REINALDO GARCIA: OK, thanks for your patience. Seems everything's working now. My name is Reinaldo Garcia. I'm with Hydronia Development. And Charlie Ogden is my co-speaker today. He is the project manager at Autodesk. And we are going to be sharing with you some of the stuff we've been working on in regards to the flood simulation plug-in for InfraWorks 360.

So we're going to organize the presentation in two parts. I will be making the introduction, actually a relatively long introduction about the software, its capabilities, and some of the things it does. And then Charlie will show you a demonstration of how the actual software works. And some pretty neat applications have been developing in the last few months. So I think we can get started.

The first part I want to-- for those of you who may be familiar with one dimensional models, hydraulic models, who has been doing any hydraulic modeling or flood simulation modeling? I suppose you are familiar with HEC-RAS, right, a 1D approach. How many of you have been doing or have done in the past two dimensional modeling? OK, one, good. HEC-RAS 2D, maybe? OK, good. So I will, for the sake of giving you a little more information about the software, I will do a little introduction of 1D versus 2D modeling. Then I'll talk about InfraWorks 360 and RiverFlow2D flood simulation model. Then Charlie will show you some examples of how the actual model works, how to set up an actual simulation, and how easy it is to work with the model. Then finally we'll show some animations of the actual model working.

So the main objectives of today's class will be to give you an understanding of how two dimensional models can be used within the framework of InfraWorks 360, and then also to provide tools to perform realistic simulations with the flood simulation plug-in. The final goal of the demonstration is to show you the workflow of the flood simulation within InfraWorks. So Charlie will go step by step on the different steps that you need to follow to perform a full two dimensional simulation.

I want to acknowledge a bunch of people that have been involved in this project for some time. Some of them are associated, or most of them are associated with Autodesk, besides Charlie. And I will also talk a little bit about how this project came to be in the first place.

So of if you are familiar with one dimensional models, the domain of assumption the one dimensional models do is that you have cross-sections and the cross-sections represents the

hydraulics on a particular site of the floodplain, and the river. But the assumptions that are involved here is that there is a single water surface elevation representing the depth or the flow within a given cross-section-- also that the velocity is perpendicular to the cross-section, and that you essentially cut plates at this charge, which means that the velocity that you get is the average velocity on the cross-section, even though you can make some certain assumptions to get a little more detail. But in essence, what you get in a one dimensional model is an average velocity in the cross-section and a constant water surface elevation.

So the main thing-- just the next one here-- the main limitation of this approach-- which is pretty good for confined flow. So if you have a river that is a valley and it's confined, these assumptions are quite appropriate. But if you have a wide floodplain where the flow can go in any direction, this is not the best approach you can follow to assess the risk of flooding in a given area. And the main reason is that when a modeler defines the cross-sections, it is essentially predetermining the directional flow. So you create a cross-section and you are telling the model the velocity will be perpendicular, always, to that cross-section.

Let me give you an example of how this turns out in a real simulation. What you see here is a floodplain with a large number of cross-sections. This is a real example. And these are HEC-RAS cross-sections that were used in a one dimensional model that was implemented in this location. Then what you see in the background are the velocity vectors obtained by a two dimensional model in the same floodplain.

Some of the things that you see here in the circles are violations of the one dimensional assumption. For instance here, you see that the velocity that is predicted by the two dimensional model is essentially parallel to the cross-section instead of perpendicular. So the assumption of perpendicular cross-section here is violated in this particular case.

There are other errors that you may not see if you use simply a 1D approach. For instance, you would be missing this overflow from this part here that is flooding all this area here, because you don't have a cross-section that represents the area between these two regions here. So there are many instances, particularly in unconfined flood plains, where the 1D approach can lead to very different results from 2D models.

So the 2D model essentially represents the complex terrain, not only the cross-sections but the whole three dimensional terrain. So at every point where you discretize the two dimensional model, you get the velocity, the depth of flow. But also, it's based on the actual

bed elevation on that location. And what you see at the right is a flexible mesh, a triangular, unstructured mesh of a two dimensional model where, at each point or at each node of that representation, you get a value of the bed elevation at this location.

Now there are different types of two dimensional models. The one that we implemented in flood simulation uses an unstructured mesh form of triangles. But you have also square type of grids where the elements are uniform in size. And the advantage of the flexible mesh is that it can represent any variable geometry that you may have in the floodplain.

This is an example of a flexible mesh in a floodplain. And you can see here that the mesh is resolved around buildings or houses that are there. And the basic computational element of the mesh is the triangle. And the triangle represents the-- in each triangle, the model calculates the velocity, which can have any direction. So you're not predetermining any direction of the velocity. The flow can go anywhere, in between the buildings or along the streets in any direction. And that direction can change in time as well.

So a little background on the flight simulation-- this started as a collaboration between Autodesk and Hydronia in 2014. It's still ongoing. We initially released the flood simulation plug-in as a Labs project. That was named by the Project Boulder. And it lasted until almost September of this year. And it graduated very recently. And it's been released as a commercial product since also September of this year.

Well, actually the flood simulation plug-in is the tip of an iceberg here. So the actual engine of the flood simulation is the RiverFlow2D model, which is much larger and more comprehensive model than the one that has been implemented so far in the flood simulation for InfraWorks. And there is no intrinsic limitation to implement the whole model. It's just a matter of development plan. So we have started by implementing just the hydrodynamic components of the model thus far.

So the full RiverFlow2D model has a number of capabilities. First, it is a combined hydrologic hydraulic model. It can do rainfall, infiltration, and also routing in two dimensions. It's based on a flexible mesh, so you have triangles that represents the geometry. It can deal with dry and wet areas, supercritical and subcritical regimes. So it can handle very fast flows. It can do hydraulic structures, bridges, gates, weirs in 2D.

And it has three add-on modules-- erosion-deposition, sediment transport, computation, water quality analysis, and model debris flow. Works in English or metric units.

And it has an option to work in GPU for very high acceleration. So the GPU version, which is essentially the same hydrodynamic model but it can run in GPU, NVidia cards it can run up to 150 times faster than the normal CPU-based model.

So the hydraulic components includes internal rating tables, sources and sinks-- to represent features like the ones you see there-- bridges in 2D, gates, culverts, and weirs. So all of these components are actually calculation algorithm that are implemented in a two dimensional mesh. So if you, for instance, you want to use a culvert, you connect two points. And then the actual culvert calculations are used to determine the flow rate within the culvert that connects these two elements. The weirs is also a tool that can be used to represent some walls or very narrow structures in the floodplain.

The hydrologic model, as I mentioned before, includes distributed rainfall. So the rainfall can vary in space and time, as well as the infiltration. So you can have different areas even with different methods of computation for the infiltration losses, including the well-known curve number SCS method.

There's been a number of large scale applications of the model. So the model can be applied to very small cases, but very large cases. This is the Red River of the North application that is being developed by NOAA, North Central River Forecast center. And this is 420 river miles of the river that has been discretized. You see here some details of the mesh there.

And the interesting data of this application is that the model is able to route 60 day hydrographs in 36 minutes, which is even less than the 1D model that has been implemented in this location, takes about three hours. So the 2D model with GPU capabilities is faster than the 1D model.

This is some data. This is field data, water surface elevation versus calculated results. And this is a calibration that has been done by NOAA. And you see here that the model is able to replicate the high watermarks that have been obtained or recorded in that area.

Now for the advantage of using RiverFlow2D within InfraWorks are many. This is some of them. First, the computational engine is very stable. So as you will see, when you run the flood simulation within InfraWorks, you essentially don't see the model running, necessarily. So the model runs. And the fact that it's so stable, it releases InfraWorks from doing a lot of checks that normally in other models you would need to do.

It preserves water volume exactly, errors of the order of 10 to the minus 14 percent. It can handle any terrain, even vertical walls within the flood plain. There are a number of capabilities that have not yet been implemented but we are still working on it. So it's a subset of the RiverFlow2D model. And as you will see, it's completely integrated now with the InfraWorks 360 graphical user interface.

Well, this is another important feature. The model is much faster than equivalent models. Next slide show a comparison we did with the UK Test 5, which is a benchmark developed by the UK Ministry of Environment for testing two dimensional models. So this is a 780,000 cell mesh. And this is the results with the RiverFlow2D GPU model. It takes about one hour. And HEC-RAS 2D takes about 25 hours. So it's about 25 times faster than HEC-RAS in this particular application.

So the typical areas of applications-- general 2D hydraulic simulations, dam-break flood analysis, floodplain risk assessments, coastal and storm surge sea level rise type of simulation in coastal areas as well it can do.

This is an animation that was provided by Angelo Espinoza, Autodesk California. And you see here, this is within InfraWorks. So you see here the flooding coming from the sea and see how the houses on Malibu area are being flooded.

Now Charlie will show you how to work with InfraWorks 360.

CHARLIE OGDEN: My name's Charlie Ogden. I'm product manager with Autodesk. I'm product owner of all the storm water solutions for Infrastructure and Civil 3D, and also in [? forks-- ?] so package low, SSA, flood simulation, the tools we have in InfraWorks and Civil 3D for modelling pipes and that sort of thing.

And what I'm going to do to start is just kind of go quickly through the flood simulation workflow, and a pretty simple example to start with. And in this case, just using Model Builder data. How many people are familiar Model Builder in InfraWorks? A few. So, how many people are familiar with InfraWorks, or using InfraWorks?

So Model Builder is a great way to get started with a model. You don't have your own data. You're maybe starting a project and you want to do some additional stuff, like look at some flood simulation.

So what we can do is start with this tool. This will get us terrain, aerial imagery data, roads, buildings, that sort of information into a model. It comes from some city mapping data, but bringing in all this [INAUDIBLE] into-- a model is a place to start. And then you can add your own data to that as well. So maybe you have a larger area from Model Builder, but you have more detailing terrain data, like from Civil 3D, or just your own DEM files. You can bring them in as well, supplement the larger area. So we'll talk about that a little.

And then so once I have some terrain data, then what I to do is basically define the area for the flood simulation, just basically drawing a polyline sort of in the model. And then define where water's flowing in and where water's flowing out of that boundary. And then we'll define the conditions, so the flow coming in at each of the inflows, what the conditions are at the outflow location.

Then we'll run the simulation. I'll do it for my first example. It's a nice small one. I have a couple other examples. I probably won't run the simulation. I'll open up one. It could take 15 minutes. I don't want to waste class time doing that, for a larger model.

Once you run the simulation, the simulation sends it to the RiverFlow2D application that does the calculations. The data comes back where you can then animate in the InfraWorks model. So you can view this animation as either depths. So what's shown up there in blue, the dark blue is deeper for water in the flood. We can also do elevations. So there's some color coding different elevations, and also color coding or theming different velocities.

So, let me just go through a quick example here. So I have this model. This is our Autodesk office in Manchester. About 10 years ago there was a flood that I'm just going to reproduce, flooding the parking up to the front of the building here from this, the Merrimack River. So this one is just a real small model, just I want to use as an example.

So, the flood simulation tools you're going to find from the Drainage Design menu, on the first one where we have our analysis tools. You'll see flood simulation as well as this snapshot. Is that better? All right, you'll see the flight simulation command here. If you have the RiverFlow2D plug-in installed, you'll see that. So selecting this, this will just prompt me to define that boundary. And then I'll define my inflows and my outflows.

So what I'm going to do is just draw in here. You kind of want to-- if you have some idea of where the extents of the flooding is going to be so that you don't have it just spilling out on the sides. So a boundary is defined. And now it's asking me for my inflow location. And I'm just

going to pick two points upriver here to define my inflow. And them I'm going to define my outflow, just by picking two points.

And then I get this dialog box where I'm going to give it some information about the inflow, the outflow, and then run the simulation. So my inflow here I'm just going to enter in a fixed flow. And I forget what I was using. So this was roughly based on the flood event at the time. And for now I'm just going to use the defaults and run this simulation. I'll take a look at some of the other settings in some of the other examples.

So now what this is doing, it's sending the data to RiverFlow2D, which is running in the background. When I did this earlier this thing closed so fast I couldn't even look at it, so I don't know what's going on. So you don't have to look at this, but this gives you the progress of what's happening. When it's finished simulating, it opens up the Animation panel.

And then I can view-- I'll do depth first. I can view an animation of the flood here and see where on the terrain it's getting flooded. So flooding the office parking lot here of our building.

The other views that you can do, you can look at the water surface elevation and theming of that. So the different colors just representing different elevations down along the flood. And then the other one is velocities. And with any of these, you can also turn on the velocity arrows. And if I zoom in-- so the colors here, the red is showing faster velocities. And if I zoom in here, you'll see the direction arrows. Not too surprising in this case, but some of the other cases we'll see some differences in the flow as it moves along.

So that was just a quick example. So what I also wanted to talk about was adding data. I mentioned Model Builder and it didn't seem like there was a lot of hands familiar with Model Builder, so I'll point that out first, and then how to add supplemental data-- if you have your own DEM file, if you have Civil 3D surfaces, that sort of thing.

So in InfraWorks, back on the home or zero doc page, this is where you can either open a new model, create it-- or sorry, open a model, create a new model, or create one from Model Builder. So up here we have Model Builder New or Open. So if you just purely have your own data, go to New and import it. And I'll show you how to do that in a minute. Or you can go to Model Builder, and find your location. So we can come down here to Las Vegas.

I think I'm wireless. I won't bring it in or anything. Where's the airport? All right, so then from here you can just draw in a polyline or some boundary, or you can do a rectangle. I'm going to

grab roughly kind of the Strip and the airport.

And so what this would do is create a model. It will bring in road data, buildings, aerial imagery, and also the elevation or DM. At least that's what we need to do the flood simulation. And you can give it a name. And pick your project. It's not letting me pick one. And just create a model.

What this is going to do, it actually builds the model in the cloud. It will send you an email when that's ready. And then you can open it up inside InfraWorks. So you'll get an email. You'll also see it once it's ready in the list of models here. I'll close that.

So that's Model Builder. And it's going to take a few minutes before that pops up here. But just a way to create a quick model. And once you have that, if you want to add your own data or you want to add your own data instead, that is done through data sources. This is where you can add, bring in, import just about any type of data. I'm just mainly going to look at the terrain data.

So common formats for that would be Civil 3D surfaces, LandXML files. A lot of the DEM or digital terrain models are in raster format. And I've shown a screenshot of all the different raster formats. They're not all DEMs. But a number of those are terrain data, like the dot BT and the DT0, 1, and 2, the DEM.

You import those. And then you have to go and configure this data-- and I'll show you in a minute-- as either imagery or terrain data. And that way it will, if you're doing it as terrain, that will bring in your terrain into the model, as a starting point. Again, you can do it after you have Model Builder as well.

So Data Sources you get to from the Main menu, in the first icon here. And it's the first command. So first thing usually you want to do is bring in data. So right up front, it opens up a panel here, which gives you a choice of all the different types of data you can bring in. The ones I mentioned were Civil 3D. This will actually bring in more than just the terrain. But if you have pipes, road data, all that stuff will come in.

And LandXML and raster-- so with raster, you need to go and pick a file. I have some data. I think this is actually DEM, but just showing you how you important the raster image. It'll show up over here on your panel. And if you double click on it, you can set up the file how you want it to be imported. So if it is DEM data, you want to set it to terrain, not imagery. Imagery would

be for the raster, the aerial that's in the background.

So I set it to terrain. Hopefully it's grabbing the coordinate system. And just close and refresh and it will bring that data in. I don't think this is DEM, so I'm not going to actually bring it in. But the DEM that is here, same thing, this 181.dem. This was imported the same way. All right, so you can see this is terrain data and where it's from. So that's getting that terrain into your model.

And then another thing I didn't do the first time was really change any Manning's values. I just used the default value across the entire model. What we can do now is use different Manning's roughness on different parts of the model. Obviously even along the river, you're going to have areas that are rocky, sandy, grass. There are trees. And you want to use a different Manning's value for each of those.

So the way we do this in the InfraWorks tool is through the coverage object. Just draw coverage areas where you want to specify a certain Manning's value. So there's three parts to that coverage, the style that the coverage uses. And then there's a mapping table that just tells it what Manning's value to use for that style.

So I'll just show you this, show you the three parts here first. If you're not familiar with coverages, just up on the Main-- actually I think from any of the Drawing menus you can get to Draw Coverage. And this just lets you draw just an area in the model used to represent a whole bunch of different things. So I'll just roughly draw in here an area. I do have some other ones in the model already too. But wherever you want to specify a certain Manning's value, you draw coverage.

Now this coverage, when I select it and look over on the right, you'll see it's using a style, which I actually picked when I drew it, for recreation. So the third part is to map that recreation style to a Manning's coefficient.

So this is probably the more complicated part of this, not that it's all that complicated. But there's just no UI for it right now. There's a file in the background-- and this is in the handout too-- where the file is. And it's just simply editing a route in the file to tell it the name of the style and what the Manning's value is.

So as an example, it just puts in the path. So in my case, I think it was coverage/zoning/recreational. And then I could enter in the Manning's value. You can also

enter runoff coefficients. So if using the drainage tools with the pipe networks, it uses that when it figures out the flow to each inlet.

So let me just open up that file. I thought I had it open, but I think with all that AV stuff I closed it. So this file has a list of a whole bunch of materials that we already have that come out of the box with InfraWorks. But down at the bottom, there's a place for user defined mapping. So all you have to do is just copy one of these rows. Paste it in. Actually it's also commented out, so get rid of that semicolon.

But then put in the name. So in my case, coverage zoning recreational, and then what the Manning's value is. I think 0.02 is my default. I'll do something different. And you might as well put in a runoff coefficient if you're putting in a new material anyway. And then just save that, rerun it.

And so what InfraWorks does, when it runs the simulation, it's passing the terrain from the flood simulation area to RiverFlow2D. And it's passing each triangle of that. And each triangle has a Manning's value. So by default it just had-- so it just had-- I had uniform, just 0.02, which just meant the whole terrain was 0.02. But instead if we just set it to distributed, it's going to pick up the individual Manning's values from each of the coverage areas. Any area that doesn't have a coverage, then it's going to use this default value that you can enter here. So I really need to run it. So that's just how you can specify different Manning's values so it's not all using one value.

All right, then a couple other things. For this one, I'll use a different model. But in many cases you might have multiple inflow areas, especially with rivers and upstream branches, that you want to specify different flow values for. So this part is actually new, adding the ability to do multiple inflow areas. And define each inflow area separately, what the flow value is for each one. And then take advantage of that in the model.

So if I go back, I'm just going to open up a different model here. It goes back. I'm having some video card issue. All right, which one?

So this model is in Troy, New York near Albany where the Mohawk River will be coming in from the left, hitting the Hudson River. So two large rivers coming together. So I want to define those two flows separately.

AUDIENCE: Question?

CHARLIE OGDEN: Yeah, sure.

AUDIENCE: Does your surface information have to have the actual depth of the body of the river?

CHARLIE OGDEN: Yeah, actually I should have pointed that out in the beginning. That would definitely make it a better model if you used the bottom of the riverbed instead of-- so Model Builder, and actually a lot of DEM files that you use will just have the terrain as the top surface of the water. So yeah, you're not going to get-- if you're trying to get a simulation of average flow, you're not going to get a good result. In the Manchester model I did, I think the flood flow was like 10 times greater than the average flow. So I think as that difference grows--

AUDIENCE: Is it pulling these surfaces off USGS, or US [INAUDIBLE]?

CHARLIE OGDEN: No, it's off-- Model Builder

AUDIENCE: The Model Builder is USGS--

CHARLIE OGDEN: USGS, OK.

AUDIENCE: Within the United States.

AUDIENCE: Because a lot of that data seems to be [INAUDIBLE]. But when you get [INAUDIBLE].

CHARLIE OGDEN: Yeah, all the water stuff is just the top surface of the water.

AUDIENCE: So how does one get the depth?

CHARLIE OGDEN: That you'd have to get-- I don't know where you'd get it, really, but either surveyed, or some sources, some locations do have the bottom.

AUDIENCE: A lot of what we do is the cross-sections that you were pointing out in yours, that's how we get our data. It's just the surveyor goes out, walks through to a river, and only--

CHARLIE OGDEN: Surveys the--

AUDIENCE: --every thousand feet or whatever we tell them to define it.

CHARLIE OGDEN: So you could bring that into Civil 3D, create a surface out of it, and then supplement this larger area.

AUDIENCE: Or you can create a surface because that doesn't work too well. It does, but it only is accurate

at that--

REINALDO GARCIA: Well not only for-- if you're working, well, in the West, for the most part the rivers are dry and that kind of would work. But if you are working in other areas where you have actually water in the river, you cannot use directly the USGS data because it ignores the [INAUDIBLE]. So the [INAUDIBLE] into survey, depending on the river, you have the cross-sections. For a two dimensional model, you need to construct a [INAUDIBLE] within the river. As you said, if you just take cross-sections every thousand feet, you have to interpolate in between.

And that's not good for a 2D model because the actual advantage of [INAUDIBLE] a 2D model is [INAUDIBLE]. And you are interpolating before using the mode, which is not the best approach. So what is normally done is you have either [INAUDIBLE] more cross-sections, closer, than you would have for the 1D model. And then integrate that with the USGS data for the floodplain. So you have one set of data within the river, the actual river channel, and then a different set of data in the floodplain, which is more common to use-- more and more common to use LIDAR there, which is must better than USGS, much more accurate than-- you have users that are doing very high resolution modeling in the floodplains, [INAUDIBLE] maybe two feet, [INAUDIBLE] feet, inches a lot of information that they tend to do starting--

The trend is to use more and more resolution with this type of model, because you have the data to support that kind of applications in the floodplain. We get all the buildings and the streets and all the different features we have on the [INAUDIBLE].

CHARLIE OGDEN: All right, so in this case-- and this one also has water at the surface. So this one I'm going to draw my boundary again. And then I'll define the two inflows separately.

All right, so one inflow-- and there's a prompt down at the bottom that's just telling me that I'm just going to single click if I want to do another inflow. And I'll pick the two points for the second inflow. On this one, since I only have two, I'm going to double click on the last point. And that will prompt for the outflow area. And I'll just pick the two points for that.

And then so in the dialog, I'll have, under inflow, I'll have two different inflows. It will highlight, you'll see in orange, the one that I currently have selected. You can also pick it in the model, and it'll change which one it's on. And then you can enter in the flow value for each of these. So just enter my flow value for the Mohawk River coming in, change to the Hudson and enter in flow.

So that's how you can set up two different inflows just by the different inflow values. This one takes a little longer to run. But what I can do is go back. I already have it run in a separate model. Changing miles is taking so long. I'll let it go back.

So a couple of other things. I've just been entering a fixed flow rate. We can also enter into a flow that changes over time, just using a simple text file. So the file here, it's just showing time and the flow value. So time is in hours. You can use decimal, hours. Mine are just fixed hours, or whole hours. So however many data points you want, you put in the text file. The number up at the top just represents how many data points there are. So I have six time flow intervals here. So there's a six up there. And then that can be selected as your inflow instead of entering a static value.

And another method-- this one is new-- is to use elevation versus time. So this could be important if you're doing coastal flooding and you want to mimic what the elevation flow is of the surge coming in, or if you're doing river scenarios where what you have is flood stage data. You can enter that if you don't flow but you have the elevation values.

So this is a similar text file. It's just hours versus elevation. And same thing up at the top is the number of data points that you have.

Let me go back here to InfraWorks. I'm just going to grab another model, and show this example. So this, while this is opening-- so this will be a coastal flooding example. Angel's taking a picture of his images.

So what I'm going to do is show-- let's see, so the area of Manhattan. This Has multiple inflow areas. And also from the sea, I'm going to use a file representing elevation versus time, based on the storm surge elevations from Hurricane Sandy. And then coming down the Hudson River, I'll use a flow value, flow versus time, coming down there. And then I'll have a free outflow area from the East River, over on the right.

Again, this is Model Builder data. So the water surface is flat. And what I'm going to do here, I'll just draw in my boundary again. So, go to Flood Simulation. Draw in a boundary. This is probably going to spill over a little into New Jersey here. Who cares about New Jersey? And just bring it around. I didn't really mean that. Double click.

And then just define my inflow areas. So one is coming from the sea over here-- so one area over here. And then my second inflow is coming in from the Hudson. I'm sorry I spun this, just

so everybody got confused.

And then lastly is the outflow. And in this case-- oftentimes-- so maybe this is not maybe a typical coastal scenario, but if you just have the coastline, your inflow is just going to be out to sea boundary. And then your outflow area can be upland, on land somewhere, and the water is just flowing in that direction, going off really on the outflow. Maybe you can say that better.

So my outlet, I'm going to use kind of upper Manhattan here and the East River. And that's going to be my outflow area. Except I messed that up. I was still doing inflows.

REINALDO GARCIA: The three conditions, it's very useful when you know you don't have any data, but you want the area to [INAUDIBLE] officially when defining it, [INAUDIBLE] the water go out or flow in, if you want. So the model will return the best combination of velocity and water [INAUDIBLE] on that [INAUDIBLE] without you having to give a specific value to it. Because [INAUDIBLE] is only relatively easy to get.

Also a storm surge in this case, we can get an estimate of how the storm surge is going to act on that open boundary. There's some open boundaries where we didn't know what's going to happen. So in that case you use the [INAUDIBLE], which is the best [INAUDIBLE].

CHARLIE OGDEN: So just defining these again, one inflow, two inflow. Let me do it again, I'm sorry-- my outflow. So I think I did one too many inflows.

What I'm going to do, instead of using static flow for-- this one is coming in from the sea. So I have an elevation versus time file, just here, my Sandy elevation, which actually-- I'll open these up just so you can see. So this is elevation versus time. So again, it's just, I did it over 27 hours, just looking online at what the elevation values were. And I just put in 10 data points. There's a lot more. I mean, you could add a whole bunch of data points over time. I just kind of simplified it for this.

So I'm using that one for coming in from the sea. And it's bringing it in here. So you can actually see the data in the table. And then for the coming down the Hudson, for this one I'm going to use discharge versus time. And I have a file for that, which it's the same type of text file. And you can see here the data. I also have it spanning over 27 hours. And this one I kind of made up the flows based on some average flows or peak flows. But now I have two inflows, one coming from the sea, one coming from the Hudson. And then the outflow is a free flow area.

So instead of running this one, because this one took, like, 15 minutes, I'm just going to go back. And this one I'll open up the one that I have.

REINALDO GARCIA: [INAUDIBLE] of the progress that you normally set the size of the triangle. So the InfraWorks will generate a mesh based on that triangle size that you select. So you use a very small triangle, will have a very dense mesh. And that will always take longer to run. If you want to do a quick run just to check, you can use a large cell size. It will run much faster. That's normally what you do when you are just [INAUDIBLE] and always make sure everything's working fine. And then when you see that you have developed the external boundary correctly, then you redefine the element size to have it smaller, then longer run. You have that control of there.

This--

CHARLIE OGDEN: I should unplug the projector.

REINALDO GARCIA: --implementation that we have now in InfraWorks for the flood simulation is the CPU version of the model. The CPU version is not the faster one. It's not the GPU version. But it's still parallelized. So if you have multiple cores, so if you have four cores or eight cores, it will use all of them, all the cores you have available. So the model will run faster the more cores you have available on your computer.

If, at some point, we implement the GPU version, that will require Nvidia cards. And that [INAUDIBLE] already take advantage of, maybe, 2,000 cores that you have on those cards, which makes the model run very quickly.

CHARLIE OGDEN: So this is the same model. I just simulated it earlier. So what I'm doing is just, in the animation player, since it's already calculated, the animation player's already open. So I can just run the animation. So I'm starting with water surface elevations. It's just generating the animation. And it should start playing. And this one's the one that gives you your color coded elevations, as the flood progresses.

AUDIENCE: Can you generate a legend for those colors?

CHARLIE OGDEN: It can't right now. But that's something we'd like to add.

AUDIENCE: How am I supposed to know what color is [INAUDIBLE]?

CHARLIE OGDEN: I'm not sure if it-- right now without a legend it's hard to. So it gives you kind of the extent of it,

but not the elevations.

AUDIENCE: [INAUDIBLE] So red meaning shallows?

CHARLIE OGDEN: I think red is--

REINALDO GARCIA: For the higher elevation, red is the--

AUDIENCE: Deepest.

REINALDO GARCIA: --highest. No, no, no-- yeah, it is, sorry. And bluer is the shallower. But the model in the background generates the large number of resource files that you can-- they are text files that you can import in Civil 3D, for instance, or other software. Because it has, for each point, you get a value for your water elevation, the velocity. So you can make use of those values to import it in Civil 3D or other software where you want to do further processing of the results. The maximum values along the whole simulation, that type of thing, those are files that are generated in the background. The impressive thing, you're not graphing all the results files, only the velocity, water elevation, and the depth.

AUDIENCE: Can you turn your mic on please?

REINALDO GARCIA: I'm sorry.

AUDIENCE: Thank you.

AUDIENCE: [INAUDIBLE].

REINALDO GARCIA: I'm sorry?

AUDIENCE: Can we export a floodplains [INAUDIBLE], like the actual extents of the floodplain?

REINALDO GARCIA: Yes.

CHARLIE OGDEN: This should only take, like, five seconds.

REINALDO I think there is a conflict of-- there is a conflict--

GARCIA:

CHARLIE OGDEN: [INAUDIBLE] unplug that?

REINALDO --graphic conflict of something.
GARCIA:

CHARLIE OGDEN: Or maybe if I just, projector only?

REINALDO You should try that.
GARCIA:

CHARLIE OGDEN: Oh, why is it even on computer only?

REINALDO I don't know. No, that didn't like it.
GARCIA:

CHARLIE OGDEN: That did not like that at all.

AUDIENCE: I [INAUDIBLE] works next project, because I've had the same issue too when I--

REINALDO Really?
GARCIA:

AUDIENCE: Yep.

REINALDO There seems to be a conflict between this computer and this.
GARCIA:

CHARLIE OGDEN: Yeah, I didn't even has InfraWorks running at the beginning, and it--

REINALDO Yeah, even the PowerPoint wasn't showing. So, now we lost it.
GARCIA:

CHARLIE OGDEN: We'll just talk to the end?

AUDIENCE: So in dry creek areas, would this be good for developing inundations studies?

REINALDO What, I'm sorry?
GARCIA:

AUDIENCE: Inundation studies.

CHARLIE OGDEN: Yeah, right, yeah. Some of the results that the model generates on-- one of the things that we want to do in the future is to add a lot of graphic capabilities that are not existing now in InfraWorks, at least in the plug-in. For instance, because the model outputs the time of inundation-- so it gives you a map of how long each area is inundated above one foot of water or one inch of water, whatever depth you provide. It gives you when the frontal wave arrives at each location. So you know, if you have an inundation coming, you know how long will it take to the water to reach each area.

So these are all maps that you can-- at least you have the point and the numeric data is exported. But eventually we plan on implementing that within InfraWorks.

AUDIENCE: So if you had multiple streams coming into one area, does it take into account different peaks on each?

REINALDO GARCIA: Yes, correct. Yeah, you have the whole interaction of the different inflows. And that's one of the advantages of the two dimensional model, that it automatically integrates that into the simulation. So you get how the timing of each of the inflows will interact within the floodplain.

AUDIENCE: So would you, on each stream, would you enter an inflow at the beginning and then-- or excuse me, a flow at the beginning and a flow where it connects into your main stream?

REINALDO GARCIA: Yes. Essentially you provide the hydrograph. And you don't need to preset anything other than the hydrograph that is coming from each stream. And once the hydrograph or the discharge at each time gets into the mesh, then the model determines how that flow is distributed. And the timings, the depth, the velocities are all accounted for in the calculation of the model. And the result files will give you that.

It will give you also the maximum elevation, time to one foot, time to two feet of water, time to peak.

It generates hazard mapping as well. For instance, the US Bureau of Reclamation has a set of hazard levels, depending on the hazard-- for instance, for vehicles, for houses. And then you get a map for each one of those hazards. And it will give you color coded areas, if its a high hazard or low hazard or medium hazard area.

So we have about five different hazard criteria implemented, because every country has a

different criteria. For instance, Switzerland has a criteria that is based on the combination of velocity and depth. And the model also outputs that automatically. So you get hazard for almost five different international criteria for flooding hazard. But the hazard we have today is the graphic hazard here.

[LAUGHTER]

This is much more difficult to overcome than the other one.

AUDIENCE: Does this export shapefiles?

REINALDO GARCIA: You can export shapefiles file from--

CHARLIE OGDEN: No, InfraWorks does not export shapefiles.

REINALDO GARCIA: The full RiverFlow2D model does export shapefiles for every graphic you want, even every time. You want to export a shapefile for that flooding at one hour, you can export that, with extent in the shapefile format. It's a generic formatting. Whoops.

AUDIENCE: Is there any of this [INAUDIBLE] on the map by any chance?

CHARLIE OGDEN: Where are yours anyway?

REINALDO GARCIA: Yeah, we do. Yeah, we do have it here. You want to try that?

AUDIENCE: Was this working before?

REINALDO GARCIA: Well we didn't try this one, because at some point this was working.

AUDIENCE: Oh, OK. It comes up. It won't stay.

REINALDO GARCIA: Yeah.

CHARLIE OGDEN: So that was the end of mine, except I wanted to play the animation.

AUDIENCE: Want to try six again?

CHARLIE OGDEN: Do you want to plug in with this to HDMI?

REINALDO GARCIA: We can try this one.

AUDIENCE: Charlie, can you export-- you mentioned shapefiles. Can you export the [INAUDIBLE] to the DWG, go in, have all the flood simulation data within it as far as 2D modelling is concerned?

CHARLIE OGDEN: No.

AUDIENCE: So at different stages of the flood, can you get that parameter still within your [INAUDIBLE]?

REINALDO GARCIA: Right now we can't. So you mean from Civil 3D, if you import InfraWorks model, you can bring in?

AUDIENCE: If you export it out from InfraWorks to Civil 3D.

CHARLIE OGDEN: To IMX? From InfraWorks, all you can export is IMX, or FBX.

AUDIENCE: That's right.

CHARLIE OGDEN: And IMX won't send it-- the other option, from Civil 3D, you can open an InfraWorks model. But this is too new. We're not bringing that over yet.

REINALDO GARCIA: I think, because this is not working either. The problem is that-- I apologize. I don't know. None of the computers can communicate with that.

We have a trial version if you want to try it yourself. It's a free version that you can use for a month or so. So if you're interested, you need to install the latest version of InfraWorks 360. And then we provide a link. We have a page. If you are interested, there is a link here. So why don't you share this.

So at the end of this page there is a link. You share it. And you can download the trial version. It's a full functioning version that lasts for a month, as I said. And it has the documentation. So if you are interested to take a look, you can perform the examples similarly as Charlie did.

AUDIENCE: No, [INAUDIBLE] froze [INAUDIBLE].

REINALDO GARCIA: I think it's that the other--

AUDIENCE: [INAUDIBLE] send someone out. [INAUDIBLE].

CHARLIE OGDEN: We only have 10 minutes anyway, so.

AUDIENCE: [INAUDIBLE].

REINALDO GARCIA: I have both connected, five and four.

AUDIENCE: Yeah, five. Four wasn't seeing anything we're doing, so [INAUDIBLE].

REINALDO GARCIA: I promise you, the software works better than this computer.

CHARLIE OGDEN: Well any other questions, I guess, while we're waiting?

AUDIENCE: This [INAUDIBLE] floodplain [INAUDIBLE] for [INAUDIBLE], determine using Hydraflow return [INAUDIBLE]. Is that something this does or is this just [INAUDIBLE]?

REINALDO GARCIA: You mean-- I'm sorry, you mean for oil?

AUDIENCE: Yeah, we take the cross sections of the river, model it, and then we put something into the floodplain and we determine what the elevation of it--

REINALDO GARCIA: Yes, right.

AUDIENCE: --is going to be. Is that what this is [INAUDIBLE].

REINALDO GARCIA: Yes. Yeah, you can do that, yeah. Because what you do is you model the existing condition. Then you modify the terrain to put whatever obstacle you want there. And then you can model that design condition, and then look at the differences, for instance. That's a typical analysis that you can do, yeah.

AUDIENCE: Because typically we do that every day.

REINALDO GARCIA: Yeah, the advantage of doing this within the InfraWorks system is that it's very simple. I mean, you just create a model in minutes. So you don't have to do a lot of work in order to look at the

mesh. It's all automatic in the background.

AUDIENCE: One concern [INAUDIBLE] is that a lot of municipalities accept the Hydraflow [INAUDIBLE]. How do you work with-- are you working around that? Can you back from InfraWorks, put it into Hydraflow, or do you have to-- how do I tell my supervisor, hey, this is a better program when you can't submit it [INAUDIBLE]?

CHARLIE OGDEN: You're using Hydraflow hydrographs?

AUDIENCE: Yeah. That's what they accept. And then they take your model and put it into their town.

REINALDO GARCIA: Well we're working with FEMA for certification of the model for FEMA FIS studies. So that's ongoing, so we don't know when that's going to be resolved. But we are working on that. That's one of the things we're doing, try to get the model approved by FEMA for floodplain analysis. That would help in that regard, because if that is resolved, then you have the FEMA approval for the model. I'm sorry?

AUDIENCE: Also [INAUDIBLE] in 2D to 1D? If he does a quick analysis to do the work, and then [INAUDIBLE] comes in, and they only accept 1D. And you can quickly do a 1D model, but [INAUDIBLE] doesn't work, [INAUDIBLE] cycle, and then all the processes without having to [INAUDIBLE] results, [INAUDIBLE]?

REINALDO GARCIA: If the area is more or less confined, the 1D results and 2D results should resemble, should be similar. But if you have a [INAUDIBLE] unconfined in the area, you cannot expect that they will be similar, because the assumptions you make in 1D are very different than the ones you make in 2D. That's one of the things that, sometimes, maybe, one municipality accepts that type of analysis. But that not necessarily is the correct one, because the assumptions that you make for 1D may not hold for that particular area. And that's not the best approach that you should follow, even though the model is known for them.

The problem is that some people assume that the 1D is the absolute truth, and so forth. Even the 2D is not perfect. I mean, you have assumptions that are done in 2D that would not hold for all other applications as well.

So maybe by tomorrow we-- so I don't think it's your computer.

CHARLIE OGDEN: I guess not. What was at the end? I was just going to talk about--

REINALDO GARCIA:	No, well, just suggestions of what people would like to see there. No, no luck? Well unfortunately it doesn't seem to be working.
	The other thing we wanted to ask you, if you have any comments or suggestions of things you would like to see implemented in this type of tool-- for instance, what you mentioned before is one of the things, try to have a certification of an agency, for instance. But if you have any particular suggestion in regards to capabilities of the tool, what you would like to see there, feel free to email us, either Charlie or myself, to make any comments you may have. For instance, the legend thing that was mentioned before is pretty relevant. I think it's something we have already on our backlog at some point. But any other suggestions you may have, we're open to hear that. That's the way we have to prioritize the development that we want to continue in the future.
AUDIENCE:	Does it generate the [INAUDIBLE]?
REINALDO GARCIA:	Yes. Yeah, you get a file with the maximum water elevations throughout the computation everywhere. So you get like the maximum extent of the flooding that happened throughout the area.
AUDIENCE:	[INAUDIBLE]
REINALDO GARCIA:	Yeah, that's part of the-- not only the high watermarks, but higher velocity areas, also, as I mentioned before, the inundation times. There are about 20 different parameters that are exported for the maximum values throughout the computation, including the high watermarks.
AUDIENCE:	[INAUDIBLE] ask a [INAUDIBLE].
REINALDO GARCIA:	So you need to go. Oh, we have reinforcement. Sorry.
AUDIENCE:	So, for example, HEC-RAS, you can generate a report. And it's pretty standard. With 2D modeling, you don't, but specific cross-sections per se. So what does the final report look like if you're putting this together?
REINALDO GARCIA:	OK, well, in the full RiverFlow2D version, you can create cross-sections, even cross sections similar to those of HEC-RAS. And then you get a report for each cross-section in the same line of HEC-RAS. You can also generate profiles along the different river channels.

We don't have that InfraWorks yet. It would be a matter of just adding the cross-sections and getting the information. Because, as I said, the full engine generates all those reports. So what you get in InfraWorks, the reporting is for each time. You get the numeric values in columns in ASCII files, similar to HEC-RAS, not in cross-sections but for the whole floodplain. But if you create-- in the meantime, if you create data files that represent the cross-sections, the model will recognize that and make the report, even though, from InfraWorks, we don't have it yet graphically.

In the full version you can draw the cross-sections and make the model export them. You can also, in the full version-- something we want to do in InfraWorks-- is to do differences analysis. So you have different scenarios and you want to compare scenarios and see what's that the higher elevation you get here versus the existing condition, for instance. And then you get maps of each of those results.

Well I think we're done already.

CHARLIE OGDEN: I think we're out of time, yeah. Thank you.

REINALDO GARCIA: Well, apologies to the-- thank you anyway.

[APPLAUSE]