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Moderator: Courtney Chambers
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Courtney Chambers: All right. At this time, I'd like to give you today's speakers on the hydraulic engineering center software for environmental analysis. The hydraulic engineering center is often abbreviated as HEC and sometimes pronounced HEC whenever we're referring to the different tools.

So with that, we've got Stanford Gibson. He is the Sediment Specialist at HEC where he has worked for over ten years. He is responsible for implementing the sediment transport capabilities and, of course, open channel hydraulics model known as HEC-RAS.

John Hickey is a Senior Hydraulic Engineer at HEC where he leads the development of the Regime Prescription Tools -- HEC-RPT -- as well as the Ecosystem Functions Model -- HEC-EFM -- and its spatial component GeoEFM.

Mark Jensen is a Senior Hydraulic Engineer at HEC and is one of the primary developers of the centers River Analysis Systems -- HEC-RAS.

Jay Pak is also a Senior Hydraulic Engineer at HEC and is responsible for implementing the Sediment Transport Module in the hydraulic modeling system -- HEC-HMS.

Todd Steissberg leads the development and application of software for integrating water quality models -- HEC-5Q and CE-QUAL-W2 with HEC or with the reservoir system simulation known as ResSim and The Water Shed Analysis Tool -- WAT.

Bill Scharffenberg is the lead developer for the HEC Hydraulic Modeling System -- HEC-HMS -- and coordinates and all aspects of the development process in addition in conducting applied research, writing program code, designing interface components, and providing technical support.

Due to the number of speakers, I'll refer you all to more detailed information about each of them in their bios on the learning exchange with the rest of today's meeting documents. Towards the end of our meeting, I'll be sure to post the link to the gateway where you can access all of today's meeting archives and bios and such. We're very happy to have you all with us today. And at this time, presenters, I'll give you the rights and we can begin.

William Scharffenberg: Well good morning. My name is Bill Scharffenberg at the Hydraulic Engineering Center and I'll begin with a short overview. Is everyone seeing the slides?

Courtney Chambers: Just one second. I just - the presenter rights just transferred over. You'll need to go through the shared desktop process. It's not showing up just yet.

William Scharffenberg: How do I do that?

Courtney Chambers: There we go. Yes.

William Scharffenberg: All right. Then I think we're ready to begin.

Courtney Chambers: Excellent...

William Scharffenberg: So as we get started, I will make a short introduction to Hydraulic Engineering Center and then we will hear from each of the presenters on the components of their software that can contribute to an environmental analysis process.

So at the Hydraulic Engineering Center, we focus on developing tools that can be applied in a general manner. So we're looking for methods and approaches in software that can work on watersheds in California or in Florida or in Ohio or most any part of the country where we need to do work.

We do create some documentation and policy documents but most of our products are software tools and the software tools come with documentation about their use, about their technical details and about best practices for implementing them in projects.

So we have software for doing the hydrologic statistical analysis. We have software for generating watershed hydrology reports. So that gives us the flows throughout the watershed that we can then input to a reservoir analysis process and the reservoir analysis tools will help us determine the best way to operate the reservoirs. We can then take the results from the reservoir analysis and input those to the river hydraulics and that gives us approaches to developing stage estimates throughout the river network. Those stage estimates can then be used in two ways. We can use them in a flood risk management process to look at economic benefits but we can also use them to do ecosystem analysis and that will be the focus of our presentation today.

In addition to the individual tools that have their component of a water resources analysis project, we have some underlying integrating technologies including the data storage system for storing large amounts of data and then integration packages that focus either on the real-time forecasting, the Corps Water Management System abbreviated CWMS.

We also have a second integrating technology that focus more on watershed analysis called the WAT and that's usually what we would use if we were doing a large complex ecosystem analysis that was integrating multiple process simulation tools.

A brief outline of how we will spend the rest of our time, I will continue with some information on the water quality capabilities within the Hydrologic Modeling System -- HEC-HMS. We will hear from Jay Pak about the sediment capabilities in that tool. We'll then continue with how to take those sediment and water quality results and contribute them to a water quality analysis in reservoirs and lakes and Todd Steissberg will present that. We'll take the results from the reservoir simulation and show how those can be used as input to a RAS project -- HEC-RAS doing water quality simulation and -- Mark Jensen will present that. We'll hear more about the sediment capabilities within HEC-RAS from Stanford and then John Hickey will wrap up by showing how information from all of these tools gets fed into the Ecosystem Functions Model -- EFM.

Continuing then with our Hydrologic Modeling System -- HEC-HMS -- the system is a fully featured hydrologic modeling package. That means that we include all the tools necessary for doing data entry of the different kinds of time series data used in hydrology like precipitation and temperature.

We have a mapping system that shows the watershed we're working in. We provide the simulation results and visualization of those results and other kinds of analysis tools. It includes everything from precipitation and evapo-transpiration and snowmelt down to the land surface where we have a plant canopy.

We have surface depression storage on the land surface. We have infiltration of the water into the soil and then simulation of the water running over the land surface, coming through interflow processes and baseflow processes and then moving the water through the channel network down towards the outlet of the watershed. If necessary, we can have losses of water through the bottom of the channel.

We'll then hear briefly now from Jay Pak about the sediment transport capabilities that have been added to the reach network.

Jay Pak: Hi. My name is Jay Pak. I'm going to talk about the sediment transport module in HEC-HMS. Now, we need to think about the erosion and sediment in our watershed. The reason why, erosion can reduce our valuable soils from the - off a watershed.

Second, it can also reduce our downstream channel and reservoir flood capacity. Also sediment carries contaminated material to the downstream. That's the reason why many planning study now considers environmental management along with the flood damage reduction.

In the future version of HEC-HMS 4.0, we're trying to include the surface erosion and sediment transfer module to support environmental management project. With this tool, we can simulate sediments from the land surface and transport through the channel and reservoir network.

Also, we can provide boundary condition for the hydraulic model like HEC-RAS. Also, we can use this tool for TMDL study for sediment. This is a schematic diagram for sediment transport processing HEC-HMS.

In this process, we have the three major elements. First element is watershed. We call subbasin element. In this element, we have two masses of two estimates - sediment (unintelligible) from the watershed. MUSLE -- Modified Universal Soil Loss Equation for pervious land. (Unintelligible) for impervious land.

Based on that, we can estimate sedigraph at the each subbasin outlet based on power function and enrichment ratio. At reservoir element, we have four options through estimated trap efficiency including three simple methods and the one variable trap efficiency method we call Chen's method.

Chen's method estimate trap efficiency for each (unintelligible) sides after each time set based on flow velocity and quick flow velocity. We have one option for sediment volume in reservoir element. Okay.

The last element is the channel element. We had a pretty similar process with HEC-RAS sediment module including sediment transport function but it's kind of simply by this version. HMS use - it takes the geometry and also just the two set of sediment bottom layer option only.

In the channel element, we have all option for sediment volume including uniform equilibrium, volume ratio, linear reservoir and Fischer's dispersion equation option.

This is the case of study results with Upper North Bosque River Watershed in Central Texas. In this the study, we used the published results from the SWAT and HSPF. As you can see here from the upper graph, SWAT HSPF validation is kind of go to 100% difference with major data but HEC-HMS, we're trying to match with major data from the five sediment gauge.

At the bottom graph is a validation. In the validation, HEC-HMS provided two results. For us, the result in the third column in here, that result we're trying to use the same validation period with the SWAT and HSPF for graph comparison but that period is a little bit overlapped with HEC-HMS calibration period.

That's the reason why we provided second results with a separate validation period in the fourth column. In here, you can see around the plus/minus 35% difference with major data I think which is good, you know, compared with the SWAT and HSPF.

In the right-hand side, the (GIS) graph, the (GIS) map we're trying to show the summary results from the HEC-HMS. You can see three different color from the watershed. Okay, dark brown, meaning more sediment (unintelligible) from the dark trouble watershed. Light brown is a less sediment (unintelligible) from the bad watershed.

In channel, you can find two color -- red and green. Red color mean is degradation. Degradation mean is more erosion in that channel systems. Green color is aggradation channel. It means there is more departure in that channel system.

Based on that results, we can provide sediment boundary conditions to reservoir and the hydraulic model. So now, I can turn over to Bill for water quality module.

William Scharffenberg: Well Jay has already mentioned that sediment is important to water quality and water quality is important to sediment. Some of our water quality constituents that were concerned with actually absorbed to the sediment and move with the sediment. That's not true for all of them. Some of them would remain dissolved only in the water so we need to pay attention to sediment when we're also doing water quality simulation.

We have coordinated our work on nutrient simulation module with the environmental laboratory in (Pittsburg). This was a multi model development team where some of the simulation components were developed at the environmental laboratory and they have been implemented in a number of models including HEC-HMS.

Right now, we are implementing this both in our reach elements that represent water moving down the channel and in our reservoir elements that can be used to represent lakes and reservoirs. We plan to be implementing this across more components of the software in the future but for now, we're already providing enough capability that it could be used in some types of water quality simulation studies.

We're providing a process diagram that illustrates the included components of the nutrient simulation module. We will make this available later for more detailed study. We're including both phosphorous and nitrogen at this time. So the lower-left corner of the diagram includes inorganic and organic phosphorous and shows the processes for how it moves. Algae is key to taking up phosphorous from the environment and releasing it back into the river when the algae die and decay.

To the right side, you see the nitrogen species and these again are linked to algae as algae take up different forms of nitrogen from the water and the algae as they die and decay impact the amount of dissolved oxygen.

One of the important components of developing our software is the validation of the software. So we've developed some very demanding and rigorous test cases. The first one I'm showing illustrate a classic oxygen sag problem where we have a certain amount of oxygen demand due to generally speaking the decay of dead algae and that causes the initial oxygen of 8 milligrams per liter to drop as the algae decay and over time, those algae decay and are removed from the system and the oxygen can recover.

And we showed that the solution we should be achieving are the diamond symbols and we see that the computed solutions by the model moved almost exactly through the expected solution indicating the software is good for use.

Oh a very difficult situation to simulate is when a very steep front of a constituent enters a reach channel and moves down through the channel. The red line illustrates that very steep front. Again, the diamonds illustrate the solution we should be achieving at the outlet of the reach and we see the proper attenuation of that steep front as it moves down to the reach.

We have similar test for the reservoir where we show that over time, the dissolved oxygen and what we called the Carbonaceous Biological Oxygen Demand or the CBOD and we're showing again solutions that move through the diamonds and these are the kinds of test that we perform in all of our software to illustrate that it is robust and ready for application and projects.

We're now going to shift to our next component which will be presented by Todd Steissberg talking about the water quality capabilities in the reservoir simulation tools.

Todd Steissberg: HEC-ResSim is our reservoir simulation model. It simulates reservoir operations for one or more reservoirs in the watershed. There are many conflicting demands in a watershed including environmental and ecological demands as well as flood protection, water and power supply and navigation.

And ResSim helps down system management using user defined set of rules. They can vary in complexities with very simple ones to much more complicated ones. The priority of each rule may vary by date, reservoir elevation, downstream conditions and other factors.

ResSim can be applied in either a steady context or use in real-time forecasting decision support. To put things in context, we're more and more we're linking our models together with each other with other models and ResSim can receive its flows from HMS and then have those flows downstream to HEC-RAS for simulating rivers not only hydraulics but now water quality.

And we link this together even our cold water management systems (unintelligible) for real-time operations open forecasting or in a steady context in HEC-WAT -- the Watershed Analysis Tool.

I'm going to be focusing on ResSim integration with other water quality models and - but ResSim has always has the capability of modeling environmental flows to a certain extent. When you put a dam in a system, you alter the timing and flows of the system, the elevations and everything are disrupted and therefore become huge to manage.

So ResSim then can simulate these environment flows. If you - reservoirs can be operated to control prudent effect to dilution with higher quality water. Our water temperature is a common criterion. You can release cooler temperature water from deeper in the water column if possible as we'll get to later and that can reduce that downstream temperatures.

For habitat concerns specifically, reservoirs can be operated to vary the quantity and timing of releases or generate pulses. ResSim can then put these flows in the concepts of the watershed with multiple demands and analyze different responses to habitat requirements.

Once you integrate ResSim with other water quality models, that's probably (unintelligible), you then can simulate a number of parameters. We have integrated ResSim using a plug-in concept with CE-QUAL-W2 and HEC-5Q. CE-QUAL-W2 is a two-dimensional water quality modeling. HEC-5Q is a pseudo-1D - sort of a 2D water quality model. And these can then simulate water temperature dissolve option and nutrients and number of constituents.

Also can be directly used to investigate into a habitat with W2 as I'll explain. So this plug-in concept allows us to somewhat loosely bind the water quality models with ResSim and then the flows from ResSim can be passed to each water quality model and the water quality models are run in turn and then the results are fed back to a ResSim for analysis. You can then re-run ResSim, adjust the tools and try to better match a habitat requirement, try to improve habitat conditions.

The systems that we have for 5Q tends to be a whole watershed concept. W2 tends to be developed as individual models for reservoir and streams. And the software then links them together in ResSim so that they pass results to each other as well as receiving flows from ResSim.

This shows an example at the bottom left of the schematic from a single W2 reservoir model. This is a Detroit reservoir in the bottom left. That is one piece of a larger watershed and they are models for various reservoirs and stream chart in the system and the top right, you see the ResSim schematic for the full watershed and these W2 models were then linked together with one another through the editor that you see a piece of them in the top left.

And then on that schematic on the right, you can select your reservoir element or scheme element and the right click and then plot the parameters that you simulated or wanted to make available. There's also a simple approach available via text files that you can view throughout the parts of the interface. And then you can investigate the water quality constituents alongside of ResSim flows to try to get a better understanding of the system.

This is an example of some basic output from - in this case the CE-QUAL-W2. We have a number of time series are provided. Any number of things can - that are simulated can be output and plotted. We focus on temperature and DO.

At the top right is the single frame of an animated vertical temperature profile. We can plot the profiles to view the temperature or DO so you can investigate the vertical structure of the reservoir and understand features of stratifications and timing of events such as (unintelligible) return and how it affects your water quality in the reservoir and then downstream.

This is a relatively new feature of CE-QUAL-W2. It's habitat volume. It allows you to view the volume or percentage of volume of viable habitat for fish and you can set by any number of fish species and temperature and DO criterion and then it will give you an assessment of this for that model run.

So they've covered ResSim by itself has been used for a while to model - to simulate environmental flows for water quality and habitat concerns. The integrated system allows you to have a system-wide analysis and management of water quality and focusing on things.

You can test multiple operational scenarios to improve downstream water quality and fish habitat. Integration with CE-QUAL-W2 specifically with new features gives the ability to analyze the habitat volume and also to look at selective withdrawal. Several dams are equipped with selective withdrawal facilities where you have vertical lead of outlets at different vertical elevations in the water column. And then you can select whether or not you want to leave more water from deeper in the reservoir. Water deeper down tends to be cooler so you can then cool off downstream temperatures. Conversely, water higher in the water column tends to be higher in dissolve oxygen and so you can then adjust your flows from where you're releasing to try to better manage the habitat downstream.

Applications of ResSim and CE-QUAL-W2 and HEC-5Q include our work with mobile district on the Apalachicola-Chattahoochee-Flint, otherwise known as ACF and the Alabama-Coosa-Tallapoosa -- ACT. Those are huge watersheds covering Alabama and Georgia. We've finished that work in 2009 but we continue with more analysis and are working with the environmental impact statement.

We have demonstration projects on the Willamette River that I showed a little bit and Lehigh River. We completed the first stage of those in 2011 and we have work coming up with HEC-WAT where we're looking at the existing temperature modeling study of the Columbia River Basin. We're using HEC-WAT to link CE-QUAL-W2 models and HEC-RAS water quality together with various inputs and various models throughout the system and we're expecting that work to be completed in 2015.

Mark Jensen: So this is Mark Jensen. We're going to be talking about the water quality and sediment transport in the HEC-RAS program. HEC-RAS is a river hydraulics computation engine program. And there's one and now two-dimensional hydraulics.

(Sed) hydraulics program, it computes river velocities, stages, profiles, and inundated areas given flow and geometry. It can be run on both steady and unsteady flow modes and it has capability of doing sediment transport and water quality which is what we'll be talking about in a bit.

One more note on that is that two-dimensional capabilities that I mentioned on bullet 1 here that the sediment transport and water quality do not work with the two-dimensional component yet. So you have to remember, one-dimensional mode for the sediment transport and water quality computations. We'll be working on other ones which I haven't done yet.

In the meanwhile, what we're looking right here, this is the main RAS window. Here's the geometry schematic where you lay out the elements and it's got some background imagery there to show how they match up. And then this is the output analysis window so we can compute maps and things like that. This is all stuff integrated directly into RAS.

Here's the water quality computation window. This is what we put our input window and on the left over here, we're going to put initial conditions, boundary conditions and then describe the parameters for the different simulations that you can do. And the different types of simulations, you can model temperature or nutrient modeling and this is the (NS) 1 package and it's similar to what or the same as what Bill Scharffenberg talking about earlier so it's a nitrogen phosphorus cycle.

And you can also model arbitrary constituents. They can be conservative or for shorter decay or, I guess, for shorter growth. Here's the schematic. So the green lines right here are the cross-sections that would come from the hydraulics model delivery setup and the water quality cells can stand one. And the limits, you can have one water quality cell between each cross-section.

But generally, the water quality constituents don’t change much from cross-section to cross-section. If you think about how much the temperature is going to change along such a river, it's almost immeasurable, you know, in the measures of tens of feet downstream. So you can (unintelligible) with them and have pure computation cells.

If you're going to model water temperature, we use a full water energy budget so here's the diagram with the fluxes. We've got the short wave coming in, long wave which goes in or out depending on which one is warmer. (Unintelligible) latent heat. A lot of these things are for water temperature modeling are - inputs are time series and so solar radiation you can input or get it measured or you can compute it based on where you are, you know, longitude, latitude and cloud cover.

Now, other things like sensible heat function of wind and some coefficients which (unintelligible) up and can compute or we can simulate water temperature. Some things we're planning on doing. We have not done yet are to think about the interaction of water temperature with the bed and how we could incorporate topographic or apparent shading and I appreciate that on a water simulation analysis.

So here's the background with some or here's the screenshot for putting in some of those time series. For the data source, there is a couple of different ways you can put it in. So they all have this capability of putting in (unintelligible) by table data then you put in. You could push this button here and that will become dialogue and you can cut and paste some things in. You can use DSS.

So DSS stands for HEC Data Storage System. That's a database developed by HEC and I don’t know if it's been discussed yet but a lot of our programs or all of our programs use DSS to transfer information point to another. It's kind of the glue that holds - one of the - part of the glue that holds them all the other or chose to bind them together.

You could cut and paste things for the table from Excel spreadsheet or you can have RAS go and open it up that runtime and grab right at that moment. Now you can put a constant value or in the case of short wave to get out of the computed based on latitude, longitude and cloud cover. And whatever (unintelligible) you could put in multiple here and you could see more down in the slides. Now, we're looking at theoretical computer long, lat and then some cloud cover.

Okay. So in addition to the boundary conditions and initial conditions, (unintelligible) to described the interaction among the constituents so this is the screen for the lectures in the phosphorus cycle that we alluded to earlier. This is based on the kinetic set up for CE-QUAL2E so the (unintelligible) variables and all the boxes in the diagram are also - yes all the - their boxes are state variables and all the (airs) between our pathways. This is how - so the atmosphere. Well, it's not state variable but it is a source of oxygen and it's - there's a variation of method where you can - and have them enter the water column and condition coefficient to describe that.

And this kind of an active plot and we do this where we can. On the left here is the table of all the coefficients that you need for the quality kinetics. And they've all got the same names that we're using QUAL2E and then a better sentence that are - so described what they actually are.

The units and then you can put the value in there or if you go over and look at like the reiteration coefficient, it's K2 and that's over here right there. You could just go in to atmosphere (unintelligible) go and change evaluate there or like I said, the spot is active. You can just click on it and then change the number right there as well. So it's a good way to visualize how things are transforming from one form - state variable to another.

So here's some output. This is water temperature in Sacramento River and it's an animation and what we're going to see is water temperature going from (unintelligible) over the course of the day maybe, maybe not. Okay it looks like my animations link is broken so we'll jump to the next slide.

Just imagine water changing color down the course of Sacramento River. Temperature plots. So output. We got the (unintelligible) where we can make the animations of it which I was hinting out there but not showing them on the previous slide. Everywhere the water (unintelligible) cells.

So this water (unintelligible) cells that show the range from this cross-section to this cross-section, as its average value and in this case, we're looking at temperature we have observed versus computer here and here's a solar radiation again time series.

Another form of output is in profile so this slide there's two things - this is a profile data of dissolved oxygen and BOD as a function of distance downstream and these symbols are the computed or the expected value based on the analytic solution to the Streeter Phelps oxygen (unintelligible). This is a similar or the same different equations that Bill said earlier in our solution with HEC-RAS.

It's actually time-bearing problem but we're running all of that (unintelligible) and well, the solution - the (unintelligible) solution is timing variant but our solution is - and RAS is unsteady state and we run out till it's, you know, it doesn’t change anymore and here's the final shot of that. So we're doing a pretty good job modeling the difference of the analytic solutions when they're available.

Applications. So there's a bunch of applications but we're necessarily not with the (LR) because there is - on the order of 100,000 (HUS) users out there in the world and they don’t all contact us if they have a problem but here's two big phase that were actually here for water quality. One is the Ohio River TMDL study by the EPA. It's an ongoing study.

They're looking at bacteria in the Ohio River and it's an old part of the country or that's where the country is developed when they combine with sewer with (unintelligible) and - or the - there's (unintelligible) where or combined with the sewer and - where they bring too much more they can handle demand that's going directly into the river and they're trying to get a good model in the whole system to do it for the TMDL study.

There's an enormous number of these events that happened and we made a minor change in interface to why you put it - by cutting tables which were in the same form that the EPA collects in them in which is just the columns of when it happened, where it was and how many expected volume and expected concentration.

So in (unintelligible), they could do the study. This is another study for the Columbia River. So water temperature model, the big system, they calibrated over hot and mild and cold winters and a couple of different alternatives now they can control reservoirs to do - to get a feel for what kind of temperatures we can expect in the Columbia.

So what's new for water quality in RAS. We're now working on NSM II so it's another version of the nutrients sub model and it's got the different - the state variables are based on the Qual2K kinetics. There's 25 for state variables and this one has a carbon cycle and we have a carbon cycle then you can compute - you can model pH. And once you get pH, you can do some other things like levels of contaminants.

So those are - this is one thing we're working on right now while the beta is out at the end of this year and then next year, we'll think about doing metals and contaminants.

So Stan.

Stanford Gibson: All right. My name is Stanford Gibson and I going to talk about sediment transport in RAS. Sediment transport has been in HEC-RAS for a while now. It's been in there since version 4.0 and because of the importance of sediment transport and river restoration, it's got a lot of use for environmental application as well as kind of standard civil work stuff.

The - what the sediment transport module does is it computes - it routes sediment through the RAS hydraulic model and then it deposits or erodes the sediment through our cross-section changing the dynamics of the cross-section - changing the shape of the cross-section and those feedbacks work through the system.

So this has been around for a while It's not new and it has kind of broad utility in restoration but there are three new features in RAS sediment that are really exciting that have some exciting environmental applications and so we're going to just look at those three today.

The first one is bank failure processes. One of the limitations of sediment transport in RAS, a one-dimensional model is that its only been vertical. We could scour down or we could deposit up but that was it and - you know, that's real utility but some of the loads some of the kind of environmentally detrimental sediment loads that go into a system are caught at the bank. The bank has fine loads. The banks cave and fail and that sediment moves downstream.

So one of the things we've added to the sediment module in HEC-RAS is the ability to scour the toe and fill the banks and all of that working together with the incision and so the model can actually incise, scour the toe and those could cause the banks to fail. We can compute those sediment loads. Those sediment loads have been added to the sediment model and routed downstream.

To do this, we've partnered with the USDA and the agriculture research station and we've included their bank failure model in RAS which really is the - it's the state of the art.

Now, the initial application of this and part of the funding actually came on from - an attempt to look at restoration of the Great Barrier Reef in Australia. They're looking at the feeder tributaries through that portion of the coast and looking at where the fine loads are coming from, the banks scour and if there's things they can do to reduce those as loads.

The second major feature that we've added to sediment transport is the ability to do unsteady sediment transport. In the past, we've done what's called quasi-unsteady sediment transport which has certain awkward quality when you move to trying to model a reservoir but with fully and steady sediment transport which is in the beta now and we're using in a project, what you can - you can actually operate your reservoir with sediment passing through your reservoir and one of the cool things that you can do is, you know, unsteady sediment transport in RAS with structures, you can use what's called rules and what that means is that you don't actually have to know beforehand how you're going to operate your gate.

You can kind of pull your operational rules into RAS and RAS will operate the gate based on the behavior of the system and what this - has been really powerful to do is help us evaluate sustainable reservoir management alternative. Things like flashing or routing, ways to try to actually move sediment through the system.

And, you know, the - we've been applying this a couple of places domestically. It's gotten a lot of interest internationally but, you know, the pilot project here is what the Gavin's Point Dam and Lewis and Clark Reservoir and that Missouri River study that's looking to pass sediment through the Lewis and Clark Reservoir to build barriers downstream endangered species.

Then finally, the third feature that we've added really addresses the 800-pound gorilla in the river restoration room and that's dam removal. HEC-RAS has been used over the last few years for dam removal. We've had some good dam removal studies that have used version 4.0 and 4.1. There are certain things that made dam removal awkward because of the kind of mass and nature of the sediment transport and so over the last few years, we've added some tools to HEC-RAS to make it to kind of refine and optimize the tools for dam removal study.

Two of these tools we've added sediment layers or stratigraphy. One of the things that we find in this old reservoir sediment behind the dams we're hoping to take out is that the deeper sediment has been there a long time and it's consolidated and it's less erodable and so you - and so sediment gets less erodable with depth. And so we can actually put that in RAS now and simulate that. So that as RAS kind of erodes through the reservoir sediments. The deeper ones are harder to erode.

The second thing we added - was the - it's after a (unintelligible) algorithm. What it is? It's a simplified scour tool that was - that scours the sediment in a reservoir after a dam has been taken out in a way that's more - that follows the physical processes more precisely.

And so recently, these tools were applied to actual dam removal study in the Corps, the Buffalo District, the Springville Reservoir in Cattaraugus Creek. This was done by the district. If you see (unintelligible) listed and you can see on the right there, that's the erosion of the sediment in the reservoir the - kind of development of the channel and then on the bottom left, you can see the, you know, overtime how the reservoir sediments erode about three-months time window you're looking at there as the sediment kind of constantly move - march to a (unintelligible) slope.

John Hickey: My name is John Hickey. I'll be talking about HEC-EFM. This will be the last stop for our segment of the presentation. It also has the fewest slides because there's an EFM webinar already posted online as part of this Corps environment gateway series.

Today, I'll focus on three things. Why EFM is applied. What it produces and new features. EFM stands for Ecosystem Functions Model. It quantifies ecosystem sponsors to change with hydrology.

It has water management applications for things like reservoir operations and diversions, an ecosystem restoration planning applications for alternatives that include channel and eddy configurations, dam removal projects. Basically anything that affects the flow and stage of your study area can be assessed using EFM.

Given a change in hydrology, EFM reports a direction in magnitude of ecosystem change. It can also express these changes as habitat maps. Some key outputs from EFM are ecological performance measures. These are statistical-based output. There's an image -- the middle image on this slide on the right-hand side -- shows a comparison of five alternatives for water (unintelligible) usage along the shorelines of a navigation pool on the Mississippi River. This was an application that was done by Saint Louis District.

Also outputs from EFM are habitat maps. In the upper right-hand image here, there's habitat maps for different floodplain plant communities. That's along the Farmington River in Connecticut. When you have habitat maps, EFM also has features for considering the connectivity of the habitats within those layers. In the lower right-hand image, there are cottonwood seedling patches along the Bill Williams River in Arizona. Again, that's a simulated output of EFM.

One more dimension, population dynamics. That's an emerging output from EFM and I'll have one slide about that later on in this presentation.

More now about the statistical features and habitat mapping features of EFM. This slide consists of two parts. On the right, there are some photographs from ecological experiment that was done in California. On the left shows the process for using and applying EFM.

I use details from the experiment to illustrate how the EFM process works. So about the experiment, young Chinook salmon all of the same size were placed in cages. Some of the cages were located in a river habitat as you see in the upper right-hand photograph. Other cages were placed in floodplain habitat -- lower right-hand image. They were allowed to rear for three or four weeks taken from the cages and measured.

And over that three or four-week time period, the fish had experienced a remarkably different growth rate. The larger fish reared in the floodplain habitat. Scientists hypothesize that those conditions provided more food and conditions that were more conducive to transforming a food intake to a growth. The scientists also hypothesize that the larger fish would stand a higher success rate in their migration from these freshwater habitats to the ocean.

So in EFM, this type of information is used to define relationships. This is the ecological input to the EFM process. For example, a relationship might be defined for Chinook salmon rearing where the fish -- the success of the fish in this life stage -- was dependent on a particular season and a particular high flow or low flow condition. In this case, a high flow condition that would inundate floodplain habitat. There would also be a duration associated with that so the fish could access that floodplain area and realize the potential for growth.

So that's one input to the EFM process. The other is hydrology. Daily values of flow and stage for your location of interest. This can come from gauge data from HMS continuous simulation, from ResSim as it thinks about the different management of reservoir systems and how those managed flows manifest downstream of reservoirs also from RAS in terms of flow stage rating curves and results from unsteady flow simulations.

What EFM does is take each of those scenarios, each one of the flow regime and consider it based on all the criteria that define those relationships -- season, duration, high flow, low flow, frequency -- those types of criteria. EFM statistically analyzes the flow regimes according to those ecological criteria and produces statistical results in the form of ecological performance measures. How well did the flow regimes meet the needs of the relationships?

Since the results are ecologically relevant, they can be imported to a river hydraulics model to create maps of depth, velocity, shear stress, other hydrologic output that are ecologically relevant and these are the spatial results of the EFM process basically habitat maps.

So statistical level of detail, time series analysis and performance measure output. Spatial level of detail, habitat maps which can be expressed as total habitat areas and habitat connectivity.

So new features in EFM, watershed scale viewing of ecological performance measures supported by a vast import of flow regimes where you have many different flow regimes that need to be assessed by EFM. The image on the right-hand side of the slide shows some of these spatial performance measures that are being viewed at a watershed scale.

Also, habitat map mosaics where certain communities are using habitat on tributaries and main stem areas and RAS can produce depths grids for both based on the flow regimes of the tributary or mainstem areas but the EFM process can treat that as a single map, a mosaic of habitat that cuts across different river systems.

This is the slide about the population dynamics. It's a new feature in this EFM suite of software. This is an animation that we think is going to be inactive here. Yes. Well, we can maybe post these animations as part of the online resources for the webinar. I'll have to ask Courtney about that.

Courtney Chambers: Yes. That should work fine, John.

John Hickey: Oh, great. What you would see here is an animation of cottonwood seedling recruitment along a river. The animation was showing how seedlings would begin to recruit and grow as a flood recession occurred. Some EFM applications and their purposes very diverse in terms of the geographical locations -- Farmington River in the northeast, Sandy River in the northwest, Bill Williams southwest, (Sedona) southeast -- basically all corners of the country for many different purposes ranging from ecosystem management, river restoration, drought contingency planning, many different uses of the EFM process.

With that, I'd like to just say thank you for attending the webinar. Here is our contact information. Please feel free to email or call. We enjoy talking about the software tools and we're always interested in hearing ideas about new features or applications of the technologies.

We also included a series of reference slides that I'll pause on each one of this just long enough for people watching the replay of the webinar online to pause and jot down some notes regarding these references.

And with that, I'd like to open it up for questions.

Courtney Chambers: Right. Thank you, John. At this time, do feel free to type your questions in the chat feature or if you're going to speak, make sure you take your phone off of mute so we'll be able to hear you.

Man: Yes.

Courtney Chambers: John, I do believe I have the AVI files for those videos. Are you all interested in showing those now or just post those on the Web site?

John Hickey: Courtney, sure. Let me pass the presenter to you.

Courtney Chambers: Okay. That sounds good.

John Hickey: And I think all you'll need to do is double click on the actual file and it'll bring up the animation.

Courtney Chambers: Okay. I'll sure do it. Just one second. In the meantime, feel free to go ahead and speak up and ask those questions if you have them.

John Hickey: Courtney, I have passed the presenter ball back to you.

Courtney Chambers: Okay. All right. I should be - just one second.

John Hickey: Great.

Courtney Chambers: Sorry. One second. Okay. I'm going to have to share my desktop. Okay. Here, just one second. Let me stop it and - All right. Are you all seeing my web meeting interface or my Window Media interface?

John Hickey: For us, it's coming across great, Courtney.

Courtney Chambers: Okay. Great. Here we go.

John Hickey: So this is the animation for that EFM Sim output and what you'll see as the animation progresses is recruitment of cottonwood seedlings and the change in color reflects growth of those new recruits. Cottonwood seedling recruitment is driven by a gentle enough recession of stage that allows their roots to grow and keep in contact with that water resource kind of a shallow connected groundwater to the actual river system.

And I believe the other animation was for the HEC-RAS temperature. So Mark, could you say a few words about the animation here?

Mark Jensen: Not much to add. That it's...

((Crosstalk))

Woman: What do the colors indicate again?

Mark Jensen: The water temperature and the scale - so - that's a - temperatures ranging from 15 to 18 degrees.

John Hickey: This is the Sacramento River in California?

Mark Jensen: Yes. Which is a pretty significant general cycle we're seeing here.

John Hickey: And a very important river for temperature management concerns, certainly some of the reservoirs in the Sacramento basin (unintelligible) in Folsom have big temperature concerns downstream for an anadromous fisheries.

Courtney Chambers: Okay. Great. We will go back to the meeting interface now. And I'm not seeing any questions yet in the chat feature. Don’t be shy if you got some. I am going to go ahead and post the link to the gateway page or the learning exchange where you can sign up for webinar announcememts if you're not already signed up as well as access today's recorded meeting as well as the PowerPoint and the bios for our presenters and then you can also see the links to past Web meetings and - along with the ecosystem functions model that John referenced that he presented last year.

So let me see if I can get that link visible to you all. Here we go. All right. Are there any other questions today or any questions? Okay. John, do you have anything else to add or any of our other presenters before we wrap up?

John Hickey: Just take the opportunity to thank people for tuning in and also, thank you, Courtney, for hosting.

Courtney Chambers: Yes, sir. Thanks for each of you all for coordinating this presentation. It's been very informative. Again, you can access today's meeting documents at that link and with that, I guess we'll wrap up today.

END