>> Dr. Henderson: I would like to welcome our presenter for today, Brian Baumgarten. Brian Baumgarten is a materials engineer with our Materials and Corrosion Laboratory Group. He obtained his bachelor's in chemical engineering from the University of Colorado, Boulder. Brian interned for four years with the Materials and Corrosion Laboratory before working in the private sector for an additional six years doing polymer chemistry. His focus was on research, test, and formulation of epoxy and polyurethane systems. Brian rejoined the Materials and Corrosion Laboratory Group in 2018, and has led numerous research and construction projects on protective coatings and geosynthetics. And with that, I would like to hand this presentation over to Brian Baumgarten.

>> Brian Baumgarten: Great, thank you, Chrissy. Can you hear me okay?

>> Dr. Henderson: I can.

>> Brian Baumgarten: Okay, great. Well, thank you for the introduction. And thank you everyone for tuning in today. The topic is going to be an introduction to geosynthetics. We're going to start off by touching on the eight different types of geosynthetics that we can use. We're going to discuss some degradation mechanisms, as well as some repair techniques. After that, we're going to move on to some projects. And the point of that is to give everyone an idea of the capabilities we have at Reclamation with the geosynthetics industry, as well as give everyone an idea of how each one of these geosynthetics can be used in conjunction with each other on different types of projects. So, let's go ahead and get started. A kind of broad definition of what geosynthetics are-- "geo" refers to earth and "synthetic" refers to human-made. So, geosynthetics are human-made materials-- polymers in our cases-- used with soil, rock, earth, or other geotechnical materials as an essential part of a project, structure, or system. So, you know, the brief definition would just be: human-made materials used on projects related to the earth. This table here outlines, on the left, the eight different types of geosynthetics that we use. And along the top are the five different functions that they can have. If you take a look at the table, you can see that some geosynthetics have multiple functions, while others have single functions. And if you take a look at the bottom, you can see that geocomposites have all five functions. So, we'll touch on that a little bit later on-- why that is. So, first one we're going to talk about is geotextiles. There are two different types, woven and nonwoven. The pictures on the right-hand side-- the top one is the woven geotextile and the bottom one is the nonwoven geotextile. They're a little bit different from each other and used a little bit differently. The woven type is a more plasticky, hard material. And the functions of it are separation, reinforcement, and drainage. So, drainage is where it differs from nonwoven. And the reason for that is-- water has a hard time passing through the plane of the woven one. And it can pass through the plane of the nonwoven geotextile. Woven geotextiles are used with pavement, roads, railroads, structures, and rip rap to name a few. And their real strength is in support, stabilization, and drainage to prevent erosion and/or collapsing of the ground around a road, railroad, or any other type of infrastructure. Nonwoven geotextiles-- they are a softer material, more like a felt. If anyone's ever done any gardening or landscaping around their house-- a weed fabric. That's what this is, just a beefed up version that is more industrial, I would say. They're also used for separation and reinforcement. But they're used for filtration opposed to drainage for the woven. So they're used with drains, geomembranes, and aggregates. As far as drains, you put them around a drain and they'll allow water to pass through and keep out substances that you don't, such as rocks or dirt or anything like that. Reclamation mainly uses these as a cushion to protect geomembranes from being punctured from aggregate on top or the subgrade. below. So, that's our main use of them, just as a protection for geomembranes that we'll talk about, actually next. So, geomembranes is kind of the main player for us. And we are responsible for moving water to certain locations and storing it as well. So we need to contain that water. And the function of the geomembrane is to do just that, contain liquids or gases. Reclamation uses these for canals, ponds, reservoirs, dam faces, rooftops, as well as other applications. And we use them to prevent water from seeping into unwanted areas. So, for example-- canals, we don't want the water to seep into the ground, and so it keeps it within the canal. The primary makeup of a geomembrane is the polymer. And there's six listed there. Those are the main ones that we use-- polyethylenes, polyvinyl chlorides... So that's the main base of the material. And then additives are added to those to improve certain properties. Some examples of those are carbon black. If you take a look at the images, you'll notice that both of those are black material, and that's generally what you're going to see. And that's because of the carbon black. And we use that to-- for UV stabilization. So to protect the geomembrane from the sun, which is one of the main degradation methods that they'll experience. Another example is plasticizers. I think when most people think of plastic, especially PVC, they think of a rigid plastic pipe. And so what a plasticizer does is it imparts flexibility on to that material so that we can have a flexible sheet. And the reason that's important is because when the liner won't move or anything like that, it can puncture and tear. So, imparting flexibility on it will prevent damage in a lot of cases. From the subgrade with rocks or any type of damage that may come from the top, such as a rock rolling down or some sort of animal walking across the liner. So, it's good for durability. And another one is biocides. And so, these are just a few examples. There's many more additives that are used in the manufacturing of these. Next, I'm going to talk about geonets. So what geonets are is grid-like materials consisting of parallel sets of ribs overlaying other parallel sets of ribs at various angles. Take a look at the images on the right. You can see those parallel ribs running across each other, and they're kind of stacked on top of each other. And there's two different types that we'll talk about in a sec. But these geo nets are often sandwiched between geotextiles. And the reason for that is that I mentioned that geotextiles-- the nonwoven kind-- will allow water to pass through that point and into the plane of the geonet. And the function of that geonet is to laterally drain liquids or gases within the point. An example where these are used is underneath. sports fields or putting greens. And what-- to prevent sitting water. So, when the water, um, goes into the ground, this will move the water out towards the edges of the putting green, say, to prevent that sitting water. There are two main types of these. The first type is a triplanar, which is on the bottom right. And they are used whenever drainage is required under high load. So if you're worried about the geonet collapsing under load, you're going to want to choose the triplanar version of this. Biplanar is on the top right. And these types of geonets are used to transport large fluid volumes under no load. So, that's pretty much how you choose between which one of those you're going to use, on a basic level. Alright, next we're going to talk about geocells. Geocells are a 3-dimensional structure, much like a honeycomb. If you take a look at this right-hand image here, you can see on the top-- that's a geonet without any sort of substance in 'em. And they're meant to hold things such as aggregate, soil, sands... That type of thing. Their function is in separation, reinforcement, or both. Reclamation has used these to retain cobble/gravel mixtures on the side slope of a detention pond, which is the image there on the right. And it's function there is to protect the underlying geomembrane, as well as reinforce the side slope. So, it's separating the geomembrane from environmental damage that it may incur. Primary uses at Reclamation are in canals and ponds. Outside of Reclamation-- and as well as inside of Reclamation, but not in-- not in my specific case-- they're used for soil stabilization, erosion control, as well as structural reinforcement for load support. Moving on to geosynthetic clay liners. What they are is hydraulic barriers that generally consists of bentonite clay sandwiched between two geotextiles or geomembranes. So the bottom right image, you can see the bentonite clay in between two geotextiles there. They're primarily used in landfill applications in place of compacted clay liners... or geomembranes. Some of the benefits of them is they're fast and easy to install. They have very low conductivity. When you hydrate a geosynthetic clay liner, it can swell up to fifteen times the size. Another advantage is they're self-healing. And in situations where compacted clay is not readily available to a construction site, they're very low cost compared to that. They can also maximize the capacity-- geosynthetic clay liners are on the millimeter scale where compacted clay liners are meters deep, so you can see how that could maximize the capacity of the landfill. Reclamation has used these before in canals, as well as ponds. Um, some of the downsides that we've found to using them in canals, specifically-- well, especially-- is they require a 12-inch minimum soil cover to provide a seal. So the geosynthetic clay liner needs something to push against when it swells. So, that will lead to significantly reducing the capacity of the canal and the efficiency of us moving water downstream. We also ran into soil sloughing off of the side slopes. And once that happens, there's no-- it can't provide a seal anymore because you don't have that cover on the side slopes. And it also is exposed to UV degradation, mechanical degradation, things like that. So we didn't have much success when we were testing those in canals. They are used in ponds pretty successfully though, for us. The next two are geogrids and geofoams. I have never used these at Reclamation. I'm sure they're used in other projects at Reclamation, I just was not involved. So, definitely not an expert on these two things. But geogrids are used to reinforce soils or other materials. In the picture on the right, you can see that reinforcing a side slope. They're used in retaining walls, side slopes, as well as to reinforce soils or other base materials below roads or other structures. Geofoams are large blocks of expanded polystyrene. They're used for slope stabilization as well, retaining wall backfill-- like the image on the right-- as well as road embankments. And an interesting one is actually pavement insulation. So it'll be placed underneath pavement to deal with cold weather environments. So that's kind of interesting. So the next one-- if everybody remembers the initial chart that I showed-- that the geocomposite was used for all five functions. So, I'll explain that now. What a geocomposite is, is a combination of any of the previously discussed geosynthetic materials. So you can combine all of these different ones to complete a task. So the goal of a geocomposite is to combine the best properties of the different types of materials to find an optimal, low-cost solution to a specific problem. And like I mentioned, geocomposites can provide separation, reinforcement, filtration, and drainage in containment because they're a combination of all of the previously discussed geosynthetic types. Some examples of these are geotextile-geonet geocomposites. So, when I talked about geonets, I mentioned that they're generally sandwiched between geotextiles, so that would be considered a geocomposite. Some other ones are geotextile-geomembrane... Geomembrane-geogrid... In that case, that would give you some more stability while the geomembrane takes care of containing the water or the gas. And lastly, geotextile-geogrid. And now we're gonna move on and talk a little bit about some repair techniques for, specifically, geomembranes and then geotextiles. There's three different methods that you can use-- a heat welder, adhesive, and adhesive tape. I would say that the most widely and economically used one is the heat welder. And essentially what that is, is a high-powered blow dryer that gets extremely hot. All geosynthetics are what's called thermoplastics. So there's two different types-- you know, thermoplastic or thermoset-- when you're dealing with polymers. And a thermoplastic, what you can do is heat it up and mold it and then it will retain its properties, while a thermoset-- once it's set in its shape, you can't change it anymore. So that's why we can heat up these geomembranes and basically melt them together to create a weld. So I would say, again, that that's the most widely used and economical because you can take that around-- once you make the initial investment on the equipment-- you can use it on endless amounts of repairs that you're going to do. And it's fairly simple once you're taught how to do it. Adhesive will create a good bond, but as you can see on that picture, it's pretty messy. I don't think they tend to be used very often. I think you would go with an adhesive tape if you were going to go the adhesive route, um, just to keep it a little bit cleaner. Adhesive tapes do create a very strong bond and they work very well. But they are going to add up if you have a lot of repairs to make. So that's just the kind of decision based on your specific situation. They're also used to construct pipe boots. And what that is, is if you have a pipe penetration in a detention pond-- say you need to have some way to seal the pipe off so that water doesn't leak through. So they're used primarily in that. Repair techniques for geotextiles-- again, the heat welder. That's definitely the preferred method. It's going to create the strongest bond between the geotextile. And in a situation where you're in wet weather, that's the only time that you would generally go to stitching-- as far as a repair's concerned. If you were, you know, fabricating these in a factory, a lot of times you'll see them stitched on machines. You can get a lot done quickly. So that's definitely another use for stitching. But as far as repair, you tend to want to use the heat welder for that. Okay, moving on to degradation mechanisms. These are any mechanism that causes chain scission, bond breaking, loss of additives, extraction, or mechanical damage that will lead to degradation. The main one we try to protect against is UV light. So, we will put covers on top of them-- geotextile covers to protect the geomembrane. And we'll do other things to try to prevent light from coming in contact with the geosynthetic. They're. getting better nowadays, so they're able to last longer out in the sun, which is something that's progressed, um, recently. So, that's good thing. Other degradation mechanisms-- radioactive material, biological, chemical... Some do better with chemical than others do. Thermal expansion and contraction, so thermal cycling. They're generally pretty good in that regard but if you're getting extremely cold temperatures, then you're going to see some of that. You can get some cracking in them over time, especially as other additives are lost. Then, finally to round it out-- oxidative, ozone, as well as vandalism-- we actually get a lot of vandalism, surprisingly, which degrades them. Alright, I'm gonna move on to talking about a canal lining research project that I was involved in that finished up in 2019 that we had a lot of good, valuable results from. Scope of the project-- So, the project that I worked on was actually part of a larger canal lining demonstration project that began in 1991. Between 1991 and 2001, six reports were written. There was an initial construction report and then some visual inspection updates, as well some seepage testing done within those reports. There was also other liners that were added in during that time. The goal of the original study was to evaluate nontraditional liners and canals with high seepage rates. So, this was up in Bend, Oregon, which is heavily in basalt volcanic formations. And we were seeing, in pre-seepage-- or sorry, pre-construction seepage tests-- that they were getting between 35 and 50% seepage, loss of water. So when you're losing half your water, you definitely want to try to address that. And it was a good area for us to conduct this study. The current question of the-- my research project was: how to-- how are the test sections performing after up to 25 years of service? So this was quite a long study, which is great. You can draw a lot of good conclusions off of something that long. The team and partners-- Jay Swihart and Mike Walsh were Bureau of Reclamation engineers. Jay Swihart was actually involved in the initial 1991 report and project. And George Koerner who works-- who is an instructor, as well as runs the Geosynthetic Research Institute. So, project approach-- So, 24 test sections were installed between 1991 and 2001 in the Arnold, North, and Ochoco Canals. Seven test sections were removed in that 10 years because they failed. And so the report that I wrote was analyzing those seven test sections that failed, a condition assessment of the 17 that remained, some sample coupon testing aimed at correlation between properties and performance, as well as a benefit-cost analysis to determine which one of the liner test sections was performing the best. Okay, so project results. So, we took a look at three different types of linings. First one was exposed geomembranes. Now, advantages of these-- they can be durable. The liner in this picture is 25 years old at the time of the picture. And as you can see, there's sitting water in the canal invert, so it's still doing its job. It's in pretty good shape. There's a few small spots of damage on it, but, um, working very well still for being 25 years old. Now, with that said, there's definitely other liners-- exposed geomembranes-- that we put in the test that failed quite quickly, so I'll touch on that a little bit more later. Another advantage-- low cost for their initial construction. And based on pre- and post- construction seepage tests, the effectiveness was at 90%. Disadvantages-- maintenance can be a little bit difficult if you're not trained, as well as higher costs. There's not a lot of people familiar with geomembrane maintenance techniques out in the field, so they tend to not want to do the maintenance if they're not familiar with it, which is a downside. Also, service conditions-- so this is a big thing. We can't control control service conditions. So, you can put one of these liners in one area and it can perform really well. Put it in another area and it can perform poorly based on what goes on. If you get, say, a herd of elk walking across, they can puncture the liner. And it might not happen in another situation. You just can't really plan for those types of things. But once the damage occurs, certain things like soil migration can happen. If you get water underneath the liner, it can start moving around the soil and compromising the canal. And if enough of that happens, you can actually have the canal fail completely. Another thing is once water gets under, you can get some liner uplift, which can move the liner around and tear it further. As well as whales, which are pretty much giant bubbles that will run down the middle of, um, the canal. So, if water can't get into it because it's like-- it's preventing the water-- then it can't get back up out once it gets downstream, so we'll get those whales. And also with the soil migration, you can get like a capacity reduction of the canal, which is bad when you're trying to move as much water as possible. Next is concrete. So in this case, it was shotcrete. About a four-inch thick shotcrete, I believe it was. We looked at reinforced and unreinforced. real performance differences between the reinforced and unreinforced. I would imagine if you put these in a really cold area or a harsher environment, that you might start to see that. But for this specific project, we did not see that. some of the advantages of concrete-- they're durable. If you take a look at this canal, there's some erosion areas, the crack on the right side of this image. But for the most part, it's in really good shape, and we're predicting if it degrades at the same rate that we saw over the first 25 years, we're anticipating we're going to get another 25 years out of it-- to get to a total of 50. Maintenance-- low-cost and fairly easy. A lot of people are familiar with it, so they're more likely to perform maintenance on it, which is a positive. And also, what they're gonna-- what a concrete liner's going to do is it's going to prevent soil migration, as well as canal failure. So we talked about, in the last slide, about how when an exposed membrane gets damaged, you can get that soil migration, whales, as well as a canal failure. So the shotcrete's going to provide ballast and it's not going to allow that water to move the soil around underneath it-- definite advantage. Disadvantage, they're the lowest effectiveness of the three that we looked at, at 70%. As well as they're fairly expensive for initial construction costs. Next what we did was we took the concrete and the geomembrane and we combined them to try to get the best of both worlds. The advantages that we saw were, again, durability. We're projecting it 50 years. The reason for that is we're talking about the durability of the concrete. And in this case-- it's the picture on the left-- you can see that concrete's in great shape and there's sitting water in it, um, after 25 years, so it's still performing quite well. Effectiveness went up to 95% with combining these two. Maintenance again, easy, low-cost-- we're referring to maintenance of the concrete 'cause you're not going to need to maintain the geomembrane underneath. Other advantages-- they prevent soil migration and canal failure, just like the concrete. And what the concrete also does is it prevents liner degradation, as well as liner uplift, because it's on top of the geomembrane, so it's protecting it. Disadvantage to this-- the only one was that it is the most expensive type. Obviously, if you're going to combine the other two, it's going to be the most expensive one. So-- The end results-- so, we came up with a benefit-to-cost ratio equation, taking into account things such as durability, effectiveness, maintenance required... And we ended up analyzing all of the test sections, and these are the results. One of the main, um, cells you want to take a look at is that bottom right one. You can see that the benefit-to-cost ratio is between 2.2 and 3.8. So it is the lowest, as well as the highest. And the reason for that is because, like I mentioned before, exposing them-- geomembranes-- we can't control the service environments, and we can't control necessarily what happens to each one of these test sections, even when they're very close to each other. So, for my money, it seems like the concrete over geomembrane is the way to go 'cause it provides consistently high benefit-to-cost ratio, so you know what you're going to get. As well as the highest effectiveness. So, the main goal of this is for us to contain the most water that we can within the canal. So, I weight heavily the effectiveness of it. Alright... moving on. Um... So, uh, this is another project that I was involved in. And this slide is really intended to highlight how geosynthetics can be used in conjunction with each other. So how we can take geotextiles and geomembranes and all the other geosynthetics that I talked about and combine them together and use them on a project. So, the following liner system that I'm going to be talking about was used at a water treatment plant. And the pond's purpose was to store water in case the plant is at capacity, there's any down time for maintenance, exit streams-- exit streams are dropping in quality for some unknown reason. So, any reason that they would need to divert water from entering into the water treatment plant, they would put it in the detention pond for storage and then pump it back into the water treatment plant to be treated. So, taking a look at this liner from top to bottom. First, we have a shotcrete cover. So, what that's going to do is a couple things-- struggling with, uh, water table problems with the old liner-- the water table was rising and the liner was being lifted up and there's a lot of potential damage there that you can incur when a liner's moving around. And it's also going to provide, just, protection from the sun as well as any type of animals, vandalism, any type of mechanical damage that the geomembrane could incur. The second later-- layer is a geotextile. And that's meant to separate the geomembrane from the shotcrete during application. So to protect the geomembrane from the shotcrete when it's being applied. Next layer is our primary geomembrane layer. Um, again, we touched on-- geomembrane's purpose is to contain water. So, this is the layer-- the primary-- the first layer that's going to prevent contaminated water from seeping into the groundwater. Next is a geotextile-geonet geocomposite leak detection layer. So, what the purpose of that is, is... um... If, for any reason, the primary geomembrane layer is compromised-- if you get a hole in it, any type of damage-- then we need to detect that in a certain way. So, what we do is we put a geonet, so that it can move that water laterally into a sump pit. And we can kind of Analyze how much water is leaking through and if we need to make a repair on the liner. Next we have a secondary geomembrane, and that is as a backup in case the primary layer gets damaged-- we're going to use a secondary layer. In this case, it's really important to keep the contaminated water out of the ground. Lastly, we are going to use a geotextile-geonet geocomposite. So, the same thing as the leak detection layer, but for a little bit different purpose. That's going to prod-- protect the secondary geomembrane from the subgrade. So any rocks, anything that could puncture it. As well as, when the water's rising from that water table, the geonet can laterally push that water towards the side of the pond to help prevent any uplift in the case where the shotcrete maybe isn't enough. So... Kind of a cool project and a good look at how they're used in conjunction with each other. Moving on to another project. So, this project involves seepage rej-- reduction through a dam face. So, what we're doing is using geosynthetic materials to reduce seepage through the face of a steel dam. This dam was constructed out of steel panels, like I said, and coated with a protective paint. Some problems that started to arise were corrosion of the steel face, Movement and heaving of the steel plate, as well as some cracking. So, the way that they addressed that-- or are going to address that-- is to use a geomembrane system to contain the water on one side of the dam. This solution utilizes batten strips, which you can see on the edges of this test section here. And that's to hold the geomembrane-- or the whole liner system-- onto the face of the dam. They also use a proprietary technology to tension down the material. We don't have as much of a concern with wind when we're dealing with canals or detention ponds. But on the side of a dam, it's big concern. So they can tension that down, keep it-- keep it on the dam face where it needs to be. Um, yeah. So there's also-- an interesting aspect of this is thinking about if water is to penetrate through that primary liner on the outside. So, we've installed the geonet inside of that to move the water down to the toe of the dam for drainage-- So that a repair can be made. Last project that we're going to talk about is, um, an elevator shaft roof repair. So, Reclamation was involved in a project at a hydroelectric plant to repair a roof that was leaking. That involved finding a waterproof and weatherproof Solution for the roof. Generally, what you use in roof applications is EPDM, which is ethylene propylene diene monomer. The reason for that is they're extremely weatherproof, extremely durable, and they're flexible at both high and low temperatures. So if you take a look at the image below, you can see there is a steel decking. And then we would put some sort of insulation on there, obviously to keep cold weather out. Some roof board. Then we'd use a bonding cement to attach the EPDM liner to the roof. They come in, generally, square/rectangular tile types, so there's going to be some sort of seam that you need to keep water from getting into. So, in that case you'd use a tape. So, we discussed that with the pipe boots and repair in an earlier slide. So, you throw some of that tape on there and it does a really good job at, um, keeping water out from where you don't want it to be. So. With that said, that is the last slide. And I will toss it back to Chrissy for any questions that anyone might have.

>> Dr. Henderson: Well, thank you very much, Brian. Looks like we have an echo. So, alright, I will fix that. Um, if-- looks like we have one question that has showed up so far. It says, um, "If possible, Brian, can you address joining, anchoring, and lapping/splicing of the various geotextiles, geofabrics, such as fabric staples, spikes, hog rings?"

>> Grace Weber: Hey, Brian, I think you're on mute.

>> Brian Baumgarten: Am I off mute now?

>> Grace Weber: Yep, you're good.

>> Brian Baumgarten: Okay. So... Sorry, I missed the very last part of that question. If you could repeat the last part, that would be good.

>> Dr. Henderson: Yeah, can you address... um, it looked like... fabric staples, spikes, hog rings. Maybe in relation to joining, anchoring, and lapping/ splicing of various geotextiles and fabrics.

>> Brian Baumgarten: Yeah, so, hog rings are generally used for connecting geonets. So that's kind of the main way. As far as anchoring 'em down, something I definitely didn't touch on is-- you use what's called an anchor trench on the top of, say, a pond or a canal. Generally about a 2x2-foot trench where you're going to bury the top of the-- the whole liner system-- in a trench and then put dirt on top of it. In the cases of the shotcrete over geomembrane sections that we did, we ran the concrete over the top of that trench. So that's how you anchor it in to-- the whole system in-- as far as lapping... In the case of, say, a geomembrane, you're going to use what's called-- it's a welding, um, machine, but it's not the exact same as, say, the-- the repair piece of equipment that I showed you. It takes the two different ends and runs them through kind of a roller with a wheel on it. And so they'll seam those on site. It's very quick. Geomembranes, like I said, you can do stitching or you can-- or geotextiles, excuse me-- you can do stitching or you can heat weld them together as well. So, I hope that addressed the question. And again, you can contact me. My information is there. If I didn't fully answer your question, I can elaborate on it.

>> Dr. Henderson: Let's see... Grace, do you have a-- Can you access some of the questions? I'm having, actually, trouble getting to them.

>> Grace Weber: Sure, um... So, we also have just a comment in here.

>> Brian Baumgarten: Okay.

>> Grace Weber: So, Jeremy wrote in: "It is important to note that geomembrane under concrete has limitations in locations with high groundwater or during rapid drawdown scenarios." So, I don't know if you have anything you want to add onto that.

>> Brian Baumgarten: Um, I guess I would have to ask more specifics about the comment. Generally, what we've seen is that the concrete's going to protect the liner from uplift in a high groundwater situation, providing some sort of ballast. So, I guess, maybe outside of this, reach out and we can discuss that a little bit further.

>> Grace Weber: Okay, um, another question-- "Which geosynthetic material is the most cost effective?"

>> Brian Baumgarten: Okay. Um, yeah, so-- I think that table touched on it a bit. That we had-- as far as the benefit-cost ratio was concerned, the concrete over geomembrane ended up finishing first. Something to keep in mind, though, is prices with Geomembranes can fluctuate based on the oil industry quite a bit. And so, you know-- again, depending on where you're going to put the geomembrane, you know, the price at the time, the service conditions... those are things you're going to want to take into account before you select a specific type. So, that can change based on the price.

>> Grace Weber: Okay, this question is from Russell Davies: "In addition to use for soil stabilization, what other creative uses for geotextiles have you employed? Also, in the case of transferred works, would, or should, USBR have some input on repairs for canal seepage when using a geo- product?"

>> Brian Baumgarten: Okay, um... So, the first part of that... Sorry, can you read the first part again? I wrote down the second part, but...

>> Grace Weber: Yeah, the first part was: "In addition to use for soil stabilization, what other creative uses of geotextiles have you employed?"

>> Brian Baumgarten: Alright, so we mainly use them for, um, protection-- as kind of a cushion for geomembranes. Um, the other one that I mentioned that we use it with is around drains. So, um, in that detention pond, it'll be used around a French drain type system to keep any type of substance you don't want in that drain out while letting the water through. So those are a couple, um, other ones that we use 'em for. As far as transferred work, I'm not sure that I... understand that question completely. Um, do you, Grace? Like, what the question's kinda asking?

>> Grace Weber: Um, I'm not sure. But, Russell, maybe you can connect with Brian offline about that.

>> Brian Baumgarten: Yeah.

>> Grace Weber: So, next question is from David: "Does BOR have a recommended installer of geomembranes or specifications of the shotcrete?"

>> Brian Baumgarten: Um, as far as recommended installers... No. What we'll do in our specifications is, we'll have a number of companies that we've used their membranes in the past or their liner systems in the past, and we will put them in there. We have some sort of properties that the geomembranes must meet. And then, um, a lot of times, you know, the contractor is going to be one installing those. So. Second part was what, Grace?

>> Grace Weber: Um, do you-- do we have any specifications for the shotcrete?

>> Brian Baumgarten: Yes, we do. We have specifications. Um, I would put you in touch with-- we have a concrete lab, um, at the TSC. So I would put you in touch with them. They're the ones that are going to handle the shotcrete specification. So, whoever that was, if you wanna reach out to me, I can put you in touch with the right people.

>> Grace Weber: Alright, the next question is: "Do you have any further plans to build on the geosynthetics research? Any future work?"

>> Brian Baumgarten: Yeah, so with regards to the project that I discussed in this presentation, I would like to go out and do further seepage studies on them. This part of the project was more of a visual assessment of how they were doing. And, I think that actually doing ponding tests on these test sections would give us some quantifiable data and, um, make our results a little bit stronger. So, that's the plan. I think that, you know, as far as-- also touching on the project, that was in this presentation-- those were older liner materials that we were looking at. And there's definitely been a lot of changes and different types and different types of technologies that we can use these days. So, I'd like to do a similar study with the more advanced technologies that we have available to us today.

>> Grace Weber: And, um, the last question we have at this time is from Victor: "Is there any history of how geomembranes perform being installed under several inches of soil or gravel?"

>> Brian Baumgarten: Yeah, um... So, we-- I guess... When we were doing our canal lining-- this particular project-- we installed a geosynthetic clay liner, which, um... is meant to accomplish the same thing of containment underneath soil. So some of the things that we ran into were, like I mentioned, sloughing of soil off of the side slopes and then the... The liner didn't end up performing very well. So, I think that would be the main issue with it-- with soil-- is that it can slough off. You can use those honeycomb-like structures-- the geocells that I mentioned. But you're starting to get into a more expensive liner type. And, with today and the technologies that we have-- and the fact that the geomembranes can last longer in the sun-- I'm not sure that I would recommend that at this time.