Ohio's Professional Soil Scientists

2020 Summer Newsletter
Volume 47, Issue 2 Part 1

Message from our president – Jeff Glanville

Very soon after the shutdown this spring, they made us take some (online obviously) training on telework. At times cheesy, it was also actually insightful. For someone like me who had never teleworked before, there were some good suggestions.

The 2 points I remember most: 1) it's tempting to work extra hours, and 2) You will probably miss the time to unwind that the commute used to provide you. Both are true in my case. I do miss the commute, which in my case was a mile and half walk to the bus stop in the morning and the same walk home in the afternoon. And since I'm in the habit of waking up about the same time every day, all I need to do in the morning is to have my 2 cups of tea, breakfast, and head upstairs to log on. I have been working more than the 40 hours per week I get paid for. My wife and I have decided we won't dine at restaurants or go on vacation, so we aren't going anywhere anyway.

We have 2 new soil scientists in Ohio NRCS this summer. We also have 2 student interns on our staff. I am currently filling in for my supervisor, and it has been nice to have extra time with them. That hasn't been too much of a difficulty for me because the office has been closed. It takes considerable time trying to guide them through the maze of forms and paperwork the federal government requires. We are really happy to have some new people.

For those of you who are retired and those of you who may not work in a large office, here is how it has been working: My office has been on phase 3, or closed status, since the pandemic began. Everyone is able to telework from home. Almost all of us have laptops, which we can take home, along with extra monitors, external hard drives, etc. Then all you need is a decent internet connection at home. Applications we use generally work just as well at home. They are trying to rotate the managers into the office a few days per pay period. My office days next week are Monday and Friday. The only other reasons people may go to the office are to pick up a government vehicle or to do some printing.

Among the cancellations/postponements have been collegiate land judging and high school land judging contests (probably), training courses, and other meetings. The North Central Regional Soil Survey Work Planning conference was this week. Everything, including the field tour, was done virtually. Most of it actually went off pretty slick.

One topic discussed in my committee discussions during the NCR conference was about trying to make historical soil information available publicly. We're not even sure what all this might include, but I always first think of original soil survey materials: maps, pedon descriptions, field notes, etc. I'm always looking for photographs or slides, either good pictures of soils and landscapes, or personnel. It may also be possible for us to add soil descriptions from private consultants to our database. If you have any such material you're willing to share, please let me know.

No, we don't yet know when we will be able to get together in-person as an organization. It may not be this year, maybe not for a long time. But we will do it one day. Until then, please contact me, or any other AOP council member, with questions, concerns, or suggestions.

Stay safe.

Survey of CPSS in Ohio

Help the Executive Committee Plan for training the next generation of Certified Professional Soil Scientists

I wanted to provide a brief update on the status of the "AOP State-wide Soil Scientist Needs Assessment I" survey. The information from this survey will help us to anticipate ongoing and future training and educational needs and also geographic trends on where consulting soil scientists are working in Ohio. This survey was distributed via individual email addresses to 81 people on July 21st and a reminder email sent July 30th. As of August 20th we have received 48 completed surveys, which come to a 59% response rate!

We would still like to hear from everyone in the AOP membership, so a reminder message will go out next week for those who have not completed a survey. Thank you again for taking the time to complete the survey and providing feedback."

Let me know if you need any further information.

Best,
Scott
Dr. M. Scott Demyan
Assistant Professor, soil and environmental mineralogy
School of Environment and Natural Resources
The Ohio State University
408B Kottman Hall
2021 Coffey Road
Columbus, Ohio 43210
USA
office: +1-614-688-3349

A message from our new treasurer

Are Your Dues Due?
Thanks for being a member of the Association of Oho Pedologists. You are a member of a unique group of Science Professionals. Being a member of the AOP affords you several benefits. Networking with similar professionals, networking with unfamiliar professionals, educational programs, great newsletter, CEU's, good food, just to name a few. Being a member also requires you to pay your dues in a timely manner. It doesn't cost much to be a member, and stay a member:

Professional - $40.00
Affiliate - $20.00
Student - $20.00
If you aren't sure if you have paid for the current year, contact Rick Griffin, AOP Treasurer at: rgriffin1741@ gmail.com; AOP in the subject line would help. Keep your membership up to date. It keeps our organization strong, informative and relevant to your professionalism.

Rick Griffin, AOP Treasurer
937 Laurel Avenue
Zanesville, Ohio 43701
rgriffin1741@gmail.com

Celebrating one of our own

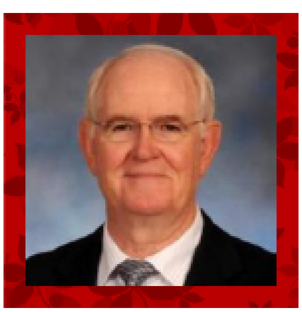
SCHOOL OF ENVIRONMENT AND NATURAL RESOURCES

ALUMNI CONNECTION

SPRING 2020

ENR HONORARY 100 INDUCTIONS ANNOUNCED FOR 2020

The ENR Alumni Society is also excited to announce the selection of the 2020 ENR Honorary 100 recipients. The Honorary 100 includes individuals who lent their support during the formative years of the School of Natural Resources. Many of these individuals expressed a desire to maintain a continuing supportive affliation with SENR. The ENR Alumni Society, with the endorsement of SENR and CFAES, works to continue the Honorary 100 as a non-dues paying affliate of the ENR Alumni Society, and annually seeks to enlarge the membership by recognizing outstanding Ohioans who have significantly demonstrated an interest in the School of Environment and Natural Resources and its mission. This year's recipients are as follows:



Jerry Bigham, PhD, SENR professor and SENR Director – Emeritus
Jerry M. Bigham joined OSU's Agronomy Department in 1977 as an Assistant Professor. In 1982, Dr. Bigham was promoted to Associate Professor and then to Professor in 1992. In 1994, Dr. Bigham became a member of the School of Natural Resources faculty following an administrative reorganization of the College of Food, Agricultural and Environmental Sciences. Ten years after his move to the school, Dr. Bigham accepted the role of interim director in August 2004, and then he was subsequentially appointed director in June 2005. It was during this time that Dr. Bigham had a vital role in incorporating and establishing the School under the new name, School of Environment and Natural Resources.

Future meeting announcements and cancelations

I will continue to send notices of webinars and on-line conferences that either do qualify for or could qualify for Continuing Education Credits. I'm working with Franklin Soil and Water Conservation District (where I still serve as an Associate Board Member after all these years, back to 1974) as they continue to develop a series of on-line educational opportunities, many of which would be of interest to soil scientists.

Memorials for recently departed friends

Larry Tornes remembering George Hall

Julie,
The newsletter is great. I wanted to send something for the George Hall tribute, but got to doing something else. Here it is:

The George Hall family were a great neighbor to us when we lived on Havendale Drive and our children were in 4-H together. I especially enjoyed working with George on field reviews, AOP activities, and the study of fractures in glacial tills and how the fractures extend down from the lower Bt and the BC horizons into the glacial till in many locations. We had a lot of good discussions on how mechanical analysis of soils correlates with engineering properties on the old Soils 5 form. I can't believe both George and his wife Carrol are no longer with us.
Larry Tornes

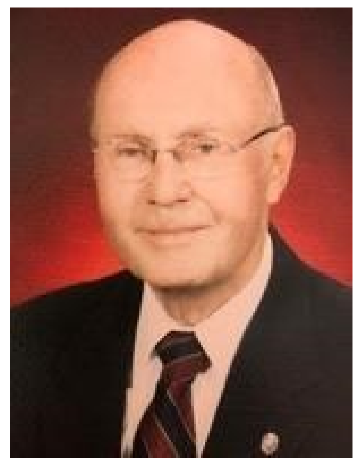
Frank Gibbs remembering George Hall

I remember Dr. Hall as being a very kind, generous and thorough instructor…
He was always very helpful and down to earth with a good sense of humor…
He taught me in the old 550 Class the basics of mapping, although in actuality, I was completely lost, but he was very patient with me… It was later in SCS, when Neil Rubel took me under his wing and taught me to map that I realized how little I knew…
I still use a couple of Dr. Hall's Slides in my Soils Presentations that he generously gave me permission to use…
He always had a smile for me, all thru my career, besides at work, I would run into him and Dr. Himes with their wives at the Old China Dynasty (now gone) on Lane Ave. Sunday afternoons…
I wish he were still alive…
God Bless Dr. Hall…
Frank Gibbs

From the July issue of CSA News

IN MEMORIAM In Memoriam George Fredrick Hall George F. Hall, a member of ASA and SSSA for 50 years, passed away on 26 Apr. 2020 at the age of 89. He was born 5 Mar. 1931 in Spickard, MO, and spent many of his formative years on the family farm in northeast Illinois. Following high school, he also tried his hand at farming before being inducted into the military. He was assigned to the U.S. 8th Army after basic training and served in Korea during 1953–1955. In 1955, Hall enrolled at Illinois State University on the GI Bill with the goal of becoming a vocational agriculture teacher. After a year, he transferred to the University of Illinois in Champaign-Urbana where he discovered his academic passion for soils while taking the introductory soil science class. Hall completed his B.Sc. in Agronomy in 1959 and his M.Sc. in soil science in 1961. His desire to learn more about the interactions between soil genesis, geomorphology, and glacial stratigraphy led him to begin Ph.D. studies at Iowa State University under the guidance of Dr. Robert V. Ruhe, who directed the landmark USDA Soil Geomorphology Project on the Iowan Erosion Surface of eastern Iowa. After completing his dissertation in 1965, Hall joined the faculty at Ohio State University in Columbus where he taught and conducted research on topics related to soil genesis and classification for the next 30 years. Hundreds of students took his pedology courses and many ultimately established successful careers in soil mapping, conservation, and natural resource management. He will be remembered by his students and advisees as an excellent teacher, a wise and understanding mentor, and an inspiring role model. Hall played a major leadership role in the Ohio Cooperative Soil Survey Program as the university's representative on the Ohio Soil Inventory Board for almost 20 years. He was a founding member of the Association of Ohio Pedologists and served the organization as both its editor and president. Hall was supported in all that he did by Carol, his wife of 61 years (also recently deceased). Together, they raised two outstanding children, Laura and Roger.

Dr. Berlie Schmidt linked through the Columbus Dispatch



Schmidt, Berlie
1932 - 2020
Berlie Louis Schmidt, of Dublin, Ohio, passed away on August 3, 2020. Berlie was the former Chairman of the Department of Agronomy at the Ohio State University in Columbus and "Go Bucks!" was his frequent exclamation. He joined the OSU faculty in 1962 at the Ohio Agricultural Research and Development Center in Wooster where he developed and led world renowned research programs in soil erosion and fertility. He was a Fellow of the Soil and Water Conservation Society of America and numerous other professional organizations. Berlie was born in Council Bluffs, Iowa on October 2, 1932 to the late Hans and Louisa (Guttau) Schmidt, of Treynor, Iowa. He graduated from Treynor High School, and just last week he sang the school fight song! Then he continued his education at Iowa State University where he earned his B.S., M.S., and Ph.D. degrees in Agronomy and Soil Management, and also researched the unique Loess soil near his home. At ISU he was a proud member of Theta Delta Chi fraternity. In the midst of his educational pursuits, Berlie married his high school sweetheart, Joanne Bruning in 1954. That same year he was drafted into the U.S. Army, serving as a Chemical Corps instructor in Hawaii where he and Joanne enjoyed living for two years. Berlie and Joanne were married for 28 years and prior to her passing had five children together, who all miss them dearly. After retiring from OSU, Berlie moved to Washington, D.C. as a National Program Director for the U.S. Department of Agricultural for global research, allowing him to travel the world. During this time, he was married to Bonni Mehlhop of Worthington, Ohio. Following his second retirement from USDA he returned to Ohio, and as a Deacon at Dublin Presbyterian Church, Berlie met Rhoda McIntyre. They were married and spent several happy years together at Friendship Village. Berlie leaves behind a legacy of love, respect, and friendship to all

who knew him. His greatest joy was spending time with his family. In addition to his parents and Joanne, Berlie is preceded in death by his brother Julian, sister Sonja, Bonni, and Rhoda. He is survived by his sister, Cynthia; children, Brian (Marina) Schmidt, Luanne (Brian) Code, Kevin (Kim) Schmidt, Kim (Kevin) Nelson, and Christy Mash; grandchildren, Amy (Sean) Crowe, Erin (Sean) Doherty, Brittany (Paul) Demmy, Hailey (Logan) Fehrenbach, Molly Nelson, Annabelle, Hans and Scarlett Schmidt, Zachary and Ethan Mash; great grandchildren, Edie, Louisa, and Samuel. Visitation will be held Monday, August 10, from 4-7pm at SCHOEDINGER FUNERAL HOME, WORTHINGTON CHAPEL, 6699 North High Street, Worthington, Ohio. All guests are asked to wear masks per local health restrictions. A private service for the family will be held. Please visit www.schoedinger.com to share memories or extend condolences.

Published in The Columbus Dispatch from Aug. 6 to Aug. 8, 2020.

A memory of Berlie Schmidt from Linda Aller (JWR)

My favorite Berlie Schmidt story actually belongs to my dear friend, Linda Aller. In the late 1970s and early 1980s, the time before this time that we were upgrading the private septic system rules, Linda Aller and Glen Hackett were running the program at the Ohio Dept. of Health. As usual, all the soil scientists were helping the effort as was Mel Palmer, Dept. of Ag. at OSU. Neither Linda nor Glen had degrees in Soil Science. Linda was trained as a geologist at Miami and OSU so she came the closest to having soils training. At some point through the effort, it was decided that Linda needed the introductory soils course which I think was a 200 level class. The Dept. of Health were supportive of her taking the class but it met at a time on Main Campus that would not fit with her work schedule. What to do? That upcoming quarter Berlie was flying up to Lima Campus on Saturdays to teach the course and run the lab. Linda could take a Saturday class but it meant driving to Lima and back from central Ohio. Berlie decided that was ridiculous, she could fly up to Lima with him. So each Saturday morning that quarter, Linda would meet him at Don Scott Airport, board the OSU plane to Lima which was ferrying up faculty from Columbus, sit and visit with Berlie as they discussed how to best develop the new rules, take the class and fly back to Columbus. Berlie helped in so many ways in the development of those rules but this story has always reminded me of his great heart and his willingness to simply make things happen when they needed to happen. I expect that could not have happened today but we were living in a simpler time.

Letters to the Editor

With these issues of the Newsletter, we are reaching out to a much larger audience. We critically need to grow the number of Certified Professional Soil Scientists (CPSS) in Ohio if we are going to meet the needs of the state in the future. Since the typical pathway to reach Certification takes nine years (4 year undergrad in Soil Science or related field including five core courses, one year internship with a CPSS, four more years of experience with oversight from a CPSS and an examination), we are not quickly going to grow our ranks before those of us who are preforming most of the work in the state decide we are too old or simply die off. Therefore, the Executive Committee has decided that it is important to reach out to you. our natural partners, staff at county soil and water conservation districts and public health departments to encourage you to cross train to take up the challenge as the older generation decides it's time to lay down our soil probes. We already have members of AOP from soil and water conservation districts and public health departments. Additional staff from those organizations comes to our annual meetings and/or field days for training. Links to this Newsletter is being sent to each soil and water conservation district and public health department in the state, in hopes that the dialogue will be expanded.

This section of the Newsletter belongs to you, our members and future members, in the hopes that if we communicate with each other, we can find pathways to move forward to train the next generation. Please send your letters and/or responses to the Editor at AOPEditor2020@gmail.com and I will include them in upcoming issues of the Newsletter which is developed and disseminated quarterly.

****

larrytornes@aol.com

Julie,

Since AOP was not able to conduct a soils training workshop this summer/fall, I would suggest you ask the membership to suggest soils training activities like workshops, reading materials, lectors, etc. that Certified Soil Scientist can attend or self study to earn CEU credits for recertification.

I am sure you saw in the Dispatch today where Berlie Schmidt passed away.

Thanks, Larry

Larry,

I'm going to make an attempt to capture webinars and training programs of interest as I find them. I will list them in a section devoted to that topic in the newsletter and/or if the turnaround time is short, I will post to the membership separately. Hopefully others will share their leads as well.

Julie

From Mark Wilson, field equipment for sale

FOR SALE – Soil Sampling and Testing Equipment.

Purchased new from manufacturer in 2017 – used only one field season

AMS Soil Auger Kit. Includes 3 ¼ in. HEX Quick Pin(QP) Regular Auger; 1 ½ in. x 18 in. Triple Lead Flighted Auger with New Male HEX QP Fitting; 4 ft. HEX QP Extension; and Hex QP Ratchet Cross Handle.

AgriDrain 4 ft. Heavy Duty Probes. Ideal for probing drain tile and other subsurface items.

Dickey-John Soil Compaction Meters (Penetrometers). Includes ½ and ¾ in. cone tips; 30 in. stainless steel probe with 3 in. incremental depth markings; rugged molded housing and handle; and color coded stainless steel dial with three compaction ranges (0-200 psi, 200-300 psi, and 300+ psi).

FieldScout SC 900 Soil Compaction Meter (Penetrometer) Kit from Spectrum Technologies. Includes ½ and ¾ in. cone tips; takes compaction readings to a depth of 18 in.; ultrasonic depth sensor captures readings in 1 in. increments; penetration resistance measured by internal load cell; connects to any GPS receiver with serial output; equipped with internal data logger and RS-232 port; records 772 measurements; includes carrying case.

Contact AOP Member Mark Wilson if interested. mwilson@landstewards.com (c) 614-506-7846

From Steve Ross

Hi Julie,

Great work on the newsletter! On the topic of people looking for soils experience/mentors. Is there a network of high school soil judging coaches who could invite soil scientist and would-be soil scientists to help judge pits and help with contests? I came over here from Indiana and that's what we did over there. That would be all about communication. I am also curious is "mentoring" would qualify as

ARCPACS CEU credits? Given that a bunch of events for CEU credits have been cancelled it seems like someone willing to mentor a would-be soil scientist would earn CEU's in doing so?

Steve Ross
Steve Ross
Soil & Site LLC
419-718-4301
cell: 575-993-4260

Steve,
About the CEUs, I think if AOP says "yes", then it should count. There is a list of high school teachers but I don't have it. My guess is that either George Derringer does or maybe Linda Pettit with Franklin SWCD. This would be a great question to post in the "Letters to the Editor" if you don't mind.
Julie

From Dan King

Hi Julie,
I have just read the Spring Newsletter and I appreciate everything you do to put this together for all of us. I have some input regarding cross training to grow the ranks of CPSS individuals. It appears that there are more older and experienced individuals in Ohio than younger individuals that have obtained their CPSS qualifications. I am a younger CPSS person who works in the private consulting sector and does not have the liberty or time to shadow a more experienced individual. My CPSS qualification is unfortunately secondary to my job as an environmental consultant.

Of course I have a background in soil sciences; I fully understand what to look for in the soil profile when assessing suitability for a leach field (i.e. redoximorphic features, fragipan, etc.). However, I am not afraid to admit that I lack certain subtle areas of expertise in the field regarding soil evaluations. Learning these nuances usually come from working with more experienced individuals. However, CPSS individuals seem to be a rarity in Ohio, which makes that difficult. Let's face it, there is not much direction from government entities or standard operating procedures to read for new CPSS individuals to conduct and assess soil evaluations.

I think it would be advantageous to hold training for everyone in septic soil evaluations, percolation and infiltration testing. I get calls at least 5 times a week from people looking for CPSS individuals to conduct septic soil evaluations on their property. In my opinion, we as a group (while we are small) should be consistent in our methods or standard operating procedures moving forward. That way it will be easier to train younger people that want to obtain their CPSS.

Thank you for your time and take care.
Best Regards,
Daniel King, CPSS, PWS

Dan,
Thanks for your kind words and your thoughts. May I post this note in the Summer issue of the AOP Newsletter? At least the dialogue is happening.
Cheers, Julie

Yes, please do put it in the next issue
Dan

Please send letters and comment to:
Julie Weatherington-Rice, PhD, CPG, CPSS
AOP Newsletter Editor
AOPEditor2020@gmail.com

A Two Part Newsletter

This ends part one of the Summer Newsletter. Our members were so generous with their forwarding of technical references and experiences that had I incorporated them all into one issue, it would have been far too large to read in a single sitting. Therefore, I am dividing the issue between AOP “News” and our ongoing attempt to offer continuing educational opportunities for our members in light of the new normal COVID-19 lifestyle we are all living. So when you tackle the second part, grab a cup of coffee or tea, time yourself and count those Continuing Education Credits.

Ohio's Professional Soil Scientists

2020 Summer Newsletter
Volume 47, Issue 2 Part 2

Journal Articles etc. of note

A Contribution from Duane Wood

Duane found this article on www.godnewsnetwork.org and sent it in. I was able to trace the article back to its original web page at Cornell University, https://news.cornell.edu/stories/2020/02/newly-found-bacteria-fights-climate-change-soil-pollutants. "Newly found bacteria fights climate change, soil pollutants"

Allison Usavage/Cornell University
David Karasz '20 prepares cultures of Paraburkholderia for scanning electron microscopy to identify cellular structures involved in chain formation.

Newly found bacteria fights climate change, soil pollutants

By Krisy Gashler |
February 20, 2020

Cornell researchers have found a new species of soil bacteria – which they named in memory of the Cornell professor who first discovered it – that is particularly adept at breaking down organic matter, including the cancer-causing chemicals that are released when coal, gas, oil and refuse are burned.

"Microbes have been here since life began, almost 4 billion years. They created the system that we live in, and they sustain it," said Dan Buckley, professor of microbial ecology in the Section of Soil and Crop Sciences in the School of Integrative Plant Science. "We may not see them, but they're running the show."

Buckley and five other Cornell researchers, along with colleagues from Lycoming College, described the new bacterium in a paper, "Paraburkholderia madseniana sp. nov., a phenolic acid-degrading bacterium isolated from acidic forest soil," published Feb. 6 in the International Journal of Systematic and Evolutionary Microbiology.

The new bacteria, madseniana, is named to honor the late Gene Madsen, the microbiology professor who started the research. He died in 2017, before he could confirm the discovery.

All plants and animals, including humans, host a collection of friendly bacteria that help us digest food and fight infection. The bacteria living in soils not only help plants grow, cope with stress and fight off pests, they're also essential to understanding climate change.

The newly discovered bacteria belong to the genus Paraburkholderia, which are known for their ability to degrade aromatic compounds and, in some species, the capacity to form root nodules that fix atmospheric nitrogen. The species name, madseniana, reflects the legacy of Madsen's work in the field of environmental microbiology.

Madsen's research focused on biodegradation – the role microbes play in breaking down pollutants in contaminated soils – with a special focus on organic pollutants called polycyclic aromatic hydrocarbons (PAHs). His work was groundbreaking in providing natural tools to address hazardous waste in areas where contaminated soils can't easily be dug up and removed.

"Gene was a humble man and a great scientist. I am so happy to see his legacy live on in this way," said Esther Angert, professor and chair of the Department of Microbiology. "It's so apt that a bacterium with these traits would be named after this remarkable environmental microbiologist. I think Gene must be smiling."

The work started in a Cornell experimental forest on Turkey Hill, a natural area stewarded by Cornell Botanic Gardens. Madsen isolated the new bacteria from the forest soil; Buckley's team brought the project to completion.

The first step was sequencing the bacterium's ribosomal RNA genes, which provided genetic evidence that madseniana was a unique species. In studying the new bacteria, the researchers noticed that madseniana is especially adept at breaking down aromatic hydrocarbons, which make up lignin, a major component of plant biomass and soil organic matter. Aromatic hydrocarbons are also found in toxic PAH pollution.

This means that the newly identified bacteria could be a candidate for biodegradation research and an important player in the soil carbon cycle.

Buckley's lab focused on the bacterium's role in the carbon cycle – the natural cycling of carbon through the Earth and the atmosphere, which scientists say has been thrown out of whack by excess human carbon emissions.

"We know remarkably little about how soil bacteria operate," Buckley said. "Soils, every year, process about seven times more carbon than all of the human emissions from cars, power plants and heating units, all over the world, just in their natural work of decomposing plant material. Because it's such a large amount of carbon going through the soil, small changes in how we manage soil could make a big impact on climate change."

In the case of madseniana, Buckley's lab wants to learn more about the symbiotic relationship between the bacteria and forest trees. Initial research suggests that trees feed carbon to the bacteria, and in turn the bacteria degrade soil organic matter, thereby releasing nutrients such as nitrogen and phosphorus for the trees.

Understanding how bacteria break down carbon in soil could hold the key to the sustainability of soil and the ability to predict the future of global climate.

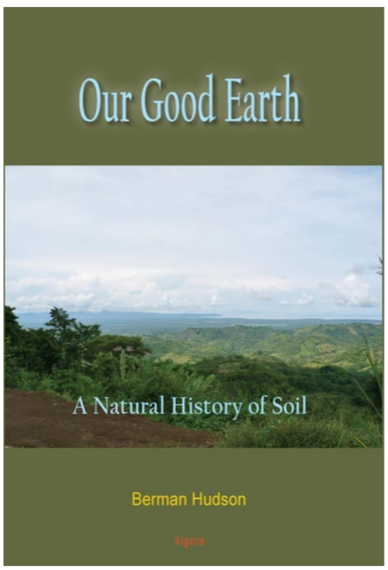
Roland Wilhelm, a postdoctoral associate in Buckley's lab, was the paper's first author. Other co-authors included Sean Murphy, a Ph.D. student in the lab; undergraduate research assistants Nicole Feriancek '22 and David Karasz '20; Christopher DeRito, a research support specialist; and Jeffrey Newman, a biology professor at Lycoming College.

This research was supported the USDA National Institute of Food and Agriculture through a McIntire Stennis grant.

Krisy Gashler is a freelance writer for the College of Agriculture and Life Sciences.

From Jerry Bigham

When I got Jerry's link, I tried to find the book at the www.algora.com link and could not but I found it on Amazon at https://www.amazon.com/Our-Good-Earth-Natural-History/dp/1628943955/ref=cm_cr_arp_d_pl_foot_top?ie=UTF8. It is surprisingly affordable at $22.95 in paperback and it has four 5 Star reviews. It looks excellent; they are claiming you can get through it with high school chemistry so this might be a good introduction for people considering the field of soil science.



Our Good Earth: A Natural History of Soil, by Berman Hudson, Ph.D.

A new book in soil science from Algora Publishing, 1732 First Avenue, New York.
Available from the publisher at www.algora.com and from Amazon.

About the Book: *Our Good Earth* describes the unique properties of soil – properties that distinguish it from everything else in the universe. The book also explains how and why soil varies across the world's land surfaces and how it has changed over time, co-evolving with the lithosphere, atmosphere, and biosphere for more than 3.5 billion years.

Soil Taxonomy recognizes 12 major kinds of soil in the world, the soil Orders. Prior to 3.0 billion years ago, only three of the Orders existed. *Our Good Earth* describes how, over the next 3.0 billion years, nine additional soil Orders appeared at intervals, usually in groups, often separated by millions of years. The book describes how events such as the formation of continents, oxygenation of the atmosphere, the formation of deserts, glaciation, and the colonization of land by vascular plants led to the arrival of new kinds of soil at different times in Earth's history.

This book is intended primarily for the instruction of students in university soil science curricula – in courses such as *Introductory Soil Science* and *Soil Genesis and Classification*. Students and practitioners of other "outdoor sciences" such as plant ecology, geology, forestry, agronomy, and wildlife biology also will benefit from reading this book.

About the Author: The author has a PhD degree in soil science and more than three decades of professional experience – as a soil scientist with the USDA and as a soil consultant to the forest products industry. Positions held include State Soil Scientist of Maryland, National Leader for Soil Interpretations, National Soil Survey Center, Lincoln, NE, and Director, National Soil Survey Program, Washington, DC. The author has conducted soil studies in Africa, Indonesia, Bulgaria, Denmark, and the United States

Virgin Islands. In addition, he has published a number of well-received scientific papers. The three most influential have altogether been cited in more than 1,000 scientific articles.

Frank Gibbs contributes this paper reviewed by a wetland friend

Evaluating the use of iron-coated tubes for wetland delineation in South Africa: A pilot study in the Kruger National Park.

I wanted to pass on this paper that my Friend and Colleague, Ralph Tiner, Reviewed… For those of you that don't know Ralph, he was in charge of Developing the USF&WS National Wetland Inventory Maps…
I met him thru Mark DeBrock, who brought me in to teach Hydric Soils for Bill Mitch's OSU Wetland Delineation Short Course after Doc Redmond stopped teaching it…
I still teach the Hydric Soils section of a Wetland Delineation Course for Ralph in Chicago every other year or so, in DuPage County (This year's class was cancelled due to the pandemic)…
Basically, Iris Tubes don't show reduction in High pH, Sodic or Salinity Soils where the microbes are inhibited…
I saw this in Tibet in 2012 at saline seeps along a salt lake (See photo attached)

Redox Features Inhibited along exterior of mounds where salt concentrations increase

Also Here is the Paper attached…
Frank Gibbs
WSCS, LLC

Water SA 46(3) 393–403 / Jul 2020
https://doi.org/10.17159/wsa/2020.v46.i3.8649

Research paper

Evaluating the use of iron-coated tubes for wetland delineation in South Africa: A pilot study in the Kruger National Park

CW van Huyssteen[1] and TL Johnson[1]

[1]*Department of Soil, Crop and Climate Sciences, Faculty of Natural and Agricultural Sciences, University of the Free State, PO Box 339, Bloemfontein 9300, South Africa*

The identification of hydric soils is important for wetland delineation and protection. South Africa currently uses the Department of Water Affairs and Forestry (DWAF) wetland delineation guidelines which can be subjective in certain contexts. A robust technical standard that can be legally conclusive is therefore required and should be developed for South African conditions. The National Technical Committee of Hydric Soils (NTCHS, 2007) in the United States of America has accepted the Indicator of Reduction in Soils (IRIS) tube methodology as a technical standard, but this had not yet been tested in South Africa. It is proposed that the NTCHS (2007) be adapted for use in South Africa. These Fe-coated tubes are installed into the soil and if reducing conditions are present, the Fe coating is removed. The aim of this study was to evaluate the use of IRIS tubes as a technical standard for wetland delineation in South Africa. The study took place in three different wetland systems (Malahlapanga, Nshawu and the Tshuthsi spruit) in the Kruger National Park. Piezometers were installed in triplicate in each zone, and the water table, pH and Eh were recorded monthly. Soils were classified, soil wetness indicators identified, and vegetation described. The study took place from September 2012 to August 2013. The areal percentage of paint removed from the top 300 mm of the IRIS tubes was quantified by scanning the tubes and then compared to the DWAF wetland indicators. It was found that the DWAF indicators and the IRIS tube method were mostly in agreement; however, the conditions at the Tshutshi spruit were not favourable for Fe reduction, and hence the use of IRIS tubes, due to the high pH values recorded. The IRIS tubes were therefore a useful tool for wetland delineation in the majority of conditions, but are not recommended in high pH, sodic environments. Further research is recommended over a wider geographical area as well as testing the MIRIS methodology (Manganese Indicators of Reduction in Soils) in wetlands that would inhibit Fe reduction.

CORRESPONDENCE
CW van Huyssteen

EMAIL
vanhuyssteencw@ufs.ac.za

DATES
Received: 24 September 2019
Accepted: 19 May 2020

KEYWORDS
guidelines
hydric soils
IRIS
reducing conditions
technical standard
wetland indicators

INTRODUCTION

Wetlands are integral in regulating water quantity as well as quality and are hence protected from exploitation under the National Water Act (RSA, 1998). Mining, agriculture, forestry, urban development, and climate change all pose major threats to South African wetlands. The identification, delineation and protection of wetlands is therefore of utmost importance. Wetlands are currently delineated using four wetland indicators: terrain unit, soil form, soil wetness, and vegetation (DWAF, 2005). When determining whether an area is a wetland or not, at least the soil wetness indicator or the vegetation indicator must be present, but the level of confidence increases with the addition of the terrain unit and soil form indicators.

In certain cases, vegetation may not be present or convincing, as it can very easily be destroyed or altered through human activities such as burning and land clearing. In this case a wetland practitioner has to rely on the soil indicators. In most cases, it is quite simple to apply the guidelines, although there may be some exceptions. For example, there have been cases where, despite there being hydrophilic vegetation and a sufficient period of water saturation, evidence of reduction in the soil is absent and the soil morphological features expected are not expressed (such as in recent alluvial deposits and sandy coastal aquifer systems; Pretorius et al., 2016; Mabuza and Van Huyssteen, 2019). Possible reasons for a lack of redoximorphic features can be attributed to low organic carbon levels, high pH, large amounts of Mn-oxides (DWAF, 2005) and high dissolved oxygen levels in the water (Vepraskas, 2001). An anthropogenic factor which contributes to difficulties in delineation, such as ploughing, may also disrupt the soil morphology making it difficult to identify mottling. If the hydrology of an area is altered (through the installation of dams and drains, or the planting of alien species with high water-use demands), it may take several years for the soil morphology to reflect this change. Relic morphological features may further cause confusion by making the soil appear wetter than it really is. Other challenges encountered are soils which are either very red (e.g. dolomite derived) or very grey (e.g. quartzite derived) as seen in the Mpumalanga Province (DWAF, 2005). In red soils, mottles and gleyed morphology may be obscured by the red colour, while in very grey soils there may be insufficient Fe to form mottles. The Department of Water Affairs and Forestry (DWAF, 2005) wetland delineation guidelines can therefore be considered to be qualitative in nature, as opposed to the more quantitative technical standards of the National Technical Committee of Hydric Soils (NTCHS, 2007).

Wetland identification and delineation can therefore pose challenges in unique cases where these guidelines need to be more objective. Currently, wetland practitioners rely heavily on their experience in these cases. However, this means that there is room for individual bias, and experience is required.

A more objective method or technical standard, is therefore required – one that can be defended in a court of law. One option may be to quantify the degree and duration of water saturation, Eh and pH. Dyes (α, α dipyridyl), pH/Eh stability diagrams, soil morphology, chemical methods, and Fe nails (Owens et al., 2008) have also all been used to detect reducing conditions; however, each has its individual limitations (USDA-NRCS, 2002).

Reduction is the chemical process that drives the formation of hydromorphic soils that occur in wetlands, under certain conditions. Therefore, wetland identification and delineation hinges on, among other factors, the measurement and characterisation of these reducing conditions. Reducing conditions are, however, the result of four coinciding factors, namely, the presence of microbes, oxidisable organic matter, the availability of electron acceptors and the degree of water saturation (Meek et al., 1968; Bouma 1983). Vepraskas and Faulkner (2001) and Vepraskas (2001) outline the four conditions required for a soil to become anaerobic and support reducing reactions. Firstly, the soil should be inundated or saturated in order to exclude atmospheric oxygen. Secondly, there should be a sufficient source of organic material to be oxidised. Thirdly, a respiring microbial population is required in order to oxidise the organic material. Lastly, the water should be stagnant or moving slowly as moving water contains dissolved oxygen which is difficult to deplete. This retards the onset of reduction and in particular the reduction of Fe. Smith and Van Huyssteen (2011; 2013) have determined, through laboratory trials with soil taken from the Weatherley catchment, in the Eastern Cape, South Africa, that there is an increase in variability of redox potential (pe), pH, Fe^{2+} and Mn^{2+} at between 70% and 80% water saturation. Onset of Fe^{3+} reduction occurred between 72% and 78% water saturation, which confirmed the hypothesis that the onset of reduction can occur from 70% saturation onwards.

However, practical technical standards for application in South Africa have remained elusive. The Indicator of Reduction in Soils (IRIS) method comprises of PVC tubes coated with synthesised Fe-oxide paint, placed into the soil, from which the Fe paint will be removed in reducing conditions (Jenkinson, 2002; Jenkinson and Franzmeier, 2006).

An advantage of the IRIS method is that it is time integrated, because the tubes remain in the soil for approximately 28 days, do not require expertise to install, and can be interpreted quantitatively. This method has, therefore, been accepted in the United States of America as a technical standard by the NTCHS (2007), but had not yet been applied or tested in South Africa. It does, however, provide a promising tool to address atypical cases that may arise and where current guidelines fail. A case in point is the Pan African Parliament wetland assessment and the resulting court ruling that found the wetland practitioner guilty of fraud (North Gauteng Regional Court, 2011).

The Kruger National Park landscape is largely unmodified and in a near-natural state in terms of development, hydrology and vegetation. It also has large variation in terms of lithology, climate, and hydrology, resulting in a number of different wetland types. This presented an opportunity to test the IRIS tube methodology over a wide ecological range and to relate the data to the traditional wetland delineation methods. The purpose of the study was therefore to evaluate the use of IRIS tubes as a technical standard for wetland delineation in the Kruger National Park.

MATERIAL AND METHODS

Three study sites were selected in the Kruger National Park (KNP) based on their differing lithology, available literature and ease of access. These were the Malahlapanga Spring mire complex, the Nshawuvalley-bottom wetland, and the Tshutshi Spruit (in order from north to south in the KNP). These three sites are all situated in the northern region of the KNP (Fig. 1). Measurements were done from 5 September 2012 to 5 August 2013. During this period, an extensive flood occurred in the Shingwedzi region, in January 2013. This resulted in several dams breaching and many access roads becoming impassable, resulting in missing monthly data for January and February of 2013 for the Malahlapanga site.

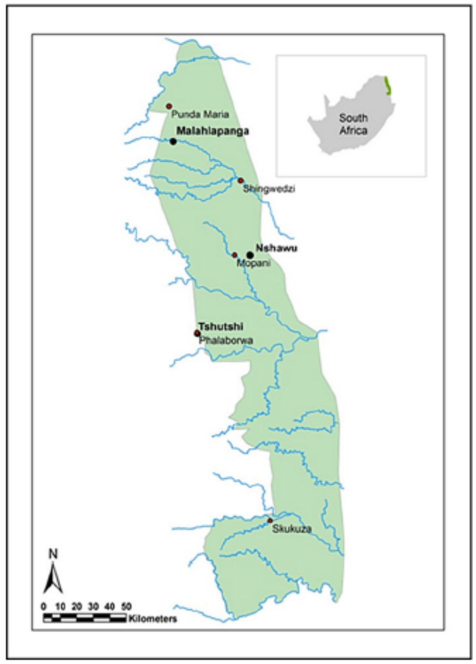


Figure 1. The selected study sites in relation to major rivers and rest camps in the Kruger National Park

Study sites

At each study site, the zones were identified to reflect the permanent, seasonal, temporary, and upland zones, using DWAF (2005) guidelines. Three replicates were then laid out in each wetland zone. This setup thus gave twelve measuring sites per wetland.

Malahlapanga

The Malahlapanga system is in the far northern region of the Kruger National Park, near the Park's western boundary, in the Shangoni section. It is situated close to a tributary stream on the southern bank of the Mphongolo river, at 22°53.243'S; 31°02.426'E (Fig. 2), and is one of several thermal springs in the Kruger National Park and is also a peat-forming system. Less than 1% of the wetlands in the Kruger National Park have accumulation of peat to greater than 300 mm. This is because the process of peat formation and accumulation requires a permanent source of water, which is unusual with the erratic rainfall and high evaporation rates characteristic of the region. Water is supplied via a permanent thermal spring in the case of Malahlapanga (Grootjans et al., 2010).

Malahlapanga is used as a water source by game, and is especially heavily utilised in the dry winter months. It is the only permanent water source for quite a distance and is thus frequented by large game, such as elephant, a factor which is thought to be contributing significantly to the system's degradation (Grootjans et al., 2010).

Water SA 46(3) 393–403 / Jul 2020
https://doi.org.10.17159/wsa/2020.v46.i3.8649

Figure 2. Google Earth image of the Malahlapanga wetland (22°53.243'S; 31°02.426'E) and the monitoring points (Google Earth, 2013). M = Malahlapanga; 1, 2, 3 = repetition number; P = permanent zone, S = seasonal zone, T = temporary zone, U = upland zone

Malahlapanga has a very gentle slope, ranging from 1.3 to 2.7%, and the elevation of the site therefore does not range over more than about 4 m, averaging 369 m amsl. The system (Fig. 2) occupies a low-lying position in the landscape and has an area of about 6 ha (Grootjans et al., 2010). Malahlapanga has 5 peat domes, in various stages of development, from which the thermal waters discharge and then drain down a system of dynamic channels towards the Mphongolo River. The northern-most mire is presumed to be the oldest (it is the largest) and has been severely trampled by elephant. The southern-most feature is a thermal pool which is thought to be the start of a new mire, where vegetation has not yet established and hence is not yet forming peat. It is believed that when the weight of peat exceeds the pressure head of the thermal water, the water will seek a new outlet and begin the formation of a new mire. An alternative theory is that there has been minor geological movement which has caused a shift in the water source (Grootjans et al., 2010).

The area receives between 450 and 500 mm of rainfall per annum (Schulze et al., 2008; Zambatis, 2003). However, Gertenbach (1980 in Grootjans et al., 2010) states the annual precipitation is between 550 and 600 mm per annum. The mean annual temperature for Malahlapanga is 22°C, while the mean annual calculated A-pan evaporation is between 2000 and 2200 mm (Schulze et al., 2008).

Much of the western area of the Kruger National Park consists of granite, gneiss, migmatite, amphibolite, schist, and undifferentiated metamorphic rock (Bristow and Venter, 1986). Malahlapanga lies within this band that runs longitudinally in a north-south direction. The site is underlain by Goudplaats gneiss (Brandl, 1981; Schutte, 1986), which was formed in the Swazianerathem (>3 090 million years BP) and is recognisable by alternating bands of light and dark material (Brandl, 1987). The Goudplaats gneiss consists mainly of tonalite, a plutonic rock with the composition of diorite but with more quartz, with a small portion consisting of granodiorite, a coarse-grained plutonic rock that consists of quartz, oligoclase or andesine, and orthoclase with biotite, hornblende or pyroxene as mafic constituents (Brandl, 1987; Soil Classification Working Group, 1991). Much of the parent material at Malahlapanga, however, appears to be alluvial in nature due to the low-lying cumulative position of the site. There is a zone of faulting 10 km to the north of Malahlapanga, namely the Dzundwini and Nyunani Faults which run in an east–west direction. However, there is an offshoot of the Nyunani Fault that runs from north to south, stopping 2 km short of Malahlapanga (Brandl, 1981). It is this fault that is thought to be the source of the spring complex.

Malahlapanga is in the Tsende Mopaneveld Region which falls under the Mopane Bioregion. This is under the umbrella of the Savanna Biome (Mucina et al., 2005). Locally, there is a sharp boundary between the surrounding veld, dominated by *Colophospermum mopane*, and the system, which is largely barren with a few patches of heavily grazed grass and small forbs. Protruding from this barren area are the peat domes, which are well vegetated due to the constant water supply. Grootjans et al. (2010) identified numerous species occurring at the bases of the mires, many of which were common hydrophytes such as *Phragmites australis* and *Miscanthus junceus*. Vegetation at Malahlapanga had been significantly disturbed by animal trampling, which allowed for the establishment of numerous small opportunistic species. True wetland vegetation indicator species were hence sparse. During this study, the obligate wetland species *Phragmites mauritianus* was noted in both the permanent and seasonal zones. A sharp boundary between the

Water SA 46(3) 393–403 / Jul 2020
https://doi.org/10.17159/wsa/2020.v46.i3.8649

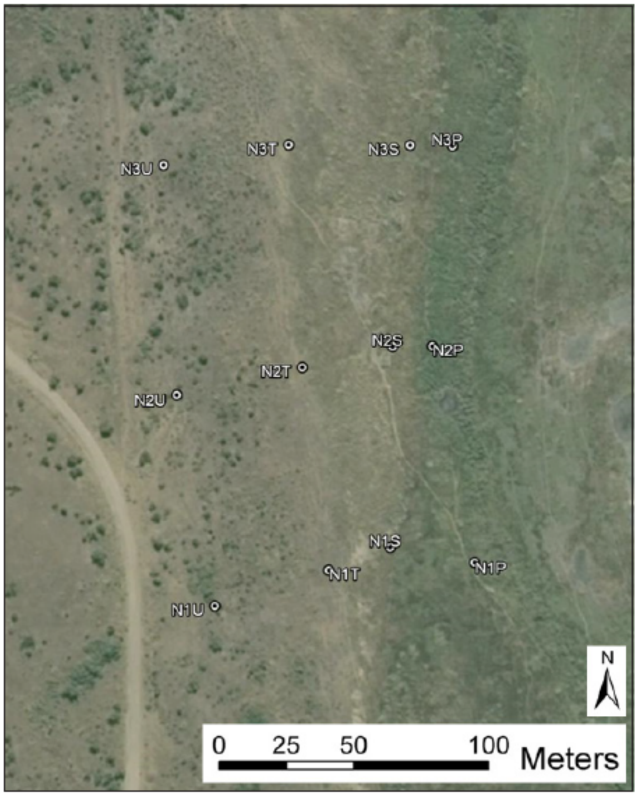


Figure 3. Google Earth image of the Nshawu wetland (23°31.326'S; 31°29.165'E) and the monitoring points (Google Earth, 2013). N = Nshawu; 1, 2, 3 = repetition number; P = permanent, S = seasonal, T = temporary, U = upland zones

barren (trampled) area and the *Colophospermum mopane* served as a boundary between the upland and the temporary wetland zone. Malahlapanga is in the fersiallitic map unit of the Venter (1990) soil map. These soils are described as being coarse fersiallitic sands and loams that are mainly red in colour. The region is also associated with lithosols, described as being fine fersiallitic sands, arenaceous sediments and loams which are also red in colour.

Nshawu

The Nshawu valley-bottom wetland (23°31.326'S; 31°29.165'E; Fig. 3) is one of the largest wetland systems in the Kruger National Park, occupying an area of 570 ha (Grundling, 2010). The wetland was characterised and assessed by Grundling in 2010 because there were concerns relating to a breached dam wall that was influencing the hydrology of the system as well as an old tourist road that was built across the wetland. Nshawu was an attractive site for this study due to its basic igneous rock geology, in contrast to the other two sites which are underlain by acidic parent materials. Nshawu also forms part of a Kruger National Park research supersite where a number of other research efforts are concentrated (Smit et al., 2013).

Nshawu is in the northern region of the Kruger National Park approximately 23 km from the Mopani rest camp and in the Mooiplaas section. The wetland runs in a longitudinal direction (roughly NNE to SSW) and drains into the Tsendze River. A section on the western bank was selected due to the clear permanent, seasonal, temporary and upland zones, as identified through the vegetation indicators. There is also a tourist road that runs along the western edge of the system which aided access. The slope is approximately 1% and the elevation 321 m amsl. Notable features of the site include the breached dam wall to the north and areas of channelisation within the wetland.

Nshawu has a mean annual temperature of 22°C (Schulze et al., 2008) and has a higher mean annual rainfall than Malahlapanga, ranging between 500 and 550 mm with an average of 525 mm (Schulze et al., 2008; Zambatis 2003). The mean annual calculated A-pan evaporation is 2000–2200 mm (Schulze et al., 2008).

Nshawu is underlain by olivine rich basalt, subordinate alkali-basalt and shoshonite which are all part of the Karoo System (Bristow and Venter, 1986). The wetland is located in a broad band of this olivine rich basalt, though it is flanked by olivine poor basalt, granophyres and rhyolite which form the Lebombo mountain range to the east. Grundling (2012) believes that there are alluvial fans that are originating in the Lebombo mountains and are influencing the channelisation of the Nshawu wetland.

There were two clear vegetation indicator species that were present in the permanent, seasonal and temporary zones, namely, *Sporobolus pyramidalis* and *Cyperus sexangularis*, which are both facultative positive wetland species. Each zone also had wetland species which were unique to the specific zone. In the permanent zone, *Leptochloa fusca* was exclusively found, while in the seasonal zone *Juncus effuses* was solely found, and in the temporary zone cf. *Sporobolus ioclados* and *Cyperusobtusi florus* were unique. The dryland zone consisted only of dryland species with the exception of *Abultilon rehmannii*, an opportunistic species. According to Mucina et al. (2005), the wetland lies within the Mopane basalt shrubland vegetation unit in the Mopane Bioregion under the

Water SA 46(3) 393–403 / Jul 2020
https://doi.org.10.17159/wsa/2020.v46.i3.8649

Figure 4. Google Earth image of the Tshutshi spruit wetland (23°57.186'S; 31°10.089'E) and the monitoring points (Google Earth, 2013). P = Tshutshi spruit; 1, 2, 3 = repetition number; P = permanent, S = seasonal, T = temporary, U = upland zones

Savanna Biome and in the Mopane Shrubveld Ecozone (Mucina and Rutherford, 2007). Venter (1990) characterised the soils of this region as being high in smectitic clays, describing them as calcareous, with a mainly brown or black pedocutanic structure.

Tshutshi spruit

The Tshutshi spruit study site (23°57.186'S; 31°10.089'E) was selected due to its proximity to the Phalaborwa Gate (Fig. 4). The Tshutshi spruit is of concern for the Kruger National Park management because it brings with it an abundance of litter and effluent (also sewage) from the upstream town of Phalaborwa and is also a continuous source of alien plant seeds. The Tshutshi spruit is a tributary of the Olifants River and rises outside the Kruger National Park's eastern boundary. It lies in the Phalaborwa section in the north region of the park, with an access road running past it. The average slope is roughly 1% and the average elevation is approximately 403 m amsl. The barren area was identified as a sodic site.

The mean annual temperature for the Tshutshi spruit area is 21°C, the mean annual rainfall is between 500 and 550 mm, with an average of 525 mm, while the mean annual calculated A-pan evaporation is 2000–2200 mm (Schulze et al., 2008; Zambatis, 2003).

The site is underlain by Archean granite of the Swaziland system, consisting of granite, gneiss, migmatite, amphibolite, schist, and undifferentiated metamorphic rocks (Bristow and Venter, 1986).

The site is within the Mopane Bushwillow Woodlands Ecozone (Mucina and Rutherford, 2007) and the vegetation unit is Phalaborwa and Timbavati Mopane Veld, also in the Mopane Bioregion of the Savanna Biome (Mucina et al., 2005). *Typha capensis* designates the permanently saturated zone while *Cyperus sexangularis* indicates the seasonally saturated zone. Venter (1990) describes the soils as fersiallitic with coarse fersiallitic sands and loams which are mainly yellow and grey in colour, with associated Lithosols.

All three of the selected wetlands, therefore, have fairly similar climate and vegetation, although they each have unique hydrological and lithological conditions.

IRIS tubes

The Fe-paint was synthesised using Rabenhorst's 'Quick (7-day) IRIS Tube Paint Recipe and Construction Procedure' (NTCHS, 2007). An X-ray diffraction (XRD), performed on the paint, indicated that the main Fe-oxide constituent was goethite. The paint was refrigerated at approximately 5°C to delay mineralogical alteration.

The IRIS tubes were constructed by first cleaning 20 mm diameter PVC conduit piping with acetone to remove dirt, glue, and ink; the piping was then sanded to provide a suitable surface for the paint to adhere to. The prepared tubes were placed on a lathe-like device constructed using a battery-powered hand-drill. A paintbrush was then used to apply two coats of goethite paint to the tube, allowing the paint to dry between coats. After the tubes were air-dried, they were placed in an oven overnight at 70°C to increase the paint's resistance to abrasion (Rabenhorst, 2006; 2008). Most of the tubes were cut to 0.5 m in length, but some were cut shorter, for use where it was impossible to auger to 0.5 m in some of the upland rocky soils and some of the temporary sites. The tubes did not protrude from the soil as in the traditional

Water SA 46(3) 393–403 / Jul 2020
https://doi.org/10.17159/wsa/2020.v46.i3.8649

method, due to the risk of animals damaging them, to avoid them being unsightly, to be more cost effective, and to hide them from inquisitive people. However, this made locating the tubes extremely difficult, especially in areas with thick vegetation cover and during the growing season. It is recommended to use small brightly coloured flags in such instances.

The IRIS tubes were installed using a 20 mm hand-driven wood drill auger. Once the hole was augured the IRIS tubes were pushed down until they were flush with the soil surface, sometimes having to be gently tapped with a hammer, while care was taken not to damage the tube. In the particularly rocky and calcareous soils it was impossible to auger a hole with such a small diameter and a 20 mm diameter metal stake was then hammered into the soil and removed with a vice grip. Five IRIS tubes were installed in a pentagon-shape around the central water monitoring well, all within 1 m^2, and in accordance with the protocol outlined by the NTCHS (2007). The IRIS tubes were replaced approximately every 28 days. The same holes were used each time. Care was exercised when removing the tubes to prevent soil from falling back into the holes, through moistening the soil by pouring a small amount of water around the tube before removing it. The tubes were extracted using a pair of narrow long-nose pliers. Care was taken to not damage the tubes or scratch the paint. The tubes at each site were labelled in a clockwise direction (starting from the same point each time) a, b, c, d, e. Once removed, the pipes were placed in plastic bags and taken to the laboratory to be washed, dried and scanned.

The cleaned IRIS tubes were lain out in their batches and a visual assessment was performed. Scratching was visually observed on some tubes as vertical striations, as opposed to the more rounded patches of reduction paint removal. Only tubes which had reduction paint removed were scanned. Using a permanent marker each tube was marked longitudinally with a small dot at 100 mm intervals. The tubes were then scanned on a custom modified flatbed scanner, at 70dpi, on the greyscale setting, with 2 scans per tube to cover the top 300 mm (Rabenhorst, 2008; 2012). The bottom 200 mm was not scanned as this depth is not used in the NTCHSs or Rabenhorst's criteria (NTCHS, 2007; 2015). The images were then cropped to one revolution of the tube using the 100 mm interval dots as guides. The images were then converted into black and white images using Adobe Photoshop CC 2014. Due to differing light conditions and the varying colours of the tubes, a threshold value had to be set for each individual tube, which was as close to the actual tube as possible. The areal percentage paint removal from the top 300 mm was then calculated. The IRIS tubes from Malahlapanga's permanent zone had to be treated differently as the organic matter from the peat stained the white PVC of the tubes black. The scans, therefore, did not differentiate the reduced and un-reduced areas. In these cases, paint removal was estimated using visual inspection. IRIS tubes with >30% paint removal were considered to be indicative of wetland conditions (NTCHS, 2007).

Water levels and measurements

Monitoring wells were constructed according to the procedure described by Sprecher (2008) and the WRP Technical Note (1993), by drilling holes, approximately 50 mm apart, along the length of a 1.5 m, 50 mm diameter PVC waste pipe. The wells were installed using a Thompson bucket auger. Wells were sunk 50–100 mm below the soil surface and were covered with grass and dung to limit animal (especially elephant) vandalism. The well holes were back-filled with river sand, with a layer of bentonite near the surface to prevent water flow along the sides of the pipe. The tops of the well pipes were sealed with waste pipe end caps. Wells were installed to a shallower depth where restricting layers impeded auguring.

The water table depth was measured from the soil surface, every 28 days, using a tape measure. A small torch was used in poor light conditions to see whether there was water present or not. When the wells were dry it was noted that the water table was not reached. Hydroperiod was calculated by multiplying the number of positive observations of water within 30 cm by the number of days between measurements.

A water sample was taken from the well using a bailer, after the water level measurement had been recorded, and poured into a small clean glass beaker. The pH was then measured in the field with a portable pH/Eh meter (HANNA HI8314 instrument and a HI3230 pH electrode). The pH meter was calibrated with 4.00 and 7.00 buffers at the beginning of each fieldwork trip.

Eh was measured in the same water sample, but with a Pt electrode (HI3230) and a HANNA HI8314 instrument. The sample was then discarded. The Eh electrode was also calibrated at the beginning of each field trip against a 230 mV standard solution. The rH (potential redox) was calculated using:

$$rH=((2\times Eh)/59)+(2\times pH)$$

All rH values <20 were considered to indicate reducing conditions (Clark 1923; Vepraskas and Faulkner, 2001).

Vegetation

The vegetation was assessed during the summer growing season. At each of the monitoring points, 25 random sampling points were selected within a 5 m radius from the monitoring well. At each of the 25 random sampling points, the nearest species were identified. Species which were not easily identifiable in the field were given a temporary name and detailed photographs were taken. All species were classified as either being present (occurring) or dominant (>50% occurrence) in terms of their abundance at the monitoring point. The species were also classified as being one of the following: dryland, opportunistic/dryland, obligate wetland, facultative wetland, and facultative negative or facultative positive plants. An obligate wetland plant is a plant that occurs for >99% of the time in a wetland or water-saturated area. A facultative wetland plant is a plant that occurs 50% of the time in wetland or water-saturated areas, a facultative positive wetland plant occurs 67–99% of the time in a wetland or water-saturated area, and a facultative negative plant occurs <25% of the time in a wetland or water-saturated area (Van Ginkel et al., 2011).

Wetland identification

The terrain unit was based on MacVicar et al. (1977), and if units of valley bottom (5) or lower foot slope (4L) were noted the indicator was assumed to be met. Soil forms were identified (Soil Classification Working Group, 1991) to determine whether the soil form was classified as a wetland soil according to the DWAF (2005) guidelines. The soil morphology was described in the top 0.3 m (one would usually look at the top 0.5 m but because the bottom 0.2 m of the IRIS tubes are disregarded the table only shows the top 0.3 m for comparative purposes). The wetland vegetation species were listed and if the plants were classified as obligate, facultative positive or facultative negative it was assumed that the vegetation indicator was met. The duration (months) of water saturation were calculated but assumptions were made due to the water table only being recorded monthly and thus the figures listed can only be used as estimated duration of water saturation.

RESULTS AND DISCUSSION

Brief descriptions of the soils for each wetland zone at each site are given in Table 1. Detailed profile descriptions and analyses are given by Johnson (2014). Tables 2 and 3 compare the DWAF (2005) wetland indicators with the IRIS tube data collected – Table 2 gives the raw data while Table 3 summarises whether each particular indicator was met or not.

Table 1. Soils of the different wetland zones per study site

Site	Wetland zone[1]	Soil classification	
		South African[2]	World Reference Base[3]
Malahlapanga	Permanent	1100 mm Champagne 1200	Gleysol (Hyperhumic, Salic)
Malahlapanga	Seasonal	450 mm Kroonstad 1000	Epigleyic Fluvisol (Siltic, Eutric)
Malahlapanga	Temporary	400 mm Katspruit 1000	Mollic, Gleyic Fluvisol (Endoruptic)
Malahlapanga	Upland	400 mm Glenrosa 1111	Hyposodic Cambisol (Endoskeletic)
Nshawu	Permanent	200 mm Katspruit 2000	Calcic Gleysol (Eutric, Vertic)
Nshawu	Seasonal	250 mm Katspruit 2000	Calcic, Mollic Gleysol (Eutric, Vertic)
Nshawu	Temporary	150 mm Steendal 2000	Bathypetric, Endogleyic, Hypercalcic Calcisol (Endoruptic)
Nshawu	Upland	240 mm Milkwood 2000	Eutric, Skeletic Leptosol (Arenic, Ochric)
Tshutshi	Permanent	800 mm Dundee 1220	Epigleyic Fluvisol (Eutric)
Tshutshi	Seasonal	20 mm Sterkspruit 2100	Epigleyic Fluvisol (Sodic)
Tshutshi	Temporary	160 mm Sterkspruit 2100	Calcic, Endogleyic Solonetz (Novic, Endofluvic)
Tshutshi	Upland	1300 mm Brandvlei 2000	Calcic, Endogleyic Fluvisol (Sodic, Eutric)

[1] *DWAF (2005),* [2] *Soil Classification Working Goup (1991),* [3] *IUSS Working Group WRB (2014)*

Table 2. Wetland indicator data and IRIS tube results for Malahlapanga, Nshawu and the Tshutshi spruit study sites

Study site	Rep	Wetland zone	Terrain unit	Soil form	Redoximorphic features within 0–30 cm	Wetland vegetation	Hydroperiod in top 30 cm (months)	Average rH during saturation in top 30 cm	IRIS paint removal (%)					
									a	b	c	d	e	Avg
Malahlapanga	1	Permanent	5	Champagne 1200	Few, coarse, faint, grey reduced Fe oxide mottles; organic O horizon	*Leptochloa fusca* (obligate), *Phragmites mauritianus* (obligate), *Pycreus* sp. (obligate)	13	16.7	48.8	46.4	47.4	45.5	48.4	47.2
	2					*Phragmites mauritianus* (obligate), *Pycreus* sp. (obligate)	7	7.8	51.4	69.3	53.4	39.1	48.3	52.3
	3					*Leptochloa fusca* (obligate), *Phragmites mauritianus* (obligate), *Fimbristylis dichotoma* (obligate), *Pycreus* sp. (obligate)	13	17.0	65.5	66.4	53.1	51.6	61.9	59.4
	1	Seasonal	5	Kroonstad 1000	Few, fine, distinct, grey reduced Fe oxide mottles; alluvial depositional stratification	*Phragmites mauritianus* (obligate)	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	2					None	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	3					None	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	1	Temporary	5	Katspruit 1000	Few, fine, faint red oxidised Fe oxide mottles; few, fine, faint grey mottles reduced Fe oxide mottles; alluvial depositional stratification	None	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	2					None	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	3					None	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	1	Upland	4L	Glenrosa 1112	No redox morphology	None	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	2					None	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	3					None	0	-	0.0	0.0	0.0	0.0	0.0	0.0
Nshawu	1	Permanent	5	Katspruit 2000	Common, fine, distinct white lime mottles; few, fine, faint red & yellow oxidised Fe oxide mottles; G horizon	*Leptochloa fusca* (obligate), *Phragmites mauritianus* (obligate), *Sporobolus pyramidalis* (facultative positive), *Cyperus laevigatus* (obligate), *Cyperus sexangularis* (facultative positive)	13	12.2	17.6	20.5	24.5	19.5	14.8	19.4
	2					cf. *Panicum infestum* (facultative negative), *Phragmites mauritianus* (obligate), *Sporobolus pyramidalis* (facultative positve), *Cyperus sexangularis* (facultative positive)	9	18.2	25.1	23.9	21.3	25.5	22.4	23.7
	3					cf. *Panicum infestum* (facultative negative), *Phragmites mauritianus* (obligate), *Cyperus sexangularis* (facultative positive)	1	15.9	19.1	20.8	16.1	63.5	22.9	28.5
	1	Seasonal	5	Katspruit 2000	Common, fine, prominent white lime mottles; G horizon	cf. *Panicum infestum* (facultative negative), *Phragmites mauritianus* (obligate), *Cyperus laevigatus* (obligate), *Cyperus sexangularis* (facultative positive), *Juncus effusus* (obligate)	3	11.5	15.9	32.9	19.5	19.0	37.2	24.9
	2					*Cyperus laevigatus* (obligate), *Cyperus sexangularis* (facultative positive), *Juncus effusus* (obligate)	1	17.9	23.9	5.3	17.6	0.0	21.9	13.7
	3					*Phragmites mauritianus* (obligate), *Sporobolus pyramidalis* (facultative positve), *Cyperus sexangularis* (facultative positive)	1	20.2	15.5	18.5	3.1	7.4	17.2	12.3
	1	Temporary	4L	Brandvlei 2000	No redox morphology	cf. *Sporobolus ioclados* (facultative negative), *Sporobolus pyramidalis* (facultative positive)	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	2					cf. *Sporobolus ioclados* (facultative negative), *Sporobolus pyramidalis* (facultative positive), *Cyperus sexangularis* (facultative positive)	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	3					cf. *Sporobolus ioclados* (facultative negative), *Sporobolus pyramidalis* (facultative positive), *Cyperus sexangularis* (facultative positive)	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	1	Upland	3U	Mispah 1200	No redox morphology	None	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	2					None	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	3					None	0	-	0.0	0.0	0.0	0.0	0.0	0.0
Tshutshi	1	Permanent	5	Dundee 1210	Many, medium, distinct, grey & yellow reduced Fe oxide mottles; common, fine, distinct, yellow, olive & brown oxidised Fe oxide mottles; alluvial depositional stratification	*Cyperus sexangilaris* (facultative positive)	1	20.7	11.7	9.2	12.0	19.3	12.3	12.9
	2					*Cyperus sexangilaris* (facultative positive)	1	20.3	0.0	0.0	0.0	0.0	0.0	0.0
	3					None	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	1	Seasonal	4L	Sterkspruit 2100	Common, coarse, faint, red, oxidised Fe oxide mottles; mottles; many, coarse, prominent black, Mn & magnetite mottles	*Sporobolus ioclados* (facultative negative)	1	21.5	9.5	12.0	10.3	0.0	0.0	6.4
	2					None	1	20.8	0.0	0.0	0.0	0.0	0.0	0.0
	3					None	1	12.2	5.2	0.0	0.0	0.0	0.0	1.0
	1	Temporary	4L/U	Sterkspruit 2100	Few, fine, faint, red, oxidised Fe oxide mottles	*Sporobolus ioclados* (facultative negative)	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	2					*Sporobolus ioclados* (facultative negative)	1	16.5	6.6	4.8	6.1	34.0	5.0	11.3
	3					None	1	12.3	0.0	0.0	0.0	0.0	0.0	0.0
	1	Upland	4U	Brandvlei 2000	Many, fine, prominent white lime mottles; many, medium, prominent, grey, yellow & olive lime mottles; few, fine, faint red oxidised Fe oxide mottles; Common, medium, faint, red oxidised Fe oxide mottles	*Sporobolus ioclados* (facultative negative)	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	2					*Sporobolus ioclados* (facultative negative)	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	3					*Sporobolus ioclados* (facultative negative)	0	-	0.0	0.0	0.0	0.0	0.0	0.0

Water SA 46(3) 393–403 / Jul 2020
https://doi.org.10.17159/wsa/2020.v46.i3.8649 399

Table 3. Summary of wetland indicator data and IRIS tube results for Malahlapanga, Nshawu and the Tshutshi spruit study sites

Study site	Rep	Wetland zone	Terrain unit	Soil form	Redoximorphic features in 30 cm	Wetland vegetation	Hydroperiod in top 30 cm	Average rH in top 30 cm	IRIS paint removal (%)					
									a	b	c	d	e	Avg
Malahlapanga	1	Permanent	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	2					Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	3					Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	1	Seasonal	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
	2					No	No	No	No	No	No	No	No	No
	3					No	No	No	No	No	No	No	No	No
	1	Temporary	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No
	2					No	No	No	No	No	No	No	No	No
	3					No	No	No	No	No	No	No	No	No
	1	Upland	No	No	No	No	No	No	No	No	No	No	No	No
	2					No	No	No	No	No	No	No	No	No
	3					No	No	No	No	No	No	No	No	No
Nshawu	1	Permanent	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	2					Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	3					Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	1	Seasonal	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	2					Yes	Yes	Yes	Yes	No	Yes	No	Yes	No
	3					Yes	Yes	Yes	Yes	Yes	No	No	Yes	No
	1	Temporary	Yes	Yes	No	No	No	No	No	No	No	No	No	No
	2					No	No	No	No	No	No	No	No	No
	3					No	No	No	No	No	No	No	No	No
	1	Upland	No	No	Yes	No	No	No	No	No	No	No	No	No
	2					No	No	No	No	No	No	No	No	No
	3					No	No	No	No	No	No	No	No	No
Tshutshi	1	Permanent	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No
	2					Yes	Yes	No	No	No	No	Yes	No	No
	3					No	No	Yes	No	No	No	No	No	No
	1	Seasonal	Yes	No	Yes	No	Yes	No	No	No	No	No	No	No
	2					No	Yes	No	No	No	No	No	No	No
	3					No	Yes	Yes	No	No	No	No	No	No
	1	Temporary	Yes	No	Yes	No	No	No	No	No	No	No	No	No
	2					No	Yes	Yes	No	No	No	No	No	No
	3					No	Yes	Yes	No	No	No	No	No	No
	1	Upland	No	Yes	Yes	No	No	No	No	No	No	No	No	No
	2					No	No	No	No	No	No	No	No	No
	3					No	No	No	No	No	No	No	No	No

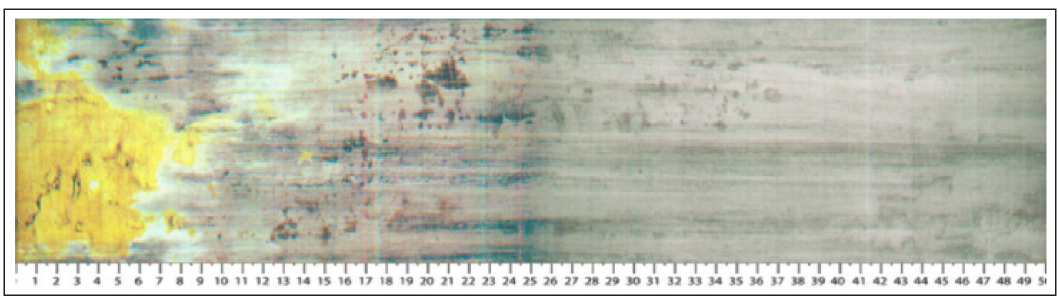


Figure 5. IRIS tube from the permanently saturated zone at Malahlapanga, showing unremoved (yellow) and removed (white) paint and peat staining (black spots and striations) for the 0–500 mm section

Malahlapanga

There was a strong agreement (100%) between the DWAF (2005) indicators and the IRIS data in the permanently saturated zone for Malahlapanga (Table 2). The terrain unit, soil form indicator, soil wetness indicator, vegetation indicator, as well as the hydrology and rH of the water confirm that the zone is indeed permanently saturated. Figure 5 shows an example of a typical IRIS tube that was installed within this zone. It can be clearly seen that the Fe paint was stripped entirely from the tube. However, grey staining from the organic matter can also be noted. This had implications when analysing the tubes using the flatbed scanner in greyscale. While it is very obvious where there was paint removal when examining the tube by eye, it was a challenge for the scanner to distinguish between the grey tone of the orange paint and the grey staining on the tube from the organic material. These tubes were treated differently from the rest of the IRIS tubes during the analysis phase, as a higher degree of accuracy was achieved via visual estimation of paint removal.

There was no paint removal from the tubes in the seasonal and temporary zones (Table 2), because the water did not rise within the top 0.5 m of the soil profile during the study period. The terrain unit, soil form indicator and soil wetness indicators did, however, indicate that wetland conditions had occurred within these zones. The soil indicators could have been relict, or the year of the study may not have been wet enough. However, even with the occurrence of the January 2013 floods, no reduction was recorded within these zones. The vegetation was misleading due to the severe trampling from animals, which prevented the establishment of certain plant species.

In the upland zone there was a lack of wetland indicators as well as no paint removal recorded from the IRIS tubes, implying that there was also a strong agreement between the methods at the dry end of this transect.

Water SA 46(3) 393–403 / Jul 2020
https://doi.org/10.17159/wsa/2020.v46.i3.8649

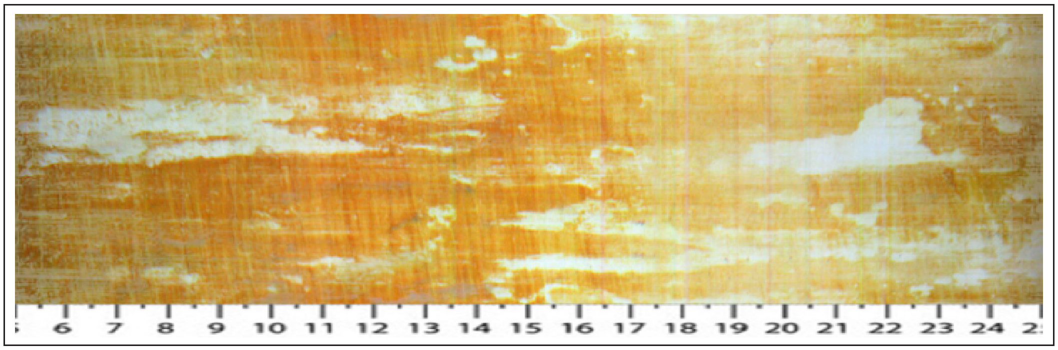


Figure 6. IRIS tube from the permanently saturated zone at Nshawu showing typical patterns of paint removal (50–250 mm section)

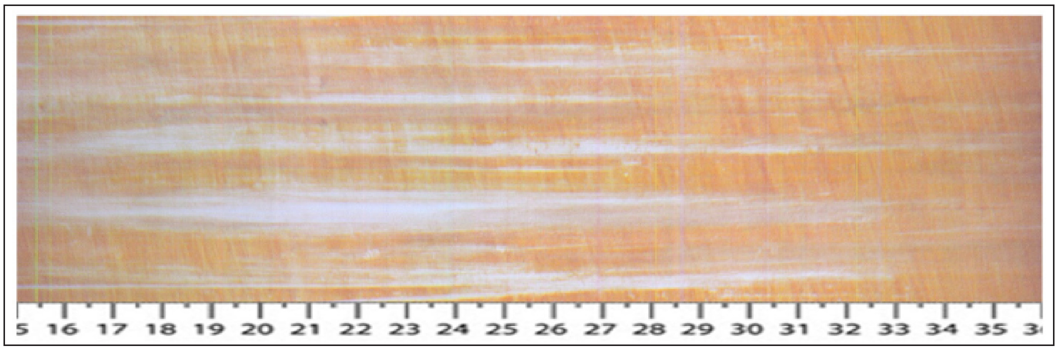


Figure 7. IRIS tube from the permanently saturated zone at Tshutshi spruit (150–350 mm section), showing scratching of paint associated with the sandy soils conditions

Nshawu

There was a fair agreement between the IRIS data and the DWAF (2005) indicators in the permanent and seasonal zones with less paint removal occurring in the seasonal zone (Table 2). While the terrain unit, soil form, soil wetness and vegetation indicators were met for the zones, along with the presence of the water table and reducing rH, there was a decrease in paint removal in the seasonal zone. In the seasonal zone, only one of the three repetitions would classify as a wetland, while the other two repetitions would not have met the criteria of both Castenson and Rabenhorst (2006) and the NTCHS (2007; 2015).

In the temporary zone, no paint removal was recorded via reduction, only via scratching from the carbonate nodules. The coarse size fraction, consisting of carbonate nodules and stones, was as high as 70%. Because of the high percentage of coarse fragments in this zone, abrasion and scratching was responsible for removing the IRIS tube paint. In the temporary zone only the terrain unit, soil form and vegetation wetland indicators were met. This means that in this zone the soil wetness indicator and IRIS tubes were in agreement as the water table did not reach the 0.5 m depth for a long enough period during the study for reduction to occur. This observation might also be due to the high pH in these soils (Johnson, 2014), due to the occurrence of lime that might suppress reduction.

In the upland zone there was a lack of wetland indicators as well as no paint removal recorded from the IRIS tubes, implying that there was also a strong agreement between the methods at the dry end of the transect.

Interestingly, reduction from the IRIS tubes was also recorded in months where 100% water saturation was not documented. While the purpose of this study was not to relate the degree of water saturation to the onset of reduction, this is an interesting result, which corroborates the finding of Smith and Van Huyssteen (2011; 2013). These authors found that the onset of reduction typically occurs at 70% water saturation but can be influenced by factors such as temperature, bulk density and organic carbon content. Further explanation for this is that the soils, being derived from a basic parent material, are higher in clays, which have a greater bulk density and higher capillary fringe than sandy soils.

The patterns caused by paint removal from the tubes at Nshawu were also interesting (Fig. 6). Paint removal often followed root channels where the microbes utilised the organic material during respiration, as opposed to vertical striations caused by scratching (Fig. 7).

Carbonate nodules, observed in the temporary zone (Johnson, 2014), are not currently defined as a wetness indicator (DWAF, 2005), since the focus is primarily on Fe, Mn, and organic carbon. However, in this study the carbonates did indicate a change in hydrology and wetland conditions, and are therefore recommended for further investigation.

Tshutshi spruit

No reduction was recorded in any of the zones at the Tshutshi spruit, despite the presence of wetland indicators and the inundation that occurred during the January 2013 flood. The terrain unit, soil wetness indicator and hydrological criteria were met for all of the zones, while the vegetation and soil form indicators were also met in the permanent zone. This suggests that perhaps the chemistry of the system was not favourable for the reduction of Fe. This wetland is associated with a sodic site and the measured pH water was extremely high (the maximum value recorded was 11.36 in the seasonally saturated zone).

Water SA 46(3) 393–403 / Jul 2020
https://doi.org/10.17159/wsa/2020.v46.i3.8649

The implication of this is that the area would have to be inundated with water for longer periods of time before Fe would be reduced. Because the system is not reducing in terms of Fe, more sensitive measurements, such as Manganese Indicators of Reduction In Soils (MIRIS; Stiles et al., 2010), should be explored.

The soils of Tshutshi spruit are very sandy, which led to paint being easily scratched off the IRIS tubes during installation and extraction. Paint removal through abrasion was therefore problematic and the paint mineralogy could possibly have been refined by determining the optimum goethite content for the paint to resist abrasion, but still be easily reduced. A more sensitive XRD analysis is required, because the one that was undertaken only detected goethite and no other Fe oxide minerals.

CONCLUSIONS

IRIS tubes offer a temporally integrated measurement methodology, measuring the prevailing redox conditions over a 3- to 4-week period, as opposed to point hydroperiod measurements. There was generally a strong agreement between the DWAF (2005) indicators and the IRIS data. However, at the Tshutshi spruit, the high pH inhibited the reduction of Fe and so the wetland indicators were not in agreement with the IRIS results. The use of MIRIS tubes should be explored in order to find an element that is reducing in the system. It would seem that acceptable results would be obtained from the IRIS tubes in the rainy season, but that systems such as Malahlapanga, which have permanent groundwater saturation, and are not governed by seasonal rainfall within the catchment, warrant the installation of IRIS tubes throughout the year. Thus, an understanding of the nature of the hydrology of the system is important for knowing when to install the tubes – i.e., installing IRIS tubes in the summer months in the winter rainfall region would be superfluous. One must also take the climate and hydrology of the system into account (NTCHS, 2007; Rabenhorst, 2008). Another example would be pans, which only flood every 50–100 years, and would be impossible to delineate during the dry years unless they are solely groundwater fed. There are both advantages and disadvantages of the method. The IRIS tubes did not perform well in sodic, high pH environments. Scratching and staining of the tubes were problematic for the analysis phase and could be overcome by refining the paint mineralogy as well as visually estimating paint removal or using mylar grids in cases where tubes are badly stained by organic matter. It is not feasible in terms of time and expense to use the method for every wetland delineation, but in problematic cases such as described in the literature review, IRIS tubes offer a useful tool for wetland practitioners to definitively determine whether reducing conditions are actively occurring within a wetland during the period of study. Further studies to test the IRIS tube methodology in different geographical areas within South Africa, and determination of technical standards to delineate sodic and ephemeral wetlands, are therefore warranted. Based on the results presented here, it also seems warranted and feasible that quantitative wetland delineation guidelines should be developed for South Africa. Care should, however, be taken during excessively dry or wet years, to not under- or overestimate wetland occurrence.

ACKNOWLEDGEMENTS

SAEON, Inkaba ye Afrika (Publication No 248), and the University of the Free State are acknowledged for partially funding this project.

REFERENCES

BOUMA J (1983) Hydrology and soil genesis of soils with aquic moisture regimes. In: Wilding LP, Smeck NE and Hall GF (eds) *Pedogenesis and Soil Taxonomy. I. Concepts and Interactions*. Elsevier Science Publishers, Amsterdam. https://doi.org/10.1016/S0166-2481(08)70604-4

BRANDL G (1981) Geological Map 2230 Messina. 1:250 000 Geological Map Series. Council for Geoscience, Pretoria.

BRANDL G (1987) Explanation: Sheet 2330 Tzaneen. 1:250 000 Geological Map Series. Council for Geoscience, Pretoria.

BRISTOW JW and VENTER FJ (1986) Notes on the Permian to Recent geology of the Kruger National Park. *Koedoe* **29** 85–104. https://doi.org/10.4102/koedoe.v29i1.522

CASTENSON KL and RABENHORST MC (2006) Indicator of reduction in soils (IRIS): Evaluation of a new approach for assessing reduced conditions in soil. *Soil Sci. Soc. Am. J.* **70** 1222–1226. https://doi.org/10.2136/sssaj2005.0130

CLARK WM (1923) Studies on oxidation-reduction. I. Introduction: *Public Health Rep.* **38** 443–455.

DWAF (Department of Water Affairs and Forestry, South Africa) (2005) A practical field procedure for the identification and delineation of wetlands and riparian areas. Department of Water Affairs and Forestry, Pretoria.

GROOTJANS AP, GRUNDLING P-L, GRUNDLING A, LINSTRŐM A, ENGELBRECHT J and PRICE JS (2010) Spring mires fed by hot artesian water in Kruger National Park, South Africa. *Mires Peat* **6** 1–10.

GRUNDLING P-L (2010) Nshawuwetland (B83C-005) assessment. In: Agenbag G (ed.) *Rehabilitation plan for Kruger National Park, B90E, B90H, B83C, Limpopo*. SANBI Report No. 5267/105782 South African National Biodiversity Institute, Pretoria.

GRUNDLING P-L (2012) Personal communication, 26 June 2012. Dr Piet-Louis Grundling, affiliated researcher, University of the Free State.

IUSS WORKING GROUP WRB (2014) *World Reference Base for Soil Resources 2014*. International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports No. 106. Food and Agriculture Organization, Rome.

JENKINSON BJ and FRANZMEIER DP (2006) Development and evaluation of Fe coated tubes that indicate reduction in soils. *Soil Sci. Soc. Am. J.* **70** 183–191. https://doi.org/10.2136/sssaj2004.0323

JENKINSON BJ (2002) Hydrology of sandy soils in northwest Indiana and iron oxide indicators to identify hydric soils. PhD thesis, Purdue University.

JOHNSON TL (2014) Evaluation of iron-coated tubes to detect reduction in soils for wetland identification in the Kruger National Park. MSc thesis, University of the Free State.

MABUZA BB and VAN HUYSSTEEN CW (2019) Effect of degree and duration of water saturation on iron, manganese, and exchangeable cations in wetland soils of Maputaland, KwaZulu-Natal, South Africa. *S. Afr. J. Plant Soil* **36** 279–287. https://doi.org/10.1080/02571862.2018.1562112

MACVICAR CN, DE VILLIERS JM, LOXTON RF, VERSTER E, LAMBRECHTS JJN, MERRYWEATHER FR, LE ROUX J, VAN ROOYEN TH and VON M. HARMSE HJ (1977) *Soil Classification: A Binomial System for South Africa*. Department of Agriculture, Pretoria.

MEEK BD, MCKENZIE AJ and GROSS LB (1968) Effects of organic matter, flooding time and temperature on the dissolution of iron and manganese from soil *in situ*. *Soil Sci. Soc. Am.* **32** 634–638. https://doi.org/10.2136/sssaj1968.03615995003200050018x

MUCINA L, RUTHERFORD MC and POWRIE LW (2005) *Vegetation Map of South Africa, Lesotho and Swaziland, 1:1 000 000 scale sheet maps*. South Africa National Biodiversity Institute, Pretoria.

MUCINA L and RUTHERFORD MC (2007) *The Vegetation Map of South Africa, Lesotho and Swaziland*. South African National Biodiversity Institute, Pretoria.

NORTH GAUTENG REGIONAL COURT (2011) State vs Stefan Frylink and Mpofu Environmental Solutions CC, Regional Division of North Gauteng. Judgment on 6 April 2011. https://cer.org.za/wp-content/uploads/2011/04/S-v-Stefan-Frylinck-2011.pdf (Accessed 20 September 2019).

NTCHS (National Technical Committee of Hydric Soils) (2007) The hydric soil technical standard. Deliberations of the national technical committee for hydric soils. https://www.nrcs.usda.gov/internet/fse_documents/nrcs142p2_052089.pdf (Accessed 20 September 2019).

NTCHS (National Technical Committee of Hydric Soils) (2015) Hydric Soils Technical Notes11: Hydric soils technical standard and data submission requirements for field indicators of hydric soils. URL: https://www.nrcs.usda.gov/internet/fse_documents/nrcs142p2_051608.pdf (Accessed 20 September 2019).

OWENS PR, WILDING LP, MILLER WM and GRIFFIN RW (2008) Using iron metal rods to infer oxygen status in seasonally saturated soils. *Catena* **73** 197–203. https://doi.org/10.1016/j.catena.2007.07.009
PRETORIUS ML, BROWN LR, BREDENKAMP GJ AND VAN HUYSSTEEN CW (2016) The ecology and classification of wetland vegetation in the Maputaland Coastal Plain, South Africa. *Phytocoenologia* **46** 125–139. https://doi.org/10.1127/phyto/2016/0057
RABENHORST MC (2008) Protocol for using and interpreting IRIS tubes. *Soil Surv. Horiz.* **49** 74–77. https://doi.org/10.2136/sh2008.3.0074
RABENHORST MC (2012) Simple and reliable approach for quantifying IRIS tube data. *Soil Sci. Soc. Am. J.* **76** 307–308. https://doi.org/10.2136/sssaj2011.0267n
RSA (Republic of South Africa) (1998) National Water Act (Act No. 36 of 1998). *Government Gazette* **19182**. Government Printer, Cape Town.
SCHULZE RE, MAHARAJ M, WARBURTON ML, GERS CJ, HORAN MJC, KUNZ RP and CLARK DJ (2008) South African Atlas of Climatology and Agrohydrology. WRC Report No. 1489/1/08. Water Research Commission, Pretoria.
SCHUTTE IC (1986) The general geology of the Kruger National Park. *Koedoe* **29** 13–36. https://doi.org/10.4102/koedoe.v29i1.517
SMIT IPJ, RIDDELL ES, CULLUM C and PETERSEN R (2013) Kruger National Park research supersites: Establishing long-term research sites for cross-disciplinary, multiscaled learning. *Koedoe* **55**(1) 7 pages. http://dx.doi.org/10.4102/koedoe.v55i1.1107
SMITH K and VAN HUYSSTEEN CW (2011) The effect of degree and duration of water saturation on selected redox indicator: pe, Fe^{2+} and Mn^{2+}. *S. Afr. J. Plant Soil* **28** 119–126. https://doi.org/10.1080/02571862.2011.10640022
SMITH K and VAN HUYSSTEEN CW(2013) Relating the onset of reduction to degree of soil water saturation. *S. Afr. J. Plant Soil* **30** 157–161. https://doi.org/10.1080/02571862.2013.843029
SOIL CLASSIFICATION WORKING GROUP (1991) *Soil Classification – A Taxonomic System for South Africa. Memoirs on the Agricultural Natural Resources of South Africa No. 15*. Department of Agricultural Development, Pretoria.
SPRECHER SW (2008) Installing monitoring wells in soils (Version 1.0). USDA –National Resources Conservation Service, Lincoln.
STILES CA, DUNKINSON ET, PING C and KIDD J (2010) Initial field installation of manganese indicators of reduction in soils, Brooks Range, Alaska. *Soil Surv. Horiz.* **51** 102–107. https://doi.org/10.2136/sh2010.4.0102
USDA-NRCS (United States Department of Agriculture – Natural Resources Conservation Service) (2006) Field Indicators of hydric soils in the United States. A guide for identifying and delineating hydric soils, Version 6.0, USDA, NRCS, Lincoln.
VAN GINKEL CE, GLEN RP, GORDON-GRAY KD, CILLIERS CJ, MUASYA M and VAN DEVENTER PP (2011) Easy identification of some South African wetland plants (grasses, restios, sedges, rushes, bulrushes, eriocaulons and yellow-eyed grasses). WRC Report No. TT 479/10. Water Research Commission, Pretoria.
VENTER FJ (1990) A classification of land for management planning in the Kruger National Park. PhD thesis, University of South Africa.
VEPRASKAS MJ and FAULKNER SP (2001) Redox chemistry of hydric soils. In: Richardson JL and Vepraskas MJ (eds) *Wetland Soils: Genesis, Hydrology, Landscapes and Classification*. Lewis Publishers, Boca Raton. https://doi.org/10.1201/9781420026238.ch4
VEPRASKAS MJ (2001) Morphological features of seasonally reduced soils. In: Richardson JL and Vepraskas MJ (eds) *Wetland Soils: Genesis, Hydrology, Landscapes and Classification*. Lewis Publishers, Boca Raton. https://doi.org/10.1201/9781420026238.ch7
WRP (Wetlands Research Programme) (1993) Installing monitoring wells/piezometers in wetlands. WRP Technical Note HY-IA-3.1. https://apps.dtic.mil/dtic/tr/fulltext/u2/a434496.pdf (Accessed 20 September 2019).
ZAMBATIS N (2003) Determinants of grass production and composition in the Kruger National Park. MSc Agric thesis, University of KwaZulu-Natal.

For anyone interested in downloading the original paper and/or learning more about the publication or the authors, here is the link, https://www.watersa.net/article/view/8649. This is a free access publication and no copy write laws have been infringed upon by reproducing the paper here.

The Technical Corner

This is a new column open to any and all members who want to discuss technical issues, equipment, new methodologies, observations, any of the discussions that we would typically have at field days and training sessions which, because of the Covid-19 Pandemic, are not available to us at this point in time. The Executive Committee is hoping that this column will encourage the ongoing dialogue that has made AOP gatherings so very informative. This issue's presentation comes to us from Dan Michael. Would you like to be next?

LARGE SCALE PERCOLATION TESTS
Dan Michael

I know many of you are familiar with the percolation tests that were often run to test the potential percolation rate of the soil. Even still when we get a call to perform a soil test lot evaluation the owner calls to order a 'Perc Test'. Somehow, the name stuck.

Typically, a perc test involved excavating a hole with a post hole digger about 2 feet deep or so. The diameter would be about 6 inches in diameter. After scarifying the sides and cleaning the hole out, one simply poured water in. First, there is a waiting period for pre-soaking. Then, readings are taken to see how fast the water falls over a given time. The more water it took to replace the water then the better the percolation rate would calculate out.

When I was a young Soil Scientist the ODNR conducted a rather large scale study in which numerous tests were conducted throughout the State on many types of soils. I remember when Petro and Donaldson came to our County. We picked out the sites. They ran the tests and recorded the results. I assume these results are still available.

These types of percolation tests do offer some information. However, it is difficult to extract real interpretations from them. We were told that to pass the test that the falling rate would have to exceed 1 inch of fall per hour. No one was ever able to tell me where that number came from.

One shortcoming of this procedure is that it simply is too small of a test to represent a large area. Usually, one is expected to do at least three holes to obtain an average. Still, that is not much of a test.

Many years ago we started performing an occasional ‘large scale percolation test’. The idea was to perform a test that would be closer to the real world water quantity requirements and landscape areas.

Most of these tests originated as a result of failing a site because it was composed of cut and fill material from gravel pit excavations. Because the fill is structureless and at least somewhat compacted, the site would be failed. Nevertheless, by feel, it did seem the sites might be able to percolate water fast enough to be used for a septic field. Saying ‘no’ to a site can make an expensive lot essentially useless.

Of course, a feeling of “It might work” is not good enough to convince the owner and the Health Department. So, we created the Larger Scale Percolation Test. Joe Ringler and I put together a procedure and some equipment to do so.

The following is an example of how a test may be performed. Each case will vary somewhat depending on the soil and what needs to be accomplished. In this example , the needed site was over what used to be a well drained high floodplain Genessee soil. Formerly, an excavator had placed a long, several foot thick ridge of of topsoil without compacting the soil. My investigations did confirm that it was not at all compacted and was composed of a loam topsoil from the surrounding area. It certainly felt like it could handle a waste water load.

In this case, the County would likely want a shallow pressure distribution system into a shallow trench. There was no local water available, so it had to be trucked in daily. A trench was dug at a length of about 60 feet. There is one important concept here: ***The test should be run at a rate that somewhat meets or exceeds the expected final usage.*** For this operation we know that the future building will require about 200 gallons per day of usage. We will want to make sure the site can handle that. From the standpoint of a Health Department official, it would certainly add a degree of comfort to show that the entire load needed has been proven. This proof would be in contrast to a few perc holes that percolated say 20 gallons per day.

Large Scale Test : Water tank through the meter into drip tubing.

Water meter connected inline between tank and dispersal field.

The setup is as follows:

1) **WATER SUPPLY**: A large volume of water is needed. Typically, it would be good to tap into a faucet. In this case a large tank was set to hold the trucked in water.
2) The water then flows through a ***meter***. (see photo).
3) The water then is distributed though ***drip irrigation tubing***. This tubing is important as a very slow emmiting system is required to avoid dumping the water too quickly. Drip tubing is excellent because it emits about the same amount of water throughout the run of the piping. If a faster gallons per minute is needed, then it can be folded back on itself to double up on the number of emmiter holes. The tubing in this case is purple in color.
4) The rest is simple. Water is simply emptied into the trench. Readings are periodically taken from the meter. ***During the test, adjustments can be made***. The rate of dispersal may be increased if it observed that the trench is not filling up at all.
5) There is another large difference in the test we run compared to a small perc test. Usually, this test is conducted over a period of a few weeks. A lot of water will be passed through the system! This long test is meant to really prove out the capabilities of the soil to handle the water load. In addition, there might be a need to show that there is not a landscape failure. For example, does the water break out of the side of the hill?
6) Near the end of the procedure we like to invite the Health Department out to witness the test and to actually observe the rate of water absorption. After all, they will be asked to approve a site that has been rejected.

This procedure may seem too involved. However, in this case, it allowed for over a million dollar project to proceed. When considering the price of the land, it is usually worth it. Incidentally, this test greatly exceeded the requirements of the expected usage.

FUTURE IMPROVEMENTS

Soon, we will be working with the Hamilton County Health Department to improve the process. The biggest problem is that the process involves too many visits. If a job was 20 miles away, the mileage for 20 round trips would be 800 miles. Of course, one must consider the labor. In summary, the process is very expensive.

With new technology cheaply available we will be trying a few additions. Likely, it is best to have an internet 'hot spot' located at the site. Then a few remote WiFi cameras will be placed. One would be on the trench. Another would be on the meter. Another might be on the tank or on the entire site. Another improvement will be to add a cheap, simple irrigation timer control on the hose outlet to better control the total flow and when it flows.

With these improvements, the process should be able to be performed more efficiently.

USES

1) In the past this test has shown to be useful for disturbed sites to prove or disprove excess **compaction**.

2) **Large Project Field Testing**. On one job, we performed this test using 4 large trenches on high bottom land. The purpose was to test if the land (many acres) could disperse water for about 200 homes at a remote site. Such a large, expensive project deserves good proof to proceed. Individual waste water systems would cost over 4 million dollars. This test really serves quality data compared to feeling a soil on serveral pits with the use of tables that are not actually field proven.
3) **Investigatative Research**. There really seems to be a strong need for some basic soil investigations. Millions of dollars are being spent on waste water systems with designs that are being based on unproven rules and regulations. Many soil types are out there that can easily number into tens or even hundreds of thousands of acres. It seems that they deserve field verification of their water absorption capabilities.

The Role of Soil Science in the History of Ohio

This is a new column that I am adding to the newsletter. We all recognize the importance of soils to the settlement and development of the State of Ohio, but few of us realize how important those soils and parent materials were to the founding of Ohio's first industry, Ceramics. This column is dedicated to documenting investigations undertaken by Ohio soil scientists that may be a bit out of the norm and/or the role of that industry in the development of the state.

The first discussion comes from my relationship with the Walnut Grove-Flint Union Cemeteries in Worthington and Sharon Township, Franklin County, Ohio. I serve on their Advisory Board and have since the mid-1990s, a left over assignment from my years on the Board of Supervisors of the Franklin SWCD. Since I live in Worthington, I just stayed on. This is a three part story that documents a Forensic Soils Investigation undertaken by AOP members here in central Ohio. It was a neat piece of research using modern technology and old fashioned field work. It also helped to answer a mystery that had its roots going back to the settlement of the Village of Worthington and Sharon Township in 1803. This is the story of the Ozem Gardner Homestead Underground Railroad "tunnel" investigation. In this issue, I will share the back story about how the legends surrounding the Underground Railroad stop developed and why they needed to be investigated. Much of this back story has been developed from the Worthington Memory Project, http://www.worthingtonmemory.org/exhibits (search Underground Railroad) and the WOSU Columbus Neighborhoods Project, https://video.wosu.org/video/underground-railroad-nuio4u/ as well as interviews with older Worthington and Sharon Township Residents over the years including members of the Gardner family. More useful information is available at https://en.wikipedia.org/wiki/Africa,_Ohio which discusses the history of Africa, Ohio and the Hanby House in Westerville. Another link to the Hanby House can be found at http://www.westervillehistory.org/Hanby%20House.html. More information on the Kelton House and Underground Railroad museum can be found at https://en.wikipedia.org/wiki/Kelton_House_Museum_and_Garden.

Ohio became a state in 1803 and it joined the Union as "Free" meaning that no one could own slaves within the boundaries of Ohio. That did not mean, however, that slaves, fleeing to Ohio, were automatically freed. To be free, they had to pass through the state, cross Lake Erie and reach Canada. Furthermore, helping an escaped slave on that northern journey was very much against the law. If you were caught, charges filed against you and you were found guilty, you could be imprisoned, all of your property seized, your family thrown out of their home and left to starve unless takin in by family or friends. This was a whole lot riskier than posting a "Black Lives Matter" sign in your yard and offending your neighbor. In spite of the severity of the punishment, Ohio was a major link on the Underground Railroad and Central Ohio had many conductors and stops.

The Village of Worthington and Sharon Township, founded in 1803, was settled by Episcopalians from Connecticut. Shortly thereafter, they were joined by Presbyterians and Methodists, mainline Christian Denominations who were rethinking the suitability of slavery and developing very strong Abolitionist views. In addition to that, from its very early days, Worthington had a community of "Free people of color", who founded St. John's, the first African Methodist Episcopal (AME) Church in Ohio. The community also included Native Americans, mostly from the Wyandotte Tribe. So it was not surprising that stops on the Underground Railroad were quickly established and an active Abolitionist organization formed, complete with conductors. Brick maker Ozem Gardner was a very early leader of the organization and used his homestead as one of the important stops.

A common route for the slaves once entering the Columbus area was a stop in the central part of the Village, later at the Kelton House. They were then often moved north to the Clinton Methodist Chapel which was located on High St. in Clintonville north of Weber Rd. From there they were moved to Worthington and surrounds where there were a number of possible stops. Then up the Olentangy River or to the Ozem Gardner Homestead on Flint Road and then on to Delaware Village or to the Hanby House in Westerville and then to the community of Africa, Ohio which was located near the Alum Creek Dam. Numerous sources have set the number of slaves passing through the Ozem Gardner homestead as more than 200 during the years the stop was in operation. The house, still in existence, was known as the "Freedom House" and is still much revered by members of the local community.

The following information is taken from the Worthington Memory Project, dated 1997:
"Ozem Gardner came to central Ohio from Ostego County, New York, in 1817. He worked as brickmaker until he could save enough money to purchase 65 acres of farmland on Flint Road in 1821. He lived in a log cabin until late 1830's. The brick farmhouse pictured here was built around 1850. An active member of the Anti-Slavery Society of Worthington, he operated an Underground Railroad station on his property. It has been said that he assisted more than 200 fugitive slaves on their journey to Canada. Ozem Gardner lived in this home until his death in 1880."

This photograph of the Homestead was probably taken sometime in the mid-1900's. The house was built over a 30 year period out of bricks on hand. We will discuss the construction and technology at greater length in the next series on the Ceramic History of Ohio. Suffice it to say that Ozem Gardner was a master brick maker and was responsible for many, if not most of the bricks used in construction in the area after 1817.

So where did those "travelers" stay while visiting the homestead. Again, our source is the Worthington Memory Project:

> "According to oral tradition, fugitive slaves found lodging on the Ozem Gardner land in a structure that looked like a dugout. A small one room structure, it was built into the bank of the creek that flowed through the Gardner farmlands. Possible uses for the structure may have been storage or a site for burning brick. The runaway slaves found shelter there until Mr. Gardner could assist them on their trip to the next station along one of several underground railroad trails that continued from that location. It has been said that on cold nights, Mr. Gardner brought the travelers into his house for warmth. An infant of one of the travelers died and was buried in the home's basement, according to reports. This photograph depicts the shelter as it stands in contemporary y times."

In August, 2018, Tom Kayatti, Sharon Township Superintendent and my daughter Susan Rice investigated the structure which can only be entered from the door opening which is inserted in the east bank of Flint Run, directly behind the house. What we know from that investigation is that the structure was built at some point in time after the beginning of the construction of the brick homestead because the bricks included in the structure were of multiple ages intermingled, not stratigraphically younger with height as they are in the house or all of one age. We know it is not a brick kiln. If it was a root cellar, the typical shelves for storage are no longer there. Of special note is the inclusion of ceramic building blocks or tiles. While first introduced in Europe about 1800, they are not manufactured commercially in the US until after 1850. But these ceramic building tiles are not commercially manufactured, they were hand extruded, probably by Ozem Gardner or one of his helpers and so could easily predate 1850. The structure was capped by a flat cement roof, probably cast in the back yard of the Homestead and pulled, slid or rolled over the ceramic masonry walls. The top of the structure is at ground level with the back yard of the Homestead. As can be seen in the old photograph, someone added soil to the roof, which, if planted, would have made it impossible to see unless you knew it was there. Given the number of types of bricks used in the construction, I'm estimating the structure would have been built sometime in the 1840s or possibly the 1850s. It clearly is old enough to have been used as safe stop on the journey.

The photograph above shows the back wall of the structure, topped off at ground level. The concrete is the collapsed roof.

The photograph top right is the north wall and the west doorway. Note the ceramic structural tiles, they are hollow and have been extruded through a pug mill. The photograph to the left shows the door frame, the combination of bricks of various ages and collapsed sections of the ceramic structural tiles. The concrete slab is part of the collapsed roof. But how did the "travelers" get into the structure? And that, of course, is the mystery. Local tradition said that there was a tunnel between the cellar of the homestead and the structure but no one has been able to find an entrance at the cellar end and the structure is clearly not safe enough to investigate.

So how did I and then later, other AOP members get involved in the search for this possible tunnel? Because of the Gardner Family Cemetery which is located directly west across Flint Run. The Gardner Family Cemetery becomes the Flint Cemetery and then is transferred to Sharon Township who eventually merges it with Worthington's Walnut Grove Cemetery to form the Walnut Grove-Flint Union Cemeteries which is a separate but related political jurisdiction of Franklin County. An excellent write-up of the Cemetery's history can be found on their web site, https://worthingtoncemetery.com/flint-union-cemetery/history/. The old part of the Cemetery is in the southeast section and the treed area to the east is actually the valley of Flint Run. If you stand on the east boundary of the cemetery, you can look across the valley into the structure.

Historic views of Flint Cemetery and Ozem Gardner's grave taken at some point in the 1900s, from the Worthington Memories Project. Cemetery map taken from the Cemetery web page.

For decades, the Union Cemetery has included, on their wish list, the purchase of the Ozem Gardner Homestead as a "forever" Cemetery office and maintenance facility. For all practical purposes, the homestead has only had two long term owners since it was originally platted so it was way down on the list of an expected reality. In 2017, the pipedream became a possibility when the property went up for sale. The house was in serious need of attention and would not be cheap to preserve. Developers wanted to buy the property, tear it down and build four new homes on the site. The family had hoped that it would be preserved. The Union Cemetery calculated how many more grave spaces we would have back in Flint Cemetery if we did not have to set aside land for an office building and maintenance facilities. The sales value of the extra plots just about equaled the cost of the Homestead, so the Township and the City of Worthington bought it for the Cemeteries and we have been working on stabilizing the structures ever since. There is a discussion of the project on the website, https://worthingtoncemetery.com/flint-union-cemetery/gardner/.

As we worked around the house, it became clear that the back porch was unsalvageable and would have to be torn off and rebuilt. But the back porch was located on top of where the reported underground tunnel was supposed to exist. If the tunnel was there, all future development in that area would have to include the preservation of the tunnel. How would we know for sure? We could take a backhoe and trench across where the tunnel was supposed to be but if we intersected it, we would severely compromise it. We had to find a non-invasive way to determine if there was a tunnel. I offered to contact old friends from the Ohio Fracture Flow Working Group for ideas and help. My first contact was to Barry Allred, USDA ARS.

And the story continues…..