Susan Moisio: ... and we really have to start thinking about this as a complete system. When we look forward, we're looking at it as one water. We're looking at it as what is the rainfall? What is coming into our conveyance and storage systems, but what's happening in our treatment works, and when we look at that, then we start to understand a complete water cycle. That's really from where we need to be as an industry. We really need to think of this complete water cycle.

Steven Ludwick: Welcome to Inflection Points, a podcast series from Jacobs. I'm Steven Ludwig, your host. That was Susan Moisio, Jacobs Global solutions director for water conveyance and storage. She's been working in the area for 32 years and has been named as one of the top 40 influencers in the water industry. While many of us take sewers for granted, this podcast begins to pull the curtain back on the highly sophisticated approach communities are taking to plan, design, and construct effective sewer systems. Susan talks about new ways communities are dealing with stormwater and sewer systems. Why working with combined sewer overflows are so important, the significance of wastewater tunnels, and how new digital tools are revolutionizing the industry.

We also talk about one water, what that is and why it's so important to the future. Inflection Points is where we meet the people of Jacobs that help create solutions that deliver a more connected, sustainable world. With that, it's on with the podcast.

Now, Susan, you were recently named the Global Water Intelligence list of the top 40 influencers in the water industry. They called you the go-to person for conveyance, systems, combined sewage overflows, and storage. How did you get into this line of work? That's so interesting.

Susan Moisio: Well, thank you. I got into this line of work, right out of college, right out of graduate school. I started with the Cincinnati Metropolitan Sewer District as an engineer in the wastewater collection division. That's the division that is responsible for collecting all the wastewater for 3000 miles of sewer in the Cincinnati metropolitan area.

Steven Ludwick: That's a big job.

Susan Moisio: That was a-

Steven Ludwick: Big job.

Susan Moisio: ... big job, but a fun job. I really enjoyed it. A lot of fieldwork, a lot of getting out in the system and understanding how the combined sewer system, how the sanitary sewer system worked. We were responsible for emission 3000 miles of sewer but also for protecting the city when the Ohio River floods. We have a flood control responsibility as well. In that role, I learned how sewer systems worked and how they didn't work because we had over 240 combined sewer overflows. Over a hundred sanitary sewer overflows, and many times our

system backed up into houses and so we had basement backups that we had to work on. My team was responsible for trying to figure out how to fix those.

Steven Ludwick: That would be an important thing to fix.

Susan Moisio: It was an important thing to fix. It was also-

Steven Ludwick: Was it a legacy system? It had to be. Cincinnati's not a new city. I assume a lot of the stuff you're dealing with was old, and the engineering had advanced a great deal.

Susan Moisio: Yes.

Steven Ludwick: I'm sure you brought a lot of that to the table.

Susan Moisio: Well, it is an old system. The combined part was some of the first part that was developed, and sewers, in the beginning, weren't-

Steven Ludwick: Before we go on.

Susan Moisio: Yes.

Steven Ludwick: I'm sorry. Can you define for us what a combined sewer overflow is?

Susan Moisio: A combined sewer overflow is an overflow from a combined sewer.

Steven Ludwick: Which is a?

Susan Moisio: All right. A combined sewer is a sewer that conveys both sanitary and storm. Let me dig into that a little bit. All right. A storm sewer is one that when it rains, water that runs off the road or off your roof, goes into a catch basin and goes into a storm sewer, and goes to the river. In the beginning, when cities were developed, they built those type of sewers, and then over time, they put the house flow, the sanitary flow into those pipes, and they were combined. It has stormwater and has sanitary.

Steven Ludwick: The rain and whatever from the runoff from the streets would eventually hook up with what comes out of the house.

Susan Moisio: Yes.

Steven Ludwick: Great.

Susan Moisio: Yes. Think about this as those pipes are going to the nearest water were to the river. That combined flow sanitary storm, when sewers were first developed. I'm going to use Cincinnati as an example because I'm more familiar with that, that combined flow went to the river, untreated.

Steven Ludwick: That was common around the world.

Susan Moisio: That was common around the world.

Steven Ludwick: That was the practice.

Susan Moisio: That was the practice. Then in the 1950s, we developed wastewater treatment plants. They were built in Cincinnati, and interceptor sewers were put in place that intercepted the combined flow, and they took about six times dry weather flow and took it to the treatment plant and treated it.

Steven Ludwick: What's six times dry weather flow?

Susan Moisio: Dry weather flow would be when it's not raining so average flow-

Steven Ludwick: I guess I should have just figured that out. Good.

Susan Moisio: We have dry weather, and we have wet weather.

Steven Ludwick: Sure.

Susan Moisio: All right. Six times dry weather flow would be what could be conveyed to the treatment plant, but then when it rains, anything greater than that would overflow into the river, and that's what a combine sewer overflow is, is that overflow to the river. It's also a combined sewer overflow could be that location where it overflows. When you get into a regulatory discussion, often there's a fine on point about where it overflows and how much it overflows, and whether it maybe intercepts two or three places. They're very complex, especially urban environments that are cities that have been older. Some of our older combined sewers in cities like Cincinnati or New York or Chicago or DC, that type of thing.

Steven Ludwick: From a lay person's perspective which would be me. It sounds like if you're overflowing sewage into something, that sounds bad.

Susan Moisio: Well, I think it could be conceived as bad but let's think about when it is overflowing. It's overflowing when it's raining and so it's a dilute mix of sewage and stormwater. People are normally not using the rivers at that time, but it does impact the river. That's what we do.

Steven Ludwick: So you plan for that and make sure it's working the way it's supposed to work?

Susan Moisio: Well, that's what we are working on. That's the work that we do is to look at these systems and understand how they're working today. How can we reduce the overflow to the river and the receiving stream? There's another piece of this, and that's climate change impacts. As we look at these systems, we understand what's happening today. Often, we're looking 20 years into the future so that we make sure we have a system that works for now until as long

as you want to be using it. Now that brings in what's happening to our systems. To the rainfall. To sea-level rise. To groundwater, all of these elements are changing with climate change. That's another piece of that. That brings some complexity into what we're doing from the standpoint of making sure that we understand the flows today. We understand the flows that we should be thinking about in terms of population change, land-use change but then overarching all of that, we really need to make sure for each community that we understand how climate change could impact them.

Steven Ludwick: You said adding some complexity, I think you were being understated to touch. If I gather things correctly that the one hundred year and the 500 year floods are happening a little bit more often than that. It's it feels like the models aren't quite caught up with how quickly things are changing. How are you helping people plan for that?

Susan Moisio: Well, I'm going to push back a little bit on it.

Steven Ludwick: Great.

Susan Moisio: I think the models are very much keeping up with that and our water resources team. I'm the conveyance and stories team and our water resources team. They are awesome, at that part of it, about running the models that give us the information on the changes to rainfall and the changes to sea-level rise. You mentioned the flood. That's a piece of that, and certainly, a flood a hundred-year flood changing would impact a city that is on a waterway. It's also about sea-level rise and storm surge and the changes in rainfall and the that's what's driving what-

Steven Ludwick: It's all of that.

Susan Moisio: It is all of that.

Steven Ludwick: Oh yeah.

Susan Moisio: All of that is going to have to... The models are very sophisticated, and we have the ability to model this and look into the future and be ready for this.

Steven Ludwick: That's great to know.

Susan Moisio: It is.

Steven Ludwick: Especially since you're working on that. I think most of us never actually think about our sewer system. Most of us have never heard of, I mean, a combined sewer overflow or any of this stuff, and we always just expect it to work. Like you turn on the lights, it's supposed to come on. You flush the toilet. It's supposed to go down everything. What you're sharing now is this super

sophisticated approach to how we're dealing with sewage systems and storm sewers and how the combined sewers, I mean, it's really sophisticated. Isn't it?

Susan Moisio: It is very sophisticated. I'm going to add another level of sophistication to this. I talked about storm flow, and I've talked about storm sewers and combined sewers. We have sanitary sewers, so that's another element of this. All of this then ends up at a treatment works. When we're looking at a system, and we're trying to understand how they run, today we have to, in the past... Maybe let me look backwards a little bit. In the past, we've looked at our collection systems as stand-alone systems. We looked at it from the standpoint of here's what's happening in my combined sewer system or my sanitary sewer system from a collection system standpoint, but all of these are conveying flow to a treatment works. We really have to start thinking about this as a complete system.

When we look forward, we looking at it as one water. We're looking at it as what is the rainfall, what is coming into our conveyance and storage systems, but what's happening in our treatment works. When we look at that, then we start to understand a complete water cycle. That's really from where we need to be as an industry. We really need to think of this complete water cycle.

Steven Ludwick: That's a shift from when you started.

Susan Moisio: It's very much a shift from when... I've been doing this for 32 years, and when I started, we were more focused on the collection system, and quite frankly, there were a lot of problems with the collection systems.

Steven Ludwick: Well, it sounds like, because if we only had to start treating sewage in the 50s.

Susan Moisio: Yes.

Steven Ludwick: Then this is all relative. I mean, yes, it's been since the 50s, but there was a lot of figuring out to do in the first, probably a couple of decades.

Susan Moisio: There was a lot of figuring out, and many utilities were consolidating, and I'm going to use Cincinnati as an example. The combined sewer system is the city of Cincinnati, but the sewer district takes care of all of Hamilton County. All of those individuals' smaller sewer systems came together to a district. Now you have not only the complexity of combined sewers and sanitary sewers, but you have systems that have been built over time and with different regulations and two different standards.

Steven Ludwick: For those people that might not be in the United States, Cincinnati is in Ohio.

Susan Moisio: It's in Ohio. It's on the Ohio River.

Steven Ludwick: How many people in the metropolitan area would you guess? A venture a guess is fine.

Susan Moisio: I'm going to venture a guess. I think 850,000 people.

Steven Ludwick: It's just a significant size.

Susan Moisio: Yes.

Steven Ludwick: We don't normally think of what you're sharing, and it's been really educational about how complicated and sophisticated this is. We know don't normally think of technology and sewers. We just think of a pipe that goes to a plant, and most of us don't know what happens to a plant, but something happens there. Are there any advancements in technology that help us monitor manage sewer systems or combine sewer systems, and how does that help mitigate what we've been taught, what you shared with us about not only extreme other events but climate change in general.

Susan Moisio: I want to look back, and I mentioned that I've been doing this for 32 years. When I first started, we were measuring flow with chart recorders.

Steven Ludwick: What's a chart recorder?

Susan Moisio: A chart recorder is the data was coming to you on a round chart and it was not electronic. As a young engineer, one of my first jobs was to take the chart recordings and then to decide what the flow was over time. You can think about, I would get a stack of these round paper charts, and my job was to post-process this information and come back with the data. Now we can pull that information from the cloud. In terms of advances, just in flow monitoring, the advances are amazing, but-

Steven Ludwick: I'm sorry to interrupt, but how does flow monitoring help you or municipality or somebody that's in charge of this? How does that work? Why is that important? I mean, I can guess, but I don't want to guess.

Susan Moisio: It's important to understand the flow and think about 3000 miles of sewer. 3000 miles of sewer, half of which of that is combined, and the flows in the combined sewer system changed depending upon the season, and they changed depending upon the rainfall.

Steven Ludwick: 3,000 miles would be about London to Rome, maybe. Maybe a little less or something like that. Or Los Angeles to New York is somewhere in that ballpark. That's a lot of sewage. That's a lot of line, I mean.

Susan Moisio: That's a lot of sewer, and it ranges from 8-inch pipe to 20 feet in diameter.

Steven Ludwick: Wow.

Susan Moisio: Very complex from the standpoint of the differences in size and the differences of material, but more important, it is spatially spread out over a large area. From the standpoint of understanding the flows that are coming to the treatment works, that's what the flow monitoring does for you. If you want to understand what you have today, you need to monitor the flows. If you want to understand projecting into the future, how you can change those flows, you have to know what you have, so you can project into the future. We build hydraulic models mathematical models of these sewer systems, and that was my last project when I was at Cincinnati MSD. I was the project manager for the development of the hydraulic model. We-

Steven Ludwick: Sorry. Cincinnati Metropolitan Sewer District?

Susan Moisio: Yes.

Steven Ludwick: MSD?

Susan Moisio: MSD. We put over 300 monitors throughout the system, and then we developed a mathematical model of the sewer system. We are able to use that model to understand how the flows in the piping network, how those flows change over time. We can use it for what's happening today, and then we can look into the future and say, what would change in the future? What if we did get a different rainfall? Today, what if that rainfall was a 10-year storm? What if it was a typical year storm? What if it changed over time, then how does that flow change? Once you have that information, then you have the ability to make changes in the system that could control that flow.

Steven Ludwick: Why is getting this right important for a community? It could be obvious, but I'm curious, I'm sure I'm missing something just from thinking it through. Having this level of sophistication is it important for businesses to operate and families to live comfortably and all that stuff?

Susan Moisio: It is, but that's the piece of it in the system. The other piece is, what we talked about earlier is what's happening in the river. From a regulatory standpoint, a community needs to have a plan to reduce those flows. In America, typically, you're trying to capture 85% of the overflow in a typical year. You need to understand what that flow is. You need to understand what your system can do, and you need to understand then where can I change the system? The opportunities that we have to change the system in the past have been, there have been three opportunities. One, you can store some flow and you might store it with storage tanks or you might put in a tunnel. An example of an iconic project that I get to work on is in London is the Thames's tide tunnel system is 26 kilometers of tunnel from the Western part of London, all the way to the Eastern part, all under the Thames's River. When they're done, they will capture 94% of the overflow in a typical year.

Steven Ludwick: That's a massive project.

Susan Moisio: That's a massive project. That that's one element. The second piece of-

Steven Ludwick: I'm sorry, just curious. When it goes into that tunnel, does it stay there until it's ready to be treated, or what happens to it?

Susan Moisio: Well, ready to be treated is yes. Simply put, it is, but that's not a very long time. That's usually about two days. You don't want to store sewage for a long time because it will go septic, so you only have about two to three days to be able to pump out the tunnel. It's a very sophisticated operation to understand what the treatment works can take. What goes into the tunnel. What comes out of the tunnel and making sure that you don't overfill a tunnel. All of that goes into it. That's the storage element. The second piece of this is you could upsize the plant and convey more flow to the plant, but then this comes in at a cost. It's not cheap to do that. Option number three would be source control. Source control could be, you could separate the system so you could install a new storm sewer and then separate into a sanitary sewer and a storm sewer.

You could also do source control, like green infrastructure, and some examples of green infrastructure would be a rain garden or rain barrels, something of that sort. The idea with green infrastructure is that you're keeping the stormwater from getting into the combined sewer system and then that stormwater is handled then it's infiltrated into the ground, or after you've retained a certain amount of it it would overflow then, but it's handled as stormwater, not as combined flow. Those are the pieces of it.

That's what we've had in the past. In the past, we've had those three options. You can store it, you can convey it, or you can reduce it. Building on your question about why is it important to monitor the flow. Now, looking into the future where we're going is understanding how the system works as a whole. If we think about it, as we have a treatment plant, we have a collection system, we have the flows that are coming into the collection system, and if you've got the ability to pull some flow off in real-time and you know what's coming to you. This is the other piece of that. Looking at your system, looking at the rainfall that is coming, because this is rainfall driven and understanding how that rainfall is impacting a portion of the system, then you have the ability in real-time to change what's coming to the treatment works.

Steven Ludwick: Wow. That sounds really high-tech and amazing.

Susan Moisio: It is high-tech, and it's amazing. It's cool, and it's fun to work on.

Steven Ludwick: That's coming down the pipe, no pun intended around water.

Susan Moisio: That's what's being done today. We're going further. Where we're going in the future is to develop a digital twin of these systems.

Steven Ludwick: What's a digital twin.

Susan Moisio: A digital twin would be a representation of how the system is set up today so it's a twin digitally. It's more than, or maybe it's different than a hydraulic model, because a digital twin could be more about how you control the system. Jacobs has a process called Replica. It's a software that we've developed that allows us to build these digital twins. A very complex treatment works, pump stations, real time control facilities, interceptors and it gives us the ability to understand how the system is operating today and then we can understand what options are available for controlling that system. Where we're heading is to automate that so that the system is receiving predictive rainfall and then making those decisions on its own and using artificial intelligence and then controlling.

Steven Ludwick: Wow.

Susan Moisio: That's where we're heading.

Steven Ludwick: That's really amazing. This digital twin will begin to learn what happens and then-

Susan Moisio: Yes.

Steven Ludwick: ... make whatever the magic it makes and makes decisions that are-

Susan Moisio: We call that engineering rather than magic.

Steven Ludwick: Great, thank you. I meant well. Thank you. That's really interesting. Now you've talked about controlling these flows and what have you. What's the intersection between private property owners and the government or government sectors on sewage handling, as well as stormwater handling, and how do they have to work together to ensure that the whole system actually works properly? Because it seems like if a private property owner isn't playing well with the city, your planning can get all messed up.

Susan Moisio: It can. I think it helps to understand it in most cities, what the utility is responsible for. If you take a typical street, the utility is responsible. Let's assume that the sewer is in the street, and we'll talk about great outside the street later. In the street, they're responsible for the mains. The manholes, and often the laterals, and the laterals are that part of the sewer that goes from your house to the main. They're responsible for that portion of it. What happens on private property is often not the responsibility of the utility, but that impacts the flows that go into the sewer system. Whether it's a combined sewer system or a sanitary sewer system. We see this more, having an impact on sanitary sewers. We not talk that much about them, but our sanitary sewers are impacted by inflow and infiltration.

Little bit about sanitary sewers. They're designed to take sanitary flow. They're designed to take the from inside your house or your business.

Steven Ludwick: All right.

Susan Moisio: They're not designed to take stormwater. As our systems are aging. In America, we have a huge problem with aging infrastructure and as they age, they're breaking down and they're accepting more of this I and I, more of the stormwater. A lot of that I and I is coming in on private property and over half of that is coming in, depending on where you are and depending on what's happening. That is the intersection of having... You need to understand where the problems are. You need to understand what is the public responsibility and what's the private citizen's responsibility and then develop a game plan for what are you going to do about that? That's how I see the intersection.

Steven Ludwick: Now, if there's a big development in a city especially, and they put a lot more pavement in. I assume there's regulations on how to deal with the water that comes off a major parking lot or something like that in order to not completely disrupt the-

Susan Moisio: There is. In every city that I've worked in, when you change and let's do it from if you were in a combined sewer system. There are regulations that say if you change the characteristics of the catchment, then you have to retain that flow so that because as we look at what we're trying to solve, we're trying to solve a problem with runoff, and runoff is exacerbated by the land use. Example of that is if you look at a parking lot and it rains, then that parking lot, the runoff is very quick and almost 100%. I happen to live on a small farm in Indiana and I'll say that the rainfall characteristics and the runoff characteristics in my hayfield are very different than what you see in a parking lot and an urban environment. That's a very simplistic view of that but in terms of land use and how the system is operating. That's the opportunity.

The opportunity is to look at our catchments and look at what's impacting our combined sewers, and can we effectively change that? You look at all of these pieces. You look at it from the standpoint of, can I change that? Can I control that? Can I store that? Should I convey it? What does all of this do to the receiving stream?

Steven Ludwick: Now, you've mentioned you have quite a bit of experience in this, and Jacob's combined with all the talent you have here has hundreds and hundreds of years of combined experience, if not thousand. What are some lessons that Jacobs has learned over the years at working on planning, design, and construction of these types of projects? I'm sure there's tons of lessons.

Susan Moisio: There are tons of lessons, but I'm going to give you the one that I think is the most important.Great.

Steven Ludwick: Great.

Susan Moisio: The one that I think is most important is that we have to look at this as one water. We have to look at it as water is a resource. It is precious, and so often, as engineers, we have looked at water as a problem. As long as we keep looking at it as a problem, we won't truly recognize how important it is. Cities are now starting to understand that, and they're starting to understand that rather than it being like I and I-

Steven Ludwick: What's I and I, sorry.

Susan Moisio: Inflow and infiltration-

Steven Ludwick: Thank you.

Susan Moisio: ... which goes into a sanitary sewer. Is that really a bad thing, or is that a resource? I think as from a lessons learned that I see in this industry in 32 years of doing this, it's about, it's a system it's about one water. It's about water is precious, and we need to understand how can we handle this resource so that we value it.

Steven Ludwick: Wow. This has been a very interesting and an amazing conversation. I'm sure we could talk for hours, but we've got to wrap it up. I'm always worried that I forgot to ask something really important. Is there anything that I didn't ask that you want to mention?

Susan Moisio: There is not. Thank you. I've really enjoyed this.

Steven Ludwick: Great. Now, where can people get more information if they want to find out more?

Susan Moisio: jacobs.com and look for the water page?

Steven Ludwick: Great. Well, thank you so much. This was terrific.

Susan Moisio: Thank you.

Speaker 3: Thank you for listening to Inflection Points, a podcast series from Jacobs. To find out more, please visit jacobs.com. Jacobs, challenging today, reinventing tomorrow.