[SQUEAKING]

[RUSTLING]

[CLICKING]

[APPLAUSE]

PROFESSOR: And our next speaker is Brock Yordy from the Geothermal Drilling Association, and he had the pleasure of collaborating with Brock this past summer to do geothermal driller pre-apprentice program.

PROFESSOR: Did she not take him out?

BROCK YORDY: So how does this work? Do I still have 20 minutes or?

PROFESSOR: So sorry, Brock. They wanted you to put it on the next guy, so.

BROCK YORDY: Oh, excellent. So we're going to do introduction to geothermal drilling, abridged in 20 minutes. There's plenty of things in here. And we have heard about how drilling affects us.

And I think any of you that are flipping the television and you come across FX and you see the movie *Armageddon,* you can see that the major premise is it's easier to teach drillers to be astronauts than it is to teach an astronaut to be a driller. When Ben Affleck asked that question, some choice words were used by Michael Bay, but in reality, suspension of disbelief is what we're looking at. Jump past that.

OK, here's my warning. The following presentation features tribal drilling knowledge acquired by drilling professionals or under the supervision of geothermal professionals. Accordingly, me, must insist that everyone who engages with drilling in this presentation consider this advice.

Drilling is the imperfect combination of science, physics, and self-taught tribal knowledge compounded over years of success and failure. Drilling is a disruptive process. We know this. The key to the success lies in your conscious choice of the drilling program that minimizes the impact of the surrounding environment. That's the borehole. That's the neighbors. That's the project staying on time.

Drillers, contractors, engineers, scientists and clients have entered into a powerful partnership to uncover the mysteries of the subsurface. We are discovering the unknown together. And how are we going to do that? Abridged version, 20 minutes, right?

It's simple. We have a drilling system, and we've seen this from the OG Karen Eubanks, who, as we've talked a lot, geology, formation, hydraulics, depth to water, subsurface challenges. Those are the things that I'm thinking about when we say, Can we drill this?

Next, that's going to align into my drilling capabilities. This is my drilling system. So what can my rig capable of doing, from horsepower to rotation to pull down to pullback to diameter, depth, angle? This is all going to drive our cost.

Next, choice of drilling method, back to that drilling program. Is it going to be using mud pumps, air compressors, sonic, dual rotary, reverse circulation? There are plenty. Hopefully, one day we get a rock melter. Maybe a laser. We keep seeing things come out all the time.

Finally, as much as we want to say autonomy is coming, and it's really cool watching the Dragon rocket go up and there's nobody really at the control, but they still-- individual can be at that stick at any moment. And this processing right here will always be very important to what we're doing. So our driller, our drilling company, our contractors' qualifications, What special tools do they bring? What methods? What applied science and fundamentals?

So as I think of that, the driller, we talk about workforce development. We talk about developing this. The Liftoff report talks about where we need to be, what we need for workforce. He and I, with Stacy right here in the front row with the time, and we have collaborated a ton on workforce development and developing these drillers.

But the critical system that I just showed you doesn't work without a competent drill crew. That's working in safety first, because we're rotating, we're percussing, we're lifting things over our heads. So as that drill crew steps up into this critical system, what's their goal for the day?

What is the quality of the installation? What is the site and environmental impacts and management? What is the goal for project completion? Staying on time, staying under budget. Did I say under budget and I'm a drill guy? Whoa.

Preparation and planning for unseen issues. For foreseeing issues, weather, those challenging geologies. Roles and responsibilities of that crew, the driller, rig operation. This is a complex process that has microsecond adjustments that need to be made at times. They need to understand this so they can have effective product installation and we get effective resource extraction so we have good project completion and good record keeping.

We have an assistant driller. They're supporting that driller, rig support, tool handling, product assembly, getting into the standards that we just talked about from pressure testing to making sure our grout, making sure we're making that right hole. And then finally, our field technician, who is doing the solids control management, because, let's face it, we love this concept of drilling and putting boreholes in.

We forget about the cubic yards of material we pull out of the ground and how we're going to do that 5 times to 90 times to 600 to 1,000 times. And we have to be able to manage that. So three people, we can get away with two. It depends on the project, the timeline and the expectations.

We're all going to become drillers today. This is the basic fundamentals. I am exerting force against our geology, and then I have to cut it. So is that in rotation? Is that in percussion? Is that in velocity? Is that in frequency, as we see with sonic drilling?

Next, I have to remove those solids or it's not a borehole. It's just a thing that we got stuck in, and, man, we don't drill more boreholes. So I have to flush it. I can do this either mechanically, that's with augers, that's with frequency, or flushing with water, air, drilling fluids, engineered solutions.

This is straight air rotary. We can see one's going into some rock here, and we have one going into a blue green shale. Nice, clean, out of the way. No water table here. How many times are we intersecting water tables and producing water? This is a big piece for us in our cost, in our responsibility as a driller.

Here's mud rotary. Conventional. Man, it looks messy. So we immediately go, we want to go back to that other slide. But we can't. We have to select the right method for the right geology.

So we get into engineered drilling solutions. Jordan, I drilled with the US military to 2,400 feet with bubbles. Got the nickname Captain Bubbles for that entire project. We can use foam with low hydraulic conductivity and carry those cuttings out.

Mud, mud rotary. Why it's been predominant throughout geothermal is because, again, it's low influence to our ground. But it creates two waste streams. And we've decided those waste streams are much harder to get rid of.

So let's look at this. We're going to talk conventional rotary. We could get into dual rotary, and I'll say, competent drilling companies, they're good. And they have invested in lots of different pieces of equipment. And here's the deal.

They're going to sell you on their system. And sometimes those systems are bougie boreholes that go 850 feet at an angle. And we need that because of the footprint and the solution. And there's other times where we can simplify this. And if you look at the Liftoff report with 80 million buildings, we need that holistic approach of everybody drilling.

This is *Armageddon.* We saw 3 degrees Celsius by 2100. That meteor is coming here. We all get to be Ben Affleck and Bruce Willis in this situation.

So as we look at this, we have mud drilling. I need to be able to remove solids from the bottom of the borehole at the bit phase, at somewhere between 60 and 150 feet per minute. Low conductivity. I'm not going to force on those fragile formations.

I get into air. I think about Stan Lee and Spider-Man. With great power comes great responsibility. Holy cow, I can move cuttings out of the hole at 7,500 feet per minute. Jobs should be done under budget, on time, like super fast. We'll have cars going back over that road.

But that's competent rock formations. That's no water. What happens when we start those waste streams? So then we start engineering solutions, either in mud or in foam, and we can start changing what we need. But the influence to that borehole wall, as we talk about that thermal conductivity test, as we talk about all of those pieces of influencing and minimizing that impact, come from us matching the right drilling method to what we're going to be in.

So what do I need out of that drilling program? I need an efficient rate of penetration, because, let's face it, with the drilling companies that are in here, time and diesel fuel, regardless of our waste stream, because guess what, clients? You're a cogenerator. That's your waste stream. We're just managing it for us. Time and diesel fuel are the most expensive pieces for our projects.

So I need to be able to have good rate of penetration and good production. Next, while doing that, I have to minimize the impact to the borehole and think about how I'm influencing that downhole geology. I talked about geology. Next to it, I said formation hydraulics.

I want you to think about-- I was in wood shop. There's this really cute individual next to me. It's Mother's Day. We're building birdhouses.

I want to ask her to prom. So I grab my birdhouse with the pine, and I drive all the screws in it, and I get it done. It fell apart two months later in Mom's yard. Amanda's birdhouse, I helped her predrill all the holes. We set it. We put the wood glue.

Our geology's the same way. When we break that fracture gradient, just the same as if I drive a screw into this right now and split this table, I can putty that. I can do things to it. But I can't fix the damage I've done to Mother Nature. So beyond that, we get through those fragile subsurface formations. We get into water production.

I want you to watch the news right now. Thank you. Princeton and Arizona came out with a connection between surface water and groundwater, talking about fossilized water. Holy cow.

It's the drill guy talking environmentalism now. It's a weird time. Drill, baby, drill? No drill better drill. We need better people drilling professionally.

So we are pumping fossilized water out of aquifers. That's going to take 10 years to 10,000 to 100,000 years to replace. So we save the planet by 2100, but we exploited all our groundwater and it went into the Atlantic. Did we save ourselves?

So we have to understand, as we produce that water, and how much and the influence. But beyond that, as we go deeper, we have to start thinking about volatile gases, CO_2, hydrogen sulfide, methane. And on that minimal impact, as we step back, dust, noise, drill solids. As we look at more campuses being done, man, Ball State, they didn't care how many dump trucks came through. Those were all Indiana farm kids.

You go to Yale, you go to Fordham, and you start thinking about how we're removing cuttings and people are like, Why are there 10 dump trucks a day coming through here? We have to think about the impact to our neighbors. Finally, I need data gathering. I need real-time analysis of that subsurface as those formations change, as we have challenges, as we have loss zones, because I have to effectively be able to grout that so that I have the right influence to the loop.

So the results of me doing this right, the hole's going to be open. Meaning, I can get product into it. It's going to be gauge. Again, my drilling influencing my geology. If we specify a 6-inch borehole, and we look at the cubic feet, or the cubic yards of grout we want to put in there, and we end up with this oblong boiler hole, we just saw what Garan talked about. We heard what Mark was talking about. We've screwed up. And now we have an ineffective system.

So I need gauge. I need stable so that I can get in and out of it. It needs to be straight in the desired direction. And we need seamless product installation, loop to bottom, grout to top, so I can have efficient resource extraction.

Sounds easy, but then we get into this situation right here. All different types of drill solids, how Mother Nature reacts to us, how our subsurface works. These spoils, as I get them out of the hole, How do I handle them? 6-inch borehole to 400 feet. It's 2.9 cubic yards.

Oh, by the way, that's why we have three people on our drill crew, because there is a lot. if we're going to increase production, you need to be able to move this stuff away. 6-inch 850 foot hole is 6.17 cubic yards. So as we start thinking about this, How many dump trucks and back trucks am I bringing into this project?

Loop installation. As we specify, two loops. The BU building with the Rygan, 1,500 feet. We think about all these different pieces. I need a good effective drilling program so I can have good grouting process.

This loop should be in the center, and that trimming should be on top of it. But I'm really bad at paint. And this is what we get. So here's our tremie to bottom, our loop to bottom.

My individual starts mixing the grout to the specified specifications that we need. The right amount of water, the right amount of bentonite, the right amount of graphite or sand. I start filling that borehole. As I fill that borehole, that tremie needs to stay 10 feet submerged in the grout so I have continuous grout column coming out.

We talk about now we're going to leave the tremie in at bottom. Now we're not going to do this. I started my career after Yordy & Sons at Halliburton. I studied grout for 10 years.

I'm bringing this grout column out of the hole with my tremie. And that's what I want to see. I want to see grout to surface. I need to effectively be able to look at that grout and know that I had a good column come out, that I didn't have channeling in that.

As we have these discussions about, ah, it just needs to be 4 feet in the ground. No. I need to see this because this is protecting us. I need to see it come to surface.

Why? Because I am replacing the native material that I just destroyed with something that meets or exceeds-- thank you-- our sealing capability. It's got to have a better standard. I need to ensure continuous contact between the loops and boreholes. We've got some brilliant individuals in here. You ask them what happens if we have a bad grout column and that air pocket.

I need to completely seal the annular space to prevent comingling of aquifers and prevent surface contamination. As we look at these projects and we go hey, there's this open area, let's put a borefield here. Is it low land? Does it flood?

My favorite question to ask when I show up on these projects is, Why isn't there a Starbucks here? If not, my greatest generation, my grandfather, they were really good at burying things, and we're going to find it. So I need to prevent that surface contamination. I need to comply with federal, state laws, and I need that thermal conductivity and borehole integrity to stay.

This is my method. Check out my hour presentation, not abridged, so we can get into this. This is what I want to talk about. Success to a drilling project is managed through these points. And whether we're doing this all because of the climate change, we have to understand how this is changing our drill and build schedule.

Next, other construction operations. What are our regulations? Location, location, location. Project timeline, and then neighbors. How am I sharing that site? How am I protecting Mother Nature? This is the reality of projects from downtown Los Angeles for George Lucas to right here just outside of Boston to a very tight location, urban church.

This is what kicks our butt, everybody. If there was a slide to take a picture of, this is the one, because every time I get on a new call to troubleshoot a problematic project, I add to this slide. So if green, local geology should not be an issue. We should have an effective amount of test boreholes to know.

So if I'm drilling a 600-hole project and I do two boreholes, is that a representative sample? No. That doesn't get us what we need. We need that subsurface data. What's hard? Man-made subsurface obstructions and contaminants, problematic sub subsurfaces as we get into fragile formations or water or artesian flow. And utilities. And those are the things that we have to be planning with the right qualified contractor.

So if I have that right, qualified contractor and we have our pilot team right there, the pilot tutorial-- thank you-- watching Skillings drill. And that was a wonderful experience with all of them. What am I doing to choose this project if you call me as a contractor? Equipment availability, tooling, drilling method, compatibility with the location, site footprint, environmental demand.

What is my timeline? What is the borefield design and borehole design? Project restoration and cleanup. That's a big piece, is managing our projects so that CSM or Clark or whoever you're using for your GC isn't like, you're going to drill another borehole and we're going to walk around in 18 inches of slop? What are my licenses? Am I IGSHPA accredited? These are all pieces.

This is what we can do at test boreholes when we're surgical. And you can see, this project, we had snow and rain. It was Chicago. It was end of October. This is how we left the job site.

So lessons learned. Every contractor is going to have an argument on why their method's the best. It's your choice how you move along with that. We need to optimize drilling every chance we can get.

What do I want? I want qualified contractors. I want the right drilling method for the area. I want test boreholes. I want test wells that give us the right data. I want us to think about what we did successfully before, and how we loop and grout that.

That was 21-ish minutes. Thank you, Stacy. Thank you, everybody.

[APPLAUSE]