DATE: June 25, 2021

TO: Darrel Pyle, City Manager

THROUGH: Shawn O'Leary, Director of Public Works

FROM: Carrie Evenson, Stormwater Program Manager

SUBJECT: Approval of Contract with Riverman Engineering, PLC, for $17,667.71 for Design and Creation of a 3D Printed Interactive Model of the Lake Thunderbird Watershed for Public Education and Outreach

office memorandum

BACKGROUND:

In August 2010, the Environmental Protection Agency placed Lake Thunderbird on its 303(d) List of Impaired Waterbodies. This led to the establishment of a Total Maximum Daily Load (TMDL) by ODEQ in November of 2013.

The TMDL established waste load allocations (WLAs) for each of the cities. These WLAs established the maximum amount of each of the key pollutants of concern, total suspended solids, total nitrogen and total phosphorus, which each city can discharge to the Lake Thunderbird watershed. The TMDL also requires the Cities of Norman, Oklahoma City, and Moore to develop and implement Compliance and Monitoring Plans describing how each city will comply with the TMDL requirements. The Compliance Plan defines the steps to be taken by the City of Norman (City) in order to reduce stormwater pollution in the watershed and meet the load reduction requirements set out in the TMDL. The Monitoring Plan defines steps the City will take to establish a baseline quantifying the amounts of pollutants in the runoff, and it also establishes a mechanism to monitor the effectiveness of Best Management Practices (BMPs) put into effect by the City as a result of its compliance efforts. ODEQ approved the City's TMDL Compliance and Monitoring Plans on September 21, 2016, and required that the Monitoring Plan be fully implemented by November 12, 2016.

Implementation of the Plans is based on a 5 year permit cycle. The City began the first 5-year cycle by implementing a Monitoring Plan to establish a baseline for flow and pollutant loading of streams flowing from or through the City to Lake Thunderbird. Public education and outreach is a key component to compliance with the Lake Thunderbird TMDL. A 3D model of the Lake Thunderbird watershed will allow the public to physically interact with the actual topography of the watershed, observe how water flows through the watershed, and how their actions can impact water quality in Lake Thunderbird in a much more engaging and direct way than other generic stormwater models currently available.

DISCUSSION:

Based on the Stormwater Division's research, no one has ever attempted to 3D print a watershed. In order to determine if this was even possible, Dr. Robert Nairn, Professor of Environmental Science at the University of Oklahoma, was consulted. Dr. Nairn was not aware of anyone currently attempting this but did have another professor in mind who might be willing to try, Dr. Russell C. Dutnell. Dr. Dutnell specializes in watershed modeling and has a passion for 3D printing. He has obtained the data he needs to model the watershed and has printed several test pieces of the Lake Thunderbird watershed. With a few

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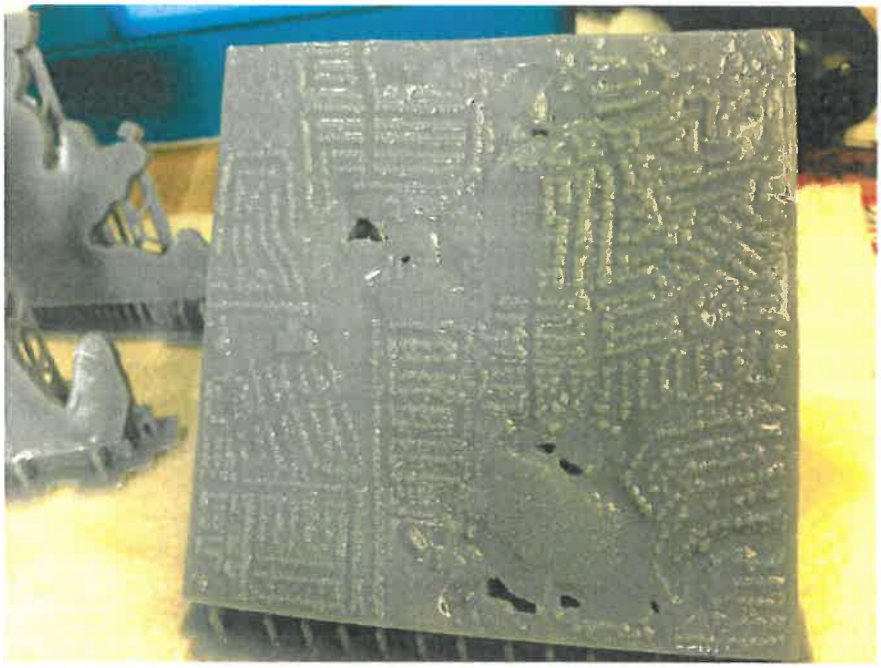
modifications, these test pieces have been successful. To complete the 3D printed model, the project will involve the following steps:

Phase 1: Prototyping
Phase 2: Obtaining DEM/LiDAR data
Phase 3: Converting DEM/LiDAR data to STL files
Phase 4: Preparing STL Files for printing
Phase 5: 3D Printing Parts
Phase 6: Priming Parts
Phase 7: Painting and assembly of watershed
Phase 8: Base construction and assembly
Phase 9: Base painting and decoration
Phase 10: Final Assembly



Prototype Section of Urban Norman including Eisenhower Elementary

Staff began negotiations with Riverman Engineering, PLC, in March 2021. Budgeted capital funds in the amount of $17,667.71 are available for this project in Account No. 50599968-46201, Project No. DR0061. The project is scheduled to begin in July 2021.

RECOMMENDATION:
Staff recommends approval of Contract between the City of Norman and Riverman Engineering, PLC, for design and construction of a 3D printed model of the Lake Thunderbird watershed.

Approved by: _____ Not Approved: _____

Reviewed by: Kathryn Walker, City Attorney

AGREEMENT FOR PROFESSIONAL SERVICES

THIS AGREEMENT is entered into between The City of Norman (OWNER) and Riverman Engineering, PLC (CONSULTANT) for the following reasons:

1. OWNER intends to model, print, and construct a 3D printed model of the Lake Thunderbird watershed for educational purposes (the Project); and,
2. OWNER requires certain professional survey, design, analysis and engineering services in connection with the Project (the Services); and,
3. CONSULTANT is prepared to provide the Services.

In consideration of the promises contained in this Agreement, OWNER and CONSULTANT agree as follows:

ARTICLE 1 - EFFECTIVE DATE

The effective date of this Agreement shall be __th day of _____, 20___.

ARTICLE 2 - GOVERNING LAW

This Agreement shall be governed by the laws of the State of Oklahoma.

ARTICLE 3 - SCOPE OF SERVICES

CONSULTANT shall provide the Services described in Attachment A, Scope of Services.

ARTICLE 4 - SCHEDULE

CONSULTANT shall exercise its reasonable efforts to perform the Services described in Attachment A according to the Schedule set forth in Attachment B.

ARTICLE 5 -COMPENSATION

OWNER shall pay CONSULTANT in accordance with Attachment C, Compensation.
Invoices shall be due and payable upon receipt. OWNER shall give prompt written notice of any disputed amount and shall pay the remaining amount.

ARTICLE 6 - OWNER'S RESPONSIBILITIES

OWNER shall be responsible for all matters described in Attachment D, OWNER'S Responsibilities. OWNER hereby represents that it owns the intellectual property rights in any plans, documents or other materials provided by OWNER to CONSULTANT. If OWNER does not own the intellectual property rights in such plans, documents or other materials, prior to providing same to CONSULTANT, OWNER shall obtain a license or right to use, including the right to sublicense to CONSULTANT. OWNER hereby grants CONSULTANT the right to use the intellectual property associated with plans, documents or other materials it owns or has the right to use for the limited purpose of performing the Services. OWNER represents that CONSULTANT'S use of such documents will not infringe upon any third parties' rights.

ARTICLE 7 - STANDARD OF CARE

The same degree of care, skill, and diligence shall be exercised in the performance of the Services as is ordinarily possessed and exercised by a member of the same profession, currently practicing, under similar circumstances. No other warranty, express or implied, is included in

this Agreement or in any drawing, specification, report, opinion, or other instrument of service, in any form or media, produced in connection with the Services.

ARTICLE 8 – INDEMNIFICATION AND LIABILITY

Indemnification. The CONSULTANT agrees to defend, indemnify, and hold harmless the OWNER, its officers, servants, and employees, from and against any and all liability, loss, damage, cost, and expense (including attorneys' fees and accountants' fees) caused by an error, omission, or negligent act of the CONSULTANT in the performance of services under this Agreement. To the extent permitted by law, including the Constitution of the State of Oklahoma, OWNER agrees to defend, indemnify, and hold harmless the CONSULTANT, its officers, servants, and employees, from and against any and all liability, loss, damage, cost, and expense (including attorneys' fees and accountants' fees) caused by an error, omission, or negligent act of the OWNER in the performance of services under this Agreement, provided such indemnification shall be applicable only to the extent sovereign immunity has been waived pursuant to Oklahoma law. The CONSULTANT and the OWNER each agree to promptly service notice on the other party of any claims arising hereunder, and shall cooperate in the defense of such claims. The acceptance by OWNER or its representatives of any certification of insurance providing for coverage other than as required in this Agreement to be furnished by the CONSULTANT shall in no event be deemed a waiver of any of the provisions of this indemnity provision. None of the foregoing provisions shall deprive the OWNER of any action, right, or remedy otherwise available to OWNER at common law.

Survival. The terms and conditions of this Article shall survive completion of the Services, or any termination of this Agreement.

ARTICLE 9 - INSURANCE

During the performance of the Services under this Agreement, CONSULTANT shall maintain the following insurance:
(a) General Liability Insurance, with a limit of
$1,000,000 per occurrence and $2,000,000 annual aggregate.
(b) Automobile Liability Insurance, with a combined single limit of $1,000,000 for each person and $1,000,000 for each accident.
(c) Workers' Compensation Insurance in accordance with statutory requirements and Employers' Liability Insurance, with a limit of $500,000 for each occurrence.
(d) Professional Liability Insurance, with a limit of
$1,000,000 per claim and annual aggregate.

CONSULTANT shall, upon written request, furnish OWNER certificates of insurance which shall include a provision that such insurance shall not be canceled without at least thirty days' written notice to OWNER. OWNER shall require all Project contractors to include OWNER, CONSULTANT, and its parent company, affiliated and subsidiary entities, directors, officers and employees, as additional insureds on their General and Automobile Liability insurance policies, and to indemnify both OWNER and CONSULTANT, each to the same extent.

ARTICLE 10 - LIMITATIONS OF RESPONSIBILITY

CONSULTANT shall not be responsible for (a) construction means, methods, techniques, sequences, procedures, or safety precautions and programs in connection with the Project; (b) the failure of any contractor, subcontractor, vendor, or other Project participant, not under contract to CONSULTANT, to fulfill contractual responsibilities to OWNER or to comply with federal, state, or local laws, regulations, and codes; or (c) procuring permits, certificates, and licenses required for any construction unless such procurement responsibilities are specifically assigned to CONSULTANT in Attachment A, Scope of Services. In the event the OWNER requests CONSULTANT to execute any certificates or other documents, the proposed language of such certificates or documents shall be submitted to CONSULTANT for review at least 15 days prior to the requested date of execution. CONSULTANT shall not be required to execute any certificates or documents that in any way would, in CONSULTANT's sole judgment, (a) increase CONSULTANT'S legal or contractual obligations or risks; (b) require knowledge, services or responsibilities beyond the scope of this Agreement; or (c) result in CONSULTANT having to certify, guarantee or warrant the existence of conditions whose existence CONSULTANT cannot ascertain.

ARTICLE 11 - OPINIONS OF COST AND SCHEDULE

Because CONSULTANT has no control over the cost of labor, materials, or equipment furnished by others, or over the resources provided by others to meet Project schedules, CONSULTANT's opinion of probable costs and of Project schedules shall be made on the basis of experience and qualifications as a practitioner of its profession. CONSULTANT does not guarantee that proposals, bids, or actual Project costs will not vary from CONSULTANT'S cost estimates or that actual schedules will not vary from CONSULTANT'S projected schedules.

ARTICLE 12 - RECORDS

CONSULTANT agrees that all final computations, exhibits, files, plans, correspondence, reports, drawings, designs, data and photographs expressly required to be prepared by CONSULTANT as part of the scope of services ("documents and materials") shall be the exclusive property of OWNER and shall, upon completion of the services or termination of this Agreement, be delivered to OWNER.

At OWNER's request, OWNER shall be entitled to immediate possession of, and CONSULTANT shall furnish to OWNER within ten days, all of the documents and materials. CONSULTANT may retain copies of these documents and materials.

Any substantive modification of the documents and materials by OWNER staff or any use of the completed documents and materials for other OWNER projects, or any use of uncompleted documents and materials, without the written consent of CONSULTANT, shall be at OWNER's sole risk and without liability or legal exposure to CONSULTANT. OWNER agrees to hold CONSULTANT harmless from all damages, claims, expenses and losses arising out of any reuse of the documents and materials for purposes other than those described in this Agreement, unless CONSULTANT consents in writing to such reuse.

CONSULTANT agrees that OWNER or its auditors shall have access to and the right to audit and reproduce any of CONSULTANT's relevant records to ensure that OWNER is receiving all services to which OWNER is entitled under this Agreement or for other purposes relating to the

Agreement. CONSULTANT shall maintain and preserve all such records for a period of at least three years after the expiration of this Agreement, or until an audit has been completed and accepted by OWNER. CONSULTANT agrees to maintain all such records in OWNER or to promptly reimburse OWNER for all reasonable costs incurred in conducting the audit at a location other than in OWNER, including but not limited to expenses for personnel, salaries, private auditor, travel, lodging, meals and overhead.

ARTICLE 13 - OWNERSHIP OF DOCUMENTS AND INTELLECTUAL PROPERTY

Except as otherwise provided herein, documents, drawings, and specifications prepared by CONSULTANT and furnished to OWNER as part of the Services, and any intellectual property rights attaching thereto, shall become the property of OWNER; provided, however, that CONSULTANT shall have the unrestricted right to their use for the purposes of its work pursuant to this AGREEMENT. CONSULTANT shall further retain its copyright and Ownership rights in its design, drawing details, specifications, data bases, computer software, and other proprietary property, and to any intellectual property developed, utilized, or modified in the performance of the Services, which intellectual property rights are identifiably separate from those transferred to OWNER hereunder.

ARTICLE 14 - TERMINATION AND SUSPENSION

This Agreement may be terminated by either party upon written notice in the event of substantial failure by the other party to perform in accordance with the terms of this Agreement; provided, however, the nonperforming party shall have 14 calendar days from the receipt of the termination notice to cure or to submit a plan for cure acceptable to the other party. OWNER may terminate or suspend performance of this Agreement for OWNER'S convenience upon written notice to CONSULTANT. CONSULTANT shall terminate or suspend performance of the Services on a schedule acceptable to OWNER, and OWNER shall pay CONSULTANT for all the Services performed. Upon restart of suspended Services, an equitable adjustment shall be made to CONSULTANT'S compensation and the Project schedule.

ARTICLE 15 - DELAY IN PERFORMANCE

Neither OWNER nor CONSULTANT shall be considered in default of this Agreement for delays in performance caused by circumstances beyond the reasonable control of the nonperforming party. For purposes of this Agreement, such circumstances include, but are not limited to, abnormal weather conditions; floods; earthquakes; fire; epidemics; war, riots, and other civil disturbances; strikes, lockouts, work slowdowns, and other labor disturbances; sabotage; judicial restraint; and delay in or inability to procure permits, licenses, or authorizations from any local, state, or federal agency for any of the supplies, materials, accesses, or services required to be provided by either OWNER or CONSULTANT under this Agreement. CONSULTANT shall be granted a reasonable extension of time for any delay in its performance caused by any such circumstances.

Should such circumstances occur, the nonperforming party shall, within a reasonable time of being prevented from performing, give written notice to the other party describing the circumstances preventing continued performance and the efforts being made to resume performance of this Agreement.

ARTICLE 16 - NOTICES

Any notice required by this Agreement shall be made in writing to the address specified below:

OWNER:

Carrie Evenson, Ph.D., P.E., CFM
Stormwater Program Manager
City of Norman
P.O. Box 370
Norman, OK 73070

Riverman Engineering, PLC
Russell C. Dutnell, P.E., Ph.D.
Owner
1504 Ann Arbor Drive
Norman, OK 73069

Nothing contained in this Article shall be construed to restrict the transmission of routine communications between representatives of OWNER and CONSULTANT.

ARTICLE 17 - DISPUTES

In the event of a dispute between OWNER and CONSULTANT arising out of or related to this Agreement, the aggrieved party shall notify the other party of the dispute within a reasonable time after such dispute arises. If the parties cannot thereafter resolve the dispute, each party shall nominate a senior officer of its management to meet to resolve the dispute by direct negotiation or mediation.

Should such negotiation or mediation fail to resolve the dispute, either party may pursue resolution of the dispute by arbitration in accordance with the Construction Industry Arbitration Rules of the American Arbitration Association; provided, however, in the event the parties are unable to reach agreement to arbitrate under terms reasonably acceptable to both parties, either party may pursue resolution in any court having jurisdiction. During the pendency of any dispute, the parties shall continue diligently to fulfill their respective obligations hereunder.

ARTICLE 18 – FAIR EMPLOYMENT PRACTICES

CONSULTANT agrees that all persons employed by CONSULTANT shall be treated equally by CONSULTANT without regard to or because of race, color, religion, ancestry, national origin, age, place of birth, disability, sex, sexual orientation, gender identity or expression, familial status, or marital status, including marriage to a person of the sex, or any other status protected by law, and in compliance with all antidiscrimination laws of the United States of America, the State of Oklahoma, and OWNER.

CONSULTANT agrees that, during the performance of this Agreement, CONSULTANT and any other parties with whom CONSULTANT may subcontract shall adhere to equal opportunity employment practices to assure that applicants and employees are treated equally and are not discriminated against because of their race, color, religion, ancestry, national origin, age, place of

birth, disability, sex, sexual orientation, gender identity or expression, familial status, or marital status, including marriage to a person of the same sex, or any other status protected by law.

CONSULTANT agrees to state in all of its solicitations or advertisements for applicants for employment that all qualified applicants shall receive consideration for employment without regard to their race, color, religion, ancestry, national origin, age, place of birth, disability, sex, sexual orientation, gender identity or expression, familial status, or marital status, including marriage to a person of the same sex, or any other status protected by law.

CONSULTANT shall provide OWNER staff with access to and, upon request by OWNER, provide copies to OWNER of all of CONSULTANT's records pertaining or relating to CONSULTANT's employment practices, to the extent such records are not confidential or privileged under State or federal law.

ARTICLE 19 - WAIVER

A waiver by either OWNER or CONSULTANT of any breach of this Agreement shall be in writing. Such a waiver shall not affect the waiving party's rights with respect to any other or further breach.

ARTICLE 20 - SEVERABILITY

The invalidity, illegality, or unenforceability of any provision of this Agreement or the occurrence of any event rendering any portion or provision of this Agreement void shall in no way affect the validity or enforceability of any other portion or provision of this Agreement. Any void provision shall be deemed severed from this Agreement, and the balance of this Agreement shall be construed and enforced as if it did not contain the particular portion or provision held to be void. The parties further agree to amend this Agreement to replace any stricken provision with a valid provision that comes as close as possible to the intent of the stricken provision. The provisions of this Article shall not prevent this entire Agreement from being void should a provision which is of the essence of this Agreement be determined void.

ARTICLE 21 - INTEGRATION

This Agreement, including Attachments A, B, C, and D incorporated by this reference, represents the entire and integrated agreement between OWNER and CONSULTANT. It supersedes all prior and contemporaneous communications, representations, and agreements, whether oral or written, relating to the subject matter of this Agreement.

ARTICLE 22 - SUCCESSORS AND ASSIGNS

OWNER and CONSULTANT each binds itself and its successors, executors, administrators, permitted assigns, legal representatives and, in the case of a partnership, its partners, to the other party to this Agreement and to the successors, executors, administrators, permitted assigns, legal representatives, and partners of such other party in respect to all provisions of this Agreement.

ARTICLE 23 - ASSIGNMENT

Neither OWNER nor CONSULTANT shall assign any rights or duties under this Agreement without the prior written consent of the other party, which consent shall not be unreasonably withheld; provided, however, CONSULTANT may assign its rights to payment without

OWNER'S consent. Unless otherwise stated in the written consent to an assignment, no assignment will release or discharge the assignor from any obligation under this Agreement. Nothing contained in this Article shall prevent CONSULTANT from engaging independent CONSULTANTS, associates, and subcontractors to assist in the performance of the Services.

ARTICLE 24 – FORCE MAJEURE
CONSULTANT and OWNER agree that neither OWNER nor CONSULTANT shall be responsible for delays or failures in performance resulting from acts beyond the control of either party. Such acts shall include, but not be limited to acts of God, strikes, lockouts, riots, acts of war, epidemics, governmental regulations imposed after this Agreement was executed, fire, communication line failures, earthquakes, or other disasters.

ARTICLE 25 – TIME OF ESSENCE
CONSULTANT and OWNER agree that time is of the essence in regard to performance of any of the terms and conditions of this Agreement.

ARTICLE 26 - NO THIRD PARTY RIGHTS
The Services provided for in this Agreement are for the sole use and benefit of OWNER and CONSULTANT. Nothing in this Agreement shall be construed to give any rights or benefits to anyone other than OWNER and CONSULTANT.

IN WITNESS WHEREOF, OWNER and Riverman Engineering, PLC, have executed this Agreement.

DATED this 23th day of JUNE, 2021.

The City of Norman
(OWNER)

Signature _____

Name DARRELL L. PYLE

Title CITY MANAGER

Date 6-22-21

Attest:

Brenda Hall

City Clerk

CITY OF NORMAN CORPORATE SEAL OKLAHOMA

Riverman Engineering, PLC
(CONSULTANT)

Signature _____

Name Russell C. Dartnell

Title Owner

Date 6/24/2021

Attest:

_____

Secretary

Approved as to form and legality this ____ day of _____ 20__.

_____

City Attorney

Attachment A. Scope of Work

3D Printing the Lake Thunderbird Watershed Proposal
Prepared by Russell C. Dutnell, P.E., Ph.D.; Riverman Engineering, PLC
May 26, 2021

In order to 3D print a model, you first have to create a "solid" model of it on the computer, that can be exported to a stereo-lithography (STL) file which 3D printer "slicing" software uses to create another file (which varies by printer) that the 3D printer uses to print the part. To my knowledge, nobody has ever 3D print a watershed. I certainly haven't, so this is new to me. The way I see it now, the project will be completed in the following 10 phases.

Phase 1: Prototyping
Phase 2: Obtaining DEM/LiDAR data
Phase 3: Converting DEM/LiDAR data to STL files
Phase 4: Preparing STL Files for printing
Phase 5: 3D Printing Parts
Phase 6: Priming Parts
Phase 7: Painting and assembly of watershed
Phase 8: Base construction and assembly
Phase 9: Base painting and decoration
Phase 10: Final Assembly

These phases are described in more detail below.

Phase 1: Prototyping

Going into this project there are many unknowns and uncertainties as to how to best create the desired 3D watershed model. The prototyping phase, which has already begun (see below), will provide guidance in determining how best to complete the remaining phases of the project.

The prototyping phase will entail obtaining various forms of data from available sources, processing the data at different scales and 3D printing it. Questions to be answered in the prototyping phase include:

- What size should the watershed model be?
- What data should be used?
- Where is the data to be obtained?
- What program, or programs, will be used to process the data?
- How thin can the parts be and still print?
- What offset is required for the lake parts to match with the land parts? (2mm works in my models, but I don't know if it will for larger pieces.)

The prototyping phase will address these issues, but it would be naïve to think that other issues will not become evident as the project progresses. Also, there are unknowns that will not be addressed in the prototype phase, such as how Phases 8-10, painting and assembly of the watershed, painting, assembly, and decoration of the base, and final assembly will be completed.

The prototyping phase has already been initiated to determine if the project was even feasible. Over 100 hours have been spent locating applicable data, downloading it, and processing it with various software. Eleven test prints have been conducted requiring over 60 hours of print time and 356 mL of resin. This work has resolved the issues regarding the watershed model size, what data should be used, potential sources for that data, and what programs will be used to process the data.

In order to minimize resin usage and the weight of the model, the part thickness, will by necessity, vary across the watershed. This is not expected to be a problem as shims can be used if needed. Early testing shows that the offset between lake and shore pieces should be increased to 0.3 mm.

Phase 2: Obtaining DEM/LiDAR data

The second phase of this project requires obtaining the required DEM and/or LiDAR data, as well as other spatial data (i.e., watershed boundary, lake boundaries and sections) needed to create the required solid (STL) files. From the work completed in Phase 1, it is anticipated that the following data will be utilized to create the watershed model:

Data	*File Type*	*Source*
Lake Bathymetry (Draper & Thunderbird)	*SHP*	*OWRB*
Lake Thunderbird watershed boundary	*SHP*	*ODEQ*
Section/Township boundaries	*SHP*	*OKMaps*
LiDAR data	*LAS*	*USGS*

The timing of this project is fortuitous because the 2018 USGS 2m LiDAR data recently became available on the Lidar Explorer web site. All of the requisite data has been downloaded.

Phase 3: Converting DEM/LiDAR data to STL files

The third phase of this project is converting the SHP and LAS files into STL files. The initial plan was to use Civil3D to accomplish this task, but during prototyping I discovered 1) that Civil3D could not open LAS files and required use of another program (ReCAP) to convert the LAS file to RCP files that it could open (which then had to be used to create a surface, which had to be extruded to create a solid), and 2) that the large quantities of data in the LAS files bogged Civil3D down so much that it quickly became obvious that it was going to be insufficient for the task at hand.

Mike Sharp, at OCC, recommended trying Global Mapper software and it is just what the Doctor ordered. The process is greatly simplified. I simply open the LAS file (for the land or SHP for the lakes), create a grid from it (a 3-click process), scale the elevation (z-axis) by two, and export it to an STL file (3-click process). Additionally, Global Mapper processes the data in the blink of an eye, so there is no waiting time.

Well, the process would be that simple if the LAS files were segmented to match the mile-sections, but sadly, that is not the case, so four or more of the LAS files first had to be combined and re-cropped to the sections and exported as a DEM file. Additionally, shoreline sections around the lakes and on the watershed boundary had to be cropped. This required another 100+ hours. Figure A-1 shows the processed DEM files of both the LiDAR and bathymetry data. Note the elevation is twice the actual elevation of the watershed.

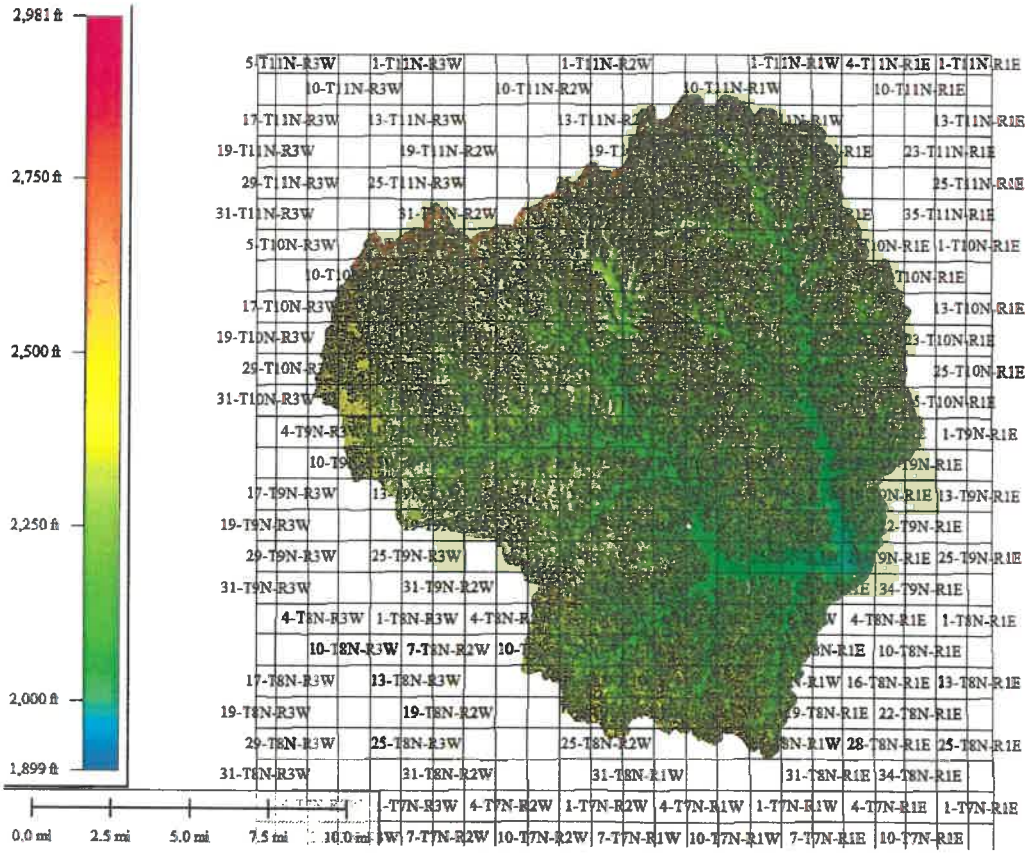


Figure A-1: Processed LiDAR and bathymetry DEM files for the data Lake Thunderbird watershed.

As mentioned previously, one of the issues to be addressed is how thick to make the parts. They have to be thick enough to print and hold their form as they cure, but not excessively thick because that wastes resin and increases the weight. The Global Mapper program creates a solid from the surface down to a specified elevation. I use the elevation range of a given part to assist me in determining what value to use.

Phase 4: Preparing STL Files for printing

In the fourth phase of this project the STL files will be prepared for printing using Chitubox "slicing" software. Preparing the STL files for printing is a two-step process: scaling and supporting.

Deciding what scale to use for the watershed model is a decision that must be made before the remaining phases may be executed. After discussion with City staff, early analysis of the watershed size, and consideration of my printers print tray size (130 mm x 78 mm (5.12" x 3.07")), it was decided that a scale of 3" to a mile would be used. At this scale, each mile section would just fit on my printer and would result in a watershed model display that is 66" x 70", which would be large enough to show the features of the watershed, yet not be too bulky to transport. The scale factor is 0.00144 (1.44%).

There are a total of 299 segments that will require printing, 17 Lake Thunderbird parts and 10 Lake Stanley Draper parts, 32 Lake Thunderbird shore parts, 16 Lake Stanley Draper shore parts, 63 watershed boundary parts, and 163 square section parts. The steps presented in Phases 2-5 will be executed 299 times to create the 3D parts needed to construct the watershed model.

Having decided on the scale for the model, the first step upon opening the "partname.stl" file in Chitubox is to scale the part down by a factor of 0.00144 (1.44%). The part is then oriented and supported to maximize the potential for successful printing and saved as "partname-supported.stl." Figure A-2 shows the "9N-2W-21-supported.stl" file in Chitubox slicing software. It is oriented at a 60° angle, though test prints have revealed the best angle to be 45°.

The full-section parts will require printing, and thus slicing, individually, but some of the lake segments and shoreline sections will be small enough to allow printing more than one part on a single print. In any case, the supported files will be sliced and saved to create PWMS files. Once the model is sliced, the software will provide an estimate of how much resin will be used to print the part and how long it will take to print. The sliced file is then copied to a thumb drive for printing.

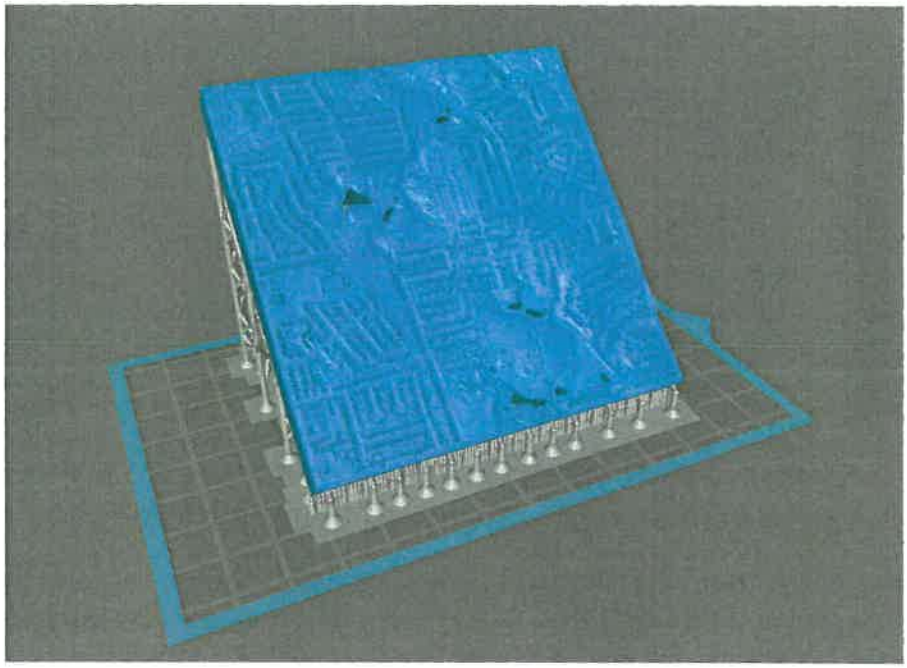


Figure A-2: Supported part "9N-2W-21-supported.stl" in Chitubox slicing software.

It should be noted that all 299 parts have already been prepared for printing, requiring an additional 80 hours. The completed Phases 1 – 4, required more of my time per part than the remaining phases will.

Phase 5: 3D Printing Parts

The fifth phase of the project is actually printing the parts. With the printer cleaned and filled with resin, the thumb drive with the PWMS file to be printed is inserted into the printer, the "Print" button is pushed, the file is selected, and the "Start" button is pushed. Of course, this is assuming that you have the various settings on the printer set correctly (but I won't go into that) and that the vat is filled with the resin you want to use. I will touch briefly on that.

There are almost as many resin brands, varieties, and colors available as there are pebbles in a stream. In general, the resins are toxic until they are fully cured. As such you should wear gloves when touching it, eye protection when you are handling the liquid, a mask when printing (unless the printer is well ventilated) and you can't simply throw anything that touches it in the trash, without curing it first.

Fortunately, Anycubic markets "Plant based Eco-Resins" that are NOT toxic. They are more expensive than toxic resins, but I prefer to use them as I see no reason to expose myself to toxins if I don't have to.

Once the print is started, the screen provides the actual time that it will take to print. The printed Section 21-T9N-R2W part, shown below in Figure A-3, used an estimated 54.5 mL of resin and took 6 hours and 22 minutes to print.

When the print is completed, the base plate assembly is removed from the printer and the part is gently pried off of the base plate into warm water with a bit of dish-washing detergent, swirled and dunked to remove excess resin clinging to the part, then rinsed in warm water. The supports are removed, and the part is cured by exposing it to UV light for a couple of hours. I use the sun. It's free. Preparing for the next print requires cleaning the base plate assembly, re-attaching it to the printer and making sure that the vat has sufficient resin in it for the next print.

It should be noted that although the time expenditure printing the parts is minimal, the printing time is not. The parts typically take 5 or 6 hours to print, so that I will typically only print two parts a day.

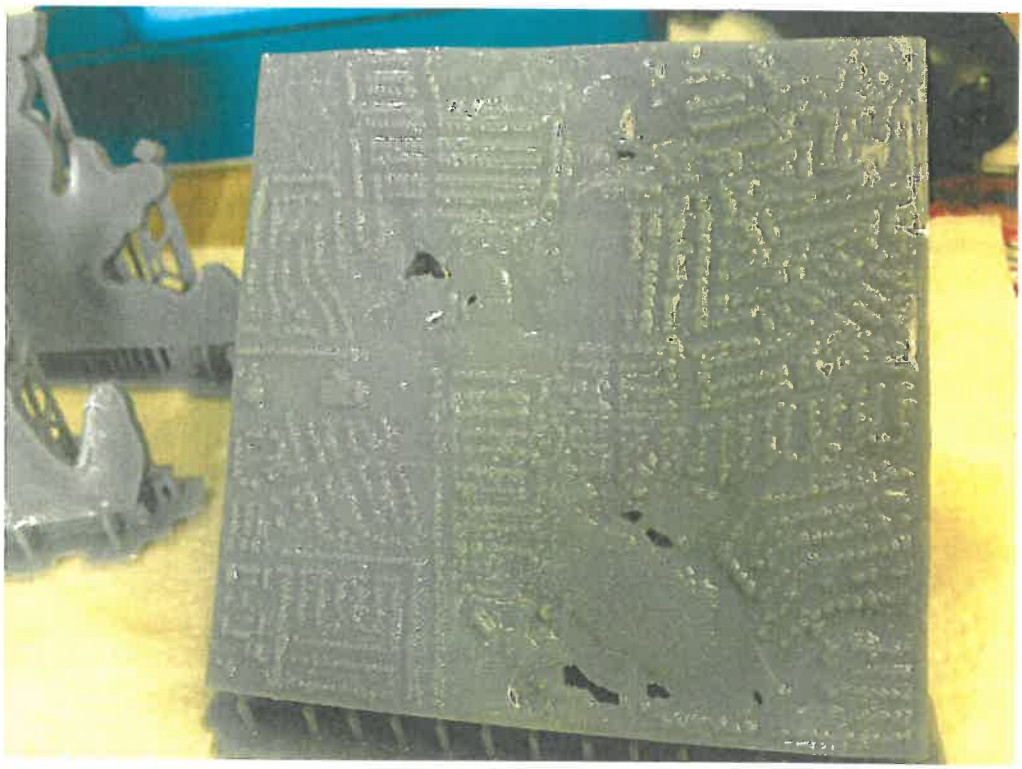


Figure A-3: Printed Section 21-T9N-R2W.

After all of the parts are printed, the remaining phases of the project will convert the 299 individual printed parts into the desired watershed model display. The order in which these phases are executed may differ from the order in which they are presented.

Phase 6: Priming and Painting Parts

The sixth phase of the project is priming and painting the parts. Although it has yet to be determined exactly how the painting and assembly of the watershed will proceed, it is almost certain that it will be painted.

Phase 7: Assembly of watershed

The seventh phase of the project is assembly of the watershed. As mentioned previously, it has yet to be determined exactly how this will be conducted. There has been discussion of getting community involvement in this process, which would be awesome, but may open a can of worms.

Phase 8: Base construction and assembly

The eighth phase of this project is the construction and assembly of the base. This could be accomplished at any time during the project, but again, it has yet to be determined how and when this is to be accomplished. It is probably desirable to make the base early in the process to assist in correctly laying out the watershed parts.

The construction process, I am currently considering is as follows:

We start with four sheets of 1/4 in. x 4 ft. x 8 ft. plywood ($36.92/sheet), cut, laid crossways, and laminated together. Then we cut two sheets of ¼" x 4' x 8' HDPE ($154.23/sheet on-line) into sixteen 18" x 18" pieces, which will fit on the engraver at the Innovation Hub. The pieces would be etched with the sections (and labels), the lake outlines, and the watershed boundary, where applicable. These pieces can then be attached to the wood base with Gorilla glue and screws and the model parts would then be adhered to the HDPE sheets using Super Glue. Fascia would be applied around the watershed. I was initially thinking of using a nice light wood, like Maple or White Oak, but we might want to use a synthetic wood that may adhere better to the plastic. Trim molding could then be used to put a frame around the outside of the assembly, similar to the one shown in Figure A-4, which shows a base I made for a diorama of the USS Bennington aircraft carrier. Although it is smaller and deeper than the frame that I envision for the 3D watershed frame, the 3D printed parts will nestle inside the fascia within the frame.

Phase 9: Base painting and decoration

The ninth phase of this project is painting and decorating the base. Although it has not been determined how the display is to be decorated, certain information must be included, including a title, scale and scalebar, data sources, credits, and any other information we may wish to add. It is envisioned that these decorations will be created in C3D and printed to clear decal paper, which may then be easily applied to the surface, as shown in Figure A-4. A few layers of clear lacquer should adhere them to the surface and protect them from being damaged. If public participation is incorporated into this project, it may be preferential to apply the decals and any other relevant information we include after the parts are assembled. On the other hand, it may not. If they get damaged, we can always replace them.

Phase 10: Final Assembly

The tenth and final phase of this project is the final assembly of the watershed model display. Final assembly as imagined here is assembling the 3D printed parts into the base, but again, if public participation becomes a component of this project, or perhaps even if there is not, there might not be a final assembly so much as an evolutionary assembly, section by section. After everything is completed, I would propose to add foldable table legs to the bottom of the base.

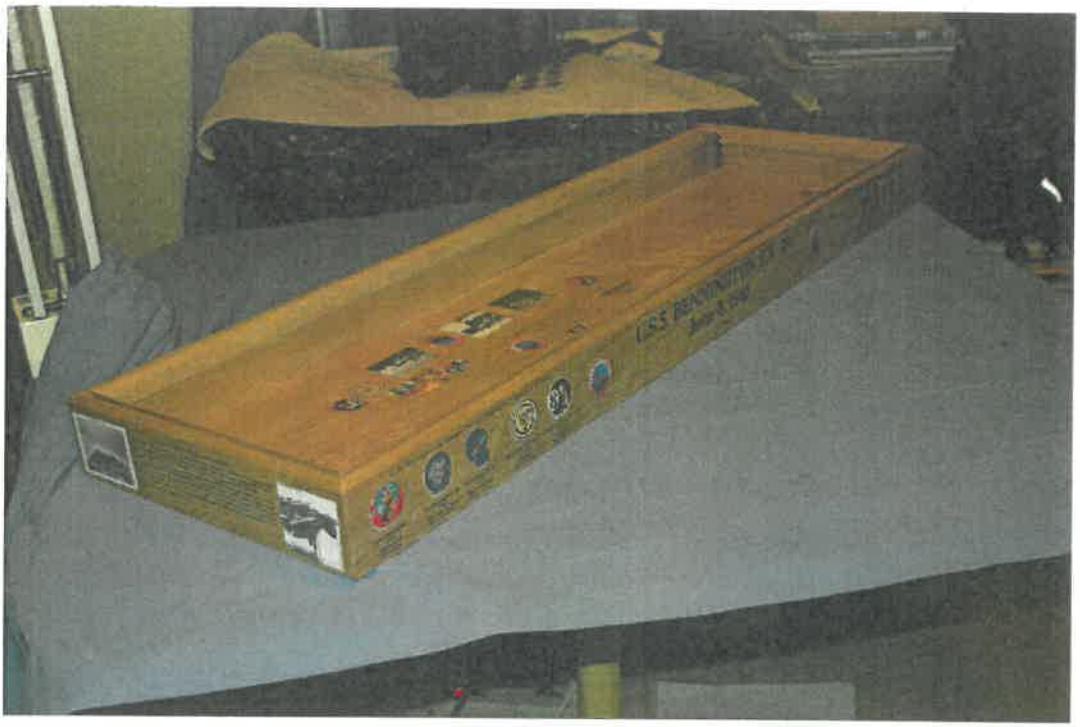


Figure 7: Base for a diorama of the USS Bennington aircraft carrier.

Software and Materials

A list of the software and materials required to complete the Lake Thunderbird watershed model is provided below in Table A-1. Efficiently converting DEM and LiDAR data to STL files (Phases 1-4) required purchasing Global Mapper software, including a LiDAR module, at a cost of $1,141.92. Printing the parts (Phase 5) will require an estimated 10 liters of resin, detergent, and will likely require replacing the FEP, at a total cost of $695.79.

Materials required for priming and painting the parts (Phase 6) and assembling the watershed (Phase 7) include primer, paint and glue. Materials required for the construction and assembly (Phase 8) and painting and decorating (Phase 9) the base include 1/4" plywood and HDPE, faux oak veneer, glue, lacquer, and 11"x17" decal sheets. The total cost for software and materials for this project is $2,667.71.

Table A-1: Software and Equipment List

Item	Cost
Global Mapper Software	$1,141.92
Total Resin/Printing Cost	$ 695.79
Plywood - 4 - 1/4"x4'x8'	$ 120.00
HDPE - 2 - 1/4"x4'x8'	$ 310.00
Fascia sheets	$ 100.00
Folding table legs (4)	$ 200.00
Primer/Paint	$ 50.00
Glue	$ 20.00
Lacquer	$ 30.00
Total	$2,667.71

Attachment B. Project Schedule

3D Printing the Lake Thunderbird Watershed Proposal
Prepared by Russell C. Dutnell, P.E., Ph.D.; Riverman Engineering, PLC
May 26, 2021

The time required to complete this project will be considerable. I have already spent well over 300 hours on it but have done the lion's share of the work required to 3D print the model (Phases 1-4). Printing of the parts has commenced, but it is going to take a while. Each part takes 5 to 7 hours to print, which means that the most I will be able to print is 2 parts/day, and many days I suspect I will only print one a day, and on some, none. Also, I am sure I will have misprints requiring reprinting parts, and with this number of prints I would be surprised if I don't have to replace my FEP at some point along the way. I think we should plan on the project taking a year to complete.

My plan is to print the parts in groups. Table B-1 provides estimated completion dates for printing the various part groups. It is a conservative schedule and assumes a starting date of June 15, 2021. You can see that the final parts are estimated to be print 13 months after the project starts. The dates will shift depending on the start date.

Table B-1: Proposed Time Schedule to 3D Print the Part Groups

Part Group	# of parts	Est. comp. Date
Lake Stanley Draper Shoreline Parts	16	7/15/2021
Lake Stanley Draper Segments	10	8/15/2021
Lake Thunderbird Shoreline Parts	31	9/15/2021
Lake Thunderbird Segments	17	10/15/2021
Land Sections - Group1 - Central Corridor	24	11/15/2021
Land Sections - Group2 - Perimeter 1 - NE	23	12/15/2021
Land Sections - Group3 - Perimeter 2 - NW	12	1/15/2022
Land Sections - Group4 - Perimeter 3 - SW	13	1/15/2022
Land Sections - Group5 - Perimeter 4 - SE	15	2/15/2022
Land Sections - Group6 - Interior 1 - South	19	2/15/2022
Land Sections - Group7 - Interior 2 - South Central	14	3/15/2022
Land Sections - Group8 - Interior 3 - West Central	11	3/15/2022
Land Sections - Group9 - Interior 4 - Central	14	4/15/2022
Land Sections - Group10 - Interior 5 - West	12	4/15/2022
Land Sections - Group11 - Interior 6 - WNW	6	5/15/2022
Land Sections - Group12 - Interior7 - NW Central	10	5/15/2022
Land Sections - Group13 - Interior8 - NW	9	5/15/2022
Land Sections - Group14 - Interior9 - North	16	6/15/2022
Land Sections - Group15 - Interior10 - East	10	6/15/2022
Land Sections - Group16 - Interior11 - NE	9	7/15/2022
Land Sections - Group17 - Interior12 - NE Central	8	7/15/2022
Total Number of Parts	299	

I should note that I have already print all of the Lake Stanley Draper lake and shoreline parts and am currently printing the Thunderbird parts, so I am currently ahead of schedule. I need to be however, because if next winter is anything like last winter, I will not be able to print from October to April.

After the parts are printed, priming and painting them shouldn't take more than a day or two, and assembly should take no more than a week, provided that the base has been constructed and assembled before the parts are all printed, like I am planning. Another week should be allowed for painting and decorating the model display and adding the legs to make it a table. If all goes to plan **the Lake Thunderbird watershed model should be completed by August, 2022.**

Attachment C. Project Fee Schedule

3D Printing the Lake Thunderbird Watershed Proposal
Prepared by Russell C. Dutnell, P.E., Ph.D.; Riverman Engineering, PLC
May 26, 2021

A proposed payment structure for completing the project is provided in Table C-1, below. Payment for Phases 1-4, obtaining and processing the DEM/LiDAR data to STL files and preparing the STL files for printing, which have been completed is due as a Lump Sum of $5,000, as soon as possible upon contract agreement. Payment for materials, totaling $2,667.71, is due upon receipt submittal.

Payment for Phase 5, 3D printing the parts, is based on the number of completed parts printed at a rate of $25.08 per printed part, and will be paid monthly, dependent on the number of parts printed. Table C-2 shows the estimated payment schedule for 3D printing the part groups.

Work for Phases 6–10 will be paid as lump sums upon completion of the Phase, at $500 for each phase. Total payments for the project sum to $17,667.71.

Table C-1: Proposed payment structure for 3D printing a model of the Lake Thunderbird watershed.

Phase	Phase Cost	Payments	Payment Type	Payment Due
Phase 1: Prototyping	$ 2,000.00	$ 2,000.00	Lump Sum	ASAP
Phase 2: Obtaining DEM/LiDAR data	$ 1,000.00	$ 1,000.00	Lump Sum	ASAP
Phase 3: Converting DEM/LiDAR data to STL files	$ 1,000.00	$ 1,000.00	Lump Sum	ASAP
Phase 4: Preparing STL Files for printing	$ 1,000.00	$ 1,000.00	Lump Sum	ASAP
Phase 5: 3D Printing Parts	$ 7,500.00	$ 7,500.00	Unit; $25.08/part	Monthly*
Phase 6: Priming and Painting Parts	$ 500.00	$ 500.00	Lump Sum	Upon completion
Phase 7: Assembly of watershed	$ 500.00	$ 500.00	Lump Sum	Upon completion
Phase 8: Base construction and assembly	$ 500.00	$ 500.00	Lump Sum	Upon completion
Phase 9: Base painting and decoration	$ 500.00	$ 500.00	Lump Sum	Upon completion
Phase 10: Final Assembly	$ 500.00	$ 500.00	Lump Sum	Upon completion
Materials and Software	$ 2,667.71	$ 2,667.71	Lump Sum	Upon receipt submittal
Total	$17,667.71	$17,667.71		

*See Table C-2 for anticipated payment Schedule.

Table C-2:Payment Schedule for Phase 5, 3D printing the parts.

Part Group	# of parts	Est. comp. Date	Payment Amount
Lake Stanley Draper Shoreline Parts	16	7/15/2021	$ 401.34
Lake Stanley Draper Segments	10	8/15/2021	$ 250.84
Lake Thunderbird Shoreline Parts	31	9/15/2021	$ 777.59
Lake Thunderbird Segments	17	10/15/2021	$ 426.42
Land Sections - Group1 - Central Corridor	24	11/15/2021	$ 602.01
Land Sections - Group2 - Perimeter 1 - NE	23	12/15/2021	$ 576.92
Land Sections - Group3 - Perimeter 2 - NW	12	1/15/2022	$ 301.00
Land Sections - Group4 - Perimeter 3 - SW	13	1/15/2022	$ 326.09
Land Sections - Group5 - Perimeter 4 - SE	15	2/15/2022	$ 376.25
Land Sections - Group6 - Interior 1 - South	19	2/15/2022	$ 476.59
Land Sections - Group7 - Interior 2 - South Central	14	3/15/2022	$ 351.17
Land Sections - Group8 - Interior 3 - West Central	11	3/15/2022	$ 275.92
Land Sections - Group9 - Interior 4 - Central	14	4/15/2022	$ 351.17
Land Sections - Group10 - Interior 5 - West	12	4/15/2022	$ 301.00
Land Sections - Group11 - Interior 6 - WNW	6	5/15/2022	$ 150.50
Land Sections - Group12 - Interior7 - NW Central	10	5/15/2022	$ 250.84
Land Sections - Group13 - Interior8 - NW	9	5/15/2022	$ 225.75
Land Sections - Group14 - Interior9 - North	16	6/15/2022	$ 401.34
Land Sections - Group15 - Interior10 - East	10	6/15/2022	$ 250.84
Land Sections - Group16 - Interior11 - NE	9	7/15/2022	$ 225.75
Land Sections - Group17 - Interior12 - NE Central	8	7/15/2022	$ 200.67
Total Number of Parts	299		$ 7,500.00

ATTACHMENT D
OWNER'S RESPONSIBILITIES

As the OWNER will serve as a conduit for information, the OWNER shall provide information pertaining to applicable studies, data, city policies and ordinances, other relevant planning studies by Norman area agencies. If data is required from other public agencies, the OWNER will assist in making requests for such data.

The OWNER shall perform the following tasks:

A. Coordinate and securing of meeting locations, times and necessary meeting materials.

B. Review and comment on Consultant materials and recommendations.

C. Assist CONSULTANT by placing at CONSULTANT's disposal all available information pertinent to the Project including previous reports and any other data relative to execution of the Project.

D. Arrange for access to and make all provisions for a room to store the model pieces and base during the assembly process as required for CONSULTANT to perform services under this AGREEMENT.

E. Examine all studies, reports, sketches, drawings, specifications, proposals and other documents presented by CONSULTANT, obtain advice of an attorney, insurance counselor and other consultants as OWNER deems appropriate for such examination and render in writing decisions pertaining thereto within a reasonable time so as not to delay the services of CONSULTANT.

F. Bear all costs incident to compliance with the requirements of this Attachment D.

G. Notify CONSULTANT in writing of the request to perform additional services at the added cost to the overall contract.