Medicative Architecture:

Bioplastic Ice fishing Huts as A Rehabilitative, Bioremediation Proposal of Contrecoeur's
Contaminated Protected Wetlands

By

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Postdoctoral Affairs in partial fulfillment of the requirements
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Master of Architecture

in

Architecture

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1. Images of ice fishing huts on off the shores of Contrecoeur (2020-02-17)
2. "Pill Identifier (Drug & Pill Finder)" - Medscape Reference." Accessed March 19, 2020. <https://reference.medscape.com/pill-identifier>.

Contrecoeur

4. Contrecoeur - Ice fishing huts in storage for the summer months

5. Contrecoeur - Protected Wildlife area, tree discoloration showing seasonal flooding heights

This thesis uses the materiality of pharmaceutical capsules as the research inspiration to examine dissolvable structures. Using the typology of the ice fishing hut, these temporary constructions will be deployed in pursuit of a community-led landscape rehabilitation. This rehabilitation aims to improve the contaminated ecosystem surrounding Contrecoeur, Quebec.

The thesis is composed of two parts. In the first part, A dialogue between the personification Contrecoeur as a patient requiring medical treatment for high concentration of contaminants found in his protected Wetlands.

The second part, a more conventional explanation of the research-by-design project including the material research into an extensive collection of dissolvable bioplastics forming the main material investigation for this project.

In conclusion, the ease of in-house fabrication of bioplastic allows the ice fishing community of Contrecoeur to self-build these dissolvable structures and engage in the rehabilitation of their local ecosystem while simultaneously continuing a culture of creative self-expression in the design of their ice fishing huts.

6. Ice fishing pill - personal sketch

"We abuse land because we see it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect."

- Aldo Leopold -

Leopold, Aldo, 1886-1948. *A Sand County Almanac, and Sketches Here and There*. Book, Whole. New York: Oxford University Press, 1987.

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Thank you

• A view of Contrecoeur's protected wetlands and wildlife area

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Lavaltrie

Contrecoeur

site of Future
Montreal Port Expansion

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KEY TERMS:

Ecology

[DIKIS-LOGOS] – relations of homes

The definition of ecology used in this thesis bears similarities to James Corner and Timothy Morton view of the term. Here, ecology relates all living and non-living matter on earth as deeply bound in a dynamic, correlated web of networks that advocates for a symbiotic relationship between human and the non-human. Where we as a human specie lives not on the land but dwells alongside the land.

Rehabilitation

[RE-HABILITAT] – Again Made-able

In this thesis the term rehabilitation refers to the act of restoration through means of therapeutic, constructive and non-invasive actions. Taking on a similar meaning to the rehabilitation process a human might experience after a medical procedure to improve, reinstate, re-establish the subject's original state of health prior to a change.

Remediator

[REMEDIUM-TOR] – The curing person

A person who or thing that remediates; to cure something or someone from an illness, discomfort or abnormalities; an agent or provider of rehabilitation.

13. GIS Data Overlay - St-Lawrence River, Human Modified Landcover and Seasonal Flood Area

x = contaminant

16. Images of ice fishing huts on off the shores of Contrecoeur (2020-02-17)
 17. "Pill Identifier (Drug & Pill Finder) - Medscape Reference." Accessed March 19, 2020. <https://reference.medscape.com/pill-identifier>.

INTRODUCTION

This research-by-design thesis explores bioplastics as a remediation material for the **rehabilitation** of contaminated landscape. The proposed project an area of wetlands along the St. Lawrence Seaway at Contrecoeur, Quebec is designated a National Wildlife Area. It would attempt to improve the current environmental conditions brought on by pollutants correlated with the City of Montreal effluent, the wetlands surrounding agricultural landcover, and a large metal manufacturing and recycling industry adjacent to the site. These varied industries are placing an environmental burden on an adjacent wildlife area and the vitality of the ecosystem. The thesis uses the typology of the ice fishing hut as a capsule made from locally sourced bioplastics embedded plant seeds and nutrients that would release when the bioplastics dissolve during spring thaw. These seeds are known as bioremediators and native to the region. Therefore, my thesis question asks how can temporary architecture use the analogy of pharmaceuticals as a means of **rehabilitation** of contaminated sites; can architecture act as a pill?

18 Conceptualized Illustration of Medical Ice Fishing Hut

"Consider this: all the ants on the planet, taken together, have a biomass greater than that of humans. Ants have been incredibly industrious for millions of years. Yet their productiveness nourishes plants, animals, and soil. Human industry has been in full swing for little over a century, yet it has brought about a decline in almost every ecosystem on the planet. Nature doesn't have a design problem. People do."

– William McDonough

1. William McDonough and Michael Braungart 1958, *Cradle to Cradle: Remaking the Way We Make Things*, 1st ed., Book, Whole (New York: North Point Press, 2002), 16.

2 Timothy Morton, *Being Ecological*, 1st ed., 2018, 82.

3 Morton, 82.

4 Donna J. Haraway, ed., "Making Kin: Anthropocene, Capitalocene, Plantationocene, Chthulucene," in *Staying with the Trouble: Making Kin in the Chthulucene* (Duke University Press, 2016), 0. <https://doi.org/10.1215/9780822373780-005>.

5 Aldo Leopold 1886-1948, *A Sand County Almanac, and Sketches Here and There*, Book, Whole (New York: Oxford University Press, 1987).

I have questioned the role of architecture within the earth's ecosystem since my undergraduate studies in architecture, urbanism and environmental and physical geography. In my view, today's architecture and materiality continue to hold an anthropocentric lens. This lens frames human at its focus with other living biota and organism peripheral to design considerations. This results in what I consider a selfish architecture; architecture should not solely benefit one species.

Tim Morton discusses this philosophy in his book 'Being Ecological' where he explains, "A hammer is a certain something a very specific something – and yet it's not a hammer exactly. It's all kinds of things to all kinds of beings. It's a landing strip for a fly. It's a surface for dust to collect on."² - "Hammers happen when you grab a metal-and-wooden thing for hammering in a picture hook"³. In this context, I believe architects have a duty as agents within the ecosystem, creating architecture that promotes a positive and **rehabilitative** system.

THESIS DELIVERY METHOD

With this thesis question in mind, I began to reflect on a pill's life cycle as it passes through the human body and how the capsule's bioplastic materiality can be applied to ice fishing huts to mimic the digestive transport of the pills with that of Earth's natural cycles.

This thesis is structured in two parts. The first part will hold a dialogue between a General Practitioner, a Pharmacologist and the personification of Contrecoeur, who has fallen ill due to Montreal's effluent discharge and industrial waste as well as the vast agricultural land that percolates into the St-Lawrence watershed. This dialogue helps to attach a notion of kinship, that Donna Haraway and Aldo Leopold strongly express a human need for , towards the ecology of Contrecoeur's wetland rehabilitation by proposing the culture of ice fishing and the ice fishing community act as symbiotic agents or the white blood cells of the ecosystem and not parasites on the land. Where this thesis seeks to reconnect our ties with the non-human, by approaching the ecosystem not as an entity we reside on but as members of a larger kin, that are part of the ecosystem.

The second part of the thesis will act as a prescription guidebook which includes two pamphlets. These two pamphlets are intended to be used both on-site as construction documents for the assembling and building of the specified ice fishing hut as well as at home to inform Contrecoeur's ice fishing community on methods in producing the bioplastics, options on seed applications, enclosure types and structural frame connections for the particular ice fishing hut documented in the pamphlets. Whereby the Guidebook will give the community an array of material and design options to allow for a continued culture of creativity, self-expression and community building while becoming agents within their ecosystem. The Guidebook is also a look into the studies performed during this thesis in order to confirm the possibility that dissolving bioplastic ice fishing huts can be built in addition to then rehabilitate the affected sites.

In the conclusion, I speculate that medicative ice fishing huts promote a successful novel approach to the **rehabilitation** for Contrecoeurs contaminated Wetlands. Whereby utilizing the community and the local culture of ice fishing can establish kinship between the ecosystem and humans, bringing the sheer scale of the site's **rehabilitative** timeline to a human scale. In addition, this design by research thesis will speak on its notion of deployable, dissolvable and decomposable temporary architectural structures for adaptive use for times of environmental crisis and states of emergencies.

19. Photo taken in Contrecoeur of Ice Fishing Hut with 'Blinky', The Simpsons Radiotave mutated fish, painted on its front.

20. Photo taken in Contrecoeur of a 'Brimbale', a type of ice fishing rod.

21 Photo taken at Contrecoeur's National Wildlife Area

CHAPTER ONE: THE SITE - PATIENT ADMISSION

22 Image of Hydrological Cycle Sources from Environment Canada

CHAPTER 1: THE SITE - Patient Admission

Contrecoeur (the site) is waiting impatiently in a sky-blue medical room, plastered with geological maps, soil horizon charts and diagrams of earth's various natural cycles. It has all but one thing on his mind ... 'what could possibly be wrong with me? For me to be feeling so unusual and weak'. Looking around he spots the diagram of the hydrological cycle. Noting the flow of water, both within the ground and above it, he follows its movement from the top of a watershed, down through small streams, seeping into the underground water table and moving its way on to a larger river and ultimately making its way down to the ocean. While some of the water gets evaporated back into the sky, all for it to rain back down onto the land. After a couple of minutes waiting on the checkup bed, the doctor walks in with Contrecoeur's medical history in her hands.

Doctor

Good Afternoon Contrecoeur! How are you feeling today?

Looking closer at Contrecoeur sitting on the bed. She continues,

Oh my dear! Contrecoeur, would you be able to get up for a moment. I need to put down the wax paper before you can sit on the bed. Don't want to be catching or spreading anything now, do we!

Contrecoeur

Oh, I'm sorry, I wasn't aware. Here, let me get up!

Grabbing the roll of waxed paper, the doctor places it on the bed and taps twice and smiles, signifying to Contrecoeur it is okay to sit back down.

As Contrecoeur begins to sit.

Doctor

So Contrecoeur, what brings you to the clinic today?

Contrecoeur

Well, I don't know to be honest. Lately I've been feeling weak and tired. I think something is off with me, but I'm not too sure. I was hoping you'd be able to answer that.

Doctor

I can definitely have a look and see what might be making you feel this way Contrecoeur. Would you be able to describe in detail other symptoms you've been having?

Contrecoeur

Well, in general I would say I'm feeling weaker. Not as "fresh" as I use to feel about a century or two ago. It's been a steady decline I would say. I've also noticed a change in my wildlife, where some creatures are not reproducing at normal rates. One being the great blue heron⁶.

6. Louise Champoux and Philippe Beaupre, "Great Blue Heron: A Sentinel Species for the State of the St. Lawrence" (Minister of the Environment and Climate Change and Quebec's Minister of Sustainable Development, Environment and the Fight against Climate Change, 2015).

Doctor

Fatigue, Weakness, difficulties with reproduction system, thanks Contrecoeur, let's take a look at your medical records. See if there is anything that might be a factor in why you're feeling this way.

She folds open Contrecoeur's medical records, only to have a couple of papers fall to the ground as the folder is thicker than usual.

Doctor

My apologies!

As she is picking up the documents and putting them back in order.

Let's, see here... so I see your born in 1667, making you 352 years old?

Contrecoeur

Well not exactly. That is just when I was given a name by Sieur Antoine Pecaudy de Contrecoeur as he was 'gifted' me by the king of France for his services⁷. I'm much older than that.

Doctor

Ah I see, that is true, you are in fact a lot older than that. I see you go as far back as post-Holocene when the Laurentian ice cap covered you⁸. In that respect let's take a look at your surrounding soil composition to get an understanding on how some of nature's cycles might be working in respect to you and your micro-ecosystem.

Flipping over some of the documents in the folder. She finds a large soil survey map of Contrecoeur, collected between 1943 to 2005 9.

⁷ Historic Canada, "Contrecoeur," in The Canadian Encyclopedia, March 4, 2015, <https://www.thecanadianencyclopedia.ca/en/article/contrecoeur>.

⁸ Arthur Dyke and Victor Prest, "Late Wisconsinan and Holocene History of the Laurentide Ice Sheet," *Géographie Physique et Quaternaire* 41, no. 2 (1987): 237-63, <https://doi.org/10.7202/032681ar>.

⁹ IRDA, "Soil Surveys," IRDA, accessed December 15, 2019, <https://www.irda.qc.ca/en/services/protection-resources/soil-health/soil-information/soil-surveys/>.

THE SOIL COMPOSITION AND GEOLOGY

LAND

Doctor

Ok, so looking at the soil survey, it looks like a large area is composed of mostly sandy soil - MS1, RS3 and RS2 to be exact. Looking north on the banks of the St-Lawrence River it begins to transition into loamier base with fine clay¹⁰ with soil types including BH4, AI3 and DJ4. (Figure #)

She starts to fold up the map and neatly place it back into the folder and seemingly simultaneously pulling out another map of the St-Lawrence Rivers riverbed sediment composition.

23 Soil Map of Contrecoeur with notes taken by the doctor

10. IRDA, "Soil Surveys," IRDA, accessed December 15, 2019, <https://www.irda.qc.ca/en/services/protection-resources/soil-health/soil-information/soil-surveys/>.

RIVERBED

Doctor

Let's see here. The St-Lawrence River passes through you as well. Your section of the St-Lawrence is quite unique actually. You see here.

As she points on the map, in the location of Contrecoeur.

This is you; you have the first large wetland area within the St-Lawrence fluvial section after Montreal's Census Metropolitan area. It is made up mostly of coastal sediments covered with submerged vegetation, permanent sediments covered with emerged or submerged vegetation as well as coastal sediments covered with emerged vegetation^{II}. Your section is unique because the rest of the fluvial section is largely made up of postglacial clay sometimes covered with sand, resulting in your section acting like a trap for sediment and other contaminations that might flow downstream as a clay and sand riverbed forms a sort of highway for sediment flows.

^{II} Magella Pelletier, "Sediment Quality in the Fluvial Section of the St. Lawrence," St. Lawrence Action Place - Monitoring the State of the St. River, 2019, 10.

24. Tablet view of sediment type in the fluvial section of the St-Lawrence River from 'Sediment Quality in the Fluvial Section of the St. Lawrence'

^{II} Magella Pelletier, "Sediment Quality in the Fluvial Section of the St. Lawrence," St. Lawrence Action Place - Monitoring the State of the St. River, 2019, 10.

Contrecoeur

Ah the makes sense, I have been noticing a 'weight gain' accumulating in those areas. Perhaps that is the reason for how I am feeling.

Doctor

Let's not jump to conclusions. There can be many factors at play with how you are feeling and your state of health. Let me pull up your land cover maps to explain some other factors that might be causing the symptoms you are dealing with.

Turning the screen on she flicks towards large scale exploded axonometric map of the land cover within Montreal's census metropolitan area and its surrounding census tracts.

LANDCOVER

Doctor

Here, look at this Contrecoeur, this is where you are within the land cover map of Montreal and its surroundings; of the 25,000 km² ¹², 18% consists of human modified land¹³. That included subcategories such as built-up areas, roads and highways, dumps as well as airports. Another 40% is reserved for agricultural purposes with its main cash crops being corn and soy. All of these land covers are within your watershed Contrecoeur¹⁴. This means a large amount of the precipitation runoff and infiltration in the soil will make its way to your wetlands making up approximately 8% of the total land cover.

She looks up to conclude her findings with Contrecoeur

With your riverbed soil conditions mentioned earlier, it looks like these two factors might play a role in how you're feeling. Is there any heavy industrial activity taking place near you?

Contrecoeur

Yes, actually! I have a large metal refinery, scrap metal processing center as well as the largest contaminated soil treatment site in Quebec.

Doctor

Oh well that's very important to know!

¹² St-Lawrence Action Plan and MDDEELCC, Land Cover Mapping of the St. Lawrence Lowlands, Landcover shape file (Government of Canada, 2018), <http://data.ec.gc.ca/data/sites/systems/land-cover-mapping-of-the-st.-lawlands/?lang=en>.

¹³ St-Lawrence Action Plan and MDDEELCC.

¹⁴ St-Lawrence Action Plan and MDDEELCC.

MONTREAL METROPOLITAN CENSUS AREA
 WORLD IMAGERY - LAND COVER DATA - FLOODING EVENTS - AGRICULTURAL LAND COVER - CONTAMINATED LAND

MONTREAL METROPOLITAN CENSUS AREA
 WORLD IMAGERY - LAND COVER DATA - HILL SHADE MAP - FLOODING EVENTS - PROTECTED ECOSYSTEMS - CONTAMINATED LAND

She turns back to her briefcase and takes out a prescription pad.

You might have been contaminated Contrecoeur. Possibly with a number of different heavy metals and their subsidiary chemicals. I'm going to request from you a number of core samples and waters samples to be taken at various points. Make sure the geologists focus more on your protected wildlife area. I feel this area is more of a concern as contaminants can bioaccumulate and affect the health of your biota.

Handing over the prescriptions.

Please try and get them done as soon as possible. There is normally a month or two waiting period between sample collection and the next appointment. The geologist will conduct their analysis and when I get the results, I will have the office administrator make an appointment with you.

Contrecoeur

Okay, I will get on that as soon as I can! All the geologist needs to know is on these prescriptions?

Contrecoeur looking down at the prescriptions marked with the coordinates for Iles de Contrecoeur's National Wildlife Area [45°51'03.0"N 73°15'12.0"W] and a note under "4 soil samples @ .3m depth taken on site. With water depths of .5m or more."

Doctor

Yes, we will know what to do with the prescription.

Contrecoeur

Thank you, I'll see you soon!

Contrecoeur gets up from the medical bed, shakes the hand of the doctor and makes his way to the door.

Doctor

Yes, have a good day Contrecoeur and stay healthy!

CHAPTER TWO: THE CONTAMINATION- Diagnosis

CHAPTER 2: THE CONTAMINATION - Diagnosis

Contrecoeur walks into the doctor's office, looks around the yellow tinged waiting room for the closest seat he can find to wait for his 1:30pm appointment. Nervously he looks around at the others patiently waiting for their names to be called by the office administrator, who is scarfing down his lunch from a Styrofoam take-away container. One site after the other gets up, seemingly weak, emotionless and weathered out as they slowly make their way to the medical room, with only one thing on their mind... "What's wrong with me, why am I feeling so odd?"

As the clock ticks to 1:50pm - the doctor's late, all that's going through Contrecoeur's mind is the hope that the doctor has good news, but deep down he and the smaller organisms, vegetation, soil cover, humans and wildlife within him know that might not be the case.

Intercom static is heard as the receptionist holds the speak button down looking for Contrecoeur's name on the call out sheet.

Receptionist

"Contrecoeur, please go to room P632. Contrecoeur please go to room P632. The doctor will be meeting you now. Thank you"

Contrecoeur, similar to the other patients earlier, marches his way to the medical room. As he enters the room and sits on the bed, covered with a fresh sheet of paper, he fidgets to get comfortable. Looking around the room, Contrecoeur glances over at the same medical tools hanging in the medical cabinet to his left and a water cycle diagram posted on the wall to the right, accompanied by a poster of a school of fish taken from below casting the fish as silhouettes against the sky above.

Doctor

Good Afternoon Contrecoeur! How are you feeling?

As she walks into the room looking over the medical notes, flipping over each page to quickly get back to familiarity with Contrecoeur's state of health. The doctor looks up, smiling at Contrecoeur, awaiting an answer.

Contrecoeur anxiously responds.

Contrecoeur

I'm feeling alright, I guess. Not much has changed, I'm still feeling tired and under the weather. Not much energy lately. Did you get any results back from the tests? I'm sure I sent them to the right address. I got them done as quickly as possible.

Doctor

No, no Mr. Contrecoeur, we got all your samples and tests, thank you! We don't typically get patients tests and results back so soon.

Contrecoeur blushes

Doctor

Although, I'm afraid you contracted a high concentration of metal contaminants and organic compounds within your National protected wildlife zone. Including PCB's, amounting to 0.128ug/g to be exact within your wetlands¹⁵. This was taken from your samples collected in between the years 2004 and 2014¹⁶. A concentration is about 3 times higher than the regulated TEL (Threshold Effect Level). The sediment quality criteria used by Environment Canada (EC) and the Ministère du Développement durable, de l'Environnement et des Parcs (MDDEP). "They are defined based on the observed biological effects on benthic and pelagic organisms and contaminant concentrations measured in sediment"¹⁷.

Contrecoeur

Oh...is this bad? What are PCBs! Is it that the reason for how I've been feeling over the past century?

Doctor

It's not quite just the PCBs, looking at the results from your sediment quality tests. There's several other contaminations affecting you, these include a mixture of Metals, Mercury, PBDE', PAH's and some pharmaceuticals¹⁸. But yes, ultimately these contaminants are affecting your state of health Mr. Contrecoeur. I am proposing you act on the PCBs as these contaminants can have bio-accumulating effects on your surrounding ecosystem.

DEFINE PCB

Doctor

And to answer your other question Mr. Contrecoeur, PCB's, known as Polychlorinated Biphenyl's, act as a larger umbrella for any combination of 209 chemicals which are similar in structure¹⁹. They are human produced organic compound introduced in the late 1920's, 1929 to be exact, as a flame-retardant fluid used as:

¹⁵. Pelletier, "Sediment Quality in the Fluvial Section of the St. Lawrence," 4.

¹⁶. Pelletier, 4.

¹⁷. Pelletier, 2.

¹⁸. Pelletier, 4.

¹⁹. Health Canada, "PCBs - It's Your Health" (Ministry of Health Canada, October 2005), 1, <https://www.canada.ca/en/health-canada/services/healthy-living/your-health/environment/pcbs.html>.

THE PAST USE OF PCB

- Coolant for electrical equipment²⁰
- Dielectrics²¹,
- In heat-transfer fluids²²,
- In carbon copy paper²³,
- Sealant and caulking compounds²⁴,
- Cutting oils²⁵
- Inks²⁶,
- Paint additives²⁷,
- Pesticides²⁸,
- Adhesives²⁹,
- Plasticizers³⁰,
- Among multiple other various uses.

Contrecoeur

Oh...well ok...but...

Contrecoeur replies nervously,

What about them is causing me to be an unhealthy host for my ecosystem?

²⁰. Health Canada, "PCBs - It's Your Health."

²¹. Health Canada.

²². "Learn about Polychlorinated Biphenyls (PCBs) | Polychlorinated Biphenyls (PCBs) | US EPA," accessed November 7, 2019, <https://www.epa.gov/pcbs/learn-about-polychlorinated-biphenyls-pcbs>.

²³. "Learn about Polychlorinated Biphenyls (PCBs) | Polychlorinated Biphenyls (PCBs) | US EPA."

²⁴. Health Canada, "PCBs - It's Your Health."

²⁵. Thanh-Thao Pham and Suzie Proulx, "PCBs and PAHs in the Montreal Urban Community (Quebec, Canada) Wastewater Treatment Plant and in the Effluent Plume in the St River," *Water Research* 31, no. 8 (August 1997): 1887-96, [https://doi.org/10.1016/S0043-1354\(97\)00025-0](https://doi.org/10.1016/S0043-1354(97)00025-0).

²⁶. Health Canada, "PCBs - It's Your Health."

²⁷. Mitchell D. Erickson and Robert G. Kaley, "Applications of Polychlorinated Biphenyls," *Environmental Science and Pollution Research* 18, no. 2 (February 1, 2011): 144, <https://doi.org/10.1007/s11356-010-0392-1>.

²⁸. Erickson and Kaley, 144.

²⁹. Erickson and Kaley, 144.

³⁰. Erickson and Kaley, 144.

THE CAUSES AND CORRELATIONS OF PCB BIOACCUMULATION

Doctor

Well their chemical structure makes them difficult to breakdown as well being known to bioaccumulate in ecosystems, sediment, plants, animals and humans. Bioaccumulation is a process which follows the order of the food chain. Where smaller organisms hold small quantities of PCB's, although moving up through the food chain the amounts and concentrations of PCB accumulates in the tissues of each proceeding predator³¹.

Doctor flips over some papers in Contrecoeur's health portfolio to find an informative pamphlet about PCB's and hands it over to Contrecoeur.

WILDLIFE AFFECTS

The direct causal **ecological** impacts of PCBs include chronic toxicity observed in birds, fish and mammals, with effects on their:

- Reproductive systems,
- Livers,
- Growth and development,
- Wasting syndrome,
- Cancers,
- Immune system alterations and
- Death through dietary accumulation³².

HUMAN AFFECTS

Contrecoeur

So... would that mean the same affects occur to the humans living, fishing, hunting and working? How do humans accumulate PCBs?

³¹. Board on Environmental Studies and Toxicology et al., A Risk Management Strategy for PCB-Contaminated Sediments (Washington, D.C., UNITED STATES: National Academies Press, 2001), 39. <http://ebookcentral.proquest.com/lib/oculcarleton-ebooks/detail.action?docID=3377826>.

³². Erickson and Kaley, "Applications of Polychlorinated Biphenyls," 39.

Doctor

The same way, through bioaccumulation. The most effected humans are those directly working with or around PCBs in industries such as waste management. Humans are also highly susceptible to PCB's by dietary ingestion of large amounts of wild game, such as fishing, hunting, wild foraging³³.

The effects of PCBs on humans is similar to those of the ecosystem. With symptoms of:

- - severe acne (chloracne)^{34 35},
- - swelling of upper eyelids³⁶,
- - discolouring of nails and skin³⁷,
- - numbness in arms and/or legs³⁸,
- - weakness³⁹,
- - muscle spasms⁴⁰,
- - chronic Bronchitis^{41 42},
- - problems related to the nervous system⁴³,
- - affects have also been studied to carry over in newborn babies⁴⁴,
- - including recent studies on PCB's being a carcinogenic⁴⁵.

Contrecoeur moves around uncomfortably, crackling the paper beneath him, closing in his shoulders, sheltering himself from feelings of vulnerability.

Contrecoeur

What does this mean for me? Can I be **rehabilitated**? Will this problem persist?

33. Health Canada, "PCBs - It's Your Health," 2.

34. Board on Environmental Studies and Toxicology et al., A Risk Management Strategy for PCB-Contaminated Sediments, 36.

35. Health Canada, "PCBs - It's Your Health," 2.

36. Health Canada, 2.

37. Health Canada, 2.

38. Board on Environmental Studies and Toxicology et al., A Risk Management Strategy for PCB-Contaminated Sediments, 37.

39. Health Canada, "PCBs - It's Your Health," 2.

40. Health Canada, 2.

41. Health Canada, 2.

42. Board on Environmental Studies and Toxicology et al., A Risk Management Strategy for PCB-Contaminated Sediments, 37.

43. Board on Environmental Studies and Toxicology et al., 37.

44. Board on Environmental Studies and Toxicology et al., 37.

45. Health Canada, "PCBs - It's Your Health," 2.

Doctor

Actually Contrecoeur, there is a study my colleague is conducting now in the pharmacology department. He is looking at bioplastics, utilizing the plants and fibers living on your land to make all types of soluble 'plastic' materials to embed and envelope seeds for phytoremediation in addition to various cultures and organisms for bioremediation. The idea is the plastics can dissolve in water and the **remediators** would be release and transported with earth's natural cycles. Maybe we can see if he has an insight on your contaminants and a healing process that might be a more **ecological** and a less intrusive **rehabilitative** approach. Would you be interested in that Mr. Contrecoeur?

Doctor hands to Contrecoeur a pamphlet of the pharmacologist's current research work.

Contrecoeur looks down at the pamphlet titled "bioplastics in the environment" and flips it open to the Bioplastic Batch #1 photo samples.

Contrecoeur

Definitely, when should I be expecting another appointment?

Doctor

I will be giving your samples and medical history over after this appointment. He should get back to me within a week and we will get the ball rolling from there. He will be conducting some material tests and trying to target the right application for your contaminants. Expect a call from our administrator in the next couple of months.

Contrecoeur slowly gets up from the hospital bed and grabs the pamphlets. Feeling beaten he grabs his jacket and turns back to doctor.

Contrecoeur

At least I finally know what's going on. Thank you and I look forward to your call. Is there anything I can do in the meantime?

33 Bioplastic Material Production - First Batch #1

Doctor

Yes, as a preventative measure, limit the amount of wild game fish and mammal consumption by humans. Have a nice afternoon Mr. Contrecoeur. We will speak soon.

Contrecoeur

Ok I will issue regulations and limits on sport fishing and hunting to help reduce the consumption as well as populations and health of the wildlife⁴⁶.

Thank you, Doctor. Have a good day!

Rehabilitation Progress Notes
Client Name: Mr. Contrecoeur Date: 11/09/2011 Location: Home
Type of Injury: Other Time: 10:00
Referral Source: Self Referral Date: 11/09/2011
Client Age: 45 Sex: M Height: 175 Weight: 75
Occupation: Farmer Education: High School
Allergies: None Medications: None
Current Health Status: Good ☒ Stable ☐ Worsening
Other Health Issues: None ☐ Yes ☐ No
Client Report: Good ☒ Good ☐ Fair ☐ Poor
Assessment / Progress (or Regimen) / Plan (Problems must include: medical, social, cultural, environmental)
Client is motivated to improve: Yes ☒ Yes ☐ No
Living situation: Family ☒ Family ☐ Alone
Social support: Good ☒ Good ☐ Fair ☐ Poor
Client progress since last clinic visit: Good ☒ Good ☐ Fair ☐ Poor
Notes: Client is motivated to improve. Client is motivated to improve. Client is motivated to improve.
Medical Response: ☐ Full ☐ Partial ☐ None ☐ Symptoms Worsening
Change, as noted below:
Medication: ☐ No Change ☐ Change ☐ Discontinue
Diet: ☐ No Change ☐ Change ☐ Discontinue
Exercise: ☐ No Change ☐ Change ☐ Discontinue
Social Support: ☐ No Change ☐ Change ☐ Discontinue
Client Report of Subjective Status: Good ☒ Good ☐ Fair ☐ Poor
Medical Narrative: Client is motivated to improve. Client is motivated to improve. Client is motivated to improve.
Medical Progress Note
Page 1 of 10

⁴⁶ Gouvernement du Québec, "Sport Fishing in Québec Fishing Periods, Limits and Exceptions" (Government of Canada), accessed February 15, 2020, https://peche.faune.gouv.qc.ca/regpec/en/Info/Reglements?id_Zone=8.

CHAPTER THREE: THE TREATMENT PROPOSAL - THE PHARMACOLOGIST

35 Conceptualized Illustration of Medical Ice Fishing Huts drifting through Montreal

THE TREATMENT PROPOSAL - THE PHARMACOLOGIST

The Doctor leaves the medical room after Contrecoeur's appointment to walk down to the pharmacology department. As she turns down wing E, she sees the pharmacologist eating a sandwich in the hospital's café.

Doctor

Ah, I was just heading to your office. How's your lunch?

Pharmacologist

Hi Doctor, it's delicious! and How are you?

As he looks up smiling with a bit of tuna salad stuck on the side of his beard.

Doctor

I'm doing good! Thanks. I actually wanted to see if you were interested in looking at the medical files of a patient I just met with. He is suffering from a list of contaminants in a protected wildlife area.

Pharmacologist

Oh... he does sound interesting! Let me see.

The pharmacologist places his tuna sandwich back in his Tupperware and wipes the crumbs off of his beard and hands, to respectfully grab Contrecoeur's medical history folder. He opens it to Contrecoeur's profile.

After looking at the name on the file he looks up.

I know this site! It is a beautiful place in both the summer and winter. I go ice fishing there. We store our huts right off the road leading to the metal refinery. It is also the proposed site for Montreal's new international shipping port.

Doctor

Oh neat! Yes, exactly him, I've also heard about its ice fishing festival. The Brimbale⁴⁷ I believe?

Pharmacologist

Yes! On Valentine weekend in February! ... A lot of people from the community come on the ice to fish in their ice fishing huts and take part in the festivities.

The Pharmacologist pauses for a second and gets an idea for how he might be able to help Contrecoeur's illness.

Actually, Doctor I think I might be able to help you. Here, come to my office.

The Doctor and Pharmacologist leave the café. Once at his office, he hands over his notebook on the material research he has been doing with bioplastics and their dissolvability with water.

Here, take a look at my journal. It has some pictures and an ingredient list for the bioplastics I've been testing and making. I'm thinking of making it into a do it yourself capsule recipe book.

Doctor

Oh, this is fascinating! But how do you believe this could help Contrecoeur?

THE NOTION OF ARCHITECTURE AS A MEDICATION

Pharmacologist

When I go ice fishing there and during the spring months, that whole wetland gets flooded due to spring thaw, ice dams being formed as well as other processes. Maybe we can use that to our advantage? And... hear me out... develop different types of ice fishing huts with specific types of bioplastics that can dissolve at different rates and densities in the water during the spring thaw, transporting the embedded **remediators** to the protected sites without causing any physical interference with wildlife and its wetlands biota. Utilizing and engaging the community, and a Canadian cultural activity as a medium for the site's **rehabilitation**.

47. "Association de Chasse et Pêche de Contrecoeur - The Festival of Brimbale," accessed December 17, 2019, <https://acpcontrecoeur.com/peche-blanche-sur-la-glace/le-festival-de-la-brimbale.html>.

Ah! So, similar to the process a pill and capsule takes within the human body... That could actually work pharmacologist ! Most of the contaminants on site can be remediated through phytoremediation techniques. For example, alfalfa (*Medicago Sativa*)... alfalfa is known to be **phytoremediators** for PCB's⁴⁸. When would you be able to get back to me with some of these huts? We can try them out with Contrecoeur? He seems very responsive to working with more **ecological** and organic remediation techniques.

Let's set a meeting in two weeks. I'm am going to need to do a bit of brainstorming, sketching, developing and testing some designs before we can develop a proper plan with Mr. Contrecoeur.

That works with my schedule, see you in two weeks!

CHAPTER THREE: THE TREATMENT PROPOSAL - THE PHARMACOLOGIST | 49

37. Photo taken on site at Contrecoeurs Ice Fishing Village

CHAPTER FOUR: PRESCRIPTION

CHAPTER 4: PERScription

Three weeks passed since the Doctor had met with the Pharmacologist when The Doctor received an email from the Pharmacologist.

Hi Doctor,

I hope all is well. I have been looking more into Mr. Contrecoeur's files, and I believe the ice fishing huts are an inexpensive, community-engaged and implementable solution to the rehabilitation for his high levels of heavy metal and organic compound contaminations. Let's set up a meeting with Mr. Contrecoeur next week to discuss and propose our plan of action, application of medicine, dosages and medication prescriptions.

Please contact me if there are any issues as well as for meeting time and place.

Regards,

Pharmacologist

A week later, Mr. Contrecoeur finds himself waiting in that same waiting room for his appointment with The Doctor and The Pharmacologist. The intercom statics on and a breath inhales over the microphones, asking Mr. Contrecoeur to make his way to room P632. Contrecoeur, hearing his name, equally takes a deep breath in, pressing his hands on his knees as he gets up from the waiting room chair. In nerve, he makes his way down the hospital hall, peeping into patient rooms to see other sites looking worse off them him. Contrecoeur didn't have to wait long in the medical room before the Doctor and The Pharmacologist entered through the back door.

Doctor

Good afternoon Mr. Contrecoeur, How have you been feeling this past month? This is the Pharmacologist here at the hospital.

Contrecoeur

Hi Doctor and Pharmacologist, it's a pleasure to meet you.

As he shakes both of their hands, sitting back down.

I've been good, trying to stay healthy, eating correctly, drinking a lot. Also, I reduced the amount of fish a fisher can keep. I would say I'm still feeling quite weak and tired, though.

Doctor

Hello Mr. Contrecoeur, that's normal, you're contaminated with heavy metals and various organic compounds that are weakening your immune system, resisting your energy and reproduction. Similar to parasites, these contaminants will alter your state of health and different tangible and intangible ways.

The Doctor pauses and looks over to the Pharmacologist.

Pharmacologist

Hello Mr. Contrecoeur, thank you for allowing me to meet with you and the doctor concerning your illness. We think we might have a non-evasive **rehabilitative** treatment we can deploy on your protected wetlands that would involve the human communities' engagement and action.

Would you be interested in hearing our plan for **rehabilitation** Mr. Contrecoeur?

Contrecoeur

Yes, pleaseeee! Very much so! But, I read over some treatments for my illness performed on other sites, and I don't want to have my wetlands comprised of dredging practices within my boating channels. I still have all forms of life living there. You might not see these species, but they are vital to my ecosystem, like my benthic community^{49 50}. I just don't want to harm anybody if there's a way not to.

Doctor

We feel the same way Mr. Contrecoeur. That's why we would like to propose a community-engaged phytoremediation and bioremediation treatments, where the community becomes agents in your **rehabilitation** by deploying medicated ice fishing huts to target your contaminants. Giving the community, which uses your wetlands, river and shorelines a vessel to engage in your **rehabilitation**. Would that be a treatment you'd be interested in deploying Mr. Contrecoeur?

⁴⁹ Pelletier, "Sediment Quality in the Fluvial Section of the St. Lawrence."

⁵⁰ Caroline Savage, Alain Armelin, and Martin Jean, "Benthic Macroinvertebrate Communities" (Minister of the Environment and Climate Change and Quebec's Minister of Sustainable Development, Environment and the Fight against Climate Change, 2013), http://planstlaurent.qc.ca/fileadmin/publications/fiches_indicateurs/Communaut%C3%A9s_benthiques_ENG.pdf.

Contrecoeur

Contrecoeur's eye light up slightly in excitement

Yes! Most definitely! I think this is an excellent method to equally allow for community -engagement in my state of health as well as keeping the **rehabilitation** non-invasive. How and when would you suggest we begin the treatment?

Doctor

The doctor takes out two pamphlets from Contrecoeur's medical folder and hands them over to Contrecoeur.

These pamphlets can be distributed out to the ice fishing community in the summer for them to begin producing the bioplastics and preparing all the off-site manufacturing and assembly prior to the ice fishing season. The first pamphlets (*Appendix # - pamphlet made for defence*) will be used to select ingredients and display the recipe for the types of bioplastics that can be made for the enclosure of the ice fishing huts on the backside a flow chart is presented to help the ice fisher select the appropriate ice fishing hut style to build. The second pamphlet (*Appendix # - pamphlet made for defence*) will be used for selecting and construction of chosen ice fishing hut. These two pamphlets will be prescribed to your along with a guidebook that will thoroughly go through information concerning this **rehabilitation** treatment.

Contrecoeur

Looking through the pamphlets, Contrecoeur flips through, the two nodding in agreement.

Oh, wow, these huts can really be customized to allow for user self-expression and adaptability. That's great because the ice fishing huts have been known for their creative and unique styles as well as colors. It will be fascinating to see what types of structures the community will generate.

Doctor

That was our exact intention Mr. Contrecoeur. As mentioned, we were thinking of the ice fishing huts acting like medications, capsules or pills. In which they can come in all different shapes, sizes and colours. All uniquely identifiable.

As with some cardiovascular medication, these huts might need to be continually prescribed as a measure to mitigate and slowly **rehabilitated** the wetlands without any invasive actions. These types concentrations won't be cured in a season Mr. Contrecoeur, this will need to be understood by the community and to instill this architectural typology as an **ecological** option to ice fishing huts, where the cost of off-season storage alone can be a higher expense than purchasing the materials of the medicinal huts.

Contrecoeur

I agree Doctor, I'll begin to hand out copies of these two pamphlets for this summer's treatment implementation as soon as I'm out of the hospital. Where would I be able to pick up copies of the pamphlets?

Doctor

You can go to the pharmacy on the ground floor, right next to the main entrance. There, all you would need to do is present this prescription

The Doctor hands over a prescription slip to Contrecoeur

and the pharmacist will give you your first box of pamphlets and the guidebook. If you've distributed all the pamphlets and feel like you need more, just come back with the prescription, and we'll recharge your box. As this is a new treatment plan, you are among to first for its implementation, so do not hesitate to reach us with any questions. As this is an ongoing engagement, we'll be conducting multiple core sample and sediment studies throughout the next couple of years to grasp the effects the medicinal ice fishing huts have on the wetlands and its immediate ecosystem. Do you have any further questions Mr. Contrecoeur?

Contrecoeur

No, not that I can think of at the moment. Thank you, it's a matter of implementing the treatment now.

Doctor

Effectively. We will be there throughout. I hope you have a lovely rest of your day and please don't be shy in contacting the pharmacologist or I.

Contrecoeur

Contrecoeur puts the two pamphlets and the prescription in his book bag and shaking their hands he says.

Thank you, have a good day!

Contrecoeur walks out of the medical room, makes a left down the hallway towards the pharmacy. After picking up the guidebook and box of pamphlets, he makes his way back to his car parked just out in the hospital's parking lot. As he gets in the car, he grabs the guidebook and starts to peer inside.

38. Photo collage of various pills and ice fishing huts sharing the ice

The Guide Book

CHAPTER 5: MATERIAL

Medicinal hard and soft capsules are designed for single dosage applications, where the capsule would contain medications or nutrients intended on being past on to the digestive system and ultimately reaching its desired destination within the human body^{51 52}. These capsules, typically made from a base mixture of gelatin or organic ingredients⁵³, can be imagined to hold the same functions to an ice fishing hut. From storing the capsules to its digestion. The capsules house the medication safely until it passes through the digestive system, dissolving, releasing its medicinal contents at the appropriate time and location.

The analogy gives direction for the project's materiality – bioplastics – and defines the essential design characteristics for the capsule. In relation to the making of the bioplastics, it is important that manufacturing is done by the ice fishing community in Contrecoeur. The following paragraph will discuss the definition and chemical composition of bioplastics and act as the material recipe book for the ice fishing community. This recipe book allows the community and individuals to explore a variety of bioplastics to produce in conjunction with the assembly of their ice fishing huts. Ice Fishing huts are deeply personal spaces, and the collection forms a vital social community. By continuing a culture of self-expression, the bio-plastic ice fishing huts aim to bridge environmental stewardship, community engagement with aesthetic.

88. Image from Pill Dissolve Macro Timelapse by Macro Room

51. Gabriele Reich, "Formulation and Physical Properties of Soft Capsules," *Pharmaceutical Capsules*, Pharmaceutical Press, London, 2004, 201-12.

52. Ajay Prakash et al., "Are Your Capsules Vegetarian or Nonvegetarian: An Ethical and Scientific Justification," *Indian Journal of Pharmacology* 49, no. 5 (2017): 401-4, https://doi.org/10.4103/ijp.IJP_409_17.

53. Reich, "Formulation and Physical Properties of Soft Capsules."

WHAT ARE BIOPLASTICS

Bioplastics, similar to plastics, are a set of chain-linked monomers forming a large chain known as a polymer. Monomers are a series of molecules holding a low molecular weight. To produce bioplastics, an organic monomer is required, which includes starches, silk, keratin, hair, rubbers, celluloses, chitins and shellacs. Bioplastic is a broad term and can often be a generalization due to having a variety of naturally derived plastics produced with various material and sensorial characteristics such as their malleability, flexibility, tensile strength, aromas they can exhaust and natural lighting visual effects ⁵⁴.

Monomers sourced from starches such as rice, corn, potatoes and tapioca, holding various individual physical molecular qualities, will be used in the production of the bioplastic enclosures of the ice fishing huts. These monomers bind with plasticizers such as sorbitol or glycerol to aid in controlling the bioplastics malleability and flexibility and tensile strengths ⁵⁵.

MAKING THE BIOPLASTICS

The following paragraphs will be a guide for making the bioplastics. This guide will include information on ingredient quantities and ratios to follow, tools and equipment to make the bioplastics as well as techniques for producing unique bioplastics with different physical, visual, aromatic and **rehabilitative** qualities.

40. Bioplastic Sample Batch #3 - Made with coriander as a seed substitute

⁵⁴. Margaret Dunne, "Bioplastic Cook Book: A catalogue of Bioplastic Recipes" (FabTextiles // IAAC, 2018), <https://fabtextiles.org/bioplastic-cook-book/>.

⁵⁵. Billie Faircloth, *Plastics Now : On Architecture's Relationship to a Continuously Emerging Material* (Abingdon, Oxon : Routledge, 2015).

Tools and Equipment:

To make bioplastics, you will need the proper tools and equipment for measuring, mixing, heating and drying. The list below includes a recommendation of tools and equipment.

Measuring:

- Scale (0.00g)

- Cups to hold ingredients

- Dessert spoon

- Measuring Cup (2 cups)

- Small pot (1L)

- Kitchen cloth

Mixing:

- Rubber spatula

- Whisk

Cooking:

- Heat source

- Cooking Thermometer

- Large Pot

41. Illustrations of Tools and Equipment needed to Produce Bioplastics.

Drying:

- Flat Trays

- Drying Rack

Measuring Mixtures:

To make your bioplastics, proceed to **table 1** to select the base ingredients. These ingredients consist of a variety of starches, plasticizers, acids and other additives, such as seeds, nutrients, essential oils, powders, and meshing, which can be interchanged within their respective categories to produce a swatch of various bioplastics. The ingredients are colour coated, giving the ice fisher reliable ingredient combinations.

After selecting the ingredients needed, proceed to **table 2** below to find the proper weight required for each ingredient. This table contains the ingredients base ratio for making a starch-based bioplastic where it can then be scaling-up to the necessary amount while continuing in keeping the bioplastics physical and visual characteristics.

42. Ingredient Box of Various Bioplastic Ingredients

Bioplastic Ingredients list

Table 1 - Bioplastic Ingredients list, color coated with tested plastics types

Bioplastic Base Mixture Ratios and Scalars

Ingredient	# of mixes	Gross Quantity	Base Ratio	Quantity	Scalar (X or +)	Total Quantity
Starches	# of starches used	10g	10g / #n	=10g / #n	#	
Plasticizers	# of plasticizers used	5 g	5g / #n	=5g / #n	#	
Acids	# of acids used	1.5 g	1.5g / #n	=1.5g / #n	#	
Water	100ml	100 ml	-	100ml	#	
Fragrance Additives	# of Scents used	10 drops	10 drops / #n	= 10 drops / #n	#	
Texture Additives	# of textures	Application dependent	Application dependent	Application dependent	#	
Post Curing Additives	# of post processes	Application dependent	Application dependent	Application dependent	#	
Structural Additives	# of additives	Application dependent	Application dependent	Application dependent	#	

Table 2 - Bioplastic Base Mixture Ratios and Scalars

Mixing:

Before mixing the ingredients, prepare a water bath to heat the mixture. Do so by taking the large pot and fill to 1/3 and place it on a heating element set at medium heat until the water bath comes to a light boil. Additionally, coat all flat trays that will be used with a lubricant, such as a sunflower oil, vegetable oil or another locally sourced oil.

Add all of the ingredients into the small pot, with wet ingredients added last. Begin vigorously whisking the mixture to dissolve the powdered ingredients into the liquids. When thoroughly mixed, place the small pot inside the large pot of heated water.

Cooking:

Begin folding in the mixture with a rubber spatula until it the mixture clears and thickens. This process will take a couple of minutes as the mixture should gradually heat up to 85°C (Checking regularly its temperature using the cooking thermometer). Remove the small pot from the small water bath and begin to pour the mixture evenly onto the trays. Spread the mixture using the rubber spatula or any other troweling device until evenly spread to a desired thickness. The thickness should be within 3mm to 15mm, although this is dependent on the desired dried thickness. An approximately 3mm

43. Images Extracted out of Timelapse of Cooking Bioplastics

thick spread mixture will dry to a thickness of approximately .5 mm of dried bioplastic as the bioplastic shrinks as it dries.

Drying:

Place the trays in a dry location with proper ventilation. The drying process is dependent on the size and the thickness of the bioplastic where it's considered completed when the bioplastic is no longer sticky or damp to the touch, beginning to peel off from the trays easily. If there are any post-curing additives to the bioplastic, this is the time for application. Some post-curing additives, such as corn starch, give the bioplastics a smoother, softer and less tacky feel to them as well as turn transparent bioplastics translucent. A tray of bioplastic measuring 380x430x3mm thick took four days to complete its drying process. Although it is wise to do larger batches at a time and pour onto multiple trays or larger trays to produce the required amount of bioplastic needed for the ice fishing hut.

Repeat this process until you have obtained your desired amount of plastics for the construction of your hut.

44. Images Extracted out of Timelapse of Cooking Bioplastics

MATERIAL CHARACTERISTICS

The characteristics of a given bioplastic are dependent not only on its ingredients forming but also on the cooking. This section will speak on techniques for achieving ideal material characteristics for the bioplastics.

Increasing Structural Integrity:

It's important to produce bioplastics that are weather, and wind resistant as the ice fishing huts will face harsh winter conditions and need to shelter its occupants for the entirety of the season. The techniques suggested below were tested on the bioplastic featured beginning on page ##.

Mixing starches:

The bioplastics tensile strength can be increased by mixing different starches, creating a more reliable chain of polymers. Marichelvam et Al. determined that a mixture of 2 parts rice starch and 1-part corn starch obtains a stronger tensile strength than other mixing ratios⁵⁶. Additionally, a combination of two-parts rice starch and one-part tapioca starch forms a bioplastic with similar to better tensile strengths yet more malleable and flexible.

Emulsifying Blueberries:

Using a blender, emulsify some of the water used to mix the other ingredients with 1/6 parts of blueberry to starch. Then, add the emulsified blueberries to the bioplastic mixture. This has been shown to help keep the bioplastics structural integrity longer under the presence of water⁵⁷ in addition to snow accumulation and rain when the temperature increases.

80-85°C:

80-85°C is understood as the optimal temperature range to reach in a boiling water bath to help maximize the material's tensile strength⁵⁸.

⁵⁶ M. K. Marichelvam, Mohammad Jawaid, and Mohammad Asim, "Corn and Rice Starch-Based Bio-Plastics as Alternative Packaging Materials," *Fibers* 7, no. 4 (2019): 32, <https://doi.org/10.3390/fib7040032>.

⁵⁷ "Development and Characterization of Cassava Starch Films Incorporated with Blueberry Pomace - ScienceDirect," accessed November 7, 2019, <https://www.sciencedirect.com/science/article/pii/S0141813017316975>.

⁵⁸ N H Zakaria et al., "Effect of Mixing Temperature on Characteristics of Thermoplastic Potato Starch Film," *IOP Conference Series: Materials Science and Engineering* 374 (June 2018): 012083, <https://doi.org/10.1088/1757-899x/374/1/012083>.

Embedded Fabric:

By embedding organic fabric into the bioplastic as a post-curing additive, you can significantly increase the tensile strength of the bioplastic. This is done by placing the fabric on the tray before pouring the mixture, embedding fabric with the bioplastic.

Adding additional Plasticizer:

Plasticizers help with the flexibility and pliability of the bioplastics, due to the hydrogen bonds between the starch mixture and the plasticizers^{59 60 61}. Resulting in the intersperse and intercalation “among and between polymer chains, disrupting hydrogen bonding and spreading the chains apart”⁶². It’s recommended to begin with 30% of the mixture be made up of one or multiple plasticizers; otherwise, the starches will remain granular and ultimately resulting in a brittle material⁶³. Additionally, the studies have also been conducted on the comparison between various plasticizers, notably glycerol, sorbitol and PEG, where the study found sorbitol to have the highest tensile strength yet glycerol being the most flexible⁶⁴.

45 Photos of Bioplastics Physical Characteristics as a result of change in quantity of plasticizer.

Properties	Sorbitol	Glycerine	PEG
Brittleness	Least Flexible	Flexible structure	Flexible structure
Tensile strength	Highest TS: 26.06MPa	14.31MPa	16.14MPa

Table 3 -Bioplastic Property Study using different Plasticizer types conducted by Mohapatra et al.

59. Oluyide Fabunmi et al., “Developing Biodegradable Plastics from Starch,” January 1, 2007, <https://doi.org/10.13031/2013.24179>.

60. Dunne, “Bioplastic Cookbook: A Catalogue of Bioplastic Recipes.”

61. ABHIJIT MOHAPATRA, SHRUTI PRASAD, and HEMANT SHARMA, “Bioplastics- Utilization of Waste Banana Peels for Synthesis of Polymeric Films” (Thesis, University of Mumbai, 2014), https://www.researchgate.net/publication/272351686_Bioplastics-_utilization_of_waste_banana_peels_for_synthesis_of_polymeric_films.

62. MOHAPATRA, PRASAD, and SHARMA.

63. M. K. Marichelvam, Mohammad Jawaid, and Mohammad Asim, “Corn and Rice Starch-Based Bio-Plastics as Alternative Packaging Materials.”

64. MOHAPATRA, PRASAD, and SHARMA, “Bioplastics- Utilization of Waste Banana Peels for Synthesis of Polymeric Films.”

Stitching Structural Patterns:

By using a sewing machine, more durable tensile material can be created by strengthening the material with a sewn grid and patterns to reduce the amount of surface area between stronger elements (i.e. the stitch). Manual stitching with larger yarn to creating different effects, patterns can create the same structural integrity within the bioplastic. By adding a layer of stitching of grids and patterns, the bioplastics will gain not only tensile strength but also further opportunities for applying a craft in building the ice fishing huts.

Adding Colours, Texturing and Personality:

The following paragraphs give the ice fishing community options in altering the bioplastics colours, texturing and patterning to help promote an exploration of self-expression and community. Additionally, the use of colours, textures in the ice fishing huts materiality allows for opportunities in generating unique interior spaces by visual characteristics of a bioplastic as privacy screens, shading and shadowing effects.

47. Bioplastic material swatch of different textures, colors and lighting effects created during production.

Acids for colour:

Bioplastics require an acidic substance in the mixture to prevent them from biodegrading too early or act as a medium for bacterial growth^{65 66 67}. Also, the acids help disperse the polymer chains, giving more room for the plasticizers to fill the chain's voids, resulting in a more consistent and malleable bioplastic sheet⁶⁸. Since the required pH level to produce a bioplastic is similar to that of vinegar and citric acids, an array of acidic "colours" can be used in the mixture to create unique colours and effects. See table 1 for a list of additives to start exploring. (show images of wine, balsamic, etc.)

Fruits:

Adding pomaces, blends, juices and jams of fruits to a mixture can begin to create unique colours derived from the fruit's pigment. This can be done by adding banana peels⁶⁹ or a blueberry pomace or other blend to the mixture⁷⁰ or even red wine. Keep in mind that not a large quantity is required to affect the colour of the bioplastic.

65. Dunne, "Bioplastic Cookbook: A Catalogue of Bioplastic Recipes."

66. M. K. Marichelvam, Mohammad Jawaid, and Mohammad Asim, "Corn and Rice Starch-Based Bio-Plastics as Alternative Packaging Materials."

67. Yu Jiugao, Wang Ning, and Xiaofei Ma, "The Effects of Citric Acid on the Properties of Thermoplastic Starch Plasticized by Glycerol," *Starch - Stärke* 57 (October 1, 2005): 494-504, <https://doi.org/10.1002/star.200500423>.

68. Jiugao, Ning, and Ma.

69. MOHAPATRA, PRASAD, and SHARMA, "Bioplastics- Utilization of Waste Banana Peels for Synthesis of Polymeric Films."

70. "Development and Characterization of Cassava Starch Films Incorporated with Blueberry Pomace - ScienceDirect."

48. Batch 1 - Agar agar (day 4)

49. Batch 1 - Gelatin Foam (day 4)

50. Batch 3 - Red Wine for color and acid

51. Batch 5 - Blueberries and sesame seeds

Seeds and Biomass:

When adding seeds, leaves and other organic material to the mixture. You are not only doing so for phyto- and bioremediation purposes. Where the design exploration of patterns and opacity gradients using seeds and other biomass can creating interesting interior lighting effects as well as shading and privacy screens in your ice fishing hut.

52 Bioplastics showing example of seed and biomass applications for various color, light and texture effects.

Troweled patterning:

Using a trowel to spread the bioplastic during the pouring process can creating thicker regions, lines, grids in the mixture to achieve various patternings in the bioplastic. This pattern will exhibit a darkening in regions that are thicker and lighter when the material is thinner.

Aromas, Fragrances and Scent:

In addition to colours and textures, you can add aromatic qualities to the bioplastic mixture. These aromatic qualities can be added separately or come as a perk with other structural and colouring techniques. Adding aromatic qualities to the bioplastic not only can be seen as a solution in hiding the smell of caught fish and bait, but the aromatic additives can create a therapeutic experience inside the ice fishing hut, as the scents well slowly defuse inside the tent surrounding the ice fisher.

Blueberries:

When adding blueberries to the mixture, not only will it help with tensile, water-resistance and visual qualities, but it can also add an aromatic layer to the ice fishing hut, filling the space with a sweet scent of blueberries. The same experience can be mimic with other local fruit variations.

Essential Oils:

Essential oils can give the user endless opportunities in embedding the bioplastic with fragrance. These essential oils can be mixed to create a unique scent within the hut.

Samples tested includes: Eucalyptus, Lavender and Patchouli

Wine:

By choosing wine as your acidic ingredient, it will additionally act as a colouring element in the mixture as well as release subtle notes of wine from the bioplastic.

The wine of choice was the Wayne Gretzky Estate #99 2018 Cabernet Merlot VQA Ontario

Bananas:

Similar to the blueberries, a banana scent would be apparent within the hut and when smelling the bioplastic.

MATERIAL ASSEMBLY AND QUANTITY CALCULATIONS

When producing the materials for the ice fishing huts, look to the selected ice fishing huts assemble pamphlet to determine the amount necessary to produce.

(Pamphlets will be featured fully during defence)

DEGRADATION AND SOLUBILITY (WEATHERING AND UTILIZATION OF ITS ENVIRONMENT)

Since the bioplastics are made up of a mixture of starches, plasticizers, water, acids and various additives, making it a hydrophilic material, where it accepts the adhesion of water molecules, the bioplastic will ultimately dissolve and biodegrade when exposed to high concentrations of water. This dissolve and biodegradation is the ideal outcome for the ice fishing huts as it will allow for a release and dispersal of the various seeds and microorganisms into the St-Lawrence River to further transporting them downstream along the shoreline of the St-Lawrence River where they would be deposited along to the affected areas during Spring thaw.

This release can ultimately be controlled and timed depending on the starch and plasticizer composition of the bioplastic, whereby the use of more rice starch in the mixture will hold the bioplastics structure longer under submerged conditions⁷¹. Other postproduction additives such as various plant oils, including soybean oil⁷², castor oil⁷³, will help keep the bioplastics hydrophobic (the opposite of hydrophilic) for longer periods. The addition of plant oils allows for the ice fisher and community a level of control over the bioplastic's water-resistance during the ice fishing season and keep the bioplastics integrity intact during its transportation for it to reach its destination on the shores of Contrecoeurs Protected Wetlands for the bioplastic and ice fishing huts second life of **rehabilitating** the contaminated soils and sediment to commence.

53 Images taken from timelapse video of bioplastic dissolving with the aid of agitation.

⁷¹ M. K. Marichelvam, Mohammad Jawaid, and Mohammad Asim, "Corn and Rice Starch-Based Bio-Plastics as Alternative Packaging Materials."

⁷² Zhu Xiong et al., "Surface Hydrophobic Modification of Starch with Bio-Based Epoxy Resins to Fabricate High-Performance Polylactide Composite Materials," *Composites Science and Technology* 94 (April 9, 2014): 16–22. <https://doi.org/10.1016/j.compscitech.2014.01.007>.

⁷³ Z. Xiong et al., "Effect of Castor Oil Enrichment Layer Produced by Reaction on the Properties of PLA/HDI-g-Starch Blends," *Carbohydrate Polymers* 94, no. 1 (2013): 235–43. <https://doi.org/10.1016/j.carbpol.2013.01.038>.

BIOPLASTIC MATERIAL STUDY SAMPLES

<p>2.1</p> <p>THICKNESS: 0.02"</p> <p>VISUAL QUALITIES: YELLOWISH, TRANSLUCENT, AIR BUBBLES</p> <p>STRUCTURAL QUALITIES: BRITTLE, RIGID, CURLS WHEN DRYING, SMOOTH, BUMPY</p>	<p>INGREDIENTS</p> <ul style="list-style-type: none"> • CORNSTARCH • GLYCEROL • WHITE VINEGAR • WATER 	<p>Visual Qualities</p>	<p>Structural Qualities</p>
<p>2.2</p> <p>THICKNESS: 0.0008"</p> <p>VISUAL QUALITIES: BEIGE, SLIGHT TRANSLUCENT, MURKY, SLIGHTY GLOSSY</p> <p>STRUCTURAL QUALITIES: FOLDS, DRAPES, FLEXIBLE, TENSILE, CREASES</p>	<p>INGREDIENTS</p> <ul style="list-style-type: none"> • - RICE FLOUR • - CORNSTARCH • - 2X GLYCEROL • - APPLE CIDER VINEGAR • - AGAR-AGAR • - WATER
<p>2.3</p> <p>THICKNESS: 0.00067"</p> <p>VISUAL QUALITIES: BEIGE, SOFT LOOKING, POWDERED, SLIGHTLY TRANSLUCENT, MURKY</p> <p>STRUCTURAL QUALITIES: FOLDS, DRAPES, FLEXIBLE, TENSILE, CREASES, WRINKLES</p>	<p>INGREDIENTS</p> <ul style="list-style-type: none"> • RICE FLOUR • CORNSTARCH • GLYCEROL • APPLE CIDER VINEGAR • AGAR-AGAR • WATER
<p>2.4</p> <p>THICKNESS: 0.002"</p> <p>VISUAL QUALITIES: TRANSLUCENT, CLOUDY, SMOOTH, GLOSSY</p> <p>STRUCTURAL QUALITIES: DRAPES ONE WAY, FOLDS, CREASES, TENSILE</p>	<p>INGREDIENTS</p> <ul style="list-style-type: none"> • RICE FLOUR • CORNSTARCH • GLYCEROL • CITRIC ACID • GELATIN • WATER
<p>2.5</p> <p>THICKNESS: 0.0012"</p> <p>VISUAL QUALITIES: YELLOWISH, TRANSLUCENT, AIR BUBBLES</p> <p>STRUCTURAL QUALITIES: DRAPES ONE WAY, FOLDS, CREASES, STRONG TENSILE RESISTANCE</p>	<p>INGREDIENTS</p> <ul style="list-style-type: none"> • RICE FLOUR • CORNSTARCH • GLYCEROL • CITRIC ACID • GELATIN • COTTON MESH • WATER

<p>3.1</p> <p>THICKNESS: ----</p> <p>VISUAL QUALITIES: GREENISH TINGE, TRANSLUCENT, CREATES NICE SHADOWS</p> <p>STRUCTURAL QUALITIES: BRITTLE, RIGID</p>	<p>INGREDIENTS</p> <ul style="list-style-type: none"> ▪ CORNSTARCH ▪ GLYCEROL ▪ WHITE VINEGAR ▪ MINT ▪ PUMPKIN SEEDS ▪ WATER 	<p>Visual Qualities</p>	<p>Structural Qualities</p>
<p>3.2</p> <p>THICKNESS: ----</p> <p>VISUAL QUALITIES: GREENISH TINGE, TRANSLUCENT, CREATES NICE SHADOWS</p> <p>STRUCTURAL QUALITIES: BRITTLE, RIGID</p>	<p>INGREDIENTS</p> <ul style="list-style-type: none"> ▪ CORNSTARCH ▪ GLYCEROL ▪ WHITE VINEGAR ▪ MINT ▪ WATER
<p>3.3</p> <p>THICKNESS: 0.001"</p> <p>VISUAL QUALITIES: RED, TRANSLUCENT, MURKY, DARTER SPOTTING, SLIGHTLY GLOSSY</p> <p>STRUCTURAL QUALITIES: FOLDS, DRAPES, FLEXIBLE, TENSILE, CREASES</p>	<p>INGREDIENTS</p> <ul style="list-style-type: none"> ▪ RICE FLOUR ▪ TAPIOCA STARCH ▪ GLYCEROL ▪ RED WINE ▪ PECTIN ▪ EUCALYPTUS OIL
<p>3.4</p> <p>THICKNESS: 0.001"</p> <p>VISUAL QUALITIES: TRANSLUCENT, CLOUDY, SMOOTH, GLOSSY, CREATES NICE SHADOWS</p> <p>STRUCTURAL QUALITIES: FOLDS, DRAPES, FLEXIBLE, TENSILE, CREASES</p>	<p>INGREDIENTS</p> <ul style="list-style-type: none"> ▪ RICE FLOUR ▪ TAPIOCA STARCH ▪ GLYCEROL ▪ CITRIC ACID ▪ PECTIN ▪ PATCHOULI OIL
<p>3.5</p> <p>THICKNESS: 0.002"</p> <p>VISUAL QUALITIES: YELLOWISH, TRANSLUCENT</p> <p>STRUCTURAL QUALITIES: RIGID, FLEXIBLE, SNAPS WITH HIGH BENDING FORCES</p>	<p>INGREDIENTS</p> <ul style="list-style-type: none"> ▪ RICE FLOUR ▪ CORNSTARCH ▪ 2X GLYCEROL ▪ CITRIC ACID ▪ GELATIN ▪ WATER

3.6

THICKNESS: -----

VISUAL QUALITIES: LIGHT BEIGE, SLIGHTLY TRANSLUCENT, SOFT, POWDERED

STRUCTURAL QUALITIES: PIZZA DOUGH LIKE CONSISTENCY, FLEXIBLE, FOLDS

INGREDIENTS

- RICE FLOUR
- TAPIOCA STARCH
- GLYCEROL
- CITRIC ACID
- GELATIN
- EUCALYPTUS OIL

Visual Qualities

Structural Qualities

3.7

THICKNESS: ----

VISUAL QUALITIES: BEIGE TINGE, TRANSLUCENT, SEEDED

STRUCTURAL QUALITIES: RIGID AND BRITTLE

INGREDIENTS

- RICE FLOUR
- CORNSTARCH
- GLYCEROL
- WHITE VINEGAR
- SESAME SEEDS (VISUAL)
- WATER

3.8

THICKNESS: ----

VISUAL QUALITIES: BEIGE TINGE, TRANSLUCENT, SEEDED

STRUCTURAL QUALITIES: DRAPES, STIFF, FOLDS, CRACKS DURING CURE, FLEXIBLE

INGREDIENTS

- RICE FLOUR
- TAPIOCA STARCH
- GLYCEROL
- CITRIC ACID
- AGAR-AGAR
- EUCALYPTUS OIL
- SESAME SEEDS

4.0

THICKNESS: ----

VISUAL QUALITIES: BROWN, OPAQUE, SEEDED, CRACKING

STRUCTURAL QUALITIES: BRITTLE, STIFF, FOLDS, CRACKS DURING CURE

INGREDIENTS

- RICE FLOUR
- TAPIOCA STARCH
- GLYCEROL
- CITRIC ACID
- COFFEE GROUNDS
- SESAME SEEDS

5.0

THICKNESS: ----

VISUAL QUALITIES: MIX OF PURPLES, BLUES AND REDS, TRANSLUCENT, SEEDED

STRUCTURAL QUALITIES: FLEXIBLE, TENSILE, FOLDS, MALLEABLE, PLIABLE

INGREDIENTS

- RICE FLOUR
- TAPIOCA STARCH
- GLYCEROL
- CITRIC ACID
- BLUEBERRY EMULSION
- SESAME SEEDS

CHAPTER 6: THE MEDICATION AND NUTRIENTS

This chapter touches on definitions for the phytoremediation and bioremediation treatments that will be employed in the ice fishing huts. It will also discuss the regulating bodies in determining and monitoring the proper annual concentrations and types of aquatic plants, wetland plants and various nutrients that can be used as not to disturb the ecosystem. This chapter is additionally associated with appendix 1 to 5 giving characteristics of the annual seed and nutrient selection to the applied on the ice fishing huts fabrication for the year of 2021. These sheets give information on the seeds morphology/physiology, growth requirements, reproduction and the phyto- and bioremediation characteristics of Contrecoeur Protected Wetlands for the year 2021.

PHYTOREMEDIATION

Phytoremediation is the act of **rehabilitation** and removal of heavy metals and organic pollutants through the use of plants⁷⁴. It is understood as a cost-effective and low impact method to remove and **rehabilitate** polluted environments as it relies on natural processes for the uptake contaminants found within the soil and sediment^{75 76}. Within phytoremediation, there are various sub-categories which include:

Phytostimulation

Phytostimulation is understood as the enhancement of microbial activity to degrade organic contaminants through the use of secretions from plant roots⁷⁷. Phytostimulation can be used to remove and metabolize the organic compounds found contaminating the wetlands.

Phytostabilization:

Phytostabilization involves the absorption of contaminants and pollutants within the rhizosphere (the soil layer directly related to plant roots). Where the contaminants can further metabolize, separate and stabilize, making them harmless within its environment as well as preventing its bioaccumulation and augmentation⁷⁸.

74. Omena Bernard Ojuederie and Olubukola Oluranti Babalola, "Microbial and Plant-Assisted Bioremediation of Heavy Metal Polluted Environments: A Review," International Journal of Environmental Research and Public Health 14, no. 12 (December 4, 2017): 1504, <https://doi.org/10.3390/ijerph14121504>.

75. Ojuederie and Babalola.

76. Metin Turan and Sezai Ercisli, "Evaluation of Phytoremediation Potential of Rose Species," Asian Journal of Chemistry 19 (November 1, 2007): 4895–4902.

77. Ojuederie and Babalola, "Microbial and Plant-Assisted Bioremediation of Heavy Metal Polluted Environments: A Review."

78 Ojuederie and Babalola.

Phytodegradation:

Phytodegradation occurs when certain species of plants are introduced to contaminated soils. These plants will begin to break down and degrade organic contaminants such as PAH and PCB's into cleaner compounds through the plant's enzymes⁷⁹.

Phytovolatilization:

Phytovolatilization is the uptake and removal of soil contaminants through the plant in which they are broken down and released into the atmosphere through the leaves as vapour⁸⁰.

Phytoextraction:

Phytoextraction is the ability of a plant's root system in the uptake contaminants from the soil, storing the contaminants in the plant⁸¹. This method of phytoremediation, although it removes the contaminants from the land, it continues to keep them stored within the plant, ultimately promoting further bioaccumulate within species who ingest that plant. This method of **rehabilitation** won't act as the chosen plant's primary method of **rehabilitation** but an additional uptake mechanism of particular contaminants while the plant's primary phytoremediation method metabolizes other contaminants.

The four first phytoremediation treatments are understood as the primary methods the Guidebook will explore for soil **rehabilitation** as these treatments will metabolize and breakdown contaminants into non-toxic and harmful elements. Other forms of bioremediation are discussed below.

BIOREMEDIATION

Bioremediation using biomass and other nutrient additives is another form explored with the design and fabrication of the ice fishing huts. This form of **rehabilitation**, referred to as bioaugmentation, focusses on the implementation of nutrients and other organic additives, known to increase bioactivity within a given ecosystem. By adding nutrients into the enclosure types found in diagrams ## (Enclosure types) the nutrients can augment the biological activity surrounding the shorelines and wetlands during spring thaw and aid in its regrow.

⁷⁹. Ojuederie and Babalola, "Microbial and Plant-Assisted Bioremediation of Heavy Metal Polluted Environments: A Review."

⁸⁰. Ojuederie and Babalola.

⁸¹. Ojuederie and Babalola.

CONCENTRATIONS AND DOSING:

Both phytoremediation and bioremediation integrations within the ice fishing huts will need to be appropriately managed and regulated by ecologists, biologists and environmental geographers as not to over-saturate the St-Lawrence River with too much nutrient and seed loading⁸² as issues with over-saturation of rivers and wetlands have been seen to cause periods of eutrophication and algae blooms drifting down the St-Lawrence and its tributaries⁸³.

For a list of nutrients available to apply on the ice fishing huts, please refer to diagram 1 as well as the Ice fishing hut flow chart on page 74.

⁸². Graham MacDonald and Elena Bennett, "Phosphorus Accumulation in Saint Lawrence River Watershed Soils: A Century-Long Perspective," *Ecosystems* 12 (June 1, 2009): 621–35, <https://doi.org/10.1007/s10021-009-9246-4>.

⁸³. MacDonald and Bennett.

54. Single-user Ice Fishing hut designed to retract and redeploy on ice.

CHAPTER SEVEN HUT DESIGN AND CONSTRUCTION

CHAPTER 7: HUT DESIGN AND CONSTRUCTION

PICKING THE RIGHT HUT

People will choose the type of ice fishing hut, and the contaminates it will remediate based on the desired fishing location. They will be selected with the use of the ice fishing hut selection chart. See the flow chart on the proceeding page.

THE LOCATION

Ice fishing is a location-based winter sport where different areas along the river are suitable for different types of fish and aquatic environments, making for a complex and strategic outdoor sport and ice fishing hut placement. Therefore, by varying the ice fishing huts densities will allow for freedom in the ice fisher for selecting a desired location along the St-Lawrence river in proximity or upstream of Contrecoeur's protected wetlands. See diagram 1 and 2 for locations.

The location of the huts is the determining factor for the types of materials to be used for assembly. If the ice fishing huts are placed further upstream along the southern shore of the St-Lawrence River, a more buoyant and water-resistant materials needs to be used so that it drifts and reach the wetlands shorelines for seed sowing and nutrient deposit. Denser ice fishing huts are designed for locations closer to the contaminated sediment and soil, to sink as the ice breaks apart during spring thaw.

55 Sketch of sediment scour based on high resolution satellite imagery of Contrecoeurs Wetlands

1. Madoja et al., "Bio-Augmentation and Nutrient Amendment Decrease Concentration of Mercury in Contaminated Soil."
2. Abubakari, Egemei, and Iyemang, "Trends in Heavy Metals (arsenic and cadmium) in Pseudomonas aeruginosa."
3. Jing, Fusi, and Kullup, "Remediation of Polychlorinated Biphenyls (PCBs) in Contaminated Soil and Sediment: State of Knowledge and Perspectives."
4. Saez, Osk, and Hase, "The Accumulation of Heavy Metals in Typha latifolia L. Grown in a Stream Carrying Secondary Effluent."
5. Chivhim, "Enhanced Phytoremediation Capacity of Chlorella vulgaris L. Grown on Pb-Contaminated Soil Using EDTA and Reduction of Leaching Risk."
6. Anderson, Guthrie, and Walton, "Bioremediation in the Rhizosphere: (Plant Roots as a Potential Treatment for Chemically Contaminated Soils) (ES ST Critical Review)".
7. Chen and Pan, "Bioremediation Potential of Sorghum Toxicity and Bioassays of Pesticides and Bioremediation of Heavy Metals by Ectomycorrhizal Fungi."
8. Li et al., "Enrichment of Degradable Microbes and Bioremediation of Petrochemical Contaminants in Polluted Soil."
9. Odeh and Fird, "Phytoremediation of Heavy Metals by Ectomycorrhizal Fungi."

Diagram 2 - Determining location three through sediment scour sketch analysis.

Observing Sediment drifts and Scours

The different locations in the site map were determined using high-resolution satellite imagery and to mark out the sediment scour being created in the St-Lawrence river by sediment erosion from its shoreline, small islands in the river, with a series of markings simulating the rivers flow stream from the wetlands. These markings helped to identify locations where the ice fishing huts can be intercepted by the river's currents, to then, drift or roll along the riverbed where the dissolving materials can reach the wetlands.

THE SIZE OF HUT

The size of the ice fishing huts is determined by the number of ice fishers to occupy its interior. Keeping the selection to a maximum of three sizes, a Small, a Medium and a Large make for a more straightforward selection process by the ice fishers. By determining the size of the ice fishing huts, the style of construction and approach to insulating will differ in order to accommodate for changes in volume and surface area that would affect the ice fishing huts structure and interior comforts.

ENCLOSER TYPE

The encloser types displayed below, in diagrams # to #, not only are designed in conformance with the material capabilities of the bioplastic but are also intended to consider proper insulation, air circulation, moisture and rain resistance during warmer winter days, privacy and visibility within and outside of the hut, in addition to aromatic consideration and method of seed and nutrient applications and dispersion. The selection of enclosure types allows for the ice fishers the ability to design a hut in a variety of unique combinations and styles, promoting creativity in the ice fisher.

Sample of Simple weave pattern done with bioplastics

ENCLOSURE TYPE LAYERS

- Layers can be made using both regular and embedded seed application types of plastic.
- Insulated layers can be made of shreaded bioplastic materials, produced from scrap pieces collected during bioplastic production.
- Layers are sown together over the initial cutout template.

Bear Claw Pattern

Flying Guise Pattern

Windmill Pattern

Nine Patch Pattern

Rising Star Pattern

Log Cabin Pattern

Flower Pattern

Parquet Pattern

Fleur de Lys Decals

Maple Leaf Decal

Favourite Sports Team Logo

Symbolizing

Diagram 4- Enclosure Types - Quilted Enclosure Variations

**ENCLOSURE TYPE
QUILTS**

The bioplastic casing to create a tufted enclosure type can also be made with embedded seed bioplastic sheets.

The bioplastic casing to create a tufted enclosure type can also use weaved enclosure type to create various effects and aesthetics

The perks of using a tufted enclosure type within the ice fishing hut allows for seeds and nutrients to fill the voided space as well as other seed application types such as pods, which can be placed into the tufted void.

To apply a tufted enclosure, use the base enclosure and apply your top layer to be tufted to the base layer. Sow together to create a pocket and tie back, using a button, the front and back layer.

A number of Tufts can be included.

ENCLOSURE TYPE TUFTED

Diagram 5 - Enclosure Type - Tufted Enclosure variations

- Direction 1: 1x Over & 1x Under
- Direction 2: 1x Over & 1x Under

- Direction 1: 2x Over & 2x Under
- Direction 2: 2x Over & 2x Under

- Direction 1: 1x Over & 1x Under
- Direction 2: Straight through

Attaching the weaving should be done on the base enclosure by sewing down the weave perimeter to the enclosure.

Mix and match weaving types on the ice fishing hut.

Diagram 6 - Enclosure Type - Weaved Enclosure Variations

ENCLOSURE TYPE WEAVED

Pelts of bioplastics are layed over each other to create the enclosure. Begin with the base enclosure then overlay and stitch the pelts on.

Pelts can be made with emdebbed seed and nutrient bioplastics as well as with reinforced plastics such as those stitched in grid patterns.

Pelting the ice fishing huts can allow for a variation of lighting effects and privacy screens to be created within the huts enclosure.

ENCLOSURE TYPE PELTED

SEED APPLICATION

The type of seed and nutrient applied to the ice fishing huts can affect the kind of seed application required. The seed and nutrient application variability is ultimately due to the need for the seeds and nutrients to survive during the fishing season and transport to Contrecoeur's wetlands. American Eelgrass is one of those plant species needing a particular seed application to be applied to the ice fishing huts. These applications come in the form of sediment pods, pockets or capsules to allow for the seedlings to be successfully sown first into the soil and grow into mature plants within the wetlands⁸⁴.

See diagrams ## for the different types of seed applications that can be used on the ice fishing huts design.

EMBEDDED

To embed seeds or nutrients into the mixture as the last step before pouring the mixture onto its respective trays.

Additional additives can be introduced as well as reinforcing applications. Such as grid sowing.

PODS

Use the sheet to make pouches where seeds can be mixed with soil to add weight and support in seed germination for aquatic type plants.

Embedded sheets, weaved or regular sheets of bioplastics can be used to produce pods.

Use a decomposable rope material to close the pod. The pods can then be placed in Tufted enclosure types.

SEED APPLICATIONS

Diagram 8 - Seed Application - Pods for seeds and nutrients

STUFFED

This method of seed application is similar and should be used in tandem with tufted and layered enclosure types.

Diagram 9 - Seed Application - Stuffed Pockets

HUT ASSEMBLY AND DESIGN

DESIGN CONCEPTION:

The design of the ice fishing huts took precedents from structural characteristics and weather-resistant features of both indigenous shelters constructed to withstand similar winter conditions to that of the St-Lawrence River⁸⁵, as well as the Frei Otto and Christopher Alexander's structural research on lightweight tensile structures⁸⁶. The parabolic curves framing the ice fishing hut not only help resist high wind loads and shed both rain and snow off of the ice fishing huts roofs. But, creating ample open space for the ice fishers to stand upright and prepare baits, lines, gut fish, grab a beer, prepare a meal and be able to quickly leave the hut to catch a fish or check the lines and bait.

The huts are designed to be easily manufactured and assembled by the ice fishing community, with the use of ingredients sourced from Contrecoeur and the St-Lawrence river vast neighbouring area of starch-based agriculture. The locally sourced ingredients will make up most of the ice fishing huts composition, making its dissolve during spring thaw a non-invasive act. By making the ice fishing huts easy to assemble, fabricate as well as customize at home, allows for rapid adoption of the bioplastic typology from the community as well as create an opportunity for annual variability in ice fishing hut designs on both an individual and community scale.

57. KATHE SHELTER - A NORTH AMERICAN INDEGENOUS SHELTER TYPOLOGY

58. FREI OTTO - TENSILE STRUCTURE DIAGRAMS

85. Jonathan. Horning. Simple Shelters : Tents, Tipis, Yurts, Domes and Other Ancient Homes, 1st U.S. ed. (New York: Walker & Co., 2009).

86. Philip Drew, Frei Otto : Form and Structure (Boulder, Colo: Westview Press, 1976).

Daylight: is shown in the central bar of the daylighting section. The below bars represent hours between midnight and sunrise, while the top portion represents the hours between sunset and midnight. Totalling a full 24hr day.

Wind Speed: The data on wind speeds represents the maximum mean wind speed in the central bar and to the left the mean wind speeds for the given month. Wind gust data and wind direction data for this given station was missing.

Temperature: The data shown is of Contrecoeurs mean maximum daily temperature for that month as well as the mean temperature for that month. The max is displayed in the central bar and gives an idea of when might the ice fishing huts transition its function.

Precipitation: Contrecoeurs precipitation data is split up into mean monthly precipitation (mm) down the central bar, mean monthly snow fall to the right and mean monthly rain fall to the left of the central bar.

CLIMATE NORMALS FOR CONTRECOEUR MEASURED BETWEEN 1990-2019

Diagram II - Ice Charts for Contrecoeur During March 2019

- Jonathan Delisle and Natasha Fee, Ice Observation Chart Sector: Contrecoeur to Grondines, Daily Ice Charts (Beauharnois to Contrecoeur: Government of Canada, n.d.),
 - Jonathan Delisle and Natasha Fee, Ice Observation Chart Sector: Beauharnois to Contrecoeur, Daily Ice Charts (Beauharnois to Contrecoeur: Government of Canada, n.d.).

OFF-SITE CONSTRUCTION

COOKING THE MATERIALS

Select ingredients in Table I and refer to chapter four for recipes.

MATERIAL QUANTITIES

Enclosures:

To establish the quantity of bioplastic needed to produce for the assembly of the desired ice fishing hut, refer to the 'material cut-out' template of the given ice fishing huts assembly pamphlet (Diagram ## - to be featured at defence) for information on its enclosures surface area. This template will help deduce an approximate volume of ingredients required to produce the bioplastic enclosure. As the ice fishing huts are meant to be customizable and hybridized to the ice fisher's aesthetic, functional needs, as well as the ice fishing huts target contaminations and location on the river will determine the quantity of material required to produce.

Stitch straps at the corner of each panel to be able to tie the enclosure to the structural frame.

Apply the enclosure types onto the base enclosure template.

Stitch together each bay of panels together to form the enclosure.

Diagram 12 - Enclosure cut-out sheet for Medium Size Ice Fishing Hut

Structural Frame:

Refer to the chosen ice fishing huts assembly pamphlet (Appendix #) to determine the quantities needed for assembling the structural frame of the ice fishing hut. Each size ice fishing hut is associated with a defined outer perimeter and rod lengths, allowing the ice fisher to cut bioplastic rods to size for following a template found in that ice fishing huts pamphlet.

Each ice fishing hut pamphlet will include a structural frame on-site assemble procedure. With methods on securing the frame.

Diagram 13 - BIOPLASTIC RODS CUT TO ROUGHLY ONE METER WITH EXTENDERS TO MAKE LONGER RODS

Fabrication of Enclosure Types, Seed and Nutrient Applications

Enclosure types and seed application assemblies are to be fabricated off-site during the summer and fall seasons in preparation for on-site construction at the start of the ice fishing season. See proceeding diagrams for information on enclosure types and seed and nutrient application types to be fabricated for chosen the ice fishing hut.

See diagrams 3-9 and 11-12 for enclosure type and seed nutrient applications.

Hybridizing enclosures:

Tools needed: hand sowing required or sowing machine - naturally decomposing thread (similar to suture thread) or organic unbleached or processed threads such as hemp ropes.

To hybridize the enclosure with an assortment enclosure types, begin by creating a base enclosure layer with the cut-out template of the chosen ice fishing hut (See diagram ##). Once the base layer is completed, hybridizing can occur by stitching together, layering on top or change sections of the cut-out with varying types of enclosures.

ON-SITE CONSTRUCTION

The ice fishing huts can begin to be deployed and assembled when weather conditions and ice charts mark a safe time to access the St-Lawrence river. After reaching the desired location to ice fish (whether it be Location A, B or C), find a designated spot on the ice deemed safe for ice fishing and begin preparing the space for the ice fishing huts on-site assembly.

Prepping site and Hut anchors:

Tools needed: Shovel, string, pin, drill with a 3/4" dia. and 1/2" drill bit that measures 9 inches in length.

Begin by clearing and placing the snow off to the edge of the site for future use. Once the site has been cleared, follow the template found in the selected ice fishing hut to draw out an outline of its base perimeter. After marking the outline of the hut, divide the base perimeter by marking off the anchor holes locations for the structural shell. Drill holes at 6 inches deep, making sure to use the proper diameter drill bit for the appropriate holes.

Structural Framing assembly:

Tools needed: hands and brackets for frame connection.

The structural frame of the ice fishing hut is designed to be easily assembled on site. Depending on the size of the ice fishing hut, they can either be assembled alone or with a party of ice fishers. See assembly pamphlet of the chosen hut size for information relating to the number of ice fishers required for assembly. Follow the steps shown in the assembly diagram to erect the structural frame successfully. Once the frame has been erected, bore a hole through the ice to retrieve some river water to pour atop the anchor holes, freezing the frame to the ice, increasing the frame's structural strength at times when the St-Lawrence rivers winter conditions become extreme.

Enclosing Hut:

Securing the enclosure to the structural frame is crucial in keeping the ice fishing hut operational for the extend of the ice fishing season. It needs to be correctly secured, that wind, snow and rain won't affect the ice fishing huts integrity as well as keep the interior sheltered. By tying down the enclosure to the frame at an interval of one foot on each structural member, using a high strength decomposable strings, will allow for the enclosure and the frame to act in tandem with one other, further strengthening the ice fishing hut.

Additional support and resistance to wind gusts

Tools required: Shovel & bucket

The excess snow removed from the site can be added around the base of the ice fishing hut, further anchoring it to the ice. If further anchoring is thought to be required, pouring some of the river's water onto the snow will solidify perimeter to the ice, unifying the ice fishing hut permanently to the ice.

In addition, one can also use the excess snow to create a windbreak or wind wall, blocking heavy winds blowing downstream of the St-Lawrence River. This additional wind barrier will, in turn, create a more comfortable immediate temporal environment as the winds will be reduced, allowing for the ice fishers to take outdoors for an extended period.

Clean up & Move-in

Upon installation of the enclosure and other features of the ice fishing hut, remove any residual assembly debris from the site before moving in and starting the ice fishing season.

General on-site assembly process for Ice Fishing Hut

- 3 Enclose frame and secure it to the structure
- 2 Erect structural frame
- 1 Holes drilled at 6 inch depth in ice to secure ice fishing hut frame to the ice

Diagram 14 - Exploded Axonometric view of basic steps of assembly

59. IMAGE OF ICE FISHING VILLAGE TAKEN FROM THE SHORE

CHAPTER EIGHT THE PROCESS - TREATMENT

CHAPTER 8: THE PROCESS - TREATMENT

DURING ITS USE (IN PILL BOX)

The ice fishing huts will allow for shelter from Quebec's harsh winter conditions during peak ice fishing season, between Mid-January to Mid-March, although due to climate change, this window is getting smaller. Its function is to provide a wind barrier, partial insulation as well as act as a sunshade for bright winter days.

ITS DEGRADATION AND JOURNEY (INGESTION)

Since the ice fishing huts are designed to dissolve when fully submerged in water due to their materiality being entirely assembled with water-soluble bioplastics. The intent is to leave the ice fishing huts abandoned on the ice for the remainder of winter, where the ice fishing huts will plunge into the river as the ice breaks apart and melts. The natural degradation and flow of ice during Spring Thaw is a reason for designing the huts for various locations. Ice drift, ice damming and the spring current is unpredictable but measurable therefore by spreading the "capsules" in multiple locations we can assure some nutrients and seeds will drift ashore in Contrecoeur's Wetlands.

60. Conceptualized Journey of Ice Fishing Huts to the Wetlands

REMEDICATION (DIGESTION)

The images below show the sowing and remediation process simulated within a terrarium constructed to mimic the shoreline and wetland conditions of Contrecoeur. This study first began by stabilizing the terrarium's ecosystem by using vegetation analogous to Contrecoeurs wetlands such as *Hedera Helix* L. and *Fatshedera Lizei* to recreate its ecosystem. In addition, the introduction of *Trichorhina Tomentosa*, an insect to help fertilize and mix the terrarium's soil. As the terrarium stabilized, a bioplastic sheet, embedded with *Medicago Sativa*, was broken apart into smaller pieces and placed in the terrarium to simulate the larger fragments of undissolved bioplastics drifting up ashore. The terrariums were watered daily to simulate Contrecoeur's annual spring rain and flooding. After a week within the terrarium, the *Medicago Sativa* seeds had sown into the soil and began sprouting.

61. Images of Terrariums with *Medicago Sativa* (top row) and Broadleaf Cattails sprouting (Bottom Row)

THE SECOND LIFE (HEALING)

The Ice fishing huts second life comes in the form of its seedlings maturing during the spring and summer months, ultimately anchoring their root system into the soil and sediment of Contrecoeurs wetlands to begin their intended **rehabilitation** process. These plants are not only intended to **rehabilitate** the current concentrations of contaminants observed and documented in Contrecoeur's Wetlands⁸⁷. But continue to act as metabolizers and filters for the potential contaminants that will drift into the wetlands by upstream effluent discharge from the city of Montreal, the wetlands neighbouring industrial park in addition to the proposal for the Montreal's port expansion to be situated upstream of the Wetlands in Contrecoeur. The remediation of Contrecoeur's wetlands would be a long process, undergoing multiple phases of plant and nutrient selections and cycles for the removal of the various heavy metal and organic compounds that have accumulated within the wetlands.

⁸⁷. Pelletier, "Sediment Quality in the Fluvial Section of the St. Lawrence."

62. Photo of Contrecoeurs wetlands

CONCLUSION

THESIS CONCLUSION:

The aim of this thesis was to look at the materiality of bioplastics as an architectural material. It used bioplastics for user-assembled/dissolvable ice fishing huts as a means of engaging a local community in the bioremediation of its ecosystem and wetlands. By personifying the town of Contrecoeur as an ill-patient seeking medical aid, the thesis examined a seasonal prescription of medicinal ice fishing huts, as a remediative vessel to lessen the effects of pollution. The project associates Contrecoeur's ecology to a set of organs in the human body, the organs working in unison allows the reader to develop a kinship towards Contrecoeur. In doing so, the first part of the thesis expresses a parallel in how humanity should view the health, treatment and rehabilitation of ecosystems with similar ethical duty and urgency as they do towards human life.

The second part of the thesis, the Guidebook, helps to answer my thesis question on how temporary architecture can use the analogy of pharmaceuticals as a means of rehabilitating contaminated sites. Can architecture act as a medicative pill? In response, the thesis conducted a series of material studies starch-based bioplastics to gauge the feasibility of the production and dissolution of bioplastics as a remediative device. These bioplastics would be used as an architectural material for ice fishing huts. The Guidebook is the resultant bioplastic recipe and ice fishing hut assembly pamphlet to be distributed throughout the ice fishing community in Contrecoeur to promote a community-engaged action plan for the bioremediation of its local wetlands.

By exploring the degree of adaptability and variability in bioplastics as a dissolvable architectural material for the rehabilitation of Contrecoeur's protected wetlands. This thesis promotes deployable, dissolvable and decomposable temporary architecture as part of a response to both environmental rehabilitation and other emergency needs and crises where temporary structures might be needed. In so doing, this thesis ultimately supports the need for architects to consider all species as well as the architecture's post use within the design development phase and material selection.

14. Images of ice fishing huts off the shores of Contrecoeur (2020-02-17)
 15. "Pill Identifier (Drug & Pill Finder)" - Medscape Reference. Accessed March 19, 2020. <https://reference.medscape.com/pill-identifier>.

POSTSCRIPT

If the thesis had a bit more time it would have looked into fluid simulation models of both sediment, water and ice flow along the fluvial section of the St. Lawrence River, where Contrecoeur and its wetlands are situated. These simulations would have allowed for more accurate analysis of the site's seasonal fluvial morphological variations. The result of this simulation would have allowed the research to better predict the precise locations of the various ice fishing hut as well as aid in determining the rate of dispersal of the dissolving bioplastics during spring thaw season.

In addition, the materiality and ingredients for the manufacturing of the bioplastics currently utilized over the counter food sources for its starches, citric acids and pectin. As the extremes of both food scarcity and an increase in food waste becomes more of a issue, this thesis would begin researching a method of utilizing food waste to reduce its dependency on still edible food and gain the proper ingredients where these ingredients can be sold in bulk stations at local home hardware stores.

The implementation of a prototype or a prototype colony of ice fishing huts, using a multi-disciplinary team made up environmental geographers, physical geographers, biochemists, biologist, architects, structural engineers, climatologist, environmental ethics experts including, if necessary, governmental bodies at the local, provincial and federal levels as this site touches on all three governing jurisdictions.

This Master of Architecture thesis sought to continue a discussion of our industrial and consumption-driven human culture, and its implications to the state of health of the ecosystems we both live off of, and exploit, for humans' (anthropogenic) economic benefit. By considering the site for this thesis not in the traditional architectural sense of having property lines and dimensions but as the client. I was able to use architecture as the vessel for the rehabilitation and preventative care for the site. By using the notion of pharmacology as architecture, I was able to explore the materiality of pill capsules, being a form of dissolvable plastic, as an architectural material for the project. This material study of bioplastics as a dissolvable temporary architectural material allowed me to ironically use plastics, production, consumption and disposal as a method for the site's rehabilitation by making the architecture the seasonal vitamins the site would need to stay healthy. The idea of this thesis project is not to promote medicating our ecosystems but to bring awareness of the possibilities of less invasive, community-driven landscape rehabilitation methods.

The Guidebook and pamphlets are intended to be instructional pieces for the community to begin practicing the production of dissolvable bioplastic ice fishing huts with the aim for them to evolve away from the guidebooks and pamphlets and onto their own production and design. With the use of dissolvable bioplastic as the main construction material for the huts, I was able to play with the irony of mass consumption, disposability of material and plastics, as well as our acceptance to pop-culture and rapid trends in digital media to give the community opportunity in continuing their creativity and self-expression in the design of their huts. This is positive waste – one where each season they would allow for a renewed approach to remediation while simultaneously exploring new methods of material making and design.

BIBLIOGRAPHY

"Association de Chasse et Pêche de Contrecoeur - The Festival of Brimbale." Accessed December 17, 2019. <https://acpcontrecoeur.com/peche-blanche-sur-la-glace/le-festival-de-la-brimbale.html>.

Board on Environmental Studies and Toxicology, Committee on Remediation of PCB-Contaminated Sediments, National Research Council, Division on Earth and Life Studies, and National Academy of Sciences. *A Risk Management Strategy for PCB-Contaminated Sediments*. Washington, D.C., UNITED STATES: National Academies Press, 2001. <http://ebookcentral.proquest.com/lib/oculcarleton-ebooks/detail.action?docID=3377826>.

Champoux, Louise, and Phillippe Beaupre. "Great Blue Heron: A Sentinel Species for the State of the St. Lawrence." Minister of the Environment and Climate Change and Quebec's Minister of Sustainable Development, Environment and the Fight against Climate Change, 2015.

"Development and Characterization of Cassava Starch Films Incorporated with Blueberry Pomace - ScienceDirect." Accessed November 7, 2019. <https://www.sciencedirect.com/science/article/pii/S0141813017316975>.

Drew, Philip. *Frei Otto : Form and Structure*. Boulder, Colo: Westview Press, 1976.

Dunne, Margaret. "Bioplastic Cookbook: A Catalogue of Bioplastic Recipes." *FabTextiles // IAAC*, 2018. <https://fabtextiles.org/bioplastic-cook-book/>.

Dyke, Arthur, and Victor Prest. "Late Wisconsinan and Holocene History of the Laurentide Ice Sheet." *Géographie Physique et Quaternaire* 41, no. 2 (1987): 237-63. <https://doi.org/10.7202/032681ar>.

Erickson, Mitchell D., and Robert G. Kaley. "Applications of Polychlorinated Biphenyls." *Environmental Science and Pollution Research* 18, no. 2 (February 1, 2011): 135-51. <https://doi.org/10.1007/s11356-010-0392-1>.

Fabunmi, Olayide, Lope Tabil, Satyanarayan Panigrahi, and Peter Chang. "Developing Biodegradable Plastics from Starch." January 1, 2007. <https://doi.org/10.13031/2013.24179>.

Faircloth, Billie. *Plastics Now : On Architecture's Relationship to a Continuously Emerging Material*. Abingdon, Oxon : Routledge, 2015.

Gouvernement of Quebec. "Sport Fishing in Québec Fishing Periods, Limits and Exceptions." Government of Canada. Accessed February 15, 2020. https://peche.faune.gouv.qc.ca/regpec/en/Info/Reglements?Id_Zone=8.

Haraway, Donna J., ed. "Making Kin: Anthropocene, Capitalocene, Plantationocene, Chthulucene." In *Staying with the Trouble: Making Kin in the Chthulucene*. O. Duke University Press, 2016. <https://doi.org/10.1215/9780822373780-005>.

Health Canada. "PCBs - It's Your Health." Ministry of Health Canada, October 2005. <https://www.canada.ca/en/health-canada/services/healthy-living/your-health/environment/pcbs.html>.

Historic Canada. "Contrecoeur." In *The Canadian Encyclopedia*, March 4, 2015. <https://www.thecanadianencyclopedia.ca/en/article/contrecoeur>.

Horning, Jonathan. *Simple Shelters : Tents, Tipis, Yurts, Domes and Other Ancient Homes*. 1st U.S. ed. New York: Walker & Co., 2009.

IRDA. "Soil Surveys." IRDA. Accessed December 15, 2019. <https://www.irda.qc.ca/en/services/protection-resources/soil-health/soil-information/soil-surveys/>.

Jing, Ran, Soliver Fusi, and Birthe V. Kjellerup. "Remediation of Polychlorinated Biphenyls (PCBs) in Contaminated Soils and Sediment: State of Knowledge and Perspectives." *Frontiers in Environmental Science* 6 (2018): 79. <https://doi.org/10.3389/fenvs.2018.00079>.

Jiugao, Yu, Wang Ning, and Xiaofei Ma. "The Effects of Citric Acid on the Properties of Thermoplastic Starch Plasticized by Glycerol." *Starch - Stärke* 57 (October 1, 2005): 494-504. <https://doi.org/10.1002/star.200500423>.

"Learn about Polychlorinated Biphenyls (PCBs) | Polychlorinated Biphenyls (PCBs) | US EPA." Accessed November 7, 2019. <https://www.epa.gov/pcbs/learn-about-polychlorinated-biphenyls-pcbs>.

Leopold, Aldo, 1886-1948. *A Sand County Almanac, and Sketches Here and There*. Book. Whole. New York: Oxford University Press, 1987.

M. K. Marichelvam, Mohammad Jawaid, and Mohammad Asim. "Corn and Rice Starch-Based Bio-Plastics as Alternative Packaging Materials." *Fibers* 7, no. 4 (2019): 32. <https://doi.org/10.3390/fb7040032>.

MacDonald, Graham, and Elena Bennett. "Phosphorus Accumulation in Saint Lawrence River Watershed Soils: A Century-Long Perspective." *Ecosystems* 12 (June 1, 2009): 621-35. <https://doi.org/10.1007/s10021-009-9246-4>.

McDonough, William, and Michael Braungart 1958. *Cradle to Cradle: Remaking the Way We Make Things*. 1st ed. Book. Whole. New York: North Point Press, 2002.

MOHAPATRA, ABHIJIT, SHRUTI PRASAD, and HEMANT SHARMA. "Bioplastics- Utilization of Waste Banana Peels for Synthesis of Polymeric Films." Thesis, University of Mumbai, 2014. https://www.researchgate.net/publication/272351686_Bioplastics-_utilization_of_waste_banana_peels_for_synthesis_of_polymeric_films.

Morton, Timothy. *Being Ecological*. 1st ed., 2018.

Ojuederie, Omena Bernard, and Olubukola Oluranti Babalola. "Microbial and Plant-Assisted Bioremediation of Heavy Metal Polluted Environments: A Review." *International Journal of Environmental Research and Public Health* 14, no. 12 (December 4, 2017): 1504. <https://doi.org/10.3390/ijerph14121504>.

Pelletier, Magella. "Sediment Quality in the Fluvial Section of the St. Lawrence." *St. Lawrence Action Place - Monitoring the State of the St. Lawrence River*, 2019, 10.

Pham, Thanh-Thao, and Suzie Proulx. "PCBs and PAHs in the Montreal Urban Community (Quebec, Canada) Wastewater Treatment Plant and in the Effluent Plume in the St Lawrence River." *Water Research* 31, no. 8 (August 1997): 1887-96. [https://doi.org/10.1016/S0043-1354\(97\)00025-0](https://doi.org/10.1016/S0043-1354(97)00025-0).

Prakash, Ajay, Hariom Soni, Abhishek Mishra, and Phulen Sarma. "Are Your Capsules Vegetarian or Nonvegetarian: An Ethical and Scientific Justification." *Indian Journal of Pharmacology* 49, no. 5 (2017): 401-4. https://doi.org/10.4103/ijp.IJP_409_17.

Reich, Gabriele. "Formulation and Physical Properties of Soft Capsules." *Pharmaceutical Capsules*. Pharmaceutical Press, London, 2004, 201-12.

Savage, Caroline, Alain Armelin, and Martin Jean. "Benthic Macroinvertebrate Communities." Minister of the Environment and Climate Change and Quebec's Minister of Sustainable Development, Environment and the Fight against Climate Change, 2013. http://planstlaurent.qc.ca/fileadmin/publications/fiches_indicateurs/Communaut%C3%A9s_benthiques_ENG.pdf.

St-Lawrence Action Plan, and MDDEELCC. "Land Cover Mapping of the St. Lawrence Lowlands." Landcover shape file. Government of Canada, 2018. <http://data.ec.gc.ca/data/sites/systems/land-cover-mapping-of-the-st-lawrence-lowlands/?lang=en>.

Turan, Metin, and Sezai Ercisli. "Evaluation of Phytoremediation Potential of Rose Species." *Asian Journal of Chemistry* 19 (November 1, 2007): 4895–4902.

USDA. "Plants Profile for *Vallisneria Americana* (American Eelgrass)." Government. USDA - Natural resources conservation service - plant database. Accessed March 4, 2020. <https://plants.usda.gov/core/profile?symbol=VAAM3>.

Xiong, Z., L. Zhang, S. Ma, Y. Yang, C. Zhang, Z. Tang, and J. Zhu. "Effect of Castor Oil Enrichment Layer Produced by Reaction on the Properties of PLA/HDI-g-Starch Blends." *Carbohydrate Polymers* 94, no. 1 (2013): 235–43. <https://doi.org/10.1016/j.carbpol.2013.01.038>.

Xiong, Zhu, Songqi Ma, Libo Fan, Zhaobin Tang, Ruoyu Zhang, Haining Na, and Jin Zhu. "Surface Hydrophobic Modification of Starch with Bio-Based Epoxy Resins to Fabricate High-Performance Polylactide Composite Materials." *Composites Science and Technology* 94 (April 9, 2014): 16–22. <https://doi.org/10.1016/j.compscitech.2014.01.007>.

Zakaria, N H, N Muhammad, A V Sandu, and M M A B Abdullah. "Effect of Mixing Temperature on Characteristics of Thermoplastic Potato Starch Film." *IOP Conference Series: Materials Science and Engineering* 374 (June 2018): 012083. <https://doi.org/10.1088/1757-899x/374/1/012083>.

PAMPHLETS

1 PICK LOCATION

LOCATION #3
LIGHT HUTS

LOCATION #2
MEDIUM HUTS

LOCATION #1
HEAVY HUTS

SEDIMENT
SCOUR

Location 3 - Light Huts

Location 2 - Medium Huts

Location 1 - Heavy Huts

- ★ PCB
- METALS
- ◆ MERCURY
- ▲ PHA
- + BDE99

CONTAMINANT CONCENTRATION

LOCATION #1
HEAVY HUTS

LOCATION #2
MEDIUM HUTS

2 PICK TYPE OF ICE FISHING HUT

3 MAKE BIOPLASTICS

1 PICK YOUR INGREDIENTS

Ingredient	# of mixes	Gross Quantity	Base Ratio	Quantity	Scalar (X or +)	Total Quantity
Starches	# of starches used	10g	10g / #n	=10g / #n	#	#
Plasticizers	# of plasticizers used	5 g	5g / #n	=5g / #n	#	#
Acids	# of acids used	1.5 g	1.5g / #n	=1.5g / #n	#	#
Water	100ml	100 ml	-	100ml	#	#
Fragrance Additives	# of scents used	10 drops	10 drops / #n	=10 drops / #n	#	#
Texture Additives	# of textures	Application dependent	Application dependent	Application dependent	#	#
Post Curing Additives	# of post processes	Application dependent	Application dependent	Application dependent	#	#
Structural Additives	# of additives	Application dependent	Application dependent	Application dependent	#	#

2 CALCULATE QUANTITIES

3 WEIGH INGREDIENTS

5 HEAT MIXTURE

4 MIX ALL INGREDIENTS

6 SPREAD BIOPLASTIC AND LET DRY IN WELL VENTILATED AREA

7 ASSEMBLE STRUCTURAL FRAME

8 ATTACH ENCLOSURE SECURELY TO FRAME

6 SET-UP SITE

9 ENJOY THE FISHING SEASON

4 HOW TO APPLY REMEDIATORS

5 MAKING ENCLOSURE TYPES

APPENDIX

MEDICAGO SATIVA

Alfalfa

Morphology/Physiology	
Active Growth Period	Spring, Summer, Fall
Fire Resistant	No
Flower Color	Purple
Flower Conspicuous	Yes
Foliage Color	Green
Foliage Porosity Summer	Moderate
Foliage Porosity Winter	Porous
Foliage Texture	Fine
Fruit/Seed Color	Brown
Fruit/Seed Conspicuous	No
Growth Form	Single Crown
Growth Rate	Rapid
Height at 20 Years, Maximum (feet)	
Height, Mature (feet)	2
Lifespan	Long
Nitrogen Fixation	High
Resprout Ability	No
Shape and Orientation	Erect
Growth Requirements	
Adapted to Coarse Textured Soils	No
Adapted to Fine Textured Soils	Yes
Adapted to Medium Textured Soils	Yes
Anaerobic Tolerance	None
CaCO3 Tolerance	High
Cold Stratification Required	No
Drought Tolerance	High
Fertility Requirement	High
Frost Free Days, Minimum	90
Moisture Use	High
pH, Minimum	6
pH, Maximum	8.5
Planting Density per Acre, Minimum	
Planting Density per Acre, Maximum	
Precipitation, Minimum	12
Precipitation, Maximum	65
Root Depth, Minimum (inches)	24
Salinity Tolerance	Medium
Shade Tolerance	Intolerant
Temperature, Minimum (°F)	-43
Reproduction	
Bloom Period	Spring
Commercial Availability	Routinely Available
Fruit/Seed Abundance	High
Fruit/Seed Period Begin	Summer
Fruit/Seed Period End	Summer
Fruit/Seed Persistence	No
Propagated by Bare Root	No
Propagated by Bulb	No
Propagated by Container	No
Propagated by Corm	No
Propagated by Cuttings	No
Propagated by Seed	Yes
Propagated by Sod	No
Propagated by Sprigs	No
Propagated by Tubers	No
Seed per Pound	226800
Seed Spread Rate	Slow
Seedling Vigor	High
Small Grain	No
Vegetative Spread Rate	Slow
Optimal for	
PCB	Yes **
Cadmium (Cd)	Yes
Lead (Pb)	Yes
Mercury (Hg)	Yes
PAH	Yes
Butyltins	Yes
Arsenic (Ag)	Yes
Chrome (Cr)	Yes
Copper (Cu)	Yes
Nickel (Ni)	Yes
Zinc (Zn)	Yes
BDE99	Yes

** Metabolizes contaminant

USDA, "Plants Profile for Medicago Sativa (Alfalfa)," Government, USDA - Natural resources conservation service - plant database, accessed February 23, 2020, <https://plants.usda.gov/core/profile?symbol=MESA>
Ran Jing, Saliver Fusi, and Birthe V. Kjellerup, "Remediation of Polychlorinated Biphenyls (PCBs) in Contaminated Soils and Sediment: State of Knowledge and Perspectives," Frontiers in Environmental Science 6 (2018): 79, <https://doi.org/10.3389/fenvs.2018.00079>
Valentin D. Piresso, Michael D. Cader, and Dan Undersander, "Resilience, Stability, and Productivity of Alfalfa Cultivars in Rainfed Regions of North America," Crop Science 59, no. 2 (2019): 800-810, <https://doi.org/10.2135/cropsci.2018.06.0372>
Canadian Food Inspection Agency Government of Canada, "The Biology of Medicago Sativa L. (Alfalfa)," March 5, 2012, <https://www.inspection.gc.ca/plant-health/plants-with-novel-traits/applicants/directive-94-02/biology/documents/medicago-sativa-1-eng/13309815254/1330981232369#461>

TYPHA LATIFOLIA

Broadleaf Cattail

Morphology/Physiology

Active Growth Period	Spring and Summer
Fire Resistant	No
Flower Color	Brown
Flower Conspicuous	No
Foliage Color	Green
Foliage Porosity Summer	Porous
Foliage Porosity Winter	Porous
Foliage Texture	Coarse
Fruit/Seed Color	Brown
Fruit/Seed Conspicuous	Yes
Growth Form	Rhizomatous
Growth Rate	Rapid
Height at 20 Years, Maximum (feet)	
Height, Mature (feet)	5
Lifespan	Moderate
Nitrogen Fixation	None
Resprout Ability	No
Shape and Orientation	Erect

Growth Requirements

Adapted to Coarse Textured Soils	Yes
Adapted to Fine Textured Soils	Yes
Adapted to Medium Textured Soils	Yes
Anaerobic Tolerance	High
CaCO3 Tolerance	Medium
Cold Stratification Required	No
Drought Tolerance	None
Fertility Requirement	Medium
Frost Free Days, Minimum	100
Moisture Use	High
pH, Minimum	5.5
pH, Maximum	8.7
Planting Density per Acre, Minimum	2728
Planting Density per Acre, Maximum	10000
Precipitation, Minimum	14
Precipitation, Maximum	180
Root Depth, Minimum (inches)	14
Salinity Tolerance	Low
Shade Tolerance	Intermediate
Temperature, Minimum (°F)	-36

Reproduction

Bloom Period	Late Spring
Commercial Availability	Routinely Available
Fruit/Seed Abundance	High
Fruit/Seed Period Begin	Summer
Fruit/Seed Period End	Fall
Fruit/Seed Persistence	Yes
Propagated by Bare Root	Yes
Propagated by Bulb	No
Propagated by Container	No
Propagated by Corm	No
Propagated by Cuttings	No
Propagated by Seed	Yes
Propagated by Sod	No
Propagated by Sprigs	Yes
Propagated by Tubers	No
Seed per Pound	
Seed Spread Rate	Moderate
Seedling Vigor	Medium
Small Grain	No
Vegetative Spread Rate	Rapid

Optimal for

PCB	Yes **
Cadmium (Cd)	Yes
Lead (Pb)	Yes
Mercury (Hg)	-
PAH	-
Butyltins	-
Arsenic (As)	-
Chromium (Cr)	-
Copper (Cu)	-
Nickel (Ni)	Yes
Zinc (Zn)	Yes
BDE99	-

** Metabolizes contaminant

USDA, "Plants Profile for Typha latifolia (Broadleaf Cattail)," Government, USDA - Natural resources conservation service - plants database, accessed February 23, 2020, <https://plants.usda.gov/core/profile?symbol=TYLA>
 Porceddu Diacanu et al., "WATER POLLUTION USING TYPHA ANGUSTIFOLIA," Annals of the Faculty of Engineering Hunedoara 17, no. 3 (2019): 695-700.
 Ahmet Samir, Erdal Onuk, and Halil Hasan, "The Accumulation of Heavy Metals in Typha latifolia L. Grown in a Stream Carrying Secondary Effluent," Ecological Engineering 33 (July 1, 2008): 278-84, <https://doi.org/10.1016/j.ecoleng.2008.05.006>.
 Michelle Stevens, "BROAD-LEAVED CATTAIL," (USDA, June 2003), https://plants.usda.gov/plantguide/pdf/cs_tylatp.pdf.

ROSA PALUSTRIS

Swamp Rose

Morphology/Physiology

Active Growth Period	Summer
Fire Resistant	No
Flower Color	Red
Flower Conspicuous	Yes
Foliage Color	Green
Foliage Porosity Summer	Moderate
Foliage Porosity Winter	Porous
Foliage Texture	Fine
Fruit/Seed Color	Yellow
Fruit/Seed Conspicuous	Yes
Growth Form	Rhizomatous
Growth Rate	Moderate
Height at 20 Years, Maximum (feet)	8
Height, Mature (feet)	8.2
Lifespan	Long
Nitrogen Fixation	None
Resprout Ability	Yes
Shape and Orientation	Erect

Growth Requirements

Adapted to Coarse Textured Soils	No
Adapted to Fine Textured Soils	Yes
Adapted to Medium Textured Soils	Yes
Anaerobic Tolerance	Medium
CaCO3 Tolerance	Low
Cold Stratification Required	No
Drought Tolerance	Low
Fertility Requirement	Medium
Frost Free Days, Minimum	95
Moisture Use	Medium
pH, Minimum	4
pH, Maximum	7
Planting Density per Acre, Minimum	2700
Planting Density per Acre, Maximum	3600
Precipitation, Minimum	35
Precipitation, Maximum	50
Root Depth, Minimum (inches)	18
Salinity Tolerance	None
Shade Tolerance	Tolerant
Temperature, Minimum (°F)	-33

Reproduction

Bloom Period	Spring
Commercial Availability	Routinely Available
Fruit/Seed Abundance	Medium
Fruit/Seed Period Begin	Summer
Fruit/Seed Period End	Summer
Fruit/Seed Persistence	Yes
Propagated by Bare Root	Yes
Propagated by Bulb	No
Propagated by Container	Yes
Propagated by Corm	No
Propagated by Cuttings	No
Propagated by Seed	Yes
Propagated by Sod	No
Propagated by Sprigs	No
Propagated by Tubers	No
Seed per Pound	
Seed Spread Rate	Slow
Seedling Vigor	Medium
Small Grain	No
Vegetative Spread Rate	Slow

Optimal for

PCB	Yes **
Cadmium (Cd)	Yes
Lead (Pb)	Yes
Mercury (Hg)	Yes
PAH	Yes **
Butyltins	Yes
Arsenic (As)	Yes
Chromium (Cr)	Yes
Copper (Cu)	Yes
Nickel (Ni)	Yes
Zinc (Zn)	Yes
BDE99	-

** Metabolizes contaminant

USDA. "Plants Profile for Rosa palustris (Swamp Rose)." Government. USDA - Natural resources conservation service - plant database, accessed February 23, 2020. <https://plants.usda.gov/core/profile?symbol=R0PA>.
 Ram Jang, Soliver Fusi, and Birthe V. Kjellerup. "Remediation of Polychlorinated Biphenyls (PCBs) in Contaminated Soils and Sediment: State of Knowledge and Perspectives." Frontiers in Environmental Science 6 (2018): 79. <https://doi.org/10.3389/fenvs.2018.00079>.
 Metin Iurek and Seza Trosil. "Evaluation of Phytoremediation Potential of Rose Species." Asian Journal of Chemistry 19 (November 1, 2007): 4895-4902.

Chenopodium Album

Lambsquarters

Morphology/Physiology	
Active Growth Period	Spring and Summer
Fire Resistant	-
Flower Color	Greenish
Flower Conspicuous	No
Foliage Color	Green or Grey or
Foliage Porosity Summer	Porous
Foliage Porosity Winter	Porous
Foliage Texture	Coarse
Fruit/Seed Color	Black *
Fruit/Seed Conspicuous	Yes
Growth Form	Rhizomatous
Growth Rate	Rapid
Height at 20 Years, Maximum (feet)	
Height, Mature (feet)	6
Lifespan	Moderate
Nitrogen Fixation	-
Resprout Ability	-
Shape and Orientation	Erect
Growth Requirements	
Adapted to Coarse Textured Soils	Yes
Adapted to Fine Textured Soils	Yes
Adapted to Medium Textured Soils	Yes
Anaerobic Tolerance	High
CaCO3 Tolerance	-
Cold Stratification Required	-
Drought Tolerance	Yes
Fertility Requirement	Medium
Frost Free Days, Minimum	100
Moisture Use	-
pH, Minimum	-
pH, Maximum	-
Planting Density per Acre, Minimum	-
Planting Density per Acre, Maximum	-
Precipitation, Minimum	-
Precipitation, Maximum	-
Root Depth, Minimum (inches)	-
Salinity Tolerance	-
Shade Tolerance	-
Temperature, Minimum (°F)	-36
Reproduction	
Bloom Period	June - August
Commercial Availability	-
Fruit/Seed Abundance	High
Fruit/Seed Period Begin	Summer
Fruit/Seed Period End	Fall
Fruit/Seed Persistence	Yes
Propagated by Bare Root	Yes
Propagated by Bulb	Yes
Propagated by Container	No
Propagated by Corm	No
Propagated by Cuttings	No
Propagated by Seed	Yes
Propagated by Sod	No
Propagated by Sprigs	Yes
Propagated by Tubers	No
Seed per Pound	
Seed Spread Rate	High
Seedling Vigor	Medium
Small Grain	No
Vegetative Spread Rate	Rapid
Optimal for	
PCB	Yes
Cadmium (Cd)	Yes
Lead (Pb)	Yes
Mercury (Hg)	-
PAH	-
Butyltins	-
Arsenic (As)	-
Chrome (Cr)	Yes
Copper (Cu)	Yes
Nickel (Ni)	Yes
Zinc (Zn)	Yes
BDE99	-

** Metabolizes contaminant

Ontario Weeds: Lambs Quarters, accessed February 28, 2020, http://www.omnifra.gov.on.ca/english/crops/facts/ontweeds/lambs_quarters.htm#tbl.

VALLISNERIA SPIRALIS

American Eelgrass

Morphology/Physiology	
Active Growth Period	Summer
Fire Resistant	Yes
Flower Color	
Flower Conspicuous	No
Foliage Color	Green
Foliage Porosity Summer	
Foliage Porosity Winter	
Foliage Texture	Fine
Fruit/Seed Color	Green
Fruit/Seed Conspicuous	No
Growth Form	Stoloniferous
Growth Rate	Rapid
Height at 20 Years, Maximum (feet)	
Height, Mature (feet)	1
Lifespan	Short
Nitrogen Fixation	None
Resprout Ability	No
Shape and Orientation	Decumbent
Growth Requirements	
Adapted to Coarse Textured Soils	Yes
Adapted to Fine Textured Soils	Yes
Adapted to Medium Textured Soils	Yes
Anaerobic Tolerance	High
CaCO3 Tolerance	Medium
Cold Stratification Required	No
Drought Tolerance	None
Fertility Requirement	Medium
Frost Free Days, Minimum	90
Moisture Use	High
pH, Minimum	5
pH, Maximum	8.8
Planting Density per Acre, Minimum	2700
Planting Density per Acre, Maximum	4800
Precipitation, Minimum	
Precipitation, Maximum	
Root Depth, Minimum (inches)	0
Salinity Tolerance	None
Shade Tolerance	Intolerant
Temperature, Minimum (°F)	-33
Reproduction	
Bloom Period	Mid Summer
Commercial Availability	Routinely Available
Fruit/Seed Abundance	Low
Fruit/Seed Period Begin	Summer
Fruit/Seed Period End	Summer
Fruit/Seed Persistence	No
Propagated by Bare Root	No
Propagated by Bulb	No
Propagated by Container	No
Propagated by Corm	No
Propagated by Cuttings	No
Propagated by Seed	Yes
Propagated by Sod	No
Propagated by Sprigs	Yes
Propagated by Tubers	No
Seed per Pound	135000
Seed Spread Rate	Moderate
Seedling Vigor	Medium
Small Grain	No
Vegetative Spread Rate	Moderate
Optimal for	
PCB	Yes
Cadmium (Cd)	Yes
Lead (Pb)	Yes
Mercury (Hg)	Yes
PAH	Yes
Butyltins	-
Arsenic (Ag)	Yes
Chrome (Cr)	-
Copper (Cu)	Yes
Nickel (Ni)	-
Zinc (Zn)	Yes
BDE99	-

** Metabolizes contaminant

USDA, "Plants Profile for Vallisneria Americana (American Eelgrass)," Government, USDA - Natural resources conservation service - plant database, accessed March 4, 2020, <https://plants.usda.gov/core/profile?symbol=VAAA>.

FLAT-PACK ICE FISHING HUT FOR ICE FISHERS ON-THE-GO

This design allows the user to pick and move between various spots on the river to sit down in shelter and ice fish. The rigid frame is made up of Polylactic acid (PLA) biodegradable plastic made from sugars. This frame will be able to handle medium strength winds while expanded and be able to contract into a flat 2m by 1.5m space for easy transport off the river. Ideally the frame would last longer than the Bioplastic tenting that will cover the frame. This will permit for multi-season use of the frame. Where the Bioplastic tenting would be a single season use, that would be left on the ice after its final use to later dissolve during spring thaw.

Flat Pack State

Detail of Pivot Point

Opened state

The geodesic dome ice fishing hut structure is designed for easy of assembly as well as for its strong structural capabilities once assembled. Seeing as this Ice fishing hut will be installed in place seasonally, A stronger structure is needed to withstand the harsh micro-climate the St-Lawrence river can experience during the winter season. The geodesic dome is constructed using PLA or another rigid bioplastic, acting as the structural frame of the dome. Where a more flexible translucent bioplastic, such as the iterations mentioned above, bringing in natural lighting, visual and sensorial aesthetics to the space. Once its seasonal function has been fulfilled, the idea is that the two different materials of the geodesic dome would have different functions and targeting difference areas of contamination. Resembling the functionality of time-released medication.

EASY ASSEMBLE GEODESIC DOME ICE FISHING HUT

TRADITIONAL ICE FISHING HUT MADE WITH A PLA FRAME

The traditional typology for a north American ice fishing hut has been adopted for this iteration. This is to allow the users to use conventional wood frame construction techniques to build the hut. Although, with unconventional materials. Similar to the preceding designs, the structure of the hut is made of PLA or other rigid bioplastic parts. Where the parts would be manufactured to resemble studs and joist. Its sheathing would be made from a softer bioplastic designed to dissolve at a quicker rate

then that of the structure. During its use, the interior of the hut would be lit up with natural lighting, taking on the colors casting through the bioplastics. In addition to its visual effects, as the plastics can be impregnated with a number of different scents. The user can also have a sensorial experience within. [i.e. Eucalyptus essential oil impregnated into the hut. Calming the nerves of a fisherman not catching fish.]