## Subirrigation

## Season 1, Episode 8

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**John McMaine:** Thanks for joining us on Streamlines, your source for water knowledge. I’m your host, John McMaine with South Dakota State University Extension. This is Episode 8.

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**John McMaine:** Hello everyone again, this is John McMaine.

**Anthony Bly:** And Anthony Bly.

**John McMaine:** And today Anthony, we are discussing subirrigation.

**Anthony Bly:** Oh my.

**John McMaine:** So, subirrigation is basically using your tile in reverse.

**Anthony Bly:** Wow.

**John McMaine:** Yeah!

**Anthony Bly:** Yeah.

**John McMaine:** Have you ever heard of such a thing?

**Anthony Bly:** Oh yeah, I have.

**John McMaine:** Yeah.

**Anthony Bly:** Yup.

**John McMaine:** And so, I’ve got a colleague of mine from North Dakota. He’s at NDSU, he’s the Extension Water Management Specialist up there and professor. And he works a lot with this concept of subirrigation, so using your tile system not just as a tile system, but also as an irrigation system. And so, we went through kind of the ins and outs of subirrigation with Tom. And it was really interesting the flexibility that a subirrigation gives you. But like every other practice we’ve talked about, almost every other practice, the site specificity or how really you need to customize that design.

**Anthony Bly:** Right.

**John McMaine:** For the site. No cookie cutters here. Anyways, I’ll let Tom introduce himself and then we’ll get into some of the discussion.

**Tom Scherer:** Yeah, I’m Tom Scherer. I’m an Extension Agricultural Engineer and Associate Professor in the Department of Agricultural and Biosystems Engineering at North Dakota State University. I’ve been here since 1991 and periodically up until about 1997, I would get a couple calls every year about tile drainage. What they really started to take off in 1999. Since then, we’ve been doing a lot of workshops and a lot of research projects. As far as I can tell, this is not a new concept. I suspect it’s been around a long time. A colleague of ours in Michigan, back in the 1980s, was doing a lot of research on small plots in subirrigation. Even developed some computer programs to help guide spacing and so forth. So that takes us up to the present day, where North Dakota South Dakota, we’re in this transition zone where the east side of the state probably gets a decent amount of rain. As we get a little bit farther, we can periodically have droughts. So, the obvious question is once a farmer installs a tile is: boy, is there a way I can put water back into here during those late July, August when my crops are really developing, the seeds, the ears, the whatever that I need to harvest to get the max benefit.

**John McMaine:** So, not a new concept.

**Anthony Bly:** No.

**John McMaine:** 1941. And it’s crazy because like, I’ll look at storm water and you can go back to ancient Greeks and ancient Romans, their storm water management. And so, it’s interesting how these concepts get recycled and updated. And, you know, I come in here, young whipper snapper, and I think I have this great idea. Look in literature and talk to Tom.

**Anthony Bly:** It’s been done.

**John McMaine:** It’s been done. A long time ago. And it was either really successful or it was a miserable failure, and I shouldn’t attempt it again. But so, as Tom said, he works a lot with subirrigation. And biggest thing with any type of irrigation, is you need a water source.

**Anthony Bly:** Correct.

**John McMaine:** And it’s challenging. Like you need the water when there’s not much water, right? So, you need irrigation when your water source is also potentially drying up. But there are some efficiencies that can be gained with subirrigation, as well as subsurface drip irrigation which is discussed in a different episode on Streamlines. But starting point for subirrigation, this is kind of my first question of how it works is, where do you get the water from typically in subirrigation. How does, what is the mechanism of operation for subirrigation?

**Tom Scherer:** You obviously have to have an entry point to put the water in. Right so, different people have done it different ways. We have, we have one gentleman up in North Central North Dakota that put in one of those systems. And he’s got 24 control structures that he pumps water to. And by the way, his water source is a drainage ditch that drains, I don’t know how many square miles, six or seven hundred. And so, he’s, he’s got a pumping system where he, he built an off-stream storage of several acre feet of water. And he’s got his pump set up so that it can either pump out of the ditch if there’s water in it or he can pump it into the pond to fill it up or he can pump out of the pond. So that’s his water source and it’s pretty decent water. It’s a very expensive system, but he’s been happy with it. So, in that case, he’s got 24 outlets from his pump. He’s got a lot of piping. It’s an 80-acre field and when he wants to drain, he lifts up basically a piece of PVC and lets the water drain out. When he wants to subirrigate, he pushes that down and then pumps into that and that’s what sets the level that goes out into his tile. That’s the first thing, as I mentioned earlier. You can pump into, if you got a lift station or if you got a control structure, you can pump into them. The gentleman that pumps has a separate main at the upper end of his field. He’s got three zones in it, two forties and one fifty. And then he’s got a manifold where he can divert the water to whichever one of those zones he wants to. So, he’s pumping directly into that main and then letting the water flow down the tile and seep into the ground. But you have to have some kind of control, I haven’t yet seen a gravity flow system other than the one I mentioned, you know, at the beginning back in 1941. My understanding is in North Carolina, a lot of the Wayne Skaggs research, they were doing that there. Putting control structures in the ditches and backing water up into their tile to subirrigate. But I haven’t seen anything like that here.

**Anthony Bly:** Sounds complicated.

**John McMaine:** It is complicated and one of the biggest takeaways I had when talking to Tom, is how important it is to think about that conceptually when you’re putting the system in in the first place. Very difficult to retrofit, in my opinion, and in practice. And it’s not something you can just go get off the shelf, right? Throw in there and you’re good to go. It’s very case dependent. Very much has to be taken into account when you design the drainage system and subirrigation system. It’s, if you just think about the concept, there’s a lot of different ways to do it. Like you can make it work for your system, but if you don’t think about it conceptually, you just try to do subirrigation based on other people’s designs, it’s not necessarily going to work for your field. So that complexity is, can be a benefit because you can tweak it, you can make it work, you can be innovative with subirrigation. But if you’re not innovative and you just take a cookie cutter design, it’s going to fail probably.

**Anthony Bly:** Yeah, it’s not going to work.

**John McMaine:** So, subirrigation, conceptually a great idea. But when the rubber hits the road, what’s the opportunity for farmers?

**Anthony Bly:** That’s what I want to know.

**Tom Scherer:** Well, I think first they have to realize there’s two different ways of doing this. And we got both here in North Dakota. The traditional way is to shutoff the lift pump and then pump water into the lift station and back water up into the main and back it up into the tile. Either with a control structure, or in our case lift stations, and we got some systems that do that. What we found is on a .1% slope, we can back the water up about 1,000 feet. Okay, trying to maintain that water level a couple of feet below surface. So, if your field is, say, 2,000 feet long, you probably have to have two mains in there. And we have one producer that has done that, he split his field and actually has two. The other way, which is far as I know at the field level scale, we got the only system that a farmer put it. Where he put in a separate main at the upper end of the field and he pumps his water into there and lets it run down a tile. And then has control structures on the outlets, to control the amount of water and the theory is you put the water into the upper end, it goes down and is going to seep out into the soil. What we kind of found is that if you put the water on too much, it actually just runs down the tile and doesn’t seep out that much. So, you get a, a large accumulation usually right at the outlet by the control structure. And in one case, the sugar beet field, there was enough extra water in that lower end, where the control structure is, that they had a disease problem. They got pretty bad rhizoctonia because of the excess moisture. And so, we found out that at least with sugar beets, it probably wasn’t worthwhile subirrigating that area. But, but that’s not the same for soybeans, which has only about a two-foot rooting depth. It really depends on the crop and how you want to put the water in.

**John McMaine:** So, what do you think?

**Anthony Bly:** There’s challenges there.

**John McMaine:** This is kind of where water management and other disciplines of agronomy would come in. I mean, disease pressure from excess water. Obviously, you’re going to have, you know, rooting issues potentially with excess water. So that’s a, that’s a challenge if you’re relying on management that may or may not happen. Not because you don’t want it to happen, but you may not have all the information you need to make the right management decision or you just may not, and that’s another step you have to do right, to go out and manage that system. So, you might not have the time available to manage it right, and then, yeah, you end up with a system that’s flooded or saturated rather than one where you have a drainage system that’s working properly.

**Anthony Bly:** It’s learn as you go I think.

**John McMaine:** It’s like a lot of things in life.

**Anthony Bly:** Yeah.

**John McMaine:** Subirrigation, learn as you go. One of the things Tom mentioned was clay layers between the tile and the ground surface.

**Tom Scherer:** Sometimes, we’ve got clay layers that are sometimes in between the tile and ground surface when it was put in. You know, it depends on your structure as you go down.

**John McMaine:** Anthony, have you seen subirrigation? I’ve actually never seen it in person, but.

**Anthony Bly:** No, I, I’ve been to, I’ve been to an event where they talked about it and presented their research projects.

**John McMaine:** One of the biggest challenges with designing and installing and operating a subirrigation system, is if your soils and your subsoils are not consistent.

**Anthony Bly:** Correct.

**John McMaine:** And you can image how this would just wreak havoc on you know, you’re putting water where you think it’s going. And in reality, it’s blocked by a clay layer or there’s some preferential flow path. Or whatever the case may be, there can be huge amounts of variability in a field. And so, if you don’t fully understand that whenever you put one of these systems in, it’s not going to work how you planned.

**Anthony Bly:** Correct.

**John McMaine:** And so, one of the things that Tom recommended as far as advances in subirrigation design and technology, is getting a better idea of what’s going on in the soil.

**Tom Scherer:** I had one gentleman, he’s got a piece of land, it’s flat on the bottom and then goes up a hill, okay. And the hill part is sandy soil, it’s sloping, it’s a pretty uniform slope going on. And typically, the water drains from that area, down to the lower area. So, he’s got a lot of water in the lower area and that needed drainage. The upper end needed drainage, too, at certain times especially in the spring. But as we got into July and August, that upper part would dry up, whereas the lower part had enough kind of natural flow of water on the ground to keep it okay. So, what he set up is, he set up a system where he just subirrigates that upper part, the sandy part. And he actually pumps out of his sump. He’s got enough water in that lower part, that he pumps out of there. And then he’s got a small supplemental well that he can pump into there. So, he pumps it up and he’s got two, I would say, thirty-acre blocks. He’s got just two valves right there. So, what he says when he’s operating it, it doesn’t have a tremendous amount of flow, but he pumps in one direction one thirty-acre chunk for about five days. Then he goes up and flips the valves and puts it the other way. And that water seeps down and moves downhill. So his drainage system is actually capturing any excess water he’s got. Very clever design. He said, you know, his yields on that sandy soil went from 100-bushel corn to 200. You know, but he used existing topography and conditions to his benefit and that’s paid off for him. It was a sizable investment, but still, he says economically it, it makes a big difference. So that extra sixty acres, you figure, you get an extra 100-bushel corn or 20, 25 bushels soybeans is economical.

**Anthony Bly:** Innovation is the name of the game here.

**John McMaine:** Innovation is the name of the game. Again, it’s not, there are no designs off the shelf.

**Anthony Bly:** Nope.

**John McMaine:** You consider your situation, and you design for that. I wouldn’t say it’s a gamble necessarily. It’s more about knowing how to work with the situation that you have. Because you know, if like that sloped piece of ground burns up, it needs water.

**Anthony Bly:** Right.

**John McMaine:** So, you know you’re going to have benefit there if you can have more water on that piece of ground.

**Anthony Bly:** He knew he had excess water, too.

**John McMaine:** And he knew he had excess. So, man. Innovation! Taking that excess water from the bottom, pumping it to the top. I mean, you’re getting the double benefit from managing the water in the downstream end and in the upstream end.

**Anthony Bly:** Yeah. That’s how I see it. I mean it’s all, it’s all situational.

**John McMaine:** So, one of the stories Tom told about was about a farmer who put in a, a drainage system and a sump, and he put a, the sump went in in the middle of a sand vein, unbeknownst to him. Which was getting water from who knows where and once that started pumping, it basically never stopped for the next five or six years.

**Anthony Bly:** Wow.

**John McMaine:** Because it’s getting, it’s not just getting water from the drainage system. It’s getting water from the whole county basically.

**Anthony Bly:** Tapped the aquifer.

**John McMaine:** Taps the aquifer, yeah so. Unfortunate situation. And a, a real example of why it’s important to know what’s going on under the ground if you’re designing a system that’s working with the mechanisms that are happening.

**Anthony Bly:** Absolutely.

**Tom Scherer:** Yeah, technology and remote monitoring of these things can help you a lot. One of the biggest things, I think, what we don’t know about drainage, and I would like to see someone really initiate it a research project on this. I think I’ve mentioned it to you before, all of our drainage design manuals and everything assumes that we know where the confining layer is or the restricted layer is, right. My hunch is, in looking at a lot of fields, like I told some farmers this summer, you got a geologically screwy area. You got layers of sand and gravel mixed in with layers of clay. And it causes strange problems sometimes. And I’d like to see somebody do some real monitoring of fields, if we can use something like an EM 31. Some kind of monitoring system. You know, you’re probably familiar with EM 38 that measures salinity. But that only goes down about a meter. I know a colleague of mine works up in Canada, Manitoba. Works with a geologist who uses that, and they mapped some fields and have been able to identify areas in the field where there’s buried sand layers, a sand channels from old glacial outwash. The reason they were doing it, the systems were not acting the way they expected to. And here they found these channels, where there were like between twelve and fifteen feet down. And so, the water would seep down there. And it’s going someplace where they didn’t expect. So, I’d like to see more research along that line. I know people have worked with ground penetrating radar, but I’d like to see something that can map out these layers. Because I, I suspect in a lot of our fields, even though they look nice and flat, I think that confined layer undulates, and I think that it would be a better tool for probably working out designs.

**John McMaine:** So, it’s really important to know what’s going on under the ground. The EM 31 tool, that Tom mentioned, it’s a ground conductivity meter. And that’s able to get, basically, soil characteristics down to several meters or multiple meters, versus just, you know, one or so meter with the EM 38. And that, that’s something that can be actually performed on a field for about six bucks an acre, that was the figure that, that Tom threw out. Is that valuable information? Would you, if you were thinking about putting a tile system in, would you think about doing that on your, on your system, on your field?

**Anthony Bly:** You know, I, I, depends on where your fields at. I mean, if it’s in an outwash plain or floodplain type area, that’s been deposited by water, you know. That, that, that would, that would be important. But like our wind-blow silts, our loess soils, are really consistent. So it wouldn’t be, you know, so valuable in those situations.

**John McMaine:** Because of the soil forming factors that were present for that soil.

**Anthony Bly:** Correct. I mean our glacial tilled soils may have some advantage there to predict how deep that parent material is. If it’s more than a meter, which, which would be really valuable.

**John McMaine:** It’s great to work with a soil scientist, yeah. So, one of the last things that I asked Tom was, kind of, if he saw any technology that was, you know, really going to be groundbreaking for subirrigation. And we, we talked about solar, and I’ll let him discuss that. But one of the, again, one of the biggest things was the concept of subirrigation is good but it’s not like you can make a technological breakthrough because everything is so site specific. So, you can make, maybe, a technological breakthrough on the overall concept. But again, like you said earlier, it’s innovation at every field that makes a difference. You’re not going to have a situation where you can pump to the top, let it gravity flow down the field. You’re not going to have a situation where you can pump out of your sump to the top. Like, those are very situation specific. And so, it requires innovation by for every design. But there are some pretty exciting technologies out there.

**Tom Scherer:** I’m not promoting it, but ever since I’ve been doing tile drainage design workshops, there’s always a question come up, is, are there any solar options. And, I’ve always had to say I haven’t seen any. Well, our local gentleman that sells these lift stations all over the United States is now putting in a solar powered pumping system. And by the way, he, he would, he said he would hire an intern or he’s looking for an engineer that would work on these projects. And he’s got more than just lift stations. He, he sells prepackaged VFD controlled irrigation systems and green handling systems. But he’s going to be installing this solar system. So, I’m hoping that that type of thing might work out. So that’s one project. And there’s always questions coming up about water quality. Three of us, myself, and then one of our area specialists up in Langdon who’s got a control drainage are trying to put together an extension bulletin to show what results we’ve got from monitoring these different systems. As you will know, every system is different. And what comes out of them is different. But we’re started in putting together an extension bulletin to kind of show some of the water quality. And, and we can’t show all of the water quality so we’re going to just focus on TDS, EC, sulfate because that’s a big problem here. Probably chloride in the soil and SAR of the water. Those would probably be the main ones that we look at. We got samples where we’ve got a tile out bedding into a drainage way. In some of our systems, we’ve taken samples upstream and downstream and then what comes out of the tile on the same day. So, you can kind of look at what’s the impact of that tile outlet onto the receiving stream.

**Anthony Bly:** It sounds like water recycling to me.

**John McMaine:** It definitely fits, I think, with drainage water recycling. And there’s a lot of opportunity for overlap with conservation drainage practices. And since this is a conservation drainage series, I wanted to wrap up with thinking about how subirrigation can contribute to these goals of conservation drainage. One being water quality. To me, the biggest thing is if you’re able to capture and reuse through the tile. You’re reducing what’s going downstream.

**Anthony Bly:** Absolutely, the nutrients as well.

**John McMaine:** The nutrients as well, right. That gives another opportunity for those nutrients to be used by your, your targeted organism.

**Anthony Bly:** The plants.

**John McMaine:** The plants, yeah. And then the other piece of conservation drainage is this resilience piece of enabling drainage systems to be able to withstand extremes in the spring, too wet, and in the summer, too dry. And it does come back to it, water source, but if you have a water source subirrigation is a good way within the same infrastructure, within the same system to give you some of that resilience in the spring and the summer.

**Anthony Bly:** Absolutely.

**John McMaine:** So, subirrigation, that’s a pretty innovative concept. But it’s not necessarily an easy one to implement, right? It has potential challenges.

**Anthony Bly:** You better make your plan.

**John McMaine:** You better make your plan. We heard about the sugar beet farmer who was too saturated and ended up with disease issues.

**Anthony Bly:** Correct.

**John McMaine:** We heard about the farmer who didn’t have enough water because the flow was too high at the top end of the drainage system, so it all ran downhill.

**Anthony Bly:** Yeah.

**John McMaine:** Then, there’s all this complex soil and drainage design, and there’s like a lot of unknowns potentially with subirrigation. And so, site specific design is critical.

**Anthony Bly:** Very critical, but it’s doable.

**John McMaine:** I guess going back to the, maybe the most exciting thing about subirrigation is conceptually, it’s flexible if you’re flexible. If you can innovate that system to make it work for your situation, it can pay dividends.

**Anthony Bly:** Oh, that’s the exciting part.

**John McMaine:** That’s the exciting part.

**Anthony Bly:** The challenging part.

**John McMaine:** That’s the exciting and the challenging part!

**Anthony Bly:** Yeah, exactly, together.

**John McMaine:** Right. So, subirrigation consistently results will vary.

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**John McMaine:** Thanks for joining us today on Streamlines! We sure had a lot of fun today, hope you did too. If you want to learn more about anything you heard today, head on over to the SDSU Extension website. But for now, I’m John McMaine.

**Anthony Bly:** I’m Anthony Bly.

**John McMaine:** And we’ll catch you next time.