent" of law and policy makers. One case I was involved in was the 100-year flood plain in a mountainous area. Paleo-hydrologic analysis showed that this watershed did not currently produce significant flooding (at least in the 100-year range), so the analyst suggested that the computed 100-year flood plain be radically reduced.

At the time I was coding a hydrologic model for a flood warning system and had analyzed the famous October 1918 storms which showed that runoff corresponded to the width of the stream plus 7-feet on each side. (This corresponded to researcher observations from that period.)

We talked and I pointed out that there was no doubt that he was technically correct for the exact 100-year flood plain (it would be just slightly higher than the 2-year flood plain), but that it would be *ethically wrong* to change from the computed flood plain because the intent of the law is that the 100-year flood plain is only slightly below the 500-year flood plain. For some rainfall above the 100-year event, the entire watershed would contribute. If we followed his suggestion then we would have houses located very near the creak and these would then be subject to catastrophic flooding and large loss of life when the 500-year (or some other frequency over the 100-year flood) happened. We stayed with the more conservative flood plain.

That discussion was in the latter half of the 1980's.

In 2013, forest fires altered the basin runoff characteristics. Suddenly, even 1 to 2-inch rains produced flooding in communities below.

At least there were no houses in the upper watershed located next the creek.

There is no practical way that law or policy makers can anticipate every unique situation. Theoretically, we could go to the courts and have them decide. But *before* we go to another

decision maker, engineers frequently have an opportunity to meet with technical specialists and make speedy, timely, and informed decisions that are in the best interest of the public.

Ethical concept: Engineers need to consider the intent of Code, not just the letter of Code.

While I was working for the Corps of Engineers planning flood control projects before the later-1970's meant building dams and channels big enough to hold what was called the "standard project flood" (SPF). The SPF was typically the largest flood of record that happened in the vicinity of the watershed in question. SPF is a very conservative design.

If you ever think some flood control projects look bigger than others, it is because some are bigger. Most cities used much lower criteria than SPF.

When I joined the Corps in 1972 we used hand calculations, a few desktop calculators that could add, subtract, multiply, and divide, a very primitive mainframe computer with paper tape input, and a slide rule. By the later 1970's computer advancements made it possible to perform hydraulic and hydrologic computations much faster. This allowed for creation of many computer runs at various frequencies of flow; something that would have been far too costly with older technology. The more efficient technology facilitated the National Economic Development (NED) guidelines that tried to optimize the cost/benefit ratio. The idea behind NED was to optimize the nation's resources by investing only in the most efficient strategy as dictated by the cost/benefit ratio. This idea sounded good, but its application was not truly achievable.

The inflation of the late 1970's led to many interest rate hikes by the Federal Reserve Board. During the early 1980's a 30-year Treasury-bond interest reached a high of over 14%. The NED guideline for interest moved upward crushing hopes for any decent size flood control structure. The ethical dilemma faced by all of us was that flood protection was now being distributed on an inequitable basis. Consider the case of two identical communities who get dams built a few years apart. The community unlucky enough to get government authorization for its project during high rate years gets a much smaller dam and much less protection.

Additionally, a second major problem surfaced. That was the notion that we could determine future land and property values with any accuracy. Back in the late 1950's our organization justified building a large concrete channel to protect valley farm land below a rapidly developing city. That land was worth $20,000 to $30,000 per acre for much of my career. However, two gentlemen involved in benefit computation had a serious disagreement. One thought the other was crooked because he placed a value of

$500 per acre, when in fact he knew it was only worth $100 per acre!

During the first hour I brought up the notion that ethics is a "battle of ideas about what is good". The 100-year dam, channel, and levee system avoid flood insurance for those protected by them. There is pressure from land developers to at least protect to the 100-year level. SPF projects cost a lot more and provide benefits that are discounted deep in the future. What I saw justified for the rest of my career were 100-year structures with favorable benefit/cost ratios.

Do we have it right with 100-year structures? I don't know. There are cases where the government is allowing people to reconstruct homes below the SPF high-water mark simply because they are above the 100-year computed flood plain. Many people feel uneasy about this.

What if Mother Nature doesn't agree with our 100-year flood computation?

The idea of SPF design is appealing to reduce catastrophic flooding, allow for some climate change, and provide a buffer for variations in materials, variations in construction technique, modeling errors, code updates, equipment malfunction, future growth variations, and challenging site requirements beyond those considered by design code.

Ethical concept: Ethics is a battle of ideas about what is "good".

Ethical concept: Allow for a historical modification of code. For example, use the computed 100-year flood plain for zoning until a larger flood occurs and then use the historical flood plain for zoning and rebuilding decisions.

Conceptual Floodwater Plan:

My all-time favorite assignment was doing the conceptual floodwater plan for the new growth area in one city. The state highway department was planning a road across the northern end of a city to link a state highway with city street near mountains. They compute the substantial runoff from the mountains and designed a series of culverts under the proposed state road. The problem came when owners of the undeveloped land that would be flooded by the culvert discharge threatened to sue. So, the state highway department modified their design by moving the culverts to a new location. The downstream owners at that location threatened to sue. So, the state highway department went to city engineering, who in turn went to the Corps of Engineers who had built many flood control works in partnership with the city. It came up to our office and landed on my desk because I had done other work in this area. Funding for the project was available and everyone was waiting. I had the use of a one tech for drafting and quantity computations. The urgency of my output was greatly communicated to me. We had a problem that required a solution.

Ethical concept: Define exactly what is needed from you. As an engineer your duty may just be a plan or even an idea. If you are the decision-maker, then a speedy decision that implements a "good plan" today may be worth more than searching for a "perfect plan tomorrow".

First, I computed pre-project hydrology and flood plains. The flooding was too widespread to just leave things in their natural state (my opinion based on over a decade of experience).

Ethical concept: Ideas about "right" usually originate with one person. If the situation is urgent and your idea is in the "good enough" category, then go with your idea and move the next step.

We needed a flood protection system (again my opinion). First, I tried a large dam, but the reservoir pool flooded too much land in my opinion.

Then I tried a large conveyance channel. It ran many miles from the mountains down to an area outside the city limit. I honestly expected this to be the big winner. But I got a big surprise. The channel got bigger and bigger with every mile downstream. By the time it reached the bottom it was enormous and very expensive (my opinion again). So, I kept looking.

I decided on a small dam to capture the mountain flows. This radically reduced the size of the upstream channel. This greatly reduced the cost because the upstream slope was steep enough to require a concrete channel. The lower half of the channel had a slight slope that allowed us to use a dirt channel. The channel intersected other flow that I routed with levees to a sump. The sump was a dry desert lake bed that we took borrow out of to make storage for the 100-year flood. Adjacent to the intersection of the flow, I zoned a multi-purpose area for a golf course overflow area. This plan had a much lower price tag.

This was just a conceptual plan study, so I avoided time-consuming useless refinement and used hand calculations and approximations in lieu of detailed computer modeling. I computed 100-year and Standard Project Flood layouts, computed cost estimates, and presented the results. The mayor looked through the plans and selected the 100-year version with the lowest price tag.

I created a detailed hydrologic model for the selected project to determine design flows and volumes. The project construction (including a 27-hole golf course) was completed by the early 1990's.

Ethical concept: Avoiding useless refinements will save time and money. The job requirements should determine the level of detailed analysis used in a floodwater engineering study. Planning requires a less detailed effort than final design.

Questions for Consideration – 3rd Hour

Imprecision:

Note that weather information sites are challenged to forecast the presence of tomorrow's moisture, not its amount. Forecasting the amount for 100-year event is an incredibly imprecise art form.

Do you have any imprecise parts in your engineering field?

Smoothed Over:

Counter examples to theory exist. I described the 6-inch rain I experienced and also a stalled hurricane that dumped 30 inches. These are just "smoothed over" with statistical techniques.

Do you ever get the intuitive feeling that "smoothed over" statistics may not be in your best interest?

Which of the following best typifies your approach to discrepancies between code and observed reality?

A. Not my job.

B. Consider system sensitivity to increased challenges

C. Responsibility belongs to code writers

D. Designing for averages is fine by me

Partner Structural Zoning:

The 100-year design has generally been accepted as a reasonable compromise between construction cost and public safety. I believe that 100-year is in the "good enough" category.

However, we could install a concrete channel to convey 10- to 100-year flows and then zone dirt areas adjacent to the channel to carry the 500- to 2000-year flows.

What is your opinion about such a "graduated system"?

Review Existing Structures:

One problem with design criteria being determined by population is that populations change.

Spillways are expensive, so in very low-density areas some agencies put earth-fill dams without spillways.

Do your local city authorities review existing structures to ensure changed urban conditions haven't rendered a floodwater project non-functional or even dangerous?

Ethical Urban Runoff:

The key ethical concept in floodwater management is

A. Not increase existing runoff

B. Increase existing runoff

C. Live on a hill and not worry about runoff

D. We are in a drought. It doesn't rain here anymore. Do I have to answer?

Personally, I practice C, but we can't all live on hills connected by bridges. The correct answer is A.

If you increase floodwater runoff because you add impervious area by constructing building, sidewalks, or parking lots you have an obligation not to dump that on your neighbors.

Code Intent:

We discussed a situation where the 100-year flood plain was technically only slightly above the 2-year flood plain and very far below the 500-year flood plain. Normally the 100-year is far above the 2-year and close to the 500-year flood plain. The currently computed flood plain that was near the 500-year level prevented development near a creak. It would be *ethically wrong* to change from the computed flood plain because the intent of the law is that the 100-year flood plain is only slightly below the 500-year flood plain.

In 2013, forest fires altered the basin runoff characteristics. Suddenly, even 1 to 2-inch rains produced flooding in communities below.

At least there were no houses in the upper watershed located next the creek.

We will now take a couple of minutes for you to consider the next question in depth.

Think carefully about your job and your organization. Is there some part of your work in which you or some other employee should be considering the intent of Code, not just the letter of Code?

Interest Rate:

We saw how the more efficient technology (computers) facilitated the National Economic Development (NED) guidelines that tried to optimize the cost/benefit ratio. The idea behind NED was to optimize the nation's resources by investing only in the most efficient strategy as dictated by the cost/benefit ratio. This idea sounded good, but its application was not truly achievable.

The inflation of the late 1970's led to many interest rate hikes by the Federal Reserve Board. During the early 1980's a 30-year Treasury-bond interest reached a high of over 14%. The NED guideline for interest moved upward crushing hopes for any decent size flood control structure. The ethical dilemma faced by all of us was that flood protection was now being distributed on an inequitable basis. Consider the case of two identical communities who get dams built a few years apart. The community unlucky enough to get government authorization for its project during high rate years gets a much smaller dam and much less protection.

Do you believe that current interest rates should have a major impact on the size of a community's flood protection?

Do you feel that this is ethical?

Future Property Value:

Additionally, a second major problem surfaced as we attempted to employ the cost/benefit computation of the National Economic Development Act. That was the notion that we could determine future land and property values with any accuracy. We discussed an example that showed how difficult land estimation was in practice.

Do you believe that flood control protection should be strictly based on future estimates of the value of property protected?

Building Below Flood of Record:

The 100-year dam, channel, and levee system avoid flood insurance for those protected by them. There is pressure from land developers to at least protect to the 100-year level, but no higher because it consumes developable land. What I saw justified for the rest of my career were 100-year structures with favorable benefit/cost ratios.

There are cases where the government is allowing people to reconstruct homes below a real flood high-water mark simply because they are above the 100-year computed flood plain. Many people feel uneasy about this.

What if Mother Nature doesn't agree with our 100-year flood computation?

How do you feel about allowing for a historical modification of code to use the computed 100-year flood plain until a larger flood occurs? Then use the new historical flood plain for zoning and rebuilding decisions. Is this an idea you could support?

More is the Enemy of Enough:

We looked at a conceptual floodwater plan I did. I avoided excessive design refinements in the planning phase. I could have done more detailed, but it would have taken too long. I had the right idea and construction proceeded quickly.

In your firm do you have cases where "more is the enemy of enough"?

In your job do you have the freedom to make decisions about what is "right"?

Are you allowed the creative freedom to propose creation of a multipurpose structure like a golf course in a flood plain?

Summation of 3rd Hour

In the third hour we applied ethics to planning. Ethical concepts drawn from the examples are:

- **Mother Nature's plans may differ from design code.**
- **Design and construct following code requirements but install overflow zones. For example, install a concrete channel to convey 10- to 100-year flows and then zone dirt areas adjacent to the channel to carry the 500- to 2000-year flows.**
- **Existing flood control structures need to be reviewed by local authorities at least once every decade to ensure changed urban conditions haven't rendered a floodwater project non-functional or even dangerous.**
- **Ethical construction = Problem Solved**
- **Do not increase the floodwater exiting your property.**
- **Engineers need to consider the intent of Code, not just the letter of Code.**
- **Ethics is a battle of ideas about what is "good"**
- **Allow for a historical modification of code. For example, use the computed 100-year flood plain for zoning until a larger flood happens and then use the historical flood plain for zoning and rebuilding decisions.**
- **Define what is exactly what is needed from you. As an engineer your duty may just be a plan or even an idea. If you are the decision-maker, then a speedy decision that implements a "good plan" today may be worth more than searching for a "perfect plan tomorrow".**
- **Ideas about "right" usually originate with one person. If the situation is urgent and your idea is in the "good enough" category, then go with your idea and move the next step.**
- **Avoiding useless refinements will save time and money. The job requirements should determine the level of detailed analysis used in a floodwater engineering study. Planning requires a less detailed effort than final design.**
- **More is the enemy of enough.**

Ethics and Floodwater Engineering - 3

1-Hour

Quiz Problems

1. Which of following is false?
    A. Being ethical empowers your subordinates.
    B. Ethical decisions are easy.
    C. Engineering decisions need to balance all risks, no matter how counter-intuitive.
    D. Ethical decisions require a balance between doing the greatest good for the greatest number while minimizing extreme harm to the lesser number.

2. Which of the following is true?
    A. Engineers need to share information with appropriate authorities about system sensitivity.
    B. Engineer computer models and computations are only tools that need to be checked against observed reality.
    C. A, B, and D
    D. The less precise the engineering is, the more ethical judgment is required to create a system that will work as needed.

3. When acting ethically in a particular situation the outcome
    A. Is a near certainty
    B. Is likely to be favorable
    C. Is likely to be unfavorable
    D. May be determined by luck.

4. Which of the following are ethical concepts?
    A. The Herculean efforts by county and city crews to remove logs from bridge openings enabled the system to function as designed.
    B. Charm and credentials are a balanced substitute for competence.
    C. The engineer is only responsible for following published design criteria, even if the system fails.
    D. Avoid make allowances for unusual challenges that are expensive.

5. Ethical concepts about system sensitivity include:
    A. None listed
    B. C and D
    C. In the absence of precise evidence, one must use judgment and experience.
    D. Engineering computations with large standard deviations need to be applied considering the sensitivity of the system.

6. The idea of a benefit/cost ratio greater than one is a good idea since it spends the taxpayer's money beneficially. However, this policy results in the government offering flood protection to legal businesses engaged in gambling and prostitution, while failing to provide flood protection to poor farm families living in cheap adobe housing because the benefits are so low that the benefit/cost ratio is less than one. Ethical actions include:
    A. Offer job training so the farmers can become card dealers.
    B. Sometimes you just have to "hold your nose" and follow the rules.
    C. Find some grant money to help the farmers.
    D. None of the above.

7. Sometimes rainfall radically exceeds the design rainfall. One way to allow for this is to
   A. Pray
   B. Live near the top of a hill and watch the flood go by.
   C. Develop the land fully and then leave the area quickly. The trick is not to play the game too long.
   D. Design and construct following code requirements but install overflow zones. For example, install a concrete channel to convey 10- to 100-year flows and then zone dirt areas adjacent to the channel to carry the 500- to 2000-year flows.

8. When population density goes from rural to urban that will
   A. Require dams to have emergency spillways
   B. Require no action
   C. Be OK as long as the new neighbors don't dump additional drainage on the old neighbors.
   D. Not change the flood plain

9. The Code specifies an exact frequency, but this system is very sensitive near that frequency. Events at the Code frequency are miniscule. Events somewhat beyond the Code frequency are catastrophic. You should:
   A. Follow Code to the letter.
   B. Consider the intent of the Code, not just the letter of the Code.
   C. Move off this potentially controversial job.
   D. Write Higher Authority for guidance.

10. Most Codes get updated to reflect changes in the industry. When Mother Nature offers us a change we should:
   A. Ignore it as a statistical fluke. We understand weather completely and got it right the first time around.
   B. Consider current real estate interest ahead of abstract "future public good".
   C. Use the computed 100-year flood plain for zoning until a larger flood occurs and then use the new historical flood plain for zoning and rebuilding decisions.
   D. Stay with the old flood plain to save taxpayer money by avoiding the expense of drawing new flood plains.